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# Open Science: Related Policies, Good Practices and Lessons for Latin America

José Luis Solleiro[*1] • Rosario Castañón[1]
Eduardo Galicia[1]

[1]*Instituto de Ciencias Aplicadas y Tecnología, Universidad Nacional Autónoma de México, Mexico City, Mexico*

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**Abstract:** This study aims to analyze the state of the art of open science (OS) related public policies adopted in 14 countries, to propose good practices for Latin America. With a qualitative approach, all pertinent policy documents were collected through a documentary study, and 12 in-depth interviews were conducted with key public and academic actors, all experienced in designing and implementing OS public policies. The main findings include: the importance of having explicit regulatory instruments; commitment to open access to publicly funded scientific production; attention to human capital formation; adoption of FAIR principles; and the incipient promotion of inclusion. The insights gained from this study can provide valuable lessons for developing OS in Latin America.

*Keywords:* **Open science, open access, public policy.**

*Corresponding author.
*E-mail address:* solleiro@unam.mx (J.L. Solleiro).
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## 1. Introduction

Understood as a new model of research based on collaborative work, OS involves a change in the way science is done aimed at opening up information on all phases of research (Fressoli & Arza, 2018; Abadal, 2021; Armeni et al., 2021), from methods, protocols, code and software, data collection and data analysis, to peer review processes and final publication (Pilar Rico-Castro, 2023). According to the OECD (2015), both digitization and adoption of Information and Communication Technologies (ICT) facilitate the opening of science by constituting tools and digital spaces for collaboration and access to knowledge, in addition to allowing the collection, processing and analysis of massive amounts of data, which may serve as a basis for research.

More recently, UNESCO (2021) conceives OS as a complex combination of scientific movements and practices that aim to make "multilingual scientific knowledge openly available and accessible to all, as well as reusable by all" (UNESCO, 2021). With this, it is intended to transcend towards diverse societal agents beyond the traditional scientific community, with special emphasis on citizenship, vulnerable and historically marginalized social sectors, and Indigenous Peoples.

In order to achieve its goals, open science must adhere to a series of values (quality and integrity; collective benefit; equity and fairness; diversity and inclusiveness) and principles (transparency and reproducibility; equality of opportunities; responsibility, respect and accountability; collaboration, participation and inclusion; flexibility and sustainability). To improve the attachment of scientific communities to these principles, public policy plays a fundamental role, as it facilitates the promotion, development and consolidation of OS (Abadal & i de Ferrer, 2021) through the exercise of the public budget allocated to support research, existing legislations, standards and norms (Moradi & Abdi, 2023).

Understood as a direct intervention of public power that seeks to influence "the elements of the system of scientific production, technological development and business innovation, [modifying] the conditions under which funders, producers and evaluators of scientific and technological knowledge carry out their activity" (Pilar Rico-Castro, 2023), public policy for the promotion of open science has favored the openness of science in the countries of the Global North through guidelines, regulations and laws that, altogether, reflect a strong commitment to open access to publicly funded scientific production. Slovenia's National Strategy of Open Access, Spain's National Open Science Strategy, France's National Plan for Open Science, the new guidance from the US White House Office of Science and Technology Policy, and Plan S in Europe are good examples.

The Global South, on the other hand, has important experiences in the design and implementation of OS policies. About nine African countries (Botswana, Ivory Coast, Uganda, Tanzania, Somalia, Kenya, Nigeria, Mozambique, and Namibia) are developing OS public policies based on the recommendation issued by UNESCO (2023), while South Africa is doing the same in collaborative dialogue with the European Union. Ethiopia has a national open access policy since 2019 (Chiware & Skelly, 2022).

In Asia, the cases of India and Malaysia stand out, with the National Data Sharing and Accessibility Policy of 2012, and the recent implementation of the Malaysia Open Science Platform (MOSP), respectively. As for China, the open access and open data practice dates back to 2001, with the Scientific Data Sharing Project (China-SDSP), and the National Medium and Long-Term Science and Technology Development Plan (2006-2020), which emphasizes "the establishment of an open mechanism for sharing scientific data and resources" (Zhang et al., 2023).

Latin America has a vast experience with open access due to the institutional policies of the main universities in the region. About 95% of open access journals in Latin America are Diamond Open Access, so publications are made immediately accessible without charge to readers or authors, which represents a great advantage over regions such as Europe and Africa, where the percentage is slightly higher than 50% (UNESCO, 2023).

Some countries, such as Venezuela and Colombia, are currently developing a national OS policy, while the "National Law for the Creation of Open Access Institutional Digital Repositories" has operated in Argentina since 2013, and the "National Systems Program for Large Instruments, Facilities and Databases", on the other hand, seeks to promote the efficient and collaborative use of equipment acquired with public funds since 2008. There is also *LA Referencia*, a network of open access repositories that seeks to give visibility to the scientific production of higher education and research institutions in Latin America, promoting open and free access to the full text, with special emphasis on the results of research financed with public funds.

Nevertheless, Latin America faces specific challenges to trigger the development of Open Science, including low levels of public investment in R&D and education, and a lower number of researchers per million inhabitants compared to European and Global South countries;

all of which is reflected in a lower accumulated scientific (open access) production in comparison with other countries and regions, despite the foresaid advantage of the diamond model. In addition, there is a lack of a regional scientific and technological set of actions to promote OS practices (Ramírez & Samoilovich, 2021).

The objective of this study is to identify policies and good practices that help in the design of open science strategies in Latin American countries, as well as regional cooperation initiatives, based on a review of the state of the art in OS and the analysis of documents related to the public policy adopted in 14 selected countries. The documentary analysis was complemented by a series of in-depth interviews with specialists in the field. We consider that the insights resulting from this study can contribute to the development of policies for the promotion of OS if they are considered by policy makers in the region.

