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# Property rights and ecological-social interactions

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Published: August 28, 2013, 8:28 pm

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Humans interact with their environment through systems of [property rights](#) and governance (that are embedded in social, political, cultural, and economic context), and thereby affect both the quantity and quality of environmental resources. While national and international economic policies have often ignored the environment, institutions could play a key role in reconciling economic development and the maintenance of environmental [carrying capacity](#) and resilience[1]. Ecology and Society[2] and Environment and Development Economics[3] describes recent research on resilience in social-ecological systems. Folke and Gunderson identify several papers which explain how better ecological-social research can help to address global environmental issues[4]. This article explains how the functioning of property rights regimes in relation to human use of the environment, is critical to the design and implementation of sustainable environmental management measures[5].

## Sustainability, sustainable development, and property rights regimes

Property rights regimes consist of [property rights](#), bundles of entitlements defining rights and duties in the use of natural resources, and property rules, the rules under which those rights and duties are exercised[6]. Property rights regimes influence the use of environmental resources, a fact that has long been well established, if not well practiced. Warming[7] wrote of the dangers of fisheries overexploitation without ownership, an argument enhanced by Gordon[8]. In “[The Tragedy of the Commons](#),” [Garrett Hardin](#) (1968) focused widespread attention on the problem of environmental degradation in the absence of rules governing use. For many years, the general interpretation of Hardin’s argument was that collectively owned property was the culprit, and that private property was necessary to sustain environmental resources. However, a rapidly expanding body of scientific evidence indicates that sustaining environmental resources is not dependent on a particular structure or type of property regime, but rather on a well-specified property rights regime and a congruency of that regime with ecological and social factors.

In this ecological and social context, sustainability is a difficult concept to interpret because it has a wide range of meanings based on different disciplines and world views. What is being sustained, how it is to be sustained, and for how long, are all open to interpretation. Regardless of the specific meaning used, it is clear that, to some extent, sustainability is a human construct. Humans use their environment for a range of objectives (see "Conceptual framework linking ecological and socio-economic systems"), which leads to different expectations as to what is to be sustained, and who is to have claims on environmental services. Cochrane argues that social (cultural) [capital](#) determines the sustainability of [environmental capital](#) by influencing management objectives, efficiency of use, and demand relating to natural resource use<sup>[9]</sup>([Chapter 2](#)).

The question of sustainability is a complicated one whose answer involves more than the generic application of a [property rights](#) regime. Property rights regimes need to reflect both general principles and specific social and ecological contexts, in order to be effective in modulating the interaction between humans and their environment. General principles include the structural and functional attributes of property rights regimes which transcend a particular context<sup>[10]</sup>. General principles are the necessary conditions for effective property rights regimes, because a property rights regime cannot succeed over the long run without them. They include several key elements, such as congruence of [ecosystem](#) and governance boundaries; specification and representation of interests; matching of governance structure to ecosystem characteristics; containment of transaction costs; and [monitoring](#), enforcement, and adaptation processes at the appropriate scale<sup>[11]</sup>.

General principles are necessary, but not sufficient in themselves for effective property rights regimes. In addition, specific attributes of social and ecological context must be represented. Social contexts contain all the dimensions of the human relationship to environmental resources, including social arrangements, cultural practices, economic uses, and political constraints. Ecological contexts contain the structure of [ecosystems](#) in which humans live and work, as well as the particular functional properties of those ecosystems. The particular details of the social and ecological context are what give a human social–environmental interaction its variety and detail. The match between a property rights regime and the contextual characteristics of the affected humans and ecosystems will determine success or failure in terms of sustainability. Better [economic valuation](#) of environmental and socio-cultural assets (see [Chapter 3](#)), and their internalization in the price system, is one means of ensuring that market forces lead to more

sustainable resource use. The more equitable distribution of resources and assets is a step toward poverty reduction and social sustainability, as is greater participation and empowerment of disadvantaged groups. Clearly, [property rights](#) regimes that specify access to the natural resource base and rights of use have a crucial role to play, in this context.

