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Linking Social and Ecological Systems for Resilience and Sustainability

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LINKING SOCIAL AND ECOLOGICAL SYSTEMS FOR RESILIENCE AND SUSTAINABILITY

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BACKGROUND PAPER AND FRAMEWORK

for Subproject 9 of the Research Program on

Property Rights and the Performance of Natural Resource Systems

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Introduction

Traditional resource management systems or other local-level systems, based on the knowledge and experience of the resource users themselves, may have the potential to improve management of a number of ecosystems types. A considerable amount of evidence has accumulated to suggest that ecologically sensible indigenous practices have or had existed, for example, in the case of some tropical forests (Alcorn 1984), island ecosystems (Costa-Pierce 1987), tropical fisheries (Johannes 1978; Ruddle and Johannes 1990), and semi-arid grazing lands (Niamir 1990). Given that Western resource management has not been all that successful in many of these environments, perhaps there are lessons to be learned from the cultural capital of societies which have elaborated these practices, a view echoed in *Our Common Future* (WCED 1987, p. 12). Ancient cultures and indigenous peoples do not have monopoly over ecological wisdom; there are cases of local, newly emergent or "neo-traditional" resource management systems which cannot claim historical continuity over generations but which are nevertheless based on local knowledge and practice appropriately adapted to the ecological systems in which they occur (e.g., Berkes 1986; Smith and Berkes 1993).

Based on these experiences, there seems to be potential for improvement of resource management in environments such as northern coastal ecosystems, arid/semi-arid land ecosystems, mountain ecosystems, tropical forest ecosystems, subarctic ecosystems and island ecosystems. As compared to the rather narrow set of prescriptions of Western resource management systems, some of which may inadvertantly act to reduce ecosystem resilience (Holling and Bocking 1990; Holling et al. 1994), non-Western resource management systems have been known to employ a diversity of property rights regimes and common property institutions, and operate under systems of knowledge which may differ substantially from Western knowledge systems (Banuri and Apffel Marglin 1993). These traditional systems represent many millenia of human experience with environmental management, and provide a reservoir of adaptations which may be of universal importance in designing for sustainability (Gadgil and Berkes 1991; Berkes et al. 1994).

There is a crisis in Western resource management science because very often its prescriptions have not resulted in sustainable resource use. Some authors attribute this fact to human "shortsightedness and greed" and to ecological uncertainty (Ludwig et al. 1993). Others think that Western scientific management may be fundamentally flawed in that its premises are based on *laissez-faire* ideology which still persists in the neoclassical economics (Daly and Cobb 1989) and in resource management science of today which treats world's life support systems as boxes of discrete "resources" the yields from which can be individually maximized (Gadgil and Berkes 1991). More and more, the systems view is replacing the view that resources can be treated as discrete entities. For example, the volume, *Investing in Natural Capital* (Jansson et al. 1994), identified the necessity of designing management which is systems-oriented and which takes into account environmental uncertainty and ecosystem resilience. This project takes the argument of Jansson et al. (1994) further by exploring how the performance of natural resource systems can be improved by supplementing scientific information with a wider range of information from resource users themselves.

Objective

The general objective of the subproject is to investigate how the resilience of certain selected ecosystems can be improved by learning from traditional and newly-emergent social-ecological systems, and how potential new principles derived from this study can be used to investigate how degraded ecosystems could be restored to generate a sustainable flow of services. To accomplish this task, social and ecological linkages in selected ecosystem types will be investigated systematically, using a common analytical framework. Specifically, in each of the study areas, we propose to investigate:

1. How the local social system has adapted to and developed a knowledge system for dealing with the dynamics of the ecosystem(s) in which it is located;

2. Specifically, how the local system maintain ecosystem *resilience* in the face of perturbations; and

3. Those combinations of property rights arrangements, institutions, and knowledge systems which accomplish the above successfully.

In addressing the above objectives, the project deals with three groups of interrelated issues:

Learning from indigenous knowledge and management systems on how to adapt to ecosystem resilience
Understanding dynamic processes of systems in transition and social/ecological systems under stress
Exploring ways to combine local and scientific knowledge and traditional and conventional resource management systems

Definitions

Some definitions are needed to establish a common vocabulary:

Common-property (common-pool) resources: A class of resources for which exclusion is difficult and joint use involves subtractability (Berkes 1989; Feeny et al. 1990).

