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What role for global change research networks in enabling transformative science for global sustainability? A Global Land Programme perspective

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Abstract

Global environmental change (GEC) and sustainability science (SS) communities' science is increasingly challenged to inform transformations to sustainability. Recognizing this, the Global Land Programme (GLP), a network of the international land system science community, is developing, testing, and launching new network infrastructures, science–policy interfaces, and co-production approaches. This paper charts the efforts of the GLP – since its 2015 joining of Future Earth, a 10-year initiative to advance global sustainability science – to support the land system science community as it endeavors to produce transformative research oriented toward sustainable development. Moving from incremental to transformational modes of knowledge co-production across scientific research networks – such as those represented under the umbrella of the Future Earth — requires that these work across multiple knowledge domains, scales, contexts, and regions, and in collaboration with a diversity of actors from global-level decisionmakers to national, regional, and local level civil society organizations as well as the private sector. Beyond the generation of fundamental science, GLP's rich co-design tradition of working with land managers and linking case-study and field-based research to global synthesis situate it as a key institution and platform accelerating transformative research oriented toward sustainable development.

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Introduction

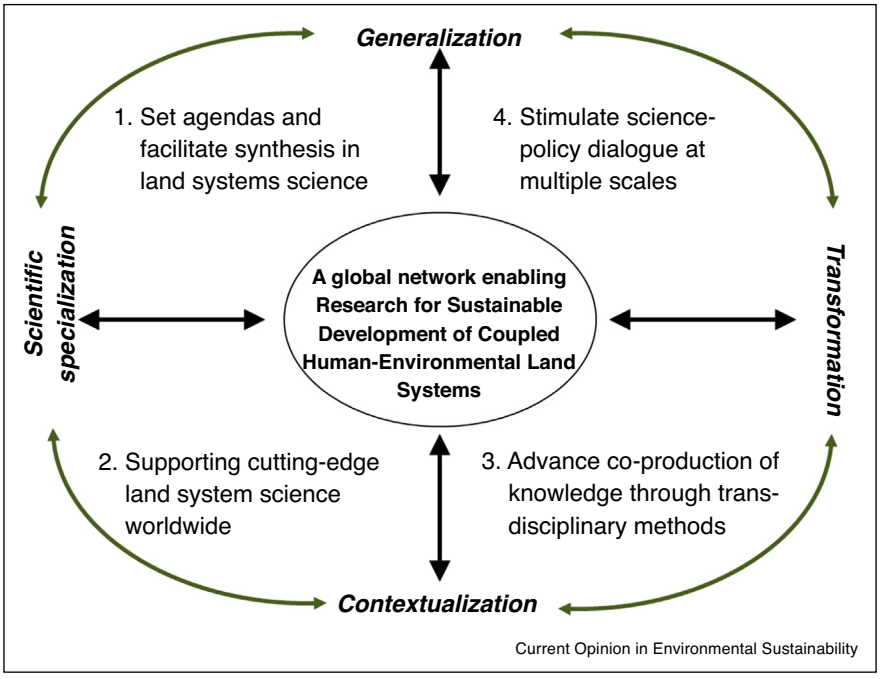
The last several decades have seen increasing calls for integrated social–environmental and/or global environmental change science (GEC) to better mobilize knowledge for the pursuit of sustainable development [1,2]. Most recently, the Future Earth research initiative – of which the Global Land Programme (GLP) is a 'global research project' (GRP) representing the land systems science (LSS) community – aims for its collection of programs and networks[4] to 'enable a systems-based approach to global sustainability through the Sustainable Development Goals' and 'provide transdisciplinary science needed to make them actionable' [3, pp 9 and 34].

