



Academic libraries in four Sub-Saharan Africa countries and their role in propagating open science

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Abstract

The study aims at examining libraries in four Sub-Saharan Africa countries and their role in propagating open science. It also seeks to explore existing open science practices, ascertain the level of participation of academic libraries in open science activities, identify the strategies used in marketing open science platforms and enumerate the challenges hindering the success of open science in the selected countries. The study was guided by the qualitative school of thought where the researcher builds a complex, holistic picture, analyses words, and reports detailed views of informants, and conducts the study in a natural setting. The study employed the multiple case study research design approach to assess how academic libraries in Ghana, Nigeria, Tanzania and Uganda promote open science. The findings show that there are few scholarly journals which exist in open access for most African academies in Ghana, Nigeria, Tanzania and Uganda. Though not massively adopted, open access institutional repositories have been used to preserve and publicize the digital contents in some academic institutions in Africa such as theses, dissertations, administrative and heritage materials, conference proceedings as well as pre-prints and post-print of journal articles. The study recommends the intensification of open science advocacy in academic libraries in Sub-Saharan Africa; institutions should ensure that there is a stable electricity supply as well as reliable internet connectivity, introducing regular training on emerging media technologies to the community members and strengthening the libraries consortium in Sub-Saharan Africa as an enabling platform to share intellectual productivity of their member countries.

Keywords

Academic libraries, open access, open science, Sub-Saharan Africa countries

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Introduction

Despite the numerous intellectual activities that are happening in Africa, only 2% of global research output is attributable to the continent (Moahi, 2012). This declining trend makes the countries which lie

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south of the Sahara Desert, commonly known as Sub-Saharan Africa countries (SSA), to account for less than 1% of the world's research output (World Bank and Elsevier, 2014).

Issues of copyright as well as inadequate and unsustainable indigenous journals have led to the dwarfing of most research from African universities and research institutes (Alemna, 2005). This reality leaves African academia with no alternative but to publish in internationally renowned peer-reviewed journals in order to ensure academic promotion and tenure. However, not many of these make it into such journals, and the few, when they do, are beyond the reach of most universities, thereby making access to them nearly impossible. This results in the repetition of research due to the lack of a reliable platform for sharing research. This means therefore that the concept of open science has not been widely enough embraced in most African institutions to enable most African scholars to share knowledge through this phenomenon.

Open science is seen as the movement to make scientific research, data and findings accessible to all levels of an inquiring society (David, 2014). The concept draws its strength from the broader definition of science which is generally described as the collecting, analysing, publishing, critiquing and re-using data. The concept of open science, as a response to the societal demand for access to collective scientific knowledge, was evident from at least the 17th century in the development of scientific societies and their journals (McClellan, 1985). Practices such as publishing research, campaigning for open access, encouraging scientists to practice open access and freely communicating scientific knowledge are what embody open science activities.

The proponents of open science indicate that financial constraints, restrictions on data usage, poor formatting of data and cultural reluctance to publish data often affect scholarly dissemination of scientific data. However, open science platforms and practices such as data curation, open source software, open access journals and open access institutional repositories (IRs) have significantly bridged the gaps in scientific research communication especially in most developing countries.

Developing countries are potentially one of the greatest beneficiaries of open science platforms due to the fact that, currently, some universities find it very difficult to pay for subscriptions required for current journals. In Africa, there has been a marked response to open access (OA) – a vehicle which drives the open science phenomenon – through a steady

development of IR initiatives particularly among universities and research institutions.

SSA region consists of 42 countries located in SSA mainland and in addition six island nations (New World Encyclopedia, 2015). However, the Directory of Open Access Repositories (DOAR) currently lists only 18 SSA countries with 126 repositories in SSA countries whose contributions to world's data research is merely 0.03% as compared to 1.4% of world's research articles (Onyacha, 2016; OpenDOAR, 2017). This is a very small contribution which may be associated with the presence of few countries in SSA which have IRs.

The major contributors in this small contribution to the world's data research from SSA countries are South Africa 63.7% followed by Kenya 14.3%, Cameroon 11.1% and Ghana 2.7%, whereas as the least contributors are Tanzania and Burundi 0.1% followed by Zambia and Sudan 0.2% (Onyancha, 2016).

