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Developing a diagnostic approach for adaptive co-management and considering its implementation in biosphere reserves

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Abstract

Innovative approaches are required to address the sustainability of ecosystems and human wellbeing. Adaptive co-management (ACM) is emerging as such an approach because it nurtures resilience and provides an arena to address the complexity and uncertainty that characterize social-ecological systems. The literature on adaptive co-management reveals considerable variation in how it is defined and operationalized, a limited basis for rigorously comparing empirical findings, and few insights about relationships to actual outcomes. In this paper, we develop a diagnostic framework for ACM and discuss its implementation in biosphere reserves. The diagnostic framework draws upon existing scholarship and involves investigating the setting, looking for activities and practices, assessing learning and collaboration, and making connections to outcomes. Biosphere reserves are identified as natural experiments with ACM and we therefore use them to illustrate how each aspect of the framework can be made operational. The framework is an important step in systematically and consistently diagnosing ACM across contexts.

Keywords: adaptive co-management, learning, networks, outcomes, social-ecological systems, biosphere reserves

1 Introduction

Adaptive co-management (ACM) is a potentially important innovation for natural resource governance and an approach that enhances the fit between institutions and ecosystems (Armitage et al., 2007: 2; Folke et al., 2005; Olsson et al., 2010). ACM brings together and builds upon two well established approaches to guide human-environment interactions - the learning or experimenting aspect of adaptive management as well as the linking function of collaborative management (Armitage et al., 2007). ACM is an interactive and dynamic learning process (Berkes, 2009; Plummer, 2009), which can be visualized as a network of heterogeneous actors that connect horizontally across levels and vertically across scales (Folke et al., 2002; Olsson et al., 2004). We define adaptive co-management here as ''…flexible, community-based systems of resource management tailored to specific places and situations, and supported by and working with various organizations at different scales'' (Olsson et al. 2004:75).

ACM is argued to nurture resilience, i.e. the capacity of a social-ecological system to persist, adapt or transform in the face of change while retaining essential functions (Schultz, 2009). However, a recent systematic review of ACM literature by Plummer et al. (2012) revealed variations in how it is defined and operationalized, a limited basis for rigorously comparing empirical findings, and few insights about relationships to actual outcomes. Addressing these issues is necessary to achieve causal inference and begin developing theory.

This paper responds to the issues identified in the review of the ACM literature by Plummer et al. (2012) and offers an initial step towards the systematic and consistent examination of ACM. In this paper, we develop a diagnostic framework for ACM and discuss how it can be made operational. We use UNESCO-MAB biosphere reserves to ground our thinking. Biosphere reserves are sites designated by UNESCO with the mission of "maintaining and developing ecological and cultural diversity and securing ecosystem services for human wellbeing" (UNESCO, 2008: 8) in collaboration with a suitable range of actors, often including local communities, government bodies and scientists. In this role biosphere reserves function as bridging organizations linking local actors and communities with other organizational levels (Schultz et al., 2007). As such they become natural experiments with ACM (see Schultz et al., 2011). We intend to apply the diagnostic framework in biosphere reserves in Sweden and Canada.

2 A Conceptual Framework for Diagnosing ACM

Understanding and addressing contemporary environmental problems are challenged by the complexity of social-ecological systems and the historical propensity for simplification (Cox, 2011). The diagnostic approach has emerged in the environmental domain in response to this challenge (Meinzen-Dick, 2007; Ostrom, 2007, 2009). Diagnosis, in a general sense, involves identifying symptoms with the goal of determining the nature of an outcome or problem and resolving it. As applied in the environmental domain by Young (2002:176) "the diagnostic approach attempts to disaggregate environmental issues, identifying elements of individual problems that are significant from a problem-solving perspective and reaching conclusions about design features necessary to address each element".

In the context of ACM, Plummer et al. (2012) argue that a diagnostic approach and framework provide a path forward to building theory with utility in guiding human-environment interactions. Overcoming the imprecision, inconsistency and confusion in the ACM scholarship revealed by their systematic review is a necessary first step to analyzing interrelationships among context, variables and outcomes. In drawing inspiration and guidance from Ostrom (2007; 2009), we develop a preliminary framework for diagnosing ACM in biosphere reserves (see Figure 1).