Cultural capital: Factors that provide human societies with the means and adaptations to deal with the natural environment and to actively modify it.

Feedback: The result of any behavior which may reinforce (positive feedback) or modify (negative feedback) subsequent behavior.

Indigenous knowledge (IK): Local knowledge held by indigenous peoples, or local knowledge unique to a given culture or society; used here interchangably with traditional knowledge.

Institutions: "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). "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).

Neo-traditional resource management systems: 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); used here interchangably with newly-emergent resource management systems. Such systems may be based on elements adapted from traditional systems used with other resources, and will become "traditional" in time.

Property rights: "Property is 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 assingnment of duty to others who may covet, or somehow interfere with, the benefit stream" (Bromley 1992); 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.

Resilience: 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. 1994). Resilience is the ability of a system to absorb perturbations.

Traditional ecological knowledge (TEK): 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; used here as a subset of indigenous knowledge.

Threshold: The point where a system flips from one equilibrium state to another.

Sustainability: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Sustainability implies not challenging ecological thresholds on temporal and spatial scales that will negatively affect ecological services and human welfare. Sustainability, as used here, is a process (Robinson et al. 1990) includes ecological, social and economic dimensions.

Western resource management systems: Resource management based on Newtonian science and expertise of government resource managers; used here interchangably with scientific resource management systems.

The Analytical Framework

The research questions posed by the subproject explicitly link ecology, economics and social science. They require an interdisciplinary, international, case study approach. To ensure focus, creative synthesis and direction, the subproject will need a common framework for the case studies, including the identification of the relevant characteristics of the ecosystem in question, and the identification of property rights arrangements, institutions and knowledge systems that characterize the case study. The framework ion Figure 1 is only one way to diagram embedded relationships. It is a heuristic device, and is not meant to imply that the various elements in the overall system are discrete boxes.

The framework in Figure 1 distinguishes five sets of elements which can be used to describe social and ecological system characteristics and linkages: (1) ecosystem, (2) people and technology, (3) local knowledge, (4) property rights, and (5) institutions.

The crucial part of the framework is in the analysis of the interactions (feedbacks) of the five elements. The framework is meant to help focus on key interactions that result in sustainable outcomes. The schema borrows from the Oakerson (1992) framework for the analysis of common property resources and from the framework for institutional analysis used by Ostrom and colleagues (Ostrom 1990). The following sections describe each of the attributes, followed by sections dealing with interactions and outcomes.

1. The Ecosystem

Ecosystems may be characterized in a large variety of ways, focusing on structure or function or both. In terms of physical attributes, for example, tropical forest ecosystems can be characterized by high temperatures and moisture. In terms of biological characteristics, for example, biodiversity and rates of nutrient cycling are high; stored energy (and biomass) are high in comparison to rates of biological productivity. Not all characteristics of ecosystems are equally significant. Recent research has made it possible to suggest that the diversity and complexity of ecosystems can be traced to a relatively small number of biotic and abiotic variables and physical processes (Holling 1992; Holling et al. 1994). It seems that a relatively few species, or groups of species, run these processes, thereby contributing to the functional performance of the ecosystem. Remaining organisms occupy niches in the system shaped by these processes. These organisms may seem to be redundant in the short term, but they are crucial in maintaining system resilience (Solbrig 1993), and serve as a system insurance for unpredictable events (Schulze and Mooney 1993; Barbier et al. 1994).

In the present study, particular attention will be directed to factors affecting the *resilience* of particular ecosystems. The concept of resilience has been defined in two very different ways in the ecological literature (Holling 1993; Holling et al. 1994). The first definition concentrates on stability at a presumed steady-state, and stresses resistence to a disturbance and speed of return to the equlibrium point. This is the conventional, equilibrium-centred, linear, cause-and-effect view of a predictive science as used in ecology, economics and some other sciences. In resource management science, this view leads to the assumption that resources are in fact manageable and yields predictable. Discrete yield levels, such as maximum sustained yields of fish or timber, can be calculated, and perturbations (such as fire and pest outbreaks) can be excluded from the system.

