Chapter 5

Using Multiple Knowledge Systems: Benefits and Challenges

Coordinating Lead Authors:⋆ Polly Ericksen, Ellen Woodley

Contributing Authors: Georgina Cundill, Walter V. Reid, Luís Vicente, Ciara Raudsepp-Hearne, Jane Mogina, Per Olsson

Review Editors: Fikret Berkes, Mario Giampietro, Thomas Wilbanks, Xu Jianchu

---

⋆When citing this article, please list both authors' names, as they share lead authorship.

BOXES

TABLES

Main Messages

The MA sub-global assessments were structured to encourage the use of multiple knowledge systems across scales, including the disciplines of scientific knowledge, practitioner (or assessment user) knowledge, and local/traditional knowledge. The multidisciplinary framework and assessment teams enabled the contribution of different facets of scientific knowledge; multistakeholder teams facilitated the sharing of practitioner knowledge; and the involvement of local resource users allowed for sharing local and traditional knowledge in several cases. There was more information, and thus analysis, from the assessments on the use of local and traditional knowledge than there was on multidisciplinary or practitioner knowledge.

Practitioner knowledge, the diverse knowledge of multiple stakeholders, contributed more in terms of information needs and expectations than in terms of ecosystem management knowledge. Few assessments had significant analysis of the contribution of practitioner knowledge to the assessment. However, the Sweden KW assessment was structured so that practitioner knowledge was fully integrated within the assessment process. In the Tropical Forest Margins assessment, practitioners became more integrated over time as there were intensive efforts to encourage stakeholder participation. Most other assessments encountered problems in utilizing practitioner knowledge, in many cases because practitioners were viewed as users of the assessment results instead of knowledge holders in their own right. Engagement of assessment users and other practitioners as knowledge holders requires more attention to how knowledge is used in policy, decision-making, nongovernmental organizations, and bureaucratic practice.

Local and traditional ecological knowledge added significant insight about locally important resources and management practices, revealing information and understanding that is not reflected in the global assessments. This included information about: names and uses of locally important plant species and practices to protect them (for example, India Local and Sinai), local drivers of change (SAfMA Livelihoods), specialized soil and water conservation practices (India Local), and coping strategies to protect human well-being (Sinai, SAfMA Livelihoods, Sweden KW). Local resource users also contributed valuable long-term perspectives about their social-ecological systems (Bajo Chirripó, Vilcanota), as well as information on key ecosystem processes that are important, uncertain, and difficult to control (Wisconsin).

The extent to which local and traditional ecological knowledge contributed to the assessments varied, due to local circumstances, the predisposition and expertise of the assessment team, and the resources allocated to understanding and using local knowledge. Local knowledge is both complex and inherently contextual, and a rigorous and comprehensive investigation and interpretation of local knowledge is needed to fully understand it in its own right. Collaborative relationships, such as those developed in Vilcanota, Peru, and Bajo Chirripó, Costa Rica, as well as participatory tools that broaden the level of enquiry, often result in the emergence of key issues of local importance. For example, in the Bajo Chirripó assessment, local participants found that much existing traditional knowledge about natural resource management strategies was being forgotten, so the assessment emphasized learning more about and reviving these management strategies instead of introducing new ones.

Sub-global assessments had to weigh the trade-offs involved in achieving tangible results versus working through the transaction costs of building a partnership consisting of different knowledge holders. Multidisciplinary and multistakeholder research involves considerable transaction costs. Working with local and traditional knowledge holders also requires time to build trust and equitable relationships. Recent work has shown that these costs are likely to decrease as social learning occurs and solid working relationships are established. In the Sweden KW assessment, transaction costs were low at the start of the assessment because of long-standing networks already in place.

The MA assumed that participation would empower local resource users in two ways: (1) through increased local ownership of the assessment process and results, and (2) through scientific validation of local knowledge, which would in turn encourage policy-makers to recognize and utilize it. However, as local participation varied from fully collaborative to extractive, so too did the potential for empowerment. At one end of the spectrum was the Vilcanota assessment, in which local resource users designed and directed the assessment process. At the other end was Western China, in which any local knowledge that was used was inserted into a scientific, state-imposed framework, making it difficult for the assessment to realize the full potential of local and traditional knowledge.

The sharing of knowledge across scales in the sub-global assessments did not occur to the extent hoped for by the MA. This was partially due to methodological issues such as uneven emphasis on different knowledge systems and problems with validation. The MA had developed procedural guidelines for validation of local and traditional knowledge at the local level, but the sub-global assessments often lacked adequate processes of validation for the use of local knowledge at higher levels. Mediating institutions or boundary organizations are usually necessary for this, and these were not present for a number of the assessments.

There is evidence that including multiple knowledge systems increased the relevance, credibility, and legitimacy of the assessment results. For example, in Bajo Chirripó, the involvement of nonscientists added legitimacy and relevance to assessment results for a number of potential assessment users at the local level. However, in many sub-global assessments, local resource users were not decision-makers, so the question of legitimacy became irrelevant in cases where they did not have the opportunity to use the assessment results.

Some sub-global assessments confirmed that local institutions have a role in conferring greater power to local knowledge holders in cross-scale decision-making. For example, in India Local and in Sweden KW, deliberate efforts were made to embed the assessment within existing institutions that link local knowledge to higher-level decision-making processes. However, in the SAfMA Livelihoods assessment, the local institutions helped to maintain knowledge but were too weak to enable local knowledge to be used in higher-level decision-making. The Vilcanota and Bajo Chirripó assessments attempted to create space to begin a dialogue between local communities and higher-scale decision-makers. The success of these efforts can only be evaluated with more time.

5.1 Introduction

This chapter assesses the experiences of the MA sub-global assessments in using multiple knowledge systems to examine the relationship between ecosystem services and human well-being. The chapter also reflects on the benefits and challenges of involving multiple knowledge systems in conducting such assessments. The intellectual and practical basis for linking multiple knowledge systems is well established, as are the difficulties of making these links in practice (Agrawal 2002; Nadasny 1999).

Recently, the incorporation of multiple knowledge systems into integrated assessments of environmental and social status has been established as critical (Pahl-Wostl 2003;

Lawrence and Elphick 2002). The MA was concerned with including multiple knowledge systems in the sub-global assessments for several key reasons (MA 2003).

- Linking human well-being to ecosystem services implies that the perspectives of and information from local (usually interpreted to mean community or village level) residents and users of the ecosystem are important to understand. Local people have particular knowledge about the ecosystems that they live and work within, as well as their own associated well-being, that others do not.
- Ideally, an assessment at any given scale should meet the needs of resource users and managers at that scale, who should be involved in defining the issues of concern. Thus local level management depends on the voices of local people, which are all too often not heard, or else are ignored or misunderstood.
- The use of multidisciplinary and multistakeholder perspectives is important in order to understand the links between ecosystem services and human well-being; an assessment is usually enhanced when informed by a variety of research, scientific, or other perspectives. Just as people from different locations speak a different language and express their ideas differently, so do scientists trained in different disciplines and people working in different organizations (NGOs, development agencies, etc).
- The gap between research and policy is often recognized but rarely solved; exploring the differences in framing, representing, and legitimating knowledge among scientific researchers and policy/decision-makers will help to close this gap.
- The process of rigorous documentation and use of local and traditional ecological knowledge is often seen as empowering local resource users, as it can link them to decision-making at higher scales and possibly catalyze decision-making capacity at the local level. However, novel institutional arrangements are often necessary for this to occur.

Along these lines, the MA adopted several principles to guide the inclusion of multiple types of knowledge in the sub-global assessments (MA 2003):

- A good assessment must be scientifically *credible,* politically *legitimate,* and respond to the needs of decision-makers (*useful*). The MA attempted to strengthen the approaches of earlier assessments by investigating the links between ecosystem condition and human well-being at multiple scales, and according to the needs of a broad group of ''users.'' ''Users'' refers to those in a decision-making capacity who will use the results of the assessment (in contrast to ''resource users,'' which is defined as those who use local ecosystem resources). For assessment findings to be credible to decision-makers at other scales, the conventional definition of scientific credibility needs to be broadened so as not to exclude local knowledge, which is often not easy to validate in scientific terms but is subject to local methods of validation. The multiscale approach requires linking multiple knowledge systems, and credibility must be established in different ways.
- The MA explicitly valued local-level knowledge and recognized that local and traditional ecological knowledge provides information that is often not documented by science (used here to mean western science, modern science, formal science, or conventional science, rather than indigenous science). The MA was also designed to be policy-relevant. The MA sub-global assessments operated on the premise that assessments should be conducted at the level where decisions are made. For example, an assessment conducted at the national level may or may not be as useful to local people as an assessment conducted at the local level. The unique contribution of the multiscale framework is that it enables the use of multiple knowledge systems, including knowledge held by resource users, practitioners, decision-makers, and researchers.
- The MA aimed to empower local resource users, through the assessment process itself, by linking local and traditional ecological knowledge to decision-making at higher levels.
- By establishing a multiscale process with assessments conducted at the sub-global level, the MA conceptual framework promoted cross-scale knowledge sharing. Researchers have promoted the need for cross-scale interactions, or dialogue, between knowledge systems, in order to foster appropriate management for social–ecological systems (Cash and Moser 2000; Berkes 2002; Young 2002). This view recognizes that knowledge is embedded in institutions, which are located at particular social, political, and economic scales, because of how societies are structured.

The MA faced two main challenges when using multiple knowledge systems (Reid 2004):

- Who establishes what appropriate ''validation'' of information is?
- Can a scientific assessment like the MA ever be seen as ''legitimate, credible, or useful'' to indigenous communities or other individuals who hold different worldviews and use different standards for evaluating the utility of information?

Conversely, these questions may be asked: How can it be ensured that a scientific assessment that utilizes local and traditional ecological knowledge will be seen as credible within the scientific community? Can an assessment that caters to the needs of multiple users be truly legitimate to any user? The MA took steps to ensure broad legitimacy; this chapter examines the process of bringing together multiple knowledge systems within the MA sub-global assessments.

In recognition of these challenges, the MA organized an international conference in March 2004 on ''Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Multiscale Assessments'' in Alexandria, Egypt. The conference provided a forum for much theoretical debate on the issues, and an opportunity for sub-global assessments to present how they dealt with using multiple knowledge systems. The conference included indigenous

groups' and local resource users' discussions of how they felt their specific cultural-based knowledge could be used together with science.

In general, the sub-global assessments used many different approaches to resolve the challenges of using multiple knowledge systems. This was, especially at the sub-global level, an experiment. This chapter explores the successes and difficulties faced in conducting this experiment. The chapter first summarizes conceptual issues surrounding the definition of knowledge. This is followed by a discussion of the benefits of using multiple knowledge systems in an assessment, drawing on the experiences of the sub-global assessments. The next section examines the design and processes used for incorporating multiple knowledge systems, and the final section highlights lessons learned.

Of the 34 sub-global assessments, 25 used either local or traditional knowledge. The examples used in this chapter are illustrative, pointing to trends among the sub-global assessments rather than quantified results. The tables, for example, highlight particular issues rather than summarize all the sub-global assessment results. The chapter presents information on the assessment process up to the end of October 2004.

5.2 Knowledge Systems

In order to understand why it is so difficult to ''link'' or to ''use'' different knowledge systems together for problem solving, some discussion of what underpins different kinds of knowledge is necessary. A knowledge system is defined, for the purposes of the analysis in this chapter, as a body of propositions actually adhered to, whether formal or otherwise, which are routinely used to claim truth (Feyerabend 1987). Knowledge is a construction of a group's perceived reality, which the group members use to guide behavior toward each other and the world around them. Knowledge systems have a social context and, in many settings, environmental knowledge is important to a group's identity (Milton 1996). Understanding knowledge as a ''context-dependent process of knowing'' requires an investigation and analysis of prevailing social norms, values, belief systems, institutions, and ecological conditions that provide the basis of a ''place'' where knowledge is applied (Woodley 2005). Knowledge may also be understood as a process of ''engagement'' (Ingold 2000), where through their actions people come to understand the world and what it affords them.

Working definitions in this chapter accept the premise that all knowledge is situated and partial. One knowledge system is never treated nor understood as inherently superior to another, nor is there a hierarchy in terms of the validity of different knowledge systems. These premises provide a consistent way to look at highly diverse knowledge systems, in order to understand the reasons that people have different yet equally valid explanations for what they observe in the world around them. Our exploration of knowledge systems includes an examination of published science, gray literature, user needs and understandings, and the knowledge of local resource users. The definitions below form the basis for discussion on how knowledge systems may differ and how a plurality of knowledge systems in an assessment may provide a firmer foundation for understanding the linkages between ecosystem services and human well-being. The definitions provide a simple platform for discussion of the MA sub-global assessments; they are not meant to provide definitive or prescriptive definitions.

Science can be defined as systematized knowledge that can be replicated and is validated through a process of academic peer review by an established community of recognized experts in formal research institutions. Scientists use a series of logical and empirical methods of systematic observation in order to understand the world. The scientific method includes making empirical observations, proposing hypotheses to explain those observations, and testing those hypotheses in consistent ways. In essence, scientific methods are impersonal and any one scientist should be able to duplicate what another scientist has done. The validation of experimental results, hypothesis confirmation, and the acceptance of theories by the broader scientific community, through a process of peer review, are viewed as critically important to the maintenance of scientific standards and the quality of research.

Science strives to be objective. However, many philosophers of science argue that all systems of knowledge have embedded assumptions that are socially derived. ''Objectivity is closely bound up with the social aspect of the scientific method, with the fact that science and scientific objectivity do not result from the attempts of individual scientists to be 'objective,' but from the cooperation of many scientists'' (Popper 1950).

Social science disciplines are distinguished from biophysical sciences by the way that problems are articulated, the type of evidence that is used to establish truth or facts, and the way that facts are transmitted, tested, and verified (see, for example, Bryman 2004). Paradigm is a term used to refer to a worldview or conceptual model to which a community of experts within a particular discipline may agree. Adherents to a particular paradigm or discipline organize and interpret observations of the world around them via the constructed knowledge system important to their particular community. All disciplines, whether within the biophysical or social sciences, have their own standards and rules.

Interdisciplinary research projects or assessment processes have to overcome the barriers to understanding that arise when knowledge derived from different processes is exchanged. These barriers may take the form of dismissing the arguments of an unfamiliar discipline, questioning the validity of data analysis, or, more simply, finding it too difficult to work within a foreign construct/worldview because the logic does not make sense (for example, Scoones 1999). Heemskerk et al. (2003) used an innovative approach to bridge disciplines by working in a group in order to produce conceptual models of human ecosystems. These models built on conventions previously established by both ecologists and anthropologists. Through the process of building a model together, the assumptions of each disci-

pline, as well as the points of agreement and disagreement were identified, revealed, and discussed.

According to Abel and Stepp (2003), ecologists and ecosystems managers recognize at least two important roles for social scientists in interdisciplinary teams. One is as ''facilitators'' who can explain culture and social resistance and may permit the easier implementation of environmental policy (Groffman and Pace 1998, cited by Abel and Stepp 2003). Another role is as ''interpreters'' of traditional ecological knowledge that may provide the basis for sustainable ecosystem management and appropriate institutions (McCay and Acheson 1987; Berkes and Folke 1998, cited by Abel and Stepp). Both of these roles are invaluable for what many now agree constitutes sound ecosystem management.

A growing body of research suggests that the study of complex social-ecological systems requires changes in the scientific approach, criteria for truth and quality, and conceptual frameworks. Properties of complex systems include non-linearity, plurality of perspectives, multiplicity of scales, and irreducible uncertainty (Gallopin et al. 2001). ''Post-normal'' science, of which the study of complex systems is a part, involves an examination of human uses and impacts, and issues of value, equity, and social justice (Funtowicz and Ravetz 1993). Hence, post normal science acknowledges uncertainty and lack of predictability as well as a necessary degree of subjectivity in scientific research. Methods associated with post normal science call for participatory approaches in which scientists work with local people or practitioners to close the gap between local/traditional and more formal scientific perspectives and to embrace values and a plurality of perspectives. Much of ''normal'' scientific practice, it is argued, is limited in its ability to handle these elements. Integrated assessments, as the sub-global assessments were designed to be, must deal with complex issues. Wilbanks (personal communication) says that these assessments require a ''sort of softer version of the scientific method: rooted in evidence, analytical approaches, peer reviews, etc., [but also able to accommodate] such things as the treatment of uncertainties, an assurance of balance among stakeholder views, and the possibility of getting the answer wrong.''

Indigenous knowledge is defined as the local knowledge held by indigenous peoples or local knowledge unique to a given culture or society (Warren et al. 1995). In this chapter, the term indigenous knowledge is used only when the sub-global assessments themselves refer specifically to the knowledge held by people who identify themselves as indigenous (for example, Bajo Chirripó and PNG).

