CHAPTER 17

Conclusions

Bridging Scales and Knowledge Systems

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Bridging Scales and Knowledge Systems is not an assessment of available knowledge—like its parent, the Millennium Ecosystem Assessment (MA)—nor is it a scientific review. Rather, it is a set of papers exploring issues related to bridging scales and knowledge systems, in particular those concerning the intersection of the two in scientific assessments. The idea of building bridges across scales and knowledge systems is not novel. Geographers have been dealing with scale issues for decades, and a sophisticated literature exists on scale and environmental management (e.g., Cash and Moser 2000). Similarly, the idea of seeking bridges across knowledge systems goes back at least to the 1950s, to C. P. Snow's famous analysis of the divide between the sciences and the humanities (Snow 1993).

Although much experience with global and large regional assessments exists, understanding the processes that affect ecosystem services and human well-being also requires attention to subglobal levels and the plurality of scales and epistemologies. What happens at the global level cannot simply be scaled down to provide an understanding on the ground, and what happens at the local level cannot simply be scaled up to interpret global phenomena (Young 2002). Scale does truly matter (see chapter 2 of this volume). Understanding a complex system, such as a global ecosystem, requires an understanding of all the levels in a hierarchy and the relations among them.

In terms of epistemology, relevant questions include the following:

- What is the appropriate kind of knowledge to deal with ecosystem services and human well-being?
- How should assessments deal with diverse kinds of knowledge, including knowledge held by those who live in a particular place?
- How and to what extent is bridging these knowledge systems possible, desirable, and doable?

A strong argument has been made for searching and accessing the full range of available knowledge (see chapters 9, 10, and 11). However, bringing different epistemologies to the same table is not without its transaction costs. What constitutes legitimate knowledge? How can one mediate between kinds of knowledge in a way that helps the decision maker use the most relevant information and interpretation regarding a particular issue? There is a "politics of knowledge" (chapter 7), just as there is a "politics of scale" (chapter 3).

The twin problems of scale and epistemology are coming under scrutiny in several efforts tackling the broader context of environmental issues (e.g., Walker et al. 2004; Kates et al. 2001). The 1992 United Nations Conference on Environment and Development in Rio de Janeiro drew attention to the significance of traditional knowledge. The Implementation Plan of the 2002 World Summit on Sustainable Development drew attention to scale by "encourag[ing] relevant authorities at all levels to take sustainable development considerations into account in decision-making" (United Nations 2002, sec. 3.18). The phrase "at all levels" appears eighty-one times in the fifty-page document.

Thus, the issues of both scale and epistemology have been on international agendas related to environmental management. Nevertheless, a systematic approach to investigate issues of scale and knowledge systems *together* is relatively novel. It is this area that the chapters in this book explore in connecting environmental sustainability to human needs. The chapters further the development of assessments by asking the questions of how to address issues of scale, how to embrace different knowledge systems in assessments, and how these two kinds of questions may be related.

Elements of Bridging

Addressing issues of scale and knowledge systems in assessments and dealing with other interlinked aspects of ecosystem management and human well-being require pluralism in ideas and approaches, as argued in postnormal science (Funtowicz and Ravetz 1993) and sustainability science (Turner et al. 2003). All of the chapters in this book make this point either explicitly or implicitly. The scope, complexity, and uncertainties around issues of ecosystem and human well-being interactions make it impossible for any one perspective, discipline, or approach to monopolize the answers and solutions. Thus, pluralism that recognizes differences in people's values, interests, institutions, or practices as legitimate and autonomous while also helping people work together in a coherent, mutually beneficial way is a practical necessity.

The growing realization that conventional science based on Western paradigms and systems of knowledge is no longer adequate to deal with complexities of environmental management (Ludwig 2001) and that knowledge is contextual has opened the space for considering other systems of knowledge in scientific assessments. However, as several authors here stress, scientific assessments are social and inherently political processes in which competing interests, values, worldviews, and options for action are negotiated. The definition of boundaries, the selection of scale, and the explicit or implicit framing of hierarchy of values and systems of knowledge are all part of this negotiation (chapters 3, 7, 8, 11, and 16).

