Leadership, Learning, and Business Beyond Boundaries: Managing Change in a Complex World
21–23 May 2026
Ljubljana, Slovenia
make learn TIIM PIConf
Management, Knowledge and Learning International Conference
Technology, Innovation and Industrial Management
Sustainable Development

Open Science, Citizen Participation, and the Preservation of Indigenous Knowledge Systems: Evidence from East African Universities

Irura Nganga
Garissa University, Kenya

Kevin Macharia
Garissa University, Kenya

Ahmed O. Warfa
Garissa University, Kenya

Elaine Chepkosgei
Garissa University, Kenya

Suleiman Gaitho
Garissa University, Kenya

Juma Iddi
Garissa University, Kenya

Enoch Mogendi
Garissa University, Kenya

Aden Ali
Garissa University, Kenya

Francis Omillo
Garissa University, Kenya

Amina Mohammed
Garissa University, Kenya

Aden Musa Mohamud
Garissa University, Kenya

David Karienye
Garissa University, Kenya

Ahmed Maalim
Garissa University, Kenya

Ahmed Abdikadir
Garissa University, Kenya

Salah Farah
Garissa University, Kenya

Grace Mbogo
Daystar University, Kenya

Martin Munyao
Daystar University, Kenya

Kevin Muriithi Ndereba
St. Paul's University, Kenya

Paul Ruto
St. Paul's University, Kenya

Mussa Mgwatu
University of Dar es Salaam, Tanzania

Mathew Senga
University of Dar es Salaam, Tanzania

Lucky Yona
Eastern and Southern African Management Institute (ESAMI), Tanzania

David Kalaba
Eastern and Southern African Management Institute (ESAMI), Tanzania

Nada Trunk
International School for Social and Business Studies (ISSBS), Slovenia

Valerij Dermol
International School for Social and Business Studies (ISSBS), Slovenia

Rafael de Miguel González
University of Zaragoza (UNIZAR), Spain

Juan Valles
University of Zaragoza (UNIZAR), Spain

Marjolein Zweekhorst
Vrije Universiteit Amsterdam (VU Amsterdam), Netherlands

Rai Sarju Sing
Vrije Universiteit Amsterdam (VU Amsterdam), Netherlands

Olesea Sirbu
European Policy Development and Research Institute (EPDRI), Slovenia

Nicu Sirbu
European Policy Development and Research Institute (EPDRI), Slovenia)

Abstract

Open Science has become an international model of improving the level of transparency, accessibility, and collaboration of research. Nevertheless, its application in higher education and research institutions in Africa is not comprehensive yet, and the potential of this application to facilitate the preservation and democratization of Indigenous Knowledge Systems (IKS) is not fully harnessed. This paper investigates Open Science status of thirty (30) higher education institutions in Kenya and Tanzania, specifically the institutional preparedness, gaps in infrastructure, the citizenry engagement, and IKS integration. The research assumed a mixed-method approach and integrated survey information on 235 respondents, a 190-participant citizen science survey, and policy, governance, and infrastructure evaluation of institutions. The data was analyzed using a combination of a descriptive and qualitative thematic analysis. The results indicate that there is a great awareness of Open Science (83%), and the strong positive attitude towards citizen science, as more than 90% of the respondents acknowledge the importance of citizen science to academia and society. Nevertheless, there is a weakness of institutional capacity. The percentage of respondents with access to formal Open Science training is only 9.8% and 90.2% of institutions do not have formal policies on Open Access and Research Data Management. There is digital infrastructure but it is not fairly distributed, and hence not well used, and there are poor interoperability and data management frameworks. The study further found that citizen science provides a pathway for integrating Indigenous Knowledge Systems into Open Science frameworks. However, tensions between openness and Indigenous data sovereignty highlight the need for governance approaches that combine FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) principles. The study concludes that the successful institutionalization of Open Science in East Africa requires not only technical and policy reforms but also the inclusion of Indigenous Knowledge through participatory, ethical, and context-sensitive frameworks.

Keywords: Open Science, Indigenous Knowledge Systems, Citizen Science, Knowledge Democratization, FAIR/CARE Principles

1 INTRODUCTION

Open Science has expanded rapidly in the global research system over the last three decades. The expansion of digital communication technologies after 1990 played a major role in this development.

The emergence of the Internet enabled scientists to communicate and publish research instantly across national borders (Marginson, 2022). Before this period, scientific collaboration across countries was limited. For example, only 1.9% of papers indexed in the Web of Science in 1970 included authors from more than one country (Marginson, 2022).

The global science system expanded significantly in the early twenty-first century. The number of scientific papers increased rapidly worldwide. Between 2000 and 2018, scientific publications indexed in Scopus grew at a rate of 4.9% per year, which was higher than the 3.5% annual growth rate of global Gross Domestic Product (GDP) during the same period (Marginson, 2022). The number of universities producing large volumes of research also increased. The Leiden ranking shows that universities publishing at least 5,000 papers rose from 131 institutions in 2006–2009 to 233 institutions in 2015–2018 (Marginson, 2022). International collaboration has become a defining feature of modern science. In 2018, 22.5% of all Scopus publications were written by authors from more than one country (Marginson, 2022). Earlier estimates also show that approximately one out of five scientific articles worldwide involve international co-authors (Lee & Haupt, 2021). These collaborations often lead to higher research impact because they combine expertise, resources, and networks from multiple countries (Lee & Haupt, 2021).

The global distribution of research capacity has also expanded. In 2000, only 30 countries produced more than 5,000 scientific papers annually, but by 2018 this number increased to 52 countries (Marginson, 2022). This shift reflects the spread of scientific infrastructure and higher education systems to more regions of the world. The development of open access publishing has also contributed to the growth of Open Science. The modern open access movement began in 2000 when scientists Harold Varmus, Patrick Brown, and Michael Eisen called for the creation of a Public Library of Science that would provide free access to scientific literature. Thousands of researchers from 180 countries supported this initiative and since then, open access publishing has expanded significantly. Institutions around the world have created repositories that provide free access to research outputs (Anglada & Abadal, 2023).

The open science movement gained further momentum during the last decade. The movement promotes transparency, reproducibility, and accessibility in research. It encourages practices such as open data, open materials, open code, and open access publications (Chuan-Peng *et al*., 2025). These practices emerged partly in response to concerns about research credibility and failures to replicate scientific findings (Chuan-Peng *et al*., 2025). International organizations have also supported the expansion of Open Science. Policies and recommendations from global bodies have encouraged governments and research institutions to adopt open science practices. These policies promote open access to research outputs and the development of open research infrastructures (Chuan-Peng *et al*., 2025).

The 2021 United Nations Educational, Scientific and Cultural Organization (UNESCO) Recommendation on Open Science provided a global policy framework that guided the implementation of open science practices across countries. UNESCO adopted the recommendation in November 2021 during the 41st session of the General Conference, and 193 member states endorsed the framework, which reflected broad international support for open science policies. The recommendation established key principles for promoting open scientific knowledge, open science infrastructures, open engagement of societal actors, and dialogue with diverse knowledge systems. It also encouraged governments and research institutions to invest in digital infrastructures such as repositories, data platforms, and collaborative research systems to support the sharing and reuse of research outputs (Anglada & Abadal, 2023). The framework further emphasized the importance of capacity building and researcher training

in areas such as open data management, open publishing, and collaborative research practices (Chuan-Peng *et al.,* 2025). In addition, the recommendation promoted inclusive participation in knowledge production, including collaboration between researchers and broader societal actors, which aligned with the broader goal of democratizing access to scientific knowledge and strengthening global research collaboration (McConnell *et al.,* 2024; Numajiri & Hayashi, 2024).

They have been actively institutionalised through the frameworks of Horizon 2020 and Horizon Europe by the European Union, which requires open access to publicly funded research results to increase scientific reproducibility and transparency (Bacalexi, 2022; Filippo and Sastron-Toledo, 2023). Also, with the creation of the European Open Science Cloud, the cross-border transfer of data becomes a seamless process with the support of legislations like the Directive on the re-use of the public sector information (Drach et al., 2022). In France, institutional alignments are further established by the Digital Republic Law (2016) and the National Plan of Open Science that offer a legal basis of systematic sharing of research results (Manco, 2022). On a supranational scale, the European Commission uses the services of expert groups like the Open Science Policy Platform to convert these general directives into practical and sustainable processes that balance the interests of the stakeholders with stringent quality evaluation indicators (Iryna et al., 2022). Outside of the European experience, new initiatives are underway to incorporate Open Educational Resources into institutional open policies such as in Finland and Switzerland where institutional policies now explicitly incorporate Open Educational Resources (OER) as a requirement in both open data and open publication requirements (Santos-Hermosa, 2024). In the same way, regional collaboration in Latin America and the Caribbean has been institutionalized, such as the European Union Community of Latin American and Caribbean States (EU-CELAC) Joint Initiative, which focuses on mutual access to research infrastructures and national legislative expansion of the open-access digital repositories (Toro et al., 2024).

