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Significance of Telecoupling for Exploration of Land-Use Change

Hallie Eakin, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffield, Birka Wicke, and Karl Zimmerer

Abstract

Land systems are increasingly influenced by distal connections: the externalities and unintended consequences of social and ecological processes which occur in distant locations, and the feedback mechanisms that lead to new institutional developments and governance arrangements. Economic globalization and urbanization accentuate these novel telecoupling relationships. The prevalence of telecoupling in land systems demands new approaches to research and analysis in land science. This chapter presents a working definition of a telecoupled system, emphasizing the role of governance and institutional change in telecoupled interactions. The social, institutional, and ecological processes and conditions through which telecoupling emerges are described. The analysis of these relationships in land science demands both integrative and diverse epistemological perspectives and methods. Such analyses require a focus on how the motivations and values of social actors relate to telecoupling processes, as well as on the mechanisms that produce unanticipated outcomes and feedback relationships among distal land systems.

Introduction

Over the last decade, connectivity between processes of land change and actors, decisions, and activities has accelerated across geographically distant places. The 2007–2008 global food crisis, the expansion of biofuel production, and the global emergence of niche and "green" markets have had widespread and often unexpected outcomes on land systems in disparate geographic locations. These

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connections are associated with accelerated urbanization as well as the development of new markets and are motivated by emergent demands of consumers with increased agency and an intensification of information and knowledge flows. On the basis of this observed "connectivity," we offer two propositions. First, nearly all land systems are now affected to some extent by these forms of connectivity, or *telecouplings*. Second, the increased significance of telecoupling for land change implies a need for integrating diverse epistemological perspectives, methodology, and analytical approaches that together complement the long-standing focus of land science on place-based research with a new focus on the networks and system interactions involved in land change. The telecoupling process links the diverse social, ecological, and economic outcomes of land change to specific, yet potentially diverse value systems held by different sets of actors—including scientists in disparate social networks. Research on telecoupling in land science is thus both embedded in the evolution of sustainability pathways for land systems as well as instrumental in the analysis of these pathways.

What Are Distal Land Connections and Telecoupling?

Teleconnections, as discussed in climate literature, have a specific reference to mesoscale atmospheric processes (e.g., ENSO) that have (concurrent) climatic consequences in geographically noncontiguous locations (e.g., Simmons et al. 1983; Trenbreth and Hurrell 1994). The idea of distal connections captures this essence of "acting at a distance": an action, phenomena, or process of change in one location has implications in a geographically distant location. In some senses this concept can be interpreted as unidirectional and linear, essentially reflecting the idea of an exogenous driver acting on a distant system. This concept has been applied to land systems (Haberl et al. 2009; Seto et al. 2012b).

The concept of telecoupling—preferred by this discussion group—captures the idea of two or more independently coupled, interacting social-ecological systems (Liu, this volume). In other words social-ecological interactions in one system generate mechanisms of influence over another. The process of telecoupling is different to the concept of coupling in that there is an element of social and spatial distance; that is, geographic separation between systems as well as a separation of social networks, institutions, and governance. The boundaries of the systems involved in the telcoupling are defined in terms of the placed-based social-ecological interactions as well as the potentially aspatial social networks, institutions, and governance structures that directly influence those interactions. There is no a priori assumption or understanding that these systems are integrally connected. They are assumed to be disconnected, and thus they are governed independently. Feedback processes, in some cases, may return the initial signal of change to the place of origin, provoking a change (in land use, policy, institutions, or behavior) in that place and causing

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a complete feedback loop. In other cases, differences in power and influence among the coupled systems may result in the implications to be essentially ignored, with potentially detrimental implications for ecological integrity and human welfare.

Because the governance of the linked systems is independent, the critical outcomes revealed in the telecoupling process tend to be indirect, emergent, and of a second or third order, such that they are more difficult to anticipate and to measure. Nevertheless, they may play a determinant role in land (social as well as ecological) outcomes in particular places. The interaction emerges essentially as an "ungoverned" process, such that the indirect outcomes of the interaction often appear unexpected or "surprising" because they lie outside the dominion of the existing governance arrangements. The disconnect between the problem origin and outcome challenge efforts at problem resolution. While existing governance and institutions may produce predictable supply and demand responses in a commodity market in two geographic locations, there may be "spillover" effects generating environmental change in a secondary resource in a third region as a result of demographic shifts provoked by the market. For example, an energy system is governed by specific suites of actors, energy policy, and regulations; while we know that many food production systems are highly energy intensive, such production systems are governed by separate policies, actors, and networks. The rapid interaction between oil prices, biofuel development, land use, and food security in urban areas that happened in 2007–2008 occurred in somewhat of a governance vacuum (Eakin et al. 2010). As these interactions and causal relations are made visible, they may be incorporated into governance, institutional design, and decision making if the volition and commitment exists, and if the problems generated through the interaction are tractable. What makes the concept of telecoupling so interesting for science is that it captures not only the "action at a distance" but also the feedback between social processes and land outcomes in multiple interacting systems. This creates both a need and an opportunity for a significant new research effort, focused on the question: How and where do telecoupled feedback processes influence global land-use change, and with what consequences?

Is the Concept of Telecoupling New?

