

Bridging barriers to advance global sustainability

Academic enterprises seeking to support society's efforts to achieve global sustainability need to change their legacy reward systems. We need new structures to foster knowledge that is deeply integrated across disciplines and co-produced with non-academic stakeholders.

Elena G. Irwin, Patricia J. Culligan, Marina Fischer-Kowalski, Kara Lavender Law, Raghu Murtugudde and Stephanie Pfirman

Across the world, universities, research organizations, funding agencies, professional societies and national academies, alike, are striving to contribute to the knowledge needed to solve the wicked problems of sustainability. Through the lens of sustainability research, many academic institutions aspire to advance solutions to climate change, land degradation, water scarcity, collapsing ecosystems, expanding urban slums and other global crises that threaten the well-being and future of our communities from local to planetary scales.

Despite well-intentioned initiatives, enormous potential and occasional successes, our academic institutions are largely failing to support society's effort to achieve global sustainability. This is due, in part, to a fundamental mismatch between the legacy reward systems that continue to govern our academic enterprises (Box 1), and the new structures needed to further sustainability research. Faculty and others engaged in research continue to be largely rewarded for their individual-level accomplishments within a specific discipline or academic unit; for example, the count of papers as a corresponding author or number of grants secured as a lead investigator.

In contrast, advancing global sustainability often requires collaboration of researchers from multiple fields. Projecting climate change impacts requires knowledge synthesis across the physical, natural and social sciences. In addition to advancing academic understanding, sustainability research is also goal oriented and often seeks to advance solutions¹. Research into the causes and consequences of deforestation, for instance, is often accompanied by proposed solutions for sustainable forest management².

There is a role for disciplinary-based research to advance sustainability, for example, in the development of membrane-based desalination technology to combat water scarcity³ or behavioural science to understand climate change risk perceptions⁴. Nonetheless, the advances needed to address the wicked problems of sustainability most

often require interdisciplinary research that synthesises academic knowledge from two or more disciplines, and beyond this, a deeper integration of knowledge, methods or ways of thinking that transcends disciplinary boundaries. An emerging research agenda for sustainable urban systems, for example⁵, emphasizes a new framework that conceptualizes these systems as multiscale, interdependent social, engineered and natural systems. This research agenda calls for convergence research on urban systems — that is, research that moves beyond interdisciplinary collaboration to achieve deep knowledge integration across disciplines to create new systems frameworks for integrative work⁶. For example, assessing the resource consumption of a city requires not only accounting for its population and other socio-demographics, but also its interconnections across space to understand how technological, environmental, or other changes in one city influence the flows of people, money, resources, goods and services across other cities. This requires new data and frameworks that can integrate the disparate approaches that are currently used to model these physical, environmental and economic interdependencies. Furthermore, when sustainability research

seeks to advance solutions, the collaboration of academics with practitioners and others outside of academia is increasingly seen as necessary⁷. Knowledge integration across a range of academic and non-academic bases is often termed transdisciplinary research⁸. We argue that nurturing and supporting sustainability research through convergence (deep integration) and transdisciplinary (co-production with stakeholders) research is essential to advance global sustainability.

In health, the paradigm of convergence research brings together life sciences, physical sciences, engineering and non-academic stakeholders to address the healthcare challenges of the twenty-first century. Resources are being provided by government and industry alike because of market opportunities associated with the 'biology economy'⁹. This type of approach is essential for sustainability research, but is harder. Problems concerning human and planetary well-being cut across many more disciplines, including the humanities. Furthermore, unlike opportunities for commercialization in healthcare, for example, private incentives are not as well-aligned with global sustainability. Because ecosystem services, such as climate regulation, are public goods, the private sector is not incentivized to

Box 1 | Individual quest for scientific truth

The prevalence of the individual, disciplinary-based reward systems is partly the result of a historical emphasis on a quest for 'the truth' pursued through basic research that is removed from practical applications. This view was championed as untainted from the economic, political, ideological and religious interests that might accompany practical application. The long-held, defining principle of individual autonomy in academic enterprises, which dates back to medieval times¹³, also helped create a culture of individual identity and achievement. As a result, 'individual

contributions to scientific truths' became an almost universal standard for judging researcher quality and remains a key criterion for tenure at universities around the globe. A potentially unintended consequence of this reward system is hyper-specialization within disciplines and fragmentation of knowledge in both research and teaching¹⁴. While this emphasis on the individual gave us the Copernican and Industrial revolutions, sustainability research requires institutional and collaborative structures to support and accelerate a so-called second Copernican Revolution¹⁵.

