LIBSENSE

STRENGTHENING OPEN SCIENCE IN AFRICA

Checklist for universities on implementing the UNESCO Recommendation on Open Science

Areas of actions

Promoting a common understanding of open science, associated benefits and challenges, as well as diverse paths to open science

- **Promote and support the common understanding of open science** as defined in this Recommendation (see the Glossary), within the scientific community and among the different open science actors, and **strategically plan and support open science awareness raising at the institutional, national and regional levels** while respecting diversity of open science approaches and practices.

- **Ensure that publicly funded research is undertaken based on the principles of open science** in line with the provisions of this Recommendation, and that the scientific knowledge from the publicly funded research, including scientific publications, open research data, open software, source code and open hardware, is openly licensed or dedicated to the public domain.

- **Encourage bibliodiversity through the diversity of formats and means of publications and diversity of business models, by supporting not-for-profit, academic and scientific community-driven publishing models as a common good**.

- **Encourage multilingualism** in the practice of science, in scientific publications and in academic communications.

- **Ensure that the needs and rights of communities**, including the rights of indigenous peoples over their traditional knowledge **should not be infringed on in open science practices**.
- **Enhance open science communication** to support the dissemination of scientific knowledge to scholars in diverse research fields, decision makers and the public at large.

- **Engage the private sector in the discussion** about the ways in which the scope of open science principles and priorities can be enlarged and mutually shared.

- **Enable open multi-stakeholder discussions on open science benefits and its real and apparent challenges** as regards, for example, competition, extraction and exploitation of data by more advanced technologies, links to intellectual property rights, privacy, security and inequalities between publicly and privately funded research, in order to

address these challenges constructively and implement open science practices in line with the values and principles outlined in this Recommendation.

Developing an enabling policy environment for open science

- **Develop or encourage policy environments**, including those at the institutional, national, regional and international levels **that support operationalization of open science and effective implementation of open science practices, including policies to incentivize open science practices among researchers**. Through a transparent participatory, multi-stakeholder process that includes dialogue with the scientific community, especially early-career researchers, and other open science actors.

- **Develop effective institutional and national open science policies and legal frameworks** that are consistent with existing international and regional law and are in line with the definition, values and principles as well as actions outlined in this Recommendation.

- **Align open science policies, strategies and actions from individual institutions to local and international levels**, while respecting the diversity of open science approaches.

- **Mainstream gender equality aspects** into open sciences policies, strategies and practices.

- **Implement policies and strategies for open science**.

- **Enhance the inclusion of citizen and participatory science as integral parts of open science policies and practices** at the national, institutional and funder levels.

- **Design models that allow co-production of knowledge with multiple actors** and establish guidelines to ensure the recognition of nonscientific collaborations.

- **Encourage responsible research and researcher evaluation and assessment practices**, which incentivize quality science, recognizing the diversity of research outputs, activities and missions.

- **Foster equitable public-private partnerships for open science and engage the private sector in open science**, provided that there is appropriate certification and regulation to prevent vendor lock-in, predatory behaviour and unfair and/or inequitable extraction of

profit from publicly funded scientific activities. Given the public interest in open science and the role of public funding, Member States should ensure that the market for services, relating to science and open science, functions in the global and public interest and without market dominance on the part of any commercial entity.

- **Design, implement and monitor funding and investment policies and strategies for science based on the core values and principles of open science**. The costs associated with operationalization of open science relate to the support of open science research, publishing, data and coding practices, the development and adoption of open science infrastructures and services, capacity building of all actors and innovative, highly collaborative and participatory approaches to the scientific enterprise.