The diagnostic framework acknowledges the social milieu and biophysical contexts in which ACM occurs. We understand (define) ACM to be a process which combines the learning aspect of adaptive management with the linking function of collaboration for the instrumental rationale of sustainability (i.e. nurturing social-ecological resilience). Accordingly, the framework considers the context in which ACM is set and then draws attention to 1) 'symptoms' of the ACM process – on-the-ground activities and practices that indicate ACM; 2) assessing learning and collaboration (networks); and, 3) making connections to outcomes. In the remainder of this section we identify and define each element of the diagnostic framework, position it in relation to scholarship, and consider strategies to make the diagnostic framework operational.

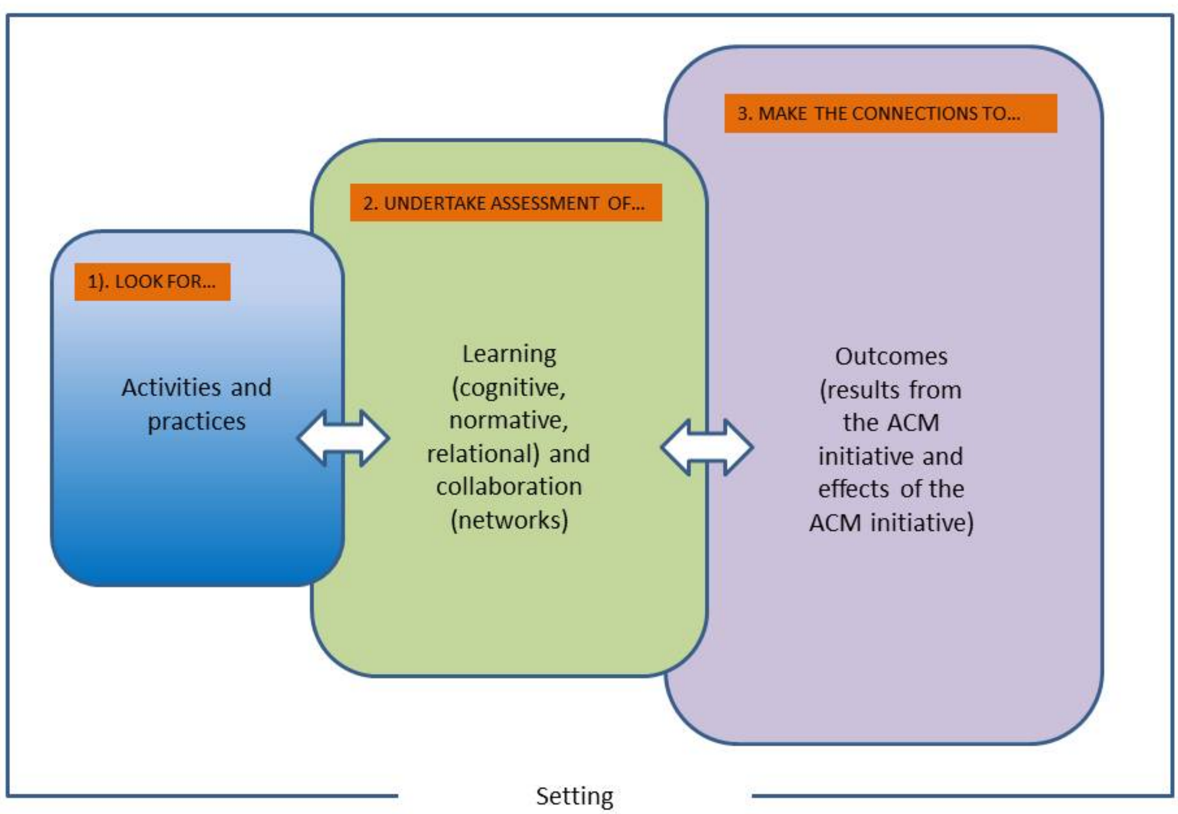

Figure 1. Conceptual framework for diagnosis ACM in biosphere reserves.

2.1 Setting

Context, as applied to natural resources, encompasses the dynamic forces at various scales that define what is both desirable and feasible (Edwards & Steins, 1999). Context has received paradoxical treatment in regard to common pool resources with a heavy reliance on bounded rationality for investigations of collective action, but a dearth of explicit identification or measurement of factors beyond location, resource characteristics, and study length (Edwards & Steins, 1999). Several frameworks have been advanced that draw explicit attention to contextual factors and/or the settings and their influences (e.g., Honadle, 1999; Edwards and Steins, 1999; Ostrom, 2007; 2009).