The option for openness is driven by a growing appreciation of the fact that lots of investment in research could have much greater impact if the outcomes are freely shared beyond borders. Open access journals, open source softwares, open knowledge communities and open access IRs have taken the lead in driving the open science movement over the last two decades (Jain, 2012; Schwartz, 2012; Suber, 2007). It is believed that the digital networked environment will continue to support this agenda so long as artificial barriers are removed. Literature abounds with the benefits and successes of open science platforms in developed world. Software engineering protocol has improved to make the creation of OA platforms easier, due to the existence of numerous open source software. Globally, it could be observed that many library associations have either signed major open science declarations or created their own open science strategies. In a survey by the Association of Research Libraries (ARL) (2008), it was discovered that 65% of surveyed libraries were either involved in journal publishing or were planning to be so in the near future (ARL, 2010). In the midst of the above strategies and practices espoused, very limited research exists as to how academic libraries in SSA are promoting open science in their academic communities. For instance, a closer look at the literature concerning IRs in Africa reveals that many of them unfortunately crash out shortly after their take-off (Christian, 2008; Corlety, 2011; Moahi, 2009). Due to the peculiar position they occupy on most campuses, librarians are expected to lead most education and outreach initiatives to the academic community about the benefits

of open science. Librarians are among the information professionals who believe in the need to remove price barriers and permission barriers which scuttle scholarly communication.

With the availability of softwares, coupled with the increasing proliferation of open science platforms, what are the corresponding strategies needed to promote these initiatives for increased usage and sustainability? Study draws attention to some concerted comprehensive efforts instituted by information professionals to ensure the free sharing of knowledge without barriers:

- training users about search technique in order to explore resources in open access platforms;
- persuading authors to contribute with self-archiving;
- establishing a standard metadata and comprehensive catalogue system;
- understanding of software and giving training to authors to comprehend and work with some open source software;
- collection management and stewardship of collections.

Software and engineering protocols for open science

Generally, a number of software programs exist to support open knowledge sharing and scholarly communication initiatives of academic libraries. These are in areas of Web 2.0 platforms such as blogs, wikis and social networking sites, integrated library management and IRs software. Among the open software programs and platforms for sharing and advancing the course of knowledge are ARNO¹, CDSware², DSpace³, ePrints⁴, FEDORA⁵, MyCoRe⁶, Invenio⁷ and Koha⁸- ILS, VRE⁹ and CoP¹⁰.

Enabling environment. Several supportive institutions have supported the open science movement in SSA. Besides the various consortia in the different countries, there are other bodies such as the International Network for the Availability of Scientific Publications (INASP) and the Carnegie Corporation of New York, the Database of African Theses and Dissertation and the Association of African Universities (AAU).

Benefits of open science

As open science platforms open up access to their holdings, their benefits to researchers and the public cannot be overemphasized. They provide diverse

advantages to academic institutions, researchers, funding agencies, publishers and the entire nation. In the view of Jain (2012), it is an effective vehicle to information exchange between and among countries.

With the availability of insufficient funding to libraries, Christian (2008) believes this type of unrestricted access to information helps researchers in the developing world. Canada (2009) further stresses that considering the limited financial resources available; the potential for researchers, educators and institutions in developing countries to benefit from OA platforms is great. OA repositories for instance lead to an increased global visibility and prestige and serve as a marketing tool to attract funding, students and quality staff. They also provide an avenue for the centralization and long-term curation of all types of institutional outputs (Johnson, 2002; Lyte et al., 2009). It is also a way of maximizing availability, accessibility, discoverability and functionality of scholarly research outputs at no cost to the users (Vrana, 2011).

Several benefits also accrue to authors who utilize the services of OA journals and IRs in terms of greater security and longer-term accessibility (Lyte et al., 2009; White, 2009).

In her briefing paper on OA repositories, advocate Swan (2010) sums up the advantages that repositories bring to an institution as:

- opening up outputs of the institution to a world-wide audience;
- maximizing the visibility and impact of these outputs as a result;
- showcasing the institution to interested constituencies – prospective staff, prospective students and other stakeholders;
- collecting and curating digital output;
- managing and measuring research and teaching activities;
- providing a workspace for work-in-progress, and for collaborative or large-scale projects;
- enabling and encouraging interdisciplinary approaches to research;
- facilitating the development and sharing of digital teaching materials and aids, and
- supporting student endeavors, providing access to theses and dissertations and a location for the development of e-portfolios.

Disadvantages of open science

Despite the benefits outlined above regarding open science to knowledge sharing, there are some

perceived disadvantages (Nielsen, 2011). In summary, these include the fact that too much unsorted information overwhelms scientists since increasing the scale of science will make verification of any discovery more difficult. Some are also of the belief that removal of barriers could result in science being used for bad things, considering the fact that the public may misunderstand science data.

Methodology

The study was guided by the qualitative school of thought where the researcher builds a complex, holistic picture, analyses words, reports detailed views of informants, and conducts the study in a natural setting (Creswell, 1998). The study employed case study research design approach which is an empirical inquiry enabling a researcher to select a small geographical area or a very limited number of individuals as the subjects of study and to closely examine the data within a specific context (Creswell, 2009; Zaidah, 2007).

