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Open Science for Accelerating the Sustainable Development Goals: Status and Prospects in Asia and the Pacific

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Achieving the United Nations Sustainable Development Goals is increasingly challenging due to widening inequality in access to scientific and technological knowledge and resources. With science remaining too discipline based, and policymakers too often science averse, there is a need for greater understanding of the opportunities and challenges of open science for science practitioners, policy makers and communities. Acknowledging that open science can be a powerful tool to reduce inequalities, UNESCO has been supporting the shift to open science. Following global multistakeholder consultation, the UNESCO Recommendation on Open Science was adopted in November 2021, establishing a universal definition, common standards and shared set of values and principles. In 2021, the UNESCO Regional Science Bureau for Asia and the Pacific partnered with the Institute for Study and Development Worldwide on local and national mapping to identify implementation strategies and mechanisms already in place to enable open science in Asia and the Pacific, and to identify what more is needed. Focused on Malaysia, Republic of Korea, Pakistan, Samoa and Uzbekistan, the study showed that while there are many examples of good practice in aspects of open science, none of the focus countries currently has in place all the policies, infrastructure, awareness and capacity building needed. Typically, clear policies on open science have not yet been articulated and funding mechanisms not yet established. Trust is a key pre-requisite for open science. Current inequities in access to open science infrastructure will need to be addressed or implementation may be unbalanced, exacerbating existing inequities at national, regional, and global scales. There are many opportunities to learn from existing efforts toward open science, but there will be no generic model; each country will need to design an open science model and implementation pathway suited to its context. A predominant message from this research was that the convening power of UNESCO should continue to be harnessed to engage countries on open science

implementation. Further, those committed to open science will need to work hard, with UNESCO, to democratize science and encourage an ethos of *"policy for science, science for policy - science for society and society for science".*

Keywords: open science, UNESCO Recommendation on Open Science, Agenda 2030, Sustainable Development Goals, science capacity building, Asia, the Pacific

INTRODUCTION

Achieving Agenda 2030 and the United Nations Sustainable Development Goals (SDGs) is increasingly challenging, not only because of the impact of the COVID-19 pandemic, but more fundamentally due to widening inequality in access to scientific and technological resources. Open science has the potential to make the scientific process more transparent, inclusive, and democratic, and it is increasingly recognized as a critical accelerator for the achievement of the SDGs (Geneva Call, 2020). The core idea behind open science is to allow scientific information, data, and outputs to be more widely accessible (open access) and more reliably harnessed (open data) with the active engagement of all stakeholders (open to society). In this way, open science breaks down boundaries to knowledge and brings pluralism in ways problems are understood and tackled. While resistance to capitalistic enclosures of knowledge has a long history across different countries and localities, the open science movement has emerged from the scientific community and has rapidly spread to a call for opening of the gates of knowledge (Geneva Call, 2020). With science remaining too discipline based, and policymakers too often science averse, there is a need for greater global understanding of the opportunities and challenges of open science for science practitioners, policy makers and communities.

Acknowledging that open science can be a powerful tool to reduce inequalities between and within countries, and with its leading international mandate for sciences, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has been working at the global level to encourage and support the shift to open science to bridge the knowledge and technology gaps between and within countries (UNESCO, 2021a). Following a global multistakeholder consultative process, and a 2020 Joint Appeal for Open Science in which the Directors-General of UNESCO, World Health Organization (WHO), the European Organization for Nuclear Research (CERN), and the United Nations High Commissioner for Human Rights (UNCHR) reaffirmed "…the fundamental right to enjoy the benefits of scientific progress and its applications and advocated for open, inclusive and collaborative science" (Geneva Call, 2020), a UNESCO Recommendation on Open Science (the Recommendation) was adopted by the 193 countries attending the 41st session of the UNESCO General Conference in November 2021. The Recommendation has, for the first time, established a universal definition, common standards and a shared set of values and principles for open science. It calls on Member States to set up regional and international funding mechanisms for open science and to ensure that all publicly funded research respects the principles and core values of open science. In adopting the Recommendation, Member States have embraced the culture and practice of open science and have committed to reporting on their progress every 4 years (UNESCO, 2021b).

In 2020, UNESCO, the International Science, Technology and Innovation Centre for South-South Cooperation under the Auspices of UNESCO (ISTIC), and the International Science Council Regional Office for Asia and the Pacific (ISC ROAP) began developing an implementation strategy and mechanisms to promote open science for accelerating SDGs in Asia and the Pacific. To support this aim, the UNESCO Regional Science Bureau for Asia and the Pacific partnered with the Sydney-based Institute for Study and Development Worldwide (IFSD) in 2021 to undertake local and national mapping to identify implementation strategies and mechanisms already in place, and to identify what more is needed to enable open science in the region. The main objectives of this work, which involved a desk top review and key informant interviews, were to: (i) explore the status of open science development in selected countries (including history, vision, and mission); (ii) identify available pools of open science resources at the country level; and (iii) make recommendations to support open science implementation to accelerate achievement of the SDGs in Asia and the Pacific (Camkin et al., 2021).

The UNESCO-IFSD study showed that while there are many examples of good practice in some aspects of open science, none of the five focus countries analyzed (Malaysia, Pakistan, Republic of Korea, Samoa, and Uzbekistan) currently has in place the necessary policies, infrastructure and awareness and capacity building needed to fully meet the requisites of open science. Nevertheless, it was clear that all countries have something to offer in terms of their learning about open science and its implementation, as well as something to learn from the others. The work on mapping of open science implementation strategies and mechanisms in Asia and the Pacific identified the need to increase efforts to support inclusive open science implementation in the region. This key finding led to a second phase of work on capacity building for open science implementation, involving a planned series of workshops with participation from Member States in Asia and the Pacific.

The analytical goal of this paper is to take stock of the progress on open science at the international level and in Asia and the Pacific to understand the prospects and needs for progressing open science implementation in the region. We first present core details of the newly adopted UNESCO Recommendation on Open Science. Then we outline our objectives and methodology for mapping open science implementation strategies and mechanisms in Asia and the Pacific. We then present and discuss the findings from the