### *1.1 OS nature and recent development*

The phenomenon of Open Science arises from the confluence of historical, technological, and societal factors. Abadal Falgueras and Anglada Ferrer (2020) consider that the origin of OS is related to the evolution from a traditional way of doing science towards a more accessible, transparent, and interdisciplinary one. The term "open science" became popular from the 2010s onwards, especially after the European Commission promoted the document "Digital Science in Horizon 2020" in 2013.

Nowadays, it is recognized that the development of Information and Communication Technologies (ICT) has been a determining factor in the exchange of information at a global scale and that facilitates communication among scientists and between these and other societal actors. On the other hand, the need for verification and reproducibility of scientific results has motivated initiatives to promote transparency in methodologies and data to promote replicability. Another factor driving the global movement towards open science has been the complexity (and cost) of research, which imposes the need to intensify collaboration between scientists from different disciplines and different institutions and countries. Finally, society's growing demand for public access to scientific information on issues such as health, nutrition, and the environment, which require international collaboration, has emerged with great force.

Based on its rapid evolution, OS is considered a new paradigm in scientific endeavor, since it implies an openness in the stages of scientific research (data collection and data analysis, peer review, and final publication) with the dual purpose that, through open access to methodologies, data, and research results, it positively impacts on the development of science and scientific collaboration, while serving the common good, addressing specific problems of society, and generating knowledge-intensive solutions.

To this end, UNESCO (2021) has issued a series of values and guiding principles in its recommendation on open science, highlighting the relevance of criteria such as inclusion, diversity, and equity, to ensure greater and better representation of vulnerable and marginalized groups in both the definition and implementation of scientific projects. It is also recognized that OS can have positive impacts on business and innovation processes, as individuals and companies may reuse data and research results (OECD, 2015; Dai et al., 2018).

In accordance with scientific communities, OS should be compatible: 1) with traditional scientific values proposed by Merton (1968): universalism, understood as science for everyone; communality, as scientific products are in the public domain; disinterestedness, for science is a public good; and organized skepticism, for science is critical, objective, and analytical; and 2) with those values emerged from the Budapest Open Access Initiative and the Bethesda Statement on Open Access Publishing; the FAIR Principles, in order to facilitate the use of research data by making them Findable, Accessible, Interoperable, and Reusable (Wilkinson et al., 2016); and the TRUST Principles, which aim for digital repositories to properly manage research data, with Transparency (establishing terms of use and digital data retention times), Responsibility (ethical standards and norms), User focus, Sustainability (efficient management for data sharing), and Technology (suitability of technical capacities) (Lin et al., 2020).

On the other hand, efforts undertaken in developing an appropriate analytical taxonomy for OS reflect a more complex conception than its mere reduction to Open Access. The most accepted taxonomy is that of Pontika et al. (2015), which considers nine dimensions: 1) Open Access; 2) Open Data, where Open Government Data (OGD) can be included; 3) Open Reproducible Research; 4) Open Science Definition; 5) Open Science Evaluation; 6) Guidelines; 7) Policies; 8) Projects; and 9) Tools. Other contributions, such as that of Silveira et al. (2023), take up these nine dimensions and add others, such as open innovation and citizen science. The latter draws on transdisciplinary research methods to democratize scientific processes by integrating members of the citizenry (students, science workers, writers, or educators), to generate a collective

intelligence for the resolution of specific social problems (Fressoli & De Filippo, 2021; UNESCO, 2021; Witt & Silva, 2022).

### 1.2 OS: key actors and the role of policy makers

In accordance with Abadal (2021), the main actors in the open science ecosystem are located in the Academy, among which researchers, librarians, and university managers stand out, followed by editors and funders. In a broader conception, some studies (OECD, 2015; Dai et al., 2018; UNESCO, 2021) often implicitly consider the actors of the quadruple helix (public authorities, industry, academia, and citizens). Other authors, such as, identify key actors in specific dimensions of the OS (politicians, data collectors and data processors, infrastructure suppliers, private companies, intermediaries, citizens, and regulators, in the case of OGD).

In the present study, based on our objective, we focus on Academia and public authorities as key actors of the OS. In general, researchers and the scientific community can individually adopt OS practices, such as the sharing of research results before the review process (in preprint format), or the collaborative discussion online of work already published (Pubpeer, for instance, is a digital platform that allows community interaction in peer review after publication). Policy makers, on the other hand, are to strengthen the benefits of OS by providing adequate data management models, interoperable standards, data exchange agreements in which society, the public and private sector participate, incentives for researchers, sustainable infrastructure, human and institutional capacities, and mechanisms for access to information (OECD, 2020).

In addition, UNESCO (2023) considers that policy makers must attend, in coordination with the stakeholders, the obstacles faced by the OS for its generalized implementation, such as the lack of infrastructure and adequate resources, the lack of incentives, and resistance to cultural change. In sum, the role of policy makers is to create a conducive environment for the development of OS, which implies "identifying the different needs and priorities, and working in collaboration in the development of policies and regulations that support Open Science" (UNESCO, 2023).

