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How norms, needs, and power in science obstruct transformations towards sustainability

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Abstract

After decades of inadequate responses to scientists' warnings about global environmental threats, leading analysts of the science-policy interface are seeking an important shift of research focus. This switch is from continued modeling and diagnoses of biogeochemical conditions in favor of enhanced efforts to understand the many socio-political obstacles to achieving just transformations towards sustainability, and how to overcome them. We discuss why this shift continues to prove elusive. We argue that rarely analyzed mutually reinforcing power structures, interests, needs, and norms within the institutions of global environmental change science obstruct rethinking and reform. The blockage created by these countervailing forces are shielded from scrutiny and change through retreats behind shields of neutrality and objectivity, stoked and legitimated by fears of losing scientific authority. These responses are maladaptive, however, since transparency and reflexivity are essential for rethinking and reform, even in contexts marked by anti-environmentalism. We therefore urge greater openness, self-critique, and power-sharing across research communities, to create spaces and support for conversations, diverse knowledges, and decisions conducive to sustainability transformations.

1. Introduction

The Nobel Peace Prize winning United Nations Intergovernmental Panel on Climate Change (IPCC) has spent three decades and five global assessments refining its message, which remains fundamentally unchanged: societies must urgently reduce emissions. But political, economic, and social institutions persistently fail to adequately respond and reduce the mounting, interlinked problems of climate change, biodiversity loss, food and water insecurity, and pandemics (IPBES 2018, Dimitrov 2020, United Nations 2020). Considering the deep societal disinclinations to adopt 'non-marginal' changes needed for transformations towards sustainability (Stern 2007, Rosswall *et al* 2015, Blythe *et al* 2018, Newell and Simms 2020, p 8)[4], decades old calls[5] to reshape research agendas are intensifying. Social science analysts of the science-policy interface urge a relative shift in relevant research agendas from continued diagnoses of biogeochemical conditions to central exploration of socio-political obstacles to urgent, just transformations, and how to overcome them (Hackmann *et al* 2014). Judging technical solutions alone insufficient, they stress that public advances 'grounded in the hard-won results of climate science' require turning attention to 'the dynamics of social and political change,' as Sterman wrote in *Science* 13 years ago (2008, p 533). Over a decade ago, Driessen *et al* (2010, p 168) similarly concluded that leading analysts concur that achieving knowledge

[4] In line with, we distinguish between superficial and transformative change, identifying the latter with major, positively disruptive re-arrangements in modes and social systems in ways that break with long-standing hierarchies of power and control over resources and social recognition. We use the term 'sustainability' in its broader meaning, which integrates environmental, social, and economic dimensions.

[5] For history dating back to the Amsterdam declaration, see Moore *et al* 2001, cited in Van der Hel (2018).

capable of supporting socio-environmental changes requires

> a drastic overhaul of science, of politics, and of the interactions between them. Science would have to relinquish its modernistic claims to truth, and along with them its monopolistic presumptions. Scientific processes must be opened up, allowing insight into their workings, and made transparent; scientists and their organizations must be made to bear social and political responsibility; the scientific system must be more closely bound to other subsystems of civil society.

We discuss why global environmental change (henceforth, 'global change') research and assessment agendas have been slow to respond to the calls for more decidedly socially-focused research—research which might help avoid the biogeochemical calamities that natural scientists have so reiteratively and painstakingly defined. We argue that an opaque mix of rarely discussed, mutually reinforcing professional interests, norms, and power-structures dominant within relevant science institutions obstruct the much-needed rethinking and reform required for just transformations towards sustainability. Drawing on others (Newell and Simms 2020), we conceptualize such transformations as major, positively disruptive re-arrangements in modes and social systems, including values, in ways that break with sustainability-obstructing dominant hierarchies of power and control over both resources and perceptions of worth and reality. We illustrate the weight of interests, norms, and unequal power-structures by drawing on our participant-observation as academic social scientists in research coordination and assessment processes pertaining to the international research platform Future Earth and the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES). Both grew from efforts to improve the societal relevance of global change research by, variously, shaping research agendas (Future Earth) and research assessments (IPBES) bearing on sustainability, but they also illustrate the limits of such efforts, due to countervailing forces.