Open science in Global south is quickly becoming a localized movement beyond a peripheral notion, with the goal of overcoming inequitable access to global knowledge via open access repositories, as well as local policy formulation. Major projects are the African Open Science Platform (AOSP), the Shodhganga in India and African Journals Online (AJOL). Even though, momentum, challenges such as limited, digital infrastructure, funding, and, language barriers still exist, they, in most cases, necessitate, localized, advocacy and, infrastructure, development. Africa has had poor involvement in the global Open Science movement even as there is the increased international focus on openness in research. Research has indicated that development of Open science on the continent has been slow since many institutions do not have the required research infrastructures and well-coordinated policy frameworks. The African research systems have frequently been characterized by the lack of digital infrastructure, data governance systems, and interoperable platforms, which facilitate the sharing and reuse of research outputs (Chiware & Skelly, 2022). The lack of investment in information and communication technologies has also restricted the capacity of universities and research institutions to employ open repositories, open data systems and collaborative digital research platforms which are core to Open Science practices (Chiware & Skelly, 2022). Such structural limitations have diminished the ability of African institutions to engage fully in the open science networks in the world.

Institutional loopholes in policy have also led to the low levels of participation on Open Science by Africa. Most of the African nations are yet to establish comprehensive national policies on open science, as well as strategies coordinated in the area of open data and publishing of open access. Lack of well-developed policy frameworks has hampered the use of open science practices at universities and research

organizations (Chiware & Skelly, 2022). Besides that, poor coordination of research institutions and insufficient understanding of the principles of open science by policymakers and researchers have influenced the development of Open Science on the continent (Chiware & Skelly, 2022). These issues have posed hindrances to the participation of many in the global knowledge sharing systems, and reduced the visibility and availability of African researches to the international scientific community.

The trend is towards more inclusive knowledge systems (a trend in Open Science) across the world. Nevertheless, the systems of Indigenous Knowledge (IKS) in Africa have long been excluded in the mainstream of formal research and education systems. Indigenous knowledge can be defined as the locally acquired skills, practices and knowledge of communities as a result of the long-term engagement between communities and their environments and social systems. These knowledge systems direct key areas of life like agriculture, natural resources management, health practices, and climate adaptation (Leal Filho et al., 2022). In most African communities, indigenous knowledge has always been passed orally and through culture, rituals, and experience of the community as opposed to being written in any official document. Although this kind of knowledge has been central to community resilience and environmental stewardship, it has been generally absent in the mainstream academic knowledge production and policy paradigm (Leal Filho et al., 2022). Such exclusion has helped to maintain a long-standing asymmetry in the world knowledge systems, with regard to the fact that locally based knowledge is underexpressed in the scientific discourse.

The exclusion of the Indigenous Knowledge Systems in Africa is intimately related to the historical and institutional processes that promoted the Western epistemologies in favor of the indigenous knowledge systems. Colonial education and missionary factors frequently pushed local knowledge to the status of an outdated, unreasonable, and irreconcilable system with the new knowledge in the sciences, which gradually eroded its social validity and transfer to subsequent generations (Leal Filho et al., 2022). Formal education systems in most instances introduced curriculums that focused on foreign knowledge systems at the expense of the local knowledge adopted locally in communities. Consequently, native knowledge has often been considered as lesser or non-scientific, such as reinforcing a dominant monoculture of knowledge production within the academic and educational institutions (Da Silva et al., 2024). This epistemic superiority and communication wall has not only narrowed the exposure of indigenous knowledge to research systems, it has also led to the loss of useful cultural and environmental knowledge that can be used to create sustainable development.

Moreover, there are still structural impediments in the learning and research institutions which restrict the inclusion of indigenous knowledge in formal knowledge regimes. In most of the settings, indigenous knowledge has been tacit and embedded on cultural practices and therefore hard to capture and integrate into the normal academic frameworks (Muwanga-Zake & Kibukamusoke, 2024). The policy structures, research paradigms and educational curriculums tend to focus on externally developed models of knowledge to the extent that there is limited room to epistemological models of the community. Therefore, a significant part of the studies carried out in African settings still makes use of the theoretical frameworks that are unlinked with the local cultural realities and knowledge traditions (Muwanga-Zake & Kibukamusoke, 2024). Such a failure to align formal research systems with indigenous knowledge does not only diminish the relevance of research findings to local populations but also curtails the potential that the indigenous knowledge has to the realization of the current issues such as climate change, biodiversity conservation and sustainable resource management.

Open Science provides a useful framework for examining how Indigenous Knowledge Systems (IKS) can be integrated into broader knowledge production processes. The principles of openness, accessibility, and knowledge sharing that characterize Open Science create opportunities for documenting and preserving indigenous knowledge that has traditionally been transmitted through oral traditions and community practices. Digital infrastructures such as repositories and data platforms can convert locally held knowledge into digital assets that can be preserved and accessed across generations, thereby increasing the visibility of indigenous knowledge within research and policy systems (Ngulube, 2023). At the same time, scholars have noted that the integration of indigenous knowledge into open science environments raises important governance considerations related to indigenous data sovereignty and community rights. Frameworks such as the CARE principles, which emphasize collective benefit, authority to control, responsibility, and ethics in indigenous data governance, have been proposed as complementary to the FAIR data principles commonly used in open science initiatives (Carroll *et al*., 2021; Nature Communications, 2024). In addition, participatory approaches such as citizen science highlight the role of local communities in knowledge production and illustrate how indigenous knowledge derived from long-term interactions with local ecosystems can contribute to scientific understanding (*Fraisl et al.*, 2023; Zidny *et al.,* 2019). Together, these perspectives suggest that Open Science provides a conceptual space in which indigenous and scientific knowledge systems can interact within more inclusive and pluralistic knowledge infrastructures.

1.1 Statement of the problem

Although the general movement towards Open science and more awareness about the importance of Indigenous Knowledge System as a source of knowledge has been gaining momentum globally, there is still a lot to be desired in the practical application of the two fields to many research systems in Africa. Though the open science enhances accessibility, transparency, and shared knowledge creation, most African research institutions still experience structural constraints that impede the use of open science infrastructure and policies. Concurrently, Indigenous Knowledge Systems are mostly non-documented, non-represented in the official research products, and insufficiently represented in the academic knowledge systems. Such a scenario poses a two-fold challenge whereby African institutions not only have challenges with insufficient engagement in open science networks across the world, but also with the ongoing marginalization of locally produced systems of knowledge. As such, the opportunities of Open Science to become a space where indigenous knowledge systems are documented, maintained, and democratized have yet to be exploited in most African institutions of higher learning. In East Africa, Kenya and Tanzania before FOSTER Project, there were less efforts regarding use of open science to safeguard the indigenous knowledge systems.

Most research on the subject of Open Science has paid considerable attention to technological infrastructures, open access publishing, and the international collaboration, but little was paid to the opportunities to implement those frameworks to address the preservation of Indigenous Knowledge Systems and their integration into academic research systems. It is on this basis that the paper investigates the state of Open Science in the selected institutions of higher learning in Kenya and Tanzania. This paper also takes into account the possible use of the Open Science infrastructures in facilitating the documentation and maintenance of the Indigenous Knowledge Systems in African research contexts. The paper continues with conceptual framework, which is followed by methodology, results and discussion of findings and implications as well as recommendations.

1.2 Research Objective

This study sought to examine the level of Open Science readiness in selected universities in Kenya and Tanzania and explore how Open Science infrastructures can support inclusive knowledge production, particularly the preservation and integration of Indigenous Knowledge Systems.

1.2.1 Specific Objectives

i. To assess the current level of Open Science readiness among selected universities in Kenya and Tanzania.

ii. To identify the infrastructure gaps and institutional needs required for the development of effective Open Science ecosystems.

iii. To examine how Open Science infrastructures can facilitate the preservation, recognition, and integration of Indigenous Knowledge Systems into university research, teaching, and community engagement initiatives.

1.3 Research questions

i. What is the current level of Open Science readiness among selected universities in Kenya and Tanzania?

ii. What infrastructure gaps and institutional needs exist for the development of Open Science ecosystems in these institutions?

iii. How can Open Science infrastructures support more inclusive knowledge production, including the preservation and integration of Indigenous Knowledge Systems?