The literature addressing questions of property rights and natural resource use is growing, but there are large gaps in knowledge [\[12\]](#). Five of these areas are explored below.

## Governance systems

Questions of governance over environmental resources have to do with the ability to predict and oversee probabilistic ecosystem responses to human behavior and management, and to external drivers such as climate. The complexity of the human systems and ecosystems affects the ability to extract consistent objectives, design meaningful control systems, and monitor response. The scale of the [ecosystem](#) in comparison with scales of social organization or legal jurisdiction determines the extent of the match between the human and environmental systems. The delineation and coordination of authority over environmental decisions is critical to relating actions to outcomes. The ways in which governance is coordinated between authorities at different levels determine consistency across scales. The success of decentralized governance systems may be improved by applying the principle of subsidiarity, which requires that each decision is made and implemented at the lowest practical and effective level.

Most studies assume that the manager is outside the system being managed [\[13\]](#). However, in the context of long-term sustainability, linked socioeconomic and ecological systems (SESs) behave as complex adaptive systems, with the managers as integral components of the system. Ostrom argues that since many biological processes occur at small, medium, and large scales, governance arrangements that can cope with this level of complexity also need to be organized at multiple scales and linked effectively together [\[14\]](#). The importance of nested institutional arrangements is emphasized, with quasi-autonomous units operating at very small, up through very large, scales. The concept of distributed governance is analyzed by Townsend and Pooley [\[15\]](#) using competing models of cooperative management, co-management, and rights-based management in the context of [fisheries](#). They pay attention to both internal and external governance issues. Fitzpatrick also looks at distributed governance in the case of Canada [\[16\]](#). He emphasizes that there is a need for partnership arrangements, especially between multiple sectors and levels of governance to meet shared objectives. Distributed authority affects governance efficiency and in particular, through the role played by user participation in lowering

management costs<sup>[17]</sup>. The contribution of user participation to governance efficiency may be analyzed in terms of the structure and function of user participation and its effect on management costs. Kaitala and Munro address the question of governance coordination over multiple jurisdictions<sup>[18]</sup>, as exemplified by transboundary fishery resources categorized as highly migratory fish stocks and straddling fish stocks. The high seas portion of the stocks are exploited by both coastal states and distant water fishing nations. The difficult issue of managing such resources (characterized by ill-defined property rights over the high seas portion of the resources) is the focus of a major United Nations intergovernmental conference.

Several case studies illustrate the application of the various principles of governance to the environmental challenges of air pollution, fishery management, and pesticide use. Tietenberg examines the question of governance design and scale through an analysis of the use of market-based mechanisms in his chapter on the transferable permits approach to pollution control problems in the United States<sup>[19]</sup>. From the various examples described, he extracts lessons for both the implementation process and program design. Townsend and Pooley consider the question of appropriate levels of authority—through a potential application of the distributed governance concept to the lobster fishery of the Northwestern Hawaiian Islands<sup>[20]</sup>. Gren and Brännlund show that although geographic differences in environmental impacts may call for region-specific environmental regulations, regional differences in enforcement costs will lead to different levels of cost-effective regulation<sup>[21]</sup>. Grima discusses the role of institutions at the international, national, and community levels (including property rights), in making the forestry sector development more sustainable<sup>[22]</sup>.

