Promoting the growing and access to scientific literature through NRENs in Africa

Marangaze Munhepe MULHANGA[1], Solange Rito LIMA[1], Venâncio MASSINGUE[2], and João Nuno FERREIRA[3]

[1]*Centro Algoritmi, Universidade do Minho, Portugal*
[2]*Universidade Eduardo Mondlane, Mozambique*
[3]*Fundação para a Ciência e a Tecnologia, Portugal*
Email: mmunhepe@di.uminho.pt, solange@di.uminho.pt, venancio.massingue@uem.mz, ferreira@fccn.pt

Abstract

Currently, it is undeniable the role of the Internet in sustaining knowledge growth through a multitude of technologies, user devices and network infrastructures. National Research and Education Networks (NRENs) promote the involvement of research and education community in the use of new services and applications oriented to support research, innovation and teaching activities. In this context, sharing knowledge in the information age is seen as a vehicle for the development of society, being digital libraries and other technological platforms used as a way of preserving and disseminating scientific production.

Against this backdrop, based on worldwide initiatives and on the Portuguese experience in the field, this article aims to present the challenges and strategies for the implementation of digital libraries and open access (OA) to scientific contents through NRENs in Africa. The focus will be given to Mozambique and its NREN, the MoRENet (Mozambique Research and Education Network), still in implementation phase. In this sense, this article addresses aspects such as: i) the access to scientific literature through digital libraries; ii) OA initiatives regarding repositories and journals; (iii) the relevance of adopting OA policies and mandates; and (iv) the role of governmental and institutional strategies and initiatives in supporting science and technology. The discussion and directives advocated in this article may also provide useful insights for identifying potential international cooperation synergies to sustain knowledge growth in developing countries.

 Keywords: Digital Libraries, Open Access, NREN, OA Policies, Knowledge Management

1. Introduction

Nowadays, developing strategies for sharing knowledge is viewed as a major issue for the progress of societies. One of the major impairments in the access to scientific information is that the full contents are not always freely available. Scientific journals serve as tools for disseminating research results in different fields of knowledge, however, the monopoly of commercial scientific publishers require from institutions substantial financial and operational efforts in the acquisition of scientific literature.

Thus, in developing countries, due to economic restrictions, the access to scientific publications depends largely on the support of some international bodies providing the access, production and use of research information and knowledge in some countries. Even in these cases, not all institutions have digital libraries and, in many cases, network connectivity is still in deficit.

For developed countries, the process of acquisition or subscription of scientific literature is carried out in various ways depending on each country initiatives. In this context, Portugal is viewed as a case of success due to the creation in 2004 of the "*Biblioteca do Conhecimento Online – B-on*", the Online Knowledge Library, whose mission is to ensure the access to a vast number of scientific publications and electronic services to the national academic community. The B-on is supported by FCT (*Fundação para a Ciência e a Tecnologia*), the managing body of the Portuguese National Research and Education Network (NREN), responsible for providing high-speed connectivity and advanced services to academic institutions and research centers.

Another way to access and divulge knowledge, especially advantageous, is through open access (OA) repositories. Developing OA repositories enables the visibility, accessibility and dissemination of the scientific production of a country. The US government, through the Office of Science and Technology Policy, and the European Council recognized the importance of OA to academic and scientific community, and released guidelines sustaining that the results of publicly funded research projects should be available through an open and unrestricted access.

The national scientific OA repository in Portugal, *Repositório Científico de Acesso Aberto de Portugal* – RCAAP, is another service provided by the Portuguese NREN. It was created especially for institutions without an OA platform, which may take advantage of RCCAP to have its own repository hosted in a cloud environment. The aggregation of repositories of institutions connected to FCT into this multi-institutional repository allows to centralize the national scientific production.

In the African context, there are still many challenges to implement digital libraries and OA, both regarding the access to scientific contents and network connectivity. The high cost of broadband access and the lack of a national and international network infrastructure based on fiber-optic are limiting factors. Despite the inherent difficulties for deploying NRENs in Africa, several initiatives have been promoted, being UbuntuNet Alliance one of the most important. Interconnecting African NRENs and sub-Saharan Africa in an international high-capacity network through GEANT is the main goal of this alliance. Achieving this goal through AfricaConnect project will enable the African research and education community to collaborate and participate effectively on NRENs mission at global level. International organizations and collaborations supporting and promoting the access and sharing of scientific publications also play a relevant role in fostering knowledge in developing countries.

In Mozambique there are several ongoing initiatives and projects for developing research and education, namely the initiatives of Eduardo Mondlane University (UEM) in the OA field and the project Mozambique Research and Education Network (MoRENet) within the Ministry of Science and Technology.

Taking into account these multiple perspectives, in particular the Portuguese experience and the Mozambican context, this paper focuses on the implementation of digital libraries and OA supported by NRENs in Africa, which is viewed as a vehicle for promoting the growth and access to scientific literature. Therefore, this paper covers aspects such as the access to scientific literature through digital libraries, OA repositories and journals (namely SABER

and RC-UEM), OA policies and mandates, and the relevance of governmental and institutional OA initiatives. The present discussion also provides a global view of the challenges and strategies to foster knowledge growth through NRENs in Africa.

This paper is organized as follows: Section 2 is devoted to discuss issues related to unrestricted access to scientific literature, including OA policies and mandates; Section 3 presents the experience of the Portuguese NREN in providing access to information to the scientific and academic community; Section4discusses the African context regarding the access to scientific information, considering repositories, journals and OA policies. Section 5 covers the current situation in Mozambique, the challenges and barriers in accessing information in this country. Finally, the conclusions of this work are drawn in Section 6.

2. Unrestricted Access to Scientific Literature

The unrestricted access to academic and scientific literature is currently under serious debate. The commercialization of scientific journals by commercial publishers is one of the most vivid examples. As it is known, scientific journals play a key role in disseminating research results. Despite its importance, libraries of higher education and research institutions face a huge challenge in the acquisition of scientific publications for its community as consequence of the monopoly of the commercial scientific publishers. In many situations, the results from research produced in these institutions are submitted freely to commercial journals and the institutions end up being forced to buy the same publications afterwards. This is one of the factors that gave rise to the OA movement (Willinsky, 2005).

OA is intended to provide access to scientific and academic literature free of restrictions, supported by information and communication technologies, which allow accessing data via the Internet. Repositories are the most used platforms in the implementation of OA, by allowing the storage of documents in an electronic format.

2.1 OA Initiatives and Repositories

Scientific OA repositories have been under debate in recent years, being one of the first international initiatives in this context promoted in 2001 by the Open Society Institute (OSI) in Budapest. This event gave rise to one of the most important documents and initiatives spearheaded by the OA movement called Budapest Open Access Initiative (BOAI), where the strategies of submission and promotion were defined considering journals and self-archiving publications in OA repositories (BOAI, 2001). In this field, BOAI defined two pathways to OA described as: (i) *Green OA* - where the authors through self-archiving must deposit their publications in a thematic or institutional repository; (ii) *Gold OA* – which refers to publication in OA scientific journals with peer review.