1.4 Conceptual Framework

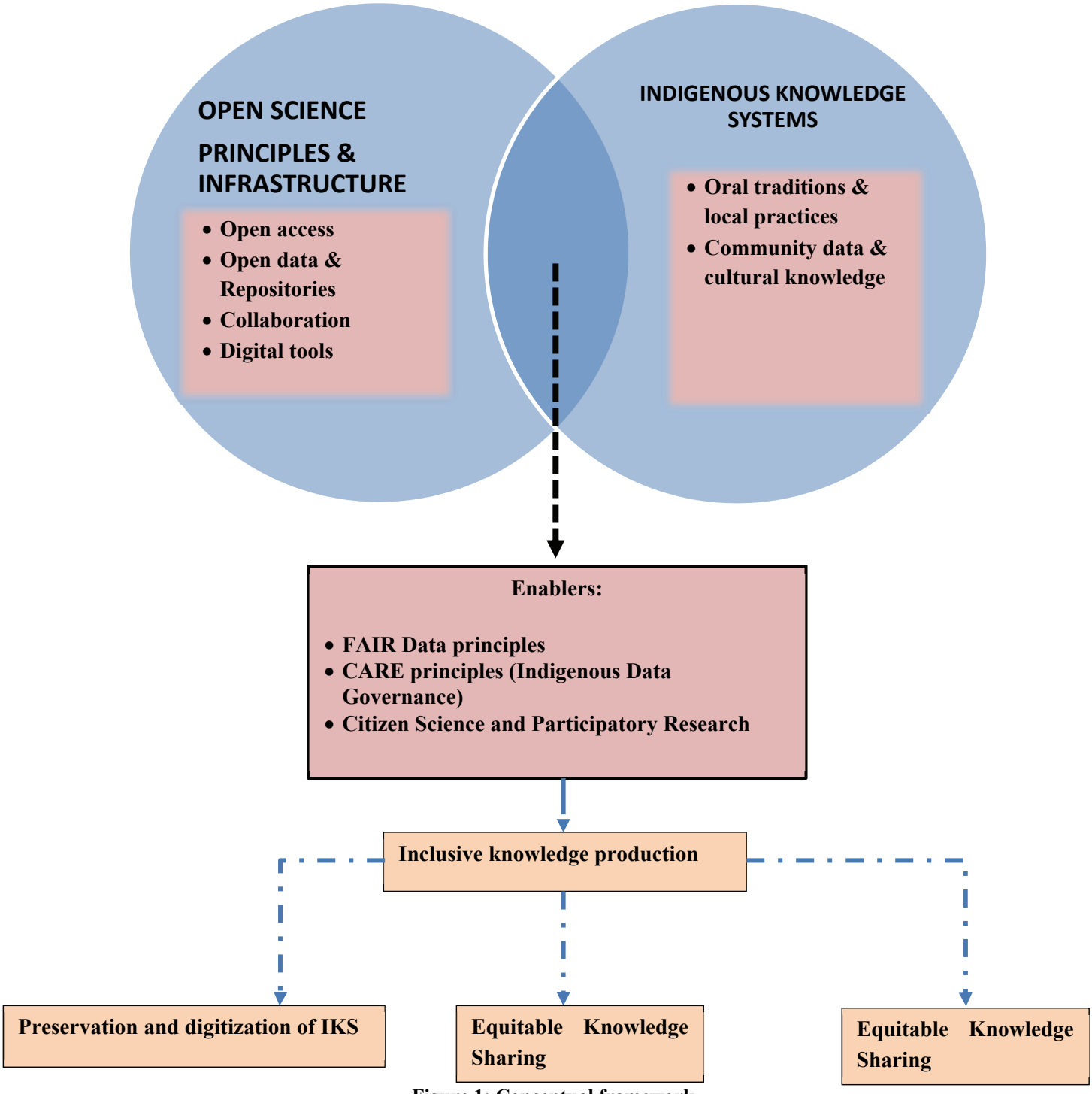

Figure 1: Conceptual framework

This conceptual framework illustrates how Open Science principles and infrastructure can support the recognition and integration of Indigenous Knowledge Systems (IKS) to promote inclusive knowledge production in universities. Open Science components such as open access, open data and repositories, research collaboration, and digital tools provide the technological and institutional foundation for sharing and managing knowledge.

In this study, Open Science readiness is conceptualized as the extent to which higher education institutions possess the necessary policy, infrastructure, governance, human capacity, and community engagement mechanisms required to effectively implement Open Science practices. Specifically, readiness is assessed across five interrelated dimensions including Policy readiness (existence of Open Access and Research Data Management frameworks), Infrastructure readiness (availability of repositories and digital research systems), Governance readiness (institutional coordination, leadership, and regulatory structures), Capacity readiness (skills, training, and awareness among stakeholders), and Engagement readiness (extent of citizen science and participatory research practices). These dimensions guided both data collection and analysis, allowing for a structured assessment of institutional preparedness for Open Science implementation.

2 METHODOLOGY

2.1 Research Design

The research design that was implemented in this study is a mixed-method research design To ensure coherence within the mixed-method design, the study adopted a complementary and sequential integration approach. The Open Science skills and capacity survey (n = 235) provided quantitative insights into awareness, training gaps, and institutional readiness across stakeholder groups. The citizen science survey (n = 190) specifically examined participatory research practices and community engagement dimensions. These survey findings were then triangulated with institutional policy and infrastructure assessments to contextualize individual-level responses within organizational systems. Together, these components form an integrated analytical framework linking individual perceptions, institutional capacity, and global reference models. The study operationalized Open Science readiness using the five dimensions outlined in the conceptual framework, linking each data source to specific components of readiness.

2.2 Study Population and Sampling

This research was aimed at stakeholders of research production, governance, and support in Kenya and Tanzania institutions of higher learning. The population of the study consisted of the academic staff of the university, researchers, postgraduate students, librarians, information technology staff, research administrators, and policy players in the research. Purposive sampling was employed to get the representation by people who are directly involved in research activities in the university. The surveys were conducted across management, faculty, administrative staff, and postgraduate students in selected higher education institutions in Kenya and Tanzania to ensure representation across decision-making, research, and support functions. Institutions were distributed across both countries to capture variation in policy environments and infrastructure development levels.

2.3 Data Sources and Instruments

Data was collected through three primary instruments: An Open Science Policy & Infrastructure Assessment, Open Science skills gap survey and a citizen science practice survey. The Open Science Policy & Infrastructure Assessment and Open Science skills gap survey were administered through online questionnaires. The questionnaires contained structured questions addressing areas such as open access publishing, open data management, research transparency, open science infrastructure and institutional support for Open Science implementation. The citizen science survey was designed to

examine the extent to which universities engage with society in the production of knowledge. The survey instrument included both closed-ended and open-ended questions focusing on community engagement, participatory research practices, citizen participation in data collection, and institutional support for citizen science initiatives. While the Open Science skills survey focused on institutional readiness and capacity gaps, the citizen science survey complemented this by examining how openness translates into participatory knowledge production practices, thereby linking institutional capacity to societal engagement.

2.4 Data Collection Procedures

Online questionnaires were used to collect the data, which was sent via institutional mailing lists, academic networks, and professional platforms. The questionnaires were carried out online so that they would be able to include a large number of institutions that geographically spread across the countries and so that the respondents would be able to reach and initiate the surveys. The surveys were voluntary and the responses were anonymous so as to promote the honest reporting of the institutional practices and capacity gaps.

2.5 Data Analysis

This study used a combination of qualitative analysis and descriptive analysis. The quantitative data obtained through surveys were analyzed using descriptive statistics to determine the patterns in the Open-science awareness, skills gaps, and institutional readiness among the respondents. The responses on research practices, the availability of infrastructure, and the extent of participation in the citizen science activities were summed up using frequencies and percentages. Thematic analysis of qualitative data acquired as a result of open-ended survey answers was carried out. This was done through coding of textual data to establish themes of recurrence in regards to institutional barriers, infrastructure requirements, governance frameworks, and opportunities of implementation of Open Science.

3 RESULTS

The results are presented in an integrated manner, beginning with individual-level survey findings and progressively linking these to institutional assessments. These findings are presented according to the key dimensions of Open Science readiness, including capacity, policy, governance, infrastructure, and community engagement.

3.1 Respondent Characteristics

The Open Science capacity assessment survey obtained 235 valid responses from thirty (30) higher education institutions in Kenya and Tanzania, representing a 94% response rate from the targeted sample of 250 respondents. The respondents were a cross-section of the academic ecosystem at the top, comprising of senior institutional leadership, policymakers and administrators, academic and research staff, technical and research support staff, and postgraduate students. The highest percentage of respondents was represented by academic and research staff (31.5% n = 74), then the postgraduate students (26.4% n = 62). The institutional leadership and senior administrative staff members represented 22.1% (n = 52) and technical and research support staff were 11.5% and administrators and policymakers were 8.5% of the respondents. The distribution was done in such a way that the views of strategic leadership, research practitioners and structural support of the institution taking part in the

implementation of Open Science practices were also gathered. Speaking of disciplinary background, the vast majority of respondents indicated their area of knowledge as social sciences (69%), then arts and humanities (9%), physical sciences and engineering (8%), computer science and information technology (6%), life sciences (5%), and health sciences (3%). The fact that most of the social science respondents did so means that a great portion of the surveyed understanding of Open Science awareness and practices is shaped by norms and research cultures in these fields.