Scientific assessments require sharing of information, deliberative exchanges, or "reasoning together" among key stakeholders—policy makers, resource managers, the private sector, the civil society, and the public at large—which presents opportunities for mutual learning (chapter 16). This mutual learning can constitute one form of bridging scales and knowledge systems. The process of "reasoning together" enhances legitimacy of policies and promotes more democratic environmental governance when the process is designed and managed well, provides for broad representation of stakeholder views, and involves different stakeholders from different levels (chapters 3, 7, and 16).

The cases included in this collection provide examples of attempts to cross the many dividing lines that hinder the communication, mutual learning, participation, and collaboration needed for assessments to successfully address interlinked issues of scale and knowledge. Several strategies have proven critically important for positive outcomes.

First is the recognition and judicious use of a mix of perspectives, methodological approaches, tools, and techniques that allow for broad stakeholder participation and the accommodation of nonformal, undocumented, or localized knowledge (chapters 9, 10, 11, 12, and 16). This includes, for example, exchanging and cross-validating paradigms (chapter 11); complementary use of qualitative and quantitative measures as well as participatory and conventional methods from a range of disciplines (chapters 9 and 14); the combination and innovation of indicators, means of measurement, and monitoring (chapters 10, 12, and 14); and development of shared visions and narratives of a common future (chapter 15).

Second is the use of methodologies and analytical approaches that allow a more complete description and understanding of the relationships across scales and of the similarities and differences of processes and phenomena at different scales. This includes the analysis of scale-dependent and scale-independent factors, the use of upscaling and downscaling techniques, the identification of characteristic scales of different processes or phenomena, and the design of monitoring systems to detect relevant changes at different scales (chapters 2, 4, and 5).

Third is the creation of forums and platforms for negotiation, conflict resolution, decision making, trust building, and joint action. This sometimes requires new mechanisms, such as multistakeholder consultations, and redefinition of roles and patterns of interaction among key actors (chapters 6, 9, and 10). It can also involve creating different types of institutions or finding new ways of responding to threats and opportunities (chapters 12 and 13) and providing for flexibility to allow for additional interested stakeholders to participate (chapter 10).

Fourth is capacity building and development of new skills for cross-scale analysis (chapter 2) and new skills among stakeholders, particularly those who have traditionally been excluded or marginalized (chapter 12). Training, exposure, and other modes of experiential learning can help level asymmetries in information, skills, and levels of confidence among stakeholders and can facilitate communication and more mutually beneficial interactions across the various divides (chapters 10 and 14).

Fifth is facilitation, mediation, and translation of information and meanings between and among stakeholders. Individuals, groups, or organizations can play these roles that have proven essential to bridging across scales and systems of knowledge (chapters 6, 7, 10, 11, 12, and 14). This includes reporting back

on assessment results and research findings to informants and participating stakeholders, which unfortunately is rarely practiced (chapters 10 and 14).

Bridging Knowledge Systems

If one point of agreement exists among the authors, it is that bridging knowledge systems is not easy. However, most agree that it is nevertheless important and necessary. The barriers to bridging include power differences (chapters 7 and 8), centralization and domination of decision making by government (chapters 8, 14, and 16), and scientists' common lack of respect for local and traditional knowledge (chapters 8 and 14). This list of barriers is not meant to be comprehensive. Other barriers also exist, including the following two that emerge from the analysis by Ericksen et al. (2005) of subglobal MA cases: (1) the lack of a common "language" and of an agreed set of assumptions about how the world works, and (2) the absence of a common means of verifying the veracity of knowledge.

The issue of power as a barrier to bridging is a systemic difference from which a number of other barriers emerge. In fact, the power issue is so fundamental that an entire school of thought argues that indigenous knowledge and science should not be bridged. According to this argument, "bridging" results only in taking indigenous knowledge out of its cultural context and inserting it into the very structures that disempower indigenous people in the first place. This not only perpetuates but also exacerbates existing power imbalances (Nadasdy 1999). Some argue that the politics of power may mean that an attempt at bridging could result only in co-option (box 17.1).