In this study therefore, four countries in SSA, that is Ghana, Nigeria, Tanzania and Uganda, were purposively selected because they are in a state of infancy in OA terms. The design enabled the assessment of how academic libraries in the four selected countries promote open science in the respective countries. Empirical documents such as books, journal articles and websites were clearly reviewed to ascertain the level of adoption of open science, various practices to propagate open science, the avenues to market such platforms and the challenges faced in promoting open science in the countries under study. In particular, the following databases and search engines were relied upon to gather resources for the study: Emerald, African Journals Online, Science Direct, LibMagazine, Library Philosophy and Practice, Google search engine, Google Scholar, Google Advance and DOAJ.

Findings

Nigeria

The state of open science adoption in Nigeria. The OA model of scholarly communication is yet to be fully adopted by researchers and other stakeholders in Nigeria (Christian, 2008). According to Gbaje (2010), in an effort to popularize OA initiative in Nigeria, a conference to bring together all stakeholders was organized in 2008 at Ahmadu Bello University, Zaria. Nigeria has 221 OA journals in African Journals Online (AJOL). Some examples of such journals are *Abia State University Medical Students'*

*Association Journal, African Journal of Anaesthesia and Intensive Care, African Journal of Economic Policy and African Journal of Library, Archives and Information Science.*¹¹

Ridwan (2015) noted that some institutions that have already installed IRs in Nigeria are University of Jos, having content such as conferences, references, learning objects and multimedia; University of Nigeria, Nsukka having content such as theses and articles; Ahmadu Bello University, Zaria with contents like theses and conferences paper, post-graduate theses and dissertations (Abdulkadir and Mohammed, 2013; Ahmadu Bello University, 2015; Musa et al., 2014); Federal University Technology Akure having contents such as theses, articles and references. He observed that DSpace and E-prints, which are both open source software programs, have been relied much upon to create the repositories. Also, the OpenDOAR (2017) lists the universities that currently have OA IRs in Nigeria in Table 1. The trend shows that the earliest IR to be established in Nigeria is that of Ahmadu Bello University, Zaria in 2005 whereas the recent ones are that of Federal Universities of Lokoja and Ndufu-Alike Ikwo in 2015.

Marketing and promotion of open science by academic libraries in Nigeria. Marketing is regarded as the anticipation, management and satisfaction of demand through the exchange process (Evans and Berman, 1985). Academic communities share a common characteristic with other non-profit organizations, i.e. instead of a tangible product, they offer services. In Nigeria, several strategies have been relied upon to market, promote or publicize open science in general of which institutional repositories and open journals are part. Among these techniques are:

1. using creative repetitive communication through word of mouth (informal), notices, posters, banners and campus radio announcements;
2. inclusion in annual reports, brochures and newsletters;
3. user education/training;
4. meetings and various fora, seminars/workshops and special events such as open days;
5. the library's homepage, other websites, face book, blogs and email.

Efforts at marketing, during the early stages, focus heavily on the use of handouts, pamphlets, bookmarks and other paper collateral to reach target audiences. Workshops and other 'mini-conferences' on the changing scholarly communication model,

Table 1. Available institutional repositories in Nigeria.

Name of institution	Name of IR	URL	Launch date	Number of items as at 2016
1 Ahmadu Bello University, Zaria	Open Access Institutional Repository at Ahmadu Bello University	http://kubanni.abu.edu.ng:8080/jspui/	2005	5919
2 Covenant University	Covenant University Repository	http://eprints.covenantuniversity.edu.ng/	2012	5832
3 Ebonyi State University, Abakaliki	Ebonyi State University Institutional Repository	http://ir.ebsu.edu.ng:8080/	2013	341
4 Federal University Lokoja	Federal University Lokoja Institutional Repository	http://repository.fulokoja.edu.ng/	2015	66
5 Federal University Ndufu-Alike Ikwo	Federal University Ndufu-Alike Ikwo Repository Archive	http://dspace.funai.edu.ng/xmlui/	2015	256
6 Federal University of Technology Minna	Federal University of Technology, Minna Institutional Repository	http://dspace.futminna.edu.ng/jspui/	2013	4435
7 Federal University of Technology, Akure, Nigeria.	Institutional Repository of the Federal University of Technology	http://dspace.futa.edu.ng:8080/jspui/	2011	2346
8 Federal University Oye Ekiti	Federal University Oye-Ekiti Institutional Repository	http://repository.fuoye.edu.ng/	2013	1103
9 Landmark University	Landmark University Repository	http://eprints.lmu.edu.ng/	2013	197
10 University of Jos	University of Jos Institutional Repository	http://irepos.unijos.edu.ng/jspui	2009	1221
11 University of Lagos	University of Lagos Institutional Repository	http://repository.unilag.edu.ng:8080/xmlui/	2013	619
12 University of Ilorin	UILSPACE	http://uilspace.unilorin.edu.ng:8080/jspui/	2013	147
13 University Of Nigeria	University of Nigeria Institutional repository	http://repository.unn.edu.ng:8080/jspui/	2008	2300

Source: OpenDOAR(2017).

the OA movement or educating faculty on related IR issues such as copyright, publishing processes, and citation analysis to draw attention to larger issues facing higher education are also useful. This is

because by capturing the attention of faculty with these issues, many opportunities unfold to highlight the value and use of the IR in a broader context as indicated by Ramirez and Miller (2011).