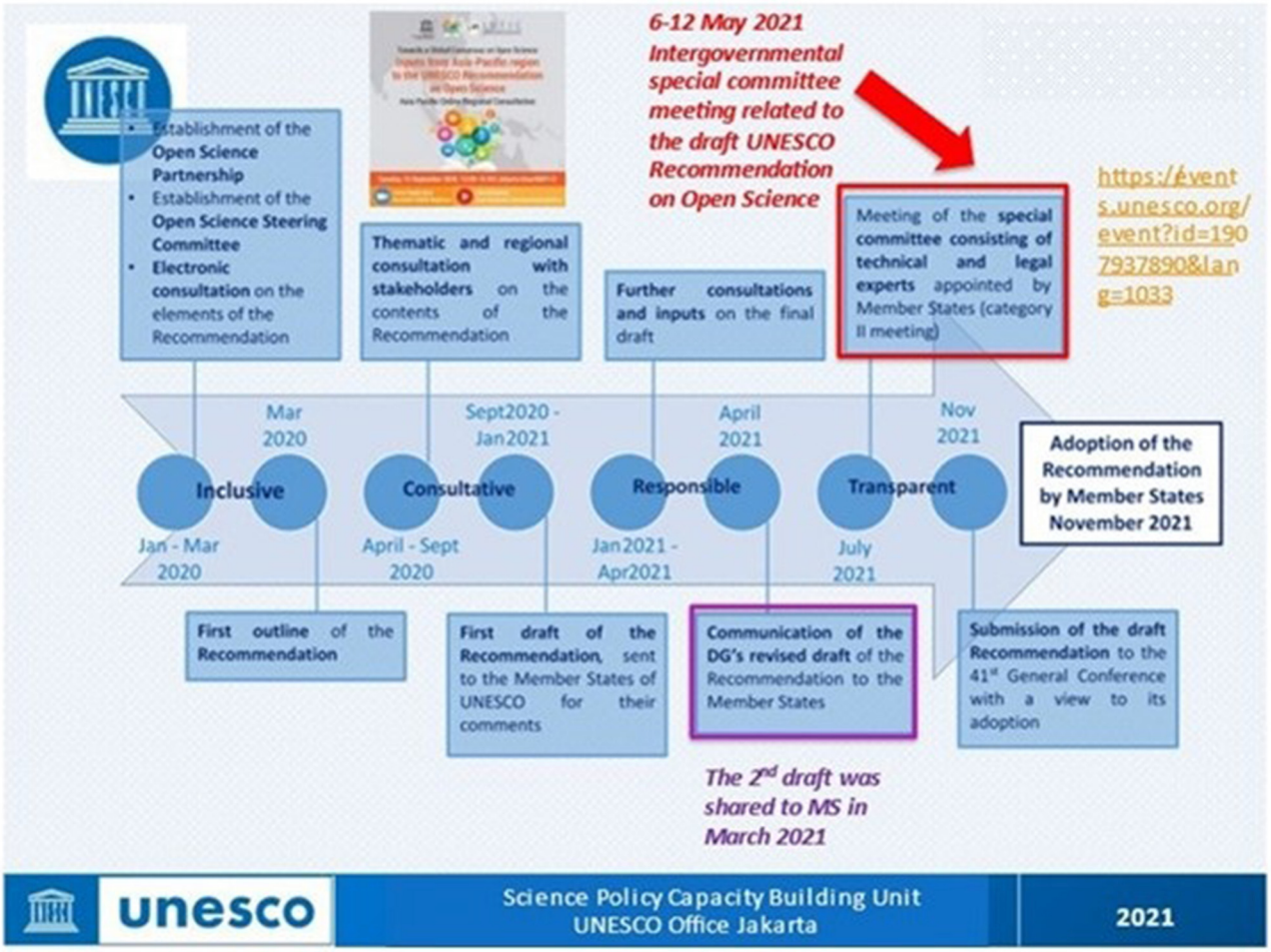

FIGURE 1 | Drafting and approval process for the UNESCO Recommendation on Open Science (UNESCO, 2021b).

desktop review and key informant interviews in relation to open science implementation strategies and mechanisms in five focus countries. Common and transversal messages and a suite of good examples are identified, and we conclude on the potential benefits of open science drawing from these examples. We then make a series of recommendations for implementation of open science in Asia and the Pacific and propose next steps for consideration, featuring the critical ongoing role of UNESCO.

BACKGROUND

Development of the UNESCO Recommendation on Open Science

UNESCO has long supported debates on open science awareness, understanding and policy development. A Strategy on Open Access to Scientific Information and Research was approved by the UNESCO General Conference at the 36th session in 2011 and a UNESCO Recommendation on Science and Scientific Researchers was approved at the 39th session in 2017. At the 40th session of UNESCO's General Conference in 2019, Member States tasked UNESCO with the development of an international standard-setting instrument on Open Science in the form of a Recommendation on Open Science to be adopted by Member States in 2021. Preparation of a Draft Recommendation was led by Member States, facilitated by an internal multisectoral UNESCO Open Science Team, supported by a broad Open Science Partnership, and steered by an Open Science Advisory Committee. A first outline of the Recommendation was provided in March 2020, followed by various stages thematic, global and regional consultation with stakeholders. The drafting and approval process for the UNESCO Recommendation on Open Science is presented in **Figure 1**.

To build a global consensus on open science, development of the Recommendation relied on an inclusive, transparent, and consultative process involving all countries and all stakeholders, including Member States, the scientific community, the key scientific international and national institutions and entities, other relevant United Nations agencies, citizens, and traditional knowledge holders (UNESCO, 2020b). UNESCO held a series

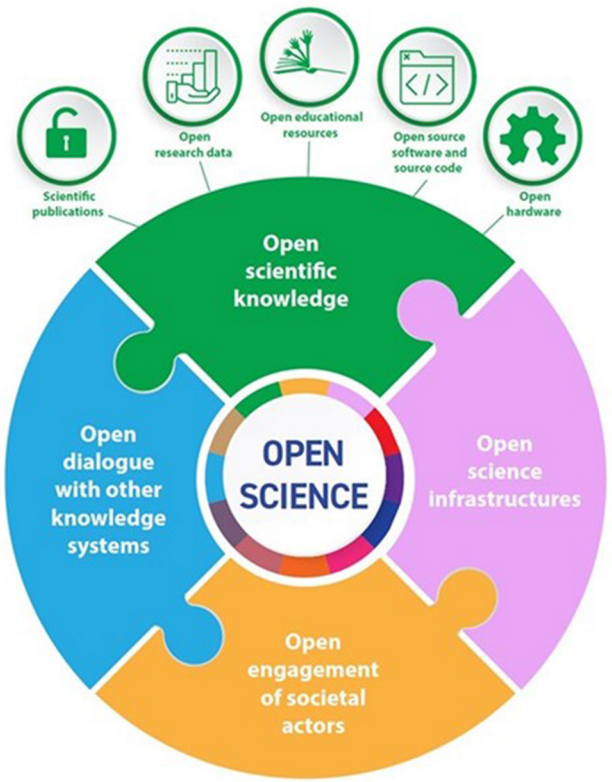

FIGURE 2 | Components of open science (Source: UNESCO, 2021c).

of online and face to face consultations to support an open debate on open science awareness, understanding and policy development to feed into the UNESCO Recommendation on Open Science. An online survey conducted between February and July 2020, open and available to anyone in English, French, and Spanish, collected information from a broad range of interested contributors, individuals, and institutions across the world. Questions centered around the meaning and definition of open science, the practices, institutions, and policies dealing with open science, and the possible negative impacts of and barriers to open science. A total of 2,959 inputs were received from 133 countries globally, including from 27 countries in Asia and the Pacific.

Respondents to the global survey generally agreed on the long-term positive impacts of open science on society. For both developed and developing countries, the most frequently mentioned benefits of open science were access to high-quality knowledge for all, access to infrastructures and FAIR data, and the acceleration of scientific discoveries to tackle societal challenges. To ensure that the benefits are equally accessible in all countries, the respondents pointed to the critical need to decrease the existing gaps in connectivity, infrastructure, capacity, training, hardware, and software within and between countries. Respondents highlighted the central role of open science practices in reinforcing international scientific collaboration and recovering from the COVID-19 pandemic. Fragmentation of policies and a lack of a global strategy on were underlined as critical key challenges for transitioning to open science. Other identified challenges were: lack of common understanding of open science and communication among stakeholders; unequal access to Internet, connectivity, and open infrastructures; evaluation and reward systems based on impact factor of journals and quantity of publications; lack of guidelines and standards for sharing data, unclear security, and protection policies; lack of incentives and coherent investment for open science; commercialized science technology and innovation vs. STI as a common good; lack of human and institutional capacities and possible administrative burdens of open science practices; and application of "one-size-fits-all" open science models without consideration for regional and disciplinary differences and language barriers.

