SUSTAINABILITY AND RESILIENCE IN NATURAL RESOURCE SYSTEMS: POLICY DIRECTIONS AND MANAGEMENT INSTITUTIONS

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Summary

Natural resources that form the backbone of much of the world's economic activity, underpin the livelihoods of much of the world's population, and have considerable cultural significance in locations around the world. Natural resource systems are also ones that require clear, deliberate management, yet are, at the same time, highly complex and uncertain. This chapter focuses on the challenge of developing policy measures and underlying institutions to support the management of natural resources in fisheries, forestry, wildlife harvesting, agriculture, mining and the like. Specifically, the chapter explores how the implementation of suitable policies and institutions can

contribute to sustainability and resilience of natural resource systems and their ecological, socio-economic, community and institutional components.

The policies discussed fall into three categories. First, those relating directly to natural resource management include (a) development of a management portfolio, (b) application of the precautionary approach, and (c) implementation of robust and adaptive management. Second, those relating to the structure of the resource system and its interaction with the broader society include (a) co-management and community-based management, (b) planning approaches that promote efficiency in resource systems, (c) management of resource sector capacity, and (d) the diversification of livelihoods. Third, those policies relating to research, information and monitoring aspects of the resource system involve (a) development and utilization of the knowledge base, and (b) approaches for monitoring sustainability in resource systems.

In promoting sustainability and resilience in resource systems, equal attention must be paid to the functioning of resource management institutions – the organizational structures within which people interact (such as a resource management agency, an association of resource users, or the marketplace) and the underlying sets of rules and constraints adopted by society to govern behavior in resource use and management. This chapter explores the characteristics of institutions that may contribute to their own sustainability and resilience, and also the institutional arrangements that may support sustainable, resilient resource systems more broadly. An example of an important attribute of sustainable, resilient institutions is the capability for self-regulation, in which resource users themselves are involved in resource management functions, thereby supporting the management institution in 'getting the incentives right', so that resource users choose to operate in accordance with regulations and to avoid anti-conservationist actions.

1. Introduction

The world's natural resources represent a fundamental link between humans and their environment. Whether in fisheries, forestry, agriculture, wildlife harvesting, or mining, the resource base clearly contributes crucial natural ingredients to development. Looking more broadly, natural resources are critical to most global industrial production… from processed foods to furniture manufacturing to the production of oil-based plastics. Nowhere is the challenge of sustainable development more obvious than in dealing with the human uses of these natural resources. Given their inherently limited quantities, interactions between resources and the humans using them are constantly confronted with the threat of over-exploitation. This leads to the clear recognition that natural resource industries require deliberate management efforts; a *laissez-faire* approach is not suitable where natural resources are involved.

Natural resource management has an extensive theoretical base, drawing on ecology, economics, and a variety of other disciplines, but in practice, management efforts have met with at best, mixed success. Indeed, a widespread dissatisfaction with failures of the past has led resource management into a state of transition, with frequent calls for new approaches. It can be argued that many problems with resource management have been due to a lack of understanding of the policy and institutional aspects involved in

managing natural resource systems. This chapter focuses on such aspects, and the manner by which suitable policies and institutions can enhance sustainability and resilience in resource systems. We begin with a discussion of the sustainability and resilience concepts themselves, turning then to an examination of policy directions that may support sustainable and resilient resource systems, and finally examining the role of institutions in resource management.

2. Sustainability and Resilience

Historically, the management of natural resources – specifically, renewable resources – has had as a major theoretical underpinning, the idea of determining a *sustainable yield*: a harvest that can be taken today without causing a decline in the resource available in future years. Two shortcomings of this perspective have become apparent, however. First, a focus on sustainable yield has an intrinsic emphasis on physical *output*, and tends to neglect the underlying natural *processes*, health of the ecosystems, and integrity of ecological interactions. Second, traditional discussions of sustainable yield in resource use have tended to ignore the corresponding human system and its sustainability, an aspect now highlighted in the ideas of *sustainable development*, laid out originally by the World Commission on Environment and Development.

