Fostering Governance and Building Capacity for Climate Change Adaptation: Can Adaptive Co-management Help?

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Abstract:

This paper explores the potential of adaptive co-management to foster climate change adaptation. Recent developments in environmental governance, its hybridization, and emerging core issues give context to the exploration. Against this backdrop, an overview of adaptive co-management is introduced. In drawing upon recent systematic reviews, the adaptive co-management literature is characterized, understanding gained from accumulated experiences to date is offered, and insights about its relationship with environmental governance presented. Although developed to address other resource and environmental issues, adaptive co-management is gaining attention as a governance strategy that may build capacity for climate change adaptation. It does this by fostering generalized adaptive capacity and offering a novel institutional arrangement to generate adaptive responses. Key questions emerging from this exploration are posed and discussed in an effort to advance the contribution of adaptive co-management to climate change adaptation.

Introduction

Human activities drive global environmental change in the era of the Anthropocene and are pushing the Earth system outside the stable state of the Holocene (Rockström et al., 2009). Climate change is one planetary boundary already transgressed and analysis by Rockström et al. (2009) reveals that continued change at the present rate will cause significant erosion of resilience for Earth system functioning. While variables such as temperature, precipitation and evapotranspiration fluctuated within a relatively narrow range in the Holocene, anthropogenic climate change is altering the variability and predictability of natural systems, and thus undermining the concept of stationarity (Milly et al., 2008). As a result, past approaches and technical designs are of limited utility for future conditions (National Research Council of the National Academies, 2009; de Loë and Plummer, 2010). Emerging research on complex systems highlights further challenges to views of stability and predictability. For example, Scheffer et al. (2009) draw attention to critical thresholds or tipping points that prompt abrupt change as a system shifts from one state to another. While mitigation is essential in this context to slow the rate of climate warming, the Intergovernmental Panel on Climate Change (IPCC) (2007) observes that even the most aggressive efforts will not prevent climate change, and thus, that adaptation is essential. In this context, "dealing with climate adaptation not only demands a rethink of how we arrange our social-ecological or social-technical systems but also how we govern them" (van Nieuwaal et al., 2009: 8).

This paper explores the role of adaptive co-management in supporting climate change adaptation. The transition underway in environmental governance, its hybridization of forms and emerging key challenges serve as an entrée into adaptive co-management. Foundational aspects of adaptive co-management are established and recent systematic reviews are drawn upon to 1) characterize the state of the adaptive co-management literature, 2) capture understanding from the body of evidence accumulated thus far, and 3) offer insights about its relationship with governance. While adaptive co-management has not typically been employed to address climate change, two main ways it supports adaptation are identified by drawing upon existing literature and preliminary applied experiences. A case study in the Niagara Region of Canada is highlighted. Four key questions to advance this governance strategy for adaptation are identified and discussed in the conclusion.

The Changing Landscape of Environmental Governance

Governance is goal oriented and steers society towards a particular end through deliberate interventions (Kooiman, 1993). All forms of governance are concerned about what could and what should be; they hold common the characteristics of 1) relationships between objects and subjects, 2) a desire for change in the relationships, and 3) perspectives on the context in which change takes place (Glasbergen, 1998). Biermann et al. (2009: 3) defines earth system governance as "the interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global) that are set up to steer societies towards preventing, mitigating, and adapting to global and local environmental change and, in particular, earth system transformation, with the normative context of sustainable development".

Literature associated with environmental governance can be nebulous (Ali-Khan and Mulvihill, 2008). Many models of governance exist relating to environmental policy (Glasbergen, 1998); each reflects norms about societal organization and taking a position on how and who should address environmental challenges. Glasbergen (1998) offers a typology encompassing the five types: regulatory control, market regulation, civil society, contextual control and self-regulation and co-operative management. While regulatory control provides the basis of environmental policy (Glasbergen, 1998) and made considerable headway with some environmental problems of twentieth century, its limitations are now realized as it alone fails to reconcile conflicts and polarized positions of actors, is unable to enforce compliance, and is limited in effectiveness under conditions of uncertainty and change which characterize contemporary environmental challenges (Holling and Meffe, 1996; Kettl, 2002). Attention has thus been shifting away from 'government' and towards alternative models of governance (Himley, 2008; Pahl-Wostl et al., 2008; de Loë et al., 2009).

