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A classification to align social-ecological land systems research with policy in Europe

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ABSTRACT

Both research and policy recognize land systems as fundamental to human life and activities. However, these two perspectives approach land from different ends and it can be difficult to see how studied variables contribute to broader policy goals. In this paper, we argue that there is a need to better select variables to study land systems as social-ecological systems, and to align research more with those policy goals. Concentrating on the European continent, we pursue three interrelated objectives: we (1) build a classification of land systems variables, (2) examine where existing land systems research is positioned in this classification, and (3) compare a set of policies and science-policy frameworks with the classified research. To do so, we conduct a systematic review of 69 peer-reviewed, empirical land systems papers, as well as four overarching policies and science-policy frameworks. We find that over 60% of the reviewed papers include both environmental and social variables, and we identify 154 unique variables studied, 57% of which are environmental. The average paper examines four times as many environmental variables as social ones. We find that policies and science-policy frameworks stress social variables more and include health and air quality aspects that are lacking in the reviewed land systems research. Our classification can help to design research that includes both social and environmental variables and is aligned with broader policy goals. We highlight social variables with available spatial data to encourage a more balanced and integrative social-ecological research design, going beyond a focus on the built and natural environment. Our classification can contribute to guiding land systems researchers towards greater policy relevance. We hope that our classification contributes to a conversation within land systems research on the selection of variables, as well as its further development.

1. Introduction

Land is among the most important resources on Earth, and alterations to land are among the most significant changes humans have made to the planet (Ellis et al., 2010). Anthropogenic land change (Turner et al., 2007) has impacted landscapes and biodiversity (e.g., via deforestation, crop selection), as well as underlying biogeochemical and hydrological processes (e.g., carbon sequestration, nutrient balances, runoff), from local to global scales (Carpenter et al., 1998; Foley et al., 2005; Pfister et al., 2011). The way land is used also has consequences for human societies regarding, for example, food availability or employment possibilities. Because of the many interacting components and actors, research is required that covers the full breadth of environmental and social categories that drive and affect people's decisions on land (Bürgi et al., 2017; Verburg et al., 2013).

Land systems are defined as the "terrestrial component of the Earth system and encompass all processes and activities related to the human use of land" (Verburg et al., 2013, p. 433). Research on land systems (from here on referred to as 'land systems research') is conducted in urban and rural settings; here we focus on the latter. Over the last three decades, land systems research shifted from a focus predominantly on land cover change to a more explicitly systems approach that considers the complex relationships between drivers of land change, land management decisions, and their outcomes, including feedbacks and teleconnections (Turner et al., 2007; van Vliet et al., 2016; Verburg et al., 2013). Traditionally, land cover change has been more heavily researched than land management because it can be studied with readily-available land cover data (e.g., European CORINE Land Cover database) and official statistical reports (e.g., using Eurostat), whereas change in land management requires information from a wider variety of sources, for example, agricultural, societal, and policy perspectives (van Vliet et al., 2016).

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Land systems research is suited to an integrated social-ecological system (SES) perspective due to the tight interconnection between nature and humans in these systems (Bürgi et al., 2017; Verburg et al., 2013). Thus, both social and ecological components should be considered in land systems research (Lambin et al., 2001). The social side includes, for example, actors' behavior and system governance, while the ecological side contains aspects of the ecosystem and its function (Ostrom, 2007). However, combining social and ecological variables and upscaling findings of local case studies to broader scales is often difficult because data types characterizing variables vary (van Vliet et al., 2016) and social and ecological conditions are heterogeneous in space. As a result, integrated land systems research addressing both social and ecological aspects is sparse.

The European continent offers a particularly interesting case of rural land systems. The long history of human interaction with the land, as well as more recent large investments in rural development and agriculture policies, have shaped the landscape as well as human-nature relationships. Europe's land area is dynamically changing: between 1990 and 2006, 26% of land in the EU27 area was converted from one land type to another, and a further 18% de-intensified and 15% intensified (Levers et al., 2015). While there is a clear divide in land development between the Eastern and Western parts of Europe, land use patterns all over Europe are diverse (Kuemmerle et al., 2016). Consequently, a great deal of research has been carried out on land systems in Europe. However, a holistic understanding of land systems as SESs is often missing. In addition, it is difficult to compare between or generalize findings from individual research studies as there is a lack of consistent use of variables and of researched components between studies.