The idea of connectivity between actions and actors in one specific geographic location and land outcomes in another is not new in the history of human environment interactions. Globalization—as understood as the increasing intensity and rate of capital flows and interdependencies across space (Held et al. 1999; Dicken 2003)—has several historical phases and has been implicated as the vehicle for "distal" linkages (primarily relations of production and consumption) for centuries. However, globalization as a diffuse, aggregated process of economic intensification and connectivity has not yet been specified in terms

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of particular causal social-environmental chains specific to a suite of actors, interacting noneconomic and economic flows and feedbacks, and place-based outcomes. Thus telecoupling as an analytical concept has the potential to transform land science and decision making at different scales.

The concept is novel in land science in several ways. First, there is an agreement that the spatial scope, intensity, and rate of connectivity is distinctly different now than in the past. The amount of land affected by the processes of interest, and the rate of change in land outcomes, is greater now than in recent history. Globalization, as a process, has served to accelerate the rate at which outcomes occur, as well as the scale and scope of outcomes.

Second, the context in which telecoupling occurs today is new and distinct. We now live in a time where many perceive that there are increasing claims to resources. In the near future, we anticipate a world with 10 billion people and are already experiencing significant constraints as we try to meet the land-based resource needs of our current population. Limitations on land availability and land-use options imply less flexibility, or fewer degrees of freedom in system response, such that the phenomena of telecoupling has potentially far more significant implications for system function than in previous points of history. The feedback linkages are "tighter," more rapid, and multiscalar; the potential for rapid acceleration to systemic transformation (surpassing thresholds) or crisis arising from multiple system interactions is potentially higher.

Third, the telecoupling of the current era is characterized by information-rich and information-intensive interactions, facilitated by the Internet, social media, and the capacities of communication that enable action (at a distance). While material flows are important in the process of telecoupling (flow of commodities, money, people), equally if not more important are nonmaterial flows. These flows are often in the form of information and knowledge and the social interpretation of that knowledge through the ideological lenses and values of specific social networks. The degree of information connectivity facilitated by globalization enables new forms of social contracts and empowerment, and constitutes an important feedback mechanism in telecoupled systems. Actors in one location can be informed of outcomes in a distant location, and their concern about the possible consequences of their actions can generate a response. There are imbalances in access to information and specific sources of knowledge, and this imbalance also translates into different degrees of agency (acknowledged or not) and positions in telecoupled systems.

Fourth, part of the ideological shifts that have occurred with the latest phase of globalization is an increased concern for sustainability and resource limitations, bringing awareness of telecoupling outcomes to new significance. These values, while not globally shared, now color more frequently how influential actors explain the ethical responsibilities for their actions and how they respond to new information (although often highly uncertain) about the (unintended) consequences of decisions in which they played a part. Globalization has enabled or facilitated "feeling (empathy) at a distance." In other words,

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today there is more concern about the consequences (good or bad) of actions that once would have been valued primarily in terms of a national context and national benefit. There are new moralities—new social contracts that are emerging as part of the globalization process—that imply new responsibilities for action. Thus there is a rising influence of the affective responses by specific social groups defined by specific values and preferences in relation to the nature of formal institutions and more informal social contracts that emerge in a globalized world (O'Brien et al. 2009). Actors who learn about outcomes (distantly) related to their actions may now be motivated to respond with behavioral or political change, creating an important feedback to the initial signals of change in the system.

Fifth, urbanization is playing a central role in creating the conditions of a telecoupled world. The process of urbanization, with the entailed rapid increase and shift in the nature of consumer demand, and an increased density of information, economic and political activity, social interactions, and knowledge creation (Seto et al. 2010, 2012b) have created a context in which telecoupling is more likely. Urban populations and places and the associated sets of values, activities, and consumption patterns have disproportionate agency globally, and thus are more likely be associated with the initial signal that produces the telecoupled effect. Urban centers, as a concentration of human activity and information, serve as nodes in telecoupled interactions and amplify signals to distant places. Urban processes also allow specific actors to obtain positions of greater relative legitimacy and facilitate their capacity to organize and acquire political influence. Urban areas thus have, potentially, an implicit if not explicit agency and responsibility in telecoupled processes.

An example of this is found in the indirect land-use changes caused by biofuel mandates. Several countries or regions have defined mandates for biofuels. The Renewable Energy Directive of the European Union, for example, specifies a 10% renewables content by 2020 across the entire membership. Other major blending mandates have been set in the United States, China, and Brazil. When environmental impacts of biofuels are evaluated, indirect land-use changes have become a central issue as they are caused by the competition for prime croplands, the international trade in agricultural commodities, and agronomic innovations facilitating crop substitutions under specific agroecological conditions (Lambin and Meyfroidt 2011). More specifically, when a bioenergy crop replaces a food crop in a field already under cultivation, or when crop production is diverted from the food market to the bioenergy market, the supply of the food crop decreases (e.g., for corn, sugarcane, potato, or wheat used for ethanol, or palm or rapeseed oil used for biodiesel). The market price for the replaced crop increases, thus causing more land to be allocated to that crop (Searchinger et al. 2008). This triggers a cascade of crop by crop substitutions, which eventually causes land conversion at the margins, a loss in ecosystem services, and could negate climate benefits from biofuels. The multiple crop substitutions and land conversion usually occur in places distant

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from the biofuel production site. As a result, there are additional environmental effects that are not immediately measurable and are difficult to attribute to the biofuel mandate. Estimating the magnitude of indirect land-use changes requires simulation experiments with global economic models, and results are sensitive to the modeling framework used and assumptions made. As quantification of their magnitude improved, indirect land-use change emissions were found to be lower than initially estimated by Searchinger et al. (2008), but still significant in the overall carbon budget of biofuels. As a result, the European Commission recently proposed limiting conventional biofuels with the risk of indirect land-use change emissions in contributing to the Renewable Energy Directive and instead encouraging advanced (low indirect land-use change) biofuels to contribute more to the targets, to decrease negative environmental impacts (EC 2012b).

