8 *Strategic Interventions, Response Options, and Decision-making*

Executive Summary

- Decision-making processes and institutions operate across spatial scales and organizational levels—from the village to the planet. Decision processes are value-based and combine political and technical elements to varying degrees. Desirable properties of decision-making processes include equity, attention to vulnerability, transparency, accountability, and participation.
- Strategies and interventions that will help meet societies' goals for the conservation and sustainable use of ecosystems include incorporating the value of ecosystems in decisions, channeling diffuse ecosystem benefits to decision-makers with focused local interests, creating markets and property rights, educating and dispersing knowledge, and investing to improve ecosystems and the services they provide.
- The choice among options will be greatly influenced by the temporal and physical scale of the problem or opportunity, the uncertainties, the cultural context, and questions of equity.
- Mechanisms for accomplishing these interventions include conventions, laws, regulations, and enforcement; contracts, partnerships, and collaboration; and private and public action.
- Institutions at different levels have different response options available to them, and special care is required to ensure policy coherence. Decision-making processes combine problem identification and analysis, policy option identification, policy choice, policy implementation, and monitoring and evaluation in an iterative fashion.
- A range of tools is available to choose among response options—from cultural prescriptive rules to cost-benefit and cost-effectiveness analysis. In the selection of an analytical tool and in the evaluation of response options, the social, economic, environmental, and historical context should be taken into account.
- Policies at each level and scale need to be adaptive and flexible in order to learn from past experience, to hedge against risk, and to consider uncertainty. However, trade-offs between the responsiveness and the stability of the policy environment need to be considered.

- Intermediate indicators may be required to link policies and actions and their impacts on ecosystems and human well-being. Quantitative indicators make the trade-offs in policy-making explicit, but qualitative information is valuable where measurement is not possible. Traditional and practitioner knowledge are important sources in addition to science.
- "Boundary organizations" that synthesize and translate scientific research and explore the policy implications can bridge the gap between science and decision-making. Journalists have a similar bridging responsibility to ensure that science and policy information is transmitted to the public in ways that are both objective and engaging.

Introduction

The context of decision-making about ecosystems is changing rapidly. World population continues to grow and become more urban, consumption is increasing, the climate is changing, and human actions increasingly influence major biogeochemical cycles and the majority of ecosystems. In addition, the ecosystems people depend on for services are more tightly coupled to each other and to human systems and in many cases are more stressed. At the same time, however, scientists and others are developing a far better understanding of how ecosystems function, how they generate ecosystem services, how those services may contribute to human welfare, and how values can be assigned to the services.

Thus the new challenge to decision-making is to make effective use of new information and tools in this changing context in order to improve the decisions that intend to enhance human well-being and provide for a sustainable flow of ecosystem services. It seems clear that the choices of the past may not be the most appropriate strategy for the future, and that even the way people think about intervening in ecosystems must be revised to take account of new information, new tools, and new contexts. In addition, some old challenges must still be addressed.

Perhaps the most important traditional challenge is the complex trade-off faced when making decisions about how to alter ecosystems with the goal of enhancing the flow of services. Increasing the flow of one service from a system, such as provision of timber, may decrease the flow from others, such as carbon sequestration or the provision of habitat. In addition, benefits, costs, and risk are not allocated equally to everyone, so any intervention will change the distribution of human well-being—another trade-off.

These trade-offs are related to a second ongoing problem: some benefits of ecosystem services are easily captured by those who have access to the system, while others are harder to capture locally. For example, it may be relatively easy for local people to capture the direct use value of timber in a forest via market prices—they are capturing the value of provisioning services. At the same time, people around the world may benefit from carbon sequestration by the forest—an indirect use value of a supporting service. Under many institutional arrangements, the people near the forest have no way to capture this other value. Further, some cultural services of ecosystems and the existence value of biodiversity are global and thus difficult for local people to capture. Because the direct use value—revenues from logging—can easily be converted into income for local people, for local and national governments, and for local, regional, and multinational firms, there is a strong incentive to log the forest. In contrast, the indirect use and existence value—carbon sequestration and appreciation of old-growth forests—are much harder to translate into income for anyone. As a result, there will be a tendency for decisions to favor the direct use even though a full analysis of the total value of ecosystem services might favor preserving or enhancing the indirect use and existence values by not logging.

The characteristics of the ecosystem, the technologies available for using it and monitoring such use, and the institutional arrangements that distribute values across groups all have consequences for what decisions are made (Ostrom et al. 1999; Dietz et al. 2002b). A great deal is understood about these problems, and the state of the science often provides guidance on the design of institutions to promote capturing the full value of an ecosystem (Costanza and Folke 1996; Stern et al. 2002).

Decision-making Processes

The Millennium Ecosystem Assessment (MA) must look carefully at decision-making processes for choosing among alternative intervention strategies. Process influences the intervention chosen. It can also influence those who bring about or respond to an intervention and who facilitate or retard the ability to adapt to changing circumstances. Of course, decision-making processes vary across jurisdictions, institutions, and cultures. But broadly accepted norms regarding decision-making and analyses of how decision processes handle information and influence implementation (Hemmati 2001; Petkova et al. 2002; Dietz 2003) suggest some desirable characteristics regarding:

- use of the best information,

- transparency and participation,
- equity and vulnerability,
- cognitive and organizational strengths and weaknesses,
- lessons from past decisions and the protection of options,
- accountability,
- efficiency, and
- cumulative and cross-scale effects.