In this sense, Vicente-Saez et al. (2020) propose a new model for the governance of Open Science and Innovation (Figure 1). In their model, the principles of openness (transparency and accessibility to scientific products, authorization and participation in scientific production) stimulate OS practices (open data sharing, open access

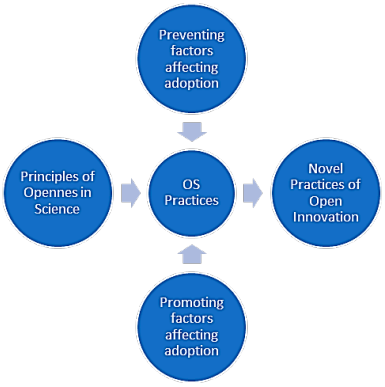



Figure 1. Conceptual model for the governance of OS. Source: Vicente-Saez et al.(2020).

publishing, open protocols, open repositories, open collaborative tools, co-creation platforms, open physical labs, etc.). Midway, policy makers must design mechanisms and roadmaps to strengthen those promoting factors affecting the adoption of OS practices (policies, open research field traditions, open learning culture, and ideology of research team leaders), and so reducing the impact of preventing factors affecting adoption (intellectual property laws, lack of incentives in career development, lack of OS standards, misconceptions of OS, and confusing publishing practices). As a result, the widespread adoption of OS practices can trigger novel practices of open innovation.

### 1.3 The influence of public policy on the development of OS

The recommendation issued by UNESCO (2021) urges member states to eliminate obstacles to the development of OS, based on their own political, administrative, and legal frameworks. In consideration of Albornoz et al. (2018), public policies are not neutral, but reflect the values, beliefs, and conceptions of policy makers and stakeholders involved in their design. Albornoz et al. (2018) find that public policy tends to address OS through: 1) Practices of Open Access (mainly in Latin America and Africa) and Open Data (mainly in Europe) as key facilitators of OS; 2) Standards that improve the quality, integrity, and citability of scientific papers, by implementing impact metrics and indicators; 3) Development of research infrastructure and data repositories; 4) Usefulness of OS in holding competitive advantages in science and technology by the Global North, or keeping global relevance in scientific matters (the case of Africa); 5) Recognition of the private sector as a funding agent that complements the enormous expense of governments in OS; 6) Recognition

of the academic community (researchers, scientists, students, research organizations, libraries, etc.) as the main beneficiaries of OS, followed to a lesser extent by citizens; 7) The difficulty in training and integrating citizenship into OS projects; 8) Recognition of OS as a facilitator and promoter of socioeconomic growth to achieve comparative advantages in global competition; 9) Recognition of OS as a collaborative mechanism to address global challenges; and 10) Recognition of OS as a model to overcome subscription-based magazines.

In addition, Manco (2022) considers that OS related public policies are not free from conflict, for they are generally formulated in a general way with general principles that may not reflect a country's reality nor the complexity of its societal issues. A contradiction identified by Fressoli and Arza (2018) is the fact that public policy guidelines promote openness as well as promote intellectual property policies (especially patents), which might generate tensions that are difficult for scientists to resolve (Fressoli & Arza, 2018). In this way, the authors propose a widespread adoption of open licenses in research activities.

In order to stimulate a widespread adoption of OS practices, Ramírez and Samoilovich (2021) propose three specific actions: 1) To elaborate proper diagnoses; 2) To rely on international collaboration as a way of developing OS; and 3) To promote collaboration between work teams and research networks in developing OS initiatives. In addition, Chiware and Skelly (2022) argue that designing proper public policies requires policy makers to consider that, rather than technical and infrastructure matters, Open Science is a complex phenomenon that implies a cultural change in both doing and understanding science, integrated by tools and mechanisms necessary for the resolution of broad societal challenges.

However, many OS public policies focus on promoting open access rather than any other taxonomical element. Abadal and i de Ferrer, (2021), for instance, find that most of the European public policies give a greater prominence to open access and the promotion of FAIR principles. In addition, the authors argue that the models for the evaluation of science "constitute the main challenge that prevents rapid progress [towards a widespread adoption of OS practices], since it will be difficult to change the habits of researchers without modifications in the system of incentives and assessment" (Abadal and i de Ferrer, (2021). A similar scenario is found in other regions:

1. Latin America's path on the creation of projects and policies from which to strengthen open access to scientific production financed with public funds is over ten years old (Donofrio & Filippo, 2019; Babini & Rovelli, 2020). However, results on the matter are still limited, and only some countries (i.e., Argentina, Colombia, and Mexico) have established public policy guidelines in this regard, while others have limited themselves to promoting institutional repositories.
2. Some Asian countries have strong open access policies (i.e., China and India), while Southeast Asia and the Pacific lack a common understanding of OS, its values, and principles, as well as having poor communication between stakeholders, all of which hinders the design and implementation of OS public policies. In this case, Malaysia is an exception that stands out for its good communication with Academia, the design of guidelines, and the proper addressing of citizen science (Camkin et al., 2022).
3. In the case of Africa, some studies (Chigwada, 2022; Chiware & Skelly, 2022; UNESCO, 2023) provide evidence that the development of OS public policy is at a very early stage, both in strengthening open access and in opening up government data. It is argued that policy design might be a mere reproduction of existing policies in Western countries without proper contextualization for African societies, where structural weaknesses such as lack of infrastructure (electricity, internet connectivity, repositories, etc.) and qualified personnel persist.

Moradi and Abdi (2023) find that very few policies address open school communication, while data sharing policies often omit specific guidance on the procedures needed to ensure availability and reusability.

At a global scale, OS policies have been promoted both by national governments, through their respective ministries of science and technology, and by multilateral organizations such as the G7, UNESCO, and OECD. In Europe, the development of OS is closely linked to the European Commission (Abadal Falgueras & Anglada Ferrer, 2020; Manco, 2022), while in Latin America, open infrastructures and the development of OS public policies have been carried out by national ministries of science and technology.

Although no relevant efforts have yet been identified in the development and implementation of regional OS policies, Latin America's infrastructure for open access stands out. The *Red Federada de Repositorios Institucionales de Publicaciones Científicas*, also known as *LA Referencia*, supports national OS strategies at the country level by adopting interoperability standards that allow visibility to the scientific production of the region (Babini & Rovelli, 2020). Based on a series of technical and organizational

agreements between national public science and technology institutions, *LA Referencia* is constituted by nodes distributed across eleven countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Mexico, Panama, Peru, and Uruguay, plus one in Spain), as well as the signing of a cooperation agreement in 2019 between the *Fundação para a Ciência e a Tecnologia* (FCT) of Portugal, in order to facilitate the transfer and collaborative development of the software necessary for the operation of the federated network of repositories.