We also discuss the inconvenience but necessity of 'opening up' science in contexts marked by interlinked concerns to preserve scientific authority and strengthen environmental policy. We argue that these concerns stoke defensive retreats behind the shields of neutrality and objectivity—responses that are ill-adapted because they suppress transparency, reflexivity, and interventions to equalize power and status between the natural sciences and the environmental social sciences and the humanities, and as such undermine the needed, deeper transformations.

2. Future Earth

Scientists' professional ambitions and livelihoods depend on continued funding of their research and salaries. This means that they have interests in maintaining the structures that help them obtain it. This is not illegitimate, but it creates resistance to efforts that might shift funds in other directions. It creates conflict of interest when (1) global change science leaders whose constituencies (and/or the science they know how to do and that they value)—stand to lose funding and prestige from proposed changes, and (2) they also have power over whether those changes will be adopted. Shielded by common associations of scientists with objectivity (Toumey 1996) and concerns to maintain the authority of science, this conflict of interest is not generally acknowledged in relevant research and policy communities, and much less openly discussed.

Investments in diagnoses and predictions of global biogeochemical realities depend upon perceptions of significant scientific uncertainty as an obstacle to purposeful policy action, and on the conviction that this uncertainty can be remedied by the funding of additional large scale global science programs (Sarewitz *et al* 2000, Sarewitz 2004). In anthropological fieldwork among U.S. and European climate scientists in the 1990s, I (Lahsen, first author) occasionally witnessed internal conversations about not 'overselling' policy-relevant science by making overly strong claims about its conclusiveness, reflecting attempts to reconcile continued science funding with policy relevance. Decades later, diagnoses of biogeochemical realities and uncertainty reduction remain the dominant center of global change research (Hackmann *et al* 2014). A study (Overland and Sovacool 2020) of the allocation of climate research funding by 333 funding sources in 37 countries found that 770% more funding went to natural science compared to social science, and that only 0.12% of funding went to social science focused on climate mitigation—that is, to prevention of climate change, as opposed to generally less transformative (Hornborg 2009, O'brien 2012) resilience and adaptation efforts.

Sometimes openings for leaps forward arise. Independent reviews of research coordinated under international programs created such opening in the late 2000s. Concluding resoundingly that global change science was high-quality but lacked societal impact, the reviews called for greater action-orientation and policy relevance and, therefore, greater integration of social science (Lahsen 2016). Repeating these conclusions in *Science*, the International Council of Science (ICSU) leaders wrote that social sciences would achieve at least the same dominance and importance as the natural sciences in the coming decade (Reid *et al* 2009). Coordinated by ICSU, leaders of the five international global change research programs and of

US and European science councils and research funders subsequently met in three 'visioning' meetings between 2008 and 2011 to discuss how to reshape research agendas for sustainability. A subset of participants, not least early career scientists, pushed for greater inclusion of social questions, including development and inequality challenges, and questioned decades-old prioritization of atmospheric and Earth system modeling and observation systems—the long-standing priority among national science foundations and science councils partnered under the Belmont Forum.

These ideas and questioning did not significantly impact what was later presented as the supposed outcome of the meeting, however: the 'grand challenges' for global sustainability research. An article published in *Science* (Reid *et al* 2010) presented the 'new' research agenda. More familiar than new, it featured improved Earth system modeling capacity and improved observational data collection (for models) as the two top unquestionable priorities. Social aspects were mostly implicit and tamed in scope, apparent in references to technological solutions, adaptation, and individualized behavior changes[6].