Such asolutions-oriented discourse is not new; participatory research [4] and transdisciplinarity [5] have long encouraged inclusion of a broader range of actors in the production of scientific knowledge. For the foundational programs that preceded Future Earth, such as the World Climate Research Programme (WCRP) and the International Geosphere Biosphere Programme (IGBP) [6] the move toward interdisciplinary and transdisciplinary research [7] marked a decisive shift, ultimately reconfiguring much of the global environmental change science institutional infrastructure. Future Earth emerges as a new research program to carry forward 'global sustainability science' defined by interdisciplinarity, co-design and co-production with societal actors, and an emphasis on important boundary work between science and society to make findings 'useable' and 'actionable' [8,9]. But this 'solutions-oriented turn' made by Future Earth, and, by extension, by the GEC science communities assembled within, necessitates a closer look at the role of science in society [10] and its normative dimensions [11•,12] and a stronger effort to activate dialogue between researchers and civil society actors, as well as decision makers [13•].

GLP's mission is to enable research for sustainable development of coupled human–environmental land systems (Figure 1). This mission entails a bridging of scientific innovation (specialization) with societal relevance (transformation) and employs place-based research (contextualization) to feed

[4] The Global Research Projects (GRPs), Knowledge Action Networks, (KANS), and Future Earth National Committees are considered to be main vehicles for the activities of Future Earth.

Figure 1



GLP's mission, overall goals, and objectives 1–4.
Adapted from: Hurni H, Wiesmann U. 2014. Transdisciplinarity in Practice. Experience from a Concept-based Research Programme Addressing Global Change and Sustainable Development. GAIA – Ecological Perspectives for Science and Society. 23(3):275–277. doi:https://doi.org/10.14512/gaia.23.3.15.

synthesis-understandings of the patterns and processes of global change (generalization). Accordingly, GLP's three overall goals are to: 1) Set and drive an agenda for the land systems science community that links scientific advancement to societal relevance; 2) develop new synthesis methods and products to connect contextual understandings to regional and global trends, drivers, and consequences; and 3) support and maintain a vibrant network of scientists enabling that work together with new assemblages of actors including civil society, government, and private sector, in new modes of science–society interaction, toward sustainable development of land systems.

Underlying these goals is the hypothesis that the development of transformative social pathways toward land-related Sustainable Development Goals (SDGs) remains inhibited by fragmented activities of involved stakeholders and their knowledge. While private actors, development practitioners, and policy makers may be strengthening their collaborations, the majority of researchers are still absent from such partnerships.

This paper, then, shares the experience of the Global Land Programme as it has worked to enable transformative science throughout its network since 2015. We describe ongoing efforts by the GLP to institutionalize knowledge co-production, set agendas for transformative science through interactive dialogue with societal partners, and generate socially relevant science. Its goal is to offer insights as to how one scientific research network (GRP) of Future Earth – albeit with a long history of its own conducting participatory, engaged research in land systems throughout the world – is working to facilitate and enable this form of transdisciplinary research as well as to build platforms for constructive and transformative engagement with societal actors through science–policy interfaces.

GEC research networks: cross-scale platforms for enabling sustainability transformations

A growing body of knowledge supports the implementation of co-production and transdisciplinary approaches at the level of individual researchers and projects [14–19]. Yet, there is much less practical insight into how transdisciplinary approaches, considered key toward enhancing the relevance of science for achieving development goals [20,21], can be effectively mobilized and scaled-up, and how GEC network infrastructures in particular can best facilitate and enable co-production and co-design of research for global sustainability. Where could science–policy interfaces be established as an aid in navigating competing development claims in concrete policy, planning, and development processes? What kinds of society–science partnerships at what scales have proven to be

effective vehicles for land systems transformations? Or could in the future? How do we support transformations as a research network? Here, we attempt to address these questions and foster discussion on the potential for international scientific networks to contribute to the SDGs and, more broadly, to societal sustainability transformations.

This paper argues that if we are to create partnerships that render knowledge 'useable,' and instill trust, as well as move from incremental to transformational modes of societal change, scientific networks and in this case the GEC 'network of networks', or 'federation' that is Future Earth, must expand their understanding of who, where, and when to engage. Part of the work of co-design and co-production is, not only for individuals but also for institutions, to critically understand our values and our role [12,22]. Thus, this assemblage of 50 000 scientists working across the world as a part of more than 20 Global Research Projects as Future Earth [3] is now called to work across multiple knowledge domains, scales, contexts, and regions, and with a diversity of actors from global-level decisionmakers to national, regional and local level civil society organizations [7].

