



Review

Monitoring in adaptive co-management: Toward a learning based approach

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ABSTRACT

The recognition of complexity and uncertainty in natural resource management has led to the development of a wealth of conceptual frameworks aimed at integrated assessment and complex systems monitoring. Relatively less attention has however been given to methodological approaches that might facilitate learning as part of the monitoring process. This paper reviews the monitoring literature relevant to adaptive co-management, with a focus on the synergies between existing monitoring frameworks, collaborative monitoring approaches and social learning. The paper discusses the role of monitoring in environmental management in general, and the challenges posed by scale and complexity when monitoring in adaptive co-management. Existing conceptual frameworks for monitoring relevant to adaptive co-management are reviewed, as are lessons from experiences with collaborative monitoring. The paper concludes by offering a methodological approach to monitoring that actively seeks to engender reflexive learning as a means to deal with uncertainty in natural resource management.

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1. Introduction

Monitoring and on-going learning are cornerstones to effective decision making amid uncertainty in natural resource management (Walters and Holling, 1990; Lee, 1993; Boyle et al., 2001; Keen et al., 2005a; Stem et al., 2005; Borrini-Feyerabend et al., 2007). The past decade has witnessed the development of a large number of conceptual frameworks for monitoring and evaluation (see for example Bellamy et al., 2001; Campbell et al., 2001; Hockings, 2003; Plummer and Armitage, 2007). However, the ways in which learning might be promoted through the practical implementation of these frameworks require further attention (Keen and Mahanty, 2005; Mahanty et al., 2007; Armitage et al., 2008). This review seeks to address this need to some extent.

Social theories of learning define learning as active social participation in the practices of a community (Lave and Wenger, 1991; Wenger, 1998), and emphasise the dynamic interaction between people and the environment in the construction of meaning and identity (Muro and Jeffrey, 2008). From a pedagogical perspective, the growing emphasis on social learning in natural

resource management represents a shift away from transmissive expert-based teaching, which characterises traditional conservation and agricultural extension activities, and toward transformative community-based learning (Capra, 2007).

There is however no universal theoretical basis or terminology for social learning (Wals and van der Leij, 2007). While some place emphasis on learning by individuals in social settings, others refer to learning at the level of the group or society (Parson and Clark, 1995). For example, while Wildemeersch (2007) defines social learning as learning that takes place in groups or social systems that operate in new, unexpected, uncertain and unpredictable circumstances, Bandura (1963) initially described social learning as the learning that individuals obtain through their interaction and observation of others in a group. This latter definition has however been criticized as being too narrow to encompass all of the different forms of learning relevant to natural resource management (Pahl-Wostl, 2006). In the field of natural resource management, social learning has thus been defined as the collective action and reflection that takes place amongst both individuals and groups when they work to improve the management of the interrelationships between social and ecological systems (Keen et al., 2005b). This is the definition adopted in this paper.

On-going reflection is a key part of the social learning process. Reflexivity refers to reflecting on the learning that has taken place during a given process, and using that reflection to stimulate more learning (Dyball et al., 2007). Keen et al. (2005b) present this reflexive process in a series of learning cycles to provide a framework for continuous reflection on actions and ideas, and on the

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relationships between knowledge, behaviour and values. The framework encourages a sequence of steps, starting with diagnosing what is important or the problem to be solved, designing or imagining what could be, doing what is possible, and then reflecting on and evaluating that practical experience. The key difference between this reflexive process and adaptive management cycles (Walters, 1986; Lee, 1993; Margoluis and Salafsky, 1998) is the emphasis on reflecting not only on objectives, actions and outcomes, but on the learning that has taken place during that process. Processes that foster social learning include; careful facilitation, small group work, repeated meetings, opportunities to influence the flow of events in a given process, open communication, diverse participation, unrestrained thinking and the inclusion of multiple sources of knowledge (Muro and Jeffrey, 2008). Collaborative monitoring, in which multiple actors are engaged in an on-going process of data gathering, analysis and decision making (see for example Danielsen et al., 2009; Guijt, 2007; Stuart-Hill et al., 2005) might offer an avenue through which to pursue social learning objectives in natural resource management.