The actual experience, however, is that the very success of such management, which may be efficient in the short-term, freezes the ecosystem at a certain stage by actively blocking out environmental perturbations and feedbacks. Instead of allowing smaller perturbations to act on the system, management causes the accumulation of larger perturbations, inviting larger and less predictable feedbacks at a level and scale which may threaten the functional performance of the ecosystem. Holling and Bocking (1990) used the examples of budworm control in Canadian forests (more and more control seems to lead to larger and larger infestations when they do finally occur) and forest fire suppression (following a century of fire suppression, nearly half of Yellowstone National Park in the USA burned down in one major fire in 1988).

In contrast to the first definition of resilience, the second definition, and the one we use here, emphasizes conditions in which disturbances (or perturbations) can flip a system from one equilibrium state to another. In this case, the important measure of resilience is the magnitude or scale of disturbance that can be absorbed before the system changes in structure by changing the variables and processes that control behavior. This is the emerging, multi-equilibrium, non-linear view of science, Holling's (1986) "science of surprise", in which causal effects and predictions are not simple matters. Rather, systems are complex and self-organizing, permeated by uncertainty and discontinuities, as in chaos theory and Prigogine's irreversible thermodynamic systems (Prigogine and Stengers 1984). Resilience in this context is a measure of robustness and buffering capacity of the ecosystem to changing conditions.

The kind of science implied by the second definition of resilience, represents a move away from the positivist emphasis on objectivity and towards a recognition that fundamental uncertainty is large, yields are unpredictable, certain processes are irreversible, and qualitative judgments do matter. This kind of science is in many ways symphatetic to "savage thought" of Levi-Strauss (1962) and many indigenous systems of environmental knowledge. The parallels between traditional ecological wisdom and this multi-equilibrium paradigm of ecological systems show promise for further inquiry.

2. People and Technology

The description of the social system starts with the people organized as user communities, and the technology employed by them. In many case study areas, it would be expected that investigators will limit their case to certain resources and user communities, e.g. the fisherpersons of the Baltic, the hunter-trappers of James Bay, and the herders of semi-arid East Africa. Even within the bounded case studies, there will be considerable complexity in the user communities, the resources they pursue and the technology they use, e.g. the smaller-scale inshore and the larger-scale offshore fisheries of the Baltic (Hammer et al. 1993). The type of technology available to potential users for exploiting a resource will be important; for example, gillnets used by the small-scale fisherpersons in the Baltic limit their areas of use, whereas the trawlers of the offshore fleet will, almost by necessity, be more mobile and exploit a larger area.

The use or choice or technology may also provide clues to distinguish user communities and perhaps also the sustainability of their practices. To illustrate, in South Kalimantan, Indonesia, Dove (1993) found two kinds of shifting cultivators, the local indigenous forest people and urban-based, opportunistic shifting cultivators. The latter group consisted of non-local, market-oriented farmers, often outfitted with chain-saws and trucks, who follow logging roads into the hills, burned the remaining timber and planted cash-crops. After 2-3 years, when the land is no longer productive, they moved up the logging road and began over. This kind of shifting cultivation was considered destructive, in contrast to that practiced by local indigenous forest people whose time-tested practices had the capability of maintaining their environment in a productive state (Dove 1993).

3. Local Knowledge

Having established who the resource users are, it is then necessary to know something about their knowledge and understanding of the local environment A farmer, fisher, logger or hunter will have a certain amount of local environmental knowledge that will allow him/her to carry out a particular activity. This local knowledge may be very substantial, especially if it includes culturally transmitted knowledge accumulated over generations. Many indigenous groups as well as other historically continuous communities, such as certain groups of North Atlantic fisherpersons, will possess traditional knowledge (Palsson 1991). In some cases, local knowledge may be organized and used in a way which, in effect, amounts to a traditional management system. Such is the case with certain shifting cultivators, Amerindian hunter-trappers, Asia-Pacific aquaculturalists and others (Alcorn 1984; Costa-Pierce 1987; Gadgil et al. 1993; Berkes et al. 1994).