Establishment of digitization centre and processes. IR has the following four characteristics as outlined by Johnson (2002):

- institutionally defined (as opposed to discipline- or subject-focused);
- scholarly (containing the products of faculty, research staff and students);
- cumulative and perpetual (the content should be preserved on a long-term basis); and
- open and interoperable (attentive to the Open Archives Initiative-Protocol for Metadata Harvesting).

Consequently, the digitization centre purposely established for the IDR project performs the following tasks:

- digitization of non-digital born theses and dissertations submitted for the award of postgraduate degrees and certificates of the university for ingest into the university IR;
- uploading digital born theses and dissertations into university IR;
- collection and uploading of post-print and pre-print scholarly publications of the scholars within the university community and also from outside the university as the case may be; and
- collection and uploading of other relevant information resources generated within the university committees such as inaugural lectures, conference proceedings; seminar and workshop papers.

Challenges of open science in Nigeria. Christian (2008) noted some of the issues identified in Nigerian universities that adversely militate against the development of free dissemination of scholarly research. Among these are:

- Lack of awareness among researchers and academics in the country's academic and research institutions about the many open science platforms for generating and sharing knowledge. This may partly be due to the low level of advocacy on the part of information professionals.
- Inadequate information and communication technology infrastructure, particularly the high cost of internet bandwidth in Nigeria.
- The problem of inadequate and erratic electricity supply to power ICT facilities in academic institutions.

- Inadequate funding also constitutes another problem. Most of the academic and research institutions in Nigeria are funded by the government. These institutions continue to grapple with percentage decline in budgetary allocations.
- Lack of support from the community in terms of usage and uploading of content. (Musa et al., 2014: 19)

Uganda

The state of open science adoption in Uganda. The situation in Uganda depicts a steady and slow approach to Open Science (GOAP, 2015). Uganda has six public universities and 30 private universities. Of these, five public and 15 private institutions belong to the Consortium of Ugandan University Libraries (CUUL). There are currently 12 Ugandan journals in the AJOL database mainly focusing on the science disciplines (<http://www.ajol.info/>). Some of these journals include but are not limited to: *African Health Sciences* (published by the College of Health Sciences, former Faculty of Medicine), *Makerere Journal of Higher Education* (published by the former Department of Higher Education, now an institute), *African Crop Science Journal* (published by the African Crop Science Society, with an editorial secretariat at the Department of Crop Science, Faculty of Agriculture), *Eastern Africa Journal of Rural Development* (jointly published by the Ugandan Agricultural Economics Association and the Department of Agricultural Economics and Agribusiness, Faculty of Agriculture).

There are currently two operational academic IRs in the country dominated by theses and dissertations (Di Salvo et al, 2015; OpenDOAR, 2016). Makerere University became the first to establish an OA repository which was launched as the Uganda Scholarly Digital Library (USDL) in 2006. The other operational academic IR is that of Regional Universities Forum for Capacity Building in Agriculture (RUFORUM IR) which was established in 2013. The details of IRs in Uganda are presented in Table 2.

Marketing and promotion of open science by academic libraries in Uganda. The Makerere University Library has been in the lead in the operational activities of the repository collaborating with other campus stakeholders towards its creation and management. The library often organizes training programmes for members of the campus community to ensure buy-in and support. Several strategies have been employed to publicize the repository of USDL and other

Table 2. Details of institutional repositories in Uganda.

Name of institutional repository	Name of institution/ organization	URL	Launch date	No. of items as at 2016	Content
Makerere University IR (Mak IR)	Makerere University, Uganda	http://makir.mak.ac.ug/	2006	513	articles, conferences, theses, unpublished, books
RUFORUM IR	Regional Universities Forum for Capacity Building in Agriculture, Uganda	http://repository.ruforum.org/oai	2013	1421	articles; conferences; theses; unpublished; books; learning objects; multimedia; special

Source: Nnam et al. (2016); OpenDOAR (2017).

repositories in Uganda such as RUFORUM. The chief among them is the use of institutional communication channels, for example flyers, posters and social channels to reach out to the campus community to notify them about new publications residing in the repositories. The fliers especially answer some frequently asked questions and then link clients to the repositories (Nnam et al., 2016).