Even so, the visioning eventually yielded the contemporary research platform Future Earth (www.futureearth.org). Emerging from extensive rethinking and debate, Future Earth's research agenda was a major leap forward. It moved beyond the five-point 'grand challenges' agenda, defining a truly new, transdisciplinary research agenda which places socio-political and development challenges among its central foci (van der Hel 2016). It was supported by a subset of natural science leaders who took to heart the reviews and the vision articulated by ICSU's leaders in *Science*. Leaders of four of the five existing global change research programs took the rare decision to terminate and merge their programs into something new and needed. For example, former directors of the International Geosphere-Biosphere Programme (IGBP) recognized that enough is known about biogeochemical realities to warrant action (Rapley 2012) and judged Future Earth 'the way forward' (Rosswall *et al* 2015, p 12). Admirably, they also engaged in rare, sincere, public reflection on the need—and struggle—to change research orientations and guiding values and assumptions, such as a scientific stance of dispassionate, distanced engagement (Rosswall *et al* 2015).

Achieving institutional change requires effective and creative entrepreneurship to create buy-in and overcome countervailing incumbent powers and institutionalized understandings, decisions, and behaviors (Dacin and Dacin 2008, Greenwood *et al* 2017). In this case, by contrast, countervailing interests and norms curtailed the needed restructuring and, thus, the transformative potential of the visioning process and Future Earth. Future Earth exists and is stretching research agendas in new, vital directions, including how to democratically govern artificial intelligence and harness it to sustainability transformations. Starved of decisive funds and power, Future Earth was born weak, however, a shadow of what was intended (Lahsen 2016). At the last hour, incumbent leaders promoting the atmospheric sciences under the World Meteorological Organization and World Climate Research Programme were unwilling to self-terminate and merge under Future Earth, backed by the natural science-dominated Belmont Forum's decision not merge its agenda and budget under Future Earth. The Belmont Forum has since joined forces with Future Earth in some endeavors, including a subprogram on transformations to sustainability. However, it continues to direct its massive budget primarily towards diagnosing biogeochemical conditions and earth system modeling[7]. The Belmont Forum showed 'no signs' that it was working in support of a strong Future Earth programme, according to a former IGBP leader. Indicative of the source of resistance, he followed this observation up by stressing the importance of changing the mindsets of Earth system scientists in favor of new understandings and new forms of scientific engagements (Rosswall *et al* 2015, p 12).

The shield of value neutrality allows incumbent interests against institutional restructuring to present the lack of support of Future Earth as a defense of quality science. Informal conversations within the resistant geosciences sub-communities expressed the unself-conscious judgment that Future Earth's research agenda lacked in quality. Yet these critics lacked expertise in social science and other areas represented in Future Earth's broad-spanning agenda, which was defined by world-leading sustainability researchers, with equal representation of social scientists.

As a social scientist working in environmental science institutions in both the US and Brazil, I (first author) have frequently encountered such lack of humble reflexivity among natural scientists

[6] For discussions of the non-transformational nature of these three emphases, see, respectively, Sterman, J D 2008 Policy Forum: Risk communication on climate change: Mental models and mass balance *Science,* 322, 532–3, OBrien, K 2012 Global environmental change II: from adaptation to deliberate transformation *Progress in Human Geography* **36** 667–76, Shove E 2010 Beyond the ABC: climate change policy and theories of social change. *Environment and Planning A*,**42** 1273–85 For more detailed account of the contrasting visions at the meeting, and of the 'grand challenges' agenda presented in the *Science* article, see Lahsen M 2016 Toward a Sustainable Future Earth Challenges for a Research Agenda. *Science, Technology & Human Values* **41** 876–98.

[7] For examples, see Lahsen M 2016 Toward a Sustainable Future Earth Challenges for a Research Agenda. *Science, Technology & Human Values* **41** 876–98. and the lack of social themes among its calls for proposals summarized at www.belmontforum.org/about/.