To support OA implementation and its evolution, national initiatives and international projects have resulted in an increased number of repositories of various types, such as institutional, governmental, multi-institutional, and disciplinary. As presented in Figure 1: Repositories in the world there are currently about 2727 repositories worldwide, being the European continent the leader with 45.5%, followed by North America with 19.8% and Asia with 18.4% of repositories (OpenDOAR, 2014).

The initiative led by the Open Archives Initiative (OAI) in 1999, allowed to answer the needs of interoperability between repositories and research of scientific publications in various areas, through the creation of a protocol for *collecting metadata records*in repositories, the OAI Protocol for Metadata Harvesting (OAI-PMH) (openarchives, 1999).

In this context, OA represents a joint effort bringing the following benefits to researchers:

- to increase visibility and use of research results;
- to increase the balance in accessing information(everyone has access: researchers, teachers, students, institutions);
- to increase visibility to authors, and valuation of intellectual property;
- to increase the return on research investment;
- to improve the production of new knowledge, promoting the use and transformation of already existent knowledge;
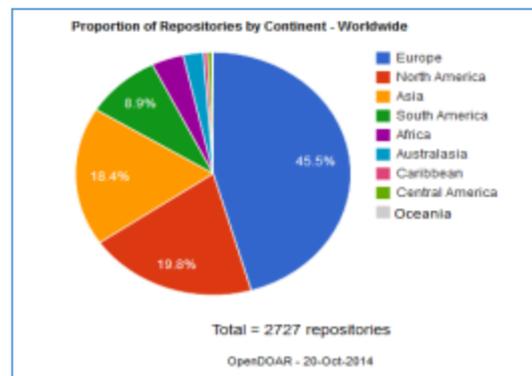- to foster interdisciplinary research.

Figure 1: Repositories in the world

Regarding the software used for the implementation of repositories, there are several tools available in open source, being EPrints and DSpace the most used. Currently, DSpace, which is a more recent software platform, has been the choice for the implementation of most repositories.

2.2 OA Policies and Mandates

OA Policies - To encourage OA, international, national and institutional policies focused on self-archiving have been adopted, which means that authors deposit the results of their work in repositories that are available freely, and without cost.

In 2004, 34 countries of the Organization for Economic Co-operation and Development (OECD) adopted a Declaration on Access to Research Data From Public Funding, recognizing that OA allows to leverage the value coming from public investments in data collection, and that the risk of unauthorized access and use of data for scientific research restrictions can decrease the quality and efficiency of research and scientific innovation (OECD, 2004).

In 2013 the government of the United States of America released a directive from the Office of Science and Technology Policy instructing federal agencies with more than 100 million dollars spent on R&D to develop plans so that the results of publicly funded research be made available in OA, including the data resulting from research (OST, 2013).

At European level, the European Union has assumed the importance of OA to academic and scientific community, and through the European Council (EC) has launched community guidelines and projects, being the Open Access Pilot in FP7 in 2008 one of the most relevant. These guidelines mainly cover the EC funded projects with EU funds, and seek to expand

approaches to its member countries to improve and maximize the access and reuse of research data, in terms of:

- the deposit of peer-reviewed research articles or final manuscripts resulting from their projects into an online OA repository;
- making their best effort to ensure open access to these articles either within 6 months or 12 months (for publications in social sciences and humanities) after publication. These periods, allows scientific publishers to ensure a profit on their investment (by charging for journal subscription), providing then OA to research articles once the embargo period has lapsed (EC, 2007).

The new guidelines of OA launched under Horizon 2020 (EC, 2013), cover the following key points for researchers:

- *licenses* - encourage authors to retain the copyright and to agree with editors on the appropriate use of licenses, such as creative commons;
- *data* – data resulting from research, including the associated metadata necessary to confirm the results, must be deposited in a scientific data repository;
- *metadata* – free access to bibliographic metadata related to the deposited publication (the terms of the funder, the action's name, the initials and number of the agreement, the publication date, the embargo period and a persistent identifier);
- *costs* – eligibility of costs of OA publishing during the project, especially in cases where the researcher has to pay an amount to publishers to have the publication in OA.

Figure 2 represents the decision process regarding the results of a research project that involves the dissemination and the protection of intellectual property through patents or other protection strategy. In the dissemination process, publications and data will be made available in free or restricted access. Community directives point out to the sharing and dissemination, and to free access to data and intellectual property.
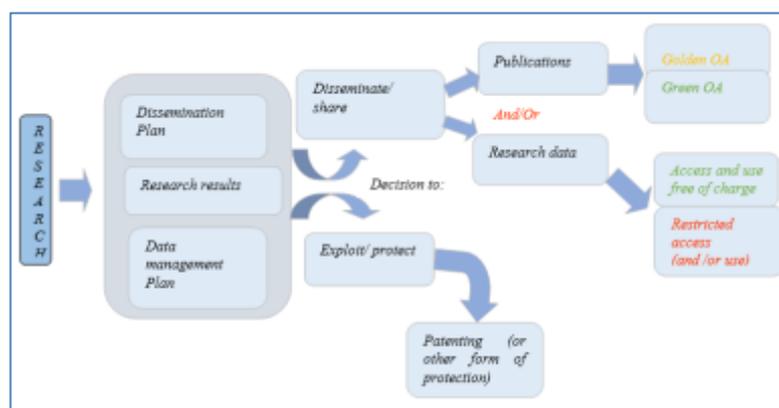

Figure 2: Open access decision process (EC, 2013)

To address the challenges presented above, mainly in Europe, and aiming to facilitate the management of science and technology under the OA movement, several countries started with the integration of existing OA systems based on the Current Research Information System (CRIS). CRIS is a concept defining any database or information system dedicated to provide information about research carried out by researchers and organizations as part of a project financed by a funding program (EuroCris, 2014). Under CRIS, for managing science and technology, there is a set of information about science and technology such as:

researchers, publications, patents, data products, facilities, equipment, services, financing programs, funding organizations, science and technology organizations, etc., and their respective relationships. The implementation of management systems of science and technology allows to answer questions such as "How many PhD students participated in research projects funded by organization X?"

OA Mandates - In general, for a country level, OA policies and mandates involve institutions, government and research funding agencies. Institutional policies are related to teachers and researchers who are authors and co-authors of publications and other documents; research centers and departments; authors of theses and dissertations approved by the institutions to promote self-archiving. The focus on dissemination within the academic and scientific community plays a leading role in the evolution of the number of documents deposited in OA repositories (Xia, et al., 2012). Most of the research projects are funded by public entities, government and research funding agencies, and they also want to see the results made available in OA.

The worldwide view of OA policies and mandates presented here is based on the Registry of Open Access Repository Material Archiving Policies (ROARMAP) portal, which gathers information around the world on policies for OA information. From the analyses carried out, it was found that there are a total of 497 mandates related to 49 countries. Considering the items registered on the ROARMAP portal, Table 1 shows the distribution of OA mandates by continents, including Institutional Mandates, Sub-Institutional Mandates, Multi-Institutional, funders mandates, thesis mandates, and mandates proposals being defined and/or unspecified (ROARMAP, 2014).