The MA is motivated by recent improvements in information about ecosystems, the services they provide, the impact of those services on human well-being, the value of those services, and the design of institutions, programs, and policies to shape behavior. In addition, new tools to use that understanding are being developed. Current decision-making practices often do not reflect these important developments. For example, relatively few decisions take account of indirect use value and very few take explicit account of existence values. As a result, many decisions about intervention into ecosystems are not based on the best possible information. Note that information about both facts and values is required and that information used to make decisions about ecosystems will always be uncertain and involve risk. Thus knowledge about uncertainty and risk is itself an important component of the decision-making process, as discussed later in the chapter.

Processes that are transparent and that involve all those who will be affected by the decision are more likely to be seen as legitimate and to find support when implemented (U.S. National Research Council 1999; U.S. EPA Science Advisory Board 2000). Further, the management of ecosystems requires locally grounded knowledge (often referred to as "traditional ecological knowledge") and must address questions that can emerge only from an understanding of local situations (Stern and Fineberg 1996; Dietz and Stern 1998; Berkes 2002). That knowledge can be obtained only by interaction with those who have local experience. Finally, since non-use values are an important contribution of many ecosystems to human welfare, people who are not local to an ecosystem but who benefit from its non-use values must also be engaged. This implies that decision-making processes should involve stakeholders effectively, a principle that has become central to risk analysis.

Although no universal prescriptions on how best to do this are possible, a growing literature on public participation in environmental decision-making provides useful guidance (Stanner 1979; Fiorino 1990; Dietz

1994; Renn et al. 1995; Slocum et al. 1995; Stern and Fineberg 1996; Chess et al. 1998; Chess and Purcell 1999; Webler 1999; Beierle and Cayford 2002). Sometimes formal negotiation and conflict resolution processes are helpful, but in almost all cases careful design of participation mechanisms is important to good decision-making.

In terms of equity and vulnerability, changing the provision of ecosystem services very often produces "winners" and "losers." For effective implementation, the benefits, costs, and risks across groups must be balanced in an equitable way (Agrawal 2002; McCay 2002). Given that many changes in ecosystems can have important impacts on the poor, special attention to the most vulnerable populations is also warranted, as is special attention to human health.

Individuals, groups, communities, and organizations have varying strengths and weaknesses in processing information (Kahneman et al. 1982; but see Cosmides and Tooby 1996; Wilson 2002). Decision processes will be most effective if they make use of the kinds of decision tools described in this chapter to compensate for limits and weaknesses.

The understanding of ecosystem dynamics will always be limited, socioeconomic systems will continue to change, and outside determinants can never be fully anticipated. As Campbell (1969) noted over three decades ago, all policies are experiments. Decisions should consider whether or not a course of action is reversible and should incorporate, whenever possible, procedures to evaluate the outcomes of actions and learn from them. That is, people should try to learn from these experiments and use that knowledge in designing new ones. Debate about how exactly to do this continues in discussions of adaptive management, social learning, safe minimum standards, and the precautionary principle (Gunderson et al. 1995b; Yohe and Toth 2000). But the core message of all approaches is the same: acknowledge the limits of human understanding, give special consideration to irreversible changes, and evaluate the impacts of decisions as they unfold.

In terms of accountability, the consequences of decisions do not always redound directly to those who make them. As noted earlier, those who might decide to harvest timber from a forest may not bear any of the consequences of disrupting the flow of supporting and cultural services and so will not take such services into consideration in making their decision. This problem is exacerbated in the face of uncertainty and risk—the relationship between a decision and its consequences is hard to see. Effective decision-making can develop only if the people making decisions are accountable for the results (Perrow 1984). Unfortunately, in many circumstances the lack of accountability removes the incentive for decision-makers to use the best information available.

In a world of scarce resources—fiscal, human, and natural—efficiency should be an important criterion for choosing among intervention options. This is a central tenet of environmental and resource economics, and there are numerous effective tools for examining the efficiency of various options, as described later. In reality, the goals of equity, encouraging learning, and protecting options need to be considered together with the goal of maximizing efficiency. This typically leads to a multicriteria decision problem.

Many decisions about interventions into ecosystems are made at a local level. As noted earlier, this involves balancing locally concentrated costs and benefits against those that are more widely distributed and harder to capture. Another way to think about this is that decisions based only on a local analysis can miss cumulative effects of the same kind of decision being taken in multiple localities. Thus, too narrow a scope of analysis results in decisions that are less than optimal from a larger perspective (Olson 1965). Appropriate decisions emerge only when all relevant scales are considered.

Although these eight features of decision processes seem consequential and deserve serious attention, it is unclear exactly how they influence decisions and implementation and especially how the impact varies across contexts. Analysis of how the characteristics of the decision process influence changes in ecosystem services and human well-being deserves careful attention in the MA.

Response Options and Strategic Interventions

There are many options for responding to the need to protect and restore ecosystems and the services they provide and to ensure the equitable distribution of the benefits of those services. Fundamentally, these options can be characterized as interventions that stimulate or suppress certain human activities and those that create knowledge or investment. They can take the form of prescriptions of behavior (that is, "command and control" or assignment of accountabilities), incentives and disincentives (that is, creating or assigning property rights or establishing markets, subsidies, and taxes), education and knowledge sharing, or direct investment and expenditure (Kaufmann-Hayoz et al. 2001; Dietz and Stern 2002).

The range of response options and strategic interventions that should be applied to a particular problem will depend on such factors as its nature (economic, environmental, or social), its scale (temporal, spatial, or institutional), and the capacity of the actor or decision-maker to make change.