While concentrating on the types or models of governance is useful for the purpose of highlighting their defining attributes, Glasbergen (1998) notes that in practice they frequently combine and are far from mutually exclusive. Lemos and Agrawal (2006) illustrated this concept by bridging ideal types of environmental governance models (state, market, community) in relation to hybridized or boundary crossing forms (e.g. co-management, public-private partnerships, private-social partnerships). Novel conceptualizations of environmental governance are emerging in light of complexity and uncertainty, often associated with climate or environmental change. Bulkeley (2005), for example, argues that new spatial grammars are required to comprehend hybrid forms and their social and ecological implications. Others (e.g., Volger, 2003; Liverman, 2004; Paavola, 2007) concentrate on the role(s) of institutions and institutional design solutions in this re-conceptualization. Duit and Galaz (2008) tackle the issues of complexity and uncertainty head-on and offer a complex adaptive system perspective on governance.

Several syntheses of environmental governance and issues or challenges have emerged recently (Lemos and Agrawal, 2006; Biermann et al., 2009; de Loë et al., 2009; Lockwood et al., 2010; Reed and Bruyneel, 2010). In drawing upon these and other efforts, it is possible to identify some cores issues or challenges. Although not an exhaustive list, these include:1) evolving expectations of accountability and legitimacy, 2) new constellations of actors and roles, 3) appreciation of fit, interplay and scale, 4) fostering adaptiveness, flexibility and learning, and 5) co-producing knowledge from diverse sources and types (de Loë et al., 2009; Armitage et al., under review; Plummer et al., under review a).

In bringing the foregoing together, insights are being gained about the requirements of governance in the context of climate change. Stemming from the reconceptualization of environmental governance set forth above, a transition is underway from an overly structural or static view of environmental governance and towards a dynamic perspective that stresses the ability to navigate interconnected and multi-level social-ecological systems (Lemos and Agrawal, 2006; Folke 2007; Ostrom, 2007; Galaz et al., 2008; de Loë et al., 2009; Plummer and Armitage, 2010). Additional aspects central to this dynamic and multi-level perspective of environmental governance include an integrative and systems orientation which links social and ecological systems (Berkes et al., 2003; Folke 2007); and institutions with characteristics of

being participatory, devolved, polycentric, deliberative and just (Kettl, 2002; Lebel et al., 2006; Huitema et al., 2009). Emerging strategies (e.g., adaptive governance, co-governance, adaptive co-management) to make such governance operational similarly assert requirements of "… collaboration among heterogeneous actors with diverse interests, institutions that are flexible and nested across scales and levels, and analytic deliberation that develops understanding through multiple knowledge systems; builds trust through repeated interactions; and fosters learning and adaptive and continuous feedback through continuous feedback" (Plummer and Armitage, 2010: 5; see also Dietz et al., 2003; Folke et al., 2005). It is important to note that these governance requirements may take several forms, and correspondingly, are open to a range of benefits and/or challenges. For example, Galaz et al., (in press) explore the governance challenge at a global scale posed by interacting planetary boundaries and concentrating on polycentric systems. In formulating three propositions and examining and the case of the Global Partnership on Climate, Fisheries and Aquaculture, they offer a nuanced perspective on polycentric governance and illuminate both its potential and limitations.

Adaptive Co-management

Adaptive co-management draws upon the collaborative and adaptive narratives that have been gaining traction in resource and environmental management over the past twenty-five years. The precise introduction of the term adaptive co-management (and the synonym adaptive collaborative management) dates to the mid-1990s and its early development occurred in two independent places (Plummer and Armitage, 2007). In the mid-1990s the Centre for International Forestry Research (CIFOR) used the term to draw attention to different social contexts of adaptive management relating to a project on criteria and indicators. It gained support in Asia and Africa, and was subsequently introduced into the scholarly literature (Colfer et al., 2001; Ruitenbeek and Cartier, 2001). At the same time, the term adaptive co-management emerged to embody a new direction for co-management scholarship which draws attention to complex adaptive systems thinking and social-ecological resilience (e.g., Folke et al., 2003; Olsson et al., 2004a).

Adaptive co-management is broadly understood as "a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, on-going, self-organized process of learning-by-doing" (Folke et al., 2002: 20). As a bridge spanning its adaptive and collaborative foundations, adaptive co-management engenders a distinct approach. Berkes et al. (2007) argue that adaptive co-management uniquely forges linkages (vertical and horizontal) for shared learning-by-doing, has a medium to long temporal horizon with multiple iterative cycles of learning and adaptation, is multi-scale in scope and all-encompassing in terms of the needs and relationships of actors, and focuses on building capacity for all involved. In so doing, adaptive co-management "…creates an 'adaptive dance' between resilience and change with the potential to sustain complex social-ecological systems" (Olsson et al., 2004a: 87) and "….may represent an important innovation in natural resource governance under conditions of change, uncertainty, and complexity (Armitage et al., 2007: 5).