Conceptual Framework

How Does Telecoupling Work?

For telecoupling to occur, two or more distinct social-ecological systems must exist, at some geographic distance from one another, such that the influence of one system over the other would not be expected or assumed. The systems may interact in a range of ways (e.g., through trade, through information exchange), but those interactions will be largely within the domain of existing governance and institutional arrangements.

Disturbance (e.g., a new technology, new information, a significant change in policy, or social mobilization in one context) to one of the systems (System A) causes the system to change rapidly, altering the type, number, or nature of linkages between that system and others (e.g., to System B, C…n) (Figure 8.1). The linkages or flows that connect the coupled systems may initially be economic, but the noneconomic and nonmaterial flows and linkages may be more instrumental in the telecoupled outcomes and feedbacks. These linkages may involve the movement of species (migration of people or species), environmental processes (dust movement, fire, carbon, nutrients), information, knowledge, ideas, and technology. These nonmarket interactions move through different media: through biophysical cycling and processes (the hydrological cycle, atmosphere, etc.), by people via social networks and migration, via the Internet or other communication media, and by banking networks and financial institutions. Each of these different forms of "flows" will have distinct modes of connectivity and nodes through which flows can be changed, amplified, or stopped. How different forms of flows are correlated in time and space is one way in which the potential for telecoupling is revealed. For example, in the EU biofuel policy example presented above, it is the process of crop substitution in places other than those producing biofuels, but which nevertheless are

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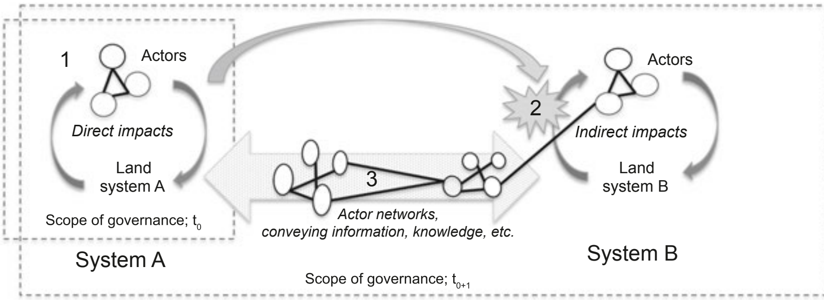

Figure 8.1 A schematic representation of telecoupling between two systems. (1) Coupled system A operates within a frame of governance; t_0 (e.g., via market transactions). (2) System A impacts on system B, producing a series of indirect outcomes and externalities, which may be unanticipated. (3) The externalities reach different thresholds of function, condition, attention, and mobilization, such that a feedback mechanism conveys pressure on the initial governance system to change its scope and address the externalities through new institutional arrangements (governance: t_{0+1}).

stimulated by changing relative prices (information) and the diversion of food stocks into fuel, that create the significant land-use change and eventually affect household food budgets in areas dependent on food imports.

Telecoupling as a land-change "problem" or concern frequently emerges when the institutions and mechanisms of governance in one system are unable to account for the consequences and interactions involving the more distant system, or they adapt too slowly to the new linkages that are formed following the disturbance. The systems' connectivities are thus "ungoverned": there are no higher-level governance structures to account for the new opportunities and risks that are entailed in the interactions. Typically, telecoupling also entails effects on livelihoods or land systems caused (indirectly) by spatially distant actors. These effects are essentially externalities (technological or pecuniary) that are unrecognized, inadequately compensated, or insufficiently mitigated. The temporal period that transpires until a telecoupled process is recognized and addressed formally in institutions and governance (something that is not inevitable) is particularly dynamic and critical. The way that ecological processes, economic systems, and social actors respond and value the resulting outcomes will potentially have a significant effect over the trajectory of development of the coupled systems and their future interrelationships.

The outcomes of telecoupling processes may be environmental or ecological (e.g., changing carbon emissions, reforestation, biodiversity loss) and/or social (e.g., an increase in well-being, loss of livelihood, population displacement). For our purposes, we are focusing on those processes that relate to land, in the form of outcomes for land-use managers and for land cover or land use, and are concerned specifically with outcomes that affect system resilience at different scales and sustainability of coupled systems and landscapes (Table 8.1).

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Table 8.1 Features of telecoupling are illustrated for three examples: coffee production in Vietnam and Mexico (Eakin et al. 2009), British tourism in Portugal (Bell et al. 2010), and emigration in Bolivia (Zimmerer 2010). In each case, there is a trigger "event" or disturbance that alters the relationship between two distant systems. There are both direct and indirect impacts of this altered relationship, producing a feedback to the governance system. In some cases, institutional changes result.