Challenges of open science in Uganda. Generally, the barriers to open science in Uganda have been the absence of comprehensive OA policies and lack of awareness among key stakeholders (Di Salvo et al., 2015; Nannozi and Kamusiime, 2013). These, coupled with poor ICT infrastructure, little zeal on the part of researchers, lack of skilled staff to manage open science projects, low search ability and restricted access to some publications (Nnam et al., 2016) stifle the growth of open science in Uganda.

Ghana

The state of open science adoption in Ghana. In Ghana, the concept of open science is followed strenuously (Asamoah-Hassan, 2010). This is evidenced by the number of journals in OA as well as the adoption of the concept of OA, IRs and the use of open source software to manage and share knowledge. Mention could be made of 27 Ghanaian journals which are all found in the AJOL Platform. These include but are not limited to: *Ghana Journal of Medical Sciences*, *Ghana Journal of Geography*, *Ghana Journal of Linguistics*, *Ghana Medical Journal* and *Ghana Mining Journal*.¹² The use of open source software is also evident in the country. The Koha- ILS Software and the D-Space repository software are relied upon by many Ghanaian academic libraries to manage resources and create OA repositories respectively.

All these initiatives are driven by the academic libraries of most institutions. Ghana has 11 public and

over 60 privately owned universities (Adam and Mahmoud, 2014). Of these institutions 37 (including all public universities) belong to the Consortium of Academic and Research Libraries in Ghana (CARLIGH). Five out of the 10 public universities as well as six of the over 60 private universities have IRs at various stages of development and operation (Bossaller and Atiso, 2015; Corleley, 2011). However, this study seeks to report on the repositories as are presented in Table 3. In all the universities, the library and IT units directly deal with the technical issues of repository development whilst collaborating with other units to oversee the operations and marketing. The Universities of Kwame Nkrumah and of Cape Coast became the first to establish IRs in 2008.

In all the repositories, there are electronic theses and dissertations, reports, journal articles, or heritage and administrative materials. However, there were differences in the proportions of such components. None of the institutions had audio or audio-visual materials in its repository. A breakdown of the respective constituents has been shown in Figure 1.

Marketing and promotion of open science by academic libraries in Ghana. The word of mouth approach of publicizing the IR as well as the use of the main university website was common to all four universities under review.

Again, education or orientation programmes were a common feature in all the study sites. Furthermore, OA week celebrations and university open days as well as campus-based radio stations were used to promote the repository. It also emerged that religious fora were also employed to reach out to the campus community about existing open science initiatives. In all these, the university library spearheads the marketing process, with irregular support coming from the Public Relations departments.

Table 3. Open access repositories of Ghanaian academic institutions.

IR name and URL	Institution/organization	Launch date	Items as at 2016	Content
KNUSTSpace: http://dspace.knust.edu.gh:8080/oai/request	Kwame Nkurumah University of Science and Technology (KNUST), Ghana	2008	5916	articles, references, conference, theses
UDS Institutional Repository (UDSpace): http://udsspace.uds.edu.gh/oai/request?verb=Identify?	University of Development Studies, Ghana	2014	538	articles, references, conference, theses, unpublished materials
University of Cape Coast Institutional Repository: http://erl.ucc.edu.gh/	University of Cape Coast, Ghana	2008	1390	articles; theses; unpublished; learning objects
UGSpace (University of Ghana Digital Collection): http://ugspace.ug.edu.gh/	University of Ghana, Ghana	2012	7154	books, special materials

Source: OpenDOAR (2017).

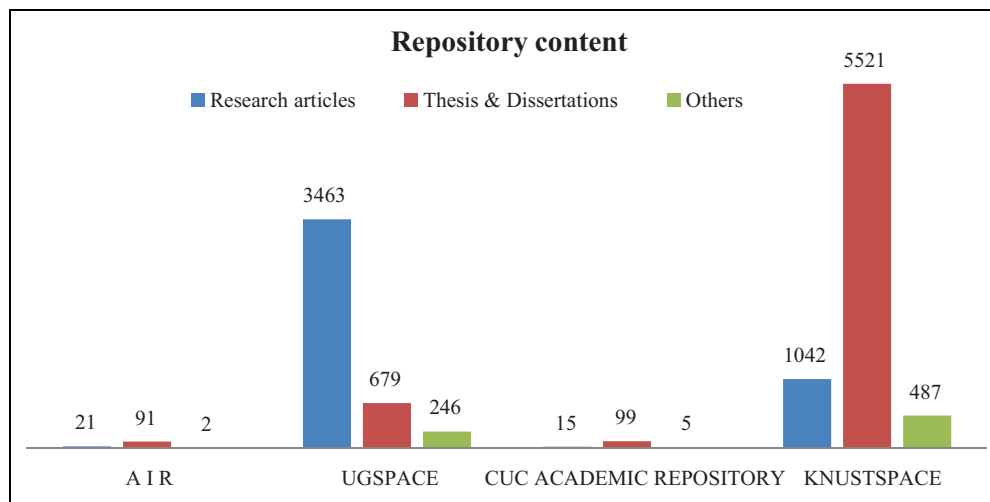


Figure 1. Materials in the various repositories. (The colour version of this figure is available in the online issue.)
Source: OpenDOAR (2017).