## *2. Materials and Methods*

In this study, a qualitative methodological strategy was implemented, consisting of an extensive documentary review of specialized sources to identify relevant OS public policies and related documents and the conduct of twelve in-depth interviews with key actors in the public and academic sectors, all of whom have extensive experience in the design, implementation, and/or analysis of OS public policies.

For the documentary review, a search was conducted in the main databases (see Table 1), considering the following exclusion criteria: 1) an analysis period of 20 years (2003-2023) in order to obtain relevant and recent information; 2) documents whose languages were not English, Spanish, or Portuguese were discarded; 3) official documents, books, book chapters and articles were considered; and 4) only those bibliographic databases were considered that allowed the search parameters to be specified and, simultaneously, the results to be exported in .csv or .txt format, in order to compare results and eliminate duplicates.

The search strategy adopted made it possible to obtain relevant documents. The analysis of the documents made it possible to identify their central elements, the actors involved, and the instruments and projects derived from OS public policies. Table 1 shows the total number of documents obtained (in bold), while the total number of documents in italics shows the documents that were analyzed based on the objective of the study.

To conduct the interviews with experts, a script was designed consisting of a series of questions aimed at identifying the characteristics, challenges, opportunities, and institutional framework of national and regional policies, instruments, and projects of OS, as well as possible success stories identified by the actors interviewed. Each interview (Table 2) was conducted remotely by videoconference with an average duration of 60 minutes.

## 3. Findings: trends in OS public policy

All documents retrieved as of April 2024 are shown in Table 3. Based on the analysis carried out, a marked interest in promoting open access and open data is identified, recognizing the crucial role of information and communication technologies (ICT) in the construction of research infrastructures and the handling of massive amounts of data. Open data refers, in all documents, to non-sensitive data generated or stored by the State, excluding data that may compromise national security or that of third parties. In some cases (China) it is established that, for the use of scientific data, research institutes, Higher Education Institutions (HEIs), and the companies involved, must provide them free of charge when dealing with issues related to national security and defense, environmental protection, government planning, and scientific research of public interest. For business activities, the parties must agree on a contract for the use of this data.

European policies often refer, for certain cases (e.g., rules and regulations for funding agencies, public research organizations, and co-funded scientific journals), to common European frameworks (in this case, best practices in the European Research Area). The Association of Swedish Higher Education Institutions, for example, participates in the European University Association (EUA) and, in this regard, its National Roadmap for Open Science seeks to establish the transition to the OS system by 2026 in line with the EUA Agenda for Open Science 2025.

On the other hand, European policies establish that the development of its digital infrastructures for data exchange and open access should be in line with the European Open Science Cloud.

Table 1. Information search strategy.

| Search strategy | Database | | | | | | Total | Total (without duplicates) |
|---|---|---|---|---|---|---|---|---|
| | Web of Science | Scopus | Proquest Academic Complete | Science Direct | OECD Repository | UNESCO Repository (UNESDOC) | | |
| "Open Science" (Title) AND "Policy" (Abstract) | 75 | 203 | 24 | 23 | 5 | 5 | 335 | **205** |
| | *10* | *18* | *1* | *1* | *4* | *5* | *39* | **35** |

Table 2. List of interviewed stakeholders.

| Position of interviewee | Institution | Country | Date |
|---|---|---|---|
| Former Minister of Science and Technology | Ministerio de Ciencia, Tecnología e Innovación Productiva | Argentina | 15-jan-24 |
| Former Coordinator | Red Iberoamericana de Indicadores de Ciencia y Tecnología (RICYT) | Argentina | 17-jan-24 |
| President | LA Referencia | Costa Rica | 25-jan-24 |
| Advisor | Consorci de Serveis Universitaris de Catalunya | Spain | 22-dec-23 |
| Principal Investigator | Proyecto “Ciencia Abierta en España” | Spain | 22-dec-23 |
| Vice President | Asociación BioEuroLatina | Spain | 12-jan-24 |
| Advisor | Malaysia Open Science Platform | Malaysia | 21-nov-23 |
| Analyst | Academy of Sciences Malaysia | Malaysia | 21-nov-23 |
| Advisor | Secretaría Nacional de Ciencia, Tecnología e Innovación | Panama | 14-nov-23 |
| Former Secretary of State | Ministerio de Ciencia, Tecnología y Educación Superior | Portugal | 07-feb-24 |
| Researcher | Universidade de Coimbra | Portugal | 28-dec-23 |
| Vice Rector for Culture and Open Science | Universidade de Coimbra | Portugal | 26-jan-24 |

Table 3. Retrieved OS public policy documents.

| Country | Executing Organization and/or Institution | Document |
|---|---|---|
| Argentina | Ministerio de Ciencia, Tecnología e Innovación Productiva | Ley Nacional de Creación de Repositorios Digitales Institucionales de Acceso Abierto |
| | | Programa de Sistemas Nacionales de Grandes Instrumentos, Facilidades y Bases de Datos |
| | | Diagnóstico y lineamientos para una política de Ciencia Abierta en Argentina |
| Colombia | Ministerio de Ciencia, Tecnología e Innovación | Política Nacional de Ciencia Abierta |
| United States | Office of Science and Technology Policy | Memorandum: Ensuring Free, Immediate and Equitable Access to Federally Funded Research |
| | U.S. House and Senate | Fair Access to Science and Technology Research Act |
| India | Ministry of Science and Technology | National Data Sharing and Accessibility Policy (NDSAP) |
| | | Science, Technology and Innovation Policy (STIP) |
| | | Scientific Research Infrastructure Sharing Maintenance and Networks (SRIMAN) Guidelines |
| | | Social Scientific Responsibility (SSR) Guidelines |
| Malaysia | Ministry of Science, Technology and Innovation (MOSTI) | National Policy of Science, Technology and Innovation (NPSTI) 2021-2030. |
| | Academy of Sciences Malaysia | Guidelines on Open Science (OS) in Public Funded Research |
| | Khazanah Research Institute | Open Government in Malaysia: Landscape, Challenges and Aspirations |