with judgment power over the 'quality' and funding of environmental social science. In Brazil, implementation of Future Earth is controlled by natural scientists whose scientific and material interests are served by the long-standing research emphasis on biogeochemical conditions and numerical methods. Environmental social science and humanities are chronically undervalued, underfunded, and, in large part, disconnected from Brazil's global environmental research community. The allocation of science funding by Fapesp (Fundação de Amparo à Pesquisa do Estado de São Paulo, the science agency of the Brazilian state of São Paulo) serves as illustration. In 2017, Fapesp spent US$ 530 million on research, only 9% of which went to social science and humanities, in addition to an unknown part of the 12% directed towards 'interdisciplinary' research (see figure 1). The total pool of funds distributed under a rare, recent (2020) Fapesp/Belmont Forum call for proposals on 'integrated qualitative and/or quantitative approaches that aim at designing transformation pathways to address sustainable development' was a mere €250 000[8]. That is only 1.5 times the monthly energy cost of sustaining a subset of Brazil's exorbitantly costly supercomputers (Sverdlik 2016), of which Brazil owns more than most countries worldwide (Mari 2015). Considering that São Paulo state produces nearly half of Brazil's science output and more than any other country in Latin America (Cruz 2019), this amount is likely much higher than what is made available in all other Brazilian states together, and more than is available in all or most other countries of Latin America.

The vastly unequal funding is also self-perpetuating, since it limits further development of social sciences and humanities research. The persistent underfunding contrasts the importance of these branches of research for understanding and fostering cultural orientations—including 'changes in the hearts and minds of the people' (Sachs *et al* 2019, p 812)—conducive to transformations towards greater environmental sustainability and socio-economic solidarity and equity (Raskin *et al* 2002, p 47, Hulme 2011, Hackmann *et al* 2014, Sachs *et al* 2019). Societal changes require sophisticated understanding of the mechanisms and ethics of fostering change—not least since conceptions of how we should live in the future diverge (Castree *et al* 2020), and perceptions of fairness are vital to ensuring cooperation and solidarity in situations of resource scarcity (Markovsky 2007). The tendency to primarily value quantitative research methods is another reflection of natural science bias, and ignores that social worlds are fueled and sustained by norms and interpretations (Alexander 2019). Although these phenomena tend to resist quantification, they should be central objects of study if the aim is to nurture transformations towards sustainability.

[8] https://fapesp.br/en/14392/new-fapespbelmont-forum-call-for-proposals. The money values are adjusted to capture purchasing power parities across currencies.

3. IPBES

From its inception, IPBES has recognized that meeting its objective of contributing to effective, just, and legitimate policies for biodiversity and human well-being requires inclusive approaches to the production and assessment of knowledge. Recognizing that equity and sustainability are intertwined, also at the levels of research production, IPBES has thus made valiant institutional efforts to include social science and attend to social aspects, including issues of participation, equity, and justice in both research and assessment processes (Tadaki *et al* 2015). It considers including the diversity of worldviews and values that people attribute to, or derive from, nature, leading to a broadening of what is seen as relevant knowledge in the assessment. Such inclusion is considered desirable to increase the quality (and completeness) of assessments, as well as their relevance for different societal and policy actors. IPBES has taken important steps to ensure diverse participation (Timpte *et al* 2018), and not without result; the Global Assessment report that was published in 2019, of which I (the second author) was a lead author, has been heralded for inclusion of Indigenous and local knowledge systems.

At the same time, for reasons discussed below, IPBES has not fundamentally moved beyond the traditional natural science approach that dominates global environmental science, despite recognition that it limits the ability to truly accommodate diverse worldviews and values. This choice, I argue, limits IPBES' potential to support transformative change. Recognition of this is urgent as IPBES is currently planning to undertake an assessment of pathways, challenges, and opportunities for transformative change.

This strong natural science modeling approach in IPBES reflects cultural norms and values embedded in science, but also more mundane and implicit considerations. I have witnessed and participated in informal conversations with the natural science biodiversity community that reflect a certain IPCC envy and a desire to raise the status of their topic. Faced with increasingly tight scientific budgets, IPBES was also an opportunity to boost their current work; many were not necessarily looking to make dramatic changes. Yet, the scientific paradigm that underpins this approach does not fit with different knowledge systems, including critical social science, humanities scholarship, and Indigenous and local knowledge systems (Díaz-Reviriego *et al* 2019). I have noted a willingness among several IPBES experts to reflect on this limitation, but this has not resulted in a fundamental rethinking of the assessment process. One key reason