Asia	Africa	Europe	North America	Oceania	South America
45	18	302	173	42	30

Table 1: OA mandates distribution by continents

3. The Portuguese Experience

In Portugal, the *Fundação para a Ciência e a Tecnologia* - FCT (through *Fundação para a Computação Científica Nacional* - FCCN unit), the managing body of the Portuguese NREN, is responsible for providing high-speed connectivity and advanced services to academic institutions and research centers. The Portuguese NREN was founded in 1987 and the evolution of its network infrastructure enabled the creation of projects supporting research and education services, especially in the last 10 years, including the access to scientific contents.

With the creation of the "Biblioteca do Conhecimento Online – B-on", in 2004, the digital library, supported by FCT, the national academic and scientific community can access to a large number of scientific publications and electronic services (B-on, 2004).Another service provided by FCT to NREN community is *Repositório Científico de Acesso Aberto de Portugal* - RCAAP, the national OA repository created in 2009, available to increase the visibility, accessibility and dissemination of results from national scientific and academic activity (FCCN, 2013). Both of these services will be addressed in the following sections.

3.1 B-on – The Digital Library

Before the creation of B-on, each Portuguese institution acquired its own scientific contents, being the only contents available to the users of the institution. Attending to this situation, the

Ministry of Science and Technology and High Education (the then Ministry of Science of Technology) decided to centralize the budget for buying scientific publications and mandate the FCCN (currently FCT) to acquire and manage the access to the information. The decision of purchasing access rights through a joint consortium proved to be advantageous as it allowed a stronger ability to negotiate with publishers.

For the fulfillment of B-on mission, several entities have been working together, as represented in Figure 3 and discussed below:

- FCT has the responsibility for political, financial and operational management. As a national public funding agency for research in science, technology and innovation, in addition to NREN management, it is responsible for the following aspects:
- political: define, validate and approve policies related to the mission and goals;
- operational: propose and execute operations to be performed under the strategic plan and activities;
- financial: finance the service based on two models, regarding funding and distribution costs, respectively.

- participating associations: primarily related to the digital libraries field, to allow joint collaboration between members and the share of experiences. B-On is associated with the following associations:
  - International Coalition of Library Consortia (ICOLC);
  - Southern European Libraries Link(SELL);
  - Counting Online Usage of Networked Electronic Resources (COUNTER);
  - **International Group of Ex Libris Users** (IGeLU).

- technology and content providers: the choice of content providers (publishers and other suppliers) and technologies (software, servers and other technological features) is based on the identification, selection and contract negotiation with suppliers. This process depends on the assessment of success guarantees by engaging the services provided. B-on, representing adherent higher education and research institutions, tried to rationalize costs through centralized negotiation with publishers and other content providers.

Figure 3: B-on service entities

Managing contents - In April 2004, B-on began its operation providing about3500titlesof six publishers, and in 2005increased its subscription content to approximately12, 500 titles from 15content providers. The services of B-on are based on contents, which undergo a cycle of five processes, as represented in Figure 4, namely: acquisition; access; support, administration, evaluation and monitoring, as described below.

Acquisition: This process is started by the community when there is the need to purchase a particular feature, and it requires the selection and analysis of the requested content. In this case, facing the proposals and suggestions made by the community, B-on makes a first screening to exclude proposals that do not fit in the integration policies. Then, the selected proposals are analyzed to see if they are really indispensable, through questionnaires for further analysis, and according to budget availability. In case of approval of the resource acquisition, this process continues to the negotiation phase with the resource provider.

Access: this aspect is related to the restrictions on accessing contents through the Internet. To the member institutions allowed to access contents, B-on provides Internet access to each content provider so that the institution can register and get authorized. Remote access to information from different places is possible using VPNs, proxies and the new federated service.

Administration: this involves managing all the information so that the processes of acquisition and access are successfully accomplished. This implies having the registration information of each institution (identification and contact), the catalogue of periodicals and the access restrictions depending on the group to which the institution belongs.

Support: this aspect targets solving problems and answering questions related to the access to contents. This process handles registration, diagnosis, triage and resolution, or forwarding to a third party.

Evaluation and monitoring: this process tracks the performance assessment of activities to improve service quality, based on the analysis of quantitative and qualitative indicators, reported issues, service failures, usage statistics, as well as the degree of user satisfaction.
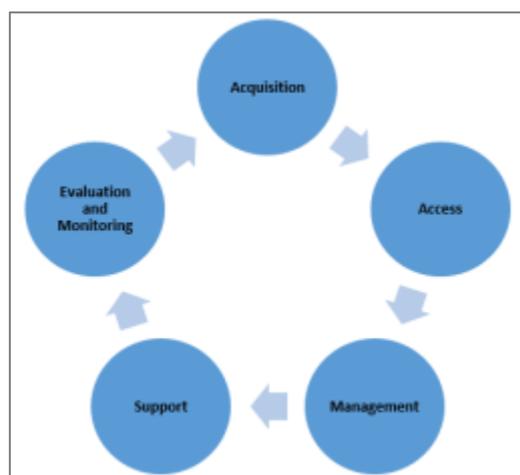

Figure 4: B-on: a cycle of five processes

Negotiating Knowledge Acquisition - From the creation of B-on, FCT provides the publications to the institutions linked to the NREN in two ways, "all-for-all" and "some-for-some", as described below:

all-for-all: the total budget that FCT centrally manages for the acquisition of scientific publications is directed to the purchase of publications for all institutions, from a major university to a small institute, providing a global access to the same publications. With this arrangement, the budget centrally managed is used to acquire contents for all participating institutions.

some-for-some: as FCT cannot buy all publications available in the market, for the institutions of the consortium interested in a particular publication (at least five institutions), FCT negotiates each particular case with the publishers. If the number of institutions is smaller than five, these institutions can negotiate directly with the publishers.

In both cases, research institutes and private entities may also take advantage from this collaborative purchase, by paying from their own budget. Public entities are subsidized and private entities pay according to a predefined model. By 2012, the settlement was a payment according to the entity size (number of researchers, etc.). From 2013 the institutions pay by usage, i.e. depending on the number of downloads in the last three years. The idea is to acquire a larger number of contents, but the most relevant to the community, and to share the costs between public and private entities. If B-on fails to sign the agreement with a publisher, the exclusion affects the entire country. This strategy is part of the rationalization of costs which requires negotiation power to be successful, which is one of the objectives of B-on.

Another important aspect to face is obtaining the overall view of the most important contents to the community. This is obtained from downloading statistics, which allow, for example, knowing what content is actually used, and whether the users are specialized in a particular small or emergent area. In this case they can buy and sign the content personally.

Analyzing the members of the consortium, B-on began its operation with 48 institutions in 2004, and in 2007 reached a maximum of 75 institutions. Until 2012, some institutions left the consortium, with a maximum of 3 per year. From 2012 to 2013, 12 institutions have left the consortium, being integrated a total of 59 institutions in that year. The cause of this loss in membership needs a thorough analysis, being out of the scope of this paper. Despite the costs involved (e.g. software and maintenance) and the number of member institutions has decreased, the B-on service can be considered a success, stressed by the contents download indicators, which have grown almost continuously, from 1,996,171 in 2004 to 9,345,809 in 2013.