Traditional ecological knowledge is a ''cumulative body of knowledge, practice and beliefs, evolving by adaptive processes (i.e., innovation and feed-back learning) and handed down through generations by cultural transmission'' about local ecology (Berkes 1999, p. 8). Traditional ecological knowledge may or may not be indigenous, but has roots firmly in the past. The Four Directions Council of Canada (1996, cited in Oviedo et al. 2000) explains: ''what is 'traditional' about traditional knowledge is not its antiquity, but the way it is acquired and used—the social process of learning and sharing knowledge. This knowledge has a social meaning . . . and varies according to age, gender and other variables.'' Traditional knowledge explicitly includes people, feelings, relationships, and sacredness (Moller et al. 2004).

Local knowledge is the term of choice for some scholars in referring to place-based experiential knowledge. In this chapter, the term local knowledge is used to express knowledge that is largely oral and practice-based in contrast to knowledge that is acquired by formal education or book-learning. Local and traditional ecological knowledge is often relational, in that human qualities are attributed to aspects of the biophysical environment. This belief often engenders a respect for elements in the environment that influence, for example, the timing and the method by which resources are extracted. For example, the harvesting methods and the timing of harvest for yellow cedar and other tree bark in the American Pacific Northwest ensures that the trees stay alive after harvest (Turner 2004).

This chapter uses the term ''local and traditional knowledge'' to describe the full range of knowledge that is encompassed in both definitions. Such knowledge may involve a ''worldview'' that is different from that of scientists and government decision-makers. On the other hand, local and traditional knowledge may, in some cases, incorporate elements of scientific knowledge and vice versa. Clear delimitations of kinds of knowledge are difficult, if not impossible (Agrawal 1995). For example, the PNG assessment found that traditional ecological knowledge is not immune to outside influences, since most coastal communities in Papua New Guinea have been exposed to western schooling and Christian teachings for several generations.

Though a community is considered to hold a certain body of knowledge collectively, information is not distributed evenly, so there is almost always a differentiation of knowledge within a community (Berkes 1999). Certain individuals may be considered the local experts on various parts of the community territory or in various subject areas. Knowledge may be differentiated according to age, status in the community, or specialization. Another critically important aspect of knowledge differentiation is gender. It is well known that women's knowledge can be significantly different from men's knowledge in some areas (Rocheleau et al. 1996). The important implication for research, and specifically for sub-global assessments, is that for the assessment to be valid and legitimate, the study design needs to take into account the issue of knowledge differentiation.

Another group of knowledge holders (and users) critical to the MA are *practitioners,* which includes resource managers, government bureaucrats, decision-makers, and personnel in NGOs, development agencies, and civil society groups. In most sub-global assessments, these are referred to as the assessment users. Although the integration of practitioners' knowledge into research is relatively unstudied, some attention has been paid to the need to understand how practitioners use knowledge for their purposes, whether implementing a development project, making a policy decision, managing a resource, interpreting and implementing a national policy at the local scale, etc. A recent series of studies commissioned by the Overseas Develop-

ment Institute and the Global Development Network through the Bridging Research and Policy Project reached a number of conclusions relevant to the MA work:

- ''Knowledge utilization appears to be almost completely context-dependent,'' so any researchers wishing to influence the policy process would do well to understand the particularities of it (Stone et al. 2001). This context includes the dominant policy narratives, that is, the prevailing wisdom the policy community uses to make policy decisions.
- The policy process is best understood as an interplay among political interests, competing discourses, and the agency of multiple actors (Crewe and Young 2002).
- Researchers wishing to successfully engage with the policy process must consider three factors: context, the type of evidence, and the linkages in place. The second factor, type of evidence, is directly relevant to this chapter, as it pertains to both the quality of the research and the communication and dissemination of research findings to policy-makers. The linkages between research and policy are also relevant in that the legitimacy of the research institution will influence acceptance or utilization of the research in policy-making (Crewe and Young 2002).

Guston (1999) proposed the concept of *boundary organizations,* which are institutions that straddle and mediate the divide between science and policy. Boundary organizations are an alternative to the standard model of the transfer and use of scientific information. Within a boundary organization, ''decision-makers are involved in the creation and maintenance of the relationship with scientists, the science-policy boundary, and the scientific and technical outputs'' (Cash and Moser 2000). The flow of information is multidirectional. Cash and Moser (2000) have also proposed that boundary organizations are useful in multiscale or integrated assessments to bridge various types of knowledge.

The use of these premises illustrating the different kinds of knowledge that may come into play in an assessment raises several issues for discussion. First, involvement of local people and use of local and traditional ecological knowledge in ecosystem assessments such as the MA is important for several reasons: it promotes participatory processes, it enables the creation or unveiling of new knowledge to share across scales, it enables the optimal use of existing knowledge, it aids in the development of indicators of change and resilience to monitor ecosystem dynamics, and it aids in the transformation of existing institutions toward ecosystem management (Gadgil et al. 2003). However, participation alone does not automatically result in multiple benefits for all involved. Allocation of financial, information and decision-making resources so that local resource users have the means to make decisions about access to and use of ecosystem resources is also important (Davidson-Hunt, personal communication). Local and traditional ecological knowledge systems not only provide recognized insights for the qualitative management of resources and ecosystems; some also display several parallels to adaptive management (Berkes et al. 2000; Alcorn et al. 2003). Adaptive management is designed to improve on a trial and error basis, an attribute inherent in the social learning process, where learning occurs at the level of society, not of the individual (Olsson et al. 2004). Berkes et al. (2000) suggest that some traditional ecological knowledge can be described as adaptive because it acknowledges that environmental conditions will always change; it also assumes that nature cannot be controlled and that yields, for example, cannot be predicted.

Second, there is a critical need for well trained, culturally sensitive, interdisciplinary teams who follow an ethical protocol in assessing human–ecosystem interactions, especially when local and traditional ecological knowledge is being used. Expertise in interpreting and working with local and traditional knowledge holders is essential when ecologists are asking questions that may be different from questions asked by local resource users. Anthropologists and others have been researching, documenting, and theorizing on the use of local, traditional, and indigenous knowledge for some time, and the importance of this knowledge in resource management has been discussed in the literature at least since the work of Julian Steward in the 1950s, evolving to the well-recognized field of ecological anthropology, which emerged during the 1960s and 1970s (Steward 1955; Davidson-Hunt and Berkes et al. 2003). Over the last 25 years, the use of local knowledge has become mainstreamed, beginning with the work of D. M. Warren, who made the topic his life's work, and with the publication of *Indigenous Knowledge Systems and Development* (Brokensha et al. 1980). It is important that respect and an ethical protocol are in place when local and traditional knowledge is used in assessments. (See Box 5.1.)

The use of local knowledge by ecological scientists is more recent and the tensions are apparent, both in the MA documents and in the literature (for example, Brosius 2004; Agrawal 2002). There has been a tendency among scientific researchers, as well as among people from outside a given community, not to concern themselves with abstract questions of epistemology or with the nuances of various techniques for gathering information about local and traditional knowledge (Nadasny 1999). This undermines any attempt to bridge local/traditional knowledge with scientific knowledge, and it often places local and traditional knowledge within a scientific framework, granting epistemological privilege to the latter. To move away from the tendency to use local and traditional ecological knowledge only within a scientific framework, steps were taken within some sub-global assessments to ensure that indigenous epistemologies and collaborative approaches themselves set the direction for the assessment.

Involving practitioners' knowledge in an assessment poses the additional challenge of including information on how knowledge is used to develop policy, as well as how practitioners take action to implement a policy or a development project. Knowledge systems are often considered as a tool for decision-makers—they draw knowledge from multiple sources and look to experts to give them pertinent information. Policy processes can be considered opportunities for cross-scale dialogue, although they are often viewed as rather closed processes until something happens which

BOX 5.1

Ethical Protocol for the Use of Local and Traditional Knowledge in Assessments

The ethics involved in working with local communities requires the establishment of, and commitment to, an ethical code of conduct, as well as respect and cross cultural understanding by all members of the assessment team within the communities where the assessment is being conducted. Specifically, the assessment team should consider:

- *Practical issues in establishing the assessment.* Initial assessment set up involves issues of how the assessment is initially received by the communities and whether there is sufficient "buy in" for the assessment to be based in the community(ies) and whether people will be willing to cooperate and collaborate with the assessment team.
- *Trust between community members and the assessment team.* A level of trust is required to assist in the generation of knowledge at the local level, which has implications both for the extent to which knowledge will be shared (Coastal BC) and how interactions with the same communities will proceed (San Pedro de Atacama).
- *Ownership of assessment results.* Ownership of the assessment process and outcomes is enhanced when there is trust and community collaboration in the assessment process. When there is community ownership of results, there is increased potential for capacity-building and empowerment of the communities involved, and a greater likelihood that the assessment results will be used by those communities. Feedback from the community on the results of the assessment is important as well as delivery of assessment results in a format that the community will use.
- *Ethical protocols.* There were ethical protocols established by the MA, stating a requirement for prior informed consent by communities and the requirement for the protection of intellectual property rights. These protocols enhance the practical aspects of conducting the assessment, and provide a foundation for trust between the assessment team and the community(ies) involved. Prior informed consent of knowledge holders is necessary for any use of data or information from a sub-global assessment, and the protocol on IPR states that communities are encouraged to provide information that can be freely shared and to clearly state what information must remain confidential (see MA IPR policies at http://www.millenniumassessment.org/en/about.policies.ip.aspx). There is an obligation on the part of the assessment team to ensure that the communities are aware of the rights that they have over their own knowledge.

Despite the checks that are in place, there remain issues that are not captured in the protocol, and these are widespread issues that occur in most development interventions that involve the use of local and traditional ecological knowledge. For example, it is difficult to make the separation between privately held knowledge and knowledge which is held by the collective community, in addition to a general lack of capacity in communities to ensure that their knowledge is not misused. MA policies and activities related to IPR are designed to help ensure that information concerning ecosystems and their links to human well-being is freely available. Notwithstanding the intent of this free flow of information, the MA sought to develop mechanisms and processes to ensure that the benefits from the application of local/traditional/indigenous knowledge in sub-global and global assessments can be obtained without compromising the rights of the holders of that knowledge.

opens up the possibility for change in the process (Keeley 2001; Blaikie and Soussan 2001). Policy change relies not only on new networks of actors but also on new knowledge to create new discourses on issues.

Third, methods and processes for data collection as well as expression, documentation, and validation of knowledge differ among knowledge systems, and these differences often lead to misunderstandings, rejections, and other forms of conflict between people with different worldviews. For example, science accepts published facts after an elaborate process of validation established by the scientific community. What is of concern is that local and traditional knowledge that is maintained or transmitted via oral, practice-based, and other "tacit" methods may not be regarded as credible within the scientific community, because the expression of local knowledge is often through practice-based procedures, and validation occurs through processes that differ from science. Science-based assessments need to recognize and honor local processes of validation, instead of insisting on validation by the standards of science.

It is a commonly held view that local/traditional and scientific knowledge can be somehow "integrated" and applied to a common purpose. However, the conceptual basis of the endeavor to integrate local/traditional and scientific knowledge has been challenged. Some researchers argue that the very idea of integration (or synthesis) implicitly assumes that knowledge is an intellectual product that can be isolated from its social context (Nadasny 1999). In this chapter, the concept of "bridging" rather than integration or synthesis is useful because it implies that the different types of knowledge retain their integrity but exchange ideas and learn from each other. (See also Chapter 11.) The concept of bridging is also a way to acknowledge that one knowledge system is not superior to the other. The means to achieve bridging is to create dialogue between knowledge systems.

An example of the sensitivity of these issues comes from the indigenous views session at the Bridging Scales and Epistemologies conference in Alexandria, Egypt, in a quotation which questions whether local people would ever be on an equal footing when the two knowledge systems are used together:

> *We can only—consciously—sit down at a table of dialogue, in a world where many worlds (or epistemologies) are welcome, where we can talk between us, and also talk with modern science. But at this table we need to leave behind arrogance and the wish or attitude to dominate. We have to come with humbleness, with eagerness to learn, with openness and respect. In this neutral space of encounter, what can everyone contribute, what is our gift? What is the gift of the scientist? Is the scientist prepared for a dialogue? Is he or she able to support us? Do they have the means to talk with us? Can they enter an alliance*

and commit to overcoming the limitations of their worldviews?

The sub-global assessments reflect the tension in this quote to some extent. In the SAfMA local assessments, local knowledge was considered a vital component of the assessment process, although all local knowledge used was validated by science. India Local is an excellent example of successful bridging, in that students, who themselves were community members, were trained to document local knowledge in collaboration with knowledgeable individuals from the community. This information was then stored in a database at the Centre for Ecological Sciences where it was evaluated by scientific experts. The knowledge was then stored at the National Innovation Foundation where it is safeguarded and where there is value added to both traditional knowledge as well as grassroots innovations in the informal sector. The Vilcanota and Bajo Chirripó assessments enabled communities to assert their knowledge and their understandings of their own environments. In these cases, the communities led the validation process and thus local knowledge was valued in its own right.

Recent work in the field of participatory research for policy change has addressed how local people's concerns can be successfully raised to others (that is, scientists and local officials or higher level decision-makers), but on their own terms. For example, Holland and Blackburn (1998) describe three models for how this can be done: In the most common model, intermediary institutions ''translate'' local voices for the benefit of policy-makers and become activists for local people. In a second model, policy-makers and local people come together directly to discuss issues, and in the third model, intermediary institutions are still active in the translation process, but they pay more attention to ensuring that participation becomes part of the policy process. In a similar vein, some scholars of local knowledge suggest that to provide space for local knowledge, institutions are required that facilitate inclusion without appropriating knowledge (for example, Berkes 1999).

In conclusion, several critical points need to be accepted by any assessment if goals such as those of the MA are to be achieved:

- *the importance of social values (including culture, spiritual, ethnic identity, etc.) and historical context* that are embedded in all types of knowledge, including science;
- *the challenges of addressing complexity and uncertainty.* The interface between society and nature involves complex system dynamics, with multiple causes, feedbacks, and responses. This suggests a high degree of complexity, where a system is difficult or impossible to analyze through the use of a simple disciplinary framework (Munda 2000). Methodological requirements for understanding the complexity of local knowledge include first and foremost methods grounded in the concepts of interaction and connectedness—that local knowledge regarding human–ecosystem relationships cannot be compartmentalized, but must be understood as a myriad of interrelations between the social and biophysical.
- *the significance of institutions, or the rules and practices upon which knowledge interactions are based.* There have been situations in which the voices of particular groups have been suppressed (for example, women, minorities), forcing them to rely on others to articulate their knowledge;
- *the validation of local and traditional knowledge.* In addition to epistemological differences between knowledge traditions, science is often viewed as being privileged or having hegemony over local, traditional, and indigenous knowledge (Scott 1998, p. 323). Satterthwaite (1996) suggests that underlying power relationships are compounded by prejudice resulting from incomprehension of different forms of logic that occur within the institutional context of a project.

5.3 Benefits of Using Multiple Knowledge Systems in an Assessment

Including multiple users in the assessment process is relatively new, but there are several previous experiences upon which the MA can reflect. Integrated assessment involves the participation of ''non-scientists'' on the basis that this involvement will improve the quality of the research, via the input of contextual and practical knowledge, experience, and values. This is especially important for complex and/or unstructured problems, terms that can certainly be applied to the MA. In a survey of the attempts by scientists to include other knowledge in integrated assessments through participatory processes, van Asselt Marjolein and Rijkens-Klomp (2002) praise the intent and acceptance of the principles of participation by assessment teams, but lament the lack of serious analysis of the actual methods and processes used to increase participation and hence the types of knowledge used in assessments.

The MA conceptual framework states that there are certain benefits of using multiple knowledge systems: information benefits, increased participation and empowerment, and broader use and application of assessment findings (MA 2003). This section explores whether these anticipated benefits were realized in the sub-global assessments.

