Science for a sustainable and just world: a new framework for global science policy?

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The challenge of global change

The magnitude and implications of human exploitation of the Earth system are becoming clearer each year to the scientists who study them and to the wider public who attempt to grasp them. The Earth's natural capital yields an annual dividend of resources that form the bedrock of the human economy and the life support system for the planet's inhabitants. However, as the world's population grows, its cumulative consumption is increasingly biting into that productive capital. Two human activities stand out, in this regard: the historical development of ever more abundant energy sources to power society and the over-extraction and over–consumption of both non-renewable and, crucially, renewable resources. These activities are not only unsustainable but have also created novel hazards. Their consequences are severe and, for future generations, potentially disastrous. We live in an era in which human society has become a defining geological force, one informally termed the Anthropocene (Zalasiewicz *et al.*, 2008; ISSC and UNESCO, 2013).

The local impact of human activity is transmitted globally through the global ocean, the global atmosphere and global cultural, economic, trade and travel networks. Conversely, these global transmission systems have a local impact that varies in magnitude according to geographic location. This results in a complex coupling between social and biogeophysical processes that has re-configured the global ecology to produce one which is novel to the Earth and to which poverty, inequality and conflict are integral. On account of multiple interdependences and non-linear, chaotic relationships that unfold differently depending on context, this coupling means that attempts to address a problem affecting one aspect of this ecology necessarily have implications for others. Society, therefore, is confronted by a global set of major converging environmental, socio-economic, political and cultural problems that must be understood as parts of a whole in providing guidance for the way in which each can be effectively addressed.

However, this is the set of problems – exemplified by the United Nations Sustainable Development Goals – that society now expects science to help solve, urgently and in ways that are both sustainable and just. Meeting this challenge will require the engagement of peoples from diverse cultures and their leaders; it will demand global responses for which neither the scientific community, nor the policy world, nor the general public is well-prepared. Whereas many sectors of society will need to become involved in this process, the scientific community will have a special role to play.

Central to the challenge is the need to de-couple growth, or even economic stasis, from environmental impact. It is becoming clearer how this might best be done through the widespread adoption of a range of proven or achievable technologies at increasingly competitive costs and of operational systems and business models operating through an enabling economic and regulatory frame. Closely tied to such necessary technological transitions, there is a need for society not only to adapt but to find appropriate ways of fundamentally transforming socio-economic systems, the values and beliefs that underpin them and the behaviour, social practices and lifestyles they perpetuate.

These complex global realities provide a powerful imperative to promote profound changes in the way that science contributes to public policy and practice.

Challenging and changing science

In the past two decades, there has been an increasing realization of the need to create public dialogue and engagement as two-way processes, if effective and equitable public policies are to be developed and implemented. However, the scale and international scope of the challenge described above require an altogether more profound approach (see, for example, Tàbara, 2013). These approaches typically cross boundaries between different disciplines (physical, social, human, engineering, medical, life sciences) to achieve greater interdisciplinarity; foster truly global collaboration embracing the full diversity of scientific voices from around the world; advance new research methods for the analysis of complex, multidisciplinary problems; and combine different types or subcultures of knowledge: specialized scientific, political/strategic, indigenous/local, community-based, individual, and holistic (see, for example, Brown *et al.*, 2010). Open knowledge systems facilitate solutions-oriented research, bringing academics and non-academics together as knowledge partners in networks of collaborative learning and problem-solving and making traditional dichotomies between, for example, basic and applied research irrelevant.

A major example of the open knowledge systems approach at the international level is Future Earth, established in 2012 by an international alliance of partners, including the International

Council for Science, International Social Science Council, UNESCO, the United Nations Environment Programme, World Meteorological Organization, United Nations University and the Belmont Forum, a group of national scientific funding agencies. Future Earth[1] provides a platform for global change and sustainability research. Through this platform, researchers from many disciplines are learning to work with non-academic partners in subject matter-based networks combining knowledge and action on oceans, health, the water– energy–food nexus, social transformations and global finance. Central to the work of Future Earth is the promotion of inter- and transdisciplinary scientific practices.

While the ultimate consequences of the runaway unsustainability of the social–ecological system are, as yet, unfathomed, there are intensified efforts to understand the system by drawing on the perspectives of all disciplines, ensuring their joint, reciprocal framing of the issues and the collaborative design, execution and application of research. At the same time, there has been a shift in emphasis beyond interdisciplinarity towards transdisciplinarity as a fundamental enabling process. Transdisciplinary research engages decision-makers, policy-shapers and practitioners, as well as actors from civil society and the private sector as partners in the codesign and coproduction of solutions-oriented knowledge, policy, and practice. It recognizes that there are multiple sources of relevant knowledge and expertise to be harnessed such that all involved actors are both producers and users of knowledge at one time or another. In this way, transdisciplinarity becomes more than a new way of infusing scientific knowledge into policy and practice, more than merely a strategic reframing of the one-way science-to-action paradigm. It is conceived as a social process of creating actionable knowledge and promoting mutual learning in ways that foster scientific credibility, practical relevance and socio-political legitimacy. It is an effort to link and integrate the perspectives of different knowledge subcultures in addressing social complexity and supporting collective problem-solving. In transdisciplinary research, scientific knowledge 'producers' cease to think of knowledge 'users' as passive information receivers, or at best as contributors of data to analyses framed by scientists. Instead, scientists integrate the concerns, values, and worldviews of policymakers and practitioners, of entrepreneurs, activists and citizens, giving them a voice in developing research that is compatible with their needs and aspirations (Mauser *et al.*, 2013).

