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OPINION



Governing Open Science

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ABSTRACT

In November 2021, Member States unanimously adopted the United Nations Educational Scientific and Cultural Organization (UNESCO) Recommendation on Open Science. As attention now turns to the implementation of the Recommendation, time is ripe for the science community to take an active role in governance of the evolving science system if a new era of open science is to serve the global public good. This paper discusses open science in terms of the paradigm shift needed, the potential and directions for the evolution of global science, and governance arrangements in the broader perspective of Anthropocene-related challenges, with the hydrological entry point at its core.

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Open science, as conceived and developed by the scientific community within the last two decades, opens new horizons for science that are essential if we are to address the many global challenges faced by humanity.

The United Nations Educational Scientific and Cultural Organization (UNESCO) has built on this by developing a Recommendation on Open Science, which was endorsed by its 193 Member States at their November 2021 General Conference (Azoulay 2021, UNESCO 2021). In doing so it seeks to intervene in the way that science is carried out, with a level of prescription that is unprecedented in its history. The Recommendation defines open science in terms of its processes: universal open access to scientific knowledge, including scientific publications, research data, software, code, and hardware; open science infrastructures; open engagement with other societal actors; open dialogue with other knowledge systems; and open science communication. UNESCO has identified *what* should be done, and now attention turns to *how* it should be done.

Much as UNESCO claims to be “the legitimate global organization enabled to build a coherent vision of open science and a shared set of overarching principles and shared values” (UNESCO 2020), it is the response of working scientists, their institutions, and funders that will determine whether a new mode of open science is achieved as the “new normal” and whether it realizes the hopes of its proponents.

This article shares the personal views of the authors, based on their involvement in the work of the International Science Council (ISC) and of one of its members, the International Association of Hydrological Sciences (IAHS) of the International Union of Geodesy and Geophysics (IUGG). Publishing it in *Hydrological Sciences Journal*, the journal of the IAHS, demonstrates how a century-old scientific

community offers a reflexive space, and how open science developments can benefit from engaging with and springboarding from the existing self-organized structures of the scientific community. Along with COVID-19-related developments, we place the discussion of open science in the context of long-term and accelerating challenges of the Anthropocene, within which the hydrological entry point provides a key aspect and illustration based on the connecting and interfacing dimensions of water in nature and societies; the increasing role of water in security issues; and the diversity of water-related contexts and epistemologies across the world.

A paradigm shift

The barriers to getting the “how” right are considerable, even though the digital revolution has created the means whereby the essential pre-requisite of open science might be achieved: that of affordable, universal, open access to the record of science (the data, ideas, and knowledge that have accumulated in many forms since the earliest days of scientific inquiry). The list of contextual realities, practices, and processes of science that could impede the UNESCO aspiration is a long and well-documented one (see for example ISC 2021). A highly asymmetric publishing market underpins high prices and excessive profits, and limits access for readers or authors or both, particularly in low- and middle-income countries. Donation of copyright by authors to publishers often places the record of science behind high paywalls and inhibits modern methods of knowledge discovery. Peer review is on life support, crumbling under pressure. The library of record is all but extinct but has not yet been replaced by a digital successor. Data, which should be regarded as first-class outputs of science,

are not routinely published as the necessary evidence for the knowledge claims based upon them. Without routine access to the vast and varied data streams of the modern digital world in an interoperable form, science will fail to respond to the complexity that is inherent in key modern concerns including the imminent environmental, social and economic crises humanity faces.

Solutions to many of these issues are fundamentally impeded by the ways in which we have come to evaluate science and scientists. Proxy assessments of value based on the numbers of publications or citations, journal impact factors or university rankings perversely incentivize counterproductive behaviours that inhibit access to the record of science, whilst driving both a predatory journal market and excessive shifts of university effort from education to research. Assessment systems based on indirect, proxy metrics are classic examples of Goodhart's Law (Koehrsen 2018) that "when a measure becomes a target, it ceases to be a good measure." Why? Because many researchers concentrate on achieving the metric rather than the property that the metric seeks to measure, an effect that is exacerbated where metrics are weak indicators of the properties for which they stand proxy, as they are in this case, and partly because when applied to people, not things, the metrics can be, and are, "gamed" (McKie 2021). These approaches are now widely regarded as inimical to the progress of science generally and of open science in particular, with increasing calls for their reform (see for example Cudennec and Hubert 2008, Koutsoyiannis *et al.* 2016, Quinn *et al.* 2018). The issue is currently being explored in a joint initiative of the ISC, the Global Young Academy, and the Inter-Academy Partnership.