Challenges of open science in Ghanaian academic institutions. The list of issues thwarting the effort of open science is never exhaustive. In general, there is a negative attitude to contents that are openly accessible. It is often misconstrued that publications in OA are not worthy or credible. This seriously defeats several efforts at consolidating the minimal gains made in OA.

It must be noted that most of the open science initiatives dwell on computer application. For that reason, computer experts become crucial. However, such human resource is very scarce in the country. Due to the lower rate of retention of IT experts, it often becomes difficult to sustain open science initiatives. Again, internet connectivity is not only expensive but often erratic. As a result, it becomes unreliable to dwell on resources online. Library users

are such that if a result is not found as and when it is sought, then it is not worth searching.

Closely related to the issue of erratic internet connectivity is the lack of stable power in the country. Since most digital initiatives rely on electricity, a lack of it really affects the smooth operations and cost of most libraries. Therefore, when it becomes difficult to meet the traditional mandate of academic libraries, little or no room is left to consider innovations such as open science. What is more, the issues of copyright and intellectual property rights usually affect the rate of populating open science platforms with contents. It often occurs that African academics sign away their right as authors completely to commercial publishers, thus making it impossible to freely disseminate their publications.

Tanzania

The state of open science adoption in Tanzania. Despite the potential for OA to facilitate scholarly communication, it has not been fully exploited in Tanzania (Lwoga and Chilimo, 2006). Open access to scholarly communication is a relatively new innovation among researchers in Tanzania. By the end of 2010, Tanzania had only two OA journals (both biomedical journals) and no OA repositories (Dulle, 2010).

A study by Mgonzo and Yonah (2014), confirmed by the DOAR, revealed that Tanzania had eight open access IRs by the end of 2014. This shows an implementation rate of only 9.8% of the 51 total numbers of institutions in Tanzania. However, OpenDOAR (2017) shows that by the end of 2016 there were nine academic institutions with IRs in Tanzania.

Tanzania lists 19 journals which are all found in the AJOL Platform. These include but are not limited to: *African Journal of Economic Review*, *Huria: Journal of Open University of Tanzania*, *Tanzania Journal of Science*, *Journal of Development Studies* and *Journal of Health Research*.¹³ The institutions with IRs, items deposited and the contents are presented in Table 4. In that table Muhumbili University of Health and Allied Sciences pioneered the establishment of IRs in Tanzania by the year 2001 which was followed by the Open University of Tanzania after 10 years. The recently established IRs in the list are that of Mzumbe and Nelson Mandela Universities.

These Universities, Colleges and many others form the Consortium of Tanzania Universities and Research Libraries (COTUL) and if continued efforts are adopted to strengthen it, there will be more knowledge sharing among the consortium members.

Marketing and promotion of open science by academic libraries in Tanzania. Most academic institutions in Tanzania employ far-reaching communication tools such as campus-wide announcements, newspaper articles, letters, post cards, brochures, bookmarks, group e-mails, give-aways, workshops, flyers, meetings, training, workshops and press releases to raise awareness.

Challenges of open science in Tanzania. The growth of open science in Tanzania is bedeviled by numerous challenges. To begin with, slow Internet speed, emanating from low Internet bandwidth supplied to most academic institutions is a great disincentive (Dulle et al., 2010). There is also the lack of a clear open science policy within the country's universities. Swan and Brown (2005) observed that policies are considered important not only for motivating the researchers

to publish in OA systems but also as a means of clarifying the objectives, processes and procedures relating to the OA activities. Unfortunately, the opposite is the case in most Tanzanian academic institutions. Furthermore, there is generally a low level of researchers' information search and publishing skills. Most researchers in the country face challenges in their inability to access and disseminate scholarly content. Other challenges include: inappropriate training opportunities for library and information professionals to keep abreast of skills and new media tools used in creating local content; lack of authors' desire in depositing their works in the institutional repository; limited financial resources for purchasing high quality scanner, digital cameras and the like.

Cross-cases analysis of the various countries

It could be realized that academic libraries have seen the worth of open science platforms to widely disseminate research across space and time. For that matter, not only are open science platforms such as open access journal and repositories relied upon to advance scholarly communication, but they are often done with open source software. Other resources such as blogs and wikis have been greatly relied upon to communicate among academic communities of practice without recourse to any physical barriers. These initiatives have really led to African research rising.

