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Linking social and ecological systems for resilience and sustainability

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Introduction

There is much evidence of poor management of ecosystems; the conventional prescriptions of resource management are in many cases not resulting in sustainability. In fact, some of the resource crashes of recent years are of greater magnitude than those observed historically. Some authors attribute this fact to human 'shortsightedness and greed', and question whether resources could ever be managed sustainably (Ludwig, Hilborn and Walters 1993). Others argue that resource management science may be fundamentally flawed as a system of thought and practice in that its premises are based on the *laissez-faire* ideology which still persists in neoclassical economics (Daly and Cobb, 1989). Gadgil and Berkes (1991) and McNeely (1991), among others, have pointed out that scientific resource management has its roots in the utilitarian and exploitative worldview which assumes that humans have dominion over nature. In the historical process of converting the world's life-support systems into mere commodities, resource management science was geared for the efficient utilization of resources as if they were limitless. Methods of resource development and management, in both biological and economic areas, have treated the environment as discrete boxes of 'resources', the yields from which could be individually maximized. The field has relied on the use of fixed rules for achieving constant yields, as in fixed carrying capacity of animals and fixed maximum sustainable yields (MSY) of fish and forest products.

Much of the development in resource management science since around the 1970s has sought to deal with the environmental and social problems created by resource mismanagement and depletion. Many of the new approaches have been reformist in nature, seeking to alleviate the excesses of classical resource management. An example would be the creation of multi-species models in fisheries, as opposed to the modelling of single

species populations and calculating fixed MSYs as if these species were not affected by changes in the populations of their competitors, predators, prey, and fluctuations of their physical environment (Larkin, 1977). Other approaches have been more radical, rejecting resource management altogether as a valid objective. One example would be deep ecology, as the preservation of ecosystems as a public good independently of their utility as resources; an extreme example would be the animal rights movement.

The basic assumption behind the work that led to the present volume is that resource management is necessary but that it requires fundamentally different approaches, not mere tinkering with current models and practices. The volume seeks to integrate two streams of resource management thought that fundamentally differ from the classic utilitarian approach. The first is the use of systems approach and adaptive management, with their emphasis on linkages and feedback controls (Holling, 1978; Walters, 1986). The systems approach is replacing the view that resources can be treated as discrete entities in isolation from the rest of the ecosystem and the social system. For example, the volume *Investing in Natural Capital* (Jansson *et al.*, 1994) explored in some detail the necessity of a systems-oriented, wide-scope ecological economics approach to sustainability.

The second stream of thought is that improving the performance of natural resource systems requires an emphasis on institutions and property rights. A people-oriented approach which focuses on the resource user rather than on the resource itself is not a new idea; many have pointed out that 'resource management is people management'. However, tools and approaches for such people management are poorly developed, and the importance of a *social science* of resource management has not generally been recognized. The present volume follows from and extends the findings of a number of books that have tried to fill this gap, including Clark and Munn (1986) on the various dimensions of sustainability; Ostrom (1990) on institutions and collective action; Bromley (1991), Hanna and Munasinghe (1995) and Hanna, Folke and Maler (1996) on property rights; McCay and Acheson (1987), Berkes (1989) and Baland and Platteau (1996) on community-based resource management; and Lee (1993) and Gunderson, Holling and Light (1995) on institutional learning and resource management.

Following the statement of objectives, this introductory chapter will review some definitions that will be widely used in the book, and will then cover five concepts or themes on which our arguments hinge: property rights, the systems approach, adaptive management, ecological resilience, and traditional resource management systems. These sections explain the

basis for the analytical framework used in the book, followed by a description of the framework itself.