There is now wide recognition that sustainability must be viewed broadly, in an 'integrated' manner that involves maintaining and enhancing ecological, socioeconomic, community and institutional well-being. The sustainable development approach has brought about an important evolution from a focus merely on 'sustaining the output' to a more integrated view in which sustainability is multi-faceted, and emphasizes the process as much as the output.

Discussion of sustainability is increasingly linked with the concept of resilience, introduced by the ecologist C.S. Holling to describe the capability of ecosystems to absorb unexpected shocks and perturbations without collapsing, self-destructing or otherwise entering intrinsically undesirable states. Specifically, Holling wrote in his paper "Resilience and stability of ecological systems" (Annual Review of Ecology and Systematics, volume 4, p.17, 1973):

"Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables and parameters, and still persist. In this definition resilience is the property of the system and persistence or probability of extinction is the result."

Thus, a resilient system is one that can absorb and 'bounce back' from perturbations (shocks) caused by natural or human actions. Holling drew a strong distinction between the concept of resilience and that of stability, which he defines as "the ability of a system to return to an equilibrium state after a temporary disturbance." He highlights the point that "a system can be very resilient and still fluctuate greatly, i.e. have low stability" and indeed notes examples that suggest that "the very fact of low stability seems to introduce high resilience."

Holling's work on resilience led to a key conclusion about management in ecological systems – that management approaches focusing on the pursuit of stability could be detrimental to resilience. Specifically, Holling noted that pursuit of a stable sustained yield for a renewable resource could change the underlying forces operating on the system to such an extent that "a chance or rare event that previously could be absorbed can trigger a sudden dramatic change and loss of structural integrity of the system."

The idea of resilience, while first formulated with ecosystems in mind, is just as relevant throughout resource systems. For natural resource systems, resilience implies that not only the relevant ecosystem, but also the corresponding human and management systems, are able to absorb perturbations, such that the system as a whole remains able to sustain (on average) a reasonable flow of benefits over time. In a resource sector, then, we can envision resilient management institutions, resilient communities, a resilient economic structure in the resource sector, and a resilient ecosystem in which the resource is located. For example, in thinking of components of human-based systems, such as communities, resilience implies a capability to persist in a 'healthy' state whatever the state of the natural system and the socioeconomic environment. The resource management system should be resilient as well: if something unexpected happens (as is bound to be the case from time to time), will management still perform adequately? Since we cannot predict the 'unexpected' impacts on a resource system, or even know the set of such possibilities, the challenge lies in designing resource management systems with the flexibility to deal as well as possible, and as often as possible, with such 'surprises'.

3. Policy Directions for Sustainable and Resilient Resource Systems

Management must play a key role in seeking to maintain and enhance the sustainability and resilience of natural resource systems. This section presents several policy directions that may help resource systems function successfully within an uncertain world, even in the face of unexpected changes in nature's course, or a poor understanding of the inherent structure and functioning of the systems. The policy directions discussed here, fall into three categories: (a) those relating directly to natural resource management, (b) those relating to the structure of the resource system and its interaction with the broader society, and (c) those relating to research, information and monitoring aspects of resource management. Specifically, the topics, to be addressed sequentially below, are as follows:

Natural resource management:

- Developing a management portfolio;
- Applying the precautionary approach;
- Robust and adaptive management.

Resource system structure and interactions:

- Co-management and community-based management;
- Planning for efficiency in natural resource systems;
- Managing resource sector capacity;
- Diversifying livelihoods.

Information and monitoring:

- Developing and utilizing the knowledge base;
- Monitoring sustainability.

3.1. Developing a Management Portfolio

A wide array of management instruments is available in natural resource systems, from use rights arrangements to technological controls. Each has its advantages and disadvantages, and an over-emphasis on any single management method is unlikely to optimize sustainability or resilience of the resource system. There will always be some situation in which any such method will fail: in other words, any single management measure cannot be considered 'safe'. Risk will be reduced if a portfolio (multiplicity) of management measures is utilized within the resource system. The key goal is for the portfolio to be mutually-reinforcing, in that the various tools each help to rectify the shortcomings of the others.

A *portfolio* of appropriate management tools can be selected on a case-by-case basis, taking into account (a) society's objectives, (b) physical and/or biological aspects of the resource, (c) human aspects such as tradition and experience, (d) the level of uncertainty and complexity in the resource sector, and (e) the predicted consequences of the various instruments.