	Coffee: Vietnam/Mexico	Tourism: U.K./Portugal	Emigration: Bolivia
Trigger	Development incentive for coffee production in Vietnam in context of deregulated market	Increasing disposable income in urban U.K. Portugal: emigration from coast	Changing opportunities in migration (including international migration and policies)
Direct impact	Increase in forest conversion to coffee Coffee enters global market	Change in residential ownership from Portuguese locals to U.K. citizens	Land-use intensification or disintensification depending on decisions (e.g., remittances)
Indirect impact	Migration, land degradation, and social conflict in Vietnam Depressed international prices	Increased interest in property amenity values but also resource degradation Urban expansion	Sustainability can increase (+) under viable land use, or decrease (–) where land use increases marginality
Feedback process	Coffee abandonment in Mexico International migration International coffee "crisis"	Temporarily vacant flats in U.K. foster in-migration in U.K. cities Mediterranean diets and new habits transfer to U.K.	Agrobiodiversity compatibility with intensification (+); soil degradation (–), e.g., terrace abandonment
Institutional change	Policy change in Mexico promotes economic diversification in coffee areas New attention in development agencies and coffee retailers to fair trade and alternative niche markets	None	Policy change and governance (*kaw-say*) in Bolivia promotes investment for agrobiodiversity compatibility with intensification and food security improvement

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The primary feedback from the outcomes to the international or "inter-system" context is often in the form of information, which will be mobilized through social networks into institutional change. For example, some group of actors (e.g., scientists, nongovernmental organizations, advocacy groups) observing the impact on System B will bring attention to undesirable or desirable outcomes. That information will, in some cases, be fed back to decision-making organizations who can then modify institutional arrangements to account for the unanticipated, secondary impacts of the system interactions. In other cases, the impacts may have such significant justice implications that affected populations are mobilized to protest, and this reaction can stimulate a policy response and the development of new governance arrangements to address the unexpected (indirect) outcomes. In yet other cases, teleconnections might remain ungoverned or uncompensated, which can be also a form of system response, exacerbating their intensity and potentially leading to thresholds of irreversible and potentially undesireable change.

A variety of new institutional arrangements might emerge from the recognition of a telecoupled interaction: actors may adopt formal standards, laws about resource use or extensions to trade agreements, or compensatory mechanisms; they may motivate voluntary actions by private actors and NGOs in terms of certifications or "sustainability round tables"; consumer education campaigns may alter consumer behavior and preferences. The emergence of these new institutional arrangements can, in turn, have additional direct and indirect impacts. They may establish new examples of governance, which are then adopted by other actor groups who are anticipating potential analogous secondary impacts of their own activities. Alternatively, new institutional arrangements may produce new unanticipated secondary impacts and consequences, creating a new telecoupling process.

New Actors and Institutions

How the telecoupled system is defined, what outcomes are considered critical, and how the process evolves is in large part determined by the networks of actors, their activities, and their agency in the coupled systems. The processes of globalization and urbanization, and the inherent institutional changes, have accentuated the agency of some actors in the global system. In most cases the telecoupling process is characterized by asymmetrical relationships of material, capital, information, and ideology, such that the influence of one group of actors or one system over another can be instrumental. Similarly, the asymmetrical influence of different actors in the coupled systems also creates asymmetries in the responsibility for action and the nature of the response.

Global NGOs, for example, have assumed increased responsibilities and gained a new scope of influence in the wake of processes of state retrenchment and the declining influence of bilateral and multilateral investment and development agencies (Bebbington 2005). The World Wildlife Fund, for example,

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has been instrumental in mobilizing boycotts against the trade of bluefin tuna and pressuring trade organizations and companies to alter production practices which damage habitats and biodiversity. Global NGOs often have a physical presence in multiple countries and collaborate closely with local NGOs; in addition, they often have a strong political agenda and a geographically diffuse—but often highly urban and relatively wealthy—social constituency to which they are accountable.

Charitable foundations, typically defined by a specific set of issues and an agenda defined by the "high net worth" founding family or individual, are now exerting far more impact globally than they did even a decade ago. The Clinton Foundation as well as the Bill and Melinda Gates Foundation are just two organizations that have a new global presence and, by partnering with national government and bilateral and multilateral development agencies, are shaping the agenda of sustainable development globally.

Similarly, the consolidation of many commodity chains and commercial systems into transnational corporations has given a few specific corporate actors significant capacity to influence land outcomes globally. Cargill, ADM, Syngenta, Apple, international design firms, real estate agents, and retailers such as Tesco or Walmart represent just a few corporations with concentrated market presence. Their corporate policy decisions (and their shareholders) can have significant direct and indirect influences on resource allocation, land use, and even public policy in distant locations. With the intensified influence of corporate and commercial actors in resource decisions and management, voluntary round tables and consortiums of these actors (e.g., around sustainable foods or specialty coffee), in which key corporate policy decisions are made, assume greater influence over telecoupled processes. At a more local level, professional associations (e.g., producer organizations or commodity groups) can play instrumental roles in adopting new ideas and technology, responding to new opportunities, and in monitoring outcomes and creating knowledge about issues for which they are concerned.

In the public sector, institutional trends, such as deregulation and decentralization, have not only provided new spaces in which private and civil society groups can mobilize and act, they have also transformed the role of public sector organizations. Municipal governments often have new responsibilities and mandates, which may be poorly funded. In seeking ways to address these responsibilities, local governments have formed new networks and associations that allow them to exchange experience, lessons, and mobilize resources. By connecting directly to international donors, financial organizations or international NGOs, such local governments essentially "skip" traditional hierarchical relationships. They forge direct connections to other places and actors globally, accelerating the diffusion of ideas, technology, and institutional frameworks.

Improved social networking technologies and the Internet have also empowered social activists and associated social movements. The International Food Sovereignty movement, for example, and the World Social Forum

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represent an internationally networked coalition of disparate activist groups (often with different local agendas) which, among other activities, are monitoring the actions of international organizations and corporations in particular places, and advocating for change in international investment and international governance.