Cultural beliefs are often found to be a key factor in apparent long-term sustainable use of resources by many groups around the world (McCay and Acheson 1989; Berkes 1989). Of particular interest to the project are cultural groups which may possess systems of knowledge different from Western knowledge (Banuri and Apffel Marglin 1993). We refer especially to knowledge related to the maintenance of ecosystem resilience, as in traditional agricultural and aquacultural systems that use a variety of species as opposed to monocultures (Warren et al. 1994). Of particular interest are cases of integrated human-nature concepts of the environment, such as the traditional concept *vanua* in Fiji which regards the land, water and human environment as one and indivisible (Ruddle et al. 1992). There is more than one possible way to organize environmental knowledge, and the diversity of systems of knowledge and environmental worldviews deserves re-examination. Cultural diversity may be related to biodiversity (Gadgil and Berkes 1991), and both may be important for improving the sustainability of the world's ecological systems, as well as for their own sake.

4. Property Rights

Western resource management science often assumes a very limited set of property rights: state-property (or regime based on government regulation), private property (or market-based regime), or else a "tragedy of the commons". This limited view has been criticized by many scholars and practitioners who find that the real world also contains many working examples of common-property (or communal-property) systems in which an identifiable group of users holds the rights and responsibilities for the use of a resource (McCay and Acheson 1987; Berkes 1989; Ostrom 1990; Bromley 1992). As well, there are many systems which show intemediate characteristics of property rights, including power and responsibility sharing arrangements (co-management) between users and government agencies (Pinkerton 1989; Hanna 1990).

Property rights arrangements in a given area may be complex because resource tenure often involves "bundles of rights", ranging from use rights to the right of sale (Schlager and Ostrom 1992). Determining 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). As well, different resources within a given area may be held under different property right regimes. For example, in the case of forest resource management in mountainous areas in Asia, patches of privately owned cropland may alternate with statecontrolled and managed forest land, common grazing land, 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; few resources, if any, are truly open-access. Claims of lack of local property rights and self-governance often indicate lack of research more than anything else. Even under rapidly changing conditions, there usually are incipient property rights. An historical and evolutionary perspective has often provided new management insights (Hanna 1990; Ostrom 1990). In many cases, rules arise and evolve according to local needs (Berkes 1989). There are parallels between the evolution of ecological systems and the evolution of social systems.

5. *Institutions*

Local and traditional knowledge do not exist in a vacuum but are embedded in local institutions. Similarly, property rights are embedded in institutions which may simply be defined as the set of rules actually used (Ostrom 1992). Rule-making as well as enforcement, dispute management, and the formulation of social norms in general and the evolution of cultural conventions dealing with natural resources are all matters that pertain to institutions.

The performance of natural resource systems is inextricably linked to the health of resource management institutions, whether governmental or local. In the case of common-property resources, institutions have to deal with 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). Ostrom (1990; 1992) has elaborated a more extensive set of design principles based on experience with long-enduring institutions for the management of commons.

Traditional and neo-traditional resource management systems are dominated by local common-property institutions (Berkes 1989; Ostrom 1990). But the analysis of institutions also needs to include questions of jurisdictions and government management 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. The literature contains many examples of local dependence on the government for the protection of communal resource management systems (Berkes 1989; Ostrom 1990; Bromley 1992). Conversely, government intervention may often be the cause of disruption of the local institution (Sporrong 1994).

Patterns of Interaction

Rules, by themselves, are no guarantee for successful outcomes. In Oakerson's (1992) analysis, patterns or strategies of interaction are the means by which rules are translated into outcomes through the choices made by individuals and groups. In the case of common property resource management, such strategies include cooperation, reciprocity, free-riding, or destructive competition leading to a "tragedy of the commons". Users are interdependent, and the behavior of individual users may be modeled as a Prisoner's Dilemma game in which cooperative outcomes become likely if the "game" is repeated, if the number of players is relatively small and the probability of repeat encounter relatively large. The availability of information and the openness of communication also improve the chances of success (Ostrom et al. 1992).

Patterns of interactions addresses the question of dynamic change and is the key to the analysis of case studies. The essential questions to be addresses are those that arise from the objectives of the subproject: (1) interactions between the social system and the natural system that lead to adaptations, (2) specifically, interactions that enable the local social system to maintain ecosystem resilience, and (3) interactions among property-rights, institutions, and knowledge systems.