Table 3. Continued.

| Country | Executing Organization and/or Institution | Document |
|---|---|---|
| China | National People´s Congress Standing Committee (NPCSC) | Science and Technology Progress Law of the People's Republic of China |
| | General Office of the State Council | Measures for the Management of Scientific Data |
| Spain | Ministerio de Ciencia e Innovación | Estrategia Nacional de Ciencia Abierta (ENCA) |
| | | Plan Estatal de Investigación Científica, Técnica y de Innovación (PEICTI) 2021-2023 |
| | | Estrategia Española de Ciencia, Tecnología e Innovación |
| | | Ciencia abierta en España 2023: informe de situación y análisis de la percepción |
| | Jefatura del Estado | Ley 17/2022 de Ciencia, Tecnología e Innovación |
| | | Ley Orgánica del Sistema Universitario |
| | Consejo Superior de Investigaciones Científicas (CSIC), Instituto de Salud Carlos III (ISCIII), y Fundación Española para la Ciencia y la Tecnología (FCYT) | Resultados del proyecto *Infraestructuras y Estándares para la Ciencia en Abierto* (INEOS) y manual de buenas prácticas para la gestión de repositorios institucionales, sistemas de gestión curricular y revistas científicas |
| Portugal | Ministério da Ciência, Tecnologia e Ensino Superior | Política Nacional de Ciência Aberta |
| | | Decreto-Lei n.º 63/2019 |
| | Fundação para a Ciência e a Tecnologia | Política de Acesso Aberto |
| | | Fórum de Gestão de Dados de Investigação (GDI) |
| France | Ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation (MESRI) | Second French Plan for Open Science |
| Sweden | National Library of Sweden | National guidelines for open science |
| | Association of Swedish Higher Education Institutions | National Roadmap for Open Science |
| Slovenia | Government of the Republic of Slovenia | Action Plan for Open Science |
| | | Decree on the implementation of scientific research work in accordance with the principles of open science |
| Mauritius | Ministry of Information Technology, Communication and Innovation | Open Data Policy |
| South Africa | Department of Science and Innovation | White Paper on Science, Technology and Innovation |
| | Department of Science and Innovation (DSI) | Draft national open science policy |
| Uganda | Ministry of Information, Communications Technology and National Guidance (MoICT) | Draft Open Data Policy |

### 3.1 The OS approach

Even though most of the documents analyzed recover the vision of OS as a set of collaborative scientific practices and its role in social welfare, some countries (China, for example) express the usefulness of OS to defend their global position in scientific and technological initiatives. Other policies, such as those of Sweden, understand OS as a complex phenomenon, in line with the fulfillment of the sustainable development goals proposed by the United Nations.

The strong focus on open access and open data in public policy, while fundamental, can also be limited due to the uneven development of the various constituent elements of OS. The interviewed actors belonging to the public sector mentioned that, although not fully achieved, public policy must overcome the conception of OS as open access and embark on a path of self-criticism to effectively address other dimensions, such as citizen science, open learning resources, and dialogue with other knowledge systems (especially those of native peoples). For the moment, few countries such as Colombia, Sweden (National Guidelines for Open Science), and Slovenia (Action Plan for Open Science) directly consider a type of promotion of citizen science, while Argentina is doing the same (Diagnosis and Guidelines for an Open Science Policy in Argentina) in the run-up to the design of its national public policy.

On the other hand, most countries stress the need for research data to adhere to FAIR principles, while only Europeans mention that their digital repositories should be of the TRUST type. The interest in open data is reflected not only in public policy aimed at the academic sector but also in government ministries. Such is the case of the open government data (OGD) public policies of India (NDSAP), Uganda, and Mauritius, which recognize the value of OGD for policy formulation, social value creation, and informed decision making in the private sector and civil society. Other countries, such as Malaysia or South Africa, have OGD strategies, without an overall public policy framework.

### 3.2 Coordination among stakeholders

The target audience of OS public policies has been researchers, followed by scientific funders, librarians, publishers and ministries of science and technology. Table 4 shows the main strategies designed by the different countries for the coordination of these actors. It is noteworthy that all the selected countries have established the deposit in digital repositories of the data and research results of those projects financed (or co-financed by at least 50% in the case of Slovenia) with public funds, for which the use of open licenses such as Creative Commons is usually established.

On the other hand, almost all countries provide for the creation of at least one body for evaluation and follow-up of the OGD policy, which usually has the function of leading the implementation of the policy among the target audience, monitoring the effectiveness of the policy, providing insights on OGD trends in the country, and evaluating the degree of openness of the national scientific output. The only exception is Uganda, whose OGD policy focuses only on public entities using non-proprietary formats for sharing their data (produced or stored by them).

Only in the policies of Slovenia and France is there an interest in supporting an open access publishing model that does not depend on charges to readers (subscription) or authors (APC), but while Slovenia directly proposes the promotion of a diamond-type model, France proposes a transition to the "Subscribe to Open" model, which consists of converting subscription journals into open access journals through the acquisition of subscriptions by existing libraries.