Bilateral development organizations and the private sector, together with global NGOs and global charitable organizations, are now also assuming new responsibility for reconstituting and enforcing failed international governance initiatives. The development of voluntary carbon markets, for example, reflects unenforced institutional designs developed in the 1992 UN Convention for Climate Change. The agency of these networks has significant system influence.

This brief overview of our conceptual framework suggests some key research questions concerning telecoupled systems in land science: How should a telecoupled land system be defined? Can we identify different types of telecoupled systems based on their functional characteristics and different pathways of emergence and development? Are there stages of emergence of telecoupling? What are the different processes through which telecoupling emerges? At what point can telecoupling be considered to be the primary force in the functional relationship between two bounded systems?

Conditions of the Telecoupled Systems

We still have much to learn about the nature of land-related telecoupled systems before a predictive model of system interactions and development can be developed. Nevertheless, it does appear that telecoupling emerges as a significant concern in land change after specific thresholds are crossed, all of which require further research. The sheer number and complexity of interactions in more complex telecoupled systems makes it particularly challenging to evaluate and anticipate when thresholds will be crossed. However, some indication may be provided by considering system functionality, condition, attention, and mobilization.

First, *functional* thresholds of influence and sensitivity are important. It is clear that one system must have characteristics that catalyze its potential for influence over others: it will be a price setter in international markets; it dominates the flow of information, capital, or technology; and perhaps it is a leader or example in the dissemination of ideas and knowledge. The other system, the “receiving” system, in contrast, will have characteristics that make it susceptible to the telecoupled signal: vulnerabilities exacerbated, for example, by the absence or reduction of domestic protections over land-use change or livelihood outcomes; the spatial extent or value of the resource affected; economic, infrastructural, or institutional conditions that trigger an elastic response of capital to new opportunities; or political conditions in which actors are well positioned to take advantage of the telecoupling and use it to their benefit.

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Each of the interacting systems will be in some temporal process of change and dynamism involving social, institutional, and economic processes that are endogenous to the system as well as interactions with other systems. The state of the systems at the time of coupling will determine the implications of the coupling for the land outcomes of concern. Germany, for example, responded rapidly to the Fukushima nuclear disaster in Japan by changing its policy toward nuclear energy. This change in policy did not occur in other nations with similar dependence on nuclear energy. In Germany, however, the Green Party had been advocating for a change in energy policy for some time and used its recently acquired new political clout to catalyze the issue into national policy as a result of the ensuing environmental disaster in Japan. In other cases, industrial development motivated by wealthy immigrants with distinct cultural and aesthetic values may stimulate the growth of supporting real estate services and industry, altering the physical landscape and land use in a particular urban context. As such, urban design assumes symbolic status as it is transferred to other, unrelated contexts and becomes a model for urban development.

Second, *conditional* thresholds of impacts need to be crossed. In land science, these thresholds are reasonably well described and understood. Conversion of land from one use to another, or one land cover to another, typically depends on the combined influences of landscape factors (biophysical environment and land management attributes) and broader livelihood influences (market signals, migration remittances, demographic trends). Livelihood and human welfare outcomes are associated with land-use changes and, consequently, such outcomes establish thresholds in associated ecosystem processes. For example, migration may trigger environmental impacts in "sending" rural communities that are either negative or positive depending on conditions of information exchange, remittance-investment decisions, and other telecoupled factors. In the case of high migration communities of Bolivian smallholder farmers, these conditions have led in some cases to degradation (soil erosion) whereas in others it has led to conservation (agrobiodiversity) (Table 8.1). Thus while these conditions are critical in shaping telecoupling processes, more research is required to understand what degree of change is sufficient under which conditions to trigger the telecoupling relationship to become a prominent driver of land outcomes.

Third, for feedback to institutional design and governance to occur, similar to what occurs in the policy cycle, there needs to be an *attention* threshold of interest and concern. Institutional change is costly, particularly when it involves otherwise disconnected systems that are not operating within an existing governance system that can easily take on the emergent concerns of the telecoupling. For this reason, institutional change is most likely to occur when the implications of the telecoupling are of sufficient scale or consequence to trigger widespread concern and attention among a powerful community. Such consequences most likely occur when there is little possibility of substituting

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the affected resource, the resource is already contested or threatened, or when claims on the resource reflect multiple values and interests.

Finally, actors who have the agency and capacity to act must be concerned about the impacts and have influence over a system that is receptive to their actions: in short, there is a threshold for *mobilization* of resources to make a change in governance. In particular, those new actors, such as those described above, who have the capacity for cross-scalar action, play important roles. These thresholds raise a further set of research questions: What are the thresholds of functional change, condition, attention, and mobilization that are critical in different types of land-related telecoupled systems? Is it possible to identify characteristic features of such thresholds that typically lead to significant system change? Can they be predicted?

Analytical Approaches

The concept of telecoupling potentially offers a new heuristic from which to evaluate and think about land-use change. Analysis of telecoupling demands the integration of different epistemological perspectives on space and spatiality—one in which Cartesian space is the primary frame and point of departure, and one in which social space and its contingent aspects of agency and power are critical. In both science and policy, the tendency to view actions primarily within clear politically or ecologically bounded systems may need to change. As a heuristic, telecoupling shifts the focus from the processes and interactions occurring in one place or system to the processes and causal chain that links land parcels to land systems, to actors and actor networks, to institutions and governance, and ultimately to other land systems and places.