Investing in open science infrastructures and services

- **Promote non-commercial open science infrastructures** and ensure adequate investment in the following:
    - **Science, technology and innovation**;
    - **Reliable Internet connectivity and bandwidth** for use by scientists and science users
    - **National research and education networks (NRENs)** and their functionality, encouraging regional and international collaboration to ensure maximum interoperability and alignment between NREN Services.
    - **Non-commercial infrastructures**, including computing facilities and digital public infrastructure and services supporting the open science approach. These should facilitate ensuring the long-term preservation, stewardship and community control of research products, including scientific information, data, source code and hardware specifications, co-operation among researchers and the sharing and reuse of research products. Any research-supporting infrastructure or service should have a strong community-led base and ensure interoperability and inclusivity. Digital infrastructures for open science should be based, as far as possible, on open source software stacks. These open infrastructures could be supported by direct funding and through an earmarked percentage of each funded grant.
    - **Federated information technology infrastructure for open science**, including high-performance computing, cloud computing and data storage where needed, and robust, open and community managed infrastructures, protocols and standards to support bibliodiversity and engagement with society. While avoiding fragmentation by enhancing the federation of existing open science

infrastructures and services, at the national, regional and international levels, attention should be given to ensuring that this infrastructure is accessible for all, internationally interconnected and as interoperable as possible, and that it follows certain core specifications, notably the FAIR (Findable, Accessible, Interoperable, and Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility and Ethics) principles for data stewardship.

- **North-South, North-South-South and South-South collaborations to optimize infrastructure use and joint strategies for shared, multinational, regional and national open science platforms**, including through the promotion of research collaborations, sharing of open science infrastructures, technical assistance, transfer and coproduction of technology related to open science and exchange of good practices under mutually agreed terms.
- **A new generation of open information technology tools** that automate the process of searching and analysing linked publications and data, making the process of generating and testing hypotheses faster and more efficient.
- **Innovative approaches at different stages of the scientific process and the international scientific collaboration**.
- **Funding for the necessary costs associated with transformation towards and maintaining open science practices, as well as the promotion of open licensing schemes**.
- **Platforms for exchanges and co-creation of knowledge between scientists and society**, including through predictable and sustainable funding for volunteer organizations conducting citizen science and participatory research at the local level.
- **Community-based monitoring and information systems** to complement national, regional and global data and information systems.

Investing in human resources, training, education, digital literacy and capacity building for open science

- **Provide systematic and continuous capacity building on open science concepts and practices**, including broad comprehension of the open science guiding principles and core values as well as technical skills and capacities in digital literacy, digital collaboration practices, data science and stewardship, curation, long-term preservation and archiving, information and data literacy, web safety, content ownership and sharing, as well as software engineering and computer science.

- **Agree on a framework of open science competencies** aligned with specific disciplines for researchers at different career stages, as well as for actors active in the private and public sectors or in civil society, who need specific competences to include the use of open science products in their professional careers; and **develop recognized skills and training programmes in support of the attainment of these competencies**. A core set of data science and data stewardship skills, skills related to intellectual property law, as well as skills needed to ensure open access and engagement with society, as appropriate, should be regarded as part of the foundational expertise of all researchers and incorporated into higher education research skills curricula.

- **Invest in and promote advanced education and the professionalization of roles in data science and data stewardship**. Enabling open science also requires data governors capable, in cooperation with the scientific community, of setting strategic directions for data management and openness at the national or local levels and advanced and professional data stewards who manage and curate data according to agreed principles, notably FAIR and CARE principles, within trusted institutions or services. In order to take advantage of the opportunities offered by open science, research projects, research institutions and civil society initiatives need to call on advanced data science skills including analysis, statistics, machine learning, artificial intelligence, visualization and the ability to write code and use algorithms with scientific and ethical responsibility.

- **Promote the use of open educational resources** (OER), as an instrument for open science capacity building. OER should therefore be used to increase access to open science educational and research resources, improve learning outcomes, maximize the impact of public funding and empower educators and learners to become co-creators of knowledge.

- **Support science communication accompanying open science practices** with a view to the dissemination of scientific knowledge to scholars in other research fields, decision-makers and the public at large. Dissemination of scientific information through scientific journalism and media, popularization of science, open lectures and various social media communications builds public trust in science while increasing the engagement of societal actors beyond the scientific community. To avoid misinterpretation and dissemination of misinformation, the quality and appropriate citation of original sources of information are of paramount importance to science communication as regards open science.