The adaptive co-management approach, which seeks to harness the adaptive management focus on learning-by-doing, monitoring and action (Holling, 1978; Walters, 1986; Walters and Holling, 1990; Daniels and Walker, 2001), and co-management's focus on collaborative and inclusive decision making (Berkes et al., 1991; Berkes, 1994; Borrini-Feyerabend, 1996; Carlsson and Berkes, 2005), is therefore a logical starting point for integrating learning based approaches to monitoring. Adaptive co-management is a governance based approach aimed at dealing with complexity and uncertainty in natural resource management (Ruitenbeek and Cartier, 2001; Olsson et al., 2004a), which relies on collaboration among a diverse set of actors, and on a form of social coordination in which actions are coordinated voluntarily by individuals and organisations in a self-organising and self-enforcing manner (Ruitenbeek and Cartier, 2001; Olsson et al., 2004b, 2006).

This paper begins by reflecting on the role of monitoring in natural resource management in general and on the particular challenges posed by adaptive co-management in this respect. This is followed by a review of existing conceptual frameworks for monitoring that are relevant to adaptive co-management, and of the lessons that have emerged from experiences with collaborative monitoring. Based on this review, a methodological approach to implementing a learning based approach to monitoring in adaptive co-management is offered.

2. The role of monitoring in natural resource management

Monitoring is conducted for a variety of reasons. On the one hand, there is general agreement that the role of monitoring is to improve our understanding of complex system dynamics (Western, 2004; Allen et al., 2005; Cumming et al., 2005; Bliss, 2006; Lynam and Stafford Smith, 2004). Within this objective, monitoring and evaluation is carried out to improve management decision making, increase transparency and accountability, reduce risk and uncertainty, foster learning, and improve the ways in which projects are implemented (Bellamy et al., 2001; Stem et al., 2005). Monitoring is also aimed at assessing the relative state of a resource or system, warning managers about an approaching event or crisis, and improving the understanding of managers about how systems function (Lynam and Stafford Smith, 2004).

From a process perspective, monitoring is often undertaken with the purpose of linking information to decision making more directly (Uychiaoco et al., 2005), and at building trust between actors through increased transparency (Andrianandrasana et al., 2005; Becker et al., 2005; van Rijsoort and Jinfeng, 2005). In collaborative settings, such as those advocated in adaptive co-

management, one of the core goals is to promote learning and the ability of decision makers to respond to social-ecological change (Folke et al., 2003).

3. Monitoring challenges posed by adaptive co-management

Complexity and scale are two fundamental challenges facing monitoring efforts in adaptive co-management. Each of these issues, as they relate to monitoring, is discussed in turn below.

3.1. Complexity

Complex adaptive systems have a number of unique attributes, including surprise, uncertainty, and non-linearity (Berkes et al., 2003; du Toit et al., 2004; Walker and Abel, 2002). Complex adaptive systems have structures and functions that cover a wide range of spatial and temporal scales, and these structures and functions are linked across scales, although change might be observable only at a given scale (Gunderson and Holling, 2002; Walker et al., 2006). Changes may be either gradual or abrupt (Walters and Holling, 1990), and are influenced by drivers of change at various scales. A driver is defined as any natural or human-induced factor that directly or indirectly causes change in a social-ecological system (MA, 2003).

Traditional approaches to monitoring that are based on linear impact chains aimed at causal description are therefore inadequate when dealing with complex systems (Boyle et al., 2001). Time delays between an intervention and an impact, combined with non-linearity, make it difficult to assign causality to a particular intervention or event (Campbell et al., 2001). This challenge is exacerbated by adaptive co-management efforts in areas where long term data from carefully designed monitoring programs do not exist (Conley and Moote, 2003; Blaikie, 2006). Since complex systems are influenced by a multitude of factors operating at various scales, a multivariate, integrated approach is essential (Bellamy et al., 2001; Connick and Innes, 2001; Campbell et al., 2001). The rate of change in variables varies from one scale to another (Lynam and Stafford Smith, 2004), and non-linear interactions mean that monitoring systems must find ways to capture both the intended and the unintended outcomes of an intervention (Bellamy et al., 2001). In addition, these outcomes might be either tangible, and therefore directly measurable, or intangible (Innes and Booher, 1999). In order to capture some of these intangible outcomes, monitoring the process of implementation as well as the outcomes is necessary (Conley and Moote, 2003; Hockings, 2003).