Telecoupling thus invites multiple points of entry for analysis and disparate lenses through which to understand its dynamics and implications. For example, telecoupling can be understood through the lens of environmental issues and sustainability concerns, as a way of bounding and framing the salience of the relationships. Research thus would tend to begin with a focus on a particular place-based problem and use that problem to define the system boundaries (e.g., deforestation in the Amazon or land degradation in the Sahel). The land parcel and its depiction in spatial analysis would be a critical starting point of analysis. Linkages are uncovered by working outward from the land-based focal problem of analysis.

An alternative approach might start with the telecoupled signal and the associated networks of actors and their activities, not the outcome on the landscape or parcel. For example, the EU Renewable Energy Directive, mandating a 10% renewable energy contribution to the EU energy portfolio, triggered a series of changes in cropping patterns and land use for the production of biofuels in the EU and in EU trading partners (Lambin and Meyfroidt 2011). In the analysis of telecoupling in this case, the signal might be a sudden rise in global

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oil prices coupled with a policy initiative in a particularly influential system to mitigate greenhouse gases. Here, the starting point of analysis might be the oil price signal and an identification of the social actors, and their networks, associated with that signal. By correlating the signal with other "flows" associated with land change (e.g., commodity prices, input prices, food prices, water, or labor demand), it may then be possible to anticipate where the telecoupling might emerge as a significant land issue. Alternatively, the entry point of analysis might be with the social networks involved: their agency, values, and capacity to instrument change.

The scope of observation and analysis consequently changes from what is often the case in land science. Multiple systems, separated in space, are typically involved in diverse possible causal and networked configurations. The emphasis is on the constitution of the linkages and nodes in the system and their implications rather than on hierarchy or scale of analysis. Networks of actors, of economic activity, and of environmental processes may occur at the same spatial scale or they may cross scales. For example, expansion of the imported quinoa market among high-end consumers in the U.S. market has led a variety of community organizations, indigenous rights groups, and food-security activitists and public officials in Bolivia to use their connections through professional linkages, personal relationships, and funding sources to pressure international food, agriculture, and human rights organizations in Europe and the United States. Together, the actions of these different social networks have combined to make the role of quinoa in telecoupling processes an issue in an international FAO forum.[1]

Analytical approaches applied to telecoupled systems, therefore, need to be able to address several key questions:

- Who are the key actors? What are their activities and values? What is their agency and how is it instrumentalized (e.g., through which networks and linkages)?
- What are the institutions and governance arrangements in which the actors are embedded?
- What is the perturbation?
- What are the consequent direct and indirect flows, and how are they associated?
- What are the land system outcomes (social, environmental, economic)? What institutions are missing?
- What are the feedback mechanisms and associated consequences?

Many of the methods that could potentially be brought to bear on these questions are well developed in other disciplines in which geo-referenced space and place are not always prominent attributes of concern (see Table 8.2). Thus

[1] A proposal was made by the Government of Bolivia for an "International Year of Quinoa" at the 37th session of the FAO in Rome, June 25–July 2, 2011. C 2011/INF/18/ Rev. 1 (see FAO 2013).

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Table 8.2 Analytical tools and lenses.

Analytical tool	Short description	Relevance for telecoupling
Actor theory-based approaches	Actor models comprise at least three nested components: • action as the dynamic interplay between activity and agency (means and meaning), • strategy of action as a combination of actions, and • institutions in which meanings of action are embedded.	An actor's capacity to influence land-use change can be discerned through his activity but also through the agency he can employ and how he is thereby influenced by external actors. Multiple interactions with other actors can be analyzed through direct influence on other actors (activity) or through shared institutions. This eventually allows indirect effects on land-use change to be identified that an actor exerts through actor networks.
Social network analysis	Allows the networked arrangements among many different actors to be analyzed in terms of various flows (e.g., information, money, material flows). The metrics permit network characteristics (e.g., density, centralization, bridging, and bonding ties) to be identified. Distinction of subgroups within networks is also an important measure.	Allows assemblages and hence system boundaries of telecoupled systems to be delineated, which then permit relevant socioecological systems to be identified and addressed. The identification of "brokers" (i.e., actors who ensure the connection between systems) highlights which actors and flows are decisive for enabling telecoupling, and hence represent leverage points for change and regime shifts
Process tracing	Identifies and decomposes all the detailed steps of the hypothesized causal chains that link some initial independent variables to the observed outcome of the dependent variable. When all steps of the causal chain, as well as their implications, are validated, and the counter-hypotheses are shown to be invalidated, then the causal link between the initial variable and the outcome can be established.	Well-suited to the longitudinal analysis of complex multidimensional cases, such as those which include nonmaterial flows and linkages that may be instrumental in land outcomes.
World city systems analysis	Scholars focus on two different aspects of global hierarchies: • differential attributes of global cities and the quantity, which involves ranking cities by the performance or level of specific traits, and • intensity of flows or linkages between them, which focuses on the interactions among cities within the hierarchy.	Explores partial "telecouplings" between cities in different nations. Theories, methods, and empirical results may be of use to those interested in land-use telecoupling.

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Table 8.2 Analytical tools and lenses *(continued)*.