Objectives

The general objective of the book is to investigate how the management of selected ecosystems can be improved by learning from a variety of management systems and their dynamics. The essential feature of this inquiry is to mobilize a *wider range* of considerations and sources of information than those used in conventional resource management. Many of the cases in the book investigate a mix of systems and their change over time, and some of the cases focus on traditional and newly emergent local systems. All chapters address the question of sustainability, and seek principles that may assist in successful resource management or help restore degraded ecosystems to generate a sustainable flow of services. To accomplish this task, social and ecological linkages in selected ecosystem types are investigated systematically, using a common analytical framework. Specifically, in each of the case studies, the authors address two objectives:

- how the local social system has developed management practices based on ecological knowledge for dealing with the dynamics of the ecosystem(s) in which it is located; and
- social mechanisms behind these management practices.

The volume is organized into four parts. Part I includes three chapters that take very different approaches to deal with the question of learning from locally devised systems. One of these is a 'traditional' system from India; the other two are from Europe, one historical and one contemporary. Part II includes three chapters from the Americas and one from Africa dealing with the emergence of new adaptive systems. These case studies show how institutions can adapt to local ecosystem characteristics and provide an understanding of some of the dynamic processes in social – ecological systems undergoing change. Part III, also with four chapters, is concerned with regional experiences as well as local experiences, and with generalizations that emerge from the accumulated body of literature from four different regions of the world. These four chapters help emphasize the point that local social systems are not isolated but are subject to national and regional influences. The four chapters in Part IV address the question of designing new approaches to management. Three of them explore the ways to combine local and scientific knowledge, or to combine traditional and conventional resource management systems.

Many previous studies have analysed the impact of human activities on the ecosystem, but few have studied the interdependence of social systems and ecological systems. Depending on the discipline base of the author(s), either the social system or the ecological system tends to be taken as a 'given'. In many volumes on resource management and environmental studies, the human system has been treated as external to the ecosystem. By contrast, studies of institutions have mainly investigated processes *within* the social system, treating the ecosystem largely as a 'black box'. Only a few studies (including some of those cited in the previous section) have explicitly analysed linkages between social systems and ecological systems. The present volume addresses this issue of linkage through its objective to *relate* management practices based on ecological understanding, *to* the social mechanisms behind these practices, in a variety of geographical settings, cultures, and ecosystems.

Definitions

Some definitions are needed to establish a common vocabulary. Our objective is *sustainability,* defined by WCED (1987) as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Sustainability, as used here, is a process and includes ecological, social and economic dimensions. We recognize that the question of 'what is to be sustained?' has to be addressed on a case by case basis (Costanza and Patten, 1995). For our general purposes, sustainability implies not challenging ecological thresholds on temporal and spatial scales that will negatively affect ecological systems and social systems. *Social systems* that are of primary concern for this volume deal with property rights, land and resource tenure systems, systems of knowledge pertinent to environment and resources, and world views and ethics concerning environment and resources. The term *ecological system* (ecosystem) is used in the conventional ecological sense to refer to the natural environment. We hold the view that social and ecological systems are in fact linked, and that the delineation between social and natural systems is artificial and arbitrary. Such views, however, are not yet accepted in conventional ecology and social science. When we wish to emphasize the integrated concept of humans-in-nature, we use the terms *social – ecological system* and *social – ecological linkages*.

The term *indigenous knowledge* (IK) is used to mean local knowledge held by indigenous peoples, or local knowledge unique to a given culture or society, consistent with Warren, Slikkerveer and Brokensha, (1995). The

term can be used interchangeably with traditional knowledge, but we prefer to use *traditional ecological knowledge* (TEK) more specifically to refer to a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment (Berkes, Folke and Gadgil, 1995). The word *traditional* is used to refer to historical and cultural continuity, recognizing that societies are constantly redefining what is considered 'traditional'. Some chapters refer to *neo-traditional resource management systems,* defined here as local resource management which does not have historical continuity but which is based on observations, experience and local knowledge of resource users themselves (as opposed to government scientists and managers). It is used here interchangeably with *newly emergent resource management systems*.