A major concern of the involved academic and research community is assuring the continuity of budget to sustain B-on. This motivates B-on to adhere to a preservation service of electronic resources called Portico (Portico, 2005). There are several solutions that preserve electronic contents and provide access to institutions after unsubscribing. Portico, according to B-on analysis, seemed to be the most appropriate solution, as it provides a wider coverage of B-on content. The strategy is to centralize the preservation process in Portico, by removing this task from libraries and publishers.

The software for managing B-on content is Ex Libris, a proprietary library management system. This is an expensive software suite when considering countries with limited financial capacities.

3.2 RCAAP - The National OA Repository

RCAAP, the Portuguese scientific OA repository created in 2009, is a meta-repository aggregating 35 institutional repositories and 5 journals, allowing free access to a vast number of scientific national publications, currently exceeding 100,000 documents (Mulhanga, Lima, Massingue, & Ferreira, 2014).

To facilitate OA for institutions without repositories, it was created within RCAAP the service - *Serviço de Alojamento de Repositórios Institucionais* − SARI, which allows institutions to have their own repository hosted in the cloud, avoiding concerns with technical aspects. With this service, centrally provided, institutions only have to worry with the management of their repositories. For institutions with a reduced volume of publications, a common repository was created within the SARI to allow the community of these institutions to have a shared repository with the outcome of their research work.

Beyond being a hosting service of repositories, RCAAP recently created the Hosting Service of Journals, which allows institutions to create a journal and to undergo the entire lifecycle of the journal, i.e. from launching the call for papers, to the support for peer reviewing, editing, and processing of scientific data.

To strengthen the visibility of OA scientific contents in Portuguese language, through a collaboration established between Brazil and Portugal, RCAAP proceeded with the aggregation of publications available in Brazilian institutional repositories.

In terms of policies and mandates, FCT is a funding agency of the Portuguese government and institutions have been promoting their mandates based on the European guidelines. For FCT, the guiding principles regarding OA policies propose that the result of publicly funded research (including research data) should be deposited as soon as possible in an OA repository.

4. The African Context

Several studies reveal that this continent has the highest costs for the use of mobile telephony and Internet (Alozie, Akpan-Obong, & Foster, 2011). Despite the challenges it has faced, according to the Internet World Stats, Africa grew by 5.2% between 2000 and 2014, and has 8.6% of Internet users in the world (IWS, 2014). Africa still lives the problem of external economic dependence that very influenced in their technological growth.

To join the global knowledge platform, the African NRENs began to emerge especially in Eastern and Southern Africa. The high cost of broadband access and the lack of national and international network infrastructure based on fiber-optic were factors that limited their deployment. Currently, with intercontinental connections to be established through submarine fiber-optic cables and locally through terrestrial fiber, broadband connectivity can be provided in most African countries, although still very expensive compared to other world regions.

As in other continents, UbuntuNet Alliance is an African association of NRENs created in 2005 by five established members and other emerging countries in eastern and Southern Africa. The main objectives of the UbuntuNet Alliance include to provide high-speed connectivity at low cost among alliance members and connect them to existing NRENs in the world, to develop and share knowledge and skills of NRENs' ICT professionals, and to develop research to improve network infrastructure. Currently it has 14 members, and, as happens elsewhere, these objectives will enable the research and education community to cooperate and participate effectively in the activities of NRENs at a global level (Ubuntunet, 2013).

Considering the challenges in terms of research and education in Africa, some organizations have contributed to the emergence of new NRENs and associated projects, namely:

<u>African Union</u> (AU) - AU has strategic areas for research and innovation, defined by the African Ministerial Council on Science and Technology. This council develops periodically the Africa Science and Technology Consolidated Plan of Action (CPA) that guides the

development of the ICT sector on the continent for two major objectives: to allow the development of science, technology and innovation as a way to eradicate poverty and achieve the sustainable development; and to ensure that Africa contributes to the overall increase in scientific knowledge and technological innovation. The new Continental ICT Strategy for Africa (CISA) launched in 2014 will guide the development of the ICT sector on the continent until 2024, and focuses on seven strategic areas: post and telecom infrastructure; capacity development; e-applications and services, enabling environment and governance; mobilization of resources and partnerships; industrialization; and research and development (AU, 2014).

Association of African Universities (AAU) - to raise the quality of higher education in Africa and to contribute to the development of the continent by promoting collaboration among member institutions is the mission of this African association (AAU, 1967).

Southern African Regional Universities Association (SARUA) - established in 2005, SARUA aims to support the revitalization and development of leadership for higher education institutions within the *Southern African Development Community* (SADC), as producers of scientific knowledge (SARUA, 2005).

AfricaConnect – this project supported by the European Commission began in 2011. It lasts for four years aiming at interconnecting the NRENs in Southern and East Africa through a high capacity network infrastructure. The fruition of one of the goals of UbuntuNet Alliance, namely the interconnection of association members through GÉANT network, will support research and education in Africa through the interconnection to the global research community. Given the challenges presented, the annual UbuntuNet-Connect conference, organized by this alliance, brings together diverse stakeholders, allowing to discuss issues related to the development and improvement of infrastructure services provided to the community for research and education.

Africa-EU Cooperation Forum on ICT – this is the forum for cooperation on ICT between Africa and Europe resulting in a joint strategy adopted at the Lisbon Summit, the EU-Africa Summit in 2007. The forum allows to foster the cooperation, the sharing of knowledge and experience between the two continents in ICT (with African NRENs playing a key role), promoting the dissemination of results of research projects in different areas of science and technology (Africa-Eu, 2009).

4.1 Accessing knowledge in Africa

To access knowledge has been one of the major challenges of the African continent. Despite the difficulties, the implementation of NRENs that is occurring will allow researchers, even if they are alone or in small groups, to have access to inside information. With respect the access to scientific literature, it is still a huge struggle for most of higher education institutions and research centers of the African continent, due to financial constraints to purchase contents to commercial publishers.

Thus, to face this shortfall in scientific literature, several African institutions provide the scientific community needs resorting to organizations that support and promote access and sharing of knowledge. These organizations, such as the International Network for the Availability of Scientific Publications (INASP), the African Academy of Sciences (AAS), the Research4Life, the Electronic Information for Libraries (EIFL), negotiate with commercial publishers to provide scientific literature free available or at low cost, support the creation of sustainable national library consortia, support open access publishing and building of institutional repositories of local contents, libraries, and intellectual property rights.

In terms of accessing information freely and without restrictions, the OA movement has been growing, bringing many advantages to the development of scientific production and innovation in Africa. In this regard, UNESCO has promoted OA actions, primarily focused on scientific information resulting from public funding. These actions, undertaken in collaboration with its strategic partners, aim to raise awareness about the benefits of OA among policy makers, researchers and knowledge managers, assisting the development and promotion of OA with special attention to African and other developing countries.