Power differences are a problem not only with indigenous communities but also with other minorities and perhaps with resource-dependent rural groups in general. The issue is recognized in the development literature in Sen's treatment (1999) of the idea of development as being all about human empowerment. It follows, therefore, that mechanisms for bridging need to address the issue of power, among the various other barriers.

Joint problem solving, which appears in several chapters, is one mechanism to help indigenous knowledge holders operate as equals with scientists and technical people. In the Arctic Borderlands Ecological Knowledge Co-op (discussed in chapter 10), aboriginal parties are engaged with scientists in long-term joint management of the environment. When local experts from the Gwich'in community of Old Crow reported that wetland lakes were drying up,

Box 17.1

Indigenous People's Views on Risks Associated with Bridging Knowledge Systems

Participants from indigenous groups in the workshop "Bridging Epistemologies—Indigenous Views," held during the Bridging Scales and Epistemologies Conference in Alexandria, Egypt (March 17–20, 2004), prepared a summary of the workshop in the form of comments made during the workshop. The comments included the following.

- A bridge between epistemologies is not possible or not desirable, because it produces invasion and domination. We can only—consciously—sit down at a table of negotiation and dialogue in a world where many worlds (or epistemologies) are welcome, where we can talk between us, and also talk with modern science.
- There is an ethical responsibility for scientists to be clear about the values, world-views and cosmovisions that are embedded in their approaches to ecosystem assessment and whose purposes are being served by that assessment. Scientists and development agents need to be critical and clear about the risks and benefits for indigenous people from assessing ecosystem goods and services, and of course they need to engage indigenous people in this risk assessment from the outset and develop mutually agreed positions.
- Local people can easily cross the bridge to modern science. As a matter of fact, they have been trying to adjust to the modern world dominated by modern science for generations. Because of the assimilationist attitude of modern science, local people have started to realize the losses of their identity, culture and self.
- To build bridges, indigenous communities need to be empowered to translate their own science in a culturally appropriate way for all people to understand and move forward and thus control how and where traditional knowledge is used, without outsiders being the "expert."

scientists followed up on these observations and confirmed the findings with remote sensing studies. In chapter 11, the task is the in situ conservation of native plants of the Andes. The indigenous people there are in the lead, and outside technical experts come to work with campesinos "with eyes, ears and heart wide open." In chapter 12, although technical experts produce the weather forecasts for communities in semiarid southeastern India, their communication to the local level strongly depends on understanding and valuing villagers' perceptions of rainfall prediction.

The development of working relationships among holders of different kinds of knowledge takes time, typically on the order of ten years based on the

comanagement literature (Berkes 2002). Hence, the ten-year-old case in chapter 10 is not an exception. Mutual trust and respect, both of which are slow to build, are preconditions for bridging epistemologies, because trust lubricates collaboration (Pretty and Ward 2001). The building of both trust and mutual respect can be assisted through appropriate institutional arrangements. Both are important for the social learning that can arise from collaborative problem solving, consistent with Wenger's emphasis (1998) on learning as participation.

Several of the cases in this book involve what Cash and Moser (2000) have called "boundary organizations." Originally, the term applied to organizations at the scientist–decision maker boundary. But more broadly, the term may apply to organizations that mediate the relationship of science to local and traditional knowledge and that stimulate collaboration. In chapter 11, the Andean Project for Peasant Technologies plays this role. In chapter 12, it is the community-managed village knowledge centers. In chapter 10, it is the Arctic Borderlands Co-op itself.

A unique mechanism for bridging involves the use of scenarios (chapter 15). The authors report on four MA experiences that used scenario development as a method for incorporating multiple epistemologies. The results seem mixed but promising; "storytelling" as the basic idea behind scenario development works well with indigenous thinking. In chapter 15, Bennett and Zurek consider the experiences successful in generating and integrating both qualitative and quantitative information into the scenarios. However, one needs to be cautious about the issue of "what counts as knowledge," given that there could be a major gap between "local locals" who often speak in metaphors and indigenous advocates who claim to speak for them (chapter 7).