Consider, for example, a management system with quantitative limits on resource extraction. This system might be made more robust by supplementing these controls with other measures such as protected areas and input controls. The latter, whether qualitative limits on the 'how, when and where' of resource use , or quantitative limits on input variables such as the amount of equipment or time used, provides an extra degree of security that ensures conservation will be achieved.

It should be added, however, that while a diversified portfolio for resource management is superior to a more narrow approach, it remains crucial to choose the right components of the portfolio. Particular management measures must satisfy certain criteria, to which we now turn.

3.2. Applying the Precautionary Approach

Uncertainties are ubiquitous in natural resource systems. It is unclear, however, to what extent these uncertainties are reducible over time, and unlikely that most uncertainties can be resolved in a clear-cut manner. Instead, many uncertainties must be addressed primarily through changes to the practice of resource management. The design of a management framework within which uncertainty can be addressed is surely a key element of a strategy for sustainable resource use.

A principal aspect of such a framework is the implementation of a *precautionary approach* to management decision-making, to ensure that we properly allow for uncertainty in our decisions, and 'err on the side of conservation'. The precautionary approach provides the 'ground rules' of management decisions, to guide scientists and

managers in better *erring on the side of caution* in the face of uncertainty. As the U.N.'s Food and Agriculture Organization has noted ("Precautionary approach to fisheries. Part 1: Guidelines on the precautionary approach to capture fisheries and species introductions." FAO Fisheries Technical Paper No. 350, Part 1. Page 6. Rome, Italy):

"Management according to the precautionary approach exercises prudent foresight to avoid unacceptable or undesirable situations, taking into account that changes… are only slowly reversible, difficult to control, not well understood, and subject to change in the environment and human values… Precautionary management involves explicit consideration of undesirable and potentially unacceptable outcomes and provides contingency and other plans to avoid or mitigate such outcomes…"

There are two approaches to implementing the precautionary approach. One, requiring the re-design of management structures and methods, is discussed in the following section. The second approach is applicable to different forms of uncertainty that can be addressed through the use of quantitative decision rules to govern management actions. A precautionary risk-averse decision rule would typically be structured so that, other things being equal, a lower level of resource use will be chosen the greater the uncertainty in key variables, such as resource status. Not only does this imply that uncertainty is less likely to produce damaging outcomes, it also helps create incentives for scientists to ensure that uncertainty is fully incorporated in their analyses, and for resource users to help to reduce uncertainty.

3.3. Robust and Adaptive Management

Many uncertainties present in resource systems are of a *structural* nature; structural uncertainty reflects basic ignorance about the nature of the resource system, its components, its dynamics, and its inherent internal interactions. Structural uncertainty can have a major impact on the outcome of management, manifesting itself in such aspects as resource dynamics and resource-environment interactions, spatial complexity, technological change and the societal/management objectives being pursued. Such uncertainties inherent in natural resource systems make it risky to rely on management methods that are sensitive to highly uncertain variables or which depend on high levels of controllability.

To deal with structural uncertainty requires substantial changes ('redesign') to the *practice* of resource management, so that its structure and methods are *robust* and *adaptive*. Specifically, *robust management* is such that it is possible to achieve a reasonable level of performance (i.e., an acceptable level of success) even if (a) we have a faulty understanding of the resource system (notably the status of the resources), its environment and the processes of change over time, or (b) the actual capability to control resource exploitation is highly imperfect. Such a policy move must overcome two counter-tendencies in many resource management systems:

- *Illusion of Certainty.* Some resource management systems suffer from an 'illusion of certainty', a perception – arising in policy, management and/or operating practices – that the world is certain and predictable, or at least that major elements of uncertainty can be safely ignored. Far from recognizing and

working within the bounds of the uncertainty, the illusion of certainty leads to the opposite result.

- *Fallacy of Controllability.* Natural resource management is intrinsically an imperfect endeavor, with resource systems at best partially controlled. Unfortunately, this is by no means universally recognized: a fallacy of controllability is often in place, reflecting a perception that in resource systems more can be known, and more controlled, than can be realistically expected.