There are over one hundred OA repositories indexed in Africa. According to Figure 5, South Africa is at the forefront with 28.2%, then Kenya with 11.7% and Nigeria with 10.7% (OpenDOAR, 2014). Africa has 54 countries and only 23 countries have one or more repositories registered in the OpenDOAR portal. These data reveal that half of African countries need to create conditions for OA through the creation of repositories within national context.
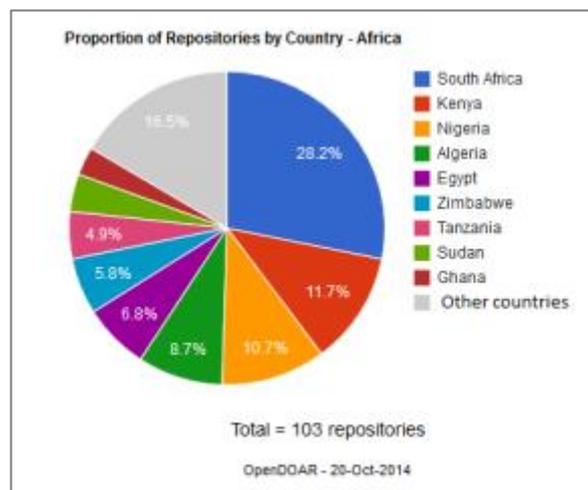

Figure 5: Repositories in Africa

Regarding scientific journals indexed in the Directory of Open Access Journals (DOAJ), South Africa with 70 and Nigeria with 38 journals, are still leading African countries. Considering African Journals OnLine (AJOL), which promotes the access to scientific literature collections produced in Africa, there are a total of 175 OA journals indexed in the corresponding platform (AJOL, 2014). Comparing the figures and the importance of NRENs for the African continent, it is considered important to analyze the current state of the UbuntuNet Alliance countries, taking a perspective in terms of OA repositories, journals and research data.

Regarding OA repositories, and according to Figure 6, the UbuntuNet Alliance has a total of 58 repositories, being South Africa with 29 and Kenya with 12, the countries which most contribute. The DR of Congo, Madagascar, Malawi and Somalia do not have repositories. Regarding OA journals, considering AJOL and DOAJ data, 82 and 92 journals, respectively, are reported for UbuntuNet Alliance countries. In AJOL, South Africa reports 39 journals, Ethiopia 19 and Kenya 10 journals, being the countries with the highest number of journals. Internationally, in DOAJ, South Africa with 70 indexed journals, Kenya with 7 and Ethiopia with 5, are leading the ranking. The data presented in Figure 6 also show that DR of Congo and Somalia have any contribution in terms of OA repositories and journals. Compared with OA research data in the Registry of Open Access Repositories (ROAR) portal, Africa has only one repository of this nature, the South African Data Archive (SADA) (ROAR, 2014).
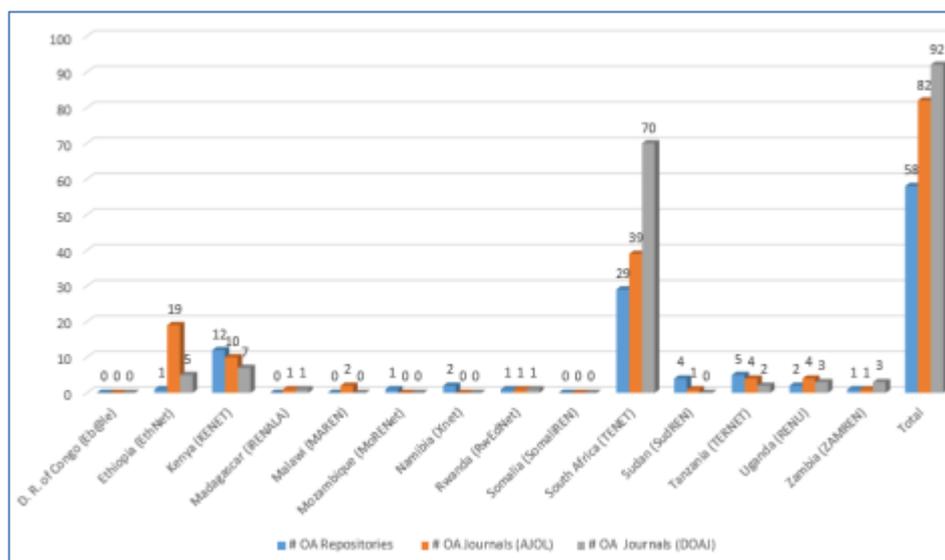
Figure 6: OA repositories and journals – UbuntuNet Alliance Countries

Regarding OA policies and mandates in Africa, the numbers are low, despite the efforts that have been made by various OA promoting bodies. According to the data presented in Table 2, there are only 15 OA mandates in Africa, belonging to the following countries: Algeria, Ghana, Kenya, South Africa and Zimbabwe. South Africa with five mandates related to three institutions and Kenya with five mandates on different institutions, are the leading countries (ROARMAP, 2014). The first higher education institution to adopt an OA mandate was the University of Pretoria in 2009.

Based on the data presented, it is relevant to examine the barriers that impede the implementation of OA initiatives in institutions and research funding bodies. Governments must design appropriate policies for the African context, create programs that promote scientific research and encourage OA. The creation of OA policies and mandates will improve the visibility of the academic community production, so that the continent, instead being a mere consumer of science, can generate and share their production with mechanisms that protect intellectual property.

Country (#)	Type of mandate	Institution(s) or Funder(s)
Algeria (1))	Institutional Mandate	Université M'hamed Bougara - Boumerdes
Kenya (5)	Institutional Mandate	University of Nairobi
	Institutional Mandate	Strathmore University
	Institutional Mandate	Jomo Kenyatta University of Agriculture and Technology
	Institutional Mandate	Kenyatta University
	Thesis Mandate	Pwani University
Nigeria (2)	Institutional Mandate	Covenant University
	Thesis Mandate	Covenant University
South Africa (5)	Thesis Mandate	University of Pretoria
	Institutional Mandate	University of Pretoria
	Thesis Mandate	University of Stellenbosch/Stellenbosch University
	Thesis Mandate	TWAS & OWSD
	Institutional Mandate	University of South Africa (UNISA)
Zimbabwe (2)	Institutional Mandate	Midlands State University
	Institutional Mandate	Bindura University of Science Education

5. Mozambique as a Case Study

Scientific research in Mozambique is still in its infancy. After independence in 1975, the number of trained teachers was insufficient to cover the needs of education and higher education in the country, and not kept pace with population growth. The civil conflict between 1977 and 1992 had a negative influence on the country's growth.

Eduardo Mondlane University (UEM) is the oldest institution of higher education in Mozambique. Founded in 1962 under the name of General University Studies of Mozambique, in 1968 it was renamed to University of Lourenço Marques (ULM) at the time which ascended to the level of University. In 1976, resulting from the reforms that have occurred and as a result of the country's independence, it was renamed to Eduardo Mondlane University. Before independence the training of most of Mozambican citizens was minimal or nil and the UEM curriculum reform that occurred at that time included new curricula and Bachelor's degree courses, to respond quickly to the needs of the labor market (Taimo, 2010).