3.2 Awareness and Understanding of Open Science

The results suggest that the general awareness of Open Science in engaging institutions is high. Only 195 respondents, who made 83.0% of the sample, said that they had heard of Open Science, and 40 respondents (17.0% of the total sample) said they had not heard of open science. This implies that the concept of Open Science is very familiar with both the staff and the students of the surveyed universities. Nonetheless, although the majority of the responses were very high, the fact that almost a fifth of the respondents are not familiar with Open Science indicates that there are still awareness gaps in the research ecosystem. Such lapses are especially prominent considering the core purpose of Open Science in modern research administration, financing adherence, and academic reporting. The results thus indicate a research setting where Open Science is widely common knowledge, but not quite a universal knowledge. This highlights the necessity to pursue further institutional sensitization and organized awareness-raising campaigns as well as more sophisticated capacity development campaigns.

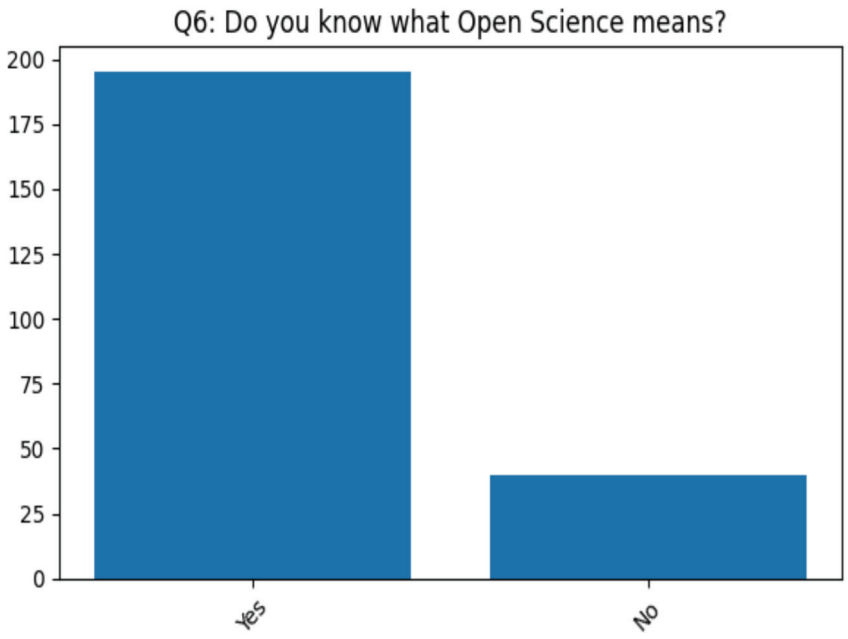

Figure 2: awareness and understanding of Open science

3.2.1 Understanding of Open Access & Open Data

About 39% of the respondents stated that they had moderate knowledge of open access and open data, whereas 33.6% stated that they had extensive knowledge of the same. Combined, this will mean that about 72% of the respondent see themselves as moderate to high in their understanding of these concepts. This demonstrates that the majority of the respondents are familiar with open access and open data in general, yet the degree of profound understanding is not high. Conversely, 32 respondents

(13.6%) said that they know only a little about open access and open data and 14 respondents (6.0%) said that they have no idea about such concepts. Another 18 respondents (7.7%) reported that they have full knowledge about open access and open data. Though this group acknowledge the existence of high level of knowledge in the research community, it is not very large. These results suggest that although there is some small group of researchers who have advanced knowledge about open access and open data, the largest number of researchers do not have enough depth to use these concepts practically.

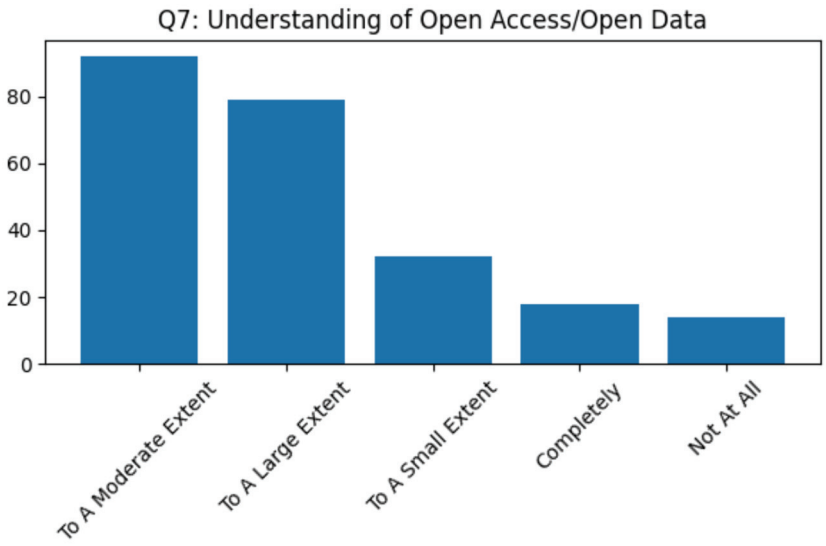

Figure 3: Understanding of open access data

3.3 Open Science Skills Gaps and Capacity Needs

The survey examined the extent to which Open Science training is institutionalized within universities. The results indicate that there are four different patterns of provision. The most prevalent type of Open Science training is the ones where respondents noted that their institutions implement the occasional workshops (89 (89) participants (37.9%)). Such activities usually involve seminars, awareness events, one-off workshops and Open Access Week activities. Although these efforts have a useful purpose in increasing awareness they are intermittent and thus they have a limited ability to contribute to creating a lasting technical capacity or integrating the Open Science practices into institutional processes. Seventy-three (73) respondents (31.1%), said that there is no Open Science training at all in their institutions. This is a critical gap, indicating that most universities do not have systematic Open Science policy, working repositories, and research data management systems. Here, Open Science literacy is not organized and rather relies on the initiative and informality of individuals. This is of notable concern especially given that almost 90 percent of the respondents consider Open science awareness to be relevant and very relevant in research activities. Moreover, 50 participants (21.3) stated that there was ad-hoc or informal training. This training is usually performed at the departmental level or by librarian orientations, peer support or supervisor directed training. Although this trend is a positive sign of grassroots interest and personal dedication to Open Science, it is also a symptom of the lack of institutional support mechanisms and standardized training programmes. Only a fifth of the respondents (23) reported the presence of regular, structured Open Science training programmes in their institutions (9.8%). Such programmes would probably contain systematic research data management training, Open Access policy briefings, repository use training, FAIR data training, and advice on how to use persistent identifiers (e.g. Digital Object Identifiers (DOIs) and Open Researcher and Contributor Identifiers

(ORCIDs)). The size of this group is very small which proves that Open Science training is still not a mainstream or routine part of staff development and postgraduate training in the majority of universities in Kenya and Tanzania. This indicates that, Open Science training is yet to be internalized in staff training or postgraduate training in the majority of Kenyan and Tanzanian universities, thus constraining systematic capacity building to the sustainable adoption.

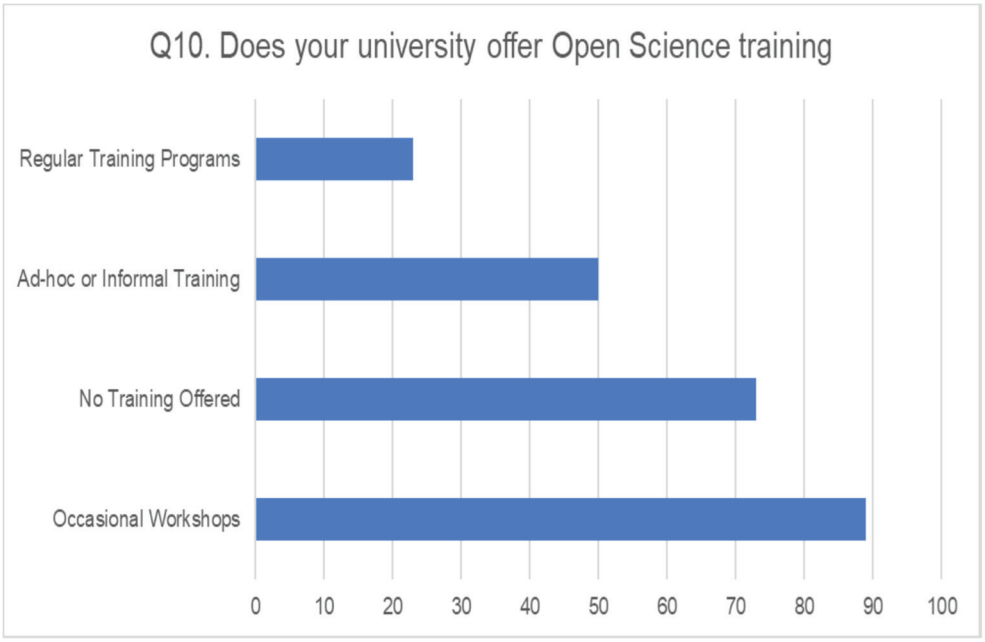

Figure 4: Capacity needs and open science training

Examples of trainings offered

Respondents frequently cited webinars, online workshops, and short-term events focusing on open access publishing, research data handling, scientific writing, and grant proposal development. The prominence of terms such as research, data, publishing, and awareness indicates that current training often emphasizes foundational research skills, with Open Science principles incorporated only tangentially. Additionally, several participants mentioned informal or ad-hoc training, including one-on-one guidance from librarians, departmental orientations, and training linked to externally funded

projects.