The analysis of patterns of interactions requires an evolutionary focus, as both social systems and natural systems have an evolutionary character (Holling 1993). There are, however, no ready guides for the study of interactions, and each case will be different. Key factors driving patterns of interaction may be externally imposed perturbations in one case, populations growth in another, and market factors in yet another.

The analysis of interactions requires a focus on feedback mechanisms. Some societies adapt to changing conditions better than others. There is very little agreement on what accounts for such variability (Kuran 1988). The key factor in successful adaptation may be the presence of appropriate feedback mechanisms which enable consequences of earlier decisions to influence the next set of decisions which make adaptation possible. "Adaptive management" of Holling and colleagues also uses this principle (Walters 1986). Conversely, factors that obliterate feedbacks may results in loss of cultural adaptations. For example, the development of market economy in a previously isolated area may "free" local people from traditional ecological constraints, triggering a population explosion or a change in worldviews.

The analysis also requires a focus on interdependencies. Just as participants in the social system are interdependent, elements of the ecological system are also interdependent. Consider the case of a mountain watershed ecosystem. The vegetation cover, soil and surface and ground water are all interdependent. But further, the social system and the ecological system are also mutually dependent. If the ecological system on the mountain watershed deteriorates, less and less environmental benefits flow from it, and the people depending on the natural capital of the ecosystem for their crops, fuel, fiber, fodder, fertilizer and other goods will become impoverished. Damage to the functional performance of the ecosystem will likely result in damage to the social system and management institutions based on it.

Outcomes

Patterns of interaction produce certain outcomes. The biophysical environment may or may not be used sustainably; the functional performance of the ecosystem may or may not be damaged; total benefits from the natural system may or may not be optimized; and benefits may or may not be shared equitably or fairly. The question of performance of natural resource systems begs the question of evaluative criteria. Oakerson (1992) suggested two criteria, efficiency (defined as Pareto Optimality) and equity. Other criteria include empowerment and livelihood security, as suggested for example by some development professionals (ICLARM 1993).

In seeking a criterion which is both human-centric and resource-centric, and not exclusively one or the other, Feeny et al. (1990) suggested sustainability *(sensu* WCED 1987). However, there are operational problems with this concept. Whereas the criteria for ecological sustainablity are relatively well known, there are no agreed-upon criteria for economic and social/cultural sustainability. In this study, our working assumption will be that social/ecological systems which have survived for extended periods of time are sustainable. This assumption is consistent with Ostrom (1990), and will facilitate the search for *mechanisms* for the resilience of the integrated social/ecological system.

Hypotheses and Conclusions

The present study attempts to develop case studies that deal with both ecological and social systems and their interactions. Identifying and understanding a few of the key feedbacks would be of great value. Linkages of social and ecological systems need to deal with the relevant attributes of the ecosystem, resource users and their technology, their local knowledge, property rights and institutions, as indicated in Figure 1. But perhaps more important, the ecological-social system, the linkages and the outcomes need to be analysed from a systems point of view. The three boxes in Figure 1 may be considered components of a system, and are in dynamic interrelationships with one another. Feedback loops among the three components are indicated with arrows.

The ecological and social system linkages result in certain outcomes. Depending on the outcome, the linkages may be modified. For example, the herders in a hypothetical grazing commons may see that the range is deteriorating, decide on collective action to limit the number of cattle, and decide on enforcement and sanctions, thus replacing the impending "tragedy of the commons" with a cooperative strategy. The scenario is highly plausible on both theoretical and practical grounds (Feeny et al. 1990; Hanna 1990).

The other possibility, as sketched in Figure 1, is that depending on the outcome, the interaction of ecological and social systems may be modified. One mechanism by which such a modification may come about is co-evolution (Norgaard 1994). In a detailed study of Indonesian irrigation and farming systems, Geertz (1963) showed that society and the natural environment mutually modified one another over a period of hundreds of years, and that property rights institutions were closely attuned to the resources used. Another way in which the interaction of social and ecological systems may be modified is through adaptations for resilience.