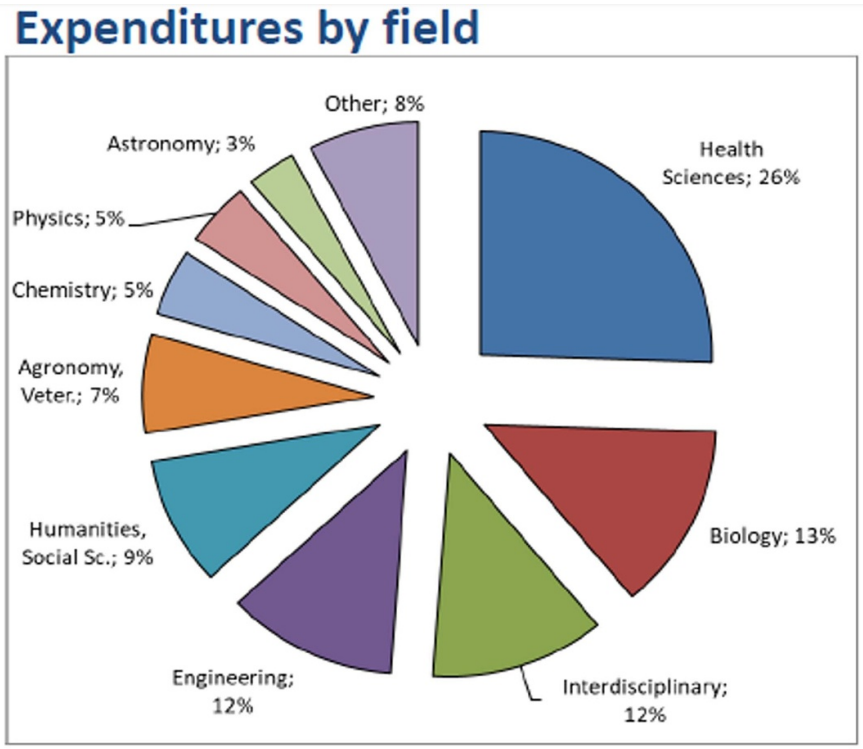

Figure 1. Division of research funds per field allocated by the science foundation in the Brazilian state of São Paulo, Brazil, in 2017.

is that the full inclusion of this diversity will inevitably involve accommodating multiple ways of knowing and living with biodiversity, including multiple, potentially conflicting interpretations of what biodiversity is and what can be done to conserve it. In other words, it would mean recognizing the existence of multiple biodiversity realities (Mol 2002, Strathern 2005, de la Cadena and Blaser 2018).

The acceptance of competing knowledge claims and definitions that such pluralism may require is challenging for IPBES, not only because it is incompatible with IPBES' current approach, but also because of concerns to preserve the assessment's scientific authority. An ongoing discussion among IPBES experts about the benefits and risks of including different knowledge systems reveals a general concern that going too far with this can weaken the assessment's scientific credibility and its authority and uptake among global governance actors. This perceived risk follows from a concern that it may reduce the ability of science to speak with one voice by means of consensus-based assessments. This mixture of scientific and political considerations explains why letting go of the idea of consensus-based knowledge that refers to a singular reality has proven to be a bridge too far for IPBES. The risk is admittedly real. The Global Assessment report's main conclusions that one million species are at risk of extinction and that the deterioration of biodiversity negatively affects human well-being were subjected to critical scrutiny in news and social media, and also in testimonies given in the US Congress, including 'extinction denialists' such as the infamous IPCC critic Patrick Moore.