Key aspects of the transition to open science identified for consideration in a global Recommendation on Open Science were: defining common principles and core values of open science and raising awareness and communicating on open science; ensuring basic infrastructures for all, such as electricity, Internet access and access to computers and open infrastructures and software; moving beyond open access to scholarly publications and standardizing practices on other elements of open science, such as open data and engagement with society; transitioning to universal open access to all publicly funded research, abolishing the traditional subscription-based models for access to research and providing financial support to no-article publishing charges (APC) journals; investing in open science—considering the financial implications of open science and developing sustainable open science business models; and promoting innovative international scientific collaborations and innovative public-private partnerships.

Associated regional consultations in Asia and the Pacific included a Regional Multi-stakeholder Workshop on Open Science for Networked Societies (Sep 2019), a post-workshop survey to understand the status of open science (Dec 2019 to Mar 2020), a survey on Technological Needs and Capacity Mapping for UNESCO Science Family on Open Science and Technopreneurship (Aug-Sep 2020) and online regional consultation on Inputs from the Asia–Pacific region to the UNESCO Recommendation on Open Science (Sep 2020). Participants from Asia and the Pacific region highlighted the following:

Key Aspects of Open Science

Respondents highlighted the importance of open science infrastructures, education tools for online courses and capacity building for open science. Common values and principles and the communication of the benefits of open science for all actors was also widely expressed, together with a broad support for science communication and outreach of reliable information without language barriers.

Landscape of Open Science - Open Science Policies and Strategies

Respondents noted national-level policies or strategies on open science that required open access as part of the funding requirements. Some of those policies were also applied at the level of scientific societies or within a specific scientific discipline, such as astronomy and genomics. Respondents also noted that existing international standards were increasingly used, including those relating to ISC World Data System and the FAIR principles. Several national open data platforms. in China, Japan and Indonesia were also referenced in the survey.

Open Science Infrastructures

Respondents from Asian and Pacific States argued that in developing countries, access to a stable power supply and Internet connectivity still needed to be considered. Access to computer code for simulations, calculations, analysis, visualization, and general data processing would also be needed. Open science guides were necessary, instructing scientists as to how they could apply for research grants and covering matters such as the handling of research data and research proposals. The need for cooperative international platforms for open science services, networking and training was highlighted in the responses from the region.

Opportunities and Challenges of Open Science

Respondents highlighted the benefits of appropriate open science infrastructures and collaborative platforms for data sharing and visualization and awareness raising. These platforms could provide understandable information for different societal actors, promoting science-based knowledge for decision-making. Respondents from Asian and Pacific states highlighted possible administrative burdens of the transition to open science. They also pointed to the need to address economic disparities (in research funding and the ability to allocate resources to the construction of infrastructures) and various levels of digitalization as important challenges for open science (UNESCO, 2020a). For Asia and the Pacific, it was highlighted that the administrative burden and lack of rewards and acknowledgment for authors related to ethical issues on data use was the first negative impact foreseen for open science, with fragmented agreements, security and protection policies, and the exploitation of information without proper reference also identified. Specific difficulties for implementation of open science in the region were lack of an international body coordinating open science and the lack of relevant nation policies, such as on intellectual property rights.

Three elements of open science can be considered highly relevant in the Asia Pacific region, compared to the global result: (i) links with indigenous and local knowledge; (ii) open innovation; and (iii) open infrastructure.

In summary, the consultation found that open science should become a global and international collaborative framework to promote core values such as inclusiveness, gender equality, and ethics; integration of social and natural sciences; citizens' engagement in the scientific process; alignment of national frameworks on legal issues, benefits and practices; combination of the top–down policymaking process and bottom–up initiatives on open science; developing of sustainable open infrastructures; changing of scientific culture toward openness and collaboration; and the valorization of citizen science and indigenous knowledge in the global South.

Aims, Objectives and Definitions for Open Science

Building on the essential principles of academic freedom, research integrity and scientific excellence, the Recommendation notes that "…open science sets a new paradigm that integrates into the scientific enterprise practices for reproducibility, transparency, sharing, and collaboration resulting from the increased opening of scientific contents, tools and processes."

The Recommendation defines open science 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" (UNESCO, 2021c).

The four components of open science are shown in **Figure 2** (UNESCO, 2021c):

Open scientific knowledge. Access to scientific knowledge should be as open as possible and any restrictions need to be proportionate and justified. In open scientific knowledge, users gain free access to scientific publications, open research data, open education resources, open source, and open hardware.

Open science infrastructure. Shared virtual or physical research infrastructures needed to support open science and serve the needs of different communities. Often the result of community-building efforts and crucial for community sustainability, they should be not-for-profit and guarantee permanent and unrestricted access to all public to the largest extent possible.

Open engagement of societal actors refers to "extended collaboration between scientists and societal actors beyond the scientific community". 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.

Open dialogue with other knowledge systems. The dialogue between different knowledge holders should recognizes the richness of diverse knowledge systems, epistemologies and diversity of knowledge producers. Open dialogue promotes the inclusion of knowledge from indigenous peoples, traditionally marginalized scholars, and local communities to enhance inter-relationships and complementarities.

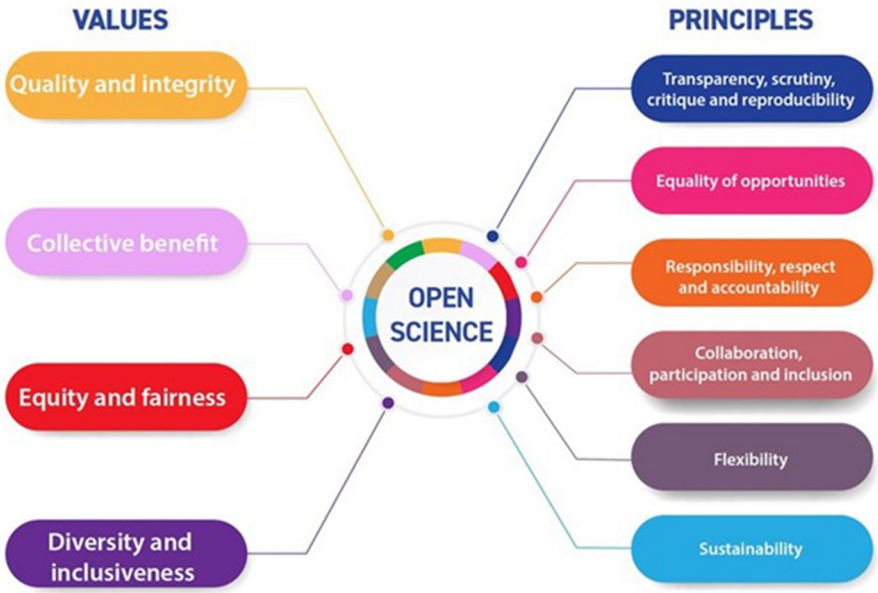

FIGURE 3 | Values and principles of open science (Source: UNESCO, 2021c).