The MA will evaluate the use and effectiveness of various response options and strategic interventions within this context. For example, as knowledge and understanding of the value of ecosystem services increases, the merits of investments to improve or restore ecosystems may become apparent. But in order to attract the financial, human, and social capital—whether public or private—needed to pursue such opportunities, incentives may be required that include the assignment of "property rights" in ecosystem services.

In addition, mainstream economics suggests that a set of property rights that is comprehensive, exclusive, enforceable, and transferable is necessary for efficient outcomes. Yet many of the problems in the economics of the environment can be understood in terms of the failure of systems of property rights to meet this ideal. The failures range from the overexploitation of open access resources to the creation of nuisance or enjoyment to others without compensation (called externalities in the language of economics). Efficient economic outcomes also require perfect information, so that all participants have the same complete information, including about the consequences of their actions. Less-than-perfect information about the functioning of ecosystems can be a significant obstacle to effective choices.

Although there is a tendency to think of property rights in terms of private property, many institutional arrangements in fact create property rights that are not fully private. The sort of village-level institutions that many societies have developed to allocate the rate and intensity of use of common property such as pastureland is an example of this. It is the breakdown or failure of these institutions to evolve that can lead to exploitation of the commons.

There is growing understanding of the functioning of common property resource regimes (Ostrom et al. 2002). Points to consider about the community using the resource include its size and cultural homogeneity, the options for mobility in and out of the community, the frequency of communication between individuals, the density of social networks, practices of reciprocity, and the degree of adherence to shared norms. The characteristics of the resource itself must also be looked at, such as its mobility, its capacity to be stored, and the clarity of its boundaries. These considerations influence the ease and cost of monitoring resource users' behavior and the state of the resource. The continuing state of the common property is the result of all these factors and the ease and cost of enforcing rules about its use.

Gaining access to economic rents from resources in the absence of effective allocation of property rights can be a powerful motivator for many individuals and groups. In many cases, central governments—as the owners of natural resources on behalf of a nation—attempt to monopolize these rents. This may make perfect sense for highly concentrated resources like minerals or crude oil, but for dispersed resources such as forests, control by the central government may stop communities from using local resources. Not surprisingly, people with no property right in local forest resources see little benefit in managing these resources in a sustainable manner.

The pursuit of resource rents helps to explain much of the political economy of the use of ecosystems. Because returns on investment are high when external costs are disregarded, the powerful and those with access to capital have strong incentives to seek these rents. The exercise of political power by individuals, families, and groups in pursuit of resource rents leads to many of the inequities observed in access to and use of natural resources. In addition, where the powerful have the means to exploit natural resources but no legitimate property right, many of the problems of sustainability, of overriding cultural and intrinsic values, and even of efficiency (in terms of broader social welfare) can be explained. Response options and strategic interventions that align property rights in ways that consider all stakeholders or that internalize all costs will be a focus of the MA.

Response options and strategic interventions can be implemented through a number of mechanisms, including international conventions; multilateral and bilateral treaties; national and local laws, regulations, and enforcement; institutional change and changes in governance structures; governmental and industrial policies; contractual agreements, partnerships, and collaboration; and private and public action.

International agreements concerned with ecosystems range from general principles, such as those contained in global framework conventions, to detailed regulatory arrangements with compliance provisions. When negotiated and approved by sovereign states, in principle these agreements constitute the boundary conditions for all related prevailing social, economic, and political national policies. In many cases, however, these conditions will depend on enactment and enforcement of laws and regulations that are designed to implement a nation's responsibilities under the agreement. A literature is emerging on the implementation and effectiveness of such treaties and conventions (Victor et al. 1998).

National-level decision-making has a special role in several respects. First, even the best-designed local or regional actions are likely to be ineffective in the absence of proper coordination (for example, a stringent and enforced protective measure in one region may simply shift a harmful activity to another region). Second, key legislative power often is anchored at the national level (although the distribution between the national and sub-national levels varies among nations). Finally, nations are the recognized parties in the increasing number of international negotiations and agreements. Nevertheless, they face domestic constraints with respect to policy-making because of the ability of sub-national entities—regional or sectoral, and government or nongovernmental—to influence processes and outcomes. Government policies to protect ecosystems can fail if they are at odds with the prevailing social reality: poverty-stricken communities have little to lose by ignoring laws on protected areas if no alternative source of living is provided and if enforcement is weak.

There also are many policies emerging among networks of private-sector firms that may have substantial impact on ecosystems and their services (Dietz and Stern 2002). These include a variety of agreements that set standards and codes of practice for the extraction of resources and the production of goods. Such policies are sometimes applied within a single nation, but there are an increasing number of international agreements as well. They are voluntary but are often coordinated with governments, international agencies, and environmental nongovernmental organizations. Just as with national and international policies, the private-sector agreements may be undermined by local economic circumstances, by a lack of technical capacity at the local level, or by conflicting performance standards within and between private firms.

One important type of strategic intervention that requires assessment is incorporation of the value of ecosystem services into decision-making. Decisions and actions that have direct or indirect effects on ecosystems are usually taken with human well-being in mind, but it is not certain that human well-being (taken broadly) has been enhanced if ecosystem effects have not been taken into consideration. For example, it is useful to think of two kinds of human actions that affect ecosystems and their services: local action that changes ecosystem services directly, and the actions of a number of individuals across a locale, region, or the planet, which produce effects that can be cumulative, dispersed, indirect, but in fact systematic. Humans change biological and chemical cycles, disperse both synthetic and natural chemicals in new ways, and alter planetary processes such as climate and the incidence of ultraviolet radiation. These cumulative or indirect effects are often unintentional, but they can have substantial impacts on ecosystems throughout the globe.