Regarding the promotion of OS, the central approach has been through: 1) A public science communication strategy aimed at citizens, as well as the consideration of integrating an OS training agenda into the educational system (Colombia); and 2) The design and implementation of awards that strengthen the prestige and effectiveness of OS (Spain), as well as awards that highlight the exemplary work of projects involved in the use and reuse of research data, and in the development of open source research software (France).

### 3.3 The OS approach

The consideration of specific inclusion, diversity, and equity criteria is an element that is usually addressed in a general way, recognizing the importance of inclusion in the OS, but without designing specific strategies to strengthen it. In other cases, this is an issue that is often ignored. Table 5 lists the inclusion criteria adopted by eight of the 14 selected countries, where the following stand out:

1. General criteria (Argentina, Colombia and China).
2. Measures in favor of multilingualism (Portugal and France, except for the reduction of publication bias in specific languages such as English).
3. Specific measures, including: a) implementation of the gender perspective as a cross-cutting category in science, technology, and innovation (Spain); b)

Table 4. Strategies designed within the framework of OS public policies.

| Strategies designed | Countries |
|---|---|
| - Open access to data and research results of publicly funded projects, through their deposit in digital repositories<br>- Adoption of FAIR principles<br>- Use of open licenses (Creative Commons)<br>- Design and implementation of training and capacity building programs in research data management<br>- Creation of at least one public policy evaluation and monitoring body<br>- Creation and maintenance of at least one nationwide OS infrastructure<br>- In cases where data cannot be opened due to copyright, descriptive metadata should be open | All (except Uganda) |
| - Adoption of TRUST principles | Slovenia, Sweden, Spain, Portugal, France, Malaysia |
| - Adherence to regional OS regulatory frameworks and infrastructures | European countries |
| - Processing charges (APC) may be subject to financing | Slovenia, Portugal, Malaysia |
| - Promotion of citizen science | Colombia, Sweden, Slovenia, Argentina |
| - Design and implementation of financial and non-financial incentives | Colombia, Malaysia, China, Spain, Sweden |
| - Adoption of qualitative indicators (research impact) instead of quantitative bibliometric indicators for evaluation of scientific research. | Argentina, Spain, Slovenia |
| - Public funding budgets | India, Malaysia, China, Spain, Slovenia |
| - Promotion of the efficient use of publicly funded scientific research infrastructure. | Argentina, India |
| - Support for a publishing business model that does not depend on APCs | Slovenia, France |
| - Generation of mechanisms for the dissemination of the OS, such as awards that strengthen prestige and effectiveness of the OS. | Spain, France |
| - All grants or funding from public entities must present a primary research data management plan according to the specificities of each disciplinary area. | Argentina |
| - Implement a strategy for public communication of science aimed at citizens<br>- Integrate into the educational system a training agenda on OS components, practices and projects<br>- Training and ethical awareness of scientific research and integrity | Colombia |
| - Public entities are obliged to use non-proprietary formats for data sharing<br>- Users must recognize the source of the information to be able to use it | Uganda |
| - Expansion of public R&D spending | South Africa |
| - Establishing a cloud services ecosystem, enabled by artificial intelligence, and conducting targeted courses for researchers in the open-source field<br>- Supporting early career researchers in OS engagement<br>- Establishing an open peer review<br>system in the national open access infrastructure repositories<br>- Establishing short and long-term financial resources for the operation of the data services ecosystem | Slovenia |

Table 4. Continued.

| Strategies designed | Countries |
|---|---|
| - Government entities should prepare a "Blacklist" of sensitive data that will not be shared<br>- Each public entity should have an "NDSAP Cell" that prepares the Black List, lists the data set to be released, and monitors the follow-up of the policy within the entity. The cell should be headed by a Chief Data Officer<br>- Encourage national private investments in research institutes to generate economically relevant research<br>- Encourage the development of partnerships and formal collaboration mechanisms between multinational companies and SMEs and public research institutions | India |
| - Linking scientific publications to their underlying research data<br>- Establishing OS requirements for publicly funded institutions<br>- Training research staff and evaluators on the opportunities and challenges of OS | Spain |
| - The State should create a fair and equal, competitive and merit-based social and institutional environment<br>- Administrative departments should compile catalogs of scientific data sources, connect them to the relevant directories and facilitate their exchange between civilian and military channels<br>- Data centers should establish clear mechanisms for data recovery in the event of possible claims<br>- For the use of scientific data, legal entities should provide them free of charge when it comes to national security and defense, environmental protection, government planning and scientific research in the public interest. For business activities, the parties must agree on a contract.<br>Repository management training for key OS stakeholders | China<br>Malaysia |

measures to attract and retain female personnel in the science and technology sector, as well as to ensure inclusive recruitment and representation of vulnerable sectors (Malaysia); and c) inclusion measures aimed at the representation of women, members of the LGBTQIA+ community, and the rural population, and measures on the social responsibility of researchers (India).

### *3.4 Policy Results*

Although there were initiatives at the beginning of this century, the development of OS public policies is rather recent (since the 2010s). In this sense, the progress of its results has not only not been as rapid as might be expected but has also been uneven. European countries, for example, concentrate the greatest progress in terms of policy implementation and infrastructure creation.

Asian countries, on the other hand, show heterogeneous development, with China leading OS infrastructure projects (Global Change Research Data Publishing and Repository, and China Science and Technology Cloud), while India shows a marked interest in both open access to government data and publicly funded research, and in the relationship between industry and academia to produce economically relevant research. For its part, the wide coverage of the Malaysia Open Science Platform, bringing together the country's leading universities and hosting more than a thousand research datasets, marks an important step forward in the development of OS.

