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Land System Science: between global challenges and local realities☆

Editorial overview

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This issue of *Current Opinion in Environmental Sustainability* provides an overview of recent advances in Land System Science while at the same time setting the research agenda for the Land System Science community. Land System Science is not just representing land system changes as either a driver or a consequence of global environmental change. Land systems also offer solutions to global change through adaptation and mitigation and can play a key role in achieving a sustainable future earth. The special issue assembles 14 articles that entail different perspectives on land systems and their dynamics, synthesizing current knowledge, highlighting currently under-researched topics, exploring scientific frontiers and suggesting ways ahead, integrating a plethora of scientific disciplines.

Land System Science

Changes in land systems, human-induced transformations of ecosystems and landscapes and the resulting changes in land cover, reach far beyond local alterations and are pervasive factors of global environmental change. Today, more than 75% of the Earth's ice-free land shows significant evidence of land use induced alterations of many environmental processes, such as primary production, the water cycle, biogeochemical cycles, the climate system, and biodiversity. On the other hand, land provides vital socioeconomic resources to society, such as of food, fuel, fibres and many other ecosystem services that support production functions, regulate risks of natural hazards, or provide cultural and spiritual services. Land system changes are the direct result of human decision making at multiple scales, with far reaching consequences for the Earth System, that feedback on human well-being and decision making. Thus, land system change is both a cause and consequence of socio-ecological processes that encompasses a huge range of spatio-temporal scales.

Land systems represent the terrestrial component of the Earth system and encompass all processes and activities related to the human use of land, including socioeconomic, technological and organizational investments and arrangements, as well as the benefits gained from land and the unintended social and ecological outcomes of societal activities. Thus, Land System Science has emerged to serve as a platform for integration of these different dimensions of global environmental change research, and aims at offering potential options for mitigation and adaption to environmental change, for example through modified land system architecture [1]. By studying the mutual interplay between social and ecological systems that shape land use and land cover, land system science operates at the interface of the social and natural sciences and requires a high level of interdisciplinary collaboration across academic disciplines as is reflected in the contributions to this issue.

Land system science has developed over the past twenty years from the study of Land Use and Land Cover Change, which initially was dominated by monitoring and modelling of the ecological impacts of land cover changes such as deforestation and desertification on the natural system [2–4]. Gradually, the research field has become more integrative, focusing on both the drivers and impacts of land change as part of global

global land-use indicators and datasets, the role of land use in the Earth System, and socio-ecological trade-offs and synergies in the land system. He is member of the Scientific Steering Committee of the Global Land Project, member of the Young Curia, of the Committee on Global Change and of the Commission of Geographic Information Science at the Austrian Academy of Sciences, member of the Commission on Ecosystem Management (CEM) at The World Conservation Union (IUCN). In 2010, he was awarded an ERC Starting Independent Researcher Grant by the European Research Council, for the project ''Land Use Intensity from a Socio-Ecological Perspective''.

Ole Mertz is an associate professor in Geography at the Department of Geosciences and Natural Resource Management, University of Copenhagen, where he leads the research group Environment and Society in Developing Countries. His research focuses on the interactions between change in land use, livelihoods and environment in developing countries with a specific focus on multi-functional land systems, forest-based agriculture and climate change adaptation/mitigation. He coordinates an EU-FP7 funded project on REDD+ in Southeast Asia (2011–2014), is member of the Scientific Steering Committee of the Global Land Project and Editor-in-Chief of Geografisk Tidsskrift-Danish Journal of Geography. He has edited nine special issues in international journals and serves as member of the Editorial Boards of the journals Human Ecology and Environmental Management.

Giovana Espindola is the executive officer of the Global Land Project (GLP). She works at the International Project Office (IPO) of GLP, which is based at the Brazilian National Institute for Space Research (INPE), and where Giovana also acts as a young researcher. Her research investigates land processes broadly in developing countries as well as focusing specifically on the case of tropical forest-agriculture frontiers in Brazil and in the Brazilian Amazon and Cerrado regions. She looks to spatiotemporal scales ranging from local case studies to national or regional analyses, with a strong focus on spatiotemporal statistics, remote sensing time series analysis and interdisciplinary approaches.

environmental change. The growing group of researchers engaged in this field led to the emergence of 'Land Change Science' as a separate, interdisciplinary, research field engaging scientists across the social, economic, geographical and natural sciences [5,6]. The increasing attention for feedbacks between drivers and impacts including adaptive behaviour [7], the interactions between social and ecological systems and teleconnections between world regions [8,9] and between cities and their rural hinterlands [10] have motivated an integrated socio-ecological systems perspective. In this perception, land systems are acknowledged as resulting from the dynamic interactions within the socio-ecological system. This perspective has also moved land system science from a focus on the most dramatic land cover changes to giving more attention to subtle changes of human interactions with the natural surroundings, including land management and the provisioning of a wide range of ecosystem services. The articles in this issue strongly reflect this shift in perspective by explicitly addressing changes in land management and the modes in which land is governed.

The Land System Science community is organized within the Global Land Project, one of the core projects of both the International Geosphere Biosphere Programme (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP) commissioned by the International Council for Science (ICSU) and the International Social Science Council (ISSC). In 2013, a new programme gathering all previous global environmental change programmes was established and named 'Future Earth' in response to a visioning process on Earth System Science and Global Sustainability initiated by ICSU [11]. The aims of the new programme, that will also host the Global Land Project, include a stronger interdisciplinary approach and a stronger focus on science that supports sustainability transitions through co-design and co-production of research together with important stakeholders. While interdisciplinarity is in the genes of Land System Science, a stronger engagement in the development of sustainability solutions provides an important opportunity for the researchers engaged in this field. Traditionally Land System Science is closely related to the fields of land use planning and land use policy. However, scientific insights are not always easily integrated in these processes and much land is owned and managed by private land owners that are not always responsive to planning and policy. Therefore, new ways of linking science and practice need to be developed to effectively translate scientific findings into sustainability solutions and implementation in practice. Important ways forward in this perspective include the evaluation and design of alternative ways to govern land resources [12–14] and the use of land systems architecture in the design of novel land systems that more optimally use spatial and temporal interactions within the land system configuration to provide ecosystem services and adaptive capacity under conditions of global environmental change [1,15,16]. Many of the articles in this issue address these challenges and illustrate the role of Land System Science as a central and critical component of global sustainability science.

Synthesis of Land System Science

The articles in this issue provide a synthesis of many, interrelated, topics in Land System Science, either from a thematic or methodological perspective. Overall, the articles can be divided into four main approaches to studying land systems: land systems dynamics, land use intensity, impacts of land change and governance of land systems.