Currently, Mozambique has near 50 higher education institutions; however, in the world ranking, Mozambican universities are in a low place. UEM is considered the best higher education institution in the country.

The 2014 report of the United Nations Program for Development (UNDP) puts Mozambique in the top 10 countries with the worst Human Development Index (HDI), placing it at 178th place (HDR, 2014). Despite being one of the world's poorest countries, Mozambique is a steady growing country, and the International Monetary Fund (IMF) forecast report of October 2013 predicted 8.3% growth for 2014, performance values that can positively influence the future of the country (IMF, 2014). Currently, economic growth is central in the concerns of the country, as well as training of qualified human resources in order to give answers to the country's fight against absolute poverty.

In this sense, the framework for the development of information society in the country, the ICT policy adopted in 2000, defines main objectives to combat poverty and improve Mozambicans life. Ensure the production and access to knowledge are some of the fundamental aspects of the ICT policy for Mozambique to become a relevant and competitive partner in the global information society.

Regarding the National Research System (NRS), only in 2000 emerged a ministry specifically dedicated to science and technology, now called the Ministry of Science and Technology (MST). In this context, a strategic plan was approved for scientific research in the country to support the development of the NRS. Thus, the NRS is managed by the government through the MST. In 2005 was created the National Research Fund (NRF), the main government agency responsible for funding research in Mozambique. The promotion of programs, projects and actions in the field of scientific research in accordance with the strategic priorities of the country are the main objectives of the NRF. From the NRF budget to support research projects, mainly resulting from external support, a large part of the investment is dedicated to the training of human resources.

Under the Science, Technology and Innovation Strategy of Mozambique (STISM) launched in 2006, to strengthen the National System of Science, Technology and Innovation, began the project for the development of the country NREN, called Mozambique Research and Education Network (MoRENet). The challenges for the effective implementation of MoRENet are enormous taking into account economic, social, technical, technological, and infrastructural aspects. In this context, there is still much to do and a great commitment and

pressure to put MoRENet fully operational. Currently, they are connected to MoRENet some institutions, with 34Mbps and 155Mbps shared Internet via SEACOM, Being Mozambique a large country with 11 provinces, MoRENet is covering two provinces, Maputo city and Maputo. The expansion of Mozambique's NREN is occurring and is expected to integrate over new 40 institutions. The implementation of the national backbone is one of the biggest challenges and connectivity is the only service provided to institutions at this stage.

5.1 Information Access in Mozambique

The lack of budget in research and education institutions to provide international scientific contents in different fields supplied by publishers is a big challenge. The effort of UEM in this context, enabled through the INASP program with whom UEM has worked since 2001, regards the negotiation with international publishers the access to journals and books without charge or at low cost price for Mozambican institutions. With INASP support, Mozambique can access to 90% of the publications paying 10% of their real value.

The acquisition model of scientific literature through commercial publishers in Mozambique is not associated with the academy of sciences of the country. In this sense UEM is the national coordinator of the consortium of universities supported by the INASP project, being responsible for channeling the budget available for paying the access to publications for the institutions of higher education in the country. Currently all Mozambican institutions of high education, public and private, access about 23 000 titles. There are other organizations with programs supporting access to scientific literature from specific areas that Mozambique and other developing countries use, namely HINARI, for biomedical, OARE, in the environmental field and AGORA for agriculture.

5.2 SABER Repository

The OA movement in Mozambique is recent, mostly driven by UEM initiatives that try to give visibility and preserve the academic and scientific production of national institutions. In order to collect, preserve, aggregate and index academic and scientific production of higher education and research institutions in Mozambique, was released in November 2009 the multi-institutional repository SABER. SABER repository is a common platform that integrates six member institutions, including the Judicial Training Center (JTC), the Higher Institute of Science and Technology of Mozambique (HISTM), the Eduardo Mondlane University (UEM), the Pedagogical University, Polytechnic University and the University of St. Thomas of Mozambique (UST). Although the institutions mentioned above are officially integrated, SABER repository maintains scientific and academic documents produced or related with Mozambique from other institutions in the country (SABER, 2009).

Key aspects to the successful implementation of SABER repository are: the contribution in terms of resources from the Ministry of Education, under the background of quality improvement and innovation; Sida/SAREC funding (Greenberg & Muchanga, 2006), the Swedish agency for international development; and the technical collaboration with University of Minho in Portugal, for setting up the repository in the chosen platform DSpace. Although being a multi-institutional repository, SABER is hosted in UEM, which is responsible for the technical support, and the administrative tasks related to the workflow of the deposit of documents. After near five years, SABER stores about three thousand documents, including teaching materials, monographs and dissertations. In more detail, according to Table 3, UEM has 2941 documents deposited, being the institution that contributes with the largest number of documents (97.77%), and the remaining 67 documents

(2.23%) are related to other member institutions. Two institutions, although integrating the repository, have no contribution in terms of contents.

Institution	# Documents
Eduardo Mondlane University	2 941
Higher Institute of Science and Technology of Mozambique	0
Judicial Training Center	20
Pedagogical University	9
Polytechnic University	38
University of St. Thomas of Mozambique	0

Table 3: distribution of contents by institution – SABER Repository

Despite the encouraging number of documents deposited in the repository, when analyzing the number of documents deposited by year (with issue date in 2009, year of release of the repository, until 21 October 2014) as a way of perceiving the real evolution of the repository, it can be seen that the number of contributions in recent years is not very high. The analysis of the metadata related to publication date (see Figure 7), shows that only 667 documents have been deposited in the period of analysis, i.e., with year of publication greater than 2009. The rest of the documents, 2341, represent years prior to 2009, where the older corresponds to 1971. It can also be seen that 2011 is the year with most documents deposited, 233, followed by 2013 with 167 documents.
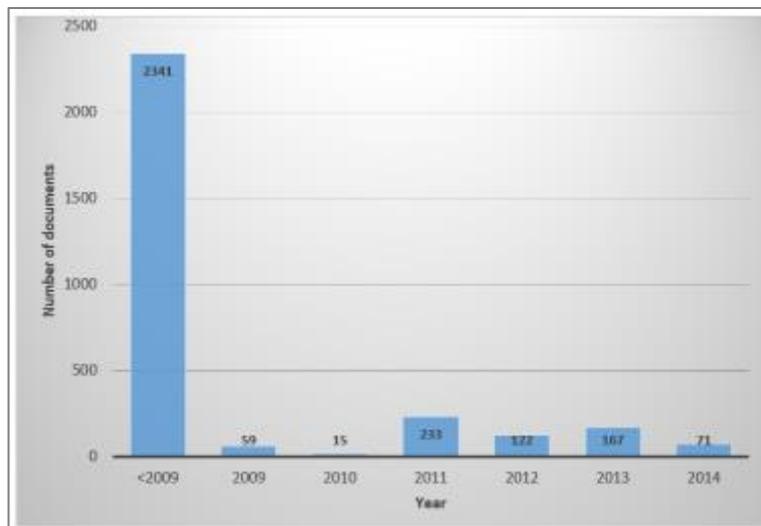

Figure 7: Number of documents per year in SABER repository

5.3 OA Journals

Scientific journals play a significant role in the dissemination of research results and knowledge sharing, especially when it is adopted the "peer review" system, which contributes to improve the quality of publications.