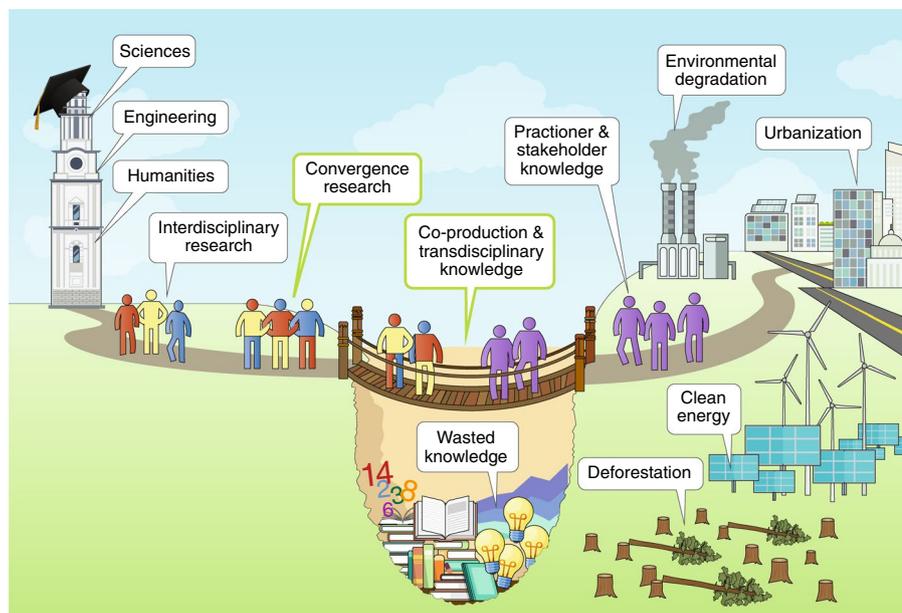


Fig. 1 | Bridging barriers to advance global sustainability.

provide them. This reduces market-based opportunities and increases reliance on public sector funding.

Government funding agencies are increasingly supporting sustainability research. In 2016, the Canadian government announced new investments in ocean science research to support sustainability of Canada's coastline, the largest in the world. But funding agencies regularly shift their priorities, making it hard to establish and nurture convergence and transdisciplinary approaches. Even when groups obtain funding, they are often left with no way to continue their work beyond relatively short (approximately five years) periods. The expectation is that researchers can secure funding for continuity, but this is often unrealistic for a field with fewer market opportunities.

The lack of academic incentives and funding for sustainability research is further compounded by the dearth of communication and outreach structures that would enable decision-makers and stakeholders to easily access relevant research. Potentially useful knowledge languishes in academic journals, racking up only citations by other researchers, and avenues for meaningfully engaging non-academic stakeholders in research design and implementation remain scarce to non-existent.

The need to transition towards a more sustainable society has seeded many initiatives, including academic centres and institutes, such as The Earth Institute at Columbia University¹⁰. Nonetheless,

our academic enterprises and their legacy structures remain largely inadequate'. New mechanisms, policies and tools specifically designed to foster convergence and transdisciplinary sustainability research are required to bridge the barriers that currently limit the effectiveness of scholars and academic institutions. These bridges should foster deep integration of disciplines (convergence), and collaboration between academic and non-academic stakeholders (transdisciplinary), that together enable the co-production, communication and application of knowledge to spur sustainable development solutions (Fig. 1). In what follows, we provide examples of institutional innovations in three areas needed to build these bridges.