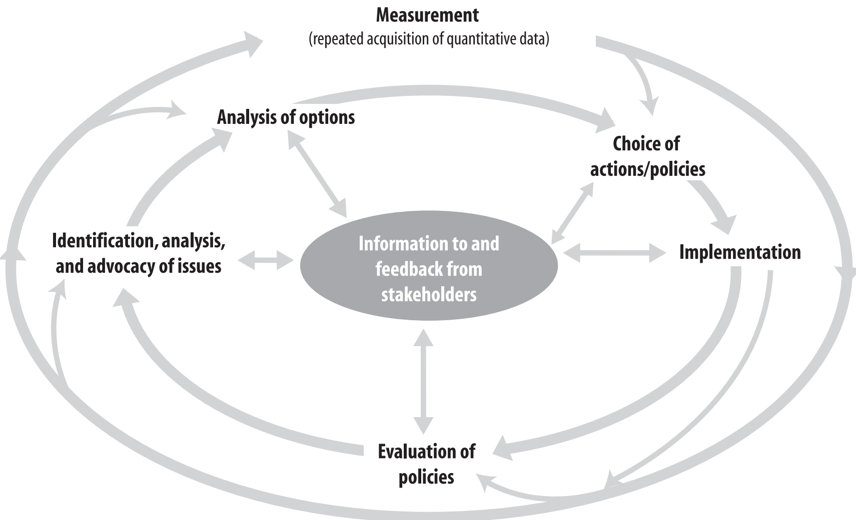
The bulk of the ecosystem degradation literature is concerned with direct interventions, but it is increasingly important to consider how indirect actions influence ecosystems, how these changes interact with direct changes, and how to develop policies and management strategies to deal with each. Conversely, many decisions that influence ecosystems made at the local level are shaped by regional, national, and global conditions (Vayda 1988; Dietz and Rosa 2002). When an ax swings to cut a tree in a forest, there is a sense in which the decision to clear land is made locally. But that decision is influenced by physical infrastructure (such as roads and mills) and by institutions (markets, enforcement of property rights, and land protection regimes) that are in turn shaped by regional, national, and global circumstances. So while decision-making is local, the local action can be shaped by global forces and have global implications.

The extent to which a full range of costs and benefits, including ecosystem services and effects, both direct and indirect, are incorporated in decision-making processes—that is, are felt by the decision-maker—determines the quality of those processes. Therefore, the efficacy and need for strategic interventions that aggregate and focus these costs and benefits on the "local decision-maker" should be assessed. In this regard, as the full costs of action have been concentrated in this way, markets will pass them to ultimate consumers to help them become informed about ecosystem effects and influenced in their consumption behavior. Markets for carbon emissions and sequestration credits are an interesting example of capturing costs and benefits that are otherwise external and making them available to local decision-makers.

Usable Knowledge

A simplified picture of the role of knowledge in decision-making is shown in Figure 8.1, which portrays three interacting processes: monitoring, the decision-making cycle, and the flow of information to and from stakeholders. Policy-making starts by identifying a problem, then it defines policy options and their choice, formulation, and implementation, and ideally it finishes with monitoring and evaluation of the results of executed actions. The process is interactive and iterative and takes place within a specific institutional structure. At all stages, decisions are based on the values, preferences, intuitions, prejudices, and social situations of the organizations and individuals who make them. The process engages all "stakehold-

FIGURE 8.1 Information in the Decision-making Cycle
See text for explanation.



ers," including effective delivery of essential information to decision-makers, communication among stakeholders, and multidirectional exchanges among information providers and information users.

Measurement assembles information from regular monitoring (the outer cycle in Figure 8.1) and other sources. The identification, analysis, and advocacy of issues all require comprehensive and detailed knowledge of human (socioeconomic) and environmental conditions and major trends, including the nature, distribution, and impact of direct and indirect drivers. Hence they need to draw on accounts, spatial assessments, a comprehensive indicator-based assessment, and sometimes also a science assessment. (See Box 8.1.)

The same tools are required for the analysis of options and the choice of actions or policies. They provide the detailed knowledge necessary to examine which issues to address and in what ways, taking account of feasibility, cost-effectiveness, and the likely impacts of different options on socioeconomic and environmental conditions as well as on particular stakeholders.

Policies are implemented through institutions. An institutional analysis is necessary to identify the constraints on implementation and what needs to be done to overcome them. Because implementation depends heavily on the active support and participation of stakeholders, they need

BOX 8.1 Accounts and Assessments

Accounts are assemblages of numerical data, converted to a common unit (money, weight, area, or energy). They can produce valuable composite indicators (constructed directly from data), such as the gross domestic product, genuine saving, and the ecological footprint.

Spatial assessments are assemblages of spatial data. They use geographic information systems to show the location, size, pattern, condition, and ecological, economic, or cultural values and characteristics of land and water areas. They provide basic information for the allocation of uses and are a means of compiling useful composite indicators, such as the status of ecosystem diversity, the extent and security of ecosystem protection, and the extent and severity of land degradation.

Indicator-based assessments are assemblages of indicator variables. Because they rely on representative indicators, they can be selective, and thus they can cover the wide array of issues necessary for an adequate portrayal of human well-being, environmental conditions, and human-environment interactions. Indicators of success are derived:

- in the biophysical/ecological sciences from different kinds of environmental data,
- in sociology and anthropology from concepts of social stability or resilience among individuals or higher organizational units,
- in political sciences from the efficiency with which policies are implemented,
- in jurisprudence from the extent of compliance with law, and
- in economics from the impacts of policy on social welfare.