Traditional and local management is contrasted with *Western resource management science*, defined as resource management based on Newtonian science and on the expertise of government resource managers. We use the term interchangeably with *scientific resource management* and *conventional resource management*. We recognize that all societies have their own science, but identify Western science and scientific method to represent a particular brand of science which is used as the basis of resource management by centralized bureaucracies in all parts of the world.

Institutions are defined as 'humanly devised constraints that structure human interaction. They are made up of formal constraints (rules, laws, constitutions), informal constraints (norms of behavior, conventions and self-imposed codes of conduct), and their enforcement characteristics' (North, 1993). Institutions are 'the set of rules actually used (the working rules or rules-in-use) by a set of individuals to organize repetitive activities that produce outcomes affecting those individuals and potentially affecting others' (Ostrom, 1992). The emphasis in the book is on institutions that deal with property rights and common property resources. Here we define *property* as the rights and obligations of individuals or groups to use the resource base; a bundle of entitlements defining owner's rights, duties, and responsibilities for the use of the resource, or 'a claim to a benefit (or income) stream, and a property right is a claim to a benefit stream that some higher body – usually the state – will agree to protect through the assignment of duty to others who may covet, or somehow interfere with, the benefit stream' (Bromley, 1992). *Common-property (common-pool) resources* are defined as a class of resources for which exclusion is difficult and joint use involves subtractability (Berkes, 1989; Feeny *et al.,* 1990). Institutions have to deal with the two fundamental management problems

that arise from the two basic characteristics of all such resources: how to control access to the resource (the exclusion problem), and how to institute rules among users to solve the potential divergence between individual and collective rationality (the subtractability problem).

The term *feedback* is used in the conventional systems sense to refer to the result of any behaviour which may reinforce (positive feedback) or modify (negative feedback) subsequent behaviour. More specifically, the book is concerned with the recognition of environmental feedbacks (e.g. depletion of particular resources, decline of catch per unit of effort) that signal for changes in management responses, and the ability of resource management institutions to receive and to respond to these signals. *Resilience* is the buffer capacity or the ability of a system to absorb perturbations; the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables and processes that control behavior (Holling *et al.,* 1995). *Threshold* is the point where a system flips from one equilibrium state to another. *Surprise* denotes the condition when perceived reality departs *qualitatively* from expectation. Surprises occur when causes turn out to be sharply different than was conceived, when behaviours are profoundly unexpected, and when action produces a result opposite to that intended (Holling, 1986).

Capital is a stock resource with value embedded in its ability to produce a flow of benefits. We make a distinction among three kinds of capital: (a) *human-made capital,* which is generated through economic activity through human ingenuity and technological change, the produced means of production; (b) *natural capital,* which consists of non-renewable resources extracted from ecosystems, renewable resources produced by the processes and functions of ecosystems and environmental services sustained by the workings of ecosystems; and (c) *cultural capital,* which refers to the factors that provide human societies with the means and adaptations to deal with the natural environment and actively to modify it (Berkes and Folke, 1994). Coleman (1990: 300–21) used *social capital* to refer to features of social organization such as trust, norms and networks. Ostrom (1990: 190, 211) used social capital to refer to the richness of social organization, and *institutional capital* to refer to the supply of organizational ability and social structures, literally the 'capital' of institutions that a society has at its disposal.

Property rights institutions

Recent advances in common-property theory have shown why institutions and property rights are important considerations for resource management

(McCay, 1995). It used to be popularly believed that users of common-property resources were always trapped in an inexorable 'tragedy of the commons' (Hardin, 1968). However, many studies, especially since the mid-1980s, have shown Hardin's generalization does not hold. *If* the resource is freely open to access by any user, a tragedy of the commons does eventually follow. However, many resources used by rural communities are not open-access but are used under communal property rights arrangements. That is, more often than not, rules exist regarding access and joint use, as shown by many of the case studies in this book, as well as in the volumes by McCay and Acheson (1987), Berkes (1989) and Bromley (1992).