3.2. Scale

A careful consideration of scale, in terms of both spatial and temporal variability, is vital during monitoring because a focus on just one scale might obscure important controlling processes at other scales (Schulze, 2000). System change also occurs at different rates, making it important to pay attention to the interactions among fast and slow changing variables (Lovell et al., 2002). In considering fast and slow changing variables, Lynam and Stafford Smith (2004) make the point that slower changing variables might be undetectable because of the 'noise' created by monitoring fast changing variables. An example here might be monitoring management decision making processes at monthly intervals versus government level policy changes regarding rights and responsibilities annually. Another challenge is the fact that while some variables change stochastically (e.g. fire, pests), other variables are easier to plan for during monitoring, such as seasonal changes in rainfall or veld condition (Schulze, 2000; Lovell et al., 2002).

Complex systems exhibit thresholds, a shift beyond which can lead to regime shifts (Scheffer et al., 2001). A threshold is exceeded when system feedbacks lead to lasting changes in the function and structure of the system (Walker et al., 2004). The challenge with the cyclical and stochastic changes just described is that they overlap with one another at various spatial and temporal scales, making system thresholds notoriously difficult to identify before they are crossed (Walker and Meyers, 2004).

Matching the frequency of monitoring to the rate of change (Western, 2004) is therefore vital, but capturing unpredictable stochastic events and surprises that might signal the crossing of a threshold is equally important. This requires a manager or monitor who is in touch with the system being monitored, which is why collaborative monitoring is so important, and this is discussed further in Section 5.

4. Existing monitoring and evaluation frameworks relevant to adaptive co-management

Analysts from various fields have made contributions to the conceptual understanding of monitoring and evaluation that hold important lessons for adaptive co-management. The contributions come from integrated natural resource management, rangeland management, resilience thinking and the co-management literature. Here two generic categories of approaches are identified based on the main objective of the frameworks developed: integrated approaches that have been designed for performance evaluation in complex systems, and user-driven approaches aimed at promoting learning and stakeholder buy-in (Table 1). The main observation that can be made from Table 1 is that while

Table 1
Frameworks that hold lessons for monitoring and evaluation in adaptive co-management.

Framework objective	Key themes	Key references
Performance evaluation in complex systems	Systems based Integrate social and ecological variables Integrate variables inside and outside local context Capture unexpected outcomes Focus on both process and performance Capturing fast and slow changing variables Capturing tangible and intangible outcomes Creating awareness about possible future trajectories Surrogates for measuring resilience ^a	Innes and Booher, 1999; Bellamy et al., 2001; Boyle et al., 2001; Gottret and White, 2001; Campbell et al., 2001; Connick and Innes, 2001; Conley and Moote, 2003; Hockings, 2003; Anderies et al., 2004; Lynam and Stafford Smith, 2004; Western, 2004; Berkes and Seixas, 2005; Bennet et al., 2005; Carpenter et al., 2005; Cumming et al., 2005; Garnett et al., 2007; Plummer and Armitage, 2007
Promoting learning and stakeholder buy-in	Collaborative monitoring and evaluation Collective sense making Conscious and deliberate learning processes Trust building Social change	Abbot and Guijt, 1998; Babu and Reidhead, 2000; Danielsen et al., 2005; van Rijsoort and Jinfeng, 2005; Mutimukuru et al., 2006; Guijt, 2007; Mahanty et al., 2007

^a Social–ecological resilience refers to a) the amount of disturbance a system can absorb and still remain in the same state or domain of attraction, b) the degree to which a system is capable of self-organisation (versus lack of organisation or organisation forced by external factors), and c) the degree to which the system can build and increase the capacity for learning and adaptation (Gunderson and Holling, 2002, as cited in Folke et al., 2002: 2).

conceptual frameworks aimed at performance evaluation abound, there are remarkably few conceptual frameworks that aim explicitly to promote a user-driven approach to monitoring and evaluation.

The most comprehensive attempt at developing a framework aimed specifically at evaluating adaptive co-management has been produced by Plummer and Armitage (2007). The authors provide parameters for performance evaluation in a framework that consists of the three components of; ecological, economic and process variables. Economic variables are drawn from the five capitals in the sustainable livelihoods framework (Chambers and Conway, 1992; Carney, 1998), while the ecological variables are drawn from the critical natural capital approach (Ekins et al., 2003) rather than ecosystem goods and services as advocated by other analysts (for example Anderies et al., 2004; Western, 2004). The framework takes cognisance of fast and slow changing variables, and also considers both tangible and intangible outcomes from adaptive co-management, as advocated by Innes and Booher (1999). Plummer and Armitage (2007) emphasise the role of institutions and power in determining project outcomes, and highlight the need to evaluate both the process and performance of initiatives (see also Hockings, 2003).

