A Commentary Article:
Closing the Loop of Reflexivity
Summary: As global lessons are emerging on the enablers of effective knowledge co-production, an inclusion of greater reflexivity may be the next frontier for the integrated assessment communities.

The boundaries between integrated assessment and sustainability action will continue to blur in the coming years. From rising temperatures and sea levels to disappearing forests and biodiversity, global integrated assessments are increasingly painting a bleak future for our planet. According to the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), global warming beyond the 1.5 °C temperature mark in the coming decades presents considerable risks, including irreversible impacts, to our society, economy, and ecosystems. Political will to act seems finally to be catching up - net zero targets have been adopted by more than 70 countries representing some 80% of greenhouse gas (GHG) emissions globally. The Race to Zero initiative includes over 1,000 cities, 5,000 firms and 400 financial institutions and integrated assessment increasingly inform new actors including central banks and financial supervisory agencies. With countries, cities, and communities increasingly turning to science-informed actions, this will mark a turning point for the global integrated assessment communities.

The global integrated assessment communities, numbering hundreds of scientific groups across the world, use coupled biophysical and socioeconomic systems models to guide policies across sectors such as energy, agriculture, water, ecosystems, and biodiversity. Integrated science, which began in the 1980s has responded to evolving policy demands for a greater integration of the human dimension and, more recently, knowledge co-production. Research is currently active to improve the usability of integrated assessment such as participatory modeling and scenario services, however such emphasis alone will likely miss greater opportunities for reflexive learning. Here, we summarize few lessons learned of knowledge co-production and identify the analytical frontiers of reflexivity.

Knowledge co-production in action
Knowledge co-production places a greater emphasis on the end-user needs as a starting point of scientific inquiry, upon which scientists and stakeholders engage in joint fact-finding. Key lessons learned of ongoing knowledge co-production include:

A blending of the natural and social sciences is crucial to the successful contextualization of integrated assessment. Social science approaches, such as institutional analysis, stakeholder mapping, qualitative interviews, and informal exchanges, are essential to identifying the latent, timely and salient demands for scientific assessment and identify any historical, political and cultural sensitivities that must be addressed simultaneously. What has worked effectively is that an interdisciplinary team starts with a governance assessment followed by integrated modeling. The concurrent use of social and natural science expertise ensures as the options for technical solution are analyzed, stakeholders also become aware of "social innovation options," that is, who must be mobilized and what institutional arrangements need to be changed so that action can be taken on science-informed solutions.

Model resolution, data access and validation currently pose barriers for effective application of global integrated assessment at finer scales. Global modeling, which typically employing a set of universal assumptions and parameters, does not allow for the inclusion of local feedbacks that may be relevant from the stakeholder viewpoint. At present, the global integrated assessments can readily be applied to transboundary scales, while country and local scale application will require a nested approach, combining global and local modeling frameworks. Such technical barriers are, however, increasingly being overcome thanks to the latest research and development, including the use of hyper-resolution modeling which provides exciting new avenues for localized knowledge co-production.

Stakeholder engagement methods such as interactive scenario development, role-play and social simulation, and design thinking offer an effective functioning of "boundary objects" that are "plastic enough to adapt to local needs… yet robust enough to maintain a common identity across site." This allows scientists and stakeholders to jointly explore the local implications of Earth system
interactions. Social and natural scientists working together may draw from a variety of disciplines such as anthropology, social psychology, education, and future studies to design common spaces for dialogue and experimentation.

**Box 1: Co-Implementing Integrated Assessment Modelling Research**

Global integrated assessment models, including multiple earth system feedbacks, are often hard-to-grasp for the non-technical audience. At the same time, on-the-ground realities of sustainability challenges are equally complex, which cannot be reduced to a set of simple equations.

The use of novel stakeholder engagement tools such as interactive scenario design, social simulation and design thinking provide a structured means for joint dialogue between scientists and stakeholders (Fig1 left).

In a Global Environmental Facilities funded initiative the Integrated Solutions for Water, Energy, and Land (ISWEL) project implemented in the Indus and Zambezi basins, for example scientists and stakeholders have experimented the use of interactive scenario design to share respective views on sustainability challenges (Fig 1 right).

Articulation of the business as usual (BAU) challenges as well as sustainability transformational pathways across water, food and energy issues are facilitated by the maps of basins topography and hydrology along with a set of visual prompts (cards) representing institutional, economic, technological, and cultural dimensions that may be relevant for stakeholders. Using a scenario in-casing approach, stakeholders elaborated and debated locally relevant narratives of issues and solution options.

As a subset of visual prompt directly corresponded to variables and parameters in the Global Integrated Assessment Models, researchers and stakeholders shared a common means of evaluating the water implications of the co-designed scenarios, both quantitatively and qualitatively. Scientist evaluated the synergies and trade-offs of technical solution options proposed by stakeholders quantitatively, while stakeholders deliberated on needed social innovation qualitatively. The quantitative and qualitative analytical results were once again deliberated in a subsequent workshop, where scientists and stakeholders developed a joint vision for the basins’ sustainability pathway.