Property rights arrangements in a given area may be complex because resource tenure often involves 'bundles of rights', including use rights, rights to exclude others, rights to manage, and the right to sell (Schlager and Ostrom, 1992). Determining the actual rights is often a challenge, as in many marine resources (Palsson, 1991). Even within an administrative area with common legal and fiscal interventions, the actual status of local property rights to resources may vary from village to village (Jodha, 1986). Also, different resources within a given area may be held under different property rights regimes. For example, in the case of forest resource management in mountainous areas in Asia, patches of privately owned cropland may alternate with state-controlled and managed forest land, common grazing land, and common grass and bush land from which users may be obtaining a diversity of products (Messerschmidt, 1993).

Generally speaking, local social systems of rights and responsibilities develop for any resource deemed important for a community. Even under rapidly changing conditions, there are usually incipient property rights; rules arise and evolve according to local needs (Berkes, 1986; 1989). Ostrom (1990) has reviewed six commons cases in depth, and a number of others in less detail, to formulate eight design principles for successful common-property regimes. Most of these design principles fall into two clusters: those dealing with access, group boundary and resource boundary issues; and those dealing with decision-making for joint use, including issues of representation, monitoring, sanctions, conflict resolution and legal recognition, consistent with the definition of common property resources.

Hardin's tragedy often results, not from any inherent failure of common property, but from institutional failure to control access to the resource, and to make and enforce internal decisions for collective use. Institutional failure could be due to internal reasons, as in the inability of the users to manage themselves, or it could be due to external reasons, as in the incursion of outsiders (Dove, 1993). Failure could also occur as a result of such

factors as population growth and technology change, especially if the changes occur too rapidly for the ability of the local social system to absorb them (Berkes, 1989; Ostrom, 1990).

The likelihood of users designing successful common property institutions will be improved if the group is relatively small and stable; if it is relatively homogenous, with the members using similar technologies and having similar values and discount rates; if there is reciprocity and trust; and if the transaction cost for making and enforcing rules is low. Not all of these conditions are necessary for success. For example, much larger numbers of users can be accommodated if users are organized in nested enterprises or multiple layers, as in the *huerta* irrigation systems in Spain (Ostrom, 1990).

The analysis of institutions also needs to include questions of jurisdiction and the respective roles of local groups and government agencies. Often the user community is dependent on the enforcement and protection of local rights by higher levels of government. Even those indigenous groups with well-functioning local management systems are dependent on the central government for the legal recognition of their rights and their protection against outsiders. Many systems of property rights show a mix of local jurisdiction and government jurisdiction. The sharing of resource management responsibility and authority between users and government agencies (co-management or collaborative management) has been receiving increased attention (Pinkerton, 1989; Jentoft and McCay, 1995; Chapter 8).

Perhaps the most striking finding of the common property literature is the rich diversity of common-property institutions and property rights arrangements, especially in the older, historically rooted resource management systems (Feeny *et al.*, 1990). Examples include Swiss alpine meadows (Netting, 1981), and the reef and lagoon tenure systems of Oceania with their diverse array of rules from island group to island group (Ruddle and Johannes, 1990; Freeman, Matsuda and Ruddle, 1991). As compared to the rather narrow set of management prescriptions based on scientific resource management, some of which may inadvertently act to reduce ecosystem resilience (Holling *et al.*, 1995), traditional common-property systems tend to be locally diverse and operate under systems of knowledge which may differ substantially from Western knowledge systems (Banuri and Apffel Marglin, 1993).