For the case of Africa, the selected countries show slow progress reflecting the early stages of opening both science and government data. Uganda's OGD policy, for example, has resulted by 2022 in the integration of 33 public entities into data sharing systems and services, while the government continues its journey in digitizing the country through the installation of the Raxio Uganda data center. Mauritius' policy has significantly improved the openness of its social (labor, gender, and education) and economic (national accounts) statistics by 2022, while in South Africa efforts to increase public R&D spending as a share of GDP have not exceeded 0.62% (compared to the desired 1.5% for the next decade). In addition, Thaldar, Gooden, and Steytler (2023) believe that South African policy must be anchored to the constitution in the right

Table 5. Inclusion, diversity, and equity criteria in the framework of public policies for OS.

| Country | Document | Criteria |
|---|---|---|
| Argentina | Diagnosis and guidelines for an Open Science policy in Argentina | - Recognize the role of local knowledge in solving socio-environmental problems<br>- Promote a culture conducive to citizen participation in the production of scientific knowledge, discussion, and the definition of research priorities |
| Colombia | National Open Science Policy | - Create a culture of openness, dialogue, inclusion, and social responsibility of the country's knowledge generating actors<br>- Strengthen and create spaces for articulation, dialogue, interaction, networks and collaborative alliances between public, private, and mixed organizations to increase the circulation and optimization of the use of open knowledge |
| India | Science, Technology and Innovation Policy (STIP) | - Equal opportunities in academic positions for women and candidates from rural areas<br>- At least 30% representation of women in committees and governing bodies<br>- Inclusion of the LGBTQIA+ community in all discussions and debates on gender equity, in order to safeguard their rights and promote their representation in science, technology, and innovation activities |
| | Social Scientific Responsibility (SSR) Guidelines | - Technical support to rural and local innovators, technical assistance in problem solving<br>- Dissemination of scientific and technological information in simple local language<br>- Scientific talks on popular topics in simple language to create scientific awareness and decrease superstitions in society<br>- Empowerment of women and vulnerable sectors with scientific and technological solutions<br>- Public knowledge institutions should prepare a code of conduct that guarantees transparency, equity, and diversity<br>- Professors, researchers, and librarians, should be sensitized by their institutions about their ethical responsibility to contribute to the betterment of society. |
| Malaysia | National Policy of Science, Technology and Innovation (NPSTI) 2021-2030. | - Provide incentives in the form of upskilling and reskilling to increase the female workforce in the science, technology, and innovation sector<br>- Implement telecommuting programs, flexible hours, or both, for the re-entry of women who have resigned due to family matters |
| | Open Government in Malaysia: Landscape, Challenges and Aspirations | - Inclusive data collection to ensure that vulnerable populations are well represented<br>- The OGD project executing unit should be made up of people representing the rural sector, citizens, indigenous peoples, men, women, and people with disabilities<br>- The OGD should provide relevant information for the development of other public projects and initiatives |
| China | Science and Technology Progress Law of the People's Republic of China | - Young, female and technical minority scientific and technical personnel have equal rights to compete for professional positions, participate in scientific and technological assessments and conduct research and development projects. |
| Portugal | Decree-Law 63/2019 | - To contribute to the dissemination of the Portuguese language by training researchers within the community of Portuguese-speaking countries. |

Table 5. Continued.

| Country | Document | Criteria |
|---|---|---|
| Spain | Science, Technology and Innovation Law 17/2022 | - Promote open, inclusive, and responsible scientific and technical research in all areas of knowledge<br>- Promote the gender perspective as a cross-cutting category in science, technology, and innovation, considering for this purpose a balanced presence of men and women in all areas of the Spanish STI system, where each sex cannot exceed 60% or be less than 40%<br>- Promote gender studies from an inclusive and intercultural vision, Establish mechanisms to eliminate gender bias in the selection and evaluation processes of research personnel in the service of public research entities<br>- Establish programs and measures for support, promotion, action, and follow-up for effective equality, including gender violence. |
| | IICTI 2021-2023 | - The gender perspective will guarantee the application of the principle of real equality between men and women in research, development, and innovation activities<br>- Application of gender equality, diversity, and inclusion principles in the design, concession and execution of public investments in research, development and innovation. |
| France | Second French Plan for Open Science | - To promote multilingualism and the circulation of scientific knowledge by translating publications by French researchers<br>- To reduce publication biases by ensuring the diversity of publications, both those with positive results, and those with negative or inconclusive results |

way, establishing the conceptual nexus between OS and the right to freedom of scientific research.

Latin America has a clear history of open access: Argentina's Digital Repositories Law and *LA Referencia* are examples of this. However, in the selected countries (Argentina and Colombia) there is an initial stage in the design of national open access public policies.

In addition, some variables, such as unequal access to education, deficiencies in the national digital infrastructure, lack of qualified scientific personnel in the management of research data, weak awareness of the main actors (academia and government) regarding the importance and benefits of OS, lack of incentives, and researchers' own resistance to change, are all factors that limit the development of OS. According to the stakeholders interviewed, for example, OS is closely linked to technological development, so if a country lacks technological development, it will surely face greater difficulties in implementing formal OS practices.

## Conclusions and lessons for Latin America

The new OS paradigm has been addressed by public policy through a strong commitment to open access to publicly funded research data and results. This accessibility to knowledge, while representing a fundamental advance, must still be strengthened by the design and implementation of other mechanisms that allow:

1. The promotion of OS in this region depends on strengthening its STI systems, dedicating greater resources to research, strengthening its scientific information repositories, and promoting effective cooperation mechanisms.
2. An open dialogue with other knowledge systems. To this end, according to the stakeholders interviewed and the criteria established in the Open Government Malaysia framework (Table 5), it is essential to improve the representativeness of marginalized communities. This may imply an adequate collection of data related to these communities, and to their integration (women, rural sector, indigenous peoples, people with disabilities, members of the LGBTQIA+ community, etc.) in the projects, policies, and programs designed.
3. The integration of citizens in the scientific processes of interest. This represents a specific challenge of infrastructure, resources, and organization that can be addressed through a standardized definition

of scientific projects, taking into account: a) which members of the public (students, workers, educators, etc.) will be actively involved; b) the stages of the project in which the public will participate (data collection, voluntary monitoring, data processing, etc.); and c) the legal and ethical aspects of the projects, such as the intellectual property derived from them, confidentiality, agreements for data exchange, and the social, political, and environmental impact of the research.