Because of the confusing and often conflicting signals sent by a large number of individual indicators, assessment methods that produce indexes (compound indicators or combinations of lower-level indicators) are much easier to interpret and can provide decision-makers with clearer and more compelling information. Examples are the Human Development Index prepared annually by the United Nations Development Programme and the Wellbeing Index put together by the International Development Research Centre of Canada and others.

Science assessments use a mixture of numerical data, spatial data, and indicator variables to formulate a scientific consensus on major issues. Whereas other evaluations are conducted regularly, science assessments tend to be produced occasionally, as the need arises. A recent example is the reports of the Intergovernmental Panel on Climate Change. Similarly, European Environment Agency reports collect, analyze, and report data on the state and direction of environmental quality in the entire European region. Models and integrated assessments conducted for the Convention on Long-Range Transboundary Air Pollution give feedback to negotiators on policy options. They can have many different impacts on the policy process: change the terms of a debate (by introducing new policy options, for example), prompt new participants to be concerned about an issue, or change the interests, behavior, or strategies of current participants.

to be informed and feedback should be obtained from them at every stage in the decision-making cycle.

Monitoring and indicator-based assessments track implementation, recording:

- whether actions or policies were implemented,
- whether they achieved their intended results, and
- whether new factors have arisen, in which case the entire cycle is repeated.

Failure to implement requires examining whether the policy was correct, the necessary constituency developed, the instruments put in place, and—if all that happened—the instruments were appropriate. If the relevant indicators used by the indicator-based assessment are unlikely to change in time, one or more intermediate or proximate indicators will be needed to establish a causal link between the actions or policies and the intended results in terms of their impacts on ecosystems and human well-being. This may be complex, as changes in the state of ecosystems and provisioning of services can be caused by several factors operating simultaneously, such as parallel policies, or by external factors such as changes in economic activities. Also, ecosystems are dynamic by nature, and human-induced changes cannot always be distinguished from natural ones. Time lags between responses and ecosystem improvement or change can be considerable, and therefore it is important to evaluate impacts on direct and indirect drivers as well.

Analytical frameworks, such as that developed by the European Environmental Agency (EEA), can be built upon in a MA-type assessment of response options (EEA 2001). The EEA framework distinguishes between the various components of policy development, implementation of measures, strategies, interventions, and ultimate impacts on ecosystems and society. It also indicates some of the key issues or questions that need to be addressed. The design and structure of objectives affect the resource requirements (financial and human), which in turn will affect the efficiency of policy outputs. In this framework, the needs of society, the impacts on the environment, and the outcomes of policies are external to the policy development process. The evaluation of different responses is always in terms of relevance of objectives and the ultimate welfare of society as a result of implementation of these responses. (Issues related to evaluating the policy-making process are discussed in the first section of this chapter.)

To be usable, knowledge needs to address the particular concerns of a user. In the context of the MA, information should have a clear connection to direct and indirect drivers, ecosystem services, and human well-being. General characteristics of good indicators are described in Chapter 7; other characteristics of indicators useful for policy-making are that they:

- relate directly to policy options, goals, or targets (such as the Millennium Development Goals);
- capture change over time;
- identify critical thresholds or the irreversibility of a change;
- provide early warning; or
- characterize the optimal, sufficient, or insufficient level of a given ecosystem service.

It is important to keep in mind that usable knowledge deals with different spatial scales, time frames, and organizational levels. The principal findings are seldom easily transferable from one scale or level to another. Indeed, in most cases the transfer of information across scales needs a special effort. One example is an evaluation of the regional or local impact of global climate change or other global phenomena. The recently stressed notion of a "place-based" science for sustainability—which should be relevant for local policy-making—points in this direction (ICSU 2002a). It is equally important—and difficult—to translate long-term impacts that may affect only future generations into terms relevant to day-to-day decision-making.

The MA will produce a wealth of policy-relevant, preferably quantitative data. This does not mean that everything must be quantified. Indeed, as noted earlier, some elements of sustainable development are intrinsically hard to quantify, and not everything can be turned into numerical data or graphical expressions. This is also true of information and knowledge on some social and economic assets. It is impossible to express in a credible way and in quantitative terms the intrinsic value of biodiversity or the nature of social relationships. But to avoid neglecting them, it is necessary to provide qualitative ways of gathering and communicating information, such as ethnographies of collective actors, assessment of cultural dimensions, case studies, qualitative studies of corruption, and qualitative surveys.

But the majority of "usable knowledge" is in the form of numerical or other quantitative information (ICSU 2002b). Among various forms of such information, indicators play an important role. Indicators provide the basis for assessing progress toward sustainable development. Long-term targets only have meaning as policy goals if progress toward them can be assessed objectively. This requires targets expressed in precise terms. Careful measurement will also improve the ability to identify interactions between different policies and deal with possible trade-offs. These are already a part of policy-making, but the advantage of measurement is that trade-offs are made explicit and transparent.

The MA aims to incorporate both formal scientific information and traditional or local knowledge. Traditional societies have nurtured and refined systems of knowledge of direct value to those societies but also of considerable value to assessments undertaken at regional and global scales. This information often is unknown to science, and can be an expression of other relationships between society and nature in general and of sustainable ways of managing natural resources in particular (ICSU 2002c). To be credible and useful to decision-makers, all sources of information, whether scientific or traditional, must be critically assessed and validated as part of the assessment process through procedures relevant to the form of knowledge.