## Equity, stewardship, and environmental resilience

Generally, the degree of equity represented by a property rights regime helps to create the incentive structure which either promotes or inhibits stewardship of environmental resources. In turn, the degree of stewardship practiced affects the level of ecosystem resilience. Exactly how equity affects stewardship and how specific stewardship practices affect resilience is still a matter of research. Definitions of equity, stewardship practices, and environmental resilience reflect a combination of local context, appropriate incentive structures, and adaptation to environmental change. The goals of equity and stewardship are commonly considered to be inconsistent with efficiency in environmental management. In a departure from the usual approach, Young and McCay look at efficiency-driven, market-based property rights systems and evaluate them for their ability to accommodate equity, stewardship, and resilience, in the

design of adaptive and flexible management regimes – after considering a number of different types of property rights systems for a variety of resources[23]. Chichilnisky and Heal emphasize that the most attractive feature of markets is efficient allocation of resources, requiring minimal intervention once an appropriate legal infrastructure is in place[24].

Several studies demonstrate the difficulties of crafting equitable schemes that promote better stewardship and resilience for the conservation of natural resources. Gadgil and Rao examine the incentives for managing [biodiversity](#) contained in India's folk traditions of nature conservation[25]. They focus on the efficiency and equity gains possible through reestablishing conservation approaches based on positive incentives to local communities. This attractive option is contrasted with current unsuccessful regulatory methods that are too centralized, sectoral, and bureaucratic. Zylicz analyzed the conflict between conservationists and a municipality in Northeastern Poland[26]. Parts of national parks are being claimed by previous landowners who feel they were not reimbursed fairly, there are private or communal enclaves left within park boundaries, and neighboring landowners protest against development constraints due to the park's existence. The fate of nature depends on the ability of conservationists to demonstrate economic benefits from investing in [natural capital](#), to prevent degradation. Parks and Bonifaz examine the joint use of environmental resources, by looking at the inconsistencies of short-term commodity production with long-term environmental sustainability in open-access [Ecuadorian](#) mangrove–shrimp systems[27]. They identify incentives to maximize short-term profits through shrimp mariculture, which have led to destruction of larval-shrimp habitats as mangrove ecosystems were converted to shrimp ponds. Gottret and White describe integrated natural resource management (INRM) in Latin America[28]. The complexity of INRM interventions requires a more holistic approach to impact assessment, which combines the traditional "what" and "where" factors of economic and environmental priorities, with newer "who" and "how" aspects of social actors and institutions.

## Traditional knowledge

The documentation and use of traditional ecological knowledge is now an internationally accepted practice. At an even deeper level, many “modern” concepts like “Gaia” and “[deep ecology](#)” have basic roots in ancient philosophies – e.g., the contribution of eastern thinking is documented in Daniels[29], Hall[30], and Hargrove[31].

Here we focus on how long-standing systems of environmental resource management and their use of traditional ecological knowledge are yielding insights into current resource management

problems. Cicin-Sain and Knecht review data on reconciling systems of traditional knowledge with modern approaches to the management of natural resources[32]. They analyze implementation challenges that both regional and national-level entities will face as they endeavor to enhance the role of indigenous knowledge and participation.

Ecosystems are complex adaptive systems, and their governance requires flexibility and a capacity to respond to environmental feedback[33]. Carpenter and Gunderson stress the need for continuously testing, learning about, and developing knowledge and understanding in order to cope with change and uncertainty in complex adaptive systems[34]. Knowledge acquisition about complex systems seems to require institutional frameworks and social networks nested across scales to be effective[35].

Knowledge of resource and [ecosystem](#) dynamics and associated management practices exists among people of communities that, over long periods of time, interact for their benefit and livelihood with ecosystems[36]. The way such knowledge is being organized and culturally embedded, its relationship to institutionalized, professional science, and its role in catalyzing new ways of managing environmental resources have all become important subjects[37]. It has been suggested that the management and governance of complex adaptive systems may benefit from the combination of different knowledge systems[38]. Some attempt to import such knowledge into the realm of scientific knowledge[39], while others argue that these knowledge systems are culturally evolved and exist as knowledge–practice–beliefs complexes that are not easily separated from their institutional and cultural contexts[40]. There are those who question the role of traditional and local knowledge systems in the current situation of pervasive environmental change and globalized societies[41], while others argue that there are lessons from such systems for complex systems management, which also need to account for interactions across temporal and spatial scales and organizational and institutional levels[42], and in particular during periods of rapid change, uncertainty, and system reorganization[43].