Plummer and Hashimoto (2011) build on the emerging literature addressing context in natural resources management and two case studies of fisheries to develop a framework for tailoring adaptive co-management and enhancing adaptability. They draw attention to the setting of adaptive co-management in terms of the context (problem/resource and social) and its embeddedness. Table 1 builds upon their efforts to identify elements of context that should be considered, and that we will investigate when considering the setting of biosphere reserves.

Table 1. Elements of context to consider for adaptive co-management initiatives in biosphere reserves

Setting of Adaptive Co-management	
Biophysical	• Biome and ecoregions (Olson et al 2001)
	• Size of area
Social	• Population (size) and density
	• Socio-economic profile (e.g., demographics, employment)
Social Ecological	• Land uses (e.g., agriculture, golf courses, forest cover, urban areas)
	• Dependence on local ecosystems for income (embeddedness)
Story of BR initiative	• Vision and goals
	• Organizational structure
	• History
	• Activities

The elements in Table 1 act as guides throughout the data collection portion of the research. They are not exhaustive and collecting additional materials that illuminate the setting of each biosphere reserve is encouraged. Information regarding the setting of each biosphere reserve will come from document analysis, a Social-Ecological Inventory (SEI) (see Section 2.2), key informant interviews, and the resilience analysis/workshops (see Section 3). The setting can be analyzed qualitatively and the elements in Table 1 can provide initial coding categories or sensitizing concepts. These should be augmented with open coding to allow additional salient setting variables to emerge.

2.2 Activities and practices that indicate ACM

There are three components of our diagnostic framework for ACM: 1) looking for on-the-ground activities and identifying the practices of the bridging organization in relation to these; 2) assessing learning and networks; and, 3) making the connection to outcomes.

The first component of our diagnostic involves identifying the specific activities that are undertaken in the ACM-initiative (i.e. as part of managing and governing), and the practices of the bridging organization in relation to these activities, with a specific focus on what they do to foster collaboration and learning. For illustrative purposes, we are concerned with the activities as part of managing and governing the biosphere reserve as well as the biosphere reserve as a bridging organization. In line with Crona and Parker (2012), we look for spaces for interaction, where stakeholders meet, as well as boundary objects (e.g., classification systems, interactive maps), with the potential of bringing various interests together. Furthermore, we look for activities in all parts of the adaptive co-management cycle (acknowledging that these often take place simultaneously), including planning/decision-making, implementation/experimentation, monitoring and assessment/evaluation. The specific activities identified provide a focus for our subsequent analysis of learning, collaboration, and outcomes. The practices of the bridging organization in relation to the activities will shed light on what works where and when.

Activities may be identified through an SEI and also assessed by participants in a questionnaire. The SEI stems from the social-ecological systems (SES) approach and an integrative premise where understanding a system requires knowledge of social components, ecological components, and their interactions. Schultz et al. (2007: 141) pioneered the method in Kristianstads Vattenrike to "…identify these local steward groups and their activities, with the ultimate aim of drawing on their experience to enhance ecosystem management at the landscape level". It has since been developed into a workbook available by the Resilience Alliance (Schultz et al., 2011) and applied in the Niagara region of Canada (Baird et al., 2014). In applying the SEI, chain referral sampling can be used to get an overview of the people who "make things happen" in the biosphere reserve. Semi-structured, open-ended interviews can be conducted with these individuals to understand their motivations, activities and involvement, perceptions of goals and outcomes in relation to the biosphere reserve. Individuals identified through the chain referral sampling (approx. 20-30 / case) can be convened for a one-day workshop. At the workshop, participants can complete a questionnaire to gain information about biosphere reserve activities and management process. The questionnaire will also assess learning and networks (see below).

Practices are investigated through interviews with the core team in the ACM initiative. In the example of biosphere reserves, interviews should be conducted with the manager and 3-5 key individuals. In order to understand how the bridging organization builds the network of ACM, we will ask how participants and partners have been identified, selected, and involved in biosphere reserve activities, both in successful projects and more challenging projects. In order to understand how they foster learning, we will ask what the biosphere reserve managers do in the various activities to foster the generation of new knowledge, facilitate knowledge exchange between actors, and promote changes in perceptions (cognitive and normative) among actors involved. In line with Crona and Parker (2012), we will probe how they manage power dynamics and how they broker between interests and understandings in order to facilitate learning.