Some of the various ways of bridging knowledge systems are summarized in table 17.1. In the first three cases, knowledge production is local and knowledge integration is generally guided by the local partner. In the other four cases, local knowledge and views supplement the scientific and technical approach or are integrated into it (or both).

Bridging Scales

An objective of "bridging scales" can mean a variety of things: understanding how processes and phenomena differ according to scale (geographic, temporal, or institutional), understanding how processes and phenomena interact across different scales, and focusing on a single scale of interest but ensuring

Table 17.1

Characterizing the cases in this volume by style of knowledge bridging and the degree to which the bridging process is dominated by one kind of knowledge or another

Case	How Knowledge Systems Are Bridged
Conservation of Andean cultivated plants (chapter 11)	Technical experts contribute to plant biodiversity assessment, within a framework guided by an indigenous approach to in situ conservation and indigenous worldview (cosmovision).
People's biodiversity registers (chapter 13)	Biodiversity management committees, organized at the level of municipalities and village councils, document local biodiversity and associated knowledge at the grass roots.
Arctic Borderlands Ecological Knowledge Co-op (chapter 10)	Ecological monitoring uses both kinds of knowledge in a program designed to involve the two kinds of knowledge and knowledge holders as equal partners.
Rainfall prediction in Tamil Nadu, southeast India (chapter 12)	Weather forecasts produced by technical experts respond to community needs and are "translated" by village knowledge centers into practical information that can be used alongside traditional weather forecasting.
Use of scenarios to integrate different kinds of knowledge into four Millennium Ecosystem Assessment cases (chapter 15)	Various stages of scenario development seek to incorporate information and views from more than one body of knowledge through the participation of a diversity of stakeholders and perspectives.
Southern African Millennium Ecosystem Assessment (chapter 9)	Informal and tacit assessments of the local people are brought into the process to improve the robustness and coverage of the assessment.
Portugal Millennium Ecosystem Assessment (chapter 4)	Scenario development is used as a mechanism to fully involve stakeholders in the assessment process. In addition, a qualitative approach to ranking the condition of ecosystem services provides a mechanism to integrate qualitative and quantitative information.

awareness of the possible importance of a multiscale context (Millennium Ecosystem Assessment 2003).

Approaches to bridging scales have generally involved three kinds of strategies (Wilbanks 2003): (a) integrating scale-related information at a single scale of interest, often either an intermediate ("regional") or a local scale, (b) seeking a metascale synthesis, or (c) concentrating on cross-scale interactions and mechanisms, such as boundary organizations.

Several of the chapters in this volume are concerned primarily with bridg-

ing scales (chapters 2, 4, 5, 9, and 16). Others are multiscale in perspective but not cross-scale in focus (Chapters 6, 10, and 14). Still others are local in perspective but within a larger structural context (chapters 11, 12, and 13), emphasizing potentials to learn from local knowledge. Regardless of the focus, however, all show that environmental assessment is rooted in a definition of the scale of attention, that scale matters (chapters 2 and 3), and that a particular scale cannot be totally divorced from other scales.

Barriers to effective cross-scale analysis are legion. Data are rarely available for processes at all relevant scales; even where comparable data may be available, rarely have studies explored the relevant causal mechanisms for different processes at different scales (chapters 2, 4, and 9). In some cases, relevant information concerning processes at particular scales may be held by local people or practitioners, but the array of barriers to bridging knowledge systems effectively makes it difficult to fully incorporate that knowledge in an assessment (chapters 3 and 10). Where data are available only for certain scales, progress has been made in developing techniques for upscaling and downscaling information; but questions remain about the challenge of understanding what types of information are scale dependent or scale independent (Wilbanks 2003).

Methodologically, the most serious challenges in bridging scales are in tracing out and understanding cross-scale interactions, for two principal empirical reasons. First, most databases are scale specific rather than scale crossing. For example, the regional climate and weather forecast information described in chapter 12 does not include locale-specific information that would ultimately describe the local weather patterns. Second, most environmental analyses and assessments focus on a particular scale of interest rather than on cross-scale linkages and transfers. Partly as a result, conceptual frameworks are also incompletely developed, although some basic dimensions have been identified (chapter 2; see also Association of American Geographers 2003).