5.3.1 Information Benefits

Several sub-global assessments illustrate how local and traditional ecological knowledge added significant insight to the assessment process (Table 5.1), providing information on locally important resources and management practices, information that is directly relevant to the assessment of ecosystem services. In the India Local assessment, where local knowledge is recognized as complementary to science, a long tradition of reliance on non-wood forest products has resulted in local people's intimate knowledge of native species and their uses, and this information added great value to the assessment of biodiversity. Local knowledge also provided an understanding of the history of surface water use, traditional irrigation and water sharing arrangements, as well as modern developments, including growing demands for water and the associated implications (India Local). In the Sinai assessment, an indigenous Bedouin participant ex-

Table 5.1. Local and Traditional Knowledge (LK) Use by Selected Sub-global Assessments (Data from assessment reports, knowledge markets, and questionnaires)

Sub-global Assessment	Local/Traditional Knowledge Recognized	Approach to Using Knowledge Systems
Tropical Forest Margins	recognized LK composed of process-based knowledge and location-specific knowledge, with the former easier to integrate across scales case study of local ecological knowledge (Indonesia); documentation and policy reform with Krui agroforestry systems (one case)	used different models to incorporate LK long-term presence considered important for obtaining LK liaised with NGOs that work at local level progress in stakeholder negotiations came from developing a shared articulation of the underlying cause-effect relations and the criteria and indicators that can reflect the various concerns
SAfMA	assessment process added value to both formal and informal knowledge, though science dominated process local coping and adaptive strategies important input to assessment	interaction of multiple knowledge systems problematic (introduces uncertainty) but also enriched findings LK was validated only at the local scale by using rigorous PRA and other methods
Coastal BC	mapping cultural-spiritual places provincially mandated land and resource management process provided framework for LK scientific systems favored due to ease of authentication and availability	reluctance to share LK at policy level due to distrust difficulties in bringing LK to an analytical process difficult to use all knowledge systems due to time constraints more time and resources required for locally acceptable modes of investigation
Sweden KW	LK for management practices, species dynamics local agricultural and biodiversity-related knowledge emphasis on social processes underlying successful ecosystem management adaptive co-management builds on institutions and learning and avoids set prescriptions of management superimposed on a particular context	mutual learning through interviews with stakeholders strong linking through networks of steward associations links made between conservation and development were considered important
San Pedro de Atacama	active collaboration with LK holders public and private knowledge used LK provided more nuanced understanding of local conditions not found on maps and data important to validate assessment processes and findings	Indigenous Law (1991) affirmed LK, however LK was not incorporated properly in the water management sector Mining Foundation promotes community development through social health and education projects the local museum, open to the public, disseminates information about local culture
PNG	robust cultural traditions, not subsumed under scientific framework rich body of LK relating to the many kinds of spiritual beings that inhabit local ecosystems close collaboration with local communities	prospects of compensation for communities distort merging of scientific and local perspectives scientific assessment of the drivers challenged by the local community as a distortion or violation of LK, because the practice of "science" was identified with the activities and claims of a private sector environmental monitoring program
Downstream Mekong	local perspective used to strengthen assessment all information was validated by local communities specific LK on medicinal plants used	consensus-driven linkage via workshops, dialogues poverty and low education impeded cross-scale understanding at local level
Eastern Himalayas	local level indigenous technologies shared among villages	links made between villages and between scientists, local government, and local resource users
India Local	mapping used to integrate LK and science assessment built on traditional forestry management practices Community Biodiversity Registers (CBRs)—compilations of LK on medicinal plants	the people working in the assessment were locals (not outsiders), which facilitated links embedded in a national effort to use LK science taken to local level: computer techniques taught to local students

	local perceptions of soil and water provided insights: history of surface water use, traditional irrigation and water sharing arrangements, modern developments (i.e., implications of increasing demands for water) sacred conservation practices documented but very heterogeneous and difficult to map used five local languages and two scripts	LK (because it is largely derived through a trial and error process, commingled with beliefs) posed great difficulties for validation
Sinai	LK was the most dominant knowledge system in assessment medicinal plant knowledge, and knowledge of water scarcity, was stressed; gender recognized as a sociocultural factor determining variations in biodiversity management; government recognizes tribal law	Bedouin associations supported in efforts to affirm the cultural transmission of knowledge conflicts in knowledge interaction due to concerns for intellectual property rights LK considered essential for higher-scale water management
Laguna Lake Basin	both local and scientific, but scientific knowledge was dominant LK only based on literature review—no data	no direct work with LK holders conflicts with the state over traditional tenure system
Portugal	local-level knowledge (incl. practices) in the case study of Sistelo practical management knowledge from users in government, industry, agriculture, and NGOs	integrated participatory methods used some conflicts between local users and the state due to appropriation of community forests
Altai-Sayan	traditional land use patterns of local communities; environmental consciousness based on religious beliefs	religious-based environmental consciousness of rural people was used to address issues on a larger scale to generate environmental awareness for conservation
Bajo Chirripó	LK provided direction for assessment, conceptual framework, and needs assessment adaptation of the MA framework was based on stories and histories from the elders about the habitat, its creation, and the norms that regulate its use, complemented by scientific literature review a first interpretation of the relation of ecosystems and human well-being was from the indigenous Cabecar perspective information validated in community gatherings convened by elders in other Cabecar communities	to be applicable, the MA framework needed to describe ecosystem services and human well-being more integrally, as the local perspective does
Vilcanota	LK given equal footing with scientific knowledge (SK) both LK and SK used to assess conditions and trends, adaptation of conceptual framework, traditional practices, local people cross-checked science entire process undertaken with community approval (local validation) problems defined by the communities knowledge mostly related to agroecosystems, also ecosystem interactions (broader definition of ecosystems that incorporates spiritual elements)	knowledge interactions were key to the assessment how to work with multiple knowledge systems not fully worked out yet, but to be performed by the technical team in consultation with local technicians and reviewed by community groups
Argentine Pampas	scientific knowledge dominated the assessment regional knowledge from farmers' groups traditional technical knowledge from retired agronomists and farmers corporate cultural knowledge from agri-business and governmental agents	no strong linkage between agents and decision-makers who operate at different scales and manage different scale-dependent knowledge conflicting interests and knowledge approaches to management among farmers, agri-business, and governmental agents workshops (driven by scientists) helpful to foster mutual understanding between stakeholders that represent conflicting knowledge systems
Wisconsin	LK used for scenario development	

plained the reasons behind the increase in some of the invasive species that were not known in the region previously, which was considered an important driver of change at the local level. In the Kristianstad Wetlands assessment, local knowledge provided historical continuity with information covering time periods that scientific studies have not covered (Sweden KW).

In the Altai-Sayan ecoregion, more than 20 different indigenous ethnic groups have lived together for centuries. The assessment reported that protection of Altai-Sayan biodiversity ultimately depends on the ability of the local communities to preserve their traditional land use practices. For example, in Mongolia people have, over millennia, developed a specific traditional approach to the use of grazing areas, which includes the formation of a particular species ratio composition of livestock (a combination of camels, horses, cattle, goats, and sheep). The specific percentage of each species in the livestock herds leads to the most uniform grazing of the whole range of grazing plant species. This practice maximizes the efficiency of the use of pasture areas. However, for the past decade, new, young herders who are not experienced in nomadic herding, along with weakening state control of grazing activities, is leading to unsustainable herding practices (Altai-Sayan).

Many local assessments found that local and traditional ecological knowledge had particular insights for human well-being. For example, in the Sinai, local knowledge is important for crisis mitigation practices. The Bedouin have a particular cropping system, based on growing a variety of crops, in order to reduce the risk of crop failures as a result of drought, a common occurrence in Sinai. Very often crops are selected so that the presence of one protects the other from pest infestation. For example, cantaloupe is grown beside *Artemisia judica,* a species that helps the cantaloupe set fruit and reduces insect infestations. Another example in Sinai is that in times of political conflicts and war, when people are cut off with no access to regular health care, they rely on their knowledge of local herbs to provide them with treatment for various diseases and illnesses. In the communities involved in the India Local and San Pedro de Atacama assessments, traditional healers are still highly valued for their knowledge of the different medicinal and nutritional properties of plants. In the India Local assessment, however, the popularity of medicinal plants is a factor leading to their decline.

In the Eastern Himalayas assessment, local knowledge used to be important to well-being in terms of ensuring livelihood security, such as rural handicraft production and food production. The SAfMA Livelihoods assessment found that local people also rely on diverse local knowledge for sustaining their livelihoods and managing risks. For example, they exploit resources over time and space and value multiple landscapes and mobility. They change labor strategies depending upon rainfall, and they use different microenvironments for agriculture, grazing, collection of wild fruits, etc. Resource and species substitution is a common adaptive strategy. In the case of water, which is a vital but scarce resource, people protect it with cultural taboos as well as management practices (SAfMA Livelihoods).

Some assessments such as Eastern Himalayas, found that communities no longer have the benefit of local or traditional ecological knowledge contributing to human well-being, due to socioecological changes, economic changes, and the loss of local and traditional knowledge. Many assessments reported that local knowledge systems were threatened or hard to articulate, because they have been so eroded. (See Box 5.2.)

Some sub-global assessments also gave examples of how local and traditional ecological knowledge deals with change, which is critical in terms of information benefits for assessments, since it is an indicator of the resilience of communities and ecosystems. In India Local, for example, local and traditional ecological knowledge bases forecasts of ecosystem productivity on bioclimatic indicators. This knowledge blends historical perceptions of crisis manage-

BOX 5.2

State–Local Interactions and Their Impact on the Transmission and Validity of Local Knowledge: South Africa

Resource patches imbued with sacred qualities according to traditional knowledge have played a well-documented role in the conservation of key ecosystem goods and services important to rural South African communities. However, a history of state intervention in the management of natural resources in South Africa has resulted in the erosion of the importance attached to "sacredness" in many instances. In South Africa, this process has been linked strongly to apartheid ideologies and policies on the one hand and to global and national trends toward scientific agriculture on the other. More recently, basic service provision has had unintended but equally important impacts on the perceived validity and importance of traditional knowledge.

Traditionally, among the isiXhosa people, local ecological knowledge developed through an adaptive process of learning by doing, and was transmitted orally between generations through story-telling, folklore, and ritual. However, state intervention in education and agriculture between the 1960s and 1990s severely undermined local confidence in indigenous knowledge and belief systems. Scientific farming practices, for example, were enforced through local rangers and state extension officers at the expense of locally developed farming practices. At the same time, the legitimacy of traditional leadership, which was linked to local and traditional belief systems, was systematically undermined by a series of policies and interventions that effectively lead to a general disillusionment with traditional leadership.

More recently, the nationwide drive to reduce inequitable access to basic services has had important, albeit unanticipated, impacts on the validity and therefore transmission of local knowledge. The provision of reticulated water in rural villages has drastically decreased local dependence on natural water sources, and therefore elders have in many cases ceased transmitting knowledge regarding sacred pools. As a result, many youngsters have begun to water their livestock in these pools, reducing vegetative cover and threatening sensitive species that were formally protected by the traditional belief systems. Similarly, traditionally protected fuelwood species reserved for ritual purposes alone, have, since the political collapse of the ranger system in the early 1990s, decreased dramatically. Fuelwood collectors, often young women, are often no longer aware of traditional taboos formerly placed on certain species and harvesting techniques.

ment with philosophy, which can provide useful precautionary principles. However, despite this potential, local and traditional ecological knowledge is not used to manage ecological crises at present. This area requires more research into the potential contribution of local and traditional knowledge since the norm is to rely on scientific models of changes such as climatic events, soil fertility decline, and pollution from various sources.

The inclusion of knowledge held or used by practitioners, such as municipal officials, was possible in the MA process either through the inclusion of practitioners in the assessment team (for example, Sweden KW) or, as was more commonly the case, through user forums. (See Chapter 6.) In the sub-global assessment user forums, practitioner knowledge was expressed according to the ''role'' of the practitioner in the management of the area under assessment or their ''need'' for information from the assessment. However, the Kristianstad Wetlands assessment reviewed all participant knowledge according to whether it was ecological, used for management, or pertained to social processes. The wetlands ecosystem has been managed through an integrated process for almost 15 years, and all groups acquire new knowledge and learn from one another through the design of the management process.

The Coastal British Columbia assessment provides an interesting insight into the use of practitioner knowledge in the assessment. The need for independent information precipitated the establishment of an independent, multidisciplinary information body and a transparent peer review process that would provide the best available information and expertise to support the development of an ecosystem-based management approach to natural resource management and planning. The team consisted of independent scientists, practitioners, and traditional and local experts, overseen by a management committee and supported by a secretariat. The five-person management committee consisted of representatives of the founding partners (the provincial government, First Nations, environmental NGOs, forest products companies) and the community at large, and was co-chaired by provincial government and First Nations representatives. In this case, ''technical'' knowledge held by assessment users was seen as too subjective and possibly biased if it was too closely aligned to particular sectoral interests, for example the timber industry. The independent nature of the information gathering process was considered important to this assessment (Coastal BC).

The Tropical Forest Margins assessment was heavily invested in a process of stakeholder engagement (strategic stakeholder analysis) in order to understand the needs and perspectives of multiple users at local, national, and international levels. While this work is on-going, the following quote offers a rare insight into the barriers that must be bridged:

> *Initial findings from the efforts to contrast ''local,'' ''public/policy'' and ''scientists/modelers'' ecological knowledge suggest that further analysis can help in reducing conflict and finding practical solutions. Local ecological knowledge on watershed functions is ''process-based'' and well-articulated for observable phenomena such as overland flow, erosion, sedimentation and filter effects. It does not depend on strict ''land use categories.'' By contrast, public or policy ''knowledge'' is based on such categories and the attributes that are supposed to go along with ''forest'' and ''non-forest'' land cover. Science can potentially bridge between ''process'' and ''pattern'' based understanding and can usefully interact in both arenas. Progress in actual stakeholder negotiations can come from developing a shared articulation of the underlying cause-effect relations and the criteria and indicators that can reflect the various concerns. Breaking through existing categories at the policy level, and especially recognizing the ''intermediate'' systems and forest mosaics as the focus of interest in natural resource management requires a change to ''evidence-based'' discourse. (Tropical Forest Margins, p. 14)*

Within the MA multiscale assessment design, local assessments were conducted at finer scales to provide information for the most appropriate levels for policy, decision-making, and action. Implicit in the inclusion of sub-global assessments was the need to link knowledge systems across scales (and hence power and decision-making levels), with a particular emphasis on social and ecological knowledge at the local level. The information benefits can only be realized if there is full participation of local/indigenous peoples both in the assessment process itself and in using the assessment findings. Other resource and assessment users also need to be brought in, so that conflicts or synergies among either knowledge or information needs can be discussed and resolved. The second benefit of the use of multiple knowledge systems, participation, is discussed in the following section.

5.3.2 Participation as a Means to Empowerment for Local Resource Users

It is generally acknowledged that care must be taken to ensure that participation is done thoughtfully and in a collaborative manner. Many practitioners of participatory rural appraisal methods acknowledge that there is a problem in using these tools as part of a routine set of exercises, instead of as the basis for real engagement, which is usually a time-consuming process (for example, Cleaver 2001; Mosse 1998). Full, collaborative participation is not easy to achieve and there are often inherent problems of treating participation superficially. Even though the mechanics of participation are built into the assessment process, effective involvement of all stakeholders often requires training in facilitation and always requires respect and an ethical protocol (Chambers 1997). In addition, partnerships are necessary for effective participation, requiring reciprocity and humility (Berkes 1999).

Others point out that participation without resource allocation can be meaningless and unfair (Paci; Davidson-Hunt, personal communication). For example, participation requires peoples' time, it tends to raise the expectations of the local participants for resource allocation, and it requires that research information and results are fed back into the community for their verification and use as well as appropriate follow up action (Narayan et al. 2000). The inclu-

sion of both resource and assessment users also raises the distinct possibility of conflicts of interests, information needs, and the knowledge or evidence that is held to be credible, relevant, and legitimate.

Experts on participatory research such as Chambers (1997) point to differences in levels of participation. Such differences can have profound implications for assessment outcomes. Table 5.2 describes the roles and influence of different knowledge groups (or participants) in the sub-global assessments. A difficult category to analyze is that of assessment user, as this group included a wide range of knowledge holders. Not every assessment made clear whether the resource users were in a decision-making capacity (San Pedro de Atacama), were collaborators in the assessment (as in Vilcanota, Bajo Chirripó, or BC Coastal), or were merely consulted for their knowledge as input into the assessment (SAfMA).

In the Bajo Chirripó assessment, all participation was collaborative. Local indigenous people were involved in assessment design, and they changed the direction and focus of the assessment. The communities decided that instead of developing a new resource management plan, they would focus on recovering lost knowledge that in the past safeguarded the integrity of the environment and ensured the sustainability of human activities. (See Box 5.3.) In the Vilcanota assessment, the indigenous Quechua groups had a key role in the problem identification process as well as the assessment of ecosystem services, indicating collaboration in the early critical stages of the assessment that will likely influence the outcome.

Table 5.2. Participants and Their Roles in Selected Sub-global Assessments (Information from knowledge markets and questionnaires)

Sub-global Assessment	Knowledge Group/Participant Category	Role in Assessment Process	Influence in the Assessment Process
Bajo Chirripó	community members	team members and users	directed the assessment objectives and framework
	biologist	team member	managed the work process
Vilcanota	international expert on indigenous issues	initiated assessment	let community control process
	"barefoot" (local) technicians	part of team and also users	facilitated work with community because they possess LK but also understand the scientific framework
Sweden KW	local resource user organizations	team members and users	contributed ecological and management knowledge
	administrative officials	team members and users	contributed ecological and management knowledge
Tropical Forest Margins	scientists (interdisciplinary team)	team members	have led research process from initiation; set priorities for product delivery
	policy-makers	assessment users	helped with problem identification and contributed knowledge
Western China	scientists	team members	managed assessment process
	politicians	team members and assessment users	assisted with scenario development
Coastal BC	scientists	team members	contributed knowledge to assessment
	government officials	team members and users	initiated assessment and provided information to analysis
	private sector	team members and users	initiated assessment, contributed information
	First Nations	team members and users	initiated assessment, contributed knowledge, gathered data
San Pedro de Atacama	indigenous community members	assessment users	contributed local knowledge to all parts of the assessment
	NGO in charge of assessment	assessment team	directed and managed the assessment process
	government officials	assessment users	contributed knowledge and expressed information needs
India Local	local community members	assessment users	contributed knowledge
	educational institutes	assessment team	facilitated process with communities
	scientists	assessment team	contributed scientific knowledge and validated local knowledge
	policy-makers	assessment users	provided enabling policy environment for assessments to be institutionalized nationally

BOX 5.3

Adaptation of Traditional Ecological Knowledge for Resource Management: Bajo Chirripó

Asociación Ixacavaa de Desarrollo y Información Indígena began the Bajo Chirripó assessment with the idea of developing a management plan for the community's resources. Through discussions and meetings with community members, it soon became apparent that in the past, a strict "management plan" had existed and was based on norms and beliefs regarding interactions between humans and their environment. The concept of reciprocity was key (between humans and the rest of the environment).