Core Values, Guiding Principles and Areas of Action for Open Science

The Recommendation presents, for the first time, a set of globally agreed core values and guiding principles of open science (UNESCO 2021c; **Figure 3**).

The core values of open science, which stem from the "rights-based, ethical, epistemological, economic, legal, political, social, multi-stakeholder and technological implications of opening science to society and broadening the principles of openness to the whole cycle of scientific research", are:

Quality and integrity - open science should respect academic freedom and human rights and support high-quality research by bringing together multiple sources of knowledge and making research methods and outputs widely available for rigorous review and scrutiny, and transparent evaluation processes.

Collective benefit - as a global public good, open science should belong to humanity in common and benefit humanity. To this end, scientific knowledge should be openly available and its benefits universally shared. The practice of science should be inclusive, sustainable, and equitable, also in opportunities for scientific education and capacity development.

Equity and fairness - open science should play a significant role in ensuring equity among researchers from developed and developing countries, enabling fair and reciprocal sharing of scientific inputs and outputs and equal access to scientific knowledge to both producers and consumers of knowledge 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.

Diversity and inclusiveness - open science should embrace a diversity of knowledge, practices, workflows, languages, research outputs and research topics that support the needs and epistemic pluralism of the scientific community as a whole, diverse research communities and scholars, as well as the wider public and knowledge holders beyond the traditional scientific community, including indigenous peoples and local communities, and social actors from different countries and regions, as appropriate.

The Recommendation identifies six guiding principles for open science: (i) Transparency, scrutiny, critique and reproducibility; (ii) Equality of opportunities; (iii) Responsibility, respect and accountability; (iv) Collaboration, participation and inclusion; (v) Flexibility; and (vi) Sustainability. These guiding principles provide a framework for enabling conditions and practices within which the above values are upheld, and the ideals of open science become reality.

Seven areas of concurrent action for Member states are imbedded in the Recommendation (**Figure 4**) and can be summarized as (abbreviated from UNESCO, 2021c): (i) Promote a common understanding of open science, associated benefits and challenges, as well as diverse paths to open science; (ii) Develop an enabling policy environment for open science; (iii) Invest in open science infrastructure and services; (iv) Investing in human resources, training, education, digital literacy, and capacity building for open science; (v) Foster a culture of open science and aligning incentives for open science; (vi) Promote innovative approaches for open science at different stages of the scientific process; and (vii) Promote international and multi-stakeholder cooperation in the context of open science and with a view to reducing digital, technological and knowledge gaps.

FIGURE 4 | Recommended concurrent action areas for open science implementation (UNESCO, 2021c).

Monitoring Open Science Implementation and Effectiveness

Policies and mechanisms related to open science should be monitored using a combination of quantitative and qualitative approaches suited to their specific conditions, governing structures, and constitutional provisions. This should involve: (i) monitoring and evaluation mechanisms to measure the effectiveness and efficiency of open science policies and incentives against defined objectives; (ii) collecting and disseminating progress, good practice, innovation and research reports on open science and its implications; (iii) developing 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, keeping the monitoring of open science explicitly under public oversight; and (iv) developing strategies to monitor the effectiveness and long-term efficiency of open science (UNESCO, 2021c).

Adoption of the UNESCO Recommendation on Open Science

The UNESCO Recommendation on Open Science was unanimously supported by all Member States at the UNESCO Science Commission Plenary on 15th November 2021 and subsequently adopted by the 193 countries attending the 41st Session of the UNESCO General Conference in November 2021.

The UNESCO General Conference recognized the urgency of addressing complex and interconnected environmental, social and economic challenges for people and the planet including poverty, health issues, access to education, rising inequalities and disparities of opportunity, increasing science, technology and innovation (STI) gaps, natural resource depletion, loss of biodiversity, land degradation, climate change, natural and human-made disasters, spiraling conflicts and related humanitarian crises. It acknowledged the vital importance of STI to responding to these challenges and the potential for expansion of information and communication technologies and global connectedness to accelerate human progress and foster knowledge society, but conversely, also the importance of narrowing the STI and digital gaps existing between and within countries and regions. The Conference acknowledge the transformative potential of open science for reducing existing inequalities in STI and accelerating progress on implementation of the 2030 Agenda and achievement of the SDGs and beyond (UNESCO, 2021d).

The UNESCO General Conference recommended that Member States (UNESCO, 2021d):

- apply the provisions of the Recommendation by taking appropriate steps, including whatever legislative or other measures may be required, in conformity with the

constitutional practice and governing structures of each State, to give effect within their jurisdictions to the principles of the Recommendation
- bring the Recommendation to the attention of the authorities and bodies responsible for science, technology, and innovation, and consult relevant actors concerned with open science.
- collaborate in bilateral, regional, multilateral and global initiatives for the advancement of open science.
- report to it, at such dates and in such manner as shall be determined, on the action taken in pursuance of the Recommendation.

MAPPING OPEN SCIENCE IMPLEMENTATION STRATEGIES AND MECHANISMS IN ASIA AND THE PACIFIC

Study Objectives and Methodology

In response to the need for a coherent regional open science policy framework and practical guidelines on the different open science elements, practices, and policies, UNESCO Jakarta established the project *Local and National Mapping on Implementation Strategies and Mechanisms to Enable Open Science for Accelerating SDGs in Asia and the Pacific*. The study aimed to contribute to the development and implementation of open science in Asia and the Pacific and to support UNESCO Office Jakarta's efforts on capacity building for open science in the region.

The main objectives of this work were to: (i) explore the status of open science development in selected countries (including history, vision, and mission); (ii) identify available pools of open science resources at the country level; and (iii) make recommendations to support open science implementation to accelerate achievement of the SDGs in the Asia and the Pacific. This study was to be the first phase of a larger body of work being coordinated through UNESCO Office Jakarta, with a second phase focusing on capacity building for implementation of open science in the region.

Through a desktop review, key informant interviews and mapping, this work built upon analysis of the background, conceptual framework, values, principles, and actions identified in the Recommendation, and a review of the global and regional outcomes of the consultation on the Recommendation during 2020 and 2021. A suite of requisites, policy and infrastructure needs for open science were identified from reports on UNESCO's consultation on open science and the literature to provide our analytical framework. A subset of five focus countries, one for each sub-region in Asia and the Pacific, was then identified by the UNESCO Regional Science Bureau for Asia and the Pacific in coordination with UNESCO field offices. The countries selected were Malaysia (Southeast Asia), Republic of Korea (East Asia), Pakistan (South Asia), Samoa (Pacific) and Uzbekistan (Central Asia). A brief summary of the results of previous UNESCO consultation on open science was prepared for each country to provide background information for the next stage of the study.

Individual and/or group key informant interviews were conducted for each focus country to identify specific approaches and actions currently taken for open science. The key informants (interviewees) were high-level representatives identified by the UNESCO Regional Science Bureau for Asia and the Pacific through a call for nomination of experts coordinated through the respective National Commissions for UNESCO. The interviewees were identified in consultation with the Science and Technology Policy Asian Network (STEPAN)[1] and with the support of UNESCO field offices. The interviews aimed to gain qualitative insights and perspectives on the current state and preparedness for implementation of open science in the focus countries against the identified requisites, policy and infrastructure needs. The results of the interviews for each focus country were reviewed and common and key messages considered in relation to their applicability at the regional scale. This new knowledge aimed to support preparation of roadmaps for open science implementation for individual focus countries and to identify examples, lessons learnt and recommendations to support capacity building initiatives for open science implementation in Asia and the Pacific. All interviewees were given the opportunity to comment on the study findings/draft report prior to finalization.