Fostering a culture of open science and aligning incentives for open science

- **Engage actively in removing the barriers for open science, particularly those relating to research and career evaluation and awards systems**. Assessment of scientific contribution and career progression rewarding good open science practices is needed for operationalization of open science. Attention should also be given to preventing and mitigating the unintended negative consequences of open science practices, such as predatory behaviours, data migration, exploitation and privatization of research data, increased costs for scientists and high article processing charges associated with certain business models in scientific publishing that may be causes of inequality for the scientific communities around the world and, in some cases, the loss of intellectual property and knowledge.

- **Combine efforts** of many different stakeholders, including research funders, universities, research institutions, publishers and editors, and scientific societies across disciplines and countries, **to change the current research culture and to recognize researchers for sharing, collaborating and engaging with other researchers and society**, and to support, in particular, early-career researchers in particular to drive this cultural change.

- **Review research assessment and career evaluation systems in order to align them with the principles of open science**. Considering that a commitment to open science requires time, resources and efforts that cannot be automatically converted into traditional academic output, such as publications, but which can have a significant impact on science and society, evaluation systems should take into account the wide breadth of missions within the knowledge creation environment. These missions come with different forms of knowledge creation and communication, not limited to publishing in peer reviewed international journals.

- **Promote the development and implementation of evaluation and assessment systems** that:
    - **build on the existing efforts to improve the ways in which the scientific outputs are evaluated**, such as the 2012 San Francisco Declaration on Research Assessment, with an increased focus on the quality of research outputs rather than quantity, and by fit-for-purpose use of diversified indicators and processes that forego the use of journal based metrics such as the journal impact factor;
    - **give value to all relevant research activities and scientific outputs** including high-quality FAIR data and metadata, well-documented and reusable software,

protocols and workflows, machine-readable summaries of findings, and teaching, outreach and engagement of societal actors;
    - **take into account evidence of research impact and knowledge exchange**, such as widening participation in the research process, influence on policy and practice and engaging in open innovation with partners beyond academia;
    - **take into account the fact that diversity of disciplines requires different approaches in open science**;
    - **take into account the fact that assessment of researchers against open science criteria should be fit for different stages of careers**, with particular attention to researchers at the beginning of their careers.

- **Ensure that the practice of open science is well known, and is taken into account as a scientific and academic recruitment and promotion criterion**.

- **Adopt policies that require and reward open access to scientific knowledge, including scientific publications, open research data, open software, source code and open hardware**, in line with the provisions of this Recommendation (see the Glossary).

- **Ensure diversity in scholarly communications with adherence to the principles of open, transparent and equitable access and supporting non-commercial publishing models and collaborative publishing models with no article processing charges or book processing charges**.

- **Enforce effective governance measures and proper legislation in order to address inequality and prevent related predatory behaviours** as well as to protect the intellectual creation of open science methods, products and data.

- **Promote materials that are in the public domain and existing open licensing schemes, copyright and other intellectual property exceptions** for research and educational uses that allow distribution and re-use of a copyright work, or work subject to other intellectual property protection, including partial or derivative use, on the condition that the creator is appropriately credited, in accordance with international law.

- **Promote high-quality and responsible research and explore the potential of open science practices to reduce scientific misconduct**, including the fabrication and falsification of results, violation of scientific ethical norms, and plagiarism.

Promoting innovative approaches for open science at different stages of the scientific process

- **Promote open science from the outset of the research process** and extending the principles of openness in all stages of the scientific process to improve quality and reproducibility, including the encouragement of community-driven collaboration and other innovative models, for example preprints, clearly distinguished from final peer-reviewed publications, and respecting the diversity of scientific practices, in order to accelerate dissemination and encourage rapid growth in scientific knowledge.