IXACAVAA therefore changed the focus of the assessment from developing a management plan to recovering lost knowledge that in the past safeguarded the integrity of the environment and ensured the sustainability of human activities. A conical shaped house represents the natural world. The flip side (also a conical house) is the spirit world and is equally important. Communities have noticed a big decline in the number of animals and the quantity of important natural resources available to them in their territory. They explain this by saying that the animals have left the natural world and are hiding in the spirit world (the upside down cone). When humans begin to act more responsibly with great reciprocity, the animals will return to the natural world (conical house). Because of the discussion of these ideas within the process of the assessment, community members in one village decided to build a conical house (which can also be physically constructed on earth and becomes a spiritual icon to the communities), which has now been completed.

In San Pedro de Atacama, the Atacameño indigenous peoples, along with several representatives of local mining companies, were members of the advisory committee; they helped to identify the focus of the assessment and offered feedback throughout the assessment process. However, the assessment team offered the following comment, which illustrates the difficulties of full participation when multiple stakeholders do not trust one another or the assessment process:

> *Mining companies have information on monitoring and studies on the situation in the Salar basin that they had not shared with locals (prior to this assessment), and locals hold knowledge about the landscape they are not prepared to share for fear it will be used against their interests. This is the main pitfall that research projects in the area have to face. To counteract this, the project has encouraged a policy of transparency and access to the information it has generated, but it has been difficult to achieve the participation of the wise men and women from the communities after past experience with other initiatives that were not totally open about their scope and objectives. A workshop with local leaders to discuss their views and possible future scenarios took one step towards overcoming this distrust. (San Pedro de Atacama)*

Local users of these three assessments had different levels of ownership over the assessment process. The capacity to influence the process in significant ways, through collaboration, contributed to the acceptance of the usefulness of the exercise in the cases of Bajo Chirripó and Vilcanota. None of the sub-global assessments were able to report (at the time of writing) on how the assessment users will ultimately use the assessment findings or benefit from the assessment experience in the future. Potential benefits may include access to assessment findings that are relevant to their political agendas, and access to MA tools and networks of communication with which they could draw attention to their causes. In the case of assessments where local and traditional ecological knowledge was used in the assessment of ecosystems and human well-being, the holders of that knowledge may be empowered by the recognition of the value of their knowledge at the national or international level.

In other assessments, it is less clear whether ''participation'' in the assessment process was consultative or collaborative in nature. Chapter 9, which assesses the responses in the sub-global assessments, emphasizes that collaboration (multisector and multi-level) is important for the best, integrated responses. The framework used in Chapter 9 lists knowledge systems as one of four features of any response, suggesting that the bridging of knowledge systems is crucial for collaborative responses.

Since knowledge and values are both situational and time-linked (Colson 1984, cited by Borofsky 1994), taking knowledge out of context is almost inevitable when knowledge systems are bridged through increased participation. When elders or other specialized knowledge holders in the community are consulted, their contribution is often confined within an established scientific framework and their vast repertoire of past experiences and what motivated them are not considered in their operative context. For example, the complex of personal relationships and the spiritual beliefs that influence how people interact within their environment may be largely overlooked in the quest to find fact-based local knowledge that is valued for environmental management. The indigenous, local or traditional knowledge that is accessible to outsiders is often confined to present day realities of secular life, information on scarce resources, and features of ecosystem change, based on long-term observation. Therefore, members of the assessment team must understand the nature of knowledge that is context-dependent and be able to interpret non-factual knowledge as well.

Table 5.3 shows that the assessments used a variety of participatory methods. In the Vilcanota and San Pedro de Atacama assessments, NGOs were the initiators of the participatory processes. However, in San Pedro de Atacama, the NGO was located outside the community and was largely composed of scientists, which may have made their role as a ''mediator'' awkward. NGOs may function as boundary organizations between local and traditional ecological knowledge and practitioners and scientists; however, they may also define the parameters for the use of local/traditional knowledge, rather than the communities doing this themselves (S. Gauntlett, personal communication). The experiences of the MA sub-global assessments in general have shown that there are often important trade-offs between developing meaningful local participation in assessments and progressing with the assessment work within a fixed time frame and within a prescribed budget. The

Table 5.3. Methods Used to Incorporate Multiple Knowledge Systems in Selected Sub-global Assessments (Information from knowledge markets and questionnaires). KI = key informant.

Sub-global Assessment	Methods Used					Who Initiated
	KI	Workshops	Household Visits	Community Meetings	Other	
Western China				+		local governor
	+					local scientists
					other participatory tools	secretariat of Western China assessment team
			+			local scientists
India Local	+				mapping, resource inventories, questionnaires, validation methods	scientists
SAfMA					collection of "tacit" knowledge through collation, evaluation, summarization, synthesis, dialectic and communication; other methods: focus groups, forum theater, story lines, cross validation, and triangulation	scientists
Sweden KW				+		EKV scientists
	+					scientists from Stockholm University
					literature reviews, including vegetation surveys and land use maps; also social-ecological inventories	EKV staff and scientists from Stockholm University
San Pedro de Atacama				+		communities, via Indigenous Development Area policy initiative
	+	+		+	Advisory Committee meetings, theater, participant observation	RIDES (Recursos e Investigación para el Desarrollo Sustentable)
Wisconsin				+	scenarios, computer games, web survey, and randomized mail survey of public responses to scenarios	assessment team
Coastal BC	+					assessment team
		+				planning tables
					literature review	assessment team
					GIS	governments, First Nations, private sector
					statistics	federal and provincial governments
					modeling	biophysical scientists
					surveys (phone, mail)	assessment team

Vilcanota assessment recognized that user engagement and the development of an assessment process by indigenous communities would take a long time; the MA Secretariat (with Board approval) set aside funds for over a year while waiting for a proposal from the Vilcanota assessment team, knowing that the process would eventually contribute information about how to advance the use of local/traditional ecological knowledge in sub-global assessments.

In summary, the MA recognized that assessments may become extractive processes, whereby particular elements of local/traditional ecological knowledge are taken out of their cultural context and used within a scientific framework. This use of local/traditional ecological knowledge may assist the research process, but it is much less clear how local users benefit from the assessment, even when it relies on their knowledge. The question that needs to be asked in every assessment is whether the information is appropriated or obtained through a transparent collaborative process, in which knowledge holders are fully aware of their rights to confidentiality. Once local and traditional ecological

knowledge is documented, there is the question of legitimacy, validation, and credibility, and who sets the standards for comparison (discussed further in the next section).

5.3.3 Use and Application of Findings

The need to be ''relevant, credible, and legitimate'' to assessment users was the main reason the MA initially decided to incorporate multiple knowledge systems. For example, the MA global Responses report recognizes that in order to assess the social and ecological impacts of a particular response, policy-makers must recognize the existence of a range of worldviews and acknowledge that the adoption of a specific policy response may privilege specific worldviews (MA *Policy Responses,* Chapter 2). This requires that knowledge holders be meaningfully engaged assessment users in order for results to be relevant, credible, and legitimate to them. This is reason to explore just how effectively the voices of local farmers, fishers, indigenous peoples, and businesses are able to contribute to the assessment process as ''users'' and how they may actually influence policy.

Chapter 6 of this volume shows that, in many cases, the initial ideas for sub-global assessments came from individuals linked to the global MA process. In general, scientists, rather than decision-makers or communities, initiated the assessment process. This suggests that relevance for scientists was established from the outset in most cases, while relevance for other users required dialogue and varied from assessment to assessment. Coastal BC was an exception, as the assessment was part on an on-going process of policy development that was requested by a coalition of users, rather than initiated by scientists. The Sweden KW and India Local assessments were embedded in ongoing management and policy innovations, so although local participation played a significant role, this may have been a product of an on-going process rather than driven by the assessment itself. There are often challenges for making externally driven processes relevant to local resource users, as they must respond to an idea generated outside the community. The imposition of ''grassroots'' processes generated from demand at higher levels is problematic because ownership is confused and contested (for example, Baumann 2000). User engagement was generally better in assessments with higher levels of meaningful resource user participation (for example, directing the research process) and where potential users saw the assessment process as something they needed. (See Chapter 6.)

Most sub-global assessment users were members of national, regional, or district governments that develop policy outside the community level. (See Chapter 6.) This raises the question of when local people are actually assessment ''users,'' since local people cannot ''use'' the assessment if they do not have broad-based decision-making power. In many cases, where decision-making power resides largely outside the community, community members are only ''consulted'', and their knowledge is extracted for the purposes of other ''users.'' However, the literature indicates that when assessment results are made available and accessible, local people will often make use of the results (for example, Berkes 1999; Alcorn et al. 2003). Although local people may not be able to influence higher-level decisions, they do make day-to-day decisions about resource management, and assessment results may be useful in this context. In addition, numerous local institutions are gaining increased authority over local resources as a result of decentralization processes; these local institutions may be able to use and benefit from the assessment results, although this is not an automatic process. Recent studies (for example, Narayan et al. 2000; Ellis and Freeman 2002; SLSA 2003) emphasize that local institutions often do not respond effectively to the needs or objectives of the poor.

Most sub-global assessments report that including local and traditional ecological knowledge and other non-scientific knowledge improved the credibility and relevance of their processes and outputs to certain users. For example, the India Local assessment addressed the information needs of the Panchayat (local) level of government, which, after the passing of the Biodiversity Act of India in 2002, gained direct control over resources such as ''minor forest products.'' In Bajo Chirripó, non-scientist participation, which focused on knowledge held by the communities, both strengthened that knowledge and increased the relevance of the assessment to the communities. The international community (including the Swedish International Biodiversity Programme) has noted the usefulness and innovative qualities of the approach being taken by the local NGO, Asociación Ixacavaa de Desarrollo y Información Indígena, and has responded by providing funding for the project. According to the assessment, ''the community members working as technicians seem to be empowered by the process, which attaches credibility to the traditional knowledge of their people'' (Bajo Chirripó).

Finally, the SAfMA Garongosa-Marromeu assessment reported that involving local resource users potentially increased the relevance and credibility of the findings; however, the utility of local/traditional knowledge can also be downgraded by the local community itself, as indicted by the comment that ''it is strange [that] in some communities we work with, they themselves downgrade their own knowledge, wanting outside 'scientific' information because it is seen as being better'' (T. Lynam, personal communication). This comment points to a long history of the power of dominant paradigms and how that may affect bridging knowledge systems.

There are more complex questions to ask as well. If the assessment users are at the national or global level, how can local and traditional ecological knowledge be seen as a credible information source? What about ethics: Was the process extractive? Are the local knowledge holders aware of the implications, in term of intellectual property rights, of sharing their knowledge with users at other scales? Similarly, if the assessment users are at the local level (as in India Local), how was capacity developed to enable local people to develop and implement policy? For example, did the assess-

ment process help or was a different institutional or policy intervention required?

The Coastal BC assessment reported that it relied too heavily on science for two reasons: (1) technical information was viewed as too closely tied to sectoral or other interest groups, and (2) bridging First Nations' knowledge took more time and resources than anticipated. The San Pedro de Atacama assessment commented that traditional knowledge does not hold the same validity as scientific knowledge for decision-makers, who prefer to stick to the predominant scientific codes sustaining government policy. Therefore, it is a challenge to generate mechanisms that allow local and traditional ecological knowledge to be incorporated into the decision-making process in a similar way to scientific knowledge (San Pedro de Atacama). This sentiment has been echoed by others involved with participatory poverty assessments (for example, Schoonmaker-Freudenberger 1998), which underscores the importance of well-designed participatory processes.

A related point is that decision-makers often want access to local knowledge on their own terms (S. Gauntlett, personal communication). Traditional weaving and carving among the Maori in New Zealand provides an example; the traditional patterns of this highly sought after art form are being copied (often without consent) by outsiders who are not concerned about the cosmology that surrounds the importance of the weavings. In accessing the design without the surrounding belief systems, the outsiders are inherently changing the knowledge systems that the artifacts are part of and this will over time affect the designs themselves. In a similar way, Nadasny (1999) argues that often decision-makers co-opt knowledge.

Assessing the credibility, legitimacy, and relevance of information for decision-makers involves difficult questions of politics and power. A model for assessing the complexity that is introduced by acknowledging the influence of political power over the knowledge that is accepted by assessment users is described by Pritchard and Sanderson (2002). Integrated assessments themselves deal with complex and inherently uncertain issues, but the reality is that alternative but equally viable models of resource dynamics exist, which means that different interest groups or political bodies can choose models to support arguments that serve their own purposes. Pritchard and Sanderson point to this as the essence of so-called ''wicked'' problems, which involve a host of academic and social perspectives that cannot be separated from issues of values, equity, and social justice; that are relevant to multiple arenas of action; and that are difficult for anyone to solve.

Few assessments comment explicitly on conflicting information, and indeed a full discussion of it is beyond the scope of this chapter. However, the Tropical Forest Margins assessment team plans to explore how to ''articulate participation across multiple groups with conflicting interests,'' because they work with both local and national user groups, which have different knowledge, and because their problem domain, land use at tropical forest margins, involves numerous trade-offs and conflicting interests.

5.4 Design and Process for Incorporating Multiple Knowledge Systems

5.4.1 MA Design: Guidelines for the Use of Multiple Knowledge Systems in Sub-global Assessments

The challenge of incorporating multiple systems of knowledge was not explicitly recognized by the exploratory steering committee that designed the basic MA structure in 1998–99. However, the committee did take the decision to include sub-global assessments within the MA structure and to include a broad array of stakeholders on the Board governing the assessment process; these decisions, in turn, led to a growing focus on the issue of knowledge systems during the technical design phase in 2001 and during the initial meetings of the MA Board.

From a practical standpoint, the decision to include sub-global assessments, and particularly local assessments, within the MA process required that the MA modify the procedures used by the Intergovernmental Panel on Climate Change (which were otherwise generally adopted for use by the MA) to enable the use of knowledge and information not published in the scientific literature. The IPCC procedures had already provided a mechanism to incorporate ''gray literature'' into that process, largely in response to concerns expressed by the private sector that the first two rounds of the IPCC were not taking full advantage of materials published by the private sector that were not available in scientific publications.

Other international forums have also addressed the need to include other sources of information and knowledge, for example the International Council for Science Series on Science for Sustainable Development. During the second technical design workshop of the MA in October 2001, the sub-global assessment ''breakout'' group developed a process and set of protocols for validating unpublished information, with a particular focus on local or community assessments. This process of validation was further refined at the first Sub-global Working Group meeting in June 2002 and the resulting mechanism was then incorporated into the MA procedures. The elements of these policies concerning the practices that would be used in working with different knowledge systems are presented in Appendix 5.1 of this chapter.

The array of proposed sub-global assessments involved in the MA during the design phase in 2001 were largely derived from a ''call for proposals'' circulated in September 2000. (See Chapter 6.) Because this initial call for proposals was circulated primarily through government, scientific, conservation NGO, and development NGO networks, the set of proposed sub-global assessments involved did not span a particularly broad range of knowledge systems. Even among the MA local assessments, most were initiated by scientists external to the communities involved. The technical design workshops in 2001 and the first meeting of the Sub-global Working Group in 2002 both encouraged the incorporation of a broader array of sub-global assessments. This was also encouraged by the MA Board, which in-

cluded individuals from indigenous communities, local assessments, and the private sector, all of whom argued for additional assessments to be established within the communities or sectors that they represented.

Efforts to expand the array of sub-global assessments to include assessments that involved using multiple knowledge systems were not particularly successful, however. Building on MA Board contacts, an effort was made during 2001 to stimulate the establishment of several additional assessments led by indigenous peoples. This involved the circulation of the sub-global assessment concept paper through several relevant NGO networks, discussions with interested individuals, and a small brainstorming session with indigenous participants at a meeting of the Convention on Biological Diversity's Subsidiary Body for Scientific, Technical and Technological Advice. Although interest was expressed in the idea, particularly by indigenous peoples involved in the CBD, no new assessments were generated through this effort. Similar steps were taken to generate ''private sector'' MA sub-global assessments and these steps also did not yield any new assessments. Despite the initial receptivity among these groups to the idea of launching new assessments, some of the likely factors that contributed to their ultimate reluctance to enter into the process included:

- the benefits of undertaking the MA sub-global assessments were not as clear to these stakeholders as they were to governments and scientists;
- the basic approach of the assessment was not something that either the private sector or indigenous communities were familiar with;
- some of the skills needed to undertake such an assessment were absent; and,
- particularly for indigenous communities, the inability of the MA to fully fund an assessment may have posed an insurmountable hurdle.