Systems approach and social–ecological linkages

The systems approach broadly refers to a holistic view of the components and the interrelationships among the components of a system. The systems

view most relevant to our discussion is the ecosystem view or the ecosystem perspective (e.g. Odum, 1989). But unlike biological ecology, which tends to view humans as external to ecosystems (e.g. Pomeroy and Alberts, 1988; Likens, 1992), we use an ecosystem perspective that does explicitly include humans or, more specifically, the *social system*. The analysis is consistent with the classical human ecology literature from Park (1936) onwards which emphasized the interactions of population, technology, organization and culture. Also, the analysis is consistent with the way many traditional societies see their relationships with the environment. With a few exceptions, including the Western industrial societies of the last 400 years or so, human societies have generally regarded themselves as *part of nature* and not separate from it. Of particular interest are cases of traditional integrated human–nature concepts of the environment, such as the *vanua* concept in Fiji which regards the land, water and human environment as a unit, one and indivisible (Ruddle, Hviding and Johannes, 1992). Several such pre-scientific ecosystem concepts are known from Europe, North America and Asia as well as throughout Oceania where they have been well documented (Costa-Pierce, 1987; Gadgil and Berkes, 1991).

It is perhaps significant that scientific concepts of ecosystem are deficient in the description and analysis of such human-in-nature systems. There is no single, universally accepted way of formulating the linkage between social systems and natural systems. Findings of the common-property literature in recent years stress the importance of social, political and economic organization, with institutions as the mediating factor that governs the relationship between a social group and the life-support ecosystems on which it depends. In the ecological economics literature, the emphasis is on the sustainable use of *natural capital* (natural resources and ecological services generated and sustained by ecosystems and their biodiversity) by the use of economic incentives and other tools, and by the use of appropriate economic institutions. To make the analysis more complete, Berkes and Folke (1994) suggested that a third kind of capital needs to be considered, *cultural capital*, by which societies convert *natural capital* into *human-made capital* or the produced means of production. In this volume, institutions are considered to be a part of this cultural capital.

It is probably true that the unity of humans and nature is an easier concept to accept in many non-Western societies than in Western ones, although a shift in worldview is well underway. However, it is also true that environmental degradation and resource depletion are an even larger problem in many non-Western societies than in Western ones, for various reasons. In this volume, we approach this dilemma by glorifying neither

Western-style nor 'traditional' non-Western style resource management. Rather, we focus on the *ability of the management system to respond to feedbacks from the environment*. One scientific management approach that explicitly emphasizes feedback learning is adaptive management.

Adaptive management

Resource management, as a branch of applied ecology, is a difficult field in which to carry out scientific research. As Hilborn and Ludwig (1993) put it, the difficulty is easy enough to explain: 'experiments take longer, replication, control, and randomness are harder to achieve, and ecological systems have the nasty habit of changing over time.' The authors do not think that the problem is the inherent complexity of the system under study. Single cells are very complex systems too, and yet research progress in molecular biology has been spectacular in providing applications based on predictive models. By comparison, predictive models in ecology are hard to come by, and this is certainly true for the various areas of resource management.

Of the various areas of difficulty mentioned by Hilborn and Ludwig (1993), recent conceptual work has focused on the propensity of ecosystems to change over time in an unpredictable manner. Further, stressed ecosystems, as in resource overexploitation, tend to change not gradually but in lurches, through threshold effects and in surprises, whereby outcomes differ from predictive models not only quantitatively but *qualitatively* (Holling, 1986; Gunderson *et al.,* 1995; Holling *et al.,* 1995).

Adaptive management deals with the unpredictable interactions between people and ecosystems as they evolve together. It takes the view that resource management polices can be treated as 'experiments' from which managers can learn (Holling, 1978; Walters, 1986). Organizations and institutions can 'learn' as individuals do, and hence adaptive management is based on social and institutional learning (Lee, 1993). Adaptive management differs from the conventional practice of resource management by emphasizing the importance of *feedbacks* from the environment in shaping policy, followed by further systematic (i.e. non-random) experimentation to shape subsequent policy, and so on. The process is iterative; it is feedback and learning-based. It is co-evolutionary (Norgaard, 1994) in the sense that it involves two-way feedback between management policy and the state of the resource. Hence, adaptive management is an inductive approach, relying on comparative studies that combine ecological theories with observation, and with active human interventions in nature, based on an