Within OA initiatives, UEM began in 2010 with the process of implementing an OA journal untitled "Revista Científica da UEM" (RC-UEM), whose mission is to present the results of national scientific production, involving UEM academic and research community and other institutions of higher education and research. This biannual journal attempts to cover specific areas in each edition, and the first edition (Number 0) was launched in 2012 with two series:

the "Series of Letters and Social Sciences" with 5 articles and a "Series of Sciences Biomedical and Public Health "with 4 articles. Only in 2014 was launched another series (Number 1), the "Science of Education Series" with 7 papers.

In 2013, despite the RC-UEM call for submission of articles, there was no series released due to the lack of contents to justify its release, as most of the papers submitted were not approved by reviewers.

The main challenges faced by RC-UEM and other endogenous magazines are mainly related to the following aspects: (I) the lack of a national scientific community and the geographic boundaries of existing research lead to a shortage of submissions. Most of Mozambican researchers work in cooperation with international institutions (for instance, involved in their MSc and PhD studies). Even when the students return to Mozambique, it is common to maintain the external link and publish their work abroad. This is one of the biggest barriers to the creation of a scientific community turned inward; (ii) facing the lack of contents, the few endogenous magazines 'die" prematurely, after two or three series; (iii) the reviewing process takes too long to be completed, impairing the process of launching a magazine edition. Moreover, as previously stated, most of the submitted works are not accepted.

5.4 Barriers to OA in Mozambique

The implementation of OA in Mozambique is still a huge challenge. Regarding SABER repository, based on the data presented above, it appears that not all adherent institutions contribute effectively for its growth, providing results of their academic and scientific activities. UEM is the most effective contributor to the initiative of information access free and without restrictions. Regarding the OA journal RC-UEM, the lack of contents has been one of the largest barriers for its launch on a regular basis. In addition, although Mozambican higher education institutions have available electronic access to international magazines, their usage remains below the expectations of the documentation services responsible for the access.

Looking for answers about the barriers that limit the success of OA in Mozambique, according to the information collected from interviews in UEM and MoRENet, through publications devoted to the development of science, technology and innovation in Mozambique, and to the release of OA, the following main barriers were identified:

• socio-cultural: resistance to change and to new behaviors related to Internet use. The academic and scientific community should be informed where and how to find information and develop a culture of sharing and disseminating knowledge;
• economic: many institutions and their communities are not sufficiently equipped with resources that facilitate the access and storage of information;
• technological: the quality of the access to information is precarious due to low speed of network connections and the constant power outage;
• intellectual property protection: to boost the intellectual property system in the country, in 2008 the STM launched the "Intellectual Property Strategy" document approved by the government, as an instrument to serve the interests of the economic, social, technological, scientific and cultural development of the country. Its implementation lacks a legal system and is not yet enshrined the national rights on intellectual property defending authors (Castro, Possas, & Godinho, 2011);
• scientific community: the research level is still low and the few researchers are in most cases bound to international research institutions. Therefore, most of publications go out of the country, which constitutes an obstacle to nationwide scientific production.

In this context, it is necessary to take more information actions, disclosing the existence of specific services that provide access to information, publishing the portals and how to use them. Nationally there are no governmental and institutional policies of OA, therefore it is necessary to raise awareness among government institutions and funding agencies of OA initiatives. The effective implementation of MoRENet can contribute not only to supply high-speed connectivity as well as a valuable partner in providing services for free access to knowledge.

Mozambique, being a Portuguese speaking country, belonging to the CPLP (Community of Portuguese Language Countries), can enjoy the experience and the existing historical relationship with Brazil and Portugal. Both countries have moved forward with new projects in the field of management science. The CONFOA, the Luso-Brazilian conference on OA resulted in a memorandum of understanding between the two countries unifying the Portuguese and Brazilian communities on developing activities of research, service management and OA, to foster and disseminate knowledge by means of OA repositories and journals in research and higher education institutions. In this context Mozambique has been represented in CONFOA by the repository SABER team, who has shown interest to integrate CONFOA initiative. The successful integration not only of Mozambique but of other CPLP countries will largely depend on the sensitivity and determination of the government's policy regarding OA issues.

Given the challenges presented so far, one of the possible solutions to turn the OA movement effective in Mozambique, is the institutionalization of the OA service (repository and journal), supported by government and other entities related with the topic. As an institutionalized service its mission should be regulated by well-defined rules so that it can support other initiatives, such as the implementation of intellectual property protection, and collaborations, namely with service projects provided by MoRENet and similar national, regional and international projects related to higher education and research.

6. Conclusions

Accessing, sharing, and disseminating scientific production are essential factors that contribute to the development of societies in various fields. Given this perspective, this paper addressed the challenges associated to information access on two fronts: the access to scientific literature through commercial publishers and the open access movement, introducing the distinct experiences of two countries: Portugal and Mozambique. The research carried out and presented in this paper intents to demonstrate that NRENs play a key role in supporting and providing information access services dedicated to the academic and scientific community.

Portugal, with the B-on service acquire scientific contents based on a cycle that ensures the provision of comprehensive scientific literature, involving two access regimes "all-for-all" and "some-for-some", and a well-structured negotiation and acquisition process with publishers. Although the contents management software used brings high costs, the demand for international scientific titles has grown since its creation, and the strategy for preserving contents is advantageous, guaranteeing that contents acquired in established contracts are not lost.

Regarding OA, Europe is leader in the number of repositories, OA policies and mandates. National and institutional EU directives have benefited the academic and scientific community considering self-archiving of all scientific output resulting from public funding, including the research data. In terms of institutional initiatives, the promotion of self-archiving of documents produced in institutions included dissertations. RCAAP, in Portugal,

has proved to be a success for institutions that did not possess repositories, which now can have their repositories centrally hosted in RCAAP. Thanks to existing mandates the number of documents from the national repository exceeds 100 000.

In Africa there is still much to do and the challenges for promoting the growth and access to scientific literature are enormous. Most NRENs are still in its implementation phase, as MoRENet in Mozambique. The deployment of MoRENet could result in an increased collaboration on OA initiatives developed by UEM, allowing the expansion of the repository SABER and of the scientific journal RC-UEM. Considering the barriers presented in the context of OA in Mozambique, it is important to gain political support to the OA initiative launched in 2009, with the creation of SABER, and to define policies and mandates. Another aspect that deserves special attention is the intellectual property protection. The strategy launched by the MST exists but remains to be implemented, being one of the barriers to the growth of the RC-UEM journal and SABER repository.

The access to international scientific contents in Africa is still sustained by international organizations and projects that negotiate with the member countries or institutions the access without charge. In the case of Mozambique, UEM coordinates this collaborative project.