The elaboration of guidelines and methods for addressing multiple knowledge systems in the MA was undertaken in parallel with the process of launching both the global and sub-global assessments. By the time the product of the design phase, the conceptual framework, was published in late 2003, the MA was committed to including sub-global assessments and different knowledge systems. For example, the MA conceptual framework (2003) states:

- . . . The management and policy options available and the concerns of stakeholders differ greatly across these scales. The priority areas for biodiversity conservation in a country defined by ''global'' value, for example, would be very different from those defined by the value to local communities. The multiscale assessment framework developed for the MA provides a new approach for analyzing policy options at all scales—from local communities to international conventions.
- 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. To be credible and useful to decision-makers, all sources of information, whether scientific, traditional, or practitioner knowledge, must be critically assessed and validated as part of the assessment process through procedures relevant to the form of knowledge.

Despite these statements of intent, the sub-global assessments struggled with the methodologies for incorporating multiple knowledge systems. The first pilot assessment conducted as part of the MA, an assessment in the Mala Village cluster in India Local, provided an early approach and methodology for conducting assessments across knowledge systems. This methodology was made available to the participants in the MA design meetings in 2001 and a presentation on the approach was made as well as copies of the approach distributed during the first meeting of the Sub-global Working Group in 2002. In general, working group meetings provided an opportunity for the sub-global assessment coordinators to learn from the methods used in the other assessments, but since the sub-global assessment teams had sometimes already made key decisions regarding the methods and design of individual sub-global assessments, they could not always fully incorporate these lessons.

The MA conceptual framework makes explicit mention of the assessments as a social process to bring the findings of science to bear on the needs of decision-makers. Reid (2004) discusses the provisions made within the MA for the inclusion of local knowledge. These provisions deal primarily with documenting and establishing the validity of non-scientific, particularly local, knowledge. They include taking self-critical notes of the assessment process, triangulating methods to test results, ensuring that the community has the opportunity to review the assessment process and findings, and review by stakeholders at higher and lower scales. Making the connection from policy statements to implementation is important because lack of guidance in how to articulate local and traditional ecological knowledge so that it is understood by all assessment users, as well as overcoming inherent mistrust and misunderstanding, hampered some sub-global assessments (as it has many other assessments and participatory projects).

The question remains as to how an indigenous group can become part of the authorizing environment when the assessment is to be ''scientific.'' Who decides what is ''belief'' and what is ''fact''? This is not an issue specific to the MA, but rather part of the wider debate on the epistemological basis of science (M. Nadkarni, personal communication). In most places where sub-global assessments were conducted, policy-related decisions are not made at the local level, so it is not clear how assessing local knowledge and including it in the overall assessment can lead to empowerment and more appropriate decision-making, two goals the MA strives for (discussed later in this chapter).

5.4.2 The MA Process: Incorporating Multiple Knowledge Systems

The MA has explicitly recognized that to achieve conservation and sustainable use of ecosystems, traditional and formal knowledge systems need to be linked and that the

influence of intangible benefits, such as spiritual and religious values, on sustainable natural resource management at the landscape level needs to be strengthened. (See MA *Current State and Trends,* Chapter 18.) Limitations and shortcomings of integrating non-formal knowledge and formal science need to be addressed up front, and the methods that are chosen to collect this knowledge should take the location-specific environments in which they operate into account (Singhal 2000). Research suggests that if traditional ecological knowledge is to be integrated with other forms of knowledge, it must be understood within its historical, socioeconomic, political, environmental, and cultural context (Berkes 1999).

As discussed in the previous section, the MA design was modified to allow the inclusion of ''non-scientific'' information in the body of knowledge being used to assess ecosystem services and human well-being. The MA Secretariat did not itself develop methods to ''bridge'' knowledge systems, as such an endeavor was regarded as beyond the scope of the project. The design of the MA largely relied on encouraging sub-global assessments to independently test methodologies for the incorporation of local and traditional ecological knowledge into scientific assessments within their own local, national, or regional context. The MA did provide a forum for the presentation and possible further development of methodologies to advance the understanding of bridging knowledge systems at the conference in Alexandria, Egypt. The MA process and working group meetings provided a forum for discussion for the sub-global assessments, within which ideas, methods and approaches to the treatment of different forms of knowledge were shared. At early meetings, a large amount of time was often spent on the topic of local/traditional/indigenous knowledge. The discussions highlighted the importance of incorporating different forms of knowledge, particularly the challenges associated with doing this. There appears to have been little attention devoted to understanding how knowledge is used in decision-making processes.

The Bridging Scales and Epistemologies conference highlighted the fact that guidance on the use of participatory methods was lacking in the sub-global assessments. One problem was that methods needed to be designed to fit the specific context of each assessment and hiring an outside consultant to advise sub-global assessments on how to adapt their process might be considered inappropriate. In the case of Vilcanota, the process is still proceeding slowly at the time of writing this volume, but control of the assessment and development of methodologies will ultimately reside with the communities involved in the assessment. The process must be allowed to develop in its own time; for this reason, it may be some time before it can be truly understood what advances the sub-global assessments have made in this field.

Most often, local and traditional ecological knowledge is explored by interdisciplinary teams, because multiple perspectives strengthen results and the interdisciplinary approach is a backbone of the entire field of participatory research. An important consideration is the fact that, overall, the MA process emphasized ecological science more than the social sciences. This has been to the detriment of the inclusion and full understanding of the potential that local and traditional ecological knowledge can make to an assessment. In many sub-global assessments, several different scientific disciplines were represented in the assessment team. There were almost always ecologists, often economists, but rarely people with long experience working with local knowledge, such as anthropologists, philosophers of science, or community-oriented researchers and development practitioners. (See Table 5.4.) Only a few assessments, such as SAfMA, Tropical Forest Margins, and Portugal, discussed how the different disciplines in the assessment teams shared knowledge or influenced the outcomes.

The Tropical Forest Margins assessment offers rich insights into achieving integration among knowledge systems. As part of their MA activities, 42 members of the assessment team participated in an online consultation on how the program has managed the goal of integrated research (Tomich et al. 2004). The results of this consultation pointed to the time and dedication that working across disciplines and interests requires, although all of the team highly valued the interdisciplinary approach and considered it essential to answering key questions. Essential to the success and longevity (10 years) of this team was commitment to a common set of research issues and shared analytical protocols, yet enough flexibility and free exchange so that new ideas could be incorporated and prior assumptions or hypotheses could be rejected. The team was assisted by the constant presence of a coordination office, which acted as a bridge between scientists and users.

The Portugal assessment, which involved 35 scientists from the natural and social sciences, provides some insight into interdisciplinary integration as well, with the recognition of ''technical and stakes'' gaps (Pereira et al. 2005). These gaps illustrate the differences in both disciplines and interests of scientists. Due to the complexity of social-ecological systems, there is a lack of scientific knowledge to predict how these systems will evolve, and scientists disagree on the future trajectory for particular social-ecological systems. These gaps were bridged somewhat during the development of scenarios and the qualitative assessment of conditions and trends. In the scenario work, the creative process of developing descriptive narratives allowed for better communication between the different scientists.

SAfMA used a ''trans-disciplinary'' approach, as the assessment team held the view that working across disciplines is indispensable when dealing with complex multiscale systems (Cundill et al. 2004). Due to limited resources, the approach involved a trade-off between the ability to include and recognize the influence of a multitude of factors and the development of an in-depth understanding of the linkages among all identified processes. The SAfMA team also had to struggle with interdisciplinary dialogues and competing explanations of events by different scientists, which made consensus difficult.

In-depth understanding of local knowledge by outsiders requires skill, training, respectful behavior, an open and non-judgmental attitude, and experience of place within an

Table 5.4. Contributions of Various Knowledge Systems to Selected Sub-global Assessments (Information from questionnaires)

	Knowledge Systems Contributing to Assessment						
Sub-global Assessment	**Ecologists, Botanists, Zoologists**	**Other Biophysical and Natural Scientists**	**Anthropologists and Sociologists**	**Economists**	**Other Socioeconomic Scientists**	**Practitioners**	**Boundary Organizations**
San Pedro de Atacama	designed and executed the assessment process; dissemination of findings		provided context and understanding of indigenous practices and traditions	designed and executed the assessment process; dissemination of findings			public sector agencies assisted with development of accurate scenarios
Coastal BC	team leaders and members for ecosystem spatial analysis, ecosystem trends, risk analysis, ecosystem-based management	geographers, foresters, mining geologists contributed to assessment; team members for ecosystem-based management, spatial analysis, and well-being assessment	team leader and members for cultural and spatial analysis, and for well-being assessment	team leaders and members of economic analysis; members of ecosystem-based management team	political scientists and lawyers contributed to, and are team leaders and members of, policy and institutional analysis; members of ecosystem-based management team		managers of overall assessment; team leaders of ecosystem-based management and well-being assessment
Sweden KW	information on species diversity, population changes, habitats, monitoring of rare species					EKV staff were part of the technical team that helped in problem identification, condition and trends and response options development	
Tropical Forest Margins	biodiversity index that enabled analysis of trade-offs with other disciplines	carbon sequestration; agronomic sustainability	insight into nonquantifiable institutional/social variables	economic profitability of land use systems		NGOs	
Portugal	conducted most of the assessment	forest and agricultural engineers assisted in conducting most of the assessment	one anthropologist involved in the socioeconomic analysis of the assessment	conducted economic evaluation of ecosystem services	social scientist collaborated with ecologist to conduct Sistelo community assessment		representatives of the public and corporate sector helped shape the assessment questions
SAfMA	primary source of knowledge for assessment; validator of local knowledge		implemented and interpreted participatory methods/results	developed socioeconomic profiles		NGO	

interdisciplinary team (Chambers 1994, 1997). It should be noted that some hold the view that only indigenous people themselves should be the ones to investigate indigenous knowledge, stemming from a belief that all knowledge is politicized (Smith 1999).

The assessment technical teams differed greatly in terms of expertise and experience. While some teams were able to progress rapidly with the general assessment work, others struggled with the design of the basic assessment. Few teams were able to work effectively with local/traditional/indigenous knowledge, due to lack of expertise, although three quarters (25 out of 34 assessments) tried to some extent. By sharing experiences, methodologies, and lessons learned, the teams with less experience in this kind of work were exposed to ideas on how to go about working with other kinds of knowledge. For example, the expert in participatory methods from SAfMA spent several months working with both the Vilcanota and the San Pedro de Atacama assessments, training them in methods of working with local knowledge holders. Assessments run by teams primarily composed of biophysical scientists were encouraged to widen their perspectives on their assessment areas, inhabitants, and sources of information. Ultimately, however, individual assessment teams, along with their advisory committees, decided to what degree they would work with local and traditional ecological knowledge systems in the context of their own assessments.

One indication of the limited experience that the sub-global assessments had in using multiple knowledge systems is that gender differentiation of local and traditional knowledge was not considered in the MA even though it is almost always recognized as critical in the study of human–ecosystem interactions (for example, FAO Sustainable Dimensions 2001). Assessment reports did not discuss the importance of understanding gender differences in knowledge, except for the Sinai assessment. As mentioned earlier, local and traditional ecological knowledge is also differentiated by age, wealth, and status in the community, all of which need to be considered in the assessments that rely on local/traditional ecological knowledge. Several assessments (for example, San Pedro de Atacama and Sinai) did note that the community elders were the primary holders of traditional knowledge.

Understanding the social, cultural, and economic context of place requires a historical analysis of trends and evolution not only of knowledge (for example, recent discoveries), but also of the use of this knowledge over time and space in different institutions. Few sub-global assessments gave much treatment to the historical context in which current knowledge use is based. San Pedro de Atacama and Eastern Himalayas both discussed economic changes in the past decade as negatively affecting local knowledge, although in San Pedro de Atacama recent political and legislative changes are encouraging a renewed interest in indigenous identity, for cultural and economic reasons. In contrast, India Local embedded the assessment in the national historical context, but did not discuss local knowledge within this.

SAfMA reports that participatory rural appraisal tools were useful for discussing local and traditional knowledge at the local scale, but in order to make it meaningful at higher scales, the knowledge had to be re-articulated so that scientists and others could relate to it. This often takes local and traditional knowledge out of its context and thus changes it. SAfMA relied on cross-validation, which puts local and scientific knowledge on an even plane, so that local experts validate scientific knowledge, and scientists validate local knowledge. In this way, as the assessment authors assert, the integrity of local knowledge can never be ''guaranteed'' by scientific standards, but by using the various techniques in a complementary way, a form of ''local peer review'' is introduced that greatly enhances the credibility of local and traditional knowledge from the perspective of scientific users (Fabricius et al. 2004).

A process is on-going in India Local, where validation of local knowledge is a concern for national policy development. Validation is done by collating local knowledge, storing it in the People's Biodiversity Register, and then transmitting it to the National Institute of Innovation, in English. In Vilcanota, two different databases were used—one in Quechua and one in Spanish—to be able to get the information to central decision-makers. In San Pedro de Atacama, biophysical scientists did not take concrete steps to exchange information and generate synergies with those with local knowledge; local knowledge was not used in the assessment for various reasons. Therefore, the challenge is to call upon scientists from all disciplines involved to develop bridges and exchange mechanisms for knowledge sharing. It will be similarly important to find institutions and decision-makers willing to share knowledge across levels as well. In this case, as well as in Vilcanota, Sinai, and Bajo Chirripó, the assessment itself can be viewed as an important first step in building awareness of the need for and benefits of bridging local knowledge with higher scale decision-making processes.

Several assessments incorporated the knowledge of assessment users (practitioners), such as government bureaucrats or local NGO workers. In the case of India Local, the involvement, support, and participation of local government (Panchayat) officials was encouraged, given their direct control over natural resource access and management at the local level; school teachers and students were responsible for the collection of local knowledge. In Sweden KW, all stakeholders were classified according to the knowledge they have, from farmers up to municipal officials. The Sweden KW framework considered that every user group has a type of basic ecological knowledge, as all stakeholders are considered to use the ecosystem services in some way. Many stakeholders have knowledge about technology and are skilled in management practices. The rarest form of knowledge, regarding the social processes behind ecosystem management, is held only by the Ecomuseum Kristianstads Vattenrike, which is the mediating institution that coordinates the social networks that collectively manage the wetlands (Sweden KW).

5.4.3 The Influence of Different Knowledge Systems

This section examines how the involvement of different scientists and a range of non-scientists influenced the assessment processes and outcomes. The intent is to explore the depth of contributions that non-scientific knowledge holders were able to make. Table 5.1 above summarizes how all the sub-global assessments viewed and used local knowledge, and the approach that different sub-global assessments took in using local and traditional knowledge systems. Note that much of the information was verbally transmitted during the knowledge market during MA Sub-global Working Group meeting held in Alexandria, Egypt, in March 2004.

Several assessments attempted to recognize the complexity of local and traditional ecological knowledge. For example, seven assessments (Coastal BC, PNG, India Local, Sinai, Bajo Chirripó, SAfMA, and Vilcanota) investigated and helped to articulate the spiritual component of local knowledge, which is important in understanding what motivates particular behavior in human–ecosystem interactions. In PNG, for example, local ecosystems are imbued with spiritual beings, an understanding of which lent insight into the patterns of resource use. In another example, in the sacred groves in India, the assessment drew upon the conservation benefits of the spiritual values associated with certain forest areas. The reworking of the conceptual framework by the Quechua community of Vilcanota, Peru, and the Cabécar in Bajo Chirripó, Costa Rica, relied heavily on spiritual components of local and traditional ecological knowledge.

A number of sub-global assessments pointed out the importance of local knowledge to cultural identity; examples include the Bedouin of the Sinai, the Atacameños in San Pedro de Atacama, the Quechua communities in Vilcanota, the Cabécar of Bajo Chirripó, and the Haida Gwaii and the north and central coast First Nations of Coastal BC. Transmission of traditional knowledge is currently having the positive effect of affirming the Atacameño culture and identity in San Pedro de Atacama and of strengthening community cohesion in Vilcanota; in both these cases, however, the need for continued support of policy-makers is important. As several researchers have noted, failure to grasp and acknowledge these deeper or more complex aspects of local knowledge, robs this knowledge of some of its inherent meaning.

Most sub-global assessments, on some level, depended upon local knowledge to complement science. For example, Western China and India Local highlight the important observations and innovations local and traditional ecological knowledge contains for soil and water conservation. SAfMA highlights the rich diversity of management practices and coping strategies (which contain observations about complex use of landscapes) based on local knowledge. The Mekong Wetlands, Viet Nam, assessment highlights the tremendous value of local knowledge of medicinal plants.