Figure 5: Images of visibility of terms related open science training

3.4 Situational assessment of Open Science policy, governance, and infrastructure

3.4.1 Institutional open science related policy

The situational assessment shows that Open Science policy in Kenya and Tanzania is gradually taking shape, but it is still fragmented and not yet fully established as a clear policy area on its own. At the national level, Open Science is not treated as a standalone policy domain. Instead, it is embedded within broader frameworks such as Science, Technology and Innovation (STI), data governance, and national development strategies. Both countries are broadly aligned with global and regional frameworks, including the UNESCO Recommendation on Open Science and the East African Community STI Policy. However, this alignment has not yet translated into clear, enforceable national policies specifically dedicated to Open Science.

In Kenya, institutions such as National Commission for Science, Technology and Innovation (NACOSTI), National Research Fund (NRF), and Kenya National Innovation Agency (KENIA) provide an important regulatory foundation for research and innovation. However, their mandates do not explicitly enforce Open Science practices. Similarly, in Tanzania, the system is more centralized under the Tanzania Commission for Science and Technology (COSTECH), but Open Science is still integrated only indirectly within broader national strategies. As a result, both countries have policy environments that show growing alignment with international agendas, but lack the clarity, coordination, and enforcement needed to turn these commitments into everyday practice.

At the university level, the picture is mixed. Many institutions have general research and ethics policies in place, which provide a starting point. However, specific policies on Open Access and Research Data Management (RDM) are often missing, still being developed, or only loosely applied. In most cases, data sharing is encouraged rather than required, pointing to a broader gap in how research data is governed. While ethics guidelines tend to be well established, they are not always linked to clear systems for data sharing or Open Science compliance.

This situation is further complicated by weak coordination within institutions. Leadership on Open Science is often inconsistent, and in many cases there are no clearly designated roles or offices responsible for driving Open Science initiatives. As a result, awareness and implementation vary widely across departments and faculties. Overall, while there are clear signs of progress, the institutional landscape remains uneven, highlighting the need for stronger coordination, clearer policies, and more structured governance mechanisms to support Open Science in practice.

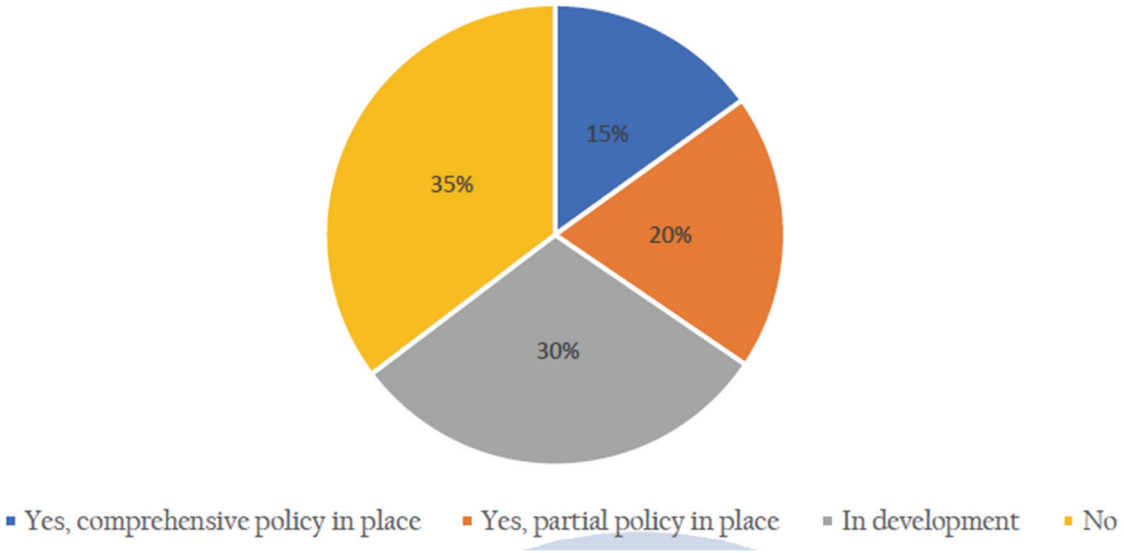

Figure 6: Presence and Formal Status of Institutional Open Science–Related Policies

3.4.2 Open science governance and infrastructure

The digital infrastructure audit shows that baseline Open Access infrastructure exists but remains uneven and insufficient for full Open Science implementation. All institutions report having some form of repository; however, their level of maturity varies. Despite this, repository use is largely voluntary, limiting completeness of research outputs. More critically, Research Data Management infrastructure is largely absent, with most institutions lacking centralized data repositories and relying instead on decentralized storage (individual devices, departmental systems, or project-based solutions). Interoperability is also weak, with limited adoption of persistent identifiers such as DOIs and ORCID and minimal integration with global systems, reducing visibility and reuse of research outputs. Technical support capacity is constrained, as Open Science infrastructure is maintained through general ICT and library functions without specialized staffing.

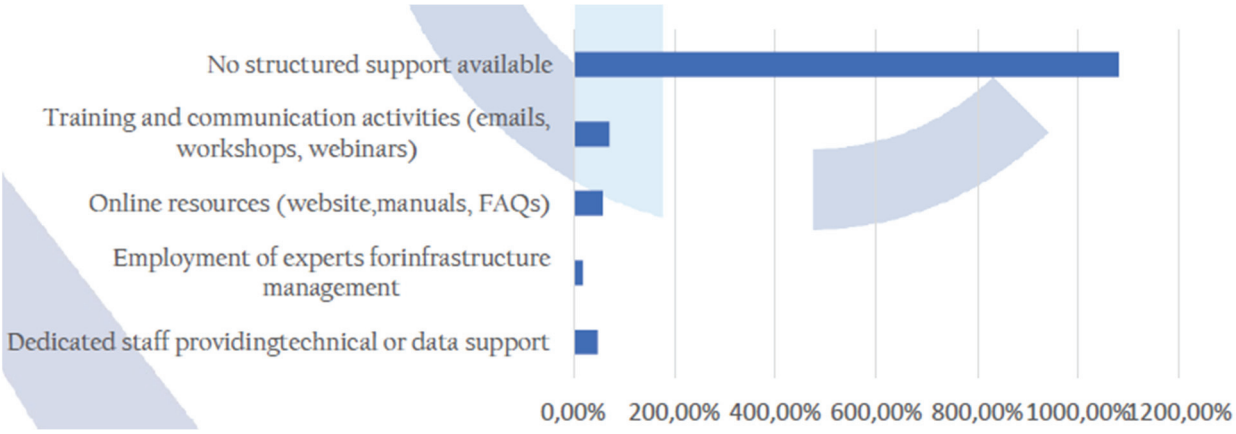

Figure 7: User Support for Open Science Infrastructure.

The assessment highlights systemic financial sustainability constraints that underpin and reinforce governance and infrastructure weaknesses. Across all participating institutions, Open Science activities are primarily funded through indirect institutional budgets or short-term external projects, with no institution reporting a dedicated Open Science budget line. Core infrastructure such as repositories is only partially funded, while critical components, including RDM systems, technical staffing, training, and system upgrades, remain under-resourced or reliant on ad hoc funding. Staffing is a particular bottleneck, with Open Science responsibilities typically assigned as additional duties without corresponding financial or workload adjustments. These patterns indicate that while foundational elements of Open Science exist, they are not yet supported by stable financial models, limiting scalability and long-term sustainability.

The results of situational assessment confirm that Open Science in Kenya and Tanzania is institutionally present but structurally underdeveloped, requiring coordinated reform across governance, infrastructure, and financing to transition from fragmented initiatives to a sustainable, system-wide model.

3.5 Citizen Science and Public Engagement Practices

3.5.1 Awareness of Citizen Science

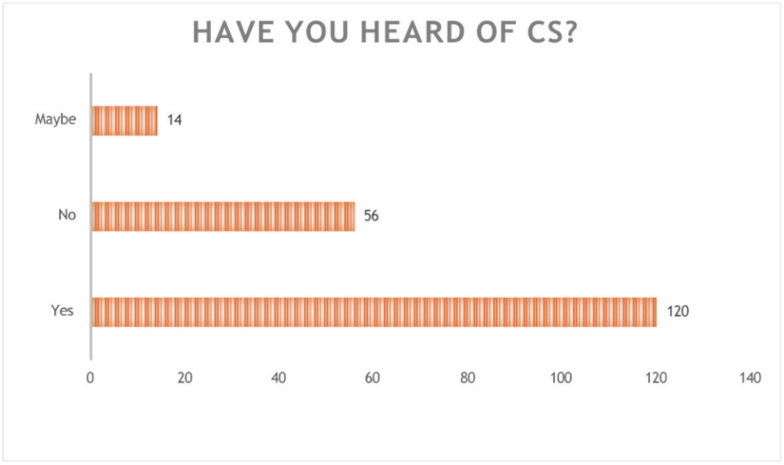

Figure 8: Bar graph showing result of citizen science awareness

The survey results revealed that a majority of respondents were familiar with the concept of citizen science. Specifically, 63 percent of respondents indicated that they had heard of citizen science, while 29 percent reported that they had not encountered the concept before. An additional 8 percent indicated uncertainty or partial familiarity with the concept. These findings suggest that awareness of citizen science is gradually increasing within higher education institutions in East Africa.