As a whole, the chapters suggest a number of directions for further investigation in bridging between scales, although these few studies can hardly be considered the final word (table 17.2). One issue cutting across any discussion of conventional models for bridging scales is the intent of the bridging, especially when the objectives are related to governance and decision making rather than knowledge enhancement (chapter 3; see also MA 2003).

Perhaps most significant of all, taken together the chapters demonstrate

Table 17.2
Approaches for bridging scales

Approach	Examples	How Scales Are Bridged in Assessments	Issues
Integration at a single scale	Chapters 10 and 11; Schellnhuber and Wenzel 1998; Mark 2000.	Use of scenarios; participatory deliberation involving parties knowledgeable about different scales; use of graphics; upscaling and downscaling of data; local experts to assist in data integration and interpretation	Combining quantitative/qualitative data; combining analytical and deliberative processes of reasoning; local capacity; tunnel vision in losing sight of processes at other scales that are of significance
Multiscale synthesis	Chapters 2, 4, 5, 6, and 9; Kasperson, Kasperson, and Turner 1995; Wilbanks 2003	Aligning "issue sets" in comparative attention to different scales; use of scenarios and narratives; acceptance of plurality of views and perspectives; use of graphics; comanagement of assessment processes; use of assessment products	Data availability; lack of consistency in form and quality; lack of comparability in assumptions behind different data sources; frequent shortage of conceptual structures for synthesis; demands for thoughtful and creative deliberation
Single scale but with analysis of cross-scale linkages and flows	Chapters 6 and 14; Association of American Geographers 2003; Cash and Moser 2000	See the cell directly above, especially comanagement	Data limitations; conceptual limitations

that bridging scales is not only desirable but also possible in many cases. This insight can help increase the sensitivity of assessments and the effectiveness of actions based on them. It also shows that the available tools and perspectives are sufficient to support multiscale bridging, even where cross-scale linkage and flow data are limited.

The Intersection of Scale and Knowledge

The interrelationships between issues of scale and knowledge illuminated by the chapters of this book are complex, but several patterns are apparent. First, incorporating multiple knowledge systems can benefit the information content and use of assessments undertaken at any scale, but the "scope" over which

different knowledge systems have the potential to contribute differs across scales. For example, local knowledge of weather indicators adds value to forecasts over periods of days or weeks but is less important for forecasts of seasonal or annual weather variation (chapter 12). Conversely, global scientific information can characterize global patterns of climate change effectively, but it has serious shortcomings in providing solutions given the site-specific context and constraints in which any solution must be implemented (chapter 6).

Because climate change and other complex systems phenomena occur at multiple scales, no single level is the "correct" one for analysis. Climate change cannot be understood at the global level alone, just as it cannot be understood at the local level alone. Since coupling occurs between different levels, the system must be analyzed simultaneously across scale. Hence, the overwhelming emphasis on global circulation models in climate change research has created a mismatch between global science and the knowledge that is needed to act locally (Wilbanks and Kates 1999). Although important elements of the needed local information can be generated from indigenous knowledge, there are limits as to the kind of information that can be accessed or used (Berkes and Jolly 2001).

The scope over which different knowledge systems can contribute is bounded both by scale and by issue, although these boundaries tend to be much more encompassing than is commonly assumed (as illustrated by chapters 10 and 13). But there are limits regarding the kind of useful information. For example, scientific knowledge can add little value to traditional understanding of the local cosmovision, and traditional knowledge will add little value to understanding the paleorecord of Earth's climate history.