In three assessments, the concept of integrating local knowledge with science was rejected: PNG, Sinai, and, to some extent, Coastal BC. Local communities in Papua New Guinea see no need for science, because their local knowledge systems are so robust and form the basis of their daily practice. Similarly, in Sinai, the Bedouin rely heavily on their own knowledge for their livelihood needs, but fear both cultural erosion and knowledge appropriation.

In Coastal BC, local and traditional knowledge was not used along with science for a number of reasons. The assessment team used all four of the recognized knowledge systems (scientific, technical, traditional, and local) to some extent. However, the timetable imposed on the assessment, the ready availability of scientists, the relative ease with which their qualifications could be authenticated, and their apparent independence, favored the use of scientific systems. In contrast, indigenous (First Nations) knowledge systems posed certain challenges: (1) the information on First Nations' traditional territory will be used politically (to support their position in treaty negotiations) and some First Nations think they will put their case at risk if they reveal the information in advance; (2) some information on spiritual sites or sites closely associated with the identity of a clan or household is highly sensitive and must not be made public; (3) some information is not available to the First Nation as a whole but is owned by particular clans or families; and (4) time is required to observe rules of behavior, negotiate with the owners of information, and grasp different worldviews and classifications—time that was not available to the assessment. The authors of the assessment stated that there was not enough time or resources to devote to incorporating traditional knowledge. With hindsight (and the passage of time), they realize that they could have made better use of indigenous and other local knowledge, particularly in the assessment of provisioning/cultural services. Specifically, they could have developed expert-based indicators on the biological and cultural diversity of food systems and the status of contributing ecosystems and species, using estimates from First Nation and other local experts as well as scientists (Coastal BC).

Six assessments achieved some form of two-way or cross-scale interactions between science and local and traditional ecological knowledge: SAfMA, San Pedro de Atacama, India Local, Sweden KW, Vilcanota, and Bajo Chirripó. SAfMA, after validating and re-interpreting local knowledge, returned some of this knowledge, along with the scientific results, back to the communities, using theater and scenarios. The methods involved in scenario development in some sub-global assessments resulted in cross-scale (both vertical and horizontal) knowledge sharing as well as bridging knowledge among multiple stakeholders, including scientists, practitioners and local/traditional knowledge holders. In SAfMA, scenarios developed at a national, regional, and basin level were presented to the community as storylines, so that the community could relate to them. The outcome was that local people were able to envision taking control of their own future as a plausible scenario. In San Pedro de Atacama, scenarios were used with the advisory group, which was composed of multiple stakeholders. The outcome was trust-building and the realization that all stakeholders need to be involved in an assessment to determine what responses should be prioritized as follow up to

the assessment. The scenarios helped both these communities to better understand the reasons for participating in assessment processes.

In India Local, local/traditional ecological knowledge was not viewed as an alternative to science, but rather as an integral part of ecosystem understanding, as only local resource users have in-depth knowledge about local biodiversity and resources. The assessment was embedded in a larger effort to acknowledge and use local knowledge, but there remain difficulties in validating some types of local knowledge and its use at a higher level is as yet untested. In Sweden KW, the distinctions between local and scientific knowledge were not presented as distinctively as in India Local, but the whole evolution of the EKV represents a multiscale and multi-knowledge holder effort to combine information for the best ecosystem understanding and management. So far, this appears to be a very successful dialogue.

In Vilcanota and Bajo Chirripó, science deferred to the local indigenous knowledge base. Both sub-global assessments spent a lot of time working with the communities to validate and reinterpret the MA conceptual framework and the science behind it in order to enhance the relevance of the MA to local communities. Science was seen important to complement and strengthen local knowledge, as well as to help address ecosystem crises that are new to the region and unfamiliar to local resource managers.

In contrast, in several assessments, no local knowledge was used. The Caribbean Sea assessment acknowledged that large organizations external to the region have more influence regionally than the countries in the region, which widens the gap between local level realities and global perceptions (KM–Caribbean Sea). In Laguna Lake Basin, only scientists participated in a review of information from secondary sources, thus current local level knowledge did not inform the assessment.

Approaches to using multiple knowledge systems also varied within assessments. Not all local assessments could use both local knowledge and science together. In Eastern Himalayas, local knowledge is scarce. In Coastal BC, local people were reluctant to share some aspects of their knowledge with outsiders. In Downstream Mekong, differences in educational and income levels impeded mutual understanding between local stakeholders and the assessment team. In Sinai, outsiders recognized the richness of Bedouin local knowledge of water harvesting and medicinal plants; however, the Bedouin are protective of this knowledge, as it is integral to their cultural identity. The SAfMA assessment incorporated local knowledge predominantly from a natural resource management perspective, and the use of these management frameworks improved the legitimacy and validity of the assessment. The process, however, was less participatory than that advocated by the proponents of community-based natural resource management (Fabricius et al. 2004) and less legitimate than a bottom up assessment in the eyes of the local people.

Table 5.2 highlights the differing influences of participants' knowledge systems on both process and outcome. From the materials available, we cannot with confidence explain how processes and outcomes were influenced by different participants. However, it is evident in several assessments that the influence of scientists and policy-makers in the assessment process and outcomes was greater than that of local and indigenous communities. For example, in Northern Range, SAfMA, Western China, Tropical Forest Margins, and Caribbean Sea, the assessment processes were defined by the teams of scientists. The San Pedro de Atacama assessment predominantly relied on science, only selectively involving local ecological knowledge, but the assessment validated the knowledge and devoted attention and resources to understanding it and reporting on it. In several assessments, science was used where local knowledge may have been more informative. For example, in Argentine Pampas, a sociologist translated the link between human well-being and ecosystem services and a government consultant was hired to consider outcomes.

Thus most assessments used local knowledge as an information source that science validated and reinterpreted for other assessment users. As of this writing, not many sub-global assessments have reached the stage of developing policy-relevant messages, which is consistent with the lack of evidence from the sub-global assessments on how to create policy–research dialogues or policy–local resource user dialogues.

5.4.4 The Utility of the MA Conceptual Framework for the Assessments

Given the complexity of local knowledge, and the issues involved in using multiple knowledge systems, the utility of the MA conceptual framework for the local sub-global assessments is important to consider. The framework represents the worldviews of scientists and some assessment users, but while it proved useful to most of the sub-global assessments, there are lessons to be learned from those where it was not found to be an effective tool for assessing human–ecosystem interactions in the local context.

In SAfMA, researchers found the conceptual framework of the MA to be insufficient to deal with dynamic local interactions, and therefore difficult to use as a starting point with the communities. To overcome this challenge, the SAfMA local-level assessments combined the adaptive renewal model (Holling 1986; Berkes and Folke 1998; Gunderson and Holling 2002) with the MA framework as a conceptual guide. This model regards social and ecological systems as intrinsically linked and posits that micro-level phenomena can affect macro-level processes as much as the macro affects the local. The model also acknowledges the adaptive capabilities of local communities and ecosystems, an aspect significantly lacking in the MA framework that was crucial for the SAfMA assessment. The sustainable livelihoods framework (Ellis 2000; www.livelihoods.org) was also used to accommodate these adaptive strategies.

In Bajo Chirripó, the basic concepts of the MA conceptual framework were understood to some extent but it was nevertheless quite foreign to community members' way of thinking. Recognizing a need to understand these concepts in the language and from the perspective of the community,

the assessment team and the Cabécar community together invested considerable time in revising the conceptual framework. A full local framework has not yet been completed/developed for this assessment, but components have been identified and discussed in the community.

In Vilcanota, the adaptation of the MA conceptual framework constituted an important part of the assessment work. (See Box 5.4.) The assessment team found that the English terms used in the framework were difficult to translate into Quechua. In addition, the diagram itself and the terms used in the conceptual framework were difficult for the community to relate to, based on their own experience of the environment. The ANDES technical team realized that to move forward with the assessment and for the communities to take ownership of the process and results, the framework would have to be based on a Quechua worldview, and not on the MA worldview, translated for their use.

The Coastal BC assessment adapted the MA conceptual framework to emphasize key relationships. The essential structure of the MA conceptual framework was unchanged except for the addition of human interactions that directly link human drivers and ecosystem services. These links reflect the key role of competition and conflict among users of ecosystem services in determining who benefits from which services and how much they benefit. A separate box in the diagram was added to Ecosystem Condition to highlight the need to maintain ecosystem integrity in order to maintain the supply of ecosystem services. Drivers were separated into ''human'' and ''ecosystem'' drivers in recognition of the distinct differences between them. Human drivers were reduced to three major groups: populations, needs and wants, and powers (such as technology, money, knowledge, access, and rights) that fuel competition and conflict among the users of ecosystem services and amplify the combined impact on the ecosystem of populations and their needs and desires. Direct and indirect drivers were merged, except for the ways in which human drivers act on the ecosystem (identified in the human impacts box). Drivers were reduced to two major groups: conversion of ecosystems (to structures and cultivation) and use of ecosystem services, which emphasized that the use of ecosystem services strongly affects ecosystem condition and hence the supply of services.

Three assessments (Sweden KW, SAfMA, and Wisconsin) used the concepts and theories of *resilience* (Gunderson and Holling 2002) and *adaptive co-management* (Olsson et al. 2004) as part of their conceptual frameworks. Sweden KW also prioritized the idea of social-ecological systems (Berkes and Folke 1998) and highlighted the role of flexible institutions and matching management practices, social processes, and ecosystem processes at various scales. (See Chapter 11.) In the Northern Highlands Lake District, Wisconsin, assessment, the MA conceptual framework volume (MA 2003) appeared too late to be used explicitly in the assessment; the framework, however, was considered useful to assessment organizers, but too technical for local users. The assessment used complexity theory to deal with the problems of unpredictability of ecological forecasts, which contributed to determining indicators of social–ecological resilience that could be drawn upon for sustainable development in the area. (See Box 5.5.)

Several assessments had few problems, if any, in using the MA conceptual framework. In Western China, where the framework was also used for three other projects, it was easily understood by local scientists but required some explanation to decision-makers. The framework was used to design a questionnaire targeted at local farmers and other community members. The San Pedro de Atacama assessment used the conceptual framework despite some initial problems for some user groups that necessitated some innovation, such as changing the meaning of words (for example, instead of conditions and trends, the assessment team use the word ''baselines'' to refer to the current situation) and introducing the conceptual framework gradually. This made it more comprehensible and less complex, and thus promoted the involvement of all users. Finally, in the Sinai assessment, the conceptual framework was used, but it was mostly understood by those with formal academic training, such as government officials working in the assessment area. However, the assessment team noted that the local Bedouins appreciated the way the framework examined connections between a good environment and a good quality of life.

5.4.5 Knowledge Systems, Institutions, and Scale

An initial MA hypothesis was that knowledge is embedded as well as privileged at specific levels. Just as the MA concerns itself with linking biophysical and social data across scales, a treatment of knowledge systems and the institutional structures that support and use them, and how knowledge and institutions interact across scales, is in order. (See Chapter 11.) Institutions are defined broadly as the rules of the game devised as constraints for shaping human action (Ostrom et al. 1994; Young 2002)

A question to be examined is whether the sub-global assessments shed light on which type of knowledge predominates in management at different scales. It appears that science is the knowledge system legitimized at national and regional scales and used as the primary source of information in most assessments, including SAfMA, Western China, Eastern Himalayas, San Pedro de Atacama, and Tropical Forest Margins. While most community assessments reported that local knowledge is very important at local levels, it is more difficult to determine whether local knowledge is legitimized as a basis for decision-making at other levels, without more information on the institutional contexts that support decisions. (See Table 5.5 for details on the relationship between knowledge systems and scale.)

A number of assessments described local or community institutions as essential for the maintenance of local knowledge. SAfMA, for example, highlights the role of social networks and rituals in maintaining and transmitting knowledge that is important for survival. However, these institutions are weak, having been considerably influenced by a history of state interference and deliberate erosion of local knowledge and customs. Stewards associations and craft associations are also important at the local scale. In

BOX 5.4

Constructing a Conceptual Framework for Quechua Communities: Vilcanota

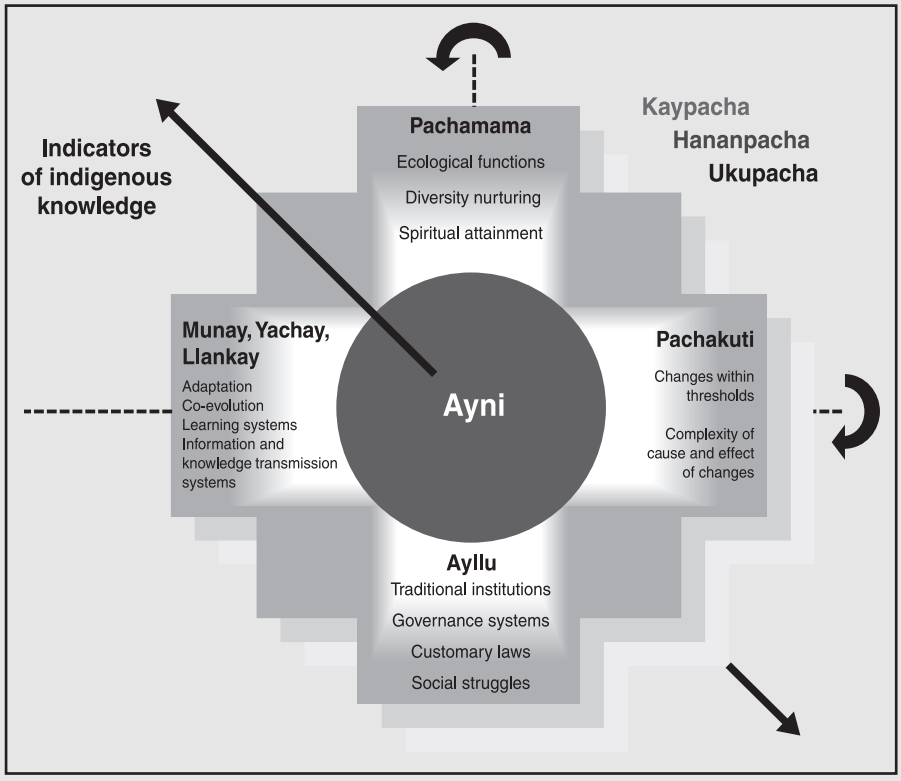
The Vilcanota assessment team initially planned to adapt the MA conceptual framework to be more easily understood by Quechua communities in Vilcanota. However, initial consultations with several Quechua communities suggested that in order to establish dialogue between the MA concepts and the Quechua communities, the team needed a framework built up from the Quechua understanding of ecological and social relationships.

The team began with the Quechua cosmovision, represented in an ancient Inca icon that embodies the Andean conception of ecosystems. This view can be interpreted to include most modern "scientific" notions of ecosystem functioning, but has several key distinctions. Concepts such as reciprocity (*Ayni*), the inseparability of space and time, and the cyclical nature of all processes (*Pachakuti*) are important components of the Inca definition of ecosystems. Love (*Munay*) and working (*Llankay*) bring humans to a higher state of knowledge (*Yachay*) about their surroundings, and are therefore key concepts linking Quechua communities to the natural world. *Ayllu* represents the governing institutions that regulate interactions among all living beings. These and other key components were then compared with key components of the MA conceptual framework in order to determine which needed to be included in the local conceptual framework for the Vilcanota assessment. The resulting framework has many similarities with the MA framework, but the divergent features are considered to be important to the Quechua people conducting the assessment (see figure).

The Vilcanota conceptual framework includes multiple scales (*Kaypacha, Hananpacha, Ukupacha*), which represent both spatial scales and the cyclical relationship between the past, present, and future. Inherent in this concept of space and time is the adaptive capacity of the Quechua people, who welcome change and have become resilient to it through an adaptive learning process (although it is recognized that current rates of change may prove challenging to the adaptive capacities of the communities).

The Southern Cross shape of the framework diagram represents the *Chakana,* the most recognized and sacred shape to Quechua people and orders the world through deliberative and collective decision-making that emphasizes reciprocity (*Ayni*). *Pachamama* is similar to ecosystem services combined with human well-being. Pachakuti is similar to the MA "drivers" (both direct and indirect). *Ayllu, Munay, Yachay,* and *Llankay* may be seen as responses, and are more organically integrated into the cyclic process of change and adaptation.

The MA's four categories of ecosystem services had to be augmented by one: Quechua working groups could not include the service of "protection" offered by the *Pachamama*—a broader vision of an ecosystem, described as "mother earth, major divinity, place where past, present and future coincide, a living system embodying humans and all living beings (including lakes, rocks, mountains, the sky etc), nurtures and cares for all"—in the four MA categories.