The potential inherent in adaptive co-management to confer social-ecological resilience and foster dynamic multi-level environmental governance has resulted in a burgeoning area of scholarship and application. Recognizing the growing amount of work on adaptive co-

management, Plummer et al. (under review b) undertook a systematic review and analysis of all peer and non-peer reviewed literature items (e.g., journal articles, book chapters, theses) on adaptive co-management prior to May 2010. A total of 108 items were included in the analysis and a clear upward trend is evident in the amount of publications addressing the subject over time. Adaptive co-management is an amalgam of conceptual and applied scholarship with 67 items being primarily theoretical and 41 mainly empirical, with conceptual and applied elements being frequently combined. The adaptive co-management items analyzed most frequently address conventional resource sectors (e.g, forestry, fishery, water, wildlife, wetlands, protected areas), with none of the items addressing the issue of climate change per se. In terms of scale, both the adaptive co-management arrangement and the resource considered almost exclusively focus on the regional or local scale.

Berkes (2007; 2009) observes that adaptive co-management has many different faces (e.g., power sharing, institution building, trust building, process, social learning, problem solving, governance) as it expands to deal with complexity. Insights about how the process of adaptive co-management takes place are growing and are particularly informed by applied experiences in two places. The first is the work in the Kristianstads Vattenrike area of Sweden, where a rich series of investigations have documented the events and processes associated with this wetland landscape and its governance over the past 35 years (e.g., Olsson et al., 2004b; Schultz 2009; Hahn, 2011). The second is the work of the Centre for International Forestry Research (CIFOR) and the analysis/reflections upon their experiences of undertaking adaptive co-management approach at 30 sites (see Colfer, 2005). While a single definitive model of adaptive co-management does not emerge from these key experiences and others, it is evident that the process 1) consists of a relatively small number of definable phases, 2) is dynamic and characterized by continuous change, and 3) takes place across levels and at multiple scales (Plummer, 2009). Numerous aspects of adaptive co-management are being explored by scholars and practitioners. The review by Plummer et al., (under review b) captures those components or variables and the extent to which they appear in the literature. These include: bridging organizations, conflict, enabling conditions, incentives, knowledge, leadership, learning, networks, organizational interactions, shared power, shared responsibility and trust. The variables of learning, knowledge and networks are receiving the greatest amount of attention in the literature thus far, with learning commanding considerable attention and a diverse array of scholarship developing within this particular aspect.

In unpacking the association between adaptive co-management and governance, the former is described as a strategy of the latter for social-ecological systems (Armitage et al., 2009; Kofinas, 2009; Plummer, 2009; Cundill, 2010; Cundill and Fabricius, 2010). 'Good governance' (ie. polycentric, legitimate, transparent, diverse actors, multi-level institutions fit to biophysical systems) also exhibits characteristics of adaptive co-management (Olsson et al., 2004a; Folke et al., 2005; Berkes 2007, 2009). Huitema et al. (2009) observe that the growing literature on governance is particularly relevant to understanding adaptive co-management because it focuses attention on its institutional prescriptions and their performance. They suggest that collating studies is required to "…improve our understanding what adaptive (co-) management is about and what it involves in terms of governance" (Huitema et al., 2009). In building this suggestion, Plummer et al. (under review a) conducted a systematic review and analysis on the adaptive co-management literature with the aim of gaining insights about its relationship to environmental

governance. The term 'governance' was explicitly mentioned 1948 times in the 108 items and 71% of the items contained at least one occurrence. Theoretical and empirical contributions of adaptive co-management literature were identified to issues or challenges prominent in the environmental governance literature of actors and roles; fit, interplay, and scale; adaptiveness, flexibility, and learning; evaluation; and, knowledge. Implications from the work highlight how adaptive co-management moves away from an overly static or structural perspective on governance and towards one suited to navigating dynamic and multilevel systems.