Policies relating to land span sectors (e.g., agriculture, economic development) and political levels from global to local. Land systems as integrated SESs play an important role in achieving policy goals, such as reduction of greenhouse gas emissions or improved rural livelihoods. Such goals are set out globally by the United Nations (UN) Sustainable Development Goals (SDGs) (UN, 2015), and across Europe by the European Union (EU) Sustainable Development Strategy (EU, 2001). Sectoral EU policies, such as the Birds and Habitat Directives, often relate to more specific aspects of land systems.

Research and policy play complementary roles in understanding and managing land systems. While policies set broad goals for governing and managing land systems across different regions (Bouwma et al., 2018; Schleyer et al., 2015), research often focuses on gaining a detailed understanding of land systems and their components in specific cases and places (Meyfroidt, 2016; van Vliet et al., 2016). Policies are set largely from the top-down, with decision-makers setting goals that affect local actors in specific contexts. Against this, land systems research provides information on environmental and social variables affecting and being affected by land use, and their interconnections. Research and policy frequently approach land systems from different ends: research often focuses on individual variables and how they interact and change within the system, whereas policies aim to achieve a certain status of environmental conditions or societal goals. While these can be complementary, it can often be difficult to see how scientific findings fit into a broader policy context, and how the individual variables studied contribute to setting or achieving policy goals.

There is a need to align research on land systems as social-ecological systems, and the selection of measurable variables therein, within the context of existing research and policy interests in European land systems. In order to address this need, we pursue three iterative, interrelated objectives in this paper: we (1) develop a classification of land systems variables, (2) examine how existing land systems research fits in the classification, and (3) compare a set of selected policies and science-policy frameworks with the classified research. In order to achieve these objectives, we conduct a systematic review of 69 peer-reviewed land systems papers as well as four overarching policies and science-policy frameworks to identify what kind of variables, indicators, and units they used. (1) Based on the scientific literature and the policies and science-policy frameworks, we develop a hierarchical classification for variables of land systems as social-ecological systems. To our knowledge, no previous such classification encompassing a systematic breadth of environmental and social components exists. (2) Using the results of the systematic review, we examine where existing land systems research on European land systems is positioned in our classification. (3) We illustrate policy and science-policy perspectives using four international, overarching frameworks on land systems. Finally, we discuss opportunities for our classification to both guide researchers in their research design and help to align research *for* policy within an integrative land systems perspective that reflects both environmental and social aspects. We hope that the classification is the beginning of a conversation within the wider field of land systems research on the deliberate and strategic selection of variables, as well as the further development of this classification.

2. Classification of environmental and social land systems variables

2.1. Methods

The development of our classification was an iterative process between (1) identifying environmental and social variables for land systems in Europe, and (2) categorizing those variables in a hierarchical classification. To identify variables for European land systems (step 1), we analyzed both scientific publications on European land systems, as well as international and European overarching, non-sectoral policies. We focused on non-sectoral policies because our starting point was the assumption that research on land systems aims to pursuit an integrated approach including aspects of both the ecological and social systems. Sectoral policies have by default a focus on the respective sector. We retrieved the scientific literature from a systematic search in Scopus and Web of Science (described further in Section 3 and Supplementary material). We found 69 articles covering various disciplines, methods, and case studies resulting in a total of 154 individual variables examined in European land systems research (full variable list in Supplementary material).

To categorize the variables (step 2), we grouped the 154 variables identified in (1) as primarily either environmental or social. Overarching policies, science-policy frameworks, and scientific literature guided our categorization. We used the UN SDGs (UN, 2015) and the EU Sustainable Development Indicators (EU, 2001) as overarching policies; the TEEBAgFood report (2015) as a science-policy framework specific to our focus on land; and scientific publications (DeClerck et al., 2016; Environment and Climate Change Canada, 2017; Lamy et al., 2016; Munteanu et al., 2014; Palonen, 2003; Seppelt et al., 2016; van Vliet et al., 2016; Vowe, 2008). Some of those publications are specific for certain aspects of the classification as we wanted to incorporate as much disciplinary knowledge as possible to reflect a state-of-the-art understanding of the different components of the classification. In addition, we gained input from an ecologist and an economist (external to the author team), in order to discuss the classification logic from their point of expertise. Nevertheless, the final categorizations and the resulting classification represent our own interpretation. We acknowledge that variables can be related to each other in a causal manner (i.e., one affecting the other), but this initial classification does not serve the purpose to illustrate causal links.

2.2. Results

Our classification consists of six hierarchical levels (represented by Roman numerals), each comprised of progressively more specific categories, from broad (I; the land system) to specific (VI; variables, often with measurable indicators) (illustrated in italics in the text) (Fig. 1; see Supplementary material for full variable list). For example, the level VI