As alluded to above, ACM is an ongoing and iterative social process with the purpose of achieving a specific set of goals. For the purpose of analysis and diagnostics, it is useful to anticipate different activities and practices in relation to various points in the ACM process. We characterize the ACM process in terms of two phases. The first phase is concerned with identifying relevant stakeholders and connecting them in various ways to achieve a social environment (a platform) for learning, deliberation and goal setting. In phase 1 the network is thus the ultimate outcome and the choices and strategies of the actors initiating the ACM process can be conceived as the predicting variables. In the second phase the actors in the network created share information, potentially learning from each other, deliberate and (hopefully) come to a set of mutually agreed upon goals for the ACM. They then organize in various ways so as to achieve these goals. How they organize, i.e. the characteristics of the network structure emerging, the centrality and potential influence of leaders/key individuals, etc are all network aspects that potentially influence actors' ability to achieve their desired goals. In phase 2 the network (created in phase 1) is thus the predictive variable affecting the outcome of the ACM. This does not assume that an ACM process will, when entering phase 2, continue. A process is likely to move between these phases in an iterative (cyclic) fashion.

2.3 Assessing Learning and Collaboration of ACM Initiatives in Biosphere Reserves

Assessing Learning

Many organizations, institutions or communities at different levels are often not equipped to deal with the complexity and cross-scale nature of the problems they face, nor are they prepared to engage in effective multi-stakeholder collaboration. Learning has thus emerged as a crucial dimension in addressing these challenges. Large-scale management experiments and the concept of ‘‘learning by doing’’ are fundamental to adaptive management (Holling 1978; Walters 1986; Lee, 1994; Cook et al. 2004). The importance of social or institutional learning (Parson and Clark 1995; Diduck et al. 2005; Keen et al. 2005) has been emphasized in relation to emerging modes of environmental governance and resource management. It draws attention to the role of collaboration, joint decision-making, and multi-stakeholder arrangements. ACM embodies the growing interest in learning related to environmental governance and management as it brings together the learning and linking functions (horizontally and vertically) of adaptation and collaboration.

How to assess learning in environmental governance and resource management broadly, and ACM specifically, is not well established. This confusion in part stems from a lack of clarity and consistency with regard to the different theories about learning, some of which emphasize individual learning and others which emphasize group or social learning (Armitage et al. 2008). In reality, a learning diagnostic tool will need to account for both individual and group (social or institutional) learning. As Fazey et al. (2005) have noted, individuals learn, not organizations. A focus only on learning at the individual scale would neglect the social context in which individual learning takes place.

We define learning here (sensu Argyris and Schön 1974) as a social process of iterative reflection that occurs when we share our experiences, ideas and environments with others. The problem of scale or unit is important, i.e., recognizing the distinction between individual and social learning as noted above. Here, we adopt the perspective of Reed et al. (2010) who suggest that social learning must involve a ‘‘. . .change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks’’.

From a diagnostic perspective, this poses a major challenge. We have devised ways to measure individual learning with increasing sophistication, but as we scale up to social units of analysis measurement becomes much more difficult. If we want to foster robust and case comparative analysis, reconciling this tension is crucial. Other measurement challenges must also be considered, for example: 1) ‘changes in understanding’ are not the same as outcomes (e.g., better decisions, achieving sustainability); and 2) changes in understanding may lead to learning outcomes, but these outcomes may be positive or negative depending on context (social, cultural, political, etc.). An effective diagnostic tool must therefore be sensitive to issues of scale or ‘unit’ of analysis, the difference between learning practices and outcomes (not framed *a priori* by a normative framework), and the complexity of interactions among practices, learning processes and outcomes. Regardless of the sensitivity of diagnostic variables, establishing causality among learning processes and outcomes is very difficult to do.

Within the diverse literature on assessment and evaluation of learning, our focus is on assessing learning by individuals engaged in an ACM process as well as ‘learning’ at a social unit of analysis. With regard to assessing changes in understanding (component two of Figure 1), three ‘dimensions’ of learning can be used: 1) cognitive; 2) normative; and 3) relational (Table 2). These dimensions of learning can be measured at different units of analysis (e.g., individual, or social group) and with the use of a questionnaire instrument. The instrument poses multiple questions (free recall, likert scale, open ended reflections) that correspond to each dimension of learning and can also be aimed at assessing changes in understanding at a group (social) unit of analysis. It can be administered at a workshop with the individuals identified through the SEI (see above).

With regards to the learning “of what”, we are interested in learning that has the potential to support social-ecological resilience, in biosphere reserves this translates to the goals and visions of that particular place. In the cognitive learning aspect, we focus on changes in participants understanding of the social and ecological processes that maintain the current landscape of the biosphere reserve and its values, testing the assumption that adaptive co-management leads to a more complex as well as shared understanding of the resource under management. For the normative learning aspect, we focus on changes in participants’ perceptions of the interaction between humans and nature, using Dunlap et al.’s (2000) New Ecological Paradigm questions. With regards to relational learning, we focus on changes in participants’ perceptions of others and their learning to work together.