In the sections that follow we briefly map the evolution of co-production approaches in LSS, charting this along the trajectory of the emergence and consolidation of land systems science as an 'interdiscipline' [23], and of the GLP as referent for the LSS community. We then present current efforts facilitated by the GLP International Programme Office (IPO) working with the GLP community to: 1) identify promising topics, lines for co-production, and research gaps via triangulation of land policy actors' knowledge needs, land-related interactions in the SDGs, and available land system science; 2) establish pilot processes of knowledge co-production between development and land systems science partners; and 3) establish network infrastructure that supports and advances further co-design and co-production of knowledge throughout the community. We conclude with a reflection on how such efforts by GRPs might contribute to an even more effective network of support for global sustainability transformations. We further posit that these foundational, 'legacy' scientific networks, such as GLP, which have in recent years tended to be relegated to the position of generators of 'fundamental science' within the Future Earth enterprise, rather constitute key institutions and cross-scale platforms capable of accelerating transformative research oriented toward sustainable development.

GLP and the evolution of science for action in LSS

The LSS community was forged by a shared worldview that the changing interactions among human systems, the terrestrial biosphere, atmosphere, and other Earth systems, are mediated by human use of land [24,25]. Accordingly, land systems 'encompass all processes and activities related to the human use of land, including socio-economic, technological, and organizational investments and arrangements as well as the benefits gained from land and the unintended social, and ecological consequences' [26••,27]. Change in land use – the purposes and activities through which people interact with land and terrestrial ecosystems – is a key process of global environmental change and, at the same time, generates many sustainability challenges [28••]. Land is the nexus of competing development claims and of crucial societal and environmental challenges and opportunities to address food security, access to water, livelihoods, land degradation, biodiversity loss, and climate change. Solutions to these challenges must balance complex trade-offs and synergies at multiple scales and demand negotiations among multiple paradigms and perspectives.

Land system science (LSS) descends from an extended lineage of human–environmental traditions, from the German *landschaft* or landscape as 'the totality of things within a territory', to cultural–historical landscape orientations and cultural ecology, to more recent blending with sustainability science where land systems are understood as complex adaptive socio-ecological systems [29,30]. Since the genesis even of GLP's precursors the LUCC and GCTE programs[5], and with GLP's previous designation as a core project of both the International Geosphere–Biosphere Programme (IGBP) and the International Human Dimensions of Global Change (IHDP) programmes, knowledge on land systems has been traditionally sought from two sources: through detailed field observations of land use change, and, as then-called 'land change science' evolved, through spatially extensive and regional studies that combined 'people to pixel' remote sensing observations with socio-economic and biogeophysical data.

By the late 2000s, land science had produced a wealth of methodological innovations and empirical observations on land-cover and land-use change, from patterns and processes to causes, but it had also reached a critical juncture [31]: the need for comparison and generalization (the ability to move beyond a specific case study or a particular model) and further theory-building that could permit LSS to navigate between context dependence and very high level generalization [28••]. Importantly, this key challenge to the scientific enterprise is also central to providing insights and evidence to inform specific policy responses [25].

As land science has grown to become an 'interdiscipline' it has sustained progressions in knowledge. Researchers

[5] GLP is a successor to the Land Use and Land cover Change project (LUCC; 1994–2005) and the Global Change and Terrestrial Ecosystems project (GCTE; 1992–2003).

spanning the natural, physical, and social sciences are working to address critical knowledge gaps in our understanding of land system change with respect to human behaviors (cognitions, culture, and decision-making) for example, to better incorporate feedback between environmental change and human activities; land use-intensity and management; globalization, trade-flows, and distant causes as exemplified by a growing field of supply-chain governance studies. Moreover, as shown by the themes of GLP's recent 4th Open Science Meeting, 'Transforming Land Systems for People and Nature,'[6] a core principle is that land systems are the 'meeting ground' for multiple claims on land (whether for biodiversity, carbon sequestration, or food security for example) and thus necessitate careful and sustained work to understand tradeoffs between various goals, values and functions, and their cross-scale interactions [32]. Accordingly, the governance of land has become a central focus of LSS moving from territorial to increasingly flow-based perspectives [33]. As LSS matures key research areas include improving the scope, relevance and evidence base for 'generalized knowledge claims' (GKCs) [34]; developing global behavioral land management models [35, this issue]; and furthering theory development of the 'middle-range' as a path toward generalized knowledge to better inform land governance and theories of change [28••].