Despite the relatively high level of awareness observed in the study, the presence of respondents who were unfamiliar with citizen science indicates that significant knowledge gaps still exist. This finding highlights the need for targeted awareness programs, academic workshops, and training initiatives to enhance understanding of citizen science methodologies and their potential benefits within academic institutions.

From the perspective of Indigenous Knowledge Systems, these findings also suggest that participatory knowledge production practices may already exist within many communities but are not formally recognized or labeled as citizen science. In many African societies, collaborative knowledge generation, communal problem-solving, and collective learning have long been embedded in traditional knowledge systems. Such practices share several characteristics with citizen science, including community participation in knowledge creation and the application of locally generated knowledge to address societal challenges.

3.5.2 Perceived Benefits of Citizen Science

Table 1: Perception of Citizen Science Benefits

Statement	Agreement (%)
CS benefits academia and society	93%
Universities should adopt CS	96%
Students should collaborate with citizens	97%
Citizens should participate in education	99%
Citizens should participate in research	97%

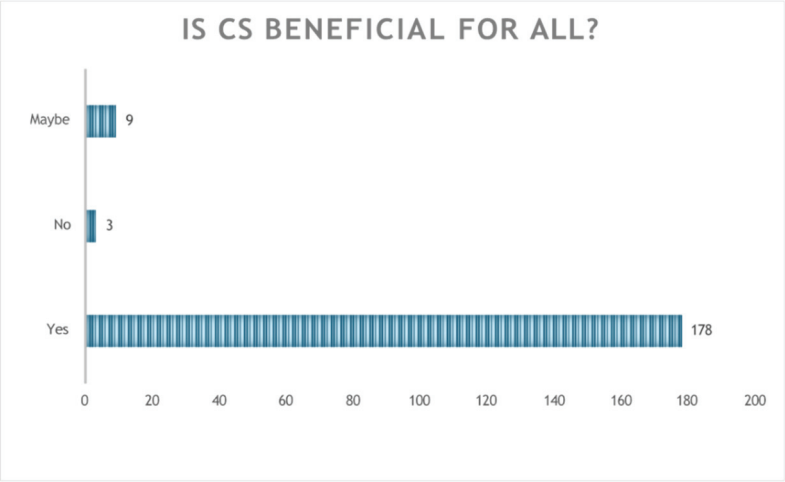

Figure 9: Bar graph showing benefits of citizen science

The findings show very strong and consistent support for citizen science among respondents. Most participants clearly recognize the value that citizen science can bring, both to universities and to society more broadly. For example, 93 percent agreed that citizen science benefits both academia and society, while an even higher proportion. These responses point to a strong openness toward more inclusive and participatory models of research within higher education institutions. They suggest that academic stakeholders are not only aware of citizen science but also see its practical value in transforming how knowledge is produced and shared. Rather than viewing communities as passive recipients of research, respondents appear to support a shift toward engaging them as active partners in the research process.

This positive outlook also resonates with Indigenous Knowledge Systems, which have long emphasized collective learning, shared knowledge creation, and the passing of knowledge across generations. In this sense, citizen science is not entirely new to the region but can be seen as aligning with existing traditions of community-based knowledge production. This alignment presents a meaningful opportunity for universities to build more inclusive and contextually relevant research systems.

3.5.3 Value of Citizen Science for Different Stakeholders

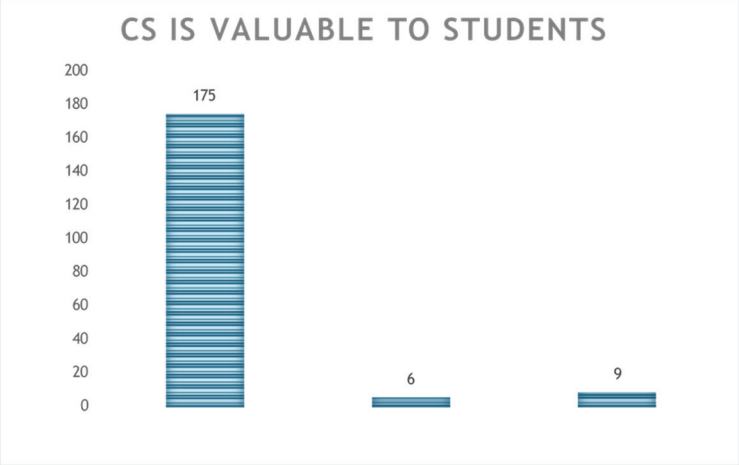

Figure 10: Bar graph showing value of citizen science to students

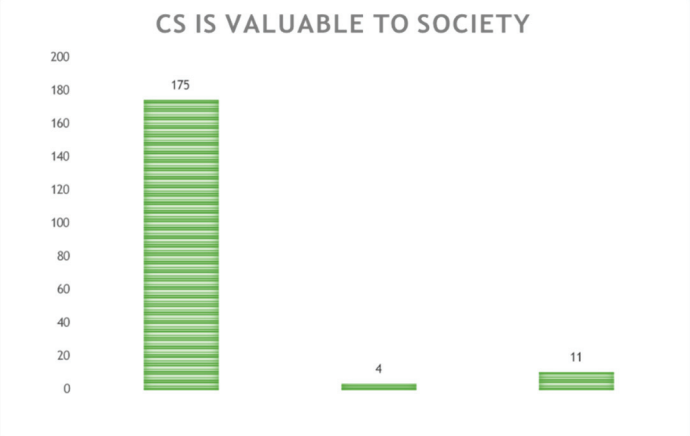

Figure 11: Bar graph showing value of citizen science to Society

The study further examined how respondents perceived the value of citizen science across different stakeholder groups. The findings indicate that citizen science is widely recognized as beneficial to multiple sectors of society. Approximately 90 percent of respondents believed that citizen science is

valuable to academics, while 92 percent indicated that it benefits students. Similarly, 92 percent of respondents believed that citizen science contributes positively to society as a whole.

Participants emphasized the importance of addressing real-world community challenges through collaborative research approaches. This perspective reflects the growing recognition that academic research should not only generate theoretical knowledge but also contribute to practical solutions that address societal needs. The emphasis on community-centered research also resonates with Indigenous Knowledge Systems, which traditionally prioritize knowledge that is directly applicable to community well-being and environmental sustainability.

3.5.4 Participation in Citizen Science Initiatives

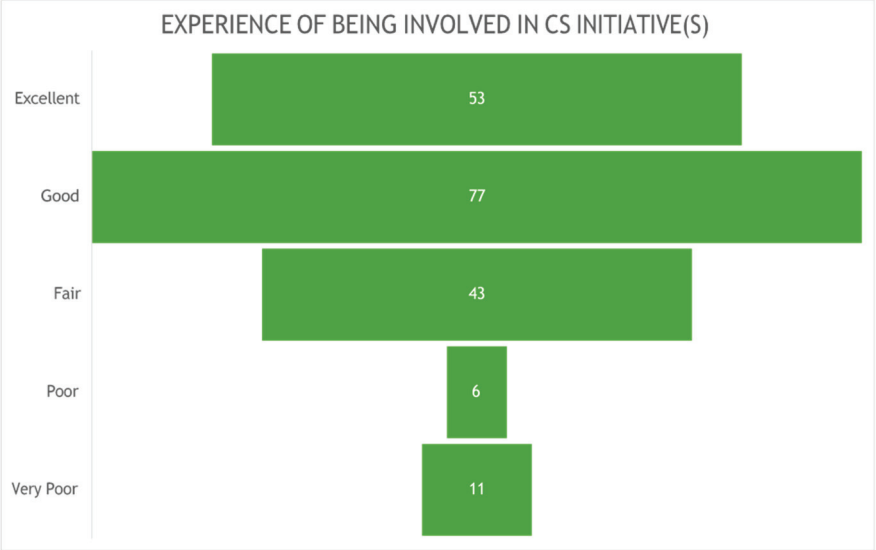

Figure 12: Bar graph showing experience in participation of citizen science

While awareness of citizen science was generally high and perceptions were largely positive, actual participation levels were noticeably lower. The survey showed that about 62 percent of respondents had taken part in citizen science activities, while 29 percent had never been involved. A further 9 percent were unsure whether what they had done could be considered citizen science. This uncertainty suggests that, although people may be engaging in related activities, they do not always recognize or label them as such. Among those who had participated, the experiences were overwhelmingly positive. Around 27 percent described their experience as excellent, and another 40 percent rated it as good. Only a small number, about 8 percent reported negative experiences. This pattern suggests that once individuals are exposed to citizen science, they tend to value it and view it favorably. In other words, the issue is less about acceptance and more about access and opportunity. The relatively moderate participation levels point to underlying barriers that may be limiting wider engagement. These appear to be largely institutional rather than attitudinal. Respondents highlighted challenges such as limited funding for participatory research, lack of institutional support, and insufficient training in citizen science methods. In addition, there seems to be a gap in awareness of available opportunities for collaboration between universities and communities. Taken together, these factors suggest that expanding citizen science in the region will require more deliberate institutional support, clearer frameworks, and increased investment in capacity building.