The findings of an assessment are likely to be used if they are acceptable to potential users or if the users at least regard the sources and process to be legitimate. A legitimate source is one judged to be so by the knowledge system concerned, whether a scientific discipline, a government, or a tradition. (Science has a way of establishing the legitimacy of its knowledge, and traditional societies have ways of establishing the legitimacy of the knowledge within a particular culture. But methods that apply across cultures or to science and traditional knowledge together do not yet exist.) A legitimate assessment process is one that satisfies users that it is fair and that their interests have been taken into account. So-called global assessments may be questioned by less powerful countries, for instance, because they feel their input was not included or that their interests were ignored; this corresponds to a lack of legitimacy (EEA 2001). This applies also to information of other kinds at national or local levels.

In some cases, wide gaps may exist between the sources of usable knowledge and the potential users. Organizations that synthesize and translate scientific research and explore its policy implications are able to bridge this gap. They are sometimes called "boundary organizations" because they facilitate the transfer of usable knowledge between science and policy and they give both policy-makers and scientists the opportunity to cross the boundary between their domains. Journalists have a similar bridging responsibility to ensure that science and policy information is transmitted to the public in ways that are both objective and engaging. Capacity building is desirable in both these areas.

Dealing with Risk and Uncertainty

Risk refers to the probability that certain actions or decisions will result in harm to humans or have adverse effects on their well-being. Since risk is inherent in all human activity and is usually associated with efforts to secure greater benefits for human well-being, it cannot be eliminated from human progress, technology development, or social innovation. But the assessment of risk, including ecological risk assessment, now has an advanced set of tools for comparing apparently dissimilar environmental threats, options for balancing risks and benefits and the potential tradeoffs, and means for ensuring equitable management policies or actions aimed at enhancing the situations of the poor and other vulnerable groups (Jaeger et al. 2001; Dietz et al. 2002a). Risk assessment has significant potential for informing the decision process, particularly when decisions are highly complex and uncertain.

The assessment process has several functions. The first is analysis, to provide the knowledge base needed to support sound decisions. This should draw, as noted throughout this report, on both scientific and traditional or lay sources of knowledge to identify and characterize the benefits and risks that various human actions or decisions will have for ecosystem services and human well-being. It should also identify alternative decision options aimed at enlarging benefits, minimizing or eliminating risks, or securing greater fairness in the distribution of benefits and risks. Such analysis should include specific appraisal of the types and magnitudes of uncertainty associated with the estimates.

A second function of assessment is that of deliberation, which is an important attribute of the process (Stern and Fineberg 1996; Dietz and Stern 1998). Deliberation refers to the consultative process and stakeholder involvement, which helps ensure completeness and inclusiveness in the values that different people attach to potential benefits and risks.

Many decisions involved in the management of ecosystems involve high levels of uncertainty or even ignorance. This has led to increased interest in a certain strategy of decision process, which can be described as adaptive management. This approach begins with the recognition that the decision situation or the management challenge is only partly knowledge, and that high levels of uncertainty or ignorance will continue to characterize the situation. In such cases, there are many advantages to structuring the decision process as on ongoing set of interventions that are essentially experiments, as described earlier, and then learning about the relationships based on the outcomes of the decision. This assumes that surprises and unexpected events occur and that management needs to be highly responsive and flexible rather than attempting to control and eliminate variability and uncertainty. The principles of adaptive management and the relevant experience in the Columbia River Basin have been examined by Lee (1993) and elaborated by others (Gunderson et al. 1995b).

Concern that the large uncertainties accompanying the threats to ecosystems and related human well-being will lead to long delays in decision-making and management response has led to increased use of the precautionary principle. As defined in Principle 15 of the 1992 Rio Declaration, this means that "[w]here there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (United Nations 1992:3). A variety of versions of this principle are now in use, with differing implications for assessment and decision-making. Though some commentators have viewed the precautionary principle as an alternative to risk analysis, it is in effect an ethical principle for particular decision situations that is largely compatible with risk analysis. Risk assessment provides valuable knowledge for when to invoke the precautionary principle and the form it might take, but this should not preclude the continuing development of risk-related knowledge to be used in future decisions.

Risk assessment and risk management techniques are often used in the broader processes of environmental impact assessment and strategic environmental assessment. The former is the process of evaluating possible environmental impacts of a proposed project, covering all possible harmful and favorable socioeconomic, cultural, and health-related impacts. Most countries have legislation requiring an environmental impact statement before a project or development is authorized, but the enforcement, practice, and quality requirements for the process vary widely across countries and even across regions within a country. Strategic environmental assessments identify and evaluate the possible environmental implications of proposed policies, broader programs, or large-scale plans in a comprehensive and systematic manner. Their scope ranges from overall sectoral policies (such as a national water policy) to comprehensive regional development strategies. They often provide the context and the background information for project-specific environmental impact assessments.

At a more comprehensive level, communities, nations, groups of nations, or international organizations regularly produce State of the Environment reports to assess environmental trends and conditions and the performance of existing environmental regulations as well as to help formulate new or revised environmental targets and policies. Such reports often identify newly emerging issues or dangerous trends that would be investigated in a strategic environmental assessment in more detail. Accordingly, the three types of activities are closely related and represent key features of the decision-making processes dealing with the interactions between people and ecosystems.