The work was conducted as two main activities, with specific outputs for each activity. *Activity 1* was a desktop review of national, regional, and global documents related to open science policy and infrastructure, including the results of previous UNESCO surveys and reports associated with open science in Asia and the Pacific. Specific inputs included: Open Science for Networked Societies and Industry 4.0 in Asia and the Pacific; the global consultation questionnaire for inputs into the development of the UNESCO Recommendation on Open Science; UNESCO Science, Engineering, Technology and Innovation (SETI) Capacity Mapping on Open Science and Technopreneurship in Asia and the Pacific; and STEPAN country reports on open science. The *main Activity 1 outputs* were a summary of the results of UNESCO consultation on open science relevant to Asia and the Pacific and identification of the most important implementation conditions and needs for open science implementation in the region. This informed the analytical framework. *Activity 2* involved mapping and assessing the current local (where feasible) and national level policies, infrastructures, and capacity building efforts in relation to open science in Asia and the Pacific. This activity included: identification of the five focus countries: identification of interviewees for each focus country; individual and group interviews; analysis of the interview results and mapping the current open science policies, infrastructures, and capacity building efforts in each focus country against the identified needs. *The main Activity 2 outputs* were a specific

[1]The Science and Technology Policy Asian Network (STEPAN) was established in 1988 as a network of researchers and institutions in the Asia-Pacific region focusing on research and training support for national science and technology management programs under the auspices of UNESCO and coordinated through UNESCO Jakarta (see http://www.unesco.org/new/en/natural-sciences/science-technology/sti-policy/asia/asia-stepan/).

TABLE 1 | Requisites, implementation conditions/needs, and practices and actions to enable open science implementation in Asia and the Pacific.

Open science requisites	Implementation conditions/needs	Practices and actions to enable conditions for implementation
1. Establish a clear roadmap and guidance for the Member States on implementation of the recommendations (This is a transversal and common need)		
Common understanding of open science and good communication among stakeholders	2. Define common principles and core values	➢ Implementing an international platform: request for UNESCO to host an open science platform ➢ Establishing an international award recognition framework ➢ Establishing an international association of open science ➢ Innovating also in science communication: nurturing the multi–culture base of open science through science communication, and citizen science.
Equal access to Internet, connectivity, and open infrastructures	3. Ensure basic infrastructures for all	➢ Implementing universal access to electricity, Internet, computers, and software ➢ Using existing infrastructure at maximum, considering the untapped university potential, and addressing the need of countries with limited resources.
Clear guidelines and standards for sharing data with security, and protection policies	4. Assure the transition to universal open access to all publicly funded research	➢ Abolishing the traditional subscription-based models for access to research ➢ Providing financial support to no-article publishing charges (APC) journals ➢ Assuring legal and sovereignty issues in patent, data security, and IP aspects
Incentives and coherent investment for open science	5. Effectively invest in Open Science	➢ Promoting human and institutional capacities of national frameworks and platforms. ➢ Data sharing at the regional and global levels within the national platforms ➢ Addressing issues of possible administrative burdens of open science practices ➢ Combining top–down and bottom–up policy making process: engaging the governments
Context-based Open Science models	6. Promote innovative international scientific collaborations	➢ Considering the regional and disciplinary differences ➢ Considering the language barriers ➢ Developing informal practices of open science: connecting traditional knowledge with scientific knowledge

Source: *Camkin et al. (2021).*

summary of outcomes of the previous UNESCO consultation on open science for each focus country; a framework of open science requisites, implementation conditions/needs, and practices/actions to enable open science in Asia and the Pacific; mapping of the interview results against the framework; identification of key and common messages; and formulation of recommendations.

A Tool for Mapping Open Science Implementation Strategies and Mechanisms

Inspired by the seven areas of action identified in the Recommendation for implementation of open science in any country, and considering the review of consultation at the global and regional level, Camkin et al. (2021) created a framework to systematize the general requisites, implementation conditions or needs, and practices and actions to enable open science implementation in Asia and the Pacific (**Table 1**).

From the consultation process undertaken by UNESCO at the global level and regionally in Asia and the Pacific, two dimensions were highlighted in terms of the challenges for transitioning to open science: *fragmentation of policies* and *lack of a global strategy* on open science. There is a need for both an international body coordinating open science, such as UNESCO, and the need to reinforce national policies to address the requisites for open science. Core values such as inclusiveness, gender equality, citizens' engagements in the scientific process, should align with a combination of top–down policymaking process and bottom–up initiatives on open science. Camkin et al. (2021) noted that changing of scientific culture toward openness and collaboration can be a real shift from the current paradigm and bring to light the valorization of citizen science and indigenous knowledge in the global South.

Three major steps were taken in preparation for the key informant interviews. As the UNESCO Regional Science Bureau for Asia and the Pacific covers five sub-regions one country was selected for each sub-region, in coordination with UNESCO field offices and based on past and present collaborations. Secondly, a summary of the results of the UNESCO consultation was prepared for each focus country, covering details of the respondents; awareness and practice in open science; views on the definition, understanding and importance of open science; crucial and missing infrastructure for implementing open science; capacity building for open science; benefits and disbenefits of current open science practices to stakeholders; institutional policies and strategies, dedicated institutions and national or regional policies and strategies for open science; awareness of international frameworks, importance of global consensus on open science and key aspects for open science implementation; and open science in the context of the coronavirus pandemic. Thirdly, a set of questions was designed for the semi-structured interviews to cover the main aspects identified in **Table 1** for open science implementation in the focus countries. These questions are presented in **Table 2**.

TABLE 2 | Questions for semi-structured key informant interviews.

Q1. Regarding a common understanding of open science and good communication among stakeholders, do you agree that there are clearly defined principles and core values of open science already set in your country?
Q2. Regarding the requisite of equal access to Internet, connectivity, and open infrastructures, would you say that basic infrastructures are ensured for all in your country?
Q3. Regarding guidelines and standards for sharing data with security, as well as protection policies, would you say that in your country these measures are in place, or previewed?
Q4. Regarding incentives for open science in your Country, would you agree there is already a significant level of effective and coherent investment in Open Science?
Q5. Regarding the establishment of context-based Open Science models that promote innovative national and international scientific collaborations, do you agree that your Country is already taking steps forward?

Source: Camkin et al. (2021).

These steps, questions and tables are a tool which may be used by other countries and regions to map open science implementation strategies and mechanisms.