3.6 Institutional Readiness for Open Science

Taken together, the results indicate that higher education institutions in Kenya and Tanzania are at an emerging stage of Open Science adoption. While awareness of Open Science principles and citizen science practices is gradually increasing, several structural constraints continue to limit full implementation. These constraints include insufficient training opportunities, limited digital research infrastructure, weak institutional policies supporting Open Science, and uneven access to technical expertise.

At the same time, the findings suggest strong interest among academic staff, students, and institutional leadership in strengthening Open Science capacities. This emerging interest provides a foundation upon which universities can build more structured initiatives aimed at promoting open, collaborative, and socially responsive research ecosystems.

3.7 Support of Open Science on preservation and integration of Indigenous Knowledge Systems

Open Science infrastructures (OSI) such as institutional repositories, open data platforms, digital knowledge archives, collaborative research networks, and training programs—have significant potential to promote inclusive knowledge production. By providing digital platforms for data sharing, knowledge dissemination, and collaborative research, these infrastructures can enable universities to integrate multiple knowledge systems, including Indigenous Knowledge Systems (IKS). Firstly, theses infrastructures can support the documentation and preservation of Indigenous Knowledge. Indigenous knowledge in many African communities is traditionally transmitted orally and is therefore vulnerable to loss. Universities in Kenya and Tanzania can use digital repositories and open-access databases to systematically document indigenous practices related to agriculture, medicine, climate adaptation, and environmental conservation. For example, universities in Tanzania have already established institutional repositories through collaborations between the Consortium of Tanzania Universities and Research Libraries (COTUL) and international partners, resulting in the establishment of 17 institutional repositories to increase the visibility of research outputs. These repositories can be expanded to include Indigenous knowledge resources alongside conventional academic research.

Additionally, OS infrastructures provide mechanisms for ethical governance of Indigenous knowledge through frameworks such as the FAIR and CARE principles. These frameworks ensure that data is not only accessible and reusable but also managed in ways that respect the rights, cultural values, and sovereignty of Indigenous communities. Therefore, these principles, universities can ensure that Indigenous knowledge is preserved, shared responsibly, and used in ways that benefit the communities from which it originates.

4 DISCUSSION

The results of this research indicate that institutions of higher education in Kenya and Tanzania are in an early and disproportionate period of Open science implementation, which is marked by a comparatively high level of conceptual knowledge and low institutionalization of practices, infrastructure, and governance structures. Although 83 per cent of the interviewees said they were aware of the concept of open science, more operational knowledge and application is limited due to a poorly designed training system, poor policy frameworks, and insufficient infrastructure. The results of this

study are not new, as it is evident that Open Science in Africa is advancing slowly because of the structural constraints of the digital infrastructure, governance frameworks, and institutionalized strategies (Chiware and Skelly, 2022).

The findings indicate that awareness is not well connected to institutional capacity. Even though most of respondents have moderate or high levels of knowledge about Open Access and Open Data, few percentage (9.8) indicated having access to structured Open Science training programmes with most institutions having to rely upon ad hoc or occasional training workshops. This is part of a wider trend regarding the institutionalization structure where adoption of Open Science in East Africa is still disjointed and reliant on short-term, externally-linked projects as opposed to institutional systems. The situational analysis also substantiates the fact that the Open Science governance structures are poorly formalized. Though universities have general research and ethics guidelines, there are no definite Open Access and Research Data Management (RDM) policies, and the area of data governance is not obligatory in most cases. This institutional disintegration is consistent with the results of other African settings, in which the lack of coordinated policy frameworks restrains the conversion of global Open Science principles into practical institutional practices (Chiware & Skelly, 2022). This challenge is supported by the infrastructure environment. Despite the fact that most institutions claim to have repositories, repositories are mostly used at will and Research Data Management systems are mostly missing with decentralized solutions to storage. This is consistent with the larger argument that to be able to institutionalize Open Science, it is necessary to have not only the availability of infrastructure, but also mandatory workflows, integration of governance, and sustainable models of financing.

Among the most notable results of this survey, one can point out a strong positive opinion about citizen science. More than 90 percent of those who responded identify its importance to academia, students, and society and almost all of them are in favor of more citizen involvement in research and education. Nevertheless, actual involvement is not high, which indicates that the participatory research models are not operationalized due to institutional barriers. This is an important finding in the context of an Indigenous Knowledge Systems (IKS). The findings imply that participatory knowledge production in the form is already present in local society, but it is not officially acknowledged in the academic circles. According to the literature, Indigenous knowledge systems are always community-based, experience and localized with their transmission often occurring via oral traditions and social practices, and not documented (Leal Filho et al., 2022). This forms a conceptual overlap between citizen science and IKS, which focus on the production of knowledge as a group and their involvement in communities. This interpretation is supported by the institutionalization framework, which puts citizen science at the center of the inclusion of Indigenous knowledge into the Open Science ecosystems. It emphasizes that community involvement must not be confined to data collection but they should be co-created, governed and share benefits which will turn citizens not into research subjects but into knowledge partners. This implies that one way citizen science might be used to integrate IKS into formal research systems is by taking on a pragmatic approach to a portal that allows Indigenous knowledge to be centralized and thereby addressed. One of the main conflicts that arise both based on the findings and the institutional framework is the conflict between openness and Indigenous data sovereignty. FAIR principles that make the data Findable, Accessible, Interoperable, and Reusable are usually defined as the operationalization of Open Science. Nevertheless, power, ownership, and cultural sensitivity are the issues that such principles do not necessarily consider. The institutional framework suggests a viable way to mitigate this limitation by advancing the idea of FAIR being combined with CARE principles as a prerequisite to the governance of the Indigenous knowledge under the Open Science regimes. This is in line with

larger academic suggestions that Open Science needs to transform the technical openness into the ethical and context-oriented knowledge governance (Carroll et al., 2021; Jennings et al., 2025).

This requirement is supported by the results of this research. The voluminous lack of organized data governance structures, along with informal repository utilization and a lack of strong policy implementation, poses the risk that the Indigenous Knowledge, in case it is digitalized, might be mined, abused, or discontextualised. As named in institutional framework, IKS should thus be considered as a special category of knowledge whereby in universities, tiers of access control, community approval and benefit sharing structures must be shared. This paper shows that the Open Science governance in East African higher education institutions remains more of a component of systemic STI and research policy frameworks as opposed to a clear, enforceable space. Such policy ambiguity has led to the poor implementation and institutional responsibility. The East African case of a dual method involving Open Science and Indigenous Knowledge seems especially pertinent because the latter is intricately embedded within the practices of the East African community and subordinated to cultural orientations. It is also consistent with the focus of UNESCO on inclusive knowledge systems, which consider the existence of different epistemological orientations (UNESCO, 2021). Moreover, the results indicate that institutional preparedness is not a technical matter only but it is also a governance challenge. Inadequate leadership coordination, the lack of committed roles of Open Science, and the lack of financial sustainability mechanisms are obstacles on the way to transitioning the fragmented efforts to the system-wide level of adoption. These gaps are filled in the institutional framework by suggesting integrated forms of governance, such as Open Science councils, data stewardship units, and community knowledge governance panels. The findings and institutional structure indicates that Open Science in East Africa is currently shifting to the early-institutionalization stage although it is still bound by structural, policy, and epistemic constraints. It is through the integration of Indigenous Knowledge System that provides a platform to further this move to go beyond technical openness to inclusive, equitable, and context-sensitive knowledge systems.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The findings from this study suggest that universities in Kenya and Tanzania are beginning to embrace Open Science, but the process is still in its early stages. There is a noticeable level of awareness among academic staff and researchers about Open Science concepts, which is encouraging. However, this awareness has not yet translated into well-structured institutional practices. In many cases, Open Science remains more of an idea that people support rather than something that is fully embedded in how universities operate.

Several challenges help explain this gap. Institutional policies on Open Science are often fragmented or not fully developed, making it difficult to guide consistent implementation. At the same time, many universities lack adequate infrastructure for managing and sharing research data, which is a key requirement for Open Science. Governance structures are also not yet strong enough to coordinate these efforts effectively. Training opportunities tend to be irregular and project-based, and much of the existing activity depends on external funding or voluntary participation in repositories. As a result, Open Science initiatives are not yet sustained at an institutional level. Overall, this points to the need for more coordinated approaches that bring together policy development, infrastructure investment, capacity building, and long-term financing within university systems.