However, this framework, along with the vast majority of other frameworks, emphasises performance evaluation at the expense of on-going monitoring, and does not provide practical guidance about how to implement the framework in collaborative settings, such as those that characterise adaptive co-management. Similarly, frameworks aimed at monitoring complexity have tended to be heavily theoretical (Bennet et al., 2005; Carpenter et al., 2005; Cumming et al., 2005), which tends to exclude local resource managers. Frameworks aimed at promoting learning and stakeholder buy-in, on the other hand, have tended to be relatively simplistic, often aimed at ecological monitoring alone and to ignore social variables and issues of scale (Danielsen et al., 2005; van Rijsoort and Jinfeng, 2005).

The following criteria for effective monitoring in adaptive co-management can be distilled from the frameworks summarised in Table 1:

- i. Recognise complexity and non-linearity and therefore seek to integrate variables at more than one spatial and temporal scale (Campbell et al., 2001; Bellamy et al., 2001);
- ii. Integrate both social and ecological variables (Bellamy et al., 2001; Connick and Innes, 2001; Plummer and Armitage, 2007);
- iii. Be predictive, and seek surrogates for resilience that help to identify approaching thresholds (Lynam and Stafford Smith, 2004; Western, 2004; Carpenter et al., 2005);
- iv. Monitor both the outcomes (performance) of natural resource management systems, and the process of implementation (Innes and Booher, 1999; Plummer and Armitage, 2007).

While these criteria provide insight into ‘what’ a monitoring system should look like, they do not assist in describing ‘how’ to conduct monitoring in an adaptive co-management context. Insights from the social learning literature offer these additional criteria for a well-designed monitoring system:

- v. Be reflexive and encourage on-going reflection on the learning that has taken place (Dyball et al., 2007);
- vi. Involve decision makers directly in indicator selection, monitoring and analysis through a collaborative process that encourages input from multiple knowledge systems (Babu and Reidhead, 2000; Muro and Jeffrey, 2008).

- vii. Effective learning is about practice, and monitoring should therefore feed directly into decision making and encourage experimentation and action (Wenger, 2000; Connick and Innes, 2001);
- viii. Encourage participants to work toward an ideal, or best practice, and encourage visioning about 'what could be' alongside 'what is currently possible' through a process of collective sense making (Keen et al., 2005b; Mutimukuru et al., 2006).

Engaging resource users and managers in the monitoring process is not a new suggestion. Indeed a wide variety of participatory ecological monitoring programmes have produced a wealth of important lessons for attempts to develop social learning based approaches to monitoring, and these are discussed in the section that follows.

5. Collaborative monitoring as an opportunity for social learning

Collaborative monitoring has been described as a process of conscious information seeking followed by shared critical analysis to inform collective decisions that affect resource management (Guijt, 2007; cited in Evans and Guariguata, 2008). Evidence suggests however that, in addition to information gathering and analysis, collaborative monitoring promotes conscious and deliberate learning processes that in turn create opportunities for consensus building, collective sense making and action (Mutimukuru et al., 2006; van Rijsoort and Jinfeng, 2005). In particular, a shift in perceptions and attitudes has been identified as a positive outcome of collaborative monitoring (Becker et al., 2005; Danielsen et al., 2005; Poulsen and Luanglath, 2005; Uychiaoco et al., 2005; van Rijsoort and Jinfeng, 2005), which is considered cornerstone to 'transformative learning', or learning that leads to a questioning of the values that underpin institutions and decision making (Keen et al., 2005b). These characteristics of collaborative monitoring make this a prime candidate approach for shifting toward learning based models in adaptive co-management.

Collaborative monitoring has been associated with increased levels of co-operation and therefore social capital between actors (Evans and Guariguata, 2008), transparency, sharing of information, and the ability to feed information directly into management decisions, thereby tightening the adaptive management cycle and increasing adaptive capacity (Fig. 1, Gray and Kalpers, 2005;

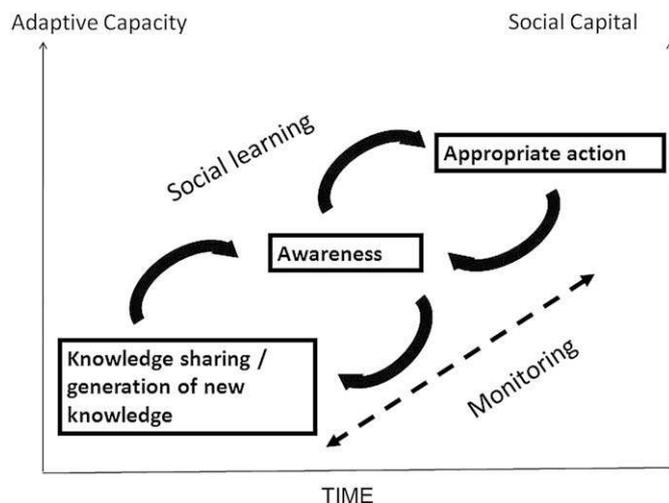


Fig. 1. The potential outcomes of collaborative monitoring.