It could be observed from the above discussions that a few scholarly journals exist in OA for most African academies in Ghana, Nigeria, Tanzania and Uganda. Again, though not massively adopted, OA institutional repositories have been used to preserve and publicize the digital contents in some academic institutions in Africa such as theses and dissertations, administrative and heritage materials, conference proceedings as well as pre-prints and post-prints of journal articles.

In spite of various benefits, developing countries' road to open science has not been smooth which among other things has to do with policy issues. Experiences suggest that a repository for instance, will only function to its full capacity when a mandate is in place to populate it. However, in many instances, open science initiatives are implemented long before relevant policies are formulated.

Again, the high cost of ICTs, connectivity and poor telecommunication in developing countries makes the sustainability of OA repositories very difficult (Canada, 2009; Giarlo, 2005). According to Dicovery (2010) developing countries are still struggling to achieve broadband services even though significant improvements have been made in access to mobile

Table 4. Institutional repositories in academic institutions in Tanzania.

Name of the institutional repository	Name of the institution/ organization	URL	Launch date	No. of items as at 2016	Content
Digital Library of Open University of Tanzania	Open University of Tanzania	http://repository-out.ac.tz/cqi/oai2	2011	338	articles, references, theses
Digital Library of Tanzania Health Community - e-Health	Ifakara Health Institute	http://ihi.eprints.org/cqi/oai2	2012	3055	articles
Mario Mgulunde Learning Resource Center Repository	Saint Augustine University of Tanzania	http://41.59.3.91:8080/xmlui	2013	28	articles, theses, learning objects, unpublished materials
MUHAS IR	Muhumbili University of Health and Allied Sciences (MUHAS), Tanzania	http://ir.muhas.ac.tz:8080/oai/request	2001	1681	articles, conferences, theses, unpublished materials
Mzumbe University Scholar Repository	Mzumbe University, Tanzania.	http://scholar.mzumbe.ac.tz/	2015	1449	articles, references, theses, books
NM-AIST Repository	Nelson Mandela African Institution of Science and Technology, Tanzania	http://dspace.nm-aist.tz/cai/request	2015	19	articles, theses, multimedia
Sokoine University of Agriculture IR	Sokoine University of Agriculture, Tanzania	1. http://www.suaire.suanet.ac.tz/oai/request	2012	646	conferences theses, unpublished materials
	Tanzania Climate Change Information Repository (TaCCIRE)	2. http://www.taccire.suanet.ac.tz/xmlui	2013	447	articles and unpublished materials
SUZA Repository	State University of Zanzibar (SUZA), Tanzania	http://repository.suza.ac.tz:8080/xmlui/	2015	30	articles, theses
University of Dar Es Salaam IR	University of Dar Es Salaam	http://repository.udsm.ac.tz:8080/Oai/	2012	3575	articles, theses, conferences.

Source: OpenDOAR (2017).

technology and infrastructure. Pickton and Barwick (2006) observe that the problem often does not lie in the initial set-up cost but regular maintenance cost.

Another drawback to the growth of repositories in Africa is the lack of institutional support. Christian (2008) opines that many cases in literature suggest that knowledge about the benefits of OA IRs is very low among the major stakeholders like lecturers, researchers, librarians and students. As such, commitment and support seldom come from key stakeholders (Pickton and Barwick, 2006).

The issue of copyright cannot also be overlooked in any discussion of challenges confronting IRs. When it

comes to alternative publishing arrangements, it often becomes difficult for researchers to negotiate their intellectual property right to their advantage. In most cases, because some researchers do not have adequate knowledge about intellectual property rights issues, they end up being too careful not to infringe publisher copyright. In the same vein, publishers have developed a subtle opposition to IRs since they see it as a competition and threat to their business (Davis and Connolly, 2007; Moahi, 2012; Pickton and Barwick, 2006). In a typical situation in Nigeria in 2008, the International Institute of Tropical Agriculture (IITA) developed an IR but the repository could not go public

due to some copyright issues. This was because copyright in research works conducted by the researchers at the Institute had been signed away to commercial journal publishers (Christian, 2008).

Closely linked to the intellectual property right issues is the difficulty in generating content, especially in the beginning. This problem stems from the unwillingness on the part of academics to deposit their research work. Research reveals that materials that are openly available hardly achieve any recognition (Davis and Connolly, 2007; Royster, 2008).

Challenges related to technical issues such as human resources, material resources and conversion of materials from their existing format to electronic format also affect the success of repositories.

Future directions

In relation to the various challenges raised above, the following recommendations are made with the key strategies, units and individuals.