The two paths ahead

Although the UNESCO Recommendation has stimulated much optimism about the potential of a global open science future, it is not difficult to envisage an open science dystopia, notwithstanding the best of intergovernmental intentions. It could emerge from a uniformly prescriptive view of the functioning of metrically managed open systems, that could replace a healthy and creative research ecology with one where inflexible proxy metrics of "productivity" are the tools of an oppressive, data-driven, managerialist system. It could "incentivize" scholars to work harder within a framework of system-wide conformity (Tyfield 2013), potentially through the tools of planning, assessment, and control that are created and marketed by publishing corporations that are accountable only to their shareholders.

In contrast, the shape of a "utopian" outcome may have been demonstrated by the creative, spontaneous and self-organized response of the global scientific community to the COVID-19 pandemic. The benefits of open science had hitherto largely been matters of conjecture, but now it could be seen in action. A wide variety of scientists creatively deployed and applied their knowledge, produced databases and websites, short-circuited the cumbersome processes of some conventional publications through the use of pre-prints, and shared data and ideas with unprecedented openness in ways that set aside conventional constraints and those across the public-private interface. Many individuals offered cogent and impressively clear analyses on public media, playing a major role in stimulating

public confidence and trust, and thereby helping to instil the responsible civic behaviour that has been crucial in inhibiting the spread of infection. But the pandemic also ruthlessly exposed some of the processes that inhibit the effectiveness of science in contributing to the global public good; and the sudden acceleration and intensification of certain valuable practices also led to flaws, some from individual researchers, some from journals and publishers, leading to perverse effects in societal translation including premature circulation, misuse and distrust (Besançon *et al.* 2021, Molldrem *et al.* 2021).

The speed and effectiveness of the response was a direct reaction to the speed with which the implications and threats of COVID-19 for individuals and populations became apparent. Scientists were quickly able to identify critical unknowns and uncertainties, and the need for new knowledge. Open, rapid interchange of data, information and ideas enabled incremental elements of knowledge to be combined to create important strands of corporate intelligence that were able to inform public health priorities, medical interventions, social and civic responses, and socio-political crisis management. While it is true that some of this corporate intelligence remained undisclosed and uncertainties fuelled controversies and misinformation, leading to dysfunctions in the data-information-knowledge-action chain, there are important lessons for the science-policy interface in the context of responding to rapidly evolving, tangible crises that must not be lost in a reversion to the pre-pandemic functioning of the science and policy communities.

Tackling the challenges of the Anthropocene in an evolved science system

Whilst the impacts of COVID-19 have been rapid and dramatic, the perceived threats of Anthropocene changes, and in particular the coupled changes in Earth's hydroclimate and biosphere, have a slower, more complex tempo. Symptoms and threats are less tangible at the scale of individuals, where long-term forecasts are harder for the public and policymakers to grasp as they challenge intuition and short-term thinking (Marshall 2014, Bai *et al.* 2016, Brondizio *et al.* 2016), and where the crises materialize heterogeneously across geography and sectors, such that motivation for general mobilization and action is weak. The inadequate progress towards most of the overarching, internationally agreed goals for environmental and development outcomes (such as the United Nations 2030 Agenda, its 17 Sustainable Development Goals (SDGs), the Paris Agreement, and the Sendai Framework) is evidence of structural inertia and divergent interests in the polycentric world. This lack of consensual appreciation of the Anthropocene and the related "Great Acceleration" (Brondizio *et al.* 2016) is an obstacle to the generalization of open science to support the necessary corporate intelligence.

How can we ensure that the experiences of the last two years catalyse a new era of open science, and that we do not fail the future by allowing science to retreat to its old, pre-pandemic ways and failing to correct some of the observed flaws and perversities? Could the lessons of the COVID-19 crisis experience prove timely in making science more agile, responsive, and efficient in facing the larger, looming global developments of the Anthropocene, including the onset of hydroclimate

change and biodiversity loss of magnitudes that the planet has not known for 10 000 years? To paraphrase Winston Churchill, how can we make sure that we do not “waste a good crisis”?

These issues are important parts of the context for open science. The prospect of a renewed impetus from the COVID-19 experience, rather than a retrenchment, will be heightened if the UNESCO Recommendation succeeds in supporting a multilateral and multilevel framework for open science that converges with and reinforces the momentum that has developed within the scientific community. The energy of the COVID-19 response now needs to be replicated in addressing the urgent global challenges as reaffirmed in 2021–2022 in strong statements from diverse international scientific and diplomatic bodies, including the Intergovernmental Panel on Climate Change (IPCC), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), United Nations Environment Programme (UNEP), UNESCO, World Meteorological Organization (WMO), International Union for Conservation of Nature (IUCN) and ISC.