The commitment to a singular world that underpins much of global environmental science is also a core value in global governance processes that the assessments are meant to inform. The very idea of global governance hinges on the notion that the planet is an appropriate scale for governance and that humans of all nations can and must come together and act for a common cause. This idea sustains the pervasive 'we are all in the same boat' narrative that figures in many global governance negotiations, but that also is strongly criticized for glossing over large inequalities within and between natiFons in terms of power and wealth, relative contribution to environmental degradation, and the distribution of benefits and burdens of environmental action. Thus, as noted elsewhere (Stirling 2010, Turnhout *et al* 2019), the continued reproduction of the linear model of science-society relations in IPBES is not just convenient for experts, it is also expected, if not demanded, by policy makers and institutionalized in the rules and procedures that govern assessment processes; global environmental science and global governance are locked into shared belief in a singular world for science to represent and assess, and for policy makers to govern. This lock-in is a clear reason behind the lack of transformation in IPBES.

If IPBES is to support transformative change rather than only call for it, it needs to provide

space for reflection and transformative learning, and it needs to transform itself and its approach to assessment (Borie *et al* 2020). This challenge is urgent for the upcoming IPBES Transformative Change assessment: traditional approaches to assessing challenges, opportunities, and pathways for transformation would be counterintuitive, paradoxical, and also deeply problematic. Failure to embrace the multiplicity of not just values, but also conceptions of biodiversity, problem framings and potential actions, can result in the assessment reproducing well-rehearsed options for policy that are insufficiently actionable and that gloss over the radically different and unequal worlds that humans and biodiversity inhabit. As Beck and Forsyth (2020, p 3) note: 'transformative change should not be seen as technically viable pathways of changing individual behavior and social values to achieve already-defined objectives (such as the 2050 Vision for Biodiversity and its connections to the Sustainable Development Goals).' Yet, opening those objectives to discussions that include diverse and potentially conflicting values and definitions of biodiversity is a formidable challenge because they are another illustration of how science and governance are locked into shared paradigms and commitments. The objectives provide a comfortable common normative starting point, structure biodiversity data collection and modeling, and inform conservation governance and management by NGOs and policy makers. If these objectives, and the values, knowledge systems, and definitions they reflect, will be used as benchmarks to assess policy options and pathways, this assessment risks the same fate as other assessment processes, and will reproduce rather than transform status quo in science, policy, and society.

4. Discussion: the necessity and productivity of openness

Status quo-supporting decisions and tendencies captured above reflect intermingled cultural and political factors and considerations. 'One world' logics and research emphasis on Earth system- and integrated assessment modeling are supported by common understandings in the natural sciences of what constitutes useful, quality science. Institutionalized norms make these decisions and understandings appear natural and right to their defenders, resulting in a lack of reflection or curiosity about alternatives.

Inside the halls of science and assessments, limitations to prevailing methods and approaches are often recognized, as is the importance of diversity and pluralism. But change feels risky. Scientific credibility is at stake and, with that, authority and careers. Similarly, policy relevance and uptake are perceived to hang in the balance, and with that the political power of global change science, given commitments to singular consensus-based science. Contexts marked by anti-environmentalism further discourage transparency, since backlash actors seek to neutralize environmental policy by promoting perceptions of self-serving, narrow scientific and political interests as the true drivers of supposed environmental agendas (Lahsen 1999). This discourages discussion of extra-scientific influences on global change research and, thus, the openness required to overhaul science and policy.

Openness can be inconvenient, as IPCC leaders learned in the 1990s when Boehmer-Christiansen, a social scientist granted access to study it, asked critical questions. Pondering why United Nations agencies are 'so involved in research rather than policy making,' she wondered: is research 'the only action governments can agree to pursue cooperatively in a world in which 'globalization' is a catch phrase, yet national interests increasingly diverge?' (Boehmer-Christiansen 1994, p 143). She noted that atmospheric sciences benefit from associated funding and prestige (Boehmer-Christiansen 1994, p 145). her criticisms made IPCC leaders disinclined to allow further scholarly participant-observation of its processes (Lahsen 1998, pp 216–20). Close observation-based analysis of IPCC decision- and evaluation-processes and related research communities remain rare (van der Hel 2016).