The use of traditional and nontechnical knowledge by itself, in combination with modern scientific knowledge, and in the restoration of previously established [property rights](#), is explored in several case studies. Pálsson[44] considers the use of practical knowledge obtained by Icelandic fishing skippers in the course of their work, exploring how fishermen’s knowledge differs from that of [fishery](#) scientists, and how the former could be brought more systematically into the process of resource management for the purpose of ensuring resilience and sustainability. A study of Cree Indians from the Canadian subarctic is presented by Berkes[45],

who analyzes the evidence regarding the distinctions of the local indigenous knowledge from Euro-Canadian, science-based wildlife and fishery management knowledge. The understanding of traditional knowledge for resource management has remained elusive, not only for development policymakers, but also for scholars engaged in such research. Traditional knowledge may be used to reestablish claims to former rights<sup>[46]</sup>. For the New Zealand Maori, traditional [property rights](#) have been recognized by customary law. The codification of existing rights and customary laws within a system of statutory law in various cultural settings is a contemporary process in many nations in the Pacific Basin, which might provide useful precedents for application worldwide.

Long et al.<sup>[47]</sup> reveal that myths, metaphors, social norms, and knowledge transfer between generations of the White Mountain Apache tribe facilitate collective action and understanding of [ecosystem](#) dynamics, and provide a cultural foundation for adaptive management and modern ecological restoration. Watson et al.<sup>[48]</sup> argue that traditional ecological knowledge serves an important function in the long-term relationships between indigenous people and vast ecosystems in the circumpolar north, and can contribute to understanding the effects of management decisions and human-use impacts on long-term ecological composition, structure, and function. Ghimire et al.<sup>[49]</sup> assess variation in knowledge relating to the diversity of medicinal plant species, their distribution, medicinal uses, biological traits, [ecology](#), and management within and between two culturally different social groups living in villages in northwestern Nepal. Devkota<sup>[50]</sup> describes how traditional knowledge embedded in Nepalese forest communities enhances natural, social and economic simultaneously, and provides a practical example of strong sustainability. These local groups are not only meeting their present demand for natural resource services, but also seeking to increase their socio-economic and environmental resources for the future.

Becker and Ghimire<sup>[51]</sup> show the important role of organizations such as non-governmental organizations (NGOs), in bridging traditional knowledge and scientific insights, and in providing social space for mobilizing a synergy between traditional knowledge and western knowledge for sustaining ecosystem services and [biodiversity](#) in a Ecuadorian forest commons. Milestad and Hadatsch<sup>[52]</sup> analyze the potential for organic farming in the Austrian Alps to flourish under the Common Agricultural Policy of the European Union in relation to the farmers' perspectives on sustainable agriculture, and whether or not organic farming and traditional practices are capable of building social–ecological resilience in the area.

## Mechanisms linking humans and environmental resources

Linkages between humans and environmental systems operate in different ways according to their structure, the systems they link, and the process by which the linkage is made. Some linkages are constructed by the informal observation of environmental characteristics on the part of users, and the gradual evolution of behavioral response. Others are established as more rapid responses to change. In cases of environmental overuse, linking mechanisms are often weak or absent, cutting off the interaction between environmental condition and human response. The particular structure of a linking mechanism reflects the economic, social, and ecological context in which it is established. The structure determines what information will be monitored, how it will be monitored, and what will be done with the information once acquired. The key question is whether the governance system promotes or even allows behavioral adaptation to environmental change. Linkages affect both [ecosystem](#) and human system adaptation and [evolution](#) through the type of feedbacks allowed.