Productivity and impact

New metrics are needed that place value on deeply collaborative work, practice-oriented outputs and real-world impact. Interdisciplinary publications in high-quality journals should be explicitly incentivized and publishing with multiple co-authors from different disciplines recognized as a positive indicator of a researcher's ability to collaborate. Just as the US National Science Foundation (NSF) has broadened research outcomes to include products that are not academic publications, such as datasets and software, metrics for research productivity and impact should also be broadened to include non-academic contributions. For example, transdisciplinary research that leads to the co-creation of a peer-reviewed sustainability

plan for a local community should be valued as highly as a refereed journal article. New forms of citation indices that measure uptake or impact of research outputs should be introduced. While measurement of long-term impact is challenging, shorter-term impacts, such as inclusion of research outputs in sustainability plans or policies, can more easily be tracked. Judgement of research contribution and impact could consider input from non-academics engaged in sustainability work. Dossiers of hiring, tenure and promotion letters might include input from expert community stakeholders. High-status awards could be created by professional societies, governments and foundations to specifically recognize collaborative teams for their contributions to global sustainability. Academic honours, such as named chairs, university professorships and election to national academies, should validate the importance of convergence and transdisciplinary approaches. And academic scholars and administrators should accept the responsibility of legitimizing these new metrics both for their own work, and the work of others — in particular, early career scholars. If 'individual contributions to scientific truths' remains the standard for judging researchers, our institutions will perpetuate their failure to support global sustainability.

Research funding mechanisms

A greater amount and variety of funding mechanisms are needed to support convergence and transdisciplinary sustainability research over longer periods of time. The NSF's Long-Term Ecological Research (LTER) programme provides a good example of sustained funding to support area-specific long-term observation, experiments and modelling. An International LTER effort (ILTER) now engages researchers, practitioners and other stakeholders in knowledge generation for sustainable ecological development at 800 sites around the globe¹¹. Equivalent LTER sites, supported through international scientific research funds provided by developed countries, should be initiated to advance convergence and transdisciplinary sustainability research.

Other mechanisms to incentivize academic and non-academic collaborations include the development of more proposal solicitations that require community partners. NSF's new Smart and Connected Communities (SCC) programme is one avenue, although academics are still the primary recipient of resources. An alternative approach might involve the chief sustainability officers of local or

state governments, or even companies, partnering with government agencies to request proposals from academic and non-academic teams that address specific sustainability challenges. The involvement of practitioners in reviewing proposals would help to ensure that funding is targeted towards advancing convergent and transdisciplinary knowledge that responds to a specific sustainability challenges and has potential use. Foundations that support sustainable development through programmes, such as the Rockefeller Foundation 100 Resilient Cities and the Bill and Melinda Gates Foundation Agricultural Development Program, could join forces in overlapping areas of interest. Spreading foundation funding across a myriad of projects and stakeholders is a barrier to global sustainability — the Co-Impact global philanthropic collaborative (<http://www.co-impact.io/>) announced in November 2017 is a new model that has potential to overcome this barrier. With increasing attention to driving positive change and sustainable development through business, global corporations like Unilever are developing their own sustainability goals. Although private sector and societal goals are not always well aligned, there are increasing opportunities for engaging companies to advance the state of practice and address the dire need for more market-based solutions to sustainable development.

Communications and outreach

Effective communication avenues and outreach that suit the needs of different stakeholder groups are required to enable the results of sustainability research to be usefully translated and applied. This requires an understanding among researchers, practitioners and potential end-users of the different communication protocols and needs of each group. Many companies have incorporated social media into the communications they use to broadcast their company's sustainability efforts¹². Lessons learned from these

approaches, and others developed in the corporate world, should be leveraged. Journals such as *Nature Sustainability* could dedicate articles to case studies and best practices as one means of disseminating globally lessons that are learned locally. The engagement of communication and outreach specialists in developing communication plans and implementing best practices could also help ensure success. Building on the US land grant extension model for higher education and outreach, universities could employ sustainability extension specialists. 'Sustainability laboratories' affiliated with research institutions or centres could offer a certain number of workplaces for several months to international candidates who apply for 'researchers in residence' status. The purpose of these visiting appointments would be to foster global interactions and learning among institutions by encouraging the transfer of knowledge and experiences to other places. This activity might be organized by the International Science Council and financed by various national funds.

As a defining challenge of the twenty-first century, it is imperative that we work to minimize the academic barriers to global sustainability. Our proposed bridges articulate the structures that we believe are necessary for supporting the convergence and transdisciplinary research essential for sustainable development. Building these bridges will require the commitment and support of scientists, administrators, funders and a multitude of non-academic stakeholders engaged in sustainability initiatives from local to global scales. Unless there is a commitment to change, academia will fail to deliver on the promise of a more sustainable world. □

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