In the first place, academic libraries in SSA should intensify their open science advocacy. It had long been realized that the 'build it and they will come' strategy does not work. For that matter, the university library staff should target highly placed individuals in the academic community such as university presidents or vice chancellors, provosts, registrars and faculty deans as well as heads of academic departments to ensure their buy-in of any initiative they undertake. It is only after this that mass promotional activities such as word of mouth, open days, OA weeks, use of notice boards and university websites can actually be effective in promoting the adoption of open science.

Again, there is the need for university administrators to ensure that there is stable electricity as well as reliable internet connectivity in their institutions. There is often the need to invest substantially in these resources since it is the only antidote to low rate of knowledge production and sharing in most African countries.

Furthermore, there should be regular training of the campus community members such as students and faculty members about emerging media technologies. This should also be interspersed with encouraging members to contribute contents into open science platforms to increase the visibility of their institutions and therefore, their own visibility. The academic libraries should assert their authority and lead in the research literacy skills of members in order that they could become reliable content contributors.

Again, in most of the countries above, there already exists a consortium of academic libraries. The

consortium libraries and member institutions should consider the establishment of a single platform to showcase and share the intellectual productivity of their member countries. In the same way that they collectively subscribe and pay for journal and database licences, they could create open science platforms to share outputs of their scholars.

Conclusion

The field of information services delivery has really changed. The library has moved from a custodian of resources to a producer of same. For this reason, there is the need to re-think the ways in which libraries in Africa embrace innovations at improving scholarly communication and knowledge sharing. This is possible if there is a readiness by these libraries to consider applying the emerging library new technologies, provided that they fit into their environment. Knowledge and experience sharing are possible if the librarians prepare the forums to discuss various issues concerning their institutions. Providing an opportunity for the library professionals to attend seminars, workshops, conferences and short training sessions prepared at the regional and international levels is of paramount importance. This is considered as an effective way through which libraries and information professionals can engage in building their capacities in order to form meaningful collaborations to push the agenda of open science in their academic communities to harness the benefits associated with OA. Developed countries should consider removing access barriers so that research findings are made available to as many academics as possible free of charge. This will accelerate research activities, enrich education and knowledge sharing.

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Notes

1. Arno is the first virtual network functions (NVF) software platform released from Open Platform Network Function (OPNFV). OPNFV is said to be a 'development-focused' release designed to foster the development of NVF, virtual network functions and use case-based testing. Available at: www.rcrwireless.com/20150605/...nfv/opnfv-unveils-arno-nfv-software-platform-tag2

2. Stands for CERN Document Server Software. CDSware supports the creation of electronic preprint servers, Online Public Access Catalogs (OPACs) and document systems on the Web. It complies with the OAI-PMH (Open Archive Initiative – Protocol for Metadata Harvesting) and uses MARC 21 as its underlying bibliographic standard. It is open source software, licensed under the terms of the GNU General Public License (Sitas, 2006)
3. Is an open source repository application developed by the community and stewarded by DURASPACE. Available at: <http://www.dspace.org/introducing>
4. An EPrints institutional repository is an information hub designed to capture research outputs, make them discoverable and re-usable, and preserve them for the future. It was created in 2000 as a direct outcome of the 1999 Santa Fe meeting that decided on the OAI-PMH protocol. Available at: <http://www.eprints.org/uk/index.php/openaccess>
5. Stands for Flexible Extensible Digital Object Repository Architecture. It is a robust, modular, open source repository system for the management and dissemination of digital content. It was in the first place established in 1997 as a research project at Cornell University. Available at: <http://fedorarepository.org/about>
6. Is a framework for presentation and management of digital contents. Available at: <http://www.mycore.de/>
7. Invenio was born at CERN as a digital library software solution to run the CERN document server, managing over 1,000,000 bibliographic records in high-energy physics since 2002. It covers articles, books, journals, photos, videos, and more. Available at: <http://invenio-software.org/>
8. Is an Open Source - Integrated Library System which was created in New Zealand in 2000. Koha is used worldwide in libraries of all sizes and it includes modules for acquisitions, circulation, cataloging, serials management, authorities, flexible reporting, label printing, multi-format notices, offline circulation for when Internet access is not available. Available at: <https://koha-community.org/about>
9. A virtual research environment comprises a set of online tools and other network resources and technologies interoperating with each other to facilitate or enhance the processes of research practitioners within and across institutional boundaries. It facilitates collaboration amongst researchers and research teams providing them with more effective means of collaboratively collecting, manipulating and managing data, as well as collaborative knowledge creation (JISC, 2013).
10. ‘Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly’ (Wenger-Trayner and Wenger-Trayner, 2015).
11. <http://www.ajol.info/index.php/index/browse/country?countryId=156&browsePage=3>
12. (<http://www.ajol.info/>).
13. (<http://www.ajol.info/>).

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