Decision Analytical Frameworks and Tools

The diverse characteristics of the decision-making situations associated with ecosystem and biodiversity management imply the need for a range of decision analytical frameworks (DAFs) and tools. A decision analytical framework is defined as a coherent set of concepts and procedures aimed at synthesizing available information from relevant segments of an ecosystem management problem in order to help policy-makers assess consequences of various decision options. DAFs organize the relevant information in a suitable framework, apply a decision criterion (based on some paradigms or theories), and identify the best options under the assumptions characterizing the analytical framework and the application at hand. It is important to note that none of the frameworks can incorporate the full complexity of decision-making; hence their results supply only part of the information shaping the outcome. And there are always hidden value judgments involved in the selection and application of DAFs.

A broad range of frameworks can be used in principle and has been used in practice to provide information for policy-makers concerned with ecosystem-related decisions at various levels. Based on Toth (2000), Table 8.1 provides an exemplary rather than an all-encompassing list. (See the MA Methods report for concise descriptions of these frameworks.) Many DAFs overlap in practice. Further, one method of analysis often requires input from other methods. As a result, a clear classification of methods and their application to real-world problems is sometimes difficult.

DAFs can be divided into several types: normative DAFs, such as decision analysis and cost-benefit analysis, that deal more directly with valuation and commensuration; descriptive DAFs that consider outcomes that may result from certain actions, such as game theory; and deliberative DAFs that deal with the discovery of information from people and by

TABLE 8.1 Decision Analytical Frameworks

Framework	Decision Principles: Optimization/ Efficiency	Decision Principles: Precautionary Principle	Decision Principles: Equity	Treatment of Uncertainty: Rigor	Treatment of Uncertainty: Form	Level of Application	Domain of Application
Decision analysis	*	+	+	*	St	X	B
Cost-benefit analysis	*	–	+	+ *	SA Sc	X	D
Cost-effectiveness analysis	*	+	+	+ *	SA Sc	X	D
Portfolio theory	*	+	–	*	St	X	D
Game theory	+	–	+	+ *	SA St	X	I
Public finance theory	*	–	*	–	SA	N-R	D
Behavioral decision theory	–	+	+	–	Sc	N-M	B
Policy exercises	+	+	+	+	Sc	X	B
Focus groups	–	+	+	–	Sc	R-M	B
Simulation-gaming	–	+	+	+	Sc	X	B
Ethical and cultural prescriptive rules	–	+	+	–	Sc	N-M	D

Compatibility with/usability of decision principles in DAFs:
– weak but not impossible + possible but not central * essential feature of DAF

Level of application:
G = Global I=Inter/Supra-national N=National R = Regional/Sectoral (Sub-national) L=Local (community)
M = Micro (Family, firm, farm) X = All

Typical domain of application:
D=Direct intervention I=Indirect influence B=Both

Uncertainty treatment:
Rigor: * high + good – moderate/low
Form: St=Model structure SA=Sensitivity analysis Sc=Scenarios

people, such as simulation-gaming. A number of DAFs, such as behavioral decision theory or portfolio theory, have elements that may be described as either normative or descriptive. Finally, there are the DAFs in traditional and transitional societies that can be typified as ethical and cultural.

Several factors determine what type of DAF can be applied and what sort of framework can provide useful information for decision-making. The context of the decision incorporates social, economic, and environmental dimensions. Most of the decisions affecting ecosystems are private ones made by individuals (as owners, operators, or users) or by firms focusing on efficiency and attempting to maximize expected returns. Such decisions are heavily influenced by the prevailing social norms and aspirations, however, and by existing rules and institutions.

An important part of the context in which private decisions take place is the existing set of rules and regulations put in place by public policies. Modern (as opposed to traditional) societies have established procedures to assess the environmental, social, and economic implications of different public decision options. They also tend to have legally prescribed or routinely adopted decision analytical frameworks to choose among the options according to widely accepted criteria for public policy. But these procedures are usually restricted to decisions of an immediate nature (such as building concessions or emission rights). Impacts from diffuse sources and cumulative impacts such as excessive land depletion are generally dealt with less efficiently. In contrast, many societies in transition economies and in developing countries do not have such established procedures; ecosystem decisions therefore appear to be more arbitrary. In many countries, both industrial and developing, short-sighted or outright flawed public policies often lead to private actions with disastrous consequences for ecosystems. Complex management situations and severe ecosystem disruptions arise from the clashes of traditional and modern societies and during the transition from the former to the latter.

The criteria considered important in any decision situation form different decision-making principles. The predominant criteria for a socially desirable or at least widely accepted decision outcome are rooted deeply in the historical traditions of managing the given ecosystem, in the prevailing social conditions (ranging from the values local actors attach to ecosystem services to the existence and enforceability of property rights and government regulations), and in the economic conditions (level of development, distribution of income, and access to resources and social services). These factors need to be considered carefully when determining the decision-making principles to guide the choice of a decision analytical framework. These principles can be used individually or in combinations as DAFs are adopted to address specific ecosystem problems. Table 8.1 indicates some general decision-making principles and their compatibility with relevant DAFs. It is clear that some DAFs can accommodate some decision principles better than others, but full incompatibility is rare.

Key characteristics of ecosystem decision problems are the spatial and temporal scales involved. They determine the jurisdictional level at which the frameworks appear to be most helpful. Table 8.1 also contains entries regarding the decision-making level at which the given DAF can be applied.

There are many ways to affect individual and social behavior determining ecosystem management. Some decision analytical frameworks are more suitable in support of decisions to regulate management directly; others are more helpful in sorting out decisions that will affect broader behavioral choices. Accordingly, another series of entries in Table 8.1 indicates whether the DAF at hand is applicable to decisions concerned with ecosystem management directly or for broader policies that influence primary or proximate drivers.