Some non-Western resource management systems are of special interest because they seem to allow less intensive use and greater biological diversity, thus help maintain resilience. These are systems in which ecosystem processes (as well as populations of target species) may be maintained and environmental feedbacks managed for the sustainability. *We hypothesize that maintaining resilience may be important for both resources and social institutions -- that the well-being of social and ecological systems is thus closely linked.*

It is possible that traditional and neo-traditional knowledge and resource management systems may escape some of the limitations of conventional scientific resource management with its assumptions of controllable nature, predictable yields, and exclusion of environmental perturbations. If so, *we hypothesize that such successful traditional knowledge* *systems will allow perturbations to enter on a scale which does not threaten the structure and functional performance of the ecosystem and the services it provides.* Resource management under such a traditional knowledge system would continuously adapt to, is modified and even evolves with these fluctuations. *We hypothesize that there will be evidence of co-evolution, making the local community and their institutions "in tune" with the natural processes of the particular ecosystem.*

Many Western resource management systems focus on high yield resources that provide a high monetary value. The production of these resources is extensively supported by the socioeconomic infrastructure, which masks the impairment of the functional performance of the ecosystem, as in modern intensive agriculture, with its various subsidies. Ecosystem simplification leads to reduced flexibility and capacity to absorb stress. In contrast, many traditional knowledge systems consciously or unconsciously consider the insurance value of diversity and the information value of environmental feedbacks.

A major objective for our subproject is to analyze, through various case studies, how damages to the functional performance of an ecosystem have been avoided. That is, we aim to study local social systems that have adapated to and developed a knowledge system for coping with their resource base in a sustainable fashion. In particular, we are interested in what the feedbacks within and between the social and ecological systems look like, and how they are managed. In the light of the above hypotheses, each case study will be designed to contribute to the overall project which will try to synthesize the following:

1) Are there similarities, general patterns and principles that can be drawn from the case studies?

2) What lessons can be learned to assist in the designing of more sustainable resource management systems?

3) How can adaptiveness and resilience be built into institutions so that they are capable of responding to the processes that contribute to the resilience of ecosystems?

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Figure 1. A framework for analyzing the link between social and ecological systems for resilience and sustainability