- **Promote, as appropriate, open peer review evaluation practices** including possible disclosure of the identity of the reviewers, publicly available reviews and the possibility for a broader community to provide comments and participate in the assessment process.

- **Encourage and value publication and sharing of negative scientific results** and those that do not conform to the results expected by the researchers who carried them out, and data associated with them, as these results also contribute to the advancement of scientific knowledge.

- **Develop new participatory methods and validation techniques to incorporate and value inputs from social actors beyond the traditional scientific community**, including through citizen science, crowdsource based scientific projects, citizen involvement in community-owned archival institutions, and other forms of participatory science.

- **Develop participatory strategies for identifying the needs of marginalized communities and highlighting socially relevant issues** to be incorporated into the science, technology and innovation (STI) research agendas.

- **Develop strategies that facilitate the deposit of data in archives** in order to promote their curation and preservation and make them usable and reusable for the appropriate time period.

- **Promote the development of shared infrastructures** for the collection, preservation and user-friendly access to open source software and source code.

- **Support scientists and other societal actors in accumulating and using open data** resources in a transdisciplinary mode to maximize scientific, social, economic and cultural benefits, and stimulate the creation of hybrid disciplinary collaborative spaces

where scientists from different disciplines interact with software developers, coders, creatives, innovators, engineers and artists, among others.

- **Encourage sharing, promote interoperability, and enhance open access of large-scale research infrastructures**, such as international infrastructures in physics, astronomy and space science, as well as collaborative infrastructures in other fields, such as health and environmental and social sciences, among others.

- **Promote open innovation practices that connect the practices of open science to more rapid translation and development of its discoveries**. Like open science, open innovation and other open science partnerships assume broad and effective engagement and participation in the innovation process as well as the discovery and development of a business model for effective commercialization of new knowledge.

Promoting international and multi-stakeholder cooperation in the context of open science and with a view to reducing digital, technological and knowledge gaps

- **Promote and reinforce international cooperation among all open science actors**, whether on a bilateral or multilateral basis.

- **Encourage international scientific collaborations**, as one of the integral practices of open science and the most important driving factor for an intensive exchange of scientific knowledge and experience, as well as the paramount for the openness of science.

- **Promote and stimulate cross-border multi-stakeholder collaboration on open science**, including by leveraging existing transnational, regional and global collaboration mechanisms and organizations. This should include joining efforts towards universal access to the outputs of science, regardless of discipline, geography, gender, ethnicity, language or socioeconomic circumstances or any other grounds, development and use of shared open science infrastructures, as well as technical assistance and transfer of technology, capacity building, repositories, communities of practice and solidarity between all countries regardless of their state of open science development.

- **Establish regional and international funding mechanisms for promoting and strengthening open science and identify those mechanisms**, including partnerships, which can support international, regional and national efforts.

- **Support the creation and maintenance of effective collaborative networks to exchange best open science practices and lessons learned** from the design, development and implementation of open science policies, initiatives and practices.

- **Promote cooperation among countries in capacity building for open science**, including infrastructure development, software sustainability and data management and stewardship and to prevent the exploitation and misuse of open data across borders.

- **Promote international collaboration on metrics for open science**.

Monitoring

- **Monitor policies and mechanisms related to open science** using a combination of quantitative and qualitative approaches, as appropriate.

- **Deploy appropriate monitoring and evaluation mechanisms to measure the effectiveness and efficiency of open science policies and incentives** against defined objectives, including the identification of unintended consequences and potential negative effects, especially on early-career researchers.

- **Collect and disseminate progress, good practice, innovation and research reports on open science and its implications**, with the support of UNESCO and with a multi-stakeholder approach.

- **Consider the development of a monitoring framework with qualitative and quantitative indicators**, within national strategic plans and shared at the international level, with objectives and actions in the short, medium and long term. **The monitoring of open science should be explicitly kept under public oversight**, including the scientific community, **and whenever possible supported by open non-proprietary and transparent infrastructures**. This monitoring aspect could include but should not be delegated to the private sector.