Climate scientist Anderson has noted that his fellow global change scientists tend to produce analyses that 'conform with prevailing political and economic hegemony' (Anderson 2015). Moreover, recent empirical research suggests that prevalent professional norms among climate scientists encourage them to underestimate and play down climate impacts (Brysse *et al* 2013, Oreskes *et al* 2019). Similarly, an earlier study (Risbey 2008) found bias in scientists' perceptions of framings of how severe a threat climate change is: scientific accounts defining associated impacts as serious were more frequently dismissed as 'value laden' compared to equally scientific accounts of the impacts as mild. Reviewing this and other evidence of conservative bias in climate scientists' judgments, Lewandowsky *et al* (2015) argue that it reflects 'seepage' of anti-environmental discourses into the scientific mainstream, even among scientists who know their underlying premises to be false. Omitting possible roles of more self-serving interests and politics in the scientific mainstream, the authors look to psychology for explanations, discussing only unconscious influences and considerations that might shape scientists' framing choices.

Considering these indications of conservative bias in climate science, and the intractable policy impasse on climate change over 25 years later, one may perceive value in Boehmer-Christiansen's uncomfortable questions, and in public acknowledgement of the social dimensions of scientific processes. One might, as some analysts recommend, encourage and embrace their diversity and, even, agonistic politics.

Frank politics and deliberations can help overcome climate policy impasses (Sarewitz 2000, Sarewitz and Pielke 2000), facilitate more precautionary and democratic decision making about dangerous technologies (Macnaghten 2020), enhance societal resilience (Thompson and Rayner 1998, Verweij *et al* 2006, Stirling 2008) and, even, be emancipatory (Swyngedouw 2010, Mouffe 2011).

Positive outcomes of transparency about politics in science are not widely recognized among global change researchers, including social scientists. Like global change natural scientists, environmental social scientists face delicate balancing of personal, professional, and policy goals when we must choose whether to produce research and writings that transgress the idealized façade of global change science. Transforming science may require more realistic accounts, yet producing them can feel dangerous, and not only to their targets. Already discouraged by fears of feeding anti-environmentalism, producing such accounts carries professional risks. If important gatekeepers judge that acceptable limits have been transgressed, this can cause attacks and exclusions from interesting and career-enhancing events and jobs. This also helps explain the relative scarcity of academic studies of internal processes of global environmental science. Privately, social scientists are ambivalent about the value of performing critical analyses ('deconstruction') of the goals and workings of mainstream climate science, afraid of aiding anti-environmentalism (Latour 2004). Privately or through omissions, such analyses are discouraged (see Nagel *et al* (2010), discussed in Lahsen (2013, p 552)). For social scientists, fears of feeding anti-environmentalism can thus justify the professionally safer choice of other topics.

We recognize that discussing interests and power operating in mainstream global change science is sensitive. Yet, we contend that it is necessary. While counterintuitive due to common, countervailing norms and assumptions, ultimately it is dangerous for scientific authority and for environmental policy to pretend that science is above the play of parochial concerns and influences and able to access and express a singular Truth. Without denying or downplaying the risk of abetting anti-environmental forces and discourses, we call attention to a possibly more serious cost of not taking this risk. As Driessen *et al* also concluded, 'opening' science is necessary to stimulate changes in norms, power structures, and assumptions, and to better align scientific research, assessments, and engagements with just transformations towards sustainability.

Sustaining the pretense that science is not 'immersed in the social' can also seem futile, and even a 'folly' (Castree 2017, p 69), given plenty of obvious evidence to the contrary. When inevitable chinks in the armor appear, the fortress mentality can backfire, feeding even fiercer doubts and conspiracy theories than if the less idealized face of science was more readily acknowledged. This happened in 2009–2010 when 'Climategate' erupted after the unauthorized, anonymous public release of IPCC scientists' internal communications (Lahsen 2013). Looking back now, Climategate serves to question widespread (yet largely unspoken) assumptions that openness about the inherently social nature of science plays into the hands of anti-environmentalism: six rigorous investigations into IPCC scientists' private emails revealed no scientific wrong-doing (Lahsen 2013), and IPCC's assessments have sustained their centrality and scientific authority. This begs reconsideration of fears of a fall into total relativism that sustain aversions to embrace the fact that human knowledge is inherent situated (Haraway 1991, Rescher 1993, Stirling 2019).