4. Diversity, equity, and inclusion of vulnerable social sectors. Finally, the inclusiveness of the OS is closely linked to the understanding of their needs. To this end, according to the actors interviewed, it is necessary to address the problems of these social sectors and create knowledge-intensive solutions (Table 6).

According to the actors interviewed, Latin America not only has a successful experience at the regional level (*LA Referencia*) that can serve as an example for the development of specific initiatives at the country and regional level, but it is also a reference at the international level in terms of open access via diamond (no subscription or publication fees). However, most Latin American journals lack the impact of others indexed in the most recognized systems, which not only have hybrid access models, but also better open access infrastructures and technical staff better trained in scientific data management. In this sense, it is essential to establish international collaborative alliances to improve technical and operational capabilities. In addition, and derived from our analysis, we identified that OS policy trends indicate that the following elements should be considered:

- Development, maintenance, and continuous operation of the national OS infrastructure.
- Adherence to FAIR and TRUST principles.
- Establishment of ongoing education and training programs in research data management, as well as in OS principles and values.
- Encourage the use of open licenses to strengthen open access.
- Consider evaluation criteria that delve into the social and economic impact of research, its possible dialogue with other knowledge systems, and the involvement of other societal actors (citizen scientists, for example), instead of concentrating exclusively on quantitative bibliometric indicators.
- Consider processing charges as objects of financing.
- Alignment with other relevant policy and regulatory frameworks.
- Design and implement effective measures to strengthen the representation and participation of women and vulnerable sectors in science, technology, and innovation systems.
- Establish decentralized bodies for the evaluation, follow-up, and monitoring of public policy on OS.

Table 6. Key elements of the interviews.

| | |
|---|---|
| General elements | - OS should be understood as: a) a way to democratize science and knowledge; b) a constantly evolving process; c) a tool to build a better, fairer, and more inclusive society; and d) a way to strengthen the collaboration of public and private entities to trigger open innovation processes.<br>- The inclusive nature of OS is related to meeting the needs of marginalized and disadvantaged communities, addressing their problems and creating knowledge-intensive solutions.<br>- OS practices require a) partnerships and collaborations with academia, publishers, and science, technology, and innovation funding agents; b) addressing issues such as ICT infrastructure, big data<br>techniques (for data visualization and analysis) and artificial intelligence, among others; and c) the generation of training programs for the development of skills that enable proper data management.<br>- For OS to have a real impact, resources are required to promote research and direct it towards solutions that affect society as a whole and specific group. In addition, access to and use of knowledge for all must be promoted, so it is necessary to encourage multilingualism and go beyond English as the only language of science. |

Table 6. Continued.

| | |
|---|---|
| Challenges or barriers | - Current evaluation systems for researchers may discourage OS practices by favoring individual over collective publication.<br>- Low levels of digitization and connectivity problems, the shortage of professionals specialized in ICT solutions, the lack of awareness among stakeholders (society, academia, and government) of the importance and benefits of OS, and the lack of coordination of agents in the design and implementation of public policies mean that OS processes remain incomplete or face major limitations.<br>- To achieve the objectives of inclusion, the following challenges must be addressed:<br>a) Acceptance of publications in languages other than English.<br>b) Modify the evaluation systems of scientists by admitting publications in different languages and means of dissemination of research.<br>c) Create policies to avoid predatory attitudes among scientific publishers.<br>d) Focus research financed with public funds on priority problems of society.<br>e) Increase the representation of marginalized communities in the design and implementation of research policies, programs, and projects.<br>f) Overcome researchers' resistance to participate in OS activities through specific incentives.<br>g) Reconcile social welfare with the interests of private initiative in the design of research projects. |
| Opportunities | - International interest in collaboration, which includes three fundamental aspects for the formation of alliances:<br>a) Training in data management.<br>b) technical training to strengthen OS infrastructures.<br>c) Advice on the development of national and institutional OS policies.<br>- Initiatives to integrate national repositories into the international network.<br>- Developments in big data and artificial intelligence can be used to strengthen data management and analysis tools.<br>- Recognition at high decision-making levels of States and multinational organizations of the need to democratize science.<br>- Promote the use of open licenses such as Creative Commons to address copyright issues. |
| Essential elements to consider in public policies | - Allocate resources to STI financing programs, including those for publishers, taking into account their field of action, size, and coverage.<br>- Design programs to strengthen critical infrastructure for STI and OS.<br>- Promote regional developments aimed at strengthening digital infrastructure, technical training, and the creation of effective mechanisms for the dissemination of knowledge.<br>- Actively promote international cooperation with the purpose of increasing regional welfare through research.<br>- Design and implement differentiated policies according to fields of knowledge, regions, and communities involved.<br>- Design and implement evaluation mechanisms that motivate collaboration among researchers and the adoption of OS practices.<br>- Create training and financing programs for the development of formal OS communities in which different actors participate (researchers, publishers, science promotion organizations).<br>- Include the principles of OS in the highest science, technology and innovation bodies of the countries.<br>- Create a legal framework conducive to the development of OS, including its various dimensions.<br>- Design programs to strengthen the technical capacities of scientific personnel.<br>- Include mechanisms to raise awareness among stakeholders about the importance of OS for social and economic development. |

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The authors have no conflict of interest to declare.

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