Second, no simple scale-dependent hierarchy related to knowledge systems exists. This is not to say that there are no scale-dependent features at all. For example, local and traditional knowledge tends to be more context dependent than scientific knowledge, and thus some aspects of this knowledge may be more relevant or meaningful at local scales. But at the same time, many aspects of this knowledge are highly relevant at other scales. Indeed, as Brosius notes in chapter 7, the tendency has been for scientists to turn to local knowledge holders for their understanding of the natural world (an aspect of knowledge that may be very scale dependent) yet to ignore their knowledge of the political world (an aspect that may be highly relevant at other scales). What emerges is a view of highly overlapping features concerning the value, relevance, and utility of different knowledge systems at different scales.

Depending on the issue and the scale being addressed, the utility of different forms of knowledge may vary. Nevertheless, it would be extremely rare to encounter an issue related to environment and development where multiple knowledge systems (local, traditional, natural science, social science, practitioner knowledge, and so forth) did not add value to the information or the influence of the assessment or both. The design choice is not simply one between a centralized versus decentralized assessment system. Rather, it is one that integrates the unique capacities at the top, bottom, and middle of the scale (Cash and Moser 2000). Since different kinds of knowledge correspond to different scales, bridging both scales and knowledge helps to bring complementary knowledge, skills, and capacity to bear on the assessment challenge.

While the chapters document the potential value of multiple knowledge systems across scales, they also provide clear evidence that society does not take full advantage of this potential. A number of barriers exist. At any given scale, there are few mechanisms to enable the incorporation of different systems of knowledge into an assessment or planning process, and the appropriate mechanism may well differ at different scales. Several chapters in this book examine early attempts to establish such mechanisms (for example, the case studies of participatory fisheries management in Brazil described in chapter 14, the weather forecasting mechanism in India described in chapter 12, or the use of scenarios discussed in chapter 15).

But in many cases these mechanisms are limited by an unsupportive institutional context or a lack of respect or recognition by other stakeholders (chapters 8, 11, and 14). Even where the institutional context is supportive, significant challenges remain. These include the difficulty of developing mechanisms that validate knowledge effectively; difficulties in communicating concepts and ideas; and fundamental gaps in the capacity of people holding different types of knowledge to represent that knowledge effectively in novel processes or arrangements. Box 17.2 provides a practical checklist for environmental assessment practitioners to help address issues of multiple scales and epistemologies.

Finally, the chapters document the fundamental political dimension of this intersection of scale and knowledge. The choice of scale (and the linked choice of what systems of knowledge will contribute most significantly) or the choice of knowledge systems (and the linked choice of what scale will dominate) influences, and is often influenced by, the agenda for decision making; it also influences which interests are most strongly reflected in the findings (chapters 3

Box 17.2

Strategies for Bridging Scales and Knowledge Systems: A Checklist for Assessment Practitioners

- Does the assessment allow for pluralism by recognizing a mix of perspectives?
- Does the assessment recognize a mix of methodological approaches, tools, and techniques that allow for broad stakeholder participation?
- Does the assessment accommodate nonformal, undocumented, or localized knowledge?
- Does the assessment use methodologies and analytical approaches that allow a more complete description and understanding of relationships across scales?
- Does the assessment use methodologies and analytical approaches that allow an understanding of similarities and differences of processes and phenomena at different scales?
- Does the assessment use forums and platforms for negotiation, conflict resolution, decision making, trust building, and joint action?
- Does the assessment undertake capacity building and development of new skills for cross-scale analysis?
- Does the assessment foster the development of new skills among stakeholders, particularly for those who have been usually excluded or marginalized?
- Does the assessment undertake facilitation, mediation, and translation of information and meanings between and among stakeholders?
- Does the assessment facilitate the building of mutual trust and respect between holders of different kinds of knowledge?
- Does the assessment allow for enough time for building mutual trust and respect?
- Are there individuals, groups, or organizations (boundary organizations) involved in the assessment that can play bridging roles?
- Does the assessment report back on assessment results and research findings to informants and participating stakeholders?
- Does the assessment use a variety of modes of communication, including those with heuristic value, such as scenarios and graphics, and processes of group deliberation?
- Are there opportunities for mutual learning?

and 7). Chapter 16 provides a positive vision for how this political dimension, if incorporated into assessment design, could in fact help to democratize environmental governance. But this political dimension also leaves the decision-making process open to strategic interventions by particular stakeholders to shape outcomes in their own interests through the choice of scale. There is

some understanding of this phenomenon in the area of indigenous knowledge (Nadasdy 1999) and comanagement (Agarwal 2001; Berkes 2002), but an explicit recognition of this political dimension of scale and knowledge in the assessment literature is overdue.