FINDINGS AND DISCUSSION

Emerging Patterns From Mapping Open Science in the Five Focus Countries

The desktop review identified the requisites for open science and the policy and infrastructure needs to support open science implementation in Asia and the Pacific (**Table 1**). A series of individual and group key informant semi-structured interviews were then conducted for the focus countries framed about a set of standard questions (**Table 2**). Of the 12 interviewees, five were from Malaysia, one from Republic of Korea, three from Pakistan, one from Samoa and two from Uzbekistan. The interviews were held between 23rd August and 29th September 2021 and lasted up to 2 h each. **Table 3** presents a summary of the results of the interviews, showing the overall position for each focus country against the identified open science requisites and the policy and infrastructures needed to support open science in Asia and the Pacific.[2]

While this study was limited to only five focus countries, with only 12 key informants spread across those countries, and although the views and perspectives of those key informants from the same country often differed on some aspects, some emerging patterns were identified in relation to the requisites for open science. These can be summarized in the following points:

- There does not appear to be a *"common understanding of open science and good communication among stakeholders"* nor *"defined common principles and core values"* in any of the five focus countries. Malaysia appears to be the most progressed, with a common understanding and good communication within academia, some piloting of draft policies and guidelines, and innovations in science communication and citizen science.
- The situation regarding *"equal access to internet, connectivity, and open infrastructures"* and *"ensuring basic infrastructures for all"* is more positive but still mixed. This requisite is met in Korea, and in Malaysia and Pakistan apart from some regional areas with specific infrastructure challenges. There are policies and objectives in place in Uzbekistan, but in Samoa there is unequal coverage and costs can be prohibitive.
- Regarding having *"clear guidelines and standards for sharing data with security, and protection policies"*, and *"allowing the transition to universal open access to all publicly funded research"*, the situation is also mixed. Republic of Korea is well-progressed in dealing with security aspects, Malaysia has recently addressed this but perhaps not yet fully, Uzbekistan appears to have addressed this, the situation in Pakistan is not clear, and Samoa has not yet addressed this need.
- On establishing *"incentives and coherent investment for open science"* and *"effective investment in open science"*, Malaysia seems to stand alone as having clearly done so, although there is still a need for more investment and capacity building. Pakistan, Uzbekistan and Republic of Korea appear not to have yet addressed this requisite, and Samoa appears to have not, at least at the government level.
- The situation regarding *"context-based open science models"* and *"promoting innovative international science collaborations"* is very mixed across the five focus countries. Malaysia appears to be meeting these requisites, and in Republic of Korea regional or disciplinary differences are being addressed but language or indigenous cultural barriers less so. Samoa may be addressing this requisite, Pakistan has not yet, and in Uzbekistan it does not appear to have been specifically addressed in relation to open science.

Opportunities to Learn From the Experience of Each Country

The study has shown that while there are many examples of good practice in various aspects of open science, none of the focus countries has in place all the necessary policies, infrastructure, and awareness and capacity building needed to meet the requisites for open science. There is still lots of work to be done. On the other hand, it was very clear that all countries have something to offer in terms of learning about open science and its implementation, as well as something to learn from the others. A summary of some of the key messages for each focus country follows. For further details, see Camkin et al. (2021).

Malaysia's model for progressing open science, consisting of the Malaysia Open Science Platform (MOSP) launched as an initiative of Ministry of Science, Technology and Innovation (MOSTI) and UNESCO, supported by the Malaysia Open Science Alliance of senior researchers and university administrators, and driven by working groups (on policy and guidelines, capacity building and awareness raising, and infrastructure), is worth exploring for other countries. Two of the strongest messages about open science from Malaysia were that *"the pre-requisite*

[2] Full details on the results and key messages drawn from the interviews for each focus country is available in the UNESCO report, Camkin et al. (2021).

TABLE 3 | Summary position for each focus country against the identified Open Science Requisites and the Policy/infrastructure needed to support open science in Asia and the Pacific.

Open science requisite	Policy/infrastructure needed to support Open Science in Asia Pacific	Malaysia (Southeast Asia)	Republic of Korea (East Asia)	Pakistan (South Asia)	Samoa (Pacific)	Uzbekistan (Central Asia)
Common understanding of Open Science and good communication among stakeholders	Define common principles and core values, by e.g.: • Implementing an international platform: request for UNESCO to host an OS platform • Establishing an international award recognition framework • Establishing an international association of OS • Innovating also in science communication: nurturing the multi–culture base of OS through science communication, and citizen science	○ Yes, in Academia ○ Still at a "pilot project" stage to draft policy and guidelines ○ Not extensively in political and social arenas ○ No ○ Yes	No/Not yet	No	Not yet a big awareness	No or not yet
Equal access to Internet, connectivity, and open infrastructures	Ensure basic infrastructures for all	○ Yes, in general, but need for more long-term support and maintenance ○ Yes ○ Yes	Yes (easily)	○ Yes ○ No ○ Yes (to some extent)	Not a good coverage (expensive) and unequal access	Not OS specific/ Policies in place and objectives
Clear guidelines and standards for sharing data with security, and protection policies	Assure the transition to universal open access to all publicly funded research	○ Not yet fully achieved ○ Yes recently ○ Yes	Clear Yes to security aspects	○ No ○ Yes	No	Yes
Incentives and coherent investment for Open Science	Effectively invest in Open Science	○ Yes, but need for more investment and funding ○ Yes, but need for more capacity building ○ Yes ○ Yes	No	No	Not at governmental level	No
Context-based Open Science models	Promote innovative international scientific collaborations	○ Yes, in general ○ Yes, in potential ○ Yes	It depends on what we consider: • Regional or disciplinary differences: YES • Language or indigenous cultural barriers: Not so much	No/not yet	Maybe	Not specifically to OS

Source: *Camkin et al. (2021).*

for open science is trust" and that there is an *opportunity to utilize and leverage on the existing infrastructures and networks* for open science implementation. The Republic of Korea has strong open science infrastructure and internet connectivity, increasing public awareness and attention to open science, privacy protection laws and operational guidelines on sharing of publicly funded research data and outputs, and a focus on science for social innovation. Two important messages about open science from the Republic of Korea were that "*open science*" *is still understood in quite different ways* and that that the *FAIR principles can be key standards/guidelines for infrastructure managers and science communicators.* In Pakistan, some scientists are very focused on open science, resulting in a good understanding of the needs for implementation and clarity about the importance of a three-pronged approach of advocacy, policy framework and capacity building of stakeholders. Important messages about open science from Pakistan included the need to encourage an ethos of "*Policy for science and science for policy - science for society and society for science*" and that *incentives should be designed to encourage open science practices by each major category of stakeholders.* Scientific and traditional knowledge is strongly connected in Samoa and throughout the Pacific, with any new knowledge contextualized through a traditional lens. Important messages from the Samoan experience include that *informal practices, which are a strongly developed component of open science in the Pacific, are a key area in which Samoa and the Pacific can share its learnings,* and open science implementation will need to be tailored to suit each culture and context and therefore *a clustered approach to connecting and supporting similar countries and regions may be appropriate.* Uzbekistan's approach demonstrates a priority on strengthening the underlying fundamentals for enabling open science. Important messages from Uzbekistan included reinforcement of the need for *context-based pathways and a model of open science suited to the history and context of the country and region,* and the need for *step-by-step implementation that establishes the fundaments for open science first.*

Important Common and Transversal Messages

From our analysis of the diverse views presented by the key informants regarding their own country's path toward open science, we highlight the following common and transversal aspects.

Messages Relating to Awareness and Capacity Building

Even among those interviewed from the same country there were different views on the status of open science. Generally, there is a lack of both common understanding of open science and good communication with stakeholders. There is reasonable awareness of open science within academia in some countries but limited or no awareness outside of academia. Demonstrating the benefits of open science to all stakeholder groups is very important. The pre-requisite for open science is trust—all stakeholder groups need to have trust in open science and trust in open science practitioners. A wide range of variation exists in promotion of innovative international scientific collaborations. There is a need to gather and profile good examples of open science. The convening power of UNESCO is the best mechanism for engaging countries in open science.