Increasingly, land system science is in a process of evolution from research *about* development of human–environmental systems to research *for* sustainable development of human–environmental systems; where land systems are the loci for sustainability transformations, whether through changes in policy at global, regional, national scales, or within specific value chains, or by improving territorial or flow-based land-systems governance. For this evolution to continue, however, land system science will benefit from stronger engagement with stakeholders toward such solutions [26••]; appropriate institutional network infrastructure to support such shifts in research practice and engagement through learning, deliberation, and reflection within the LSS community [11•]; and actively undertaking processes of knowledge co-production via a diversity of science–policy interfaces. For GLP, setting and driving a community-integrated agenda means not only that individual LSS researchers might identify normative values, questions, perspectives, and assumptions multiply present in their research [11•], but that GLP has a similar responsibility to support and operationalize co-design and transdisciplinarity into our network organizational modes and practices. The practices must percolate up. Over the past three years, guided by a Scientific Steering Committee, the International Programme Office (IPO), located since 2016 at the Centre for Development and Environment at the University of Bern, Switzerland, has coordinated GLPs now-1300 researcher-members, Working Groups, Nodal Offices, and Fellows to assemble network infrastructure and processes, which can further enable the generation of transformative science across the GLP ecosystem.

Enabling a scientific network for transformative science: GLP 2016-21

GLP is now working to 'mainstream' co-production approaches into our network via the four pillars structuring our operational plan (See Figure 1). The IPO has approached this task through a portfolio of activities, working first to identify knowledge 'supply' and 'demand' relationships between the land policy and land science communities, employing this analysis to identify and pilot promising lines of co-production between development and land systems science partners, all the while maintaining a strong component of 'infrastructuring'[7] to further support co-design and co-production of knowledge within the community. We expand on this experience in the following sections.

Identifying and developing promising lines of co-production

How do the normative framework of the United Nation's 2030 Agenda, the research agenda of land systems science, and the knowledge needs of development and land policy communities align? In order to better understand knowledge needs of these communities, as well as the capacity of land system science to provide knowledge in those domains, the IPO conducted a series of activities over the last two years, including a survey of land policy actors and a meta-analysis of GLP papers providing knowledge on systemic interactions between SDG targets. A detailed description of this process and results are described in Ehrensperger *et al.* [37, this issue] but the process has aided GLP to better identify those questions being asked by the policy community (i.e. questions *needing* answers) as well as to identify knowledge available (i.e. *where* the answers could be found) and, most importantly, to specifically identify knowledge gaps as identified by the land policy community that are not being currently met by the LSS community. For example, knowledge supplied by the sampled GLP scientists LSS literature and the concerns of surveyed societal partners was best matched with interactions between climate change and the environment and between climate change and food security, while the greatest mismatches concerned a direct focus on issues of poverty raised by land policy actors with a near absence of explicit references to such issues in the sampled literature.

[6] www.glp.earth/osm-2019.

[7] The term 'Infrastructuring' borrowed in Science and Technology Studies (STS) denotes the Socio-technical mechanisms for constituting and supporting a public [36].

With this understanding – of knowledge gaps and synergies, as in the previous example, and normative positioning of institutional researching – GLP is better equipped to work with societal actors and communities, first, on the areas where existing questions and knowledge overlap and, second, on how to better identify how the LSS community might contribute to the generation of new knowledge. A key point is that the identification of knowledge gaps can further support a reorientation of the land systems science agenda toward themes and topics that societal actors value. Contextualizing targets, implementing the SDGs will require answers at multiple scales and ultimately will be implemented by people in places. While such exercises are initial pilots at this point, these are the types of activities that could greatly aid scientific networks in understanding knowledge needs of societal actors in a variety of contexts and scales of governance, further serving the development of collaborations and ensuring the usefulness of science together with societal actors moving forward.