Additional key features of the ecosystem decision problem are related to the level of complexity and uncertainty involved and the availability of data. Two columns in Table 8.1 provide indications of the ability of the framework to address uncertainties. The first series indicates the level of rigor (high, good, or moderate/low) at which the given framework can treat uncertainties. The second class of entries shows the typical form adopted for uncertainty analysis in the framework (inherent in the model structure, as in classic decision analysis; parametric or Monte Carlo-based sensitivity analysis; or scenarios).

There is no formal assessment or "decision analysis" in traditional societies. In some circumstances, environmental, demographic, economic, and technological forces lead to unsustainable practices in traditional societies (e.g., Krech III 1999). But many indigenous peoples have been managing their ecosystems in a sustainable manner for centuries or even millennia (Ostrom et al. 2002). The information basis of their management practices was grounded in long-standing experience, conscious observation, and inadvertent "experiments" triggered by natural events or human incidence. The guidelines distilled from these very long-term observations were incorporated into religious rules, cultural rituals, and other social-behavioral principles. From time to time, collisions between traditional societies and ecosystems led to ecosystem degradation (mostly temporary, sometimes permanent) or to social disruptions that were resolved by changing management practices, technologies, or social arrangements.

Rapid socioeconomic changes overwhelming the institutional capacities of ecosystem management have caused the largest shifts in ecosystem structure, function, diversity, and productivity. This situation characterized the period when modern societies first encountered previously unknown regions. The inadvertent introduction of alien species, ranging from microscopic pathogens (against which local people and ecosystems were not immune) to mammals (for example, rodents abundant on ships), and the deliberate introduction of new value systems (precious metals), management practices (cut and run), and technologies (chain saw) disrupted traditionally established balances between society and ecosystems. Similar processes can still be observed in the "transition" societies of many developing countries: the old values and rule systems concerning ecosystem management have broken down but no new rules or enforcement capacities have been put in place. These societies and social situations clearly require assessment and decision analytical capacities in order to establish the new ecosystem management rules and organize their enforcement, but there is hardly any sign of such efforts due to the lack of resources and, often, interest.

Only recently has the need to integrate indigenous ecological knowledge into ecosystem assessments and into developing resource management plans been recognized (e.g., Agrawal 1995; Appiah-Opoku and Mulamoottil 1997; Hellier et al. 1999). Often this recognition comes late. Actual efforts undertaken are characterized by varying degrees of integrity and intensity. The increasing assimilation of indigenous peoples, even in remote rural regions, into the modern socioeconomic system has greatly eroded traditional ecological knowledge—in many regions, irreversibly. If indigenous institutions of ecosystem management (social, political, and judicial institutions and religious beliefs, norms, and practices) have also largely disappeared, it does not make much sense to attempt to reincarnate them. A more sensible strategy is likely to be to firmly establish modern institutions and regulatory mechanisms in order to prevent further degradation and possibly to promote restoration of ecosystem quality and services. Given the lack of modern monitoring equipment and scientific data about ecosystems, traditional ecological knowledge may well make valuable contributions to the development of modern management strategies in these areas.

In contrast, in regions where indigenous institutions and knowledge are still reasonably intact and play a significant role in using ecosystem services, it is worth considering how to incorporate them into the modern institutional and regulatory framework. Taboos rooted in religion, harvesting rules overseen by the community, and penalties imposed by the indigenous judicial system are likely to be more effective ways to protect and use ecosystems sustainably than reliance on disrespected, ill-enforced, or corruption-plagued government regulation.

Yet in the dynamics of the real world, as social change and economic transformation are proceeding inexorably, the co-management of ecosystems by traditional rules and modern regulation faces new challenges from time to time. Downs (2000) argues that cultural acceptability of any alternative practice is key, especially at the local scale of the village or indigenous population, so including them in the decision-making is important to achieve sustainability. The selection of DAFs to help craft socially just, acceptable, environmentally effective, and economically efficient policies becomes a particularly delicate task. It is all the more complex because indigenous perceptions and management of ecosystems are far from homogenous. Atran et al. (2002) observe that three groups who live in the same rain forest in Guatemala show profoundly different behaviors, cognition, and social relations in relation to the forest.

In some regions where indigenous communities have persisted on the periphery of modern societies (in the United States, Canada, Australia, and Mexico), there has been increasing concern in recent years about integrating traditional values and knowledge in modern assessment and decision analytical frameworks (Goma et al. 2001; Paci et al. 2002). The ultimate objective is to step beyond assessment and, by acknowledging the rights and incorporating the environmental knowledge of indigenous communities, to make progress towards co-management of ecosystems (Faust and Smardon 2001).

In summary, the choice of the decision analytical framework to support the formulation of policies and measures regarding ecosystem management is influenced by a large number of factors. They range from the social, economic, and cultural context to the geographical and related jurisdictional scale, and from the complexity and uncertainty characteristics of the problem to the preferred nature of the intervention. Advanced analytical frameworks (such as multicriteria decision analysis or cost-benefit analysis) have been widely and successfully used to select among policy options in public and private sectors in many industrial countries. In contrast, some regions with severe environmental problems and high risks of ecosystem degradation are ones in which traditional ecological knowledge and management schemes have faded away but new assessment processes and management systems are still weak or hardly established. In many countries, increasing attempts to combine modern analytical techniques with traditional ecological knowledge, where it still exists, indicate a promising future direction.