Conclusions

The chapters in this book demonstrate that both the information contained in assessments and the influence of assessments can be enhanced by incorporating multiple knowledge systems and multiple scales. No one scale, time frame, or approach to creating knowledge is fundamentally privileged over others. All offer insights, and each has contributions to make. For instance, the book demonstrates the value of global scales in capturing broad understandings from science, technology, and global trends, but also the value of local scales in capturing local knowledge and better understanding of certain processes. It demonstrates the rich texture of realities rooted in local-scale, fine-grained interactions, as sources of learning and essential elements in ensuring that action agendas are effective and equitable, without detracting from the importance of knowledge and resources for action that also exist at more general scales.

Yet, the selection of scale and knowledge systems to incorporate in an assessment is not politically neutral. The choice of scales and sources of knowledge in an assessment may be primarily driven by the desire to enhance the quality of information in the assessment or its use by decision makers, or it may be driven by the desire to empower (or disempower) specific groups or to serve an advocacy role. This political dimension is an inherent feature of assessment design that deserves to be more explicitly recognized by practitioners. While no assessment could be entirely politically neutral, it is clear that assessments that strive to incorporate information and perspectives from multiple scales, and that do not create artificial barriers to legitimate sources of knowledge, are likely to be more credible, balanced, and accurate from the vantage point of all stakeholders.

Addressing scale and knowledge issues *together* brings further potential benefits. Since different kinds of knowledge correspond to different levels, bridging both scales and knowledge helps do a better job than bridging scales or bridging knowledge alone. Different social actors at different levels of organization will possess complementary knowledge, skills, or capacities. The potential efficiency in partnerships can be captured by bringing together these

comparative advantages. Doing so also serves the political problem referred to above, since a single scale and a single knowledge system will be more likely to favor particular stakeholders than will a broader process. In the long run, this approach can help to democratize environmental governance.

Bridging scales and knowledge systems is realistically possible in many cases; it is not just an academic ideal. But significant barriers do exist, and both research and further experience will be needed to reduce those barriers. There is no one formula for bridging knowledge systems or bridging scales; bridging may take one of many forms, as appropriate to the situation. But there are at least three institutional and procedural characteristics shared by the effective experiences described in this volume.

First, boundary organizations often play an important role in helping to bridge scales and epistemologies. To be effective, most institutions must focus on particular scales; we cannot expect all institutions to deal with all scales and all systems of knowledge. But an important niche exists for individuals and institutions that can establish expertise and experience in helping to promote information flow and analysis across scales and across knowledge systems.

Second, processes designed to bridge scales and knowledge systems require considerable time and effort. Time is needed to address many logistical and procedural issues, such as agreeing on a conceptual framework and harmonizing the data. Most important, time is necessary for building trust and developing mutual respect, the two preconditions for effective bridging processes.

Third, bridging usually calls for using a variety of communication modes rather than choosing a single "optimal" mode. It is very rare that a single mode of communication will in fact be optimal at all scales and for all different knowledge systems. In the experiences examined in this volume, the most effective mechanisms for communication were typically those with strong heuristic value, such as scenarios and graphics, and processes of group deliberation, such as scenario building and visioning.

The costs in both time and expenses associated with assessment processes that embrace multiple scales and multiple knowledge systems can be high, and depending on the goal or purpose of an assessment, these costs may not be easy to justify. Historically, it has been the exceptional assessment that has used multiple scales or multiple knowledge systems. But in our view, we are now at a stage where it should be assumed that an assessment process would address multiple scales and incorporate multiple relevant systems of knowledge, unless

a more limited assessment could be justified. The benefits of bridging are clear, and while many obstacles remain, a wide array of methods, tools, and examples now exists that can inform future assessments.

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