Establishing pilot science policy interfaces between development and LSS partners

Science–Policy Interfaces (SPIs), broadly defined, consist of relations between scientists and other actors in policy processes which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making and/or research [38,39]. In general, the GEC research community has focused its participation in SPIs on global assessments, or 'boundary organizations,' such as the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES) or the United Nations Convention to Combat Desertification's Science–Policy Interface (UNCCD SPI). These are undoubtedly critical fora. However, SPIs can encompass a range of institutional structures at a variety of scales, and can serve as key places for researchers and stakeholders to engage 'in learning from doing change and with the messy, ill-defined and context-specific world of practice' through iterative approaches to develop, design, and test diverse practices and processes aimed at facilitating change [40,41].

In an effort to engage more directly with civil society organizations with aligned value propositions, GLP has established a science–policy partnership with the International Land Coalition (ILC), a global alliance of civil society and intergovernmental organizations working toward transformative land governance (https://www.landcoalition.org/). GLP and ILC are now implementing several joint initiatives. For example, ILC facilitates 'National Engagement Strategy' (ILC–NES) platforms which operate in over 25 countries throughout the Global South. The NES support civil society and government actors to work together to implement land-related policies in alignment with various global initiatives designed to support better land governance including ILC's own '10 commitments to people-cantered land governance'; the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security (VGGTs); and the Framework and Guidelines on Land Policy in Africa. Within this overall scope, each NES encounters national realities that require context-specific priority setting as well as access to relevant land systems-related knowledge and science. Recognizing the divergent incentive structures that can prevent science–civil society engagement, GLP is now working with ILC to establish a 'Catalyst Fund' instrument that will fund research initiatives co-designed by ILC members and GLP scientists toward meeting these knowledge needs. In one such pilot effort, land scientists at the IPO worked with the ILC–NES in Togo to support development and launching of a report on sustainable land management practices to national-level policy makers.

Additional efforts with ILC include ongoing scientific input into the process of developing appropriate indicators and methodologies for ILC's Commitment 6: 'Locally Managed Ecosystems' and the joint production of a 'Science for Action' knowledge series which will package existing land system science and ILC research into briefs that are accessible to a broad and grassroots audience to disseminate to the ILC membership and beyond.

What perhaps distinguishes this new partnership from more traditional transdisciplinary approaches toward high-level GEC policy platforms is the potential for collaborative problem-solving processes and joint-experimentation *directly* with civil society partners, building 'social legitimacy for proposed transition pathways to sustainable societies' [21]. And just as important, allowing for the possibility that by approaching problem solving in this way, we may also confront the structures, values, and goals that underpin complex problems at a deeper level and harness the potential for coordinated and networked activities between land systems scientists and land policy actors to serve as leverage points [42].

Community 'infrastructuring' for co-production

LSS is working to systematically produce insight into the ways that land systems act as causes and consequences of global change. The IPO has approached its task of coordinating the GLP community as an exercise in laying the groundwork for a science capable of supporting and facilitating sustainability; accordingly, several GLP Working Groups have been established on key themes in alignment with our Science Plan and to create nuclei of activity and momentum on key topics such as telecoupling, rural–urban interactions, mountain futures, remote sensing in the big data era, behavioral models of land use change, and others, further honing our ability to engage with partners within and beyond Future Earth. GLP

Fellows and Nodal Offices further support the community's capacity to engage through relevant science policy interfaces, regional fora, and initiatives. Additionally, GLP will continue to work to strengthen and facilitate participation from the Global South through various funding and training initiatives as well as to maintain and further community cyberinfrastructure for global transdisciplinary engagement.