Andrianandrasana et al., 2005; Becker et al., 2005; Uychiaoco et al., 2005; Poulsen and Luanglath, 2005). Social capital refers to the features of social life, such as networks, bonds, norms and trust, that enable participants to act together to pursue shared objectives (Coleman, 1988; Putnam, 1995). Social capital is therefore closely related to adaptive capacity, which refers to the ability of a system to adapt to change and respond to disturbances (Armitage, 2005), or to expand the range of variability within which it can cope (Adger, 2003).

This tight link between information gathering and decision making is considered vital for on-going learning in social contexts (Wenger, 2000; Connick and Innes, 2001). From a management perspective, collaborative approaches tend to increase the probability that monitoring data will be considered valid, will be understood, and will be used to improve decision making (Gottret and White, 2001; Poulsen and Luanglath, 2005).

Fig. 1 has been developed based on a combination of lessons that have emerged from the collaborative monitoring literature, and on the lessons that are emerging from experiences with social learning in other settings. Knowledge sharing is an essential first step in both the social learning and the collaborative monitoring process (Babu and Reidhead, 2000; Muro and Jeffrey, 2008). This process involves multiple actors, who bring with them different interpretations of cause and effect relationships in social-ecological systems. Awareness raising is therefore a critical component of the learning process during monitoring because local ecological knowledge, particularly that pertaining to the underlying causes of change in ecosystems, can be unevenly spread within communities, and is often held by individuals rather than groups (Chalmers and Fabricius, 2007). To achieve social learning in the sense of a change in a widely held set of beliefs, values and norms (Sayer and Campbell, 2004; Keen et al., 2005b), awareness of the social and ecological consequences of actions must be developed. The term 'appropriate action' in Fig. 1 refers to management actions that are ecologically and socially appropriate for the given context. Reflection is an on-going process that should take place throughout the collaborative monitoring process in order to stimulate learning (Dyball et al., 2007). Reflection is indicated by the feedback loops between the various steps illustrated in Fig. 1.

However, while collaborative monitoring holds promise for operationalising learning in adaptive co-management, the approach does pose a number of challenges. The first is ensuring that simpler methods are able to detect trends and changes outside of the local context (Danielsen et al., 2009). The outcomes of a monitoring program will be influenced by dynamic interactions between actors and processes operating at scales above and below the operational scale of decision making (Armitage, 2005), and therefore assumptions about the 'correct' scale at which to address and monitor processes pose difficulties (Cash et al., 2006).

The long term sustainability of collaborative monitoring is another challenge and is influenced by incentives for resource users to participate in data collection and analysis for monitoring (Hockley et al., 2005; Topp-Jørgenson et al., 2005; Poulsen and Luanglath, 2005). This is particularly important in developing countries, where trade-offs are often necessary between precision and sustainability (Brashares and Sam, 2005; Uychiaoco et al., 2005; Danielsen et al., 2009). Evidence from Laos suggests that monitoring may cease when funding disappears (Poulsen and Luanglath, 2005), and analysts suggest that collaborative monitoring cannot be sustained unless obvious benefits accrue to local people (Noss et al., 2005; Stuart-Hill et al., 2005). While some argue that collaborative monitoring approaches are cheaper (Brashares and Sam, 2005; Uychiaoco et al., 2005), others warn that collaborative approaches come with considerable costs because of the time