Messages Relating to Policy

There is typically a lack of comprehensive national policies on open science. Science, education, culture, and ICT are all linked and inseparable. To be sustainability, open science needs to be linked to national blueprints for education, economy etc. Top-down, bottom-up approaches to policy development are often preferred, but it is not the approach in all countries and different strategies are needed to promote open science. Incentives and coherent investment for open science is lacking in most countries. Incentives are needed to encourage open science practices by all stakeholders, not just researchers. The availability of guidelines and standards for sharing data is highly variable. Tailoring open science policy and implementation to meet contextual needs is critical. Redirection of existing infrastructure, networks and capacity building toward open science can support implementation. It is important to value and have long-term career paths for open science support and custodian roles. Open science should be positioned as an enabler to tackle pressing regional and global issues. Individual and institutional champions for open science are needed in all stakeholder groups, particularly at high levels within government.

Messages Relating to Availability and Accessibility of Infrastructure

Affordability and equity of access to open science infrastructure is highly variable between countries and in some cases within countries. Despite global recommendations, open science won't happen unless the support structures are in place in individual countries. In most cases there is a lack of dedicated resources for open science implementation. Mechanisms for meeting the long-term costs of support and infrastructure maintenance did not exist in any of the focus countries. The UNESCO-IFSD study has shown that while there are many examples of good practice in aspects of open science, none of the focus countries currently has in place all the necessary policies, infrastructure and awareness and capacity building needed to meet the requisites for open science. There is still lots of work to be done. On the other hand, it was very clear that all countries have something to offer in terms of learning about open science and its implementation, as well as something to learn from the others.

Common and transversal messages from the five focus countries suggest there is a widespread need to increase the levels of awareness and understand amongst key stakeholder groups and the general community of what open science is, what benefits it can bring, and at what costs. Identifying champions for open science can support discussion to help address concerns about open science and develop the necessary trust for its implementation. Clear policies on open science have not yet been articulated in most countries, and mechanisms for funding open science are not yet clear. Imbedding open science within national blueprints for education, science and technology, economy etc. may create opportunities for redirecting existing

financial, human, and other resources toward open science implementation. While there is opportunity to learn from the efforts to date toward open science in each country, there will be no generic model for open science and each country will need to design an open science model and implementation pathway that suits its context. Importantly, current inequities in access to the necessary infrastructure for open science within and between countries will need to be addressed or the implementation of open science may be unbalanced and exacerbate existing inequities at national, regional, and global scales (Camkin et al., 2021).

CONCLUSIONS

Open science can be a powerful tool to reduce inequalities between and within countries. With its leading international mandate for sciences, UNESCO has been working at the global level to encourage and support this shift. Through its adoption by the UNESCO General Assembly in November 2021, the UNESCO Recommendation on Open Science has, for the first time, established a universal definition, common standards and a shared set of values and principles for open science. The long and comprehensive consultative process undertaken by UNESCO globally has brought to light several conditions for implementation that may be common even in different contexts. A key one is that open science implementation requires very strong political commitment, consistent institutionalization of the internal networking of the actors involved (academia in the forefront, publishers, and editors of journals, administrative organizations, stakeholders, NGOs etc.), reliable and adequate infrastructure (e.g., internet connectivity and bandwidth, technology accessible for all, internationally interconnected and interoperable), and also including non-commercial infrastructures and open science support services.

In adopting the Recommendation, countries have embraced the culture and practice of open science, but they need to be prepared for the challenges mentioned in this paper. The global effort to address the COVID-19 pandemic has clearly demonstrated the benefits of more open dissemination of scientific data, information and research results regarding human health, and environmental issues. There are great opportunities to learn more from more diversified sources of knowledge, including local and indigenous knowledge, and a lot to learn from the efforts of others toward open science implementation. But developing deep trust between open science practitioners, all stakeholders and the broader community is a pre-requisite for normalizing open science. Current inequities in access to the necessary infrastructure for open science within and between countries will need to be addressed or the implementation of open science may be unbalanced and exacerbate existing inequities at national, regional, and global scales.

Implementing open science will dramatically impact on the current status quo in academic research publication processes, and funding mechanisms. The necessary shifts in those systems will demand a strong and consistent strategy agreed among all partners in this process, including for example the establishment of national, regional, and international alternative funding sources for open science. One critical mechanism to push this shift may be for all Member States to establish a requirement that all publicly funded research respects the principles and core values of open science, and that all public funding prioritizes the publication of research following an open science model. Open science does not, however, necessarily require additional funding. The refinement of national, regional, and local blueprints for education, science, and technology, may create opportunities for redirecting existing financial, human, and other resources toward open science implementation.

Of all the messages received during the UNESCO-IFSD study to map open science implementation strategies and mechanisms in Asia and the Pacific, the most consistent message was that the convening power of UNESCO should be harnessed to continue to engage countries on open science implementation. Those individuals, organizations and countries committed to open science will need to work hard, with UNESCO, to democratize science and encourage an ethos of *"policy for science, science for policy - science for society and society for science"*. This critical umbrella role for UNESCO could be supported by refining the Global Open Science Partnership and Open Science Advisory Committee framework that was in place for consultation on the draft Recommendation and refocusing it on the opportunities and challenges for open science implementation.

RECOMMENDATIONS TO SUPPORT OPEN SCIENCE IN ASIA AND THE PACIFIC

From the analysis of results of the interviews for the five focus countries and considering the previous review of the road map toward the UNESCO Recommendation on Open Science, we have drawn recommendations for enhancing implementation of open science principles and practice in Asia and the Pacific. The recommendations are sourced from both the key informant interviewees and our own reflections of the research findings, and are presented in five groupings: (i) The role of UNESCO; (ii) Awareness, capacity building and social support for open science; (iii) Policies and institutional frameworks; (iv) Infrastructure and platforms to support open science; and (v) Operationalizing open science in Asia and the Pacific.

The Role of UNESCO

It was consensual among all the interviewees that the convening power of UNESCO should be harnessed to engage countries on open science. Therefore, the first recommendation of this study is that UNESCO should continue to play a guiding role for open science implementation. The efforts of UNESCO and others toward open science implementation should encourage an ethos of "*policy for science, science for policy - science for society and society for science*". It is further recommended that UNESCO build upon the formal consultative infrastructure organized for the development of the Recommendation on Open Science and establish a counseling and advisory board to support the implementation of open science and facilitate the umbrella role of UNESCO that all countries consulted were requesting.

Awareness, Capacity Building and Social Support for Open Science

There is no doubt that a key pre-requisite for open science is trust of all stakeholders in open science and open science practitioners. This requires policymakers to develop a "Quadruple Helix" approach, effectively engaging government, research and scientific institutions, companies, and citizens in collaboration on open science policymaking, resourcing, and implementation. Recommended actions, including creating awareness, setting up dedicated departments for open science, and national open science policies that provide a roadmap for open science practices, all need development as they are key components to help stakeholders overcome reluctance and create more confidence toward open science. Open science can help address big global issues (e.g., climate change, pandemics), and some research communities are already strongly linked with global sharing practices. Pilot demonstration of open science for certain challenges (starting with those where open science is a naturally good fit and then moving to others) to showcase the benefits of open science and help maintain and grow interest in it is recommended. At the practitioner level, small international projects should be established to support progress on open science in countries with the most need.