These results stress the relevance of cooperation to foster knowledge in developing countries, by learning from success cases and sharing experiences, and to obtain technical and funding support in an initial deployment phase. The development of NRENs is a key aspect to provide a consistent technological and communication platform engaging the research and education community in the common objective of promoting knowledge growth.

Acknowledgments

References

Alozie, N. O., Akpan-Obong, P., and Foster, W. A. (2011, September).'Sizing up information and communication technologies as agents of political development in sub-Saharan Africa.' *Telecommunications Policy, 35*.

Castro, C. A., Possas, C., and Godinho, M. M. (2011). Propriedade Intelectual nos Países de Língua Portuguesa: temas e perspectivas. (e-papers, Ed.)

Portico (2005). Portico: http://www.portico.org/digital-preservation/ [accessed October 2014]

AAU. (1967). The Association of African Universities: http://www.aau.org/page/about-aau

Africa-Eu. (2009). Africa-EU Cooperation Forum on ICT: http://www.erafrica.eu/fr/323.php

AJOL. (2014). African Journals Online: http://www.ajol.info/ [accessed October 2014].

AU. (2014). African Union: http://ie.au.int/fr/sites/default/files/Press%20Release%20-EN_8.pdf [accessed October 2014].

BOAI*.** **(2001). Budapest open access initiative*: **www.budapestopenaccessinitiative.org**

***B-on*.** **(2004).** *Biblioteca do Conhecimento online*: **http://www.b-on.pt/index.php?lang=en**

EuroCRIS. (2014). Curent Research Information Systems:http://www.eurocris.org/

EC. (2007). European Commission: http://ec.europa.eu/research/fp7/

EC. (2013). European Commission:

http://ec.europa.eu/research/participants/data/ref/h2020/mga/gga/h2020-mga-gga-multi_en.pdf

FCCN. (2013). Fundação para a Ciência e a Tecnologia-FCCN: http://www.fccn.pt/pt/

Greenberg, A., & Muchanga, A. (2006). *Evaluation of Sida Information and Communications Technologies.* Sida. http://www.oecd.org/derec/sweden/37310728.pdf

HDR. (2014). *Human Development Report*. http://hdr.undp.org/sites/default/files/hdr14-report-en-1.pdf

IMF.(2014, May). International Monetary Fund: http://www.imf.org/external/pubs/ft/scr/2014/cr14148.pdf

IWS. (2014). *Internet World Stats*: http://www.internetworldstats.com/stats_.htm [accessed October 2014]

Mulhanga, M. M., Lima, S. R., Massingue, V., & Ferreira, J. N. (2014).' Expanding Scientific Knowledge Frontiers: Open Repositories in Developing Countries Supported by NRENs'. *World Conference on Information Systems and Technologies (WorldCIST 14).* Springer.

OECD. (2004). The Organisation for Economic Co-operation and Development (OECD): http://www.oecd.org

openarchives. (1999). http://www.openarchives.org

OpenDOAR. (2014). *Directory of Open Access Repositories*: http://www.opendoar.org

OST. (2013). USA - Office of Science and Technology *Policy*:

http://www.whitehouse.gov/blog/2013/02/22/expanding-public-access-results-federally-funded-research

ROAR. (2014). *Registry of Open Access Repositories*: http://roar.eprints.org/

ROARMAP. (2014). *Registry of Open Access Repositories Mandatory Archiving Policies*: http://roarmap.eprints.org/ [accessed October 2014].

SABER. (2009). SABER Repository: www.saber.ac.mz [accessed October 2014].

SARUA. (2005). Southern African Regional Universities Association: http://www.sarua.org

Taimo, J. U. (2010). *Ensino Superior em Moçambique: História, Política e Gestão.* Ph.D Thesis, Universidade Metodista de Piracicaba.

https://www.unimep.br/phpg/bibdig/pdfs/2006/USQUKAQXVOQD.pdf

UbuntuNet.(2013). Ubuntunet Alliance Annual Report:

http://www.ubuntunet.net/sites/default/files/annual-report-2013.pdf

Waete, R., Moura, M. A., & Mangue, M. (2012). 'Acesso Livre à Informação Científica em Países em Desenvolvimento: O Caso dos REPOSITÓRIOS "SABER" (Moçambique) e Digital da UFMG (BRASIL).'*Encontros Bibli: revista eletrônica de biblioteconomia e ciência da informação,* v. 17, pp.195-210.

Willinsky, J. (2005). *The Access Principle: The Case for Open Access to Research and Scholarship.* MIT Press.

Xia, J., et al (2012). *A review of open access self-archiving mandate policies*. **(P. L. Academy,**

Ed.) *vol. 12(1)*, pp. . 85-102.

Biographies

Marangaze Munhepe Mulhanga is a PhD Student at the Department of Informatics, University of Minho, Portugal. In 2007 completed 5 year degree in Systems and Informatics Engineering and received her MSc degree in Computer Networks and Services Engineering in 2010, from the same university. From 2006 to 2008 she worked as an ICT technical support (data and voice) in the department of network and telecommunications in a Portuguese bank (i.e. Finibanco). Her research interests include national research and education networks, next generation networks, ICT policies and regulatory aspects of telecommunication, and science and innovation management.

Solange Rito Lima graduated in 1992, received her MSc and PhD degrees in Computer Communications from the University of Minho, Braga, Portugal, in 1997 and 2006, respectively. She is currently an Assistant Professor in Computer Communications at the same University. Her research interests include multiservice networks and protocols, QoS, traffic control and monitoring issues in IP networks.

Venâncio Massingue, is a Professor at the Department of Mathematics and Informatics at Eduardo Mondlane University (EMU), Mozambique. Graduated in 1992 in electro technical engineering at EMU, he holds a Doctoral degree in ICT from the Technology University of Delft (TUDelft), Netherlands. From 1996 to 1998 he masterminded the development of the Mozambique ICT Policy and ICT Strategy that were later approved by the Cabinet. From 1997 to 2005 he was Vice-Rector at UEM and from 2005 to 2012 he was Minister of Science and Technology of Mozambique. In 1998, he received the UNESCO Albert Einstein Medal for Science and Technology.

João Nuno Ferreira completed in 1991 the 5 year degree in Systems and Informatics Engineering at University of Minho, Portugal. In 1993 completed the Data Communications, Networks and Distributed Systems MSc at University College London. In 2003 completed an MBA at Porto Business School (UPBS).Between 1991 and 1993 worked as an ICT specialist at Department of Informatics, at University of Minho. Between 1997 and 1998 was also teacher at Atlântica University, Portugal. On October 1993 joined FCCN, as Technical Manager. In this period was responsible for a wide range of networking services and national and international projects. Recently the main focus of activity has been the connectivity services and projects of *Rede Ciência, Tecnologia e Sociedade* (RCTS), namely the implementation of a fiber optics network. Additionally has developed this platform for the advancement of Science and R&D in the context of the European research networks and the

GÉANT network. On December 10th 2013, was appointed Member of the Board at *Fundação para a Ciência e a Tecnologia* IP, the science funding agency. He's responsible for all ICT related activities. On January 11th 2013, was appointed President of the Board of Directors at *Fundação para a Computação Científica Nacional* (FCCN).