A fundamental and, indeed, necessary underpinning for the further development of open knowledge systems is currently being created by national and international initiatives for 'open science' and 'open data' (The Royal Society, 2012). The moves towards wider public engagement in recent years have led naturally to the aspiration that science should become an overtly public enterprise rather than one conducted behind closed laboratory and library doors, that publicly funded science should be done openly, that its data should be open to scrutiny, that its results should be available freely or at minimal cost, that scientific results and their implications should be communicated more effectively to a wide range of stakeholders, and that scientists should engage publicly in the transdisciplinary mode. Open science is also a crucial counterbalance to business models built on the capture and privatization of socially produced knowledge through the monopoly and protection of data. If the scientific enterprise is not to founder under such pressures, an assertive commitment to open data, open information and open knowledge is required from the scientific community.

Challenging science policy

Do the discourses about open knowledge systems and, more broadly, of open science, amount to a new science policy paradigm or framework – one that moves away from seeing the value of science through the (often national) lens of the knowledge economy towards valuing science as a public enterprise working for a sustainable and just world?

In theory, yes. Narratives about basic concepts of science policy have indeed shifted in that direction. For example, within large parts of the scientific community, notions of scientific relevance now focus less on the language of national economic growth and competitiveness, more on the need for transformative research oriented towards finding solutions to the global challenges we face.

We have also seen changes in how the science–policy interface or nexus is understood: from a one-way delivery system based on a linear model of knowledge transfer, with its language of impact and uptake and its dualistic mechanisms of knowledge production and use (e.g. via policy briefs, assessments and some advisory systems), towards a multidirectional model of iterative interaction, with feedback loops and acknowledgement of the messy decision-making processes on both sides.

Last but not least, we are seeing shifts in the geopolitics of science and, particularly, in how we formulate attempts to overcome global knowledge divides. Capacity-building has become capacity development but both have essentially remained locked into the idea of support as a form of catch-up aid for the global South. That thinking is changing towards notions of capacity mobilization, recognizing excellence and the need to support regional science systems in order to foster truly global integration and collaboration. Has a shift towards a new science policy framework been realized in practice? There are encouraging signs of change in this direction. At the international level, Future Earth

1. see: www.futureearth.org

provides a new institutional framework for the promotion of integrated, transdisciplinary scientific practice. More importantly, perhaps, financial support for a such practice has been committed through the multilateral funding initiatives of the Belmont Forum and, more recently, through the International Social Science Council's Transformations to Sustainability Programme.[2]

At the same time, a critical reality check of prevailing science policy practices suggests the opposite. Universities, globally, have a vital role to play here. They are unique among human institutions in the range of knowledge they enfold, in sustaining and reinvigorating inherited knowledge, creating and communicating new knowledge. Only too often, though, that knowledge is still contained and communicated in disciplinary siloes, reinforced by exclusive disciplinary approaches to academic training, funding priorities and incentive mechanisms. Old ways of producing scientific knowledge are perpetuated by traditional forms of evaluation based on unyielding and inappropriate metrics, as well as enduring reward and career advancement systems. Researchers are rarely encouraged (let alone rewarded) to acquire the socio-cultural competencies and engagement skills needed to manage cross-cultural, inter- and transdisciplinary processes.

Creating the conditions of possibility

Science policy is not yet 'walking the talk' of an open knowledge, open science policy framework. The onus lies not only with universities but also with those national science policy bodies that set research priorities, allocate funding and devise incentive systems to recognize and respond to the broader imperative that such a framework entails. In particular, we need creative and co-ordinated solutions from them for a better integration of the natural, social and human sciences in fields such as global change and sustainability research. We also need dedicated support for open, inclusive processes of producing solutions-oriented knowledge in partnership with societal stakeholders. We also need science policy-makers to be critical and reflexive. Theme-focused research must not crowd out creative explorations of unregarded territory to which we owe many of the insights and technologies upon which the modern world is built and where creative solutions for a future world are likely to arise. It is, therefore, vital for there to be careful monitoring and evaluation of the difference the codesign and coproduction of knowledge between academics and non-academics makes to the practice and effectiveness of policy.

Why is this so important? Committed support for integrated, solutions-oriented, transdisciplinary science has real implications for what it means to be a scientist in the Anthropocene – for how they practice their art, how we train them, evaluate and reward them, for the kinds of career systems we put in place. This has implications for how we fund research and whether and how science can respond to current demands for it to contribute solutions to critical global challenges and to support transformations to sustainability. It will determine the role that science plays in shaping the future path of humanity on planet Earth.

2. See: www.belmontforum.org; www.worldsocialscience.org/activities/transformations

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