Governance of open science

We argue that the creativity and effectiveness of the global scientific response to the pandemic was an outcome of the structure and ethos of scientific effort as it has evolved post-World War II, relying greatly on the self-organizing capacities of scientists and science institutions that would also be a sound basis on which to build a modern edifice of open science. Crucial to further development will be the stances taken by the governance bodies of science. At a high level, and in most countries, such governance has been exercised by a triad of key players: governments; their arm's length funding agencies; and science institutions, largely universities and learned societies. Common implicit, and sometimes explicit, premises within this triad have been that whilst governments may articulate their priorities and set research budgets for their funding agencies, decisions on how resources are allocated, and how it is organized should be the responsibility of researchers, and that giving scientists the freedom to follow their inspiration is the best way to maximize the return on society's investment in research. A large part of the broad spectrum of scientific understanding underlying the pandemic response has been the product of decades of public investment inspired from within the above triad. Much originated from university research that was curiosity-driven in an ethos of academic freedom, spontaneity and creativity, all essentials for a new era of open science.

There is, however, a rapidly emerging new actor that is increasingly intervening in this system: the technology corporations that are metamorphosing from publishing company antecedents. They are evolving as multi-sided data–science–knowledge platforms (Gatti 2020) that, through their control of much of the data *of* science, and the data *about* science derived from their publishing activities, have the potential to monopolize the provision of wide-ranging services for

scientists and their institutions, thereby dominating strategic intelligence and the trajectory and effective governance of large parts of the scientific enterprise. Similar developments by other societal sectors, based on the ingestion of vast data volumes deployed through proprietary software and closed algorithms, have handed exorbitant market power to dominant players. The ultimate development of corporate power in the science sector could be privatization of the access to knowledge and the further marketization of publicly funded science – outcomes inimical to the global public good (Boulton 2021) that we believe science should serve.

As the great global challenges increasingly dominate the scientific agenda, as private technology companies invade what has hitherto been a public space, and as open science is taken up intergovernmentally, the question arises whether the governance of the scientific enterprise should be taken back into the hands of the international scientific community. Can we conceive a form of international governance of key open science elements that is distributed, not centralized, and operates to agreed standards in ensuring affordable, equitable access to the record of science, including data resources, in ways that are sensitive to regional and disciplinary needs?

The journal-based publishing system faces deep questions in the digital era. Digitalization offers the opportunity to create an unbiased “record of versions” based on platform-agnostic discovery services, normalization of pre-prints (Drury 2022), servers, overlay reviews, open licences and citable data, and new, more efficient and effective processes of peer review, whereby the scientific dynamism that emerged during the pandemic could be sustained. A more systematic use of the science community's organizations is needed in the processes of peer review, rather than the current ad hoc systems that are crumbling beneath the weight of demand. These priorities and the collection of and access to data about science that are essential to disciplinary, institutional, national and international strategies need to be governed by agreed standards and through or mandated by the international representative bodies of science. The concern for the evolving governance paradigm for open science is recognized in the UNESCO Recommendation, which states that “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” (UNESCO 2021).

The “open science frontier” for a new global science

How can the science community play an effective role in navigating this crossroads? One way would be for regional and disciplinary scientific organizations and trans-disciplinary networks to play a central part. With water being essential to life and health, hydrological processes and changes being at the heart of the climate system and the Anthropocene syndrome (Brondizio *et al.* 2016, Blöschl *et al.* 2019, Caretta *et al.* 2022) and hence of systemic risks (Sillmann *et al.* 2022); SDG6 being strongly linked to other SDGs (ICSU 2017; United Nations 2018); and water security being central to many actual engineering, societal and geopolitical dynamics (Young *et al.*

2015, Ceola *et al.* 2016, Di Baldassarre *et al.* 2019) – hydrology is a critical discipline where open science needs to, and could, progress rapidly in all of the aspects covered by the UNESCO Recommendation (Cudennec *et al.* 2020, Hall *et al.* 2022, Nardi *et al.* 2022). Self-organized and innovative approaches from the scientific communities in such critical disciplines, coordinated and facilitated by international representative bodies of science such as the ISC in partnership with UNESCO, other thematic multilateral agencies and third parties could pave the way to an effective “open science frontier.”

Now that the UNESCO Recommendation has been adopted, creative pathways to change and implementation will be required. They should be sensitive to the processes that maintain the creativity of the scientific enterprise, aware of the roadblocks that impede the adoption of open science, and prepared to act in concert and partnership with the science community. Disciplines and multidisciplinary initiatives that are central to urgent socio-environmental questions of the day must actively participate in this effort. They must also recognize the need for national and local adaptations and implementation supported by the science community’s self-organizing capacity and experience, its innovative power, and its multidisciplinary richness.

Disclosure statement

No potential conflict of interest was reported by the authors.

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