The move to robust management requires a re-thinking of these tendencies, and of the very philosophy of management. There is a need to focus on the challenge of developing management measures that optimize the overall sustainability of inherently uncontrollable resource systems. While clearly a desirable attribute for management of any highly uncertain system, 'robustness' is not easily achieved. New structural and decision-making tools, notably the Precautionary Approach and the Ecosystem Approach, will help in this direction.

Furthermore, no matter how successful a management system is in lessening the overall sensitivity to uncertainty, such uncertainties will not disappear. Thus it remains important to institutionalize *adaptive management*, which has two principal implications. First, there is a need to account systematically for uncertainty by properly using available information, and seeking out new information, through continuous monitoring of the natural resource system. Second, adaptive management involves maintaining a capability and willingness to make appropriate adjustments, over both short and long time scales, adapting in a timely manner to unexpected circumstances, so that management goals are not compromised.

Adaptive management requires that resource use plans, and individual business plans for resource industries, must be flexible, to allow for the uncertain nature of the natural resource. This requires a more flexible approach in which new information is integrated with existing data on a regular basis, with management actions reassessed accordingly. This does not imply the need to respond drastically to even the smallest apparent change in the resource, but there must be the *capability* to adapt to change – over long time frames and in the short-term. In particular, while ideally it would be desirable from a resource user's perspective to adopt fixed annual production plans, the apparent *stability* so obtained may be at the expense of ecological (and long-term economic) well-being.

3.4. Co-management and Community-Based Management

In a co-management system, a suitable combination of government agencies, resource users, communities and the public is involved in resource management – specifically developing, implementing and enforcing management measures – based on the sharing of decision-making power and taking responsibility to ensure the resource sector's sustainability. Co-management is rapidly expanding and evolving in natural resource systems, in many cases replacing a top-down governmental management style that dominated in the recent past, and that tended to create conflict between resource users and managers – something that is reduced with successful co-management. The matter of who should participate in co-management is complex. For example, participation in some *operational* management decisions may be restricted to only those directly

involved among resource users and government, while *strategic* management decisions (over policy that affects the overall direction of resource use) may require co-management arrangements in which the public can also play a major role. It should be noted as well that while participation is important to management, it is equally relevant to resource sector *research*, where resource industries and non-governmental organizations are increasingly playing an important role.

Community-based management (CBM) can be seen as a form of co-management, in which much of the management authority rests at a local level, held within a suitable management body comprising resource users, organizations and community representatives. This CBM approach can be effective in combining two key features of sustainable resource management. First, it can provide the means to make use of local resource knowledge and indigenous methods of resource management (discussed in the following). Second, such local control can provide more efficient, effective resource management, by bringing the community's moral pressure to bear on the actions of resource users. In other words, resource users not only have a greater incentive to support the management measures, they are under pressure to do so from their own community, which had itself developed the management measures and is dependent on a sustainable resource system.

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Biographical Sketch

Dr. Anthony Charles is a professor of Management Science and Environmental Studies at Saint Mary's University, in Halifax, Canada. He is an internationally-recognized expert on policy and management approaches for sustainable natural resource use, as well as on the use of indicator frameworks, bio-economic models and socio-economic analysis to assess natural resource industries. Dr. Charles specializes particularly in coastal and marine problems, and has been awarded a Pew Fellowship in Marine Conservation, in recognition of his work supporting fishery conservation and fishing communities. He focuses his research at the interface of conservation and resource use, covering such topics as appropriate policy promoting sustainability and resilience in resource systems, development of protected areas, impacts of climate change on coastal resources, and community-based natural resource management. Dr. Charles is the author or co-author of a wide range of publications, including the books *Sustainable Fishery Systems*, *Integrated Fish Farming* and *Community Fisheries Management Handbook*. Within Canada, Dr. Charles works regularly with community organizations dealing with natural resources, as well as at larger scales – as a founding member of Canada's Fisheries Resource Conservation Council, Dr. Charles provided guidance to the national government on responses to the dramatic 1990s fishery collapse. He also works with international bodies such as the FAO (serving both as a consultant and as a Visiting Scientist) and the OECD (producing several policy documents), and has undertaken a range of research and capacity-building projects in developing regions of the world, notably Latin America and Asia.