- **Develop strategies to monitor the effectiveness and long-term efficiency of open science**, which include a multi-stakeholder participatory approach. Such strategies could focus on strengthening the nexus between science, policy and society, increased transparency and accountability for inclusive and equitable quality research, which effectively responds to global challenges.

Glossary

Open Science

For the purpose of this Recommendation, open science is defined as an inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community. It comprises all scientific disciplines and aspects of scholarly practices, including basic and applied sciences, natural and social sciences and the humanities, and it builds on the following key pillars: open scientific knowledge, open science infrastructures, science communication, open engagement of societal actors and open dialogue with other knowledge systems.

Open scientific knowledge: scientific publications, open research data, open research data, **open research data, open hardware,**

Open scientific knowledge refers to open access to scientific publications, research data, metadata, open educational resources, software, and source code and hardware that are available in the public domain or under copyright and licensed under an open licence that allows access, re-use, repurpose, adaptation and distribution under specific conditions, provided to all actors immediately or as quickly as possible regardless of location, nationality, race, age, gender, income, socio-economic circumstances, career stage, discipline, language, religion, disability, ethnicity or migratory status or any other grounds, and free of charge. It also refers to the possibility of opening research methodologies and evaluation processes. Users therefore gain free access to the following:

a. **Scientific publications** that include, among others, peer-reviewed journal articles and books, research reports and conference papers. Scientific publications may be disseminated by publishers on open access online publishing platforms and/or deposited and made immediately accessible in open online repositories upon publication, that are supported and maintained by an academic institution, scholarly society, government agency or other well established not-for-profit organization devoted to common good that enables open access, unrestricted distribution, interoperability and long-term digital preservation and archiving. Scientific outputs related to publications (e.g. original scientific research results, research data, software, source code, source materials, workflows and protocols, digital representations of pictorial and graphical materials and scholarly multimedia material) that are openly licensed or dedicated to the public domain should be deposited in a suitable open repository, following appropriate technical standards that allow them to be properly linked to publications. A paywalled method

of publication, where immediate access to scientific publications is only granted in exchange for payment, is not aligned with the present Recommendation. Any transfer or licensing of copyrights to third parties should not restrict the public's right to immediate open access to a scientific publication.

b. **Open research data** that include, among others, digital and analogue data, both raw and processed, and the accompanying metadata, as well as numerical scores, textual records, images and sounds, protocols, analysis code and workflows that can be openly used, reused, retained and redistributed by anyone, subject to acknowledgement. Open research data are available in a timely and user-friendly, human- and machine-readable and actionable format, in accordance with principles of good data governance and stewardship, notably the FAIR (Findable, Accessible, Interoperable, and Reusable) principles, supported by regular curation and maintenance.

c. **Open educational resources** that include teaching, learning and research materials in any medium – digital or otherwise – that reside in the public domain or have been released under an
open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions, as defined in the 2019 UNESCO Recommendation on Open Educational Resources (OER), in particular those related to the understanding and use of other openly accessible scientific knowledge.

d. **Open source software** and source code that generally include software whose source code is made publicly available, in a timely and user-friendly manner, in human- and machine-readable and modifiable format, under an open license that grants others the right to use, access, modify, expand, study, create derivative works and share the software and its source code, design or blueprint. The source code must be included in the software release and made available on openly accessible repositories and the chosen license must allow modifications, derivative works and sharing under equal or compatible open terms and conditions. In the context of open science, when open source code is a component of a research process, enabling reuse and replication generally requires that it be accompanied with open data and open specifications of the environment required to compile and run it.

e. **Open hardware** that generally includes the design specifications of a physical object which are licensed in such a way that said object can be studied, modified, created and distributed by anyone, providing as many people as possible with the ability to construct, remix and share their knowledge of hardware design and function. In the case of both open source software and open

hardware, a community-driven process for contribution, attribution and governance is required to enable reuse, improve sustainability and reduce unnecessary duplication of effort. Software code, description of tools, samples of equipment and equipment itself may be freely circulated and adapted provided that this complies with the national legislation in terms of ensuring safe use.