*Figure 1 Recent Cases of Stakeholder Engagement (Left) ISWEL Scenario Co-design (Right)*
Finally, the concurrent implementation of stakeholder engagement and research planning is crucial to navigate the competing needs for simplicity and context-specificity on the one hand, and analytical rigor and systematic knowledge accumulation on the other. Scientists may, for example, be asked to use a simplified model or to deliver analytical outputs according to a certain political timeline. Meeting these end-user demands, although important, should not be the sole determinants of our research implementation. Researchers should instead reserve sufficient room for scientific advancement, articulating the novelty of the research vis-a-vis the existing body of literature.

Towards Reflexive knowledge co-production

While the global integrated assessment communities continue to advance the frontiers of knowledge co-production, this provides unique opportunities for debates and learning regarding the appropriate means of achieving a just climate transition.\textsuperscript{16} Deeper reflection on beliefs and norms, beyond the mere use of science, will be an essential catalyst for such endeavor. Reflexivity allows open debate on the desired goals, means, and necessary trade-offs in the transition. Being reflexive, which encompasses the larger socio-political questioning of values, assumptions, and power, is often distinguished from being reflective, which is deeper cognitive processing.\textsuperscript{17}

When applied to knowledge co-production, reflexivity pertains not only to marginal improvement in the way integrated assessment addresses particular societal demands for science but also to deeper reflection that allows our science–policy institutions to evolve appropriately. While the importance of reflexivity in knowledge co-production is beginning to be recognized,\textsuperscript{18} it is yet to be seen as an overarching framing that can be operationalized to foster a greater potential. Here, we offer a framework on reflexive knowledge co-production, outlining key dimensions and priority research agenda (Fig 2).
As natural scientists strive for improved downscaling of global integrated assessment models, equally important is social science expertise on appropriate theories, methods, and empirical insights to contextualize knowledge co-production. As noted in our lessons learned, contextualization of knowledge co-production can be facilitated by various social science research, together with the use of boundary objects. While we often focus on this abstract (global) to contextual (local) application of science as a goal of co-production, our new framing emphasizes that local application should also foster greater sense-making of sustainability challenges and opportunities by local actors, thereby leading to scaling of actions. At the same time, we may also foster a contextual (local) to abstract (global) upscaling and reflexive synthesis, developing and testing new theories and methods as well as prompting deeper questioning. Using global integrated assessment, we may track not only global progress on sustainability actions but also improving on our science-policy institutions.
Operationalizing reflexive knowledge co-production framework will require concerted efforts globally, aimed at systematic knowledge accumulation, scaling of approaches, and deeper reflection on the way scientists engage in knowledge co-production. This can be achieved, for example, through the use of common research protocols for the gathering of stylized facts, development of theories and testing of hypotheses, and the identification of shared questions for global deliberation. The existing global platforms such as Future Earth, the Coupled Model Intercomparison Project (CMIP), the Intergovernmental Panel on Climate Change (IPCC), The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and emerging networks including the Global Adaptation Mapping Initiative could form communities of practice for such purposes. The scientific community-wide synthesis is common for fields such as medicine, and standardized research protocols is already widely used for climate downscaling exercises and social science research on common pooled resources such as forest. Recent efforts such as the Earth System Governance Taskforce on Knowledge Cumulation, global systematic synthesis for adaptation, and the Nature Futures Framework for biodiversity assessment are also moving in this direction.

Adding elements of reflexivity could catalyze this global synthesis. Based on our application of global integrated assessment modeling, we have identified questions that merit transdisciplinary reflection. These include but are not limited to: the need for a major rethink of global modeling, such as greater integration of multiple sphere feedbacks and the use of modular and flexible approaches for local application; and the need for a major rethinking of capacity building, involving not only local researchers, but private sector and civil society organizations. Reflexivity will also be helpful for questioning established concepts, theories, and approaches that are built using particular disciplinary lenses and also for learning from the viewpoints of stakeholders. In fostering deeper reflection, the integrated assessment community should not shy away from openly addressing the other known
challenges such as underrepresentation of social science and humanities, groups of, for example, female scientists, and groups from non-European and North American countries.

The frontier of systems analysis lies between the edge of scientific analysis and the realm of the human spirit, as Dr. D.H. Meadows described nearly two decades ago. But such distinction increasingly blurs as the global integrated assessment communities and stakeholders work to solve the grand sustainability challenges of our time. As analyses are increasingly embedded within the agency of actors, this offers greater opportunity to close the loop of reflexivity.

References


4 https://www.isimip.org/about/.


19 https://www.cochrane.org/

20 https://cordex.org/

21 http://ifri.forgov.org/resources/methods/

22 https://www.earthsystemgovernance.org/research/task-force-on-knowledge-accumulation/

23 https://globaladaptation.github.io/

24 https://www.irdrinternational.org/what_we_do/working_groups/12

25 https://ipbes.net/scenarios-models