Analytical tool	Short description	Relevance for telecoupling
Assemblages	The concept of "assemblages" suggests the coming together and interaction of multiple things. This is used to theorize and study structural change in social relations and the global political economy. Assemblages do not privilege specific units of analysis or predetermined causal relationships.	May be a useful heuristic device to capture the complexity of analyzing the interaction among fragments of institutional forms, ideas, and actors across historical periods. Can be useful in examining the sets of actors and varieties of agencies across space that are then telecoupled to land uses.
Economic models	A wide variety of economic tools and modeling approaches are potentially applicable: • computable general equilibrium models capture linkages between input and output markets and can thus be used to study how changes in one market affect individuals in a distal market, • models of economic growth and migration capture flows of people, goods, capital, and firms across regions and feedback effects, and • models of social interactions capture the influence of groups and networks on individual choices.	Useful to capture the implications of interregional flows of people, goods, and services in specific places as well as the relative influence of particular flows on observed outcomes.
Diffusion theory	Addresses how innovations spread through space and time. Has been used in fields from communications to marketing to understand how information, knowledge, ideas, lifestyle, and consumer patterns "travel" through society and are adopted over time by an increasing number of people. The mechanisms by which this process of diffusion occurs relate to knowledge and interactions among people.	Can help identify the nature of the force (e.g., idea, policy), the communication channels, the time, and the systems (actors, linkages) that enable an innovation to flow through the system. Uses concepts such as critical mass and tipping points which should be considered when analyzing what makes two systems coupled.
Organization theory	Used to understand how organizations arrange actors and processes to obtain a goal.	Can help us identify the individuals, structures, processes, and motivations that guide the behavior of the key actors.

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Table 8.2 *continued*

Analytical tool	Short description	Relevance for telecoupling
Trend analysis	An analytical approach in business (financial management, marketing) is employed to try and predict future behavior. Quantitative and qualitative methods are employed. To conduct marketing research, one tools consists of identifying "trendsetters" and following their actions, decisions, and interactions with others to detect the birth of a new trend.	As urban lifestyles become globally adopted, changes in patterns of consumption or interest of small but influential populations can be the origin of changes in behavior at a large scale and the telecoupling of distal systems.
Multisite studies	These are places of study that are connected by processes rather than comparable units of analysis or systems features. Such a study might involve all sites in which the activities along a commodity chain take place and use different methods for each site.	Is essential for analyzing telecoupling since, by definition, it occurs at multiple sites, with different actors, and activities of interest in each site.
Flow analysis	This general category of analytical tools incorporates commodity/value chain analysis, life cycle analysis, material flow analysis, and other methods that trace systematically the movement of material (energy, goods, capital) through a system.	Accounts for the movement of material and value between systems, and thus the feedbacks and linkages in telecoupled interactions.
Pathway analysis	Focuses on strategies that arise from decisions taken by individual actors, households, and groups of people. It stresses that opportunities and constraints on decision makers are imposed by other actors as well as higher-level institutions.	Is relevant for telecoupling analysis, which pays attention to the role of actors in dynamics and feedback.
Scenario and visioning	Different fields have developed strategies and procedures for scenario construction and analysis as well as participatory visioning activities. These approaches entail facilitating the construction of possible and plausible futures with key social actors, in which the indirect and direct consequences of actions and development trends can be explored.	May enable telecoupled land outcomes to be predicted and anticipated, and adverse outcomes avoided, through anticipatory actions and social learning.

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integrating approaches requires innovation in analysis: How can social networks and their geographic influence be represented spatially? Are there ways in which tools common to land science can be employed to represent the material and nonmaterial flows critical in telecoupled systems? Can the different values that specific actors associate with land change be represented as attributes of parcels and places? Is it important to present evidence that specifically quantifies the degree of land system change associated with the initial telecoupled signal, and if so, what methods will enable this given the indirect and second- or third-order interactions observed in these systems?

Global Land-Change Implications: Vulnerabilities, Risks, Opportunity, and Adaptation

The undesirable impacts of telecoupling processes have drawn attention to these linkages. Nevertheless, it is important to recognize that the telecoupling process is driven by different—and possibly incongruous—values associated with diverse social actors, some of whom are in distal locations from where the impacts have materialized and may thus not have an accurate understanding of the causal relations or implications of the telecoupling outcomes they observe. For example, the concept of "food miles" gained attention in the popular press and media in the United Kingdom during 2005–2006, as a measure of the impact of food transport on the environment. The concept began to be used by activist environmental organizations to argue for the purchase of local food. This campaign threatened the viability of some types of food export from New Zealand to the United Kingdom, and hence potentially the livelihood of many New Zealand farmers. However, subsequent evaluation of the energy and emissions performance of a sample of food products using life cycle analyses (Saunders et al. 2006) revealed that locally supplied foods in the United Kingdom typically had significantly higher energy and emissions costs than the competing imports from New Zealand, due to the different production, storage, and transport systems and their cumulative performance. Here, the telecoupling which enabled U.K. NGOs to influence significantly the behavior of consumers unexpectedly prompted higher environmental impacts, due to misleading and incomplete information.

Thus, how telecoupling outcomes are valued will always be challenging and depend very much on assumptions and the framing of the process (e.g., "land grabbing" vs. "REDD+"), what attributes of a specific land system are affected, what social actors are present and mobilized to act, the spatial or temporal scale at which outcomes are evaluated, and the context in which the telecoupling occurs. One of the concerns with growing influence of telecoupling is that in a time of more acute resource scarcity, telecoupling may have redistributive implications, both enhancing and limiting the possibilities of action for different populations and actors in particular places. This redistribution

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may be positive (beneficial) or negative. Such outcomes are not only important to understand for development trends, but also have ethical implications for both science and governance.