Open science infrastructures

Open science infrastructures refer to shared research infrastructures (virtual or physical, including major scientific equipment or sets of instruments, knowledge-based resources such as collections, journals and open access publication platforms, repositories, archives and scientific data, current research information systems, open bibliometrics and scientometrics systems for assessing and analysing scientific domains, open computational and data manipulation service infrastructures that enable collaborative and multidisciplinary data analysis and digital infrastructures) that are needed to support open science and serve the needs of different communities. Open labs, open science platforms and repositories for publications, research data and source codes, software forges and virtual research environments, and digital research services, in particular those that allow to identify unambiguously scientific objects by persistent unique identifiers, are among the critical components of open science infrastructures, which provide essential open and standardized services to manage and provide access, portability, analysis and federation of data, scientific literature, thematic science priorities or community engagement. Different repositories are adapted to the specificity of the objects they contain (publications, data or code), to local circumstances, user needs and the requirements of research communities, yet should adopt interoperable standards and best practices to ensure the content in repositories is appropriately vetted, discoverable and reusable by humans and machines. Open innovation testbeds including incubators, accessible research facilities, open license stewards, as well as science shops, science museums, science parks and exploratories, are additional examples of open science infrastructures providing common access to physical facilities, capabilities and services. Open science infrastructures are often the result of community-building efforts, which are crucial for their long term sustainability and therefore should be not-for-profit and guarantee permanent and unrestricted access to all public to the largest extent possible.

Open engagement of societal actors

Open engagement of societal actors refers to extended collaboration between scientists and societal actors beyond the scientific community, by opening up practices and tools that are part of the research cycle and by making the scientific process more inclusive and accessible to the broader inquiring society based on new forms of collaboration and work such as crowdfunding, crowdsourcing and scientific volunteering. In the perspective of developing a collective

intelligence for problem solving, including through the use of transdisciplinary research methods, open science provides the basis for citizen and community involvement in the generation of knowledge and for an enhanced dialogue between scientists, policymakers and practitioners, entrepreneurs and community members, giving all stakeholders a voice in developing research that is compatible with their concerns, needs and aspirations. Furthermore, citizen science and citizens' participation have developed as models of scientific research conducted by non-professional scientists, following scientifically valid methodologies and frequently carried out in association with formal, scientific programmes or with professional
scientists with web-based platforms and social media, as well as open source hardware and software (especially low-cost sensors and mobile apps) as important agents of interaction. For the effective reuse of the outputs of citizen and participatory science by other actors, including scientists, these products should be subject to the curation, standardization and preservation methods necessary to ensure the maximum benefit to all.

Open dialogue with other knowledge systems

Open dialogue with other knowledge systems refers to the dialogue between different knowledge holders, that recognizes the richness of diverse knowledge systems and epistemologies and diversity of knowledge producers in line with the 2001 UNESCO Universal Declaration on Cultural Diversity. It aims to promote the inclusion of knowledge from traditionally marginalized scholars and enhance inter-relationships and complementarities between diverse
epistemologies, adherence to international human rights norms and standards, respect for knowledge sovereignty and governance, and the recognition of rights of knowledge holders to receive a fair and equitable share of benefits that may arise from the utilization of their knowledge. In particular, building the links with indigenous knowledge systems needs to be done in line with the 2007 United Nations Declaration on the Rights of Indigenous Peoples and principles for Indigenous Data Governance, such as, for example, the CARE (Collective Benefit, Authority to Control, Responsibility and Ethics) data principles. Such efforts acknowledge the rights of indigenous peoples and local communities to govern and make decisions on the custodianship, ownership and administration of data on traditional knowledge and on their lands and resources.