Fear of 'feeding' anti-environmentalism by letting down the protective shield of value neutrality and disinterestedness also ignores the logic of politics in the age of 'fake news.' Sustaining pretenses that science is not inherently socially immersed matters little, or less, where there is no sincere engagement with facts. When convenient, pseudofacts are easily 'conjured' as facts, and vice versa (Lahsen 2005). In other words, acknowledging that diversity, conflicts, interests, and norms partly shape scientific content and assessment processes could well be less dangerous than often assumed.

It behooves us to ask if suppression of discussion of interests and power structures in science do not work more *against* than *for* the desired environmental protections.

Answers depend on subjective opinions about whether science is doing the best that it can, and all that is needed. We argue that the suppression creates a lack of transparency that sustains the unproductive status quo in science. Scientific institutions are adept at expunging 'uncomfortable knowledge' (Rayner 2012), evidence that academics also participate in the reproduction and reinforcement of unequal power and privilege distributions through 'interacting social, economic, cultural, political, discursive, cognitive, technical and wider material phenomena' (Stirling 2019, p 2).

A socially beneficial countermeasure to this is participatory and deliberative processes characterized by accountability, diversity, humility, and equitable power relations. If well-designed, such processes can help challenge and alter incumbents' narrow interests, logics, and approaches (Turnhout *et al* 2020), enabling outcomes with higher buy-in and attention to broader, common interests (Fung 2006, 2015, Atlee 2012, 2017, Alexander 2016, Bächtiger *et al* 2018, Stirling 2019, Turnhout *et al* 2019, Macnaghten 2020).

5. Conclusion

We have argued that (a) norms, interests, needs, and power structures in global change science favor continued diagnoses of biogeochemical conditions over research seeking to understand and overcome socio-political obstacles to transformations towards sustainability, and (b) that greater openness, self-critique, and power-sharing across research communities are needed to create spaces and support for conversations and diversity of knowledges conducive to such transformations. Allowing scrutiny of the internal workings of science, such openness is perfectly compatible with scientific authority, and it is most conducive to policy impact and societal change.

In global change science, earth system (especially atmospheric) science leaders sit at the top of a hierarchy of power and prestige. They are beneficiaries of the status quo in research agendas *and*, dangerously, also control decisions about continuity versus transformation. Some have used this power responsibly, even relinquished it. Others have not. In science as in society, decisions about change (and funding) should not lie with those with attachments to the old order. Funders can help make interventions to ensure that (Arnott *et al* 2020), and generally help drive needed changes in research practices.

The social sciences and humanities have their own sub-cultural dynamics and limitations. Nevertheless, they can offer vital knowledge of how social orders reproduce themselves and how they can change, democratically, in direction of transformations towards sustainability (Dacin and Dacin 2008, Scoones *et al* 2015).

Hannah Arendt has provocatively claimed that no one must be allowed to be an educator unless they assume responsibility for addressing the world's dire problems (Arendt and Kohn 2006, p 186). Her point extends to researchers. What is ultimately at stake are the conditions for political (re)creation (Straume 2019), and whether humans seize on existent possibilities to reconcile respect for planetary boundaries with development aspirations and human well-being. The window of opportunity is rapidly narrowing (Randers *et al* 2018, 2019, Steffen *et al* 2018, Sachs *et al* 2019). If the stubborn obstacles to safe, just, and accountable transformations towards sustainability persist, we will lose the opportunity. Biogeochemical dynamics may be easier to study, and they may lend themselves better to the more prestigious numerical methods. To ensure just transformations towards sustainability and bring the hard-won results of climate science to benefit societies, however, attention must now center at least as much on the task of understanding and directing the dynamics of social and political change. The endgame is a successfully conducted realization of the capabilities of current and future generations to privilege human wellbeing over financial gain and ensure the viability of their natural worlds.

Data availability statement

No new data were created or analyzed in this study.

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