Table 2: Cognitive, normative and relational dimensions of learning

Learning variable	Example sub-variables	Example instruments / methods
Cognitive	• New knowledge • Restructuring existing knowledge • Vertical, horizontal transmission of information/knowledge	• Cognitive mapping • Concept maps
Normative	• Shift in viewpoint • Shift in values • Shift in paradigms • Convergence of views	• Social network analysis • Mental models
Relational	• Cooperation • Trust (levels of) • Acceptance/incorporation of different knowledge • Ability to relate well • Knowledge of other perspectives • Presence of knowledge brokers, leaders	• Social network analysis • Deliberative democratic methods • Psychological factor questionnaires

Framework from Munaretto and Huitema (2012), Baird et al. (in review); Sub-variables reflect broader set of authors (Pahl-Wostl and Hare, 2004; Ison et al., 2004; Ison and Watson 2007; Muro and Jeffry 2008, etc.).

A challenge for any diagnostic tool is to adequately address the dynamic aspects of learning. Several important dynamics that need to be captured include: 1) interactions or the dynamic between individual and social learning; 2) interconnections among the three dimensions of learning processes (cognitive, normative, relational); 3) the relationship between learning process and outcomes that are important to separate for the purposes of a diagnostic exercise, although in reality such distinctions are artificial; and 4) the relationship or dynamic between 'changes in practice' and 'changes in understanding'.

Assessing Collaboration: Networks

The role of social networks in co-management processes has been repeatedly emphasized (Schultz 2009, Olsson et al 2007, Olsson et al 2004) yet the ubiquity of social relations makes it almost nonsensical to discuss networks as a binary variable determined by their presence or absence (see Bodin and Crona 2009 for a review of social networks in natural resource governance). The nuances of social relational structures, and the outcomes they give rise to, have been the focus of sociologists and related disciplines for many years (Coleman 1990, Borgatti 2003). As such, multiple theories exist that can help us theorize around how aspects of social networks contribute in specific ways to ACM outcomes.

In line with the diagnostic framework guiding this research (Figure 1), the departure point for assessing networks is looking for practices, actor characteristics and strategies. In assessing networks both phases of ACM described above can be considered. The aforementioned SEI methodology facilitates the identification of relevant stakeholders. Inquiry can be made to these stakeholders about their social ties (see below). The aim with these two steps is to illuminate the relevant stakeholders and gain insights about how they connect in relation to the ACM initiative. In the questionnaire respondents may be asked to list individuals important for different activities related to and recognized by the biosphere reserve, as well as actors who are 'core to the ACM process in terms of how often they 1) exchange information and/or knowledge related to the governance of the biosphere reserve and 2) coordinate actions related to the governance of the biosphere reserve. Posing open-ended inquiries to understand the choices and strategies of the actors initiating the ACM process may also be beneficial. Conducting a follow up network assessment of the actors who are 'core' to the ACM process after a period of time provides an opportunity to gain insights about how networks develop. As biosphere reserves are natural experiments with ACM, these steps allow 1) identification of the network structure in relation to the ACM process and 2) the assessment of longitudinal changes to the network over time as a result of participation in the ACM process.

Regardless of which phase may be the focus of attention, three broad clusters of network characteristics can be said to be of vital importance; social cohesion, heterogeneity and centralization. Below we outline each in turn and examine their relevance to an ACM diagnostic.

Social cohesion

The concept of social cohesion, and its potential causal effect on social outcomes, is pervasive in the social sciences. It refers to dense social relations among actors in a network and is frequently referred to as social capital (see Coleman 1990, Putnam 2000). The key benefit associated with social cohesion is that it is postulated to promote trust and reciprocity, lower conflict and thus facilitate collaboration and learning (e.g. Coleman 1990, Granovetter 2005). It has often been invoked by scholars of conservation and development as something that promotes positive governance outcomes (Woolcock and Narayan 2000, Pretty 2003, Pretty and Smith 2004). Social capital has been defined in a multiplicity of ways and critics have contended that it is not a predictor but in fact an outcome emerging from well-functioning institutions (North 1990, Wade 1994). Nonetheless, more recent work suggests that in reality it may be somewhere in between, where social capital has some predictive power, in combination with other variables such as good leadership (Krishna 2002, Bodin and Crona 2008, Crona et al in prep).