The study also highlights an important opportunity in the use of citizen science and Indigenous Knowledge Systems (IKS) to make Open Science more inclusive. Many respondents expressed positive views about citizen science, indicating a willingness to involve communities more actively in research processes. This opens the door for universities to move beyond traditional models of knowledge production and engage communities as partners rather than just research subjects. In particular, the close relationship between citizen science and Indigenous knowledge offers a pathway for integrating local knowledge into formal research systems.

At the same time, the findings emphasize that openness must be approached carefully. Integrating Indigenous knowledge into Open Science requires attention to ethical considerations, including respect for cultural values, informed consent, and fair sharing of benefits. This is where the principles of FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective benefit, Authority to control, Responsibility, Ethics) become especially important. These frameworks can help ensure that knowledge is shared in ways that are both accessible and respectful.

In summary, strengthening Open Science in East Africa will require more than just technical solutions. It will depend on building institutional systems that support collaboration, recognize diverse forms of knowledge, and create an environment where participation in knowledge production is both inclusive and equitable.

5.2 Recommendations

5.2.1 Recommendation for policy

Governments ministries, management of higher education bodies such as universities should develop and implement comprehensive Open Science policies that explicitly integrate Indigenous Knowledge governance frameworks. These policies should institutionalize Open Access and Research Data Management systems while incorporating both FAIR and CARE principles to ensure that Indigenous data sovereignty, cultural protocols, and community consent mechanisms are protected. National and institutional policies should also mandate the establishment of governance structures such as Open Science councils, data stewardship offices, and Indigenous knowledge advisory committees to provide oversight, accountability, and ethical guidance in the management of research data and community knowledge.

5.2.2 Recommendation for best practice

Higher education and research institutions should strengthen institutional capacity for Open Science through investment in sustainable digital infrastructure, structured training programs, and participatory research platforms that support citizen science initiatives. Similarly, Institutions should upscale from voluntary repository use toward mandatory research data management (RDM) workflows supported by dedicated technical units and trained data stewards. In addition, universities should develop collaborative research models that involve communities in the co-creation, documentation, and validation of Indigenous knowledge, ensuring that local knowledge holders are recognized as research partners and beneficiaries within the knowledge production process.

5.2.3 Recommendation for theory

The study recommends developing of integrated theoretical frameworks that link Open Science, citizen science, and Indigenous Knowledge Systems within the context of inclusive knowledge governance. Scholars should explore how the combination of the FAIR and CARE principles can inform new models of ethical data governance that balance openness with cultural protection and knowledge sovereignty. Expanding theoretical perspectives in this area will contribute to a more context-sensitive understanding of Open Science in the Global South and support the development of research paradigms that recognize pluralistic knowledge systems and participatory approaches to scientific inquiry.

6 REFERENCES

Ajani, Y. A., Oladokun, B. D., Olarongbe, S. A., Amaechi, M. N., Rabiu, N., & Bashorun, M. T. (2024). Revitalizing indigenous knowledge systems via digital media technologies for sustainability of indigenous languages. *Preservation, digital technology & culture*, *53*(1), 35-44.

Anglada, L., & Abadal, E. (2023). *Open access: A journey from impossible to probable, but still uncertain*. *Profesional de la Información, 32*(1), e320113.

Bacalexi, D. (2022). *Open science policy session* (Doctoral dissertation, CIEM; CNRS).

Camacho Toro, R., Cumba Garcia, L. M., Galvis, L. A., Echeverría-King, L. F., Pantović, B., Alarcón-López, C., ... & Benavides, S. (2024). The needed link between open science and science diplomacy—A Latin American perspective. *Frontiers in Research Metrics and Analytics*, *9*, 1355393.

Carroll, S. R., Herczog, E., Hudson, M., Russell, K., & Stall, S. (2021). Operationalizing the CARE and FAIR principles for Indigenous data futures. *Scientific Data, 8*, 108. https://doi.org/10.1038/s41597-021-00892-0

Chiware, E. R. T., & Skelly, J. (2022). Open science policies and their actors: A systematic review. *Frontiers in Research Metrics and Analytics, 7*, 950139. https://doi.org/10.3389/frma.2022.950139

Chuan-Peng, H., Xu, Z., Lazić, A., Bhattacharya, P., Seda, L., Hossain, S., Jeftić, A., Özdoğru, A. A., Amaral, O. B., Miljković, N., Ilchovska, Z. G., Lazarević, L. B., Bao, H. W. S., Ghodke, N., Moreau, D., Elsherif, M., Chinchu, C., Ghai, S., Carneiro, C. F. D., … Azevedo, F. (2025). *Open science in the developing world: A collection of practical guides for researchers in developing countries*. *Advances in Methods and Practices in Psychological Science, 8*(3), 1–26. https://doi.org/10.1177/25152459251357565

Da Silva, C., Pereira, F., & Amorim, J. P. (2024). The integration of indigenous knowledge in school: a systematic review. *Compare: A Journal of Comparative and International Education*, *54*(7), 1210-1228.

De Filippo, D., & Sastrón-Toledo, P. (2023). Influence of research on open science in the public policy sphere. *Scientometrics*, *128*(3), 1995-2017.

Drach, I., Popovych, M., Polishyk, O., & Polishchuk, O. (2022). Global cooperation in Open Science policies and procedures to ensure the sustainable development of society. In *SHS Web of Conferences* (Vol. 141, p. 01023). EDP Sciences.

Dubernet, M. L., Berriman, G. B., Barklem, P., Choi, K., Foster, A., Gordon, I., ... & Vastel, C. (2022). Atomic and Molecular Databases Open Science for a sustainable world. *Proceedings of the International Astronomical Union*, *18*(S371), 72-84.

Fraisl, D., et al. (2023). Citizen science in environmental and ecological research: Opportunities, challenges, and policy relevance. *Nature Reviews Methods Primers, 2*, Article 64.

Gallagher, R. V., et al. (2020). Open science principles for accelerating trait-based ecological research. *Nature Ecology & Evolution*.

Hunter, A. (2021). *Co-developing openness: Indigenous knowledge and data governance and open science in Canada* (Master's thesis, Carleton University).

Jennings, L., Jones, K., Taitingfong, R., Martinez, A., David-Chavez, D., Alegado, R. 'A., Tofighi-Niaki, A., Maldonado, J., Thomas, B., Dye, D., Weber, J., Spellman, K. V., Ketchum, S., Duerr, R., Johnson, N.,

Balch, J., & Carroll, S. R. (2025). Governance of Indigenous data in open earth systems science. *Nature Communications, 16*, 572. https://doi.org/10.1038/s41467-024-53480-2

Kanu, I. A., & Ndubisi, E. J. O. (Eds.). (2020). *African indigenous knowledge systems: Problems and perspectives*. Association for the Promotion of African Studies (APAS).

Kwiek, M. (2021). What large-scale publication and citation data tell us about international research collaboration in Europe: Changing national patterns in global contexts. *Studies in Higher Education, 46*(12), 2629–2649. https://doi.org/10.1080/03075079.2020.1749254

Leal Filho, W., et al. (2022). Indigenous knowledge systems and climate change adaptation: A systematic review. *Environmental Science & Policy*.

Lee, J. J., & Haupt, J. P. (2021). Scientific globalism during a global crisis: Research collaboration and open access publications on COVID-19. *Higher Education, 81*(5), 949–966. https://doi.org/10.1007/s10734-020-00589-0

Leonelli, S. (2023). *Open science and systems of practice: Rethinking openness, epistemology, and inclusion*. (Preprint).

Manco, A. (2022, September). Content analysis of institutional policies on open science. In *26th International Conference on Science, Technology and Innovation Indicators, STI 2022*.

Marginson, S. (2022). What drives global science? The four competing narratives. *Studies in Higher Education, 47*(8), 1566–1584. https://doi.org/10.1080/03075079.2021.1942822

Muwanga-Zake, J. W. F., & Kibukamusoke, M. (2024). Sustainability of Africa through technological innovations and indigenous knowledge systems: a discussion of key factors and way forward. *African Journal of Social Work*, *14*(2), 59-69.

Ngulube, P. (2023). From orality to digital assets: Managing Indigenous knowledge in Africa in the wake of the open science movement. *The Serials Librarian, 84*(5–8), 71–85. https://doi.org/10.1080/0361526X.2023.2296880

Numajiri, H., & Hayashi, T. (2024). Analysis on open data as a foundation for data-driven research. *Scientometrics*, *129*(10), 6315-6332.

Ocholla, D. N. (2025). The complex marriage: Interfacing open science and open indigenous knowledge. *Library Management, 46*(3/4), 252–267. https://doi.org/10.1108/LM-11-2024-0125

Santos-Hermosa, G. (2024). Impact and Implementation of UNESCO's Recommendation on Open Educational Resources in Academic Libraries: SPARC Europe Case Study. *Research in Learning Technology*, *32*, 3183.

UNESCO. (2021). *UNESCO recommendation on open science*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000379949