For land science, the concern is particularly in relation to significant thresholds of change in land use and associated ecological and social processes. Telecoupling, for example, that results in sudden land-cover conversions, land abandonment, or shifts in land governance with consequent implications on resource management and use can potentially have significant global consequences for land-change trends. More broadly, regime shifts in land systems have implications for broader system resilience and capacity to manage shocks over the long term.

National governments may be more concerned with the potential threat to human and national security. Where telecoupling outcomes are undesirable in a particular place, social conflict may result. Land, as a scarce resource, is highly valued in many cultural and economic contexts. Telecoupling processes that result in marginalization of disenfranchisement of local populations to land and land activities has, in the past, provoked revolution and violence. For example, the French, Russian, and Mexican revolutions derived their strong impetus from exploited local land-working populations and resulted in transforming the social order. These experiences have been repeated in many colonial situations, where inequities in land-holding rights prompted civil unrest and eventual removal of colonial powers. Repeated land-reform movements, both local and national, have been prompted by inequalities provoked by changes in land use and market demand; they have resulted in less extreme transformations, but still transformatory realignment of rights to significant amounts of land. How such outcomes can be potentially anticipated is a potential subject for land science and governance in a telecoupled world.

Conversely, society in general may be better equipped today to manage these complex relationships through the same information and knowledge that has contributed to these accelerated linkages. People and organizations have the potential to anticipate consequences and mobilize collectively to act to avoid undesirable outcomes. The rising influence of social networks and information systems has given actors a capacity to "skip scale," redistributing agency to finer scales and enhancing the capacity of cross-space interactions. Through such connections actors can be both flexible and innovative in their responses. Telecoupling can also lead to other adaptive responses and opportunities via market specialization of actors newly linked to market signals, linkages between previously disconnected social networks operating at different scales, and the diffusion of institutional innovation and social mobilization to other systems that have yet to experience undesirable outcomes but wish to anticipate possible problems.

Outcomes of telecoupling processes that are valued as "positive" by some actors and communicated through knowledge networks can also be recognized and supported at higher levels of decision making. For example, various production

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standards associated with eco-certification have been adopted by other agents, even though they may not be seeking certification, given the benefits of the practices. This creates positive spillover effects to other producers, companies, investors, or governments. In some cases, sustainability standards become embedded in public policies or reinforce existing policies (Steering Committee of the State-of-Knowledge Assessment of Standards Certification 2012).

The new institutional changes that have been noted as an outcome in some telecoupled systems have in part been brought about by the recognition of responsibility by consumers, corporations, governments, or other actors in the systems that are the source of the telecoupled signal. Making telecoupling "visible" through information and knowledge networks can thus lead to enhanced agency and new forms of social contracts, mediated by sustainability certifications and standards or codes of corporate responsibility. These new institutions can "institutionalize" some of the externalities of the telecoupling process through the same linkages and flows that initially were the cause of the problem. This added value, then, can bring important benefits to telecoupled regions.

Research Needs, Opportunities, and Limitations

The development and application of the concept of telecoupled systems in land science opens up a stimulating range of challenging research questions: How can land science engage with other disciplines in a transdisciplinary project to analyze the nonmaterial dimensions of telecoupling, such as financial flows, social networks and values, and information and symbolic relationships? How can understanding of these procedures be most effectively integrated into established land science? Are there stages of emergence of telecoupling? Can we identify different types of telecoupled systems depending on their functional characteristics and different pathways of emergence and development? At what point does the functional relationship between two bounded coupled systems assume sufficient importance in the overall operation of the two systems for them to be conceived as primarily telecoupled systems? What tools and methods will enable tracing of indirect and second- or third-order interactions observed in these systems? What are the thresholds of functional change, condition, attention, and mobilization that are critical in prompting change in different types of telecoupled system? Most significantly, perhaps, where do telecoupled feedback processes critically influence global land-use change, with what consequences and potentials for improved governance?

It is important to recognize the limitations associated with this emerging conceptual approach. It could be argued that telecoupling is nothing new, and thus that it adds little novel insight. There have always been distal connections in human affairs, and so perhaps the current situation is different by degree, but not in essence. As is clear from the preceding account, we subscribe to the view that the social and nonmaterial feedback processes that have been enabled by

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modern technologies and new governance arrangements are substantively different in their nature and effect from anything that has gone before, and that they are potentially game changing in global land science. While it is by no means clear that the concept of telecoupling can be operationalized in an effective way *within* land science as it is currently constituted, the global significance of the phenomenon lays obligation upon the land science community to find ways to engage with the necessary concepts and analytical tools. This may require the development of a transdisciplinary land science, with profound implications for methodology and reporting.

Conclusion

The increased concern over telecoupling in land-change processes highlights the importance of system perspectives and integrated hybrid analyses in revealing the important drivers and feedbacks in land systems. The analysis of telecoupled systems also reveals the importance of social actors and their associated values, preferences, and networks on land change. Among those actor networks is the scientific community: science plays a significant role in making visible the relationships and consequences of value to the science community as well as to other actors. Telecoupled processes will be revealed because they affect attributes of value in a particular land system—attributes of the land itself, or social features and activities associated with land use. Understanding those configurations of values and the social systems in which they are embedded will define how the telecoupling process affects pathways of sustainability in land systems, and the relative influence of specific actor networks in defining the trajectories of those pathways.

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