Given the multifaceted view and definitions of social capital in the literature we use the term social cohesion to denote the density of relations among actors. While there is no consensus as to how it should be measured social network analysis offers a replicable and transparent methodology to collect field data that measures social relations among actors. The SNA literature has proposed several measures for capturing social cohesiveness. Closure is one (e.g. Burt 2000, 2005) which has recently been adapted by Sandström and Rova (2010) for an adaptive management context. It is a compound measure including two submetrics; i) *k*-cores or triangles, which capture dense social structures (see also Crowe, 2007), and ii) the presence of coordinating actors that can bridge otherwise unconnected groups. The argument is thus that closure can be achieved either directly through many connections or indirectly through coordinating actors.

K-cores are easily computed if whole-network data exists for the set of actors involved in the ACM process (e.g. Crona et al in prep). Similarly, exponential random graph modeling (ERGM) can be used to estimate transitivity (i.e., the tendency of actors in a network to form triangles) (Robins et al., 2007). Centralization of officially elected leaders or other key individuals is similarly computed from whole-network data using standard softwares such as Ucinet or R (SNA package).

Heterogeneity

The notion of heterogeneity in social networks is related to the diversity of actors in terms of their attributes. Diversity of actors and knowledge systems is commonly invoked as beneficial to ACM as it promotes multiple systems perspectives and enables the ability to capture different system dynamics (e.g. Carlsson and Sandström, 2008). It can also increase legitimacy for the rules and norms once developed and thus likely increases compliance (Schneider, et al., 2003). While inclusion of heterogeneous actors can be beneficial it is likely to also increase friction and conflict as diverse agendas and perspectives are exposed to one another (e.g. Provan, et al., 2007). To mediate between divergent ideas and to reap the benefits of combining multiple perspectives there is thus a need to have actors who can provide brokerage and bridge structural holes in the network (Burt 2000). The notion of brokerage and bridging of structural holes is akin to the notion of institutional entrepreneurs – actors who leverage resources to create new or transform existing institutions (DiMaggio, 1998; Garud, Hardy, & Maguire, 2007; Maguire, Hardy, & Lawrence, 2004, see Battilana et al 2009 for a review) – and has been used in the context of natural resource governance to understand governance outcomes (Crona, et al., 2011). One methodology available to capture heterogeneity and its effects on network structures and governance outcomes is exponential random graph modeling (ERGM) where one can explore how actor attributes determine the propensity for ties to occur among actors.

Centralization

Centralization in networks refers to the tendency of relations to center around one or a few actors. The degree of network centralization assesses the degree to which centralities of constituent actors differ among each other, i.e. the variability in centrality amongst network members (Wasserman and Faust, 1994). Centralization can be included as a sub-metric of closure and social cohesion, as outline above, but it also has distinct contributions as a stand-alone metric. A higher degree of centralization has been suggested to facilitate efficiency and coordination. Networks with a high degree of centralization have a high capacity for coordination among actors in the periphery (Leavitt 1951, Bodin and Crona 2009), and tentative results show that high degrees of network centralization appears positively correlated with collective action in resource governance, mainly through the positive effect on central actors' abilities to prioritize and coordinate activities (Sandström, 2008). This leads us to the question of *who* the central actors are? A central actor without ambitions, visions and strategies to promote the goals of the ACM process is likely to instead create a barrier to effective outcomes (Bodin and Crona 2008, Crona and Bodin 2010). Thus understanding the interplay between the attitudes and capabilities of highly central actors in centralized networks is critical for understanding how ACM processes may or may not achieve their stipulated goals.

While the three concepts elaborated above are highlighted because of their high potential to influence the ACM process it is worth noting that there respective relevance may differ over time. This links back to our initial argument of viewing ACM as multi-phase process. To illustrate what we mean let's take a simple example. High centralization is likely to be of importance in an early stage of ACM where stakeholders may not yet have formed mutual ties and thus coordination and facilitation by one (or a group of) central actor(s) may be necessary to create a shared vision and collective action. Once relations between stakeholders have been formed that are independent of the initiating actor, the network may become increasingly dense and over time trust and reciprocity among actors is postulated to grow. But ACM is a dynamic process, which must respond to dynamics at institutional scales beyond the actual ACM process. An example constitutes a window of opportunities appearing and presenting an opportunity to impact on policy change. In response to such an opportunity the network may again benefit from a more centralized structure and the perceived need to a timely and coordinated response may in fact drive the evolution of such a structure. Once the event has passed the network may revert to a more modular structure with multiple sub-clusters connected through brokers (as discussed above). This may in fact be beneficial as it allows clusters of actors to work in smaller groups or and develop specific knowledge of one aspect of the (eco)system in focus and not overtask actor with too many concomitant social ties.