PNG, Bajo Chirripó, and Vilcanota, ritual and spiritual beliefs help to maintain and validate local knowledge. The Bedouins of the Sinai protect their knowledge by maintaining a strong cultural identity, and they are reluctant to share their knowledge with outsiders. In Sweden KW, India Local, and San Pedro de Atacama, the transmission of local and traditional ecological knowledge is supported by the education system. In PNG and Sinai, the practice of storytelling and intergenerational transmission are still viable ways to maintain local knowledge, while in San Pedro de Atacama (as elsewhere) elders no longer transmit their knowledge to younger generations in such a regular fashion. Experiential learning has long been a mechanism by which local and traditional ecological knowledge evolves,

BOX 5.5

Complexity in Scenario Development: Wisconsin

The future of the Northern Highlands Lake District of Wisconsin is uncertain. For that reason, the assessment team decided that conventional scientific tools were inadequate for conservation planning, since these methods do not take into account *uncertainty, contingency,* and *reflexivity* (Carpenter 2002, cited in Peterson et al. 2003). For example, when the *uncertainty* of forecasts is rigorously evaluated it is usually found that the prediction is uncertain, meaning that it assigns roughly equal probability to a wide range of extremely different outcomes. Ecological predictions are *contingent* on drivers that are difficult to predict, such as human behavior. The *reflexivity* of human behavior further constrains the possibility of ecological predictions (Funtowicz and Ravetz 1993)—if predictions are made and taken seriously, people will change their actions in response to the predictions, making accurate forecasts difficult (Carpenter et al. 1999).

In the assessment, a scenario planning approach was adopted to take into account the problem of prediction and to deal with model limitations and uncontrollable, irreducible uncertainties in a structured way so as to create management plans for sustainable development. The assessment involved a series of workshops to determine who the key actors are in the district, the key ecological services the district provides, the district's history, the key social–ecological linkages, and the external drivers that may affect the district. In doing so, the assessment identified critical processes that are important, uncertain, and difficult to control and worked to identify key components of resilience and possible actions to assure that the system remains resilient.

and transmission of local and traditional knowledge is strongly dependent on its practice (Ingold 2000). In places where traditional practices still support livelihoods and access to the resource base is assured, practice-based knowledge thrives.

When institutions change (as when rules governing access to resources change or when changes in economic conditions result in the disuse of certain resources), local and traditional knowledge may be eroded or lost. In San Pedro de Atacama and the Eastern Himalayas, the decline in the economic significance of traditional agriculture and crafts has led to the abandonment of some local and traditional knowledge. However, indigenous knowledge is dynamic—as some knowledge and practices are lost, other kinds of knowledge and practices are elaborated (Berkes 1999). In San Pedro de Atacama, efforts are under way to link indigenous culture and knowledge to the tourism industry. The indigenous population, represented by the Consejo de Pueblos Atacameños (Atacameño People's Council), is undergoing a process to recover and affirm its identity, which includes the expression of cultural and spiritual values connected to the ecosystem. Indigenous people are looking to develop a leading role in the growing tourism industry by infusing these particular cultural features into tourism activities (ethnotourism and agrotourism).

Discussion of decision-making and empowerment of local people requires not just including their knowledge, but also dealing with local and community institutions regarding the acquisition, treatment, and transmission of knowledge. For local communities to participate in decision-making at higher levels of political organization, these knowledge institutions need to be functional, either recreated or newly established. The Sweden KW and India Local assessments were embedded in institutional structures designed to enable interactions among knowledge held at different scales (and with different amounts of power). The India Local assessment evolved both in response to a perceived lack of interaction between science and local knowledge (Gadgil et al. 2003) and the changing policy structure that enabled natural resource management and use of local knowledge at the local level (Gokhale and Gadgil 2004). In Richtersveld National Park, the importance of local people in conservation was recognized by ensuring protected use rights (SAfMA). In San Pedro de Atacama, national laws were passed to protect indigenous rights, but implementation at the local level involves new, nontraditional institutions reaching out to local communities; the assessment team chose to work at the local level because of local people's distrust of local institutions. The Vilcanota and Bajo Chirripó assessments attempted to create space to begin a dialogue between local communities and higher level decision-makers.

The success of each of these efforts can only be evaluated with more time. However, in the three assessments most committed to ensuring that local knowledge is heard at higher levels (India Local, Vilcanota, and Bajo Chirripó), key community members who have also been trained in the scientific worldview were important for the bridging of knowledge systems.

5.5 Lessons Learned: Incorporating Multiple Knowledge Systems in Future Assessments

Many sub-global assessments demonstrated a real will and desire to engage with local and traditional knowledge holders and other non-scientist assessment users. Most assessment teams were multidisciplinary and involved multiple stakeholders. The analysis in this chapter focused more on the use of local and traditional knowledge than on the synergies and conflicts among various disciplines and stakeholders.

The sub-global assessments that used local and traditional ecological knowledge reported on the utility of such knowledge for assessment. Most importantly, the assessments stressed the value of this knowledge for the daily livelihood practices and strategies of most local resource users. However, the outcomes of these efforts to include more than just scientific knowledge varied greatly according to:

- the level of effective participation of local users and their role in decision-making;
- the development of capacity in local institutions to work with local and traditional knowledge;
- the strength or intactness of local and traditional knowledge systems;
- the interest and will on the part of local communities and other assessment users;

Table 5.5. Institutions, Scale, and Knowledge Systems in Selected Sub-global Assessments (Information from assessment reports)

Sub-global Assessment	Knowledge Systems Used in Assessment	Scale at which Institution that Uses the Knowledge Operates	Interaction of Knowledge Systems across Different Scales
Sweden KW	combined and collaborative (science, decision-maker, and local resource user)	cross-scale: EKV (along with social networks) local scale: recent initiatives for learning in schools; stewards associations	the EKV documents interpreted local knowledge for higher scales, and enables local management by connecting to these higher-level decision-makers stewards associations enabled horizontal sharing of knowledge
SAfMA	science local	legitimized at the national, regional scales often most important for local scale but little "power" at any scale; social networks and rituals at local level maintain its use	little interaction of science with local knowledge, though assessment tried to facilitate this; science still the basis for decisions at national level; local knowledge used for "survival"; local knowledge threatened by historical weakening and economic trends in Richtersveld National Park, local people important to conservation efforts and their participation is institutionalized
Northern Range	science	national, in the form of research organizations, public agencies, individuals	science has multiple cross-scale interactions: global, regional, and sub-national
San Pedro de Atacama	science traditional	national and local—for mining, tourism patchy local (elders hold it; only used for pastoral, agricultural activities); other local users try to protect local and traditional knowledge from further weakening national: law encourages participation in development and resource management	science still dominates ecosystem management at all scales "national" institutions assisted local social institutions trying to revive traditional knowledge for social identity purposes
India Local	combined and collaborative local and traditional ecological knowledge	People's Biodiversity Register (PBR) used at both local and national scales	PBR enabled science and local knowledge interactions and use for both local and national decisions
Eastern Himalayas	science local	dominates at local and higher levels via importance to economic activities survives at local level if artisan families still transmit; only use of knowledge can preserve local and traditional knowledge, which is threatened by disuse and decline in economic importance; no local control over resources	interaction between science and local people constrained by differences in logic and worldviews
Bajo Chirripó	indigenous local	local, via internal mechanisms; indigenous spiritual beliefs being lost, so social processes such as education being used to support its continued use	assessment a process for cultural validation, and recovery of knowledge allowed local people to interact with higher scales
Vilcanota	indigenous science	at the local scale, customs maintained; many involve rituals functions at national and higher scale	assessment aimed to achieve interaction of local and indigenous people with science and government (at higher levels) by empowering local people with the assistance of scientists and international donors science chose to defer to local knowledge for the assessment

Tropical Forest Margins	international research science	important at global level; expected to transfer to national institutions; increasingly learning from national and local	interaction at global and national scales enabled because the Tropical Forest Margins assessment was a boundary organization; coordination office provided institutional memory for interdisciplinary learning
	national research science	national and local research institutions important for training and learning	
	local	local; migrants bring outside knowledge from different locations	process-based knowledge worked better than location-specific knowledge for migrants, as well as for integration with science
Sinai	science	national and higher	science does not consult with Bedouins, although in the area of medicinal plants, interest is growing
	local, indigenous	special protection for knowledge on ecosystems and human well-being as they rely on it in crisis; local traditions, community regulation, and legal norms protect it; intergenerational transmission via stories and tribal meetings	

- the predisposition of the sub-global assessment team toward including local/traditional, practitioner, and multidisciplinary knowledge;
- the amount of time and funds devoted to the process of using multiple knowledge systems in the sub-global assessments; and
- the level of expertise and/or training available to guide the investigation and use of multiple knowledge systems in the sub-global assessments.

The first four factors, though distinct from an assessment process, can be specifically built into the process, or influenced during the initial stages of attracting interest in an assessment. The latter three can be designed and modified at the beginning of or during an assessment process. Future assessments would be wise to carefully consider how best to allocate time, resources, and expertise according to the availability and importance of different types of information and knowledge sources.

The impact of using local and traditional ecological knowledge was generally limited by the overall weakness of understanding how to best utilize multiple knowledge systems within the MA, as reflected in the conceptual framework, MA policy and methods, the type of scientists writing the assessments, and the composition of the assessment teams themselves. This problem is best illustrated by the absence of a chapter in the MA conceptual framework report (MA 2003) that discusses theoretical and practical issues around using multiple knowledge systems. This contrasts with separate chapters devoted to each of the other components of the MA framework: ecosystem goods and services, drivers, multiscale assessments, and responses.

The contributions of practitioner knowledge were largely limited by the MA assessment processes, which consulted with government officials, development agencies, local authorities, and NGOs to find out what their information needs were, rather than to investigate the type of knowledge these practitioners have about the management of social-ecological systems. Fuller engagement of assessment users and other practitioners as knowledge holders would require more attention to how NGOs and ministries use and acquire knowledge in policy- and decision-making. This is, as already noted, a fairly new field of inquiry mostly conducted by political scientists, institutional theorists, and some researchers attempting to better influence policy processes. Only the Tropical Forest Margins assessment seriously analyzed its own policy–research interactions.

Numerous scholarly and practical analyses exist on the issues of multidisciplinary research, participatory research and assessments, and the policy relevance of research. However, considerable transaction costs are involved in multidisciplinary and multistakeholder research. Working with local and traditional knowledge holders also requires time to build trust. The sub-global assessments had to weigh the trade-offs involved in achieving results versus working through the transaction costs of building a broad coalition. Recent work has shown that as social learning occurs, and firm working relationships are established, these costs are likely to decrease. In both Sweden KW and Tropical Forest Margins, networks had been functioning for at least ten years, and relationships were well established before the assessments began. In Sweden KW, the existing institution, the EKV, which has been in place since 1989, has the sole purpose of coordinating among knowledge systems and facilitating social networks that arise to resolve particular problems. The assessment was able to take advantage of this to avoid the transaction costs that other assessments had to face. The Tropical Forest Margins assessment team had also been working together for ten years; team members consciously reflected on the efforts required in the first few years to learn how to work together and appreciate all points of view. As a result, communication across disciplines and interests improved considerably.

Key issues that have been problematic for the sub-global assessments—knowledge documentation, validation, and use—can be addressed in two ways. First, local and traditional ecological knowledge documentation usually either requires leadership by the local people/communities involved or else an assessment team well trained in cross-cultural and participatory techniques. The validation process at the local level should not require the verification of local and traditional ecological knowledge against the standards of science. Instead, local methods of validation should

be upheld. Second, the assumption in the MA conceptual framework was that successful assessments share three basic features: they are scientifically credible, politically legitimate, and salient (that is, responsive to decision-makers' needs). It is questionable whether a small farmer, for example, who has expert knowledge, is a decision-maker at higher levels, beyond his or her day-to-day livelihood decisions. It is therefore necessary to understand the cross-scale institutional structure in which knowledge is used and decisions are made in the current location of an assessment. Future sub-global assessments, especially at the local level, could benefit from an analytical framework that more closely links institutions and knowledge. The scholarly literature on this is not as accessible to a wide range of readers as would be desirable, but an assessment process that truly bridges different knowledge systems should strive to overcome this problem.

The MA conceptual framework regarded elements of ecosystems as services and presented nature as ''other,'' something that people might act on or exploit but from which their lives are ontologically distinct. Yet, as this chapter illustrates, perceptions of ecosystem services vary across cultures. Thus the MA worldview may exclude key alternative local framings, such as a dynamic landscape perspective that views biological patterns throughout the region as being shaped through the interaction of social and ecological processes over time (Fairhead and Leach 2003; Batterbury and Bebbington 1999). The conceptual framework did, however, provide opportunities for modification and expansion, and some sub-global assessments incorporated other frameworks that challenged normal science and drew upon complexity science. There is much to learn from these adaptations of the MA conceptual framework as they challenge conventional scientific perspectives of ecosystems and human impacts within them.

In terms of methods, although each assessment reports using a range of participatory tools, it is far more difficult to tell what level of participation local users achieved (consultative or collaborative), and how much space the assessment created for mutual reflection and consideration of the offerings of multiple knowledge systems to the assessment goals and objectives. The task of an integrated assessment is particularly difficult, and demands extensive resources, since it needs to recognize the multidimensional nature of impacts, but also requires methods that are sensitive to a plurality of perspectives from diverse intellectual disciplines (MA *Policy Responses,* Chapter 3).

In terms of empowerment of local and indigenous resource users, there are only two clear examples of where the local populations were engaged to the extent that they took the lead in assessment design and implementation (Vilcanota, Bajo Chirripó). This could potentially happen in more local assessments if some of the previously identified conditions are met, such as the existence or establishment of local institutions that provide the catalyst for local knowledge to take the lead and engage science instead of the other way around. Another important condition that would help promote local leadership and empowerment is the involvement of expertise (whether local or from outside the communities) to facilitate mutual understanding so that one knowledge system is not dominated by another. Empowerment involves more than using local knowledge at a higher scale—it also means recognizing the intrinsic value and complexity of local knowledge as well as the existence of local institutions, and their ability to take the lead in the assessments and in the control over resource allocation and results of the assessments.

Each assessment was additionally confronted with practical implementation constraints. Common constraints included: limited funding, lack of data and information, and time constraints (due to the voluntary nature of the expert contributions and to the tight MA timeframe). Particularly important were the lack of local and technical expertise to conduct the assessment and to deal with conflicting knowledge, and lack of familiarity with appropriate tools and methods with which to study local knowledge systems. For example, SAfMA found that time constraints allowed for communities to respond to the scenarios that were presented to them, but not to evaluate these responses and apply critical thought (Cundill et al. 2004).

Thus the assessments' efforts to include local/traditional ecological knowledge varied in ability to cover all of the issues pertinent to the MA, for example envisioning plausible futures and suggesting policy responses. Local and traditional ecological knowledge contributes to policy recommendations and management practices if a strong and external institutional structure is in place, as in India Local, and Sweden KW. It is quite possible, in the two cases that took a more collaborative approach to working with local knowledge (Vilcanota, Bajo Chirripó), that with more time, a process for articulating local knowledge and linking it to decision-making processes may evolve. However, in the short term, the sub-global assessments have largely limited the role of local and traditional knowledge to a consultative one, helping to describe the state of ecosystems and human well-being within an established framework, but not taking full advantage of this knowledge system.

Using practitioner knowledge was also constrained by the MA framework and protocol, in that practitioners were limited by their role as assessment users. While they may also have been knowledge holders and indeed a number of the sub-global assessments reported that they contributed information, their major role was to express information needs, and hence guide the priority questions for the assessment. Knowledge becomes a slippery and value-laden issue when political and power interests are at stake, as they inevitably are in resource management. Future endeavors to assess the links between human well-being and ecosystem condition may well learn from the lessons provided by the MA sub-global assessments. These assessments, several of which are ongoing and will be a continuing source of information, provide a range of community-based case studies by which to examine how local and traditional ecological knowledge, practitioner knowledge, scientific knowledge, and the multiple disciplines therein, may work together for a common goal of sustainable ecosystem management and human well-being.

Appendix 5.1. Policies of the Sub-global Working Group Related to Local Knowledge and Community Assessments

These policies were developed by the Sub-global Working Group in 2002 to help guide their assessments in handling issues related to the use of different forms of knowledge.

Review Procedures

Sub-global assessments may develop review processes tailored to the circumstances of the assessment and the scale at which it is undertaken. Each sub-global assessment must provide a description of its review process to the MA Panel and Board at the time of its approval. Sub-global assessment review processes must meet the following criteria:

- the review process must be independent. An independent party not involved in the governance or operations of the sub-global assessment must have the authority to determine whether reviewer inputs have been sufficient, and whether the comments have been adequately handled;
- relevant governments (for the scale at which the assessment is conducted), NGOs, regional institutions and other organizations as appropriate must be contacted in advance to identify appropriate reviewers, and reviews should be requested from all these sectors;
- reviews should be requested with the aim of obtaining a balanced representation of views within the region involved, and among scientific, technical and socioeconomic perspectives;
- reviewers should include experts involved in the larger and smaller scale assessments within which the assessment is nested, or that are nested within the assessment;
- all written review comments, and the responses to those comments, should be provided in their original language to the MA Secretariat, where they will be kept on file.