Policies and Institutional Frameworks

Open science is still seen and understood in quite different ways, so the public and political discourse on the core values and principles of open science needs to be further developed. On one hand, an overarching open science policy or program is needed to support efforts to incorporate public opinion, traditional knowledge, or informal practice of citizens into national science systems. On the other hand, open science policy and practice needs to suit the culture of each context. There will be common features, such as the need for and benefit from sharing data and information, but understanding what works for each culture and context, including the role of formal and informal practices, will be critical. A strong recommendation is that open science should become part of the SETI landscape/ecosystem rather than seeking ongoing dedicated funding in parallel. For this, answers are needed on how to link open science with national blueprints for education, science, the economy etc.

Infrastructure and Platforms for Open Science

Inequities in access to the necessary infrastructure for open science within and between countries needs to be addressed or the implementation of open science will be unbalanced and may exacerbate a range of existing inequities at national, regional, and global scales. Integrated platforms are needed to connect platforms run by different organizations, with links between research and education networks and science infrastructure. There is a need to standardized platforms to exchange project data with provision for public access, and there is an opportunity to collect more data by machines supported by good data traffic control.

Operationalizing Open Science in Asia and the Pacific

This study showed that there is still a long way to go before all the necessary policies, infrastructures, and awareness and capacity building needed to meet the requisites for open science in Asia and the Pacific are in place. It was clear from the five focus countries, however, that there are very relevant lessons to be learned from each context and the specific experience of each country. The common and transversal messages shows that there is a widespread need to increase the levels of awareness and understand amongst key stakeholder groups and the general community regarding the meaning of open science, and of the roles, costs and benefits of implementation. More trust needs to be developed and clearer policies need to be articulated with other policy areas, particularly education, science, and the economy, with adequate support and funding mechanisms. To be successful, any open science policies will need to be implemented in careful consideration of each country's political, cultural, and social context.

There are many examples of good open science practices, but also widespread need for further implementation of supporting conditions, including necessary policies, infrastructure, and awareness and capacity building needed to meet the requisites for open science. Specific needs include to demonstrate the benefits of open science to all areas of society; identify the resources available and incentives for investment in open science; set clear guidelines and standards for sharing data within open science objectives; diagnostics of existing infrastructure, networks and other logistics that can support open science; enhance universal conditions of affordability and equity of access to open science infrastructure between and within countries; and ensure mechanisms to meet the long-term costs of open science infrastructure maintenance and support.

Upscaling the findings and lessons from five focus countries, we propose a list of initial actions to help establish the conditions for operationalizing open science in Asia and the Pacific.[3]

- *Establish a UNESCO-led program of capacity building for open* science, including: an *Open Science Dialogues Series on key issues*; *an Open Science Demonstration Project* to gather a set of examples demonstrating the benefits of open science practices to all stakeholder groups in a range of different contexts; *an ongoing mechanism for co-learning* from open science dialogue between countries, clustered around similar contexts and likely pathways toward open science; and *a partnership between UNESCO and coordinators of regional platforms* to support information sharing between all countries in Asia and the Pacific, and globally.
- *Create a "Champions of Open Science" taskforce in each country* with high-level representation from government, science, industry, and the community to focus government attention on open science.
- *Gather and publicly share good examples of open science activities that demonstrate* the benefits for the full range of

[3]See Camkin et al. (2021), for further details on these suggestions.

stakeholders; how open science is helping to address the big challenges of our time, at a range of different scales; and how open science can be implemented in a range of different contexts.

- ➢ *Promote gender equality, disability, and social inclusion* (GEDSI) in all aspects of open science, including knowledge generation, capacity building, policy formulation and implementation.
- ➢ *Take a clustered approach to capacity building for open science implementation* based on groups most similar in context and likely pathways to open science.
- ➢ *Provide long-term career paths for those that support and are custodians* of open science.
- ➢ *Establish a balance between top-down and bottom-up approaches to developing open science policies*.
- ➢ *Maintain long-term support for international collaborations* to sustain and grow open science as an enabler for tackling pressing regional and global issues.
- ➢ *Create incentives that focus on both researchers and other stakeholders* to establish broad commitment to open science.
- ➢ *Create the support mechanisms needed to enable scientists and researchers to publish* results in higher quality journals with peer review processes.
- ➢ *Focus on supporting the conversion of data through information into policy briefs*.
- ➢ *Incorporate the FAIR principles as one of the key standards/guidelines* for infrastructure managers and science communicators.
- ➢ *Periodically review the use of Research and Education Networks*.
- ➢ *Explore and create opportunities and incentives for open access journals* and other publications to follow a not-for-profit approach.

Consistent with one of the strongest messages received through this study, most of these suggestions are necessarily generic—they will require further discussions and modifications to operationalize in a way that is most appropriate for each national and sub-regional context.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The associated data is included in the report (Camkin et al., 2021). The report is currently with UNESCO Office Jakarta for consideration. Requests to access these datasets should be directed to a.sugiura@unesco.org.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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REFERENCES

Camkin, J., Neto, S., Bhattarai, B., and Ojha, H. (2021). *Local and National Mapping on Implementation Strategies and Mechanisms to Enable Open Science for Accelerating SDGs in Asia and the Pacific*. Jakarta: UNESCO Office Jakarta.

Geneva Call (2020). *The Geneva Call: A Joint Appeal for Open Science. Directors-General of UNESCO, WHO and CERN, and the United Nation High Commissioner for Human Rights*. Available online at: https://www.who.int/publications/m/item/joint-appeal-for-open-science (accessed December 8, 2021).

UNESCO (2020a). *Final Report on the Draft Text of the UNESCO Recommendation on Open Science*. Circular letter CL/4349. UNESCO Director General. Available online at: https://unesdoc.unesco.org/ark:/48223/pf0000376130 (sccessed July 8, 2021).

UNESCO (2020b). *Towards a Global Consensus on Open Science: Report on UNESCO's Global Online Consultation on Open Science*. UNESCO. Available online at: https://unesdoc.unesco.org/ark:/48223/pf0000375217?posInSet=5&queryId=28473ea4-beb9-4029-9e75-fb5421b8f4a2 (accessed July 9, 2021).

UNESCO (2021a). *UNESCO Sets Ambitious International Standards for Open Science*. UNESCO press release 2021-128, November 25, 2021. Available online at: https://www.unesco.org/en/articles/unesco-sets-ambitious-international-standards-open-science (accessed December 8, 2021).

UNESCO (2021b). "Towards a UNESCO recommendation on open science: building a global consensus on open science," in *Dr Hans Thulstrup, Officer-in-Charge, UNESCO Regional Science Bureau for Asia and the Pacific. AASSA – AIPI International Webinar on Digital Scholarly Communication* (Jakarta).

UNESCO (2021c). *UNESCO Recommendation on Open Science*. United Nations Educational, Scientific and Cultural Organization. Available online at https://unesdoc.unesco.org/ark:/48223/pf0000379949 (accessed December 8, 2021).

UNESCO (2021d). *About Open Science. Open Science: Making Science More Accessible, Inclusive and Equitable for the Benefit of All*. UNESCO Natural Sciences. Available online at: https://www.unesco.org/en/natural-sciences/open-science (accessed December 8, 2021).

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