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Response to Van Noordwijk *et al.* 2011. "Feedback Loops Added to Four Conceptual Models Linking Land Change with Driving Forces and Actors"

Feedback Loops in Conceptual Models of Land Change: Lost in Complexity?

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Though feedbacks are an inherent part of land-change systems, they are not an integral part of the described conceptual models but describe rather a different dimension of land-change systems. The conceptual models of land change, driving forces and actors can provide the science community with guidance on choosing appropriate methodology without overdue complexity.

Feedbacks are an inherent property of complex systems, such as those studied in land science (Turner et al. 2007). This has been pointed out repeatedly (Lambin et al. 2006, Verburg 2006, Briassoulis 2008). Furthermore, the need to better understand the role of feedbacks between human and environmental systems within the context of land change is one of the priority research themes of the Global Land Project of IHDP and IGBP (GLP 2005). Van Noordwijk and colleagues (van Noordwijk et al. 2011) correctly point out that feedback loops are not explicitly mentioned in the four conceptual models discussed in our contribution on linking land change with driving forces and actors (Hersperger et al. 2010).

The primary goal of the organizational heuristic presented in Hersperger et al. (2010) is to clarify the conceptual models that underlie different approaches to land-change analysis based on the interrelations of the three main components: driving forces, actors, and land change. Feedbacks and multiple scale issues were omitted in our contribution, which merely describes the different ways in which interrelations between driving forces, actors, and land change are conceptualized in operational land-change research.

One single conceptual framework to describe land system dynamics could be of great benefit to the land science research community. There have been frequent requests for the development of an overarching theory of land-change science that could provide the foundation for such a framework (Rindfuss et al. 2004, Lambin et al. 2006). However, attempts for full conceptualization of human–environment systems have failed or have remained at a high level of abstraction disconnected from empirical research. The complexity of the multiscale human–environment interactions in land change, the lack of an overarching theory of land science, and the wide variety of research approaches available rule out the possibility of one single conceptual framework to describe land system dynamics.

Different papers have explicitly analyzed how feedbacks in land-change studies are represented (Verburg 2006, Liverman and Cuesta 2008, Schaldach and Priess 2008). The list with four main types of feedbacks suggested by van Noordwijk and colleagues (2011) is by no means exhaustive. Other types include the following:

Direct physical feedback: In contrast to the feedbacks described by van Noordwijk et al. (2011), these feedbacks are not mediated by human decisions. Example: Forest fires are linked to land change, which affects the regional climate, which in turn affects the land cover.

Feedbacks among actors on the same scale: feedbacks in social networks

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Feedback across time: dependence on current and historic land use (Verburg 2006)

Feedback between local, regional, national, and international processes: Depending on the research question at hand, certain types of feedbacks need more attention than others.

Feedback mechanisms in land-change systems are very diverse and should be core to land-change science. However, there is no use in linking all components in a conceptual diagram with conceptual feedback loops. Furthermore, the conceptual models presented do not necessarily differ in their representation of feedbacks. As van Noordwijk et al. (2011) suggest, it is likely that agent-based approaches (conceptual model A-C) are capable to better represent feedbacks arising from the response of agents to land change, including learning and adaptation. However, such approaches may have difficulty in representing feedbacks across larger scales, given their tendency to focus on case studies of relatively small extent. On the contrary, even in the most simple conceptual models of land-change interactions (model DF-C), it is possible to present feedbacks as has been exemplified by Claessens et al. (2009), who integrated diverse types of feedback in a land-change model that is normally applied without accounting for such feedbacks.

Therefore, we would like to argue that feedbacks are not by definition an integral part of the described conceptual models but rather a different dimension of land systems. The identification of feedbacks is only a step toward integrating feedbacks in land-change studies. The further conceptualization of the feedback dimension will clearly enhance our understanding of land-change systems. Analogous to the organizational heuristic of models for linking land change with driving forces and actors, a heuristic of feedbacks could be useful to guide model choice and communication of research results as well as theory development. In conclusion, we acknowledge the merits of simplifying conceptualizations as well as comprehensive empirical system studies for future development in land-change science.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol16/iss2/resp1/responses/

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