Folke and Berkes[\[53\]](#) present a systems view of social and ecological interactions, which stresses the need for active social adaptations to environmental feedbacks and the use of traditional ecological knowledge. Particular attention is paid to the lessons that can be learned to assist in the design of more sustainable resource management systems – improving their adaptiveness and resilience. Chopra[\[54\]](#) describes the management of natural resources and the environment for livelihoods and welfare based on three empirical studies in India, to show that the endowment of social capital may be measured by how well individuals cooperate across the traditional division of institutions (state, market and non-market).

Berke and Folke[\[55\]](#) look at management practices based on local ecological knowledge and offer the following guiding principles for designing management systems that build resilience in social-ecological systems: (1) "flow with nature," (2) enable the development and use of local ecological knowledge to understand local [ecosystems](#), (3) promote self-organization and institutional learning, and (4) develop values consistent with resilient and sustainable social-ecological systems.

Nested forest tenure systems, [fisheries](#), and joint [farming–forestry](#) systems, help to determine the function of linkages. Mexican resource tenure systems function as “shells” that provide the superstructure within which activities are developed and operate[\[56\]](#). Such shells are linked in very specific ways to the larger “operating system” in which the shell is embedded. The best course of action for promoting ecologically sustainable resource management is to support

existing structures. Hammer<sup>[57]</sup> focuses on the links between ecological and social systems in Swedish fisheries, especially in the Baltic Sea. He compares traditional small-scale and current large-scale management systems, in terms of how they promote linkages between social and ecological systems, and finds that large-scale systems are more vulnerable because of their failure to process ecosystem feedbacks.

Social-ecological linkages help to analyze the broader parametric effects of fishing on the whole biotic and environmental system <sup>[58]</sup>. The fundamental cause of [overfishing](#) lies in the social institutions that either cannot grasp the complexities of biological interactions, or have insufficient means to control the inputs. This institutional difficulty, combined with the uncertainty characterizing [marine systems](#), suggest the appropriateness of a multilevel governance system that captures the social–ecological linkages on different scales. Pradham and Parks<sup>[59]</sup> look at how the interactions between forests and subsistence agricultural systems in Nepal’s villages are influenced by the activities of rural farming communities that depend on the forest for various subsistence products. Past government efforts to protect forest resources by excluding local communities have resulted in the opposite effect. Destruction of the social–ecological linkages at the local level has resulted in village residents perceiving forests as open-access resources, and this has led to further environmental degradation. Sastry<sup>[60]</sup> examines the spatial dimensions of making development more sustainable in the mountainous Western Ghats region of India, from the economic, social and environmental perspectives. He proposes an integrated model which promotes three distinct forest ecosystems to operate at three different altitudes where three separate socioeconomic systems operate. The model helps to rejuvenate forests while maintaining ecological balance – based on the “unity in diversity” approach. Satake and Iwasa<sup>[61]</sup> use a Markov model of social-ecological coupling to show that myopic decisions by private landowners will push entire landscapes towards [agricultural](#) use, although the forested state is more socially optimal. A long run management view and enhanced forest recovery is the remedy.

## Poverty, population and natural resource use

Linkages among poverty, population and natural resource use are discussed here in the context of [property rights](#). A broader discussion is provided in "Economic, social, and environmental elements of development". The population policy literature reflects the current view that previous successes in family planning directed at the supply side of population growth, cannot be sustained without paying serious attention to reducing both the demand for births and the

momentum of population growth<sup>[62]</sup>. Proposed policies include establishing formalized systems of property rights to resources, in addition to education of women to enhance economic standing, and incentives to postpone childbearing to later years<sup>[63]</sup>.

Dasgupta<sup>[64]</sup> finds that population growth is in varying degrees linked to poverty, to gender inequalities in the exercise of power, to communal sharing of child-rearing, and to an erosion of the local environmental–resource base. These linkages suggest that population policy should contain not only measures such as family planning programs, improved female education, and [employment](#) opportunities, but also other measures to alleviate poverty, and provide basic household needs.