3 Making the connection to outcomes

The conceptual framework (Figure 1) highlights our specific efforts to connect the ACM process to outcomes in a specific and consistent manner. In drawing heavily upon the resilience-based framework for evaluating adaptive co-management (Plummer and Armitage, 2007), we focus on key aspects identified in the ACM literature for assessing the outcomes. Specifically, we are interested in capturing the results/products from the ACM initiative as well as their consequences/effects (recognizing these are not mutually exclusive). Providing specific criteria and indicators is problematic because of the importance of context (Plummer and Armitage, 2007; Plummer and Hashimoto, 2011. Rather, the following tables are to: 1) make operational the outcome aspect of the research; 2) provide guidance to researchers during the data collection process (i.e. background information collection, semi-structured interviews, participant observations, workshops); and, 3) act as a preliminary coding key for analysis.

Variables to make connections to outcomes can be articulated in different ways, and the strategies to measure outcomes may overlap with those used to assess learning and networks. Table 3 concentrates on the results/products from the ACM process. In drawing upon work by Innes and Booher (1999) and Plummer and Armitage (2007), attention is directed to the tangible and intangible results/products accruing as part of the ACM process (first order) and beyond the ACM process (second order). We are cognizant of the need to be clear about independent (ACM initiative) and dependent variables, while also recognizing the closeness of feedback loops among ‘products’, ‘effects’ and the process of ACM. For example, outcomes can also be used to make sense of what is being learned. Following Argyis and Schon (1978), social learning theorists often draw attention to learning loops (Keen et al. 2005; Diduck 2010) as a way to reflect changes in understanding. Single-loop learning involves fixing errors from routines (modifying harvest strategies), double-loop learning involves correcting errors by rethinking management goals, adjusting values and policies, and triple-loop learning involves more fundamental changes in governance norms and protocols (Pahl-Wostl 2009). The examples contained in Table 3 are not intended to be exhaustive. Data regarding the results of the ACM initiative will come from document analysis, in-depth interviews with biosphere reserve managers, participant observations (i.e. logs of researchers about the process) and the questionnaire with the individuals’ core to the biosphere reserve management process.

Table 3. Results/Products from ACM initiative (adapted from Plummer and Armitage, 2007)

Example first order outcomes (from the specific initiative)	
Tangible • Resource management plans • Resolution of conflict/dispute and/or agreement regarding resource issue • Undertaking collective actions to resolve problems • Codified statement of actions • Agreed upon sanctions • New or modification of institutional arrangement(s) (formal and/or informal) - policies, strategies, organization, etc. • New cooperative undertakings	Intangible • Enhanced legitimization for policies and actions • Greater adaptive capacity (flexibly live with uncertainty and deal with cross-scale dynamics) • Social and human capital (see effects in Table 4) • Creative ideas for solving problems • Encourages contemplation and questioning of routines, values and governance (see effects in Table 4) • Improved decision making • Changes in understanding of human-environment interactions • Enhanced adaptability, flexibility
Example second order outcomes (outside boundaries of the project)	
• New co-operative undertakings beyond the specific issue • Extends engagement and learning across scales • Changes in perceptions (attitudes) and actions (behaviours) • Enhances the efficiency and effectiveness of responding other issues within the problem domain • Outgrowth(s) from the initial arrangement to address additional issues within the problem domain	

Table 4 focuses on the consequences/effects from the ACM process and reflect its instrumental rationale for sustainability/social-ecological resilience. Table 4 is adapted from Plummer and Armitage (2007). It is scale-specific and starts from the local perspective or focus of the ACM initiative (e.g., resource, protected area, sub-watershed). Plummer and Armitage (2007: 65) build upon the idea of 'surrogates for resilience' (Berkes and Seixas, 2005; Carpenter et al., 2005) and use of the term 'parameters' to:

> … denote a focus on higher-order but critical components, processes and structures of social–ecological systems which can be used as a focal point to orient an evaluation of adaptive co-management (see also Wilson et al., 1996). Thus, the parameters suggested here are meant to be: forward looking rather than oriented to measures of the current state or condition of the system; should reinforce one another, address multiple facets of concern and be replicable; be theoretically grounded (i.e., identifiable in the literature); and highlight cross-scale influences (see Berkes and Seixas, 2005).