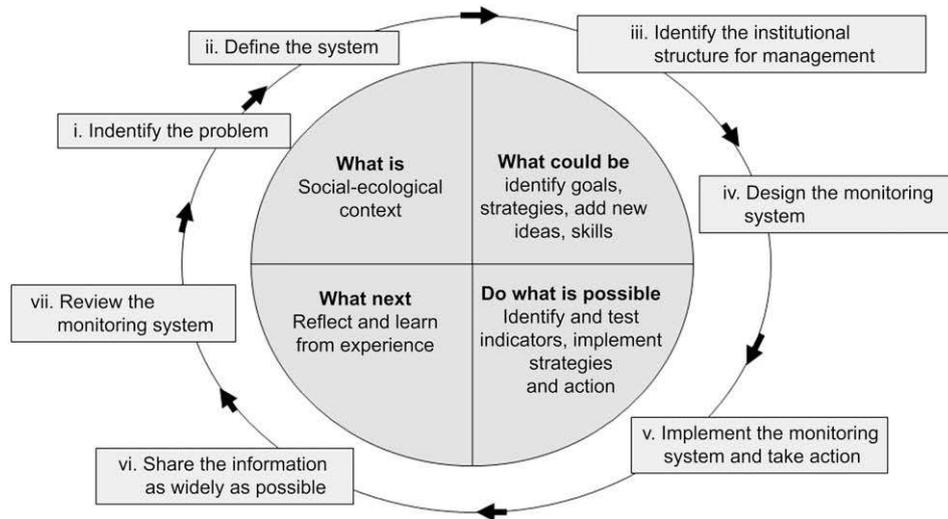


Fig. 2. A social learning approach to monitoring (adapted from Babu and Reidhead, 2000; Keen et al., 2005b; Stringer et al., 2006).

needed to facilitate a learning process between many actors (Mutimukuru et al., 2006).

The wealth of experience in collaborative monitoring approaches therefore suggests that social learning might be integrated relatively seamlessly into existing monitoring programs, provided that sufficient human and financial resources are dedicated to this purpose. The many existing conceptual frameworks (Table 1) can help guide project design to avoid the many conceptual challenges associated with complexity and scale in these collaborative approaches. Based on this review, the paper concludes by presenting a methodological approach to integrating social learning into collaborative monitoring processes.

6. Conclusions and synthesis

Fig. 2 is based on the work of a number of analysts who have suggested steps for policy oriented monitoring (Babu and Reidhead, 2000), collaborative monitoring (Abbot and Guijt, 1998), social learning in environmental management (Keen et al., 2005b), participation in adaptive management (Stringer et al., 2006) and analysing co-management in general (Carlsson and Berkes, 2005). A social learning approach to monitoring entails a cyclical process of problem identification, visioning, monitoring, taking action, reflection and redefining the problem (Fig. 2). The broad steps in this process include:

- i. *Identify the problem that needs to be solved:* Identify the information needs, the different kinds of knowledge that are relevant, and who is going to use the information.
- ii. *Define the social–ecological system of interest:* Define the unit of analysis, i.e. a resource system, a community, a group; identify the social, political, economic and ecological drivers that influence the system of interest.
- iii. *Identify the institutional structure for data collection, analysis and action:* Identify the objectives of monitoring and evaluation from the perspective of all participating actors; revisit steps 1 and 2 using participatory methods and approaches, and adjust if necessary; define the extent to which each group is willing to take part in monitoring; map the essential management tasks to be performed; define the short-term, medium term and long term decision that must be taken and identify who is responsible for these tasks.
- iv. *Design the monitoring system:* With stakeholders, identify indicators for impact and process monitoring; identify data

collection methods and frequency of data collection depending on time, skills, and nature of variable being monitored; decide who is responsible for the different activities; identify analytical methods, matched to the level of expertise of participants; test and fine-tune methodologies with participants, training workshops and practical activities may be necessary.

- v. *Take action and implement the monitoring system:* Refine or change methods if it becomes clear that they are not providing the information required.
- vi. *Share the information and learn from actions:* Collate and analyse data; involve those who collected the information and those who are going to use the information in analysis; build capacity to identify trends and understand results; share information periodically, but regularly; integrate findings into decision making processes; encourage decision making bodies to adjust activities in response to monitoring results; reformulate the findings for different audiences using appropriate presentation methodologies, but be aware of misrepresenting data.
- vii. *Review the monitoring system:* revisit the problem to be solved, is it the same as before? Redefine the social–ecological system based on new understanding from monitoring; change the institutional structure where necessary; redefine methods where necessary.

This review has aimed to steer attention away from the ever increasing variety of conceptual models that are available for dealing with resource management dilemmas, and toward a renewed focus on approaches and methodologies that help resource managers better cope with uncertainty and change in complex systems. While ‘learning’ is becoming an increasingly common concern among analysts working in the field of environmental management, not enough effort has yet been put into defining how to achieve this in a practical sense. Collaborative monitoring holds promise in this regard, and deserves greater attention as a means to integrate learning based approaches in adaptive co-management, and indeed into environmental management more generally.

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