Even as GLP endeavors to broaden researcher-members' direct engagement with a variety of societal actors, the Working Group on Co-production of Sustainable Land Systems is attempting to work *within* the community to foster the adoption and multiplication of co-produced socio-ecological knowledge; this is done through the establishment of a community of practice, provision of methodological guidance, and knowledge brokering between GLP and other relevant communities.

Over the years, the LSS community has worked to establish community norms and standards, to solidify the role of the Global Land Programme (GLP) as the de facto organization for this type of research, to develop LSS-specific theories and frameworks, and to establish accepted means of knowledge production. In this way, 'LSS is knowledge infrastructure-in-the-making' [24]. Reflecting on GLP as an 'infrastructuring' effort enables a view of the variety of material and non-material components of which it consists, the efforts required for their integration, and the ongoing work required to maintain it.

Conclusion: challenges and ways forward

To be capable of supporting transformations as a research network requires that we engage as a community – or even, as in the case of our role within Future Earth, as a community of communities – in a structured discussion of what is needed and how best to proceed. A land systems perspective on development challenges can potentially contribute to understanding pathways and leverage points in fundamental ways. But, as Nielsen *et al.* write in this issue, "this goal requires a stronger engagement with the normative implications of scientific practice, research topics, questions, and results" [11•].

Though the GLP is in the process of testing and experimenting with co-production and normative approaches toward the generation of research *for* sustainability, challenges to sustaining and building networks for transformation are multiple. Among these, the need for better metrics to assess the effectiveness of our efforts, including more robust methods of policy evaluation (e.g. counterfactuals-based), and a deeper engagement with institutions and organizations engaged in land policy and land governance broadly defined. Transformations can occur through changes in policy at global, regional, national scales, or within specific value chains or by improving territorial or flow-based governance of land systems. While continuing to stimulate science policy dialogue at multiple scales through participation in scientific assessments and reports (IPBES, IPCC, UNCCD, GSDR), ongoing experimentation is needed to understand what kinds of society–science partnerships at what scales best serve as vehicles for land systems transformations.

This last point – regarding what kinds of partnerships at what scales can catalyze land system transformations – requires that we also reflect on our role within the socio-institutional organization of GEC science through Future Earth, in which GLP is embedded. If, for Future Earth, co-production [3] is understood as a strategic instrument for, and form of practical engagement [43•,44] than this collective effort that is Future Earth must also successfully generate transformative science across scales and contexts, with a diversity of societal actors [45]. Importantly, 'top–down' planetary-scale technical approaches to global environmental governance [46] will not be enough to ensure transformation. Instead we must recognize that, as O'Brien cautions, " . . . a missing detail in pursuit of the great leap from knowledge to action may include a better understanding of how change comes about" and as crucially, "a better understanding of where change happens or at least starts" [47••]. In other words, perhaps for the Sustainable Development Goals (SDGs) to be realized, we must work, first, to harness the great advances in understanding human–environment systems not in order to identify systemic challenges but rather opportunities for change. And, second, on that basis, to craft concrete pathways through reflexive, engaged approaches with societal actors, increasingly mobilizing the urgently needed scientific knowledge about social, behavioral, economic, and technological levers for change.

This paper has attempted to illustrate how GRPs can serve as vehicles for contextualized co-produced research and related activities with societal actors. Owing to the long-held orientation toward interdisciplinarity and sustainability, with GLP's transition to Future Earth in 2015, LSS was already well-positioned to serve as a platform for integration of insights from different disciplines, for translation of knowledge into action, and for new ways of linking science and practice to effectively translate scientific findings into sustainability solutions and implementation [26••]. As long as science is guided by an ever-increasing amount of individual observations that per definition must question and compete with each other, GRPs are a pre-requisite and a key to collective action, which is needed to address real world problems, to create debate and consensus, to bring perspectives together, and to engage. Going forward it will be key that the GEC scientific effort – now being led by Future Earth – identifies more effective ways to integrate such activities and approaches to doing science *for* sustainability

transformations into the purpose, governance, and institutional design of our common effort.

Conflict of interest statement

Nothing declared.

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