The parameters set forth in Table 4 act as guides throughout the data collection portion of the research in biosphere reserves as well as initial codes for analysis. While collecting primary data on ecological and livelihoods is beyond the scope of the research, appropriate methods to investigate landscape changes etc. should be employed. Information on effects of the ACM initiative will be gained from document analysis, the questionnaire, semi-structure interviews, and participant observations. Table 4 provides categories for open coding the semi-structured interview responses as well as a structured key for axial coding all background information (e.g., documents, websites, brochures) and participant observation notebooks (all electronically in format consistent with QSR NVIVO).

In addition to the aforementioned techniques that will provide information on outcomes, it may be useful to conduct a resilience assessment in each case, building on the method developed by the Resilience Alliance (Resilience Alliance, 2010). Stakeholders can be brought together in a series of workshops that follows a flexible structure to define the focal system (including historical and current disturbances, valued attributes of the system, issues of concern, and uncertainties), system dynamics (including potential thresholds, multiple states of the system, and slow and fast drivers of change), cross-scale interactions (including general and specified resilience), and synthesize findings. The resilience assessments will provide a basis for comparison when it comes to the ability to persist, adapt and transform in the face of change, and how this ability is affected by the design of ACM.

Table 4. Consequences/effects of the ACM initiative (adapted from Plummer and Armitage, 2007)

Instrumental rationale of ACM	To solve resource problems through a collaborative and adaptive process that fosters ecologically sustainable livelihoods (social-ecological resilience).]									
Ultimate parameters of concern	Ecological sustainability				Enhanced livelihoods					
Parameters of concern	Ecological components	Relationships and functions	Diversity	Memory and continuity	Increased well-being	Decreased poverty	Increased income	Decreased vulnerability	Increased food security	Sustainable resource use
Examples of secondary parameters * #	Species (e.g., keystone species)	Key ecological processes (fire)	Species richness and diversity	Ecosystem protection (e.g., reserves)	Livelihood assets or capital stocks Human capital (skills, knowledge, health, etc.) Social capital (networks, groups, rules, norms, sanctions; relationships of trust, reciprocity, exchange) Natural capital (stocks (fish) and key ecological services (nutrient cycling) Physical capital (infrastructure and producer goods) Financial capital (financial resources - cash, bank deposits, livestock, jewels and regular inflows of money)					
	Stocks (e.g., fish)	Species interactions	Response diversity	Landscape patchiness, landscape mosaics	Vulnerability context Trends (e.g., market change) Shocks (economic, biophysical) Seasonality					
	Landscape change	Productivity and biomass			Policies, institutions and processes (linked to “Process Component”) Institutions, organizations, policies (formal, informal) Decision making context (social processes, culture, gender, age, class, caste, etc.)					
	Hydrology	Nutrient cycling, food web disruptions								
		Concentrations of pollution (e.g., from lagoon aquaculture)								

* source, sink and life-support attributes. Dependent on the dominant ecosystem type in the BR. # adapted from Department for International Development (DFID), 1999

4 Summary and Outlook

ACM provides one approach to address complexity and uncertainty in natural resource management and environmental governance settings. Its potential to nurture resilience has important implications for building the capacity of a social-ecological system to persist, adapt or transform. As with many nascent concepts, ACM is variously defined and operationalized and therefore a limited basis exists upon which empirical findings may be rigorously compared and relationships to actual outcomes established. In this discussion paper, we respond to these issues by developing a conceptual framework for diagnosing ACM. The diagnostic approach taken and the conceptual framework developed provide a structure for systematically and consistently examining ACM. In drawing upon existing work by ACM scholars, we focus attention on investigating the setting in which ACM occurs, look for activities and practices, assess learning and collaboration, and make connections to outcomes. We also discuss how the diagnostic may be made operational using the example of biosphere reserves.

We see the conceptual approach for diagnosing ACM and methodological considerations discussed in this paper as important steps in the maturation of ACM scholarship. Implementation through field research and analysis of the results in a biosphere reserve context will enrich the proposed framework and manner in which it is implemented. Through this process of continual refinement, we aspire to cultivate and advance a framework that may be employed to diagnosis ACM in a systematic and consistent manner across a variety of resource contexts and geographical locations. Such an approach raises future prospects about the ability of making causal inferences and ultimately to developing theories of ACM.

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