Community-based Assessments

Community-based assessments generally will include significant amounts of information gathered from individuals, and based on local, traditional, and/or indigenous knowledge. These assessments should meet the review process criteria described above. In addition, they should also establish a process for ''validating'' information obtained through interviews, or based on such knowledge, as part of the application by the assessment to become a component of the MA. Typically, the validation process should include many, if not all, of the following features:

- self-critical review notes or reflective diaries: the researcher should record information on his or her own perceptions of where information being recorded may be incomplete, biased or in error;
- triangulation: multiple sources of information should be obtained, particularly for critical pieces of information;
- review by communities: members of the community should be given an opportunity to review the findings prior to finalization of the assessment;
- review by stakeholders at higher and lower scales: individuals who may not have detailed local knowledge of the area being assessed, but with knowledge of the region in which the assessment is located, should be given an opportunity to review the findings prior to finalization of the assessment.

For the MA working group assessment reports (including the synthesis report of the Sub-global Working Group), additional requirements exist for the use of information based on personal communication from individuals with local/traditional/indigenous knowledge, or direct input from working group members with such knowledge.

- Metadata concerning the personal communication (e.g. names of people interviewed, dates and types of notes recorded, presence or absence of self-critical review notes by the researcher, sources of triangulation, etc.) should be made available to the Co-Chairs of the working group.
- Where a working group member provides direct input of local/traditional/indigenous knowledge, the working group Co-Chairs should be given the following information:
  - basis for knowledge of the particular issues (e.g., length of time living in the area, individuals from whom historical information was obtained, etc.);
  - names and contact information for 1–2 persons who can be contacted for more information about the source.

References

Abel, T. and J.R. Stepp, 2003: A new ecosystems ecology for anthropology. *Ecology and Society,* **7(3).** Available at www.consecol.org/vol7/iss3/art12/.

Agrawal, A., 1995: Dismantling the divide between indigenous and scientific knowledge. *Development and Change,* **26(3),** 413–439.

Agrawal, A., 2002: Indigenous knowledge and the politics of classification. *International Social Science Journal,* **173,** 287–297.

Alcorn, J., J. Bamba, S. Masiun, I. Natalia, and A.G. Royo, 2003: Keeping ecological resilience afloat in cross-scale turbulence: an indigenous social movement navigates change in Indonesia. In: *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change,* F. Berkes, J. Colding, and C. Folke (eds.), Cambridge University Press, Cambridge, UK, pp. 299–327.

Batterbury, S.P.J. and A.J. Bebbington, 1999: Environmental histories, access to resources and landscape change: An introduction. *Land Degradation and Development,* **10,** 279–289.

Baumann, P., 2000: *Sustainable Livelihoods and Political Capital: Arguments and Evidence from Decentralization and Natural Resource Management in India.* ODI Working Paper 136, Overseas Development Institute, London.

Berkes, F., 1999: *Sacred Ecology: Traditional Ecological Knowledge and Resource Management.* Taylor and Francis, Philadelphia and London.

Berkes, F., 2002: Cross-scale institutional linkages, perspectives from the bottom up. Chapter 9 in: E. Ostrom, T. Dietz, N. Dolsak, P.C. Stern, S. Stonich and E.U. Weber (eds.), *The Drama of the Commons.* National Academy Press, Washington, DC, pp. 303–321.

Berkes, F., J. Colding, and C. Folke, 2000: Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications,* **10,** 1251–1262.

Berkes, F., J. Colding, and C. Folke, 2003: *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* Cambridge University Press, Cambridge, UK.

Berkes, F. and C. Folke (eds.), 1998: *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience.* Cambridge University Press, Cambridge, UK.

Blaikie, P. and J. Soussan, 2001: Understanding policy processes: Livelihood Policy Relationships in South Asia, Working Paper Number 8. Leeds University.

Borofsky, R., 1994: On the knowledge and knowing of cultural activities. In: *Assessing Cultural Anthropology,* R. Borofsky (ed.), Hawaii Pacific University, Hawaii, pp. 331–347.

Brokensha, D., D.M. Warren, and O. Werner (eds.), 1980: *Indigenous Knowledge Systems and Development.* University Press of America, Lanham, MD.

Brosius, J.P., 2004: What counts as local knowledge in global environmental assessments and conventions? Paper presented at *Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Multi-Scale Assessments,* March. Alexandria, Egypt.

Bryman, A., 2004: *Social Science Research Methods*. Oxford University Press, Oxford.

Carpenter, S.R., 2002: Ecolgical futures: Building an ecology of the long now, *Ecology* **83,** 2069–2083.

Carpenter, S.R., W.A. Brock, P.C. Hanson, 1999: Ecological and social dynamics in simple models of ecosystem management, *Conservation Ecology* **3(2),** 4. Available at http://www.consecol.org/vol3/iss2/art4.

Cash, D.W. and S.C. Moser, 2000: Linking global and local scales: Designing dynamic assessment and management processes. *Global Environmental Change,* **10,** 109–120.

Chambers, R., 1994: Participatory Rural Appraisal (PRA): Analysis and experience. *World Development,* **22,** 1253–1268.

Chambers, R., 1997: *Whose Reality Counts?* IT Publications, London.

Cleaver, F., 2001: Institutions, agency and the limitations of participatory approaches to development. In: *Participation: The New Tyranny?,* B. Cooke and U. Kothari (eds.), Zed Books, London, pp. 36–55.

Colson, E., 1984: The reordering of experience: Anthropological involvement with time, *Journal of Anthropological Research* **40**:1–13.

Crewe, E. and J. Young, 2002: *Bridging Research and Policy: Context, Evidence and Links*. RAPID Working Paper 173, Overseas Development Institute and Global Development Network, London.

Cundill, G., C. Fabricius, and N. Marti, 2004: Foghorns to the future: Using knowledge and transdisciplinarity to navigate the uncharted waters of complex social-ecological system. Paper presented at *Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Multi-Scale Assessments,* March. Alexandria, Egypt.

Davidson-Hunt, I. and F. Berkes, 2003: Learning as you journey: Anishnaabe perception of social-ecological environments and adaptive learning. *Conservation Ecology,* **8(1),** 5. Available at www.consecol.org/vol8/iss1/art5.

Ellis, F., 2000: *Rural Livelihoods and Diversity in Developing Countries*. Oxford University Press, Oxford.

Ellis, F. and H.A. Freeman, 2002*: Rural livelihoods and poverty reduction strategies in four African countries*. LADDER Working Paper 30, University of East Anglia, Norwich.

Fabricius, C., R. Scholes, and G. Cundill, 2004: Mobilising knowledge for ecosystem assessments. Paper presented at *Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Multi-Scale Assessments,* March. Alexandria, Egypt.

Fairhead, J. and M. Leach, 2003: Practising ''biodiversity'' in Guinea: Nature, nation and an international convention. *Oxford Development Studies,* **31(4),** 427–439.

FAO, 2001: *Women—Users, Preservers and Managers of Agrobiodiversity*. FAO Sustainable Dimensions Gender and Development Fact Sheet, Food and Agriculture Organization of the United Nations, Rome.

Feyerabend, P., 1987: *Farewell to Reason*. Verso, London.

Four Directions Council, 1996: *Forests, Indigenous Peoples and Biodiversity: Contribution of the Four Directions Council to the Secretariat of the Convention on Biological Diversity,* Four Directions Council, Lethbridge.

Funtowicz, S.O. and J.R. Ravetz, 1993: Science for the post-normal age. *Futures,* **25(7),** 739–755.

Gadgil, M., P. Olsson, F. Berkes, and C. Folke, 2003: Exploring the role of local knowledge in ecosystem management: Three case studies. In: *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change,* F. Berkes, J. Colding, and C. Folke (eds.), Cambridge University Press, Cambridge, UK, pp. 189–209.

Gallopin, G., S. Funtowicz, M. O'Connor, and J. Ravetz, 2001: Science for the 21st century: From social contract to the scientific core. *International Social Science Journal,* **168,** 219–229.

Gokhale, Y.M. and M. Gadgil, 2004: Evolving institutional mechanisms for bridging scales and epistemologies—An Indian case study. Paper presented at *Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Multi-Scale Assessments,* March. Alexandria, Egypt.

Groffman, P.M. and M.L. Pace, 1998: Synthesis: What kind of a discipline is this anyhow? In: *Successes, Limitations, and Frontiers in Ecosystem Science,* M.L. Pace and P.M. Groffman (eds.), Springer-Verlag, New York, pp. 473–481.

Gunderson, L. and C.S. Holling, 2002: *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press, Washington, DC.

Guston, D.H., 1999: Stabilizing the boundary between politics and science: The role of the Office of Technology Transfer as a boundary organization. *Social Studies of Science,* **29(1),** 87–112.

Hanna, S.S., C. Folke and K.-G. Mäler, 1996: Property rights and the natural environment. In: *Rights to Nature: Ecological, Economic, Cultural, and Political Principles of Institutions for the Environment*. K.-G. Mäler (ed.), Island Press, Washington, DC, pp. 1–10.

Heemskerk, M., K. Wison, and M. Pavao-Zuckerman, 2003: Conceptual models as tools for communication across disciplines. *Conservation Ecology,* **7(3),** 8. Available at http://www.consecol.org/vol7/iss3/art8.

Holland, J. and J. Blackburn (eds.), 1998: *Whose Voice? Participatory Research and Policy Change*. Intermediate Technology Publications, London.

Holling, C., 1986: The resilience of terrestrial ecosystems: Local surprise and global change. In: *Sustainable Development of the Biosphere,* W.C. Clark and R.E. Munn (eds.), Cambridge University Press, Cambridge, UK, pp. 292–317.

Ingold, T., 2000: *Perception of the Environment: Essays on Livelihood, Dwelling and Skill*. Routledge, London and New York.

Keeley, J.E., 2001: Influencing policy processes for sustainable livelihoods: Strategies for change. Lessons for Change in Policy and Organizations **2.** Institute for Policy Studies, Brighton.

Lawrence, A. and M. Elphick (eds.), 2002: *Policy Implications of Participatory Biodiversity Assessment*. Summary report, European Tropical Forest Research Network International Seminar for Policy-Makers and Implementers, May 2003, Department for International Development, London.

McCay, B. and J.M. Acheson (eds.), 1987: *The Question of the Commons: The Culture and Ecology of Communal Resources*. University of Arizona Press, Tucson, AZ.

MA (Millennium Ecosystem Assessment), 2003: *Ecosystems and Human Well-Being: A Framework for Assessment*. Island Press, Washington, DC, 245 pp.

Milton, K., 1996: *Environmentalism and Cultural Theory: Exploring the Role of Anthropology in Environmental Discourse*. Routledge, New York.

Moller, H., F. Berkes, P. O'Brian Lyver, and M. Kislalioglu, 2004: Combining science and traditional ecological knowledge: Monitoring populations for co-management. *Ecology and Society,* **9(3),** 2.

Mosse, D., 1998: Process-oriented approaches to development practice and social research. In: *Development as Process: Concepts and Methods for Working with Complexity,* D. Mosse, J. Farrington, and A. Rew (eds.), Routledge, London, pp. 3–30.

Munda, G., 2000: *Conceptualising and Responding to Complexity*. Environmental Valuation in Europe Policy Research Brief 2, Cambridge Research for the Environment, Cambridge, UK.

Nadasny, P., 1999: The politics of TEK: Power and the ''integration'' of knowledge. *Arctic Anthropology,* **36(1/2),** pp. 1–18.

Narayan, D., R. Chambers, M. Kaul Shah, and P. Petesch, 2000: *Voices of the Poor. Crying out for Change*. Oxford University Press, New York, 314 pp.

Olsson, P., C. Folke, and T. Hahn, 2004: Social-ecological transformations for ecosystem management: The development of adaptive co-management of wetland landscapes in southern Sweden. *Ecology and Society,* **9(4),** 2. Available at www.ecologyandsociety.org/vol9/iss4/art2.

Ostrom, E., R. Gardner, and J. Walker, 1994: *Rules, Games, and Common-Pool Resources*. University of Michigan Press, Ann Arbor, MI.

Oviedo, G., L. Maffi, and P.B. Larsen, 2000: *Indigenous and Traditional Peoples of the World and Ecoregion Conservation: An Integrated Approach to Conserving the World's Biological and Cultural Diversity.* World Wide Fund for Nature, Gland, Switzerland.

Pahl-Wostl, C., 2003: Polycentric integrated assessment. In: *Scaling Issues in Integrated Assessment,* J. Rotmans and D.S. Rothman (eds.), Swets & Zeitlinger, Lisse, the Netherlands, pp. 237–261.

Pereira, H.M., T. Domingos, and L. Vicente, 2005: Assessing ecosystem services at different scales in the Portugal MEA (unpublished manuscript).

Peterson, G.D., G.S. Cumming, and S.R. Carpenter, 2003: Scenario planning: A tool for conservation in an uncertain world. *Conservation Biology,* **17(2),** 358–366.

Pritchard, J.L. and S.E. Sanderson, 2002: The dynamics of political discourse in seeking sustainability. In *Panarchy: Understanding Transformations in Human and Natural Systems,* L.H. Gunderson and C. Holling (eds.), Island Press, Washington, DC, pp. 147–169.

Popper, K.R. [1945] 1950: The sociology of knowledge. In: *The Open Society and Its Enemies*. Princeton University Press, Princeton, pp. 211–233.

Reid, W., 2004: Bridging scales and epistemologies in the Millennium Ecosystem Assessment. Paper presented at *Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Multi-Scale Assessments,* March. Alexandria, Egypt.

Rocheleau, D., B. Thomas-Slayer, and E. Wangari (eds.), 1996: *Feminist Political Ecology: Global Issues and Local Experiences*. Routledge, New York.

Satterthwaite, A., 1996: *Public Voices and Wilderness in Environmental Assessment: A Philosophical Examination of Resource Policy Decisions*. Ph.D. Dissertation, York University, UK.

Schoonmaker Freudenberger, K., 1998: The use of RRA to inform policy: tenure issues in Madagascar and Guinea. In: *Whose Voice? Participatory Research and Policy Change,* J. Holland and J. Blackburn (eds.), Intermediate Technology Publications, London, pp. 67–79.

Scoones, I., 1999: New ecology and the social sciences: What prospects for a fruitful engagement? *Annual Review Anthropology,* **28,** 479–507.

Scott, J.C., 1998: *Seeing Like a State*. Yale University Press, New Haven and London.

Singhal, R., 2000: A model for integrating indigenous and scientific forest management: Potentials and limitations for adaptive learning. In: *Forestry, Forest Users and Research: New Ways of Learning,* A. Lawrence (ed.), European Tropical Forest Research Network Publication Series 1, Waginengen, the Netherlands, pp. 133–140.

Smith, L.T., 1999: *Decolonizing Methodologies: Research and Indigenous Peoples,* Zed Books, St. Martin's Press, London and New York.

Steward, J., 1955: The concept and method of cultural ecology. In: *Theory of Culture Change: The Methodology of Multilinear Evolution,* University of Illinois Press, Urbana, pp. 30–42.

Steward, J., 1955: *The Concept and Method of Cultural Ecology—Theory of Culture*. University of Illinois Press.

Stone, D., S. Maxwell, and M. Keating, 2001: *Bridging Research and Policy*. Paper presented at *Bridging Research and Policy Conference*. Department for International Development, Warwick University.

Sustainable Livelihoods in Southern Africa Team, 2003: *Decentralizations in Southern Africa*. Program for Land and Agrarian Studies, University of the Western Cape, Cape Town.

Tomich, T.P., J.C. Alegre, V. Areskoug, A. Cattaneo, J. Cornelius, et al., 2004: The challenges of integration: Report of an on-line consultation among researchers of the Alternatives to Slash-and-Burn (ASB) Programme. Paper presented at *Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Multi-Scale Assessments,* March. Alexandria, Egypt. Available at http://www.asb.cgiar.org/PDFwebdocs/Tomich_etal_2004_TheChallengeofIntegration_2.2.pdf.

Turner, N.J., 2004: *Plants of Haida Gwaii*. Sono Nis Press, Winlaw, British Columbia.

van Asselt Marjolein, B.A. and N. Rijkens-Klomp, 2002: A look in the mirror: Reflection on participation in integrated assessment from a methodological perspective. *Global Environmental Change,* **12,** 167–184.

Warren, D.M., L.J. Slikkerveer, and D. Brokensha (eds.), 1995: *The Cultural Dimension of Development: Indigenous Knowledge Systems*. Intermediate Technology Publications, London.

Wilbanks, T.J., 2003: Geographic scaling issues in integrated assessments of climate change. In: *Scaling in Integrated Assessment,* J. Rotmans and D.R. Rothman (eds.), Swets & Zeitlinger, Lisse, the Netherlands, pp. 5–34.

Woodley, E., 2005: Local and indigenous ecological knowledge as an emergent property at a complex system: A case study in the Solomon Islands. In: *Source Book on Participatory Research and Development,* CIP-UPWARD, IDRC, and IFAD (in press).

Young, O.R., 2002: Institutional interplay: The environmental consequences of cross-scale linkages. Chapter 8 in E. Ostrom, T. Dietz, N. Dolsak, P.C. Stern, S. Stonich, and E.U. Weber (eds.), *The Drama of the Commons*. National Academy Press, Washington, DC.