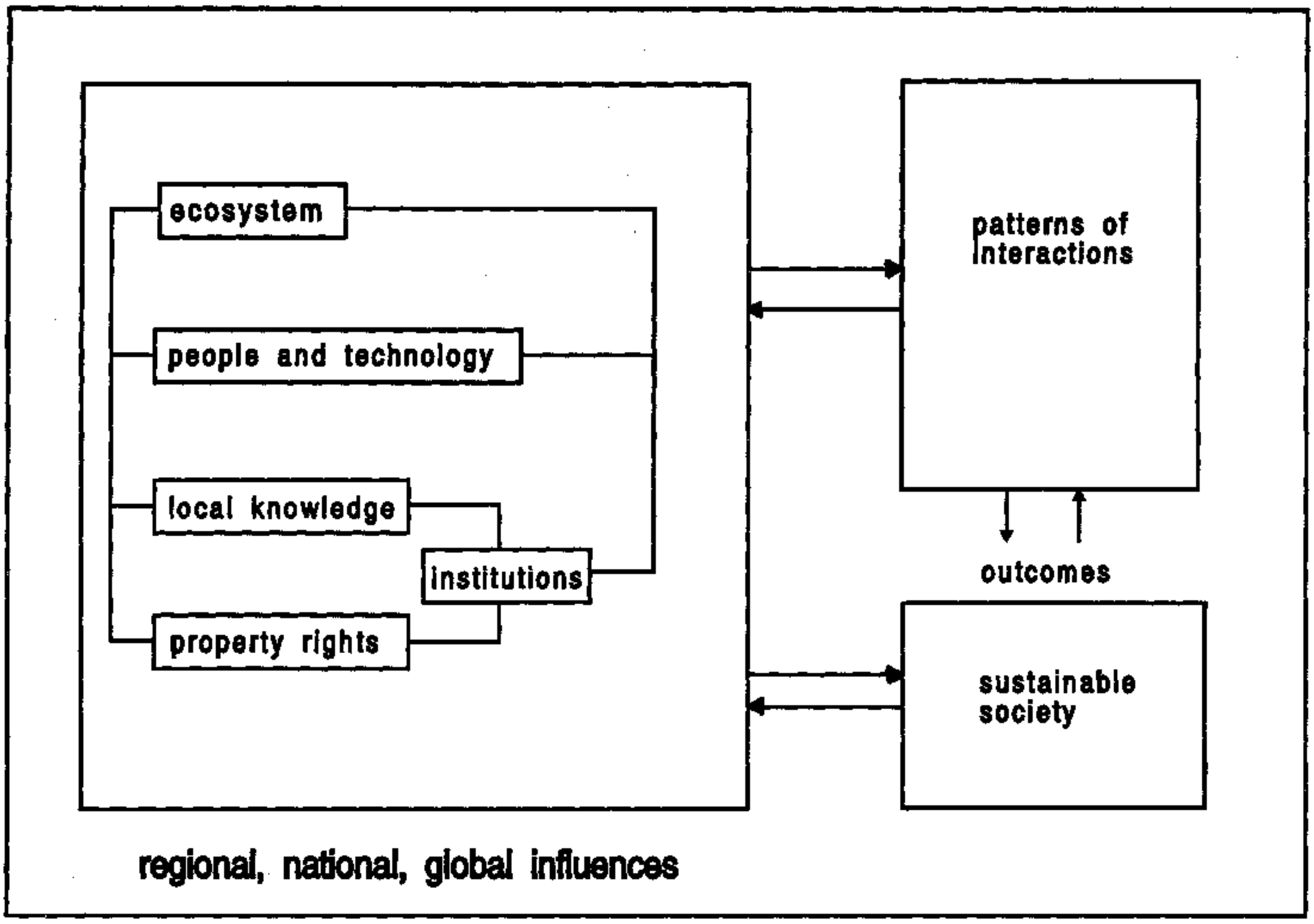

Table 1. Tentative summary of questions to investigate as part of the framework.

General Objectives
- How has the local social system adapted to and developed **a** knowledge system for dealing with the dynamics of ecosystem(s) in which it is located?
- How does the local system maintain ecosystem *resilience* in the face of perturbations?
- What are viable combinations of property rights arrangements, institutions and knowledge systems which accomplish the above successfully?

Resource Users and their Technology
- Who are the users of a particular study area?
- What resources do they use?
- Can the users be characterized as user-groups or user communities?
- What are the positions held?
- What are the characteristics of communities of users in terms of numbers, homogeneity, ethnicity and general socioeconomic conditions?
- What technologies are used and by whom?

Local Knowledge and Traditional Knowledge Systems
- What local knowledge do they possess in relation to the resource base?
- Is there much of culturally transmitted traditional knowledge?
- Are there traditional management systems?
- Do they have a distinct system of knowledge or worldview?

Property Rights
- What are the major resources and who holds the property rights to them?
- What is the nature of the land (or water) tenure and what rights are involved?
- What are the relevant rules for resource use, especially regarding access?
- Who makes these rules, especially regarding collective action?
- Who enforces the rules and how?
- Are there sanctions and how are they structured (graduated or not)?

General Hypotheses
- The well-being of social and ecological systems, through the maintenance of resilience, is closely linked.
- Successful traditional management systems allow perturbations on a scale which does not threaten the functional performance of the ecosystem.
- Successful traditional management systems show evidence of social-ecological system co-evolution.
- Western resource management aims to maximize yields or values, whereas traditional systems manage resilience to optimize values and yields.
- Traditional systems are designed to respond to and manage environmental feedbacks.

Synthesis Questions
- Are there similarities, general patterns and principles, and policy recommendations that can be drawn from the case studies?
- What lessons can be learned to assist in the designing of more sustainable resource management systems?
- How can adaptiveness and resilience be built into institutions so that they are capable of responding to the processes that contribute to the resilience of ecosystems?

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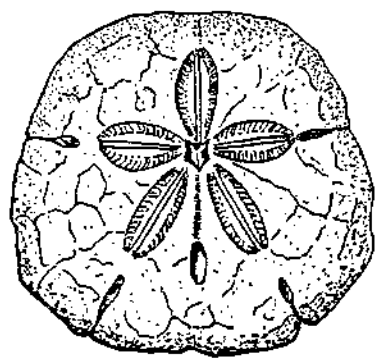

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