Jodha<sup>[65]</sup> shows how poverty affects resource use behavior based on desperation. He argues that the current unsustainable pattern of resource use in the Himalayas is due to the replacement of traditional conservation-oriented resource management systems with more recent extractive systems. He examines the driving forces underlying this shift and discusses ways to restore some of the beneficial properties of the traditional systems.

Munasinghe<sup>[66]</sup> shows that oversimplifying the complexities of the poverty-population-resource use linkage, could lead to inequitable and unwarranted conclusions. He argues that under appropriate circumstance, people may be considered a social resource that would complement and strengthen the natural resource base, and enhance [economic prosperity](#) – see "Economic, social, and environmental elements of development". Grima<sup>[67]</sup> examines agricultural practices in fragile lands and hill areas, to better understand the trade offs among development, poverty alleviation and sustainable use of [natural capital](#).

## Lessons learned and conclusions

Both general principles and specific social and ecological context play a crucial role in the design, implementation, and maintenance of [property rights](#) regimes for environmental resources.

*Governance Systems:* General principles of governance were discussed in relation to matching the scale and complexity of ecological systems with property rights regimes, ensuring that sets of rules are consistent across different levels of authority, distributing authority to achieve representation and contain transactions costs, and coordinating between jurisdictions. Specific properties of governance were presented for limiting [air pollution](#), managing a [fishery](#), and enforcing regional environmental regulations.

*Equity, Stewardship, and Environmental Resilience:* General principles were discussed in terms of the relationship between equity, stewardship, environmental resilience, and efficiency in [property rights](#) regimes designed for a range of environmental resources. Specific interactions were analyzed in the contexts of traditional systems for maintaining [biodiversity](#) in India, changing property rights to national parks in Poland, and mangrove–shrimp production systems in [coastal Ecuador](#).

*Traditional Knowledge:* General principles of traditional knowledge were discussed in terms of the interaction between international environmental policy on the use of traditional knowledge and the implementation of local-level resource management systems that use traditional knowledge. Specific properties of traditional knowledge were presented in the contexts of practical knowledge about fishing in Iceland and Canada, and the restoration of Maori property rights in New Zealand.

*Mechanisms linking humans and environmental resources:* General principles of mechanisms that link humans to their environment were discussed in terms of their structures and the processes by which they allow humans to observe environmental change, adapt their behavior to reflect environmental change, and create knowledge in the process. Specific properties of linking mechanisms were presented in the contexts of forest tenure systems in [Mexico](#), fisheries management in Sweden and elsewhere, and the interaction between [agriculture](#) and [forestry](#) in Nepal.

*Poverty, population and natural resource use:* General principles of the connection between population and poverty were discussed in terms of the intermediate linkages of gender equality, child-rearing practices, women’s education, and general [employment](#) opportunities. Specific properties of the population–poverty connection were presented in the context of the relationship of population growth to poverty and unsustainable forest use. Simple generalizations may lead to wrong conclusions, because the poverty-population-resource use nexus is complex.

The diverse papers discussed in this section are woven together by a common thread – the interaction of social and ecological systems through [property rights](#) to produce environmental outcomes. They show how the ecological context shapes human organization and behavior, and the human context in turn shapes ecological organization and response. The structure of governance, values of equity and stewardship, traditional knowledge, linking mechanisms, and conditions of poverty and population all form a part of that context. The analysis of property rights regimes confirms that the [co-evolutionary path](#) which humans and their environment

follow (see "[Economic, social, and environmental elements of development](#)") is indeed determined by the interaction of socioeconomic and ecological contextual elements.

**Note:** The author welcomes comments, which may be sent to [MIND](#).

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Previous: *Conceptual framework linking ecological and socio-economic systems* | [Table of Contents](#) | Next: *Environmental and social assessment*

## Citation

Munasinghe, M. (2013). Property rights and ecological-social interactions. Retrieved from <http://www.eoearth.org/view/article/51cbeeab7896bb431f699811>