Adaptive co-management is garnering considerable attention because it aims to bring about purposeful change. Adaptive co-management is anticipated to enhance the robustness of social-ecological systems (Olsson et al., 2004a) and orients them towards sustainable trajectories (Folke et al., 2002). It is also identified to potentially address the problem of fit (Olsson et al., 2007), act as an arena to address uncertainty that is good, right and authentic (Fennell et al., 2008), and build adaptive capacity (Armitage, 2007; Fabricius et al., 2007). The systematic review and analysis by Plummer et al., (under review b) revealed more than 40 actual outcomes from adaptive co-management in the literature and a record of mixed success thus far. In drawing upon case study evidence Armitage et al. (2009) synthesize key conditions for success in adaptive co-management to include: well-defined resource system, small scale, social entities with shared interest, clear property rights, access to adaptable portfolio of management tools, commitment to a long-term institution-building process, capacity building and resources, open to plurality of knowledge systems and sources, and supportive policy environment. Caution should be noted about being overly optimistic. For example, Nadasdy (2007) highlights the need to critically question the sociopolitical context and framing of interests and Fennell et al. (2008) observe how adaptive co-management is not immune from tensions of efficiencies, equity, and marginalization. Adaptive co-management is not a governance panacea and needs to be tailored to particular contexts (Armitage et al., 2009; Berkes, 2009; Plummer and Hashimoto, 2011).

How Does Adaptive Co-management Support Climate Change Adaptation?

This section explores how adaptive co-management supports climate change adaptation. Conceptualizations of adaptive capacity and adaptation serve as an entrée to investigate this relationship. Adaptive capacity, in the context of climate change, concerns the ability of a system to modulate exposure and sensitivity and influence its vulnerability (e.g., Adger, 2003; Smit and Wandel, 2006; Engle, 2011). In the social-ecological systems literature the notion of adaptive capacity is often positioned in relation to the concept of resilience. Adaptive capacity from this perspective concerns "…the ability of a social-ecological system to cope with novel situations without losing options for the future" (Folke et al., 2002: 17) and requires nurturing diversity for reorganization and renewal; fostering opportunities for self-organization towards sustainable trajectories; bringing together different types of knowledge for learning; and, learning to live with uncertainty and change (Folke et al., 2003). In building upon the diverse array of meanings associated with adaptive capacity, Plummer and Armitage (2010: 6) take an integrative perspective and frame the concept within scholarship on institutional dynamics and environmental governance. In so doing, they argue that "…adaptive capacity is determined by the suite of resources (technical, financial, social, institutional, political) held, and the social processes and structures through which they are employed and mediated (i.e., governance)".

Adaptive capacity has a close relationship with the concept of adaptation. Adaptive capacity manifests in adaptations (Smit and Wandell, 2006) and in simple terms describes the ability of a system to adapt (Engle, 2011). Adaptation, in the context of environmental change, is "an adjustment in ecological, social, or economic systems in response to observed or expected changes in environmental stimuli and their effects and impacts in order to alleviate adverse impacts of change" (Nelson et al., 2007: 398). The concerns and intricacies of the adaptation research agenda are considerably broad and reviewing them is beyond the scope of this paper (see Smit and Smithers, 1997; Smit and Pilifosova, 2003; Smit and Wandel, 2006; Engle, 2011). Especially pertinent to this exploration are the features of adaptive responses as well as the processes by which adaptation occurs. Several forms and levels of adaptive responses are classified (see Smit and Wandel, 2006). These include the timing of the response (e.g., anticipatory, concurrent, reactive), intent of the action (e.g., autonomous, planned), and its form (technological, financial, institutional). The approaches or mechanisms by which adaptation comes about may be considered adaptation strategies (Adger, 2003) or pathways (sensu Tompkins and Adger, 2004; Pelling, 2011).

Although there is relatively little experience with adaptive co-management in relation to climate change, there are two main ways in which it supports adaptation. First, adaptive co-management builds generalized adaptive capacity. This assertion is strongly supported by adaptive co-management scholarship that emphasizes this relationship (e.g., Armitage 2007; Fabricius et al., 2007; Armitage et al., 2009; Plummer et al., under review b). As Engle (2011) observes, it is important to distinguish what builds adaptive capacity or acts to limit adaptation. These factors generally fall under the literature on determinants of adaptive capacity and across scales it has been found to be influenced by economic development, technology and social factors (Nelson et al., 2007). Armitage (2005) draws attention to the operational (e.g., technical, financial, social, institutional, political) and strategic (e.g., power, scale, knowledge, community, culture) factors that influence adaptive capacity in community-based natural resource management and Gupta et al., (2010) offer the Adaptive Capacity Wheel as a means to assess adaptive capacity from an institutional perspective. In adaptive co-management specifically, there are several factors identified which foster adaptive capacity. For example, Fabricius et al., (2007) observe that adaptive co-managers have adaptive capacity, which "…becomes possible through leadership and vision, the formation of knowledge networks, the existence or development of polycentric institutions, the establishment and maintenance of links between culture and management, the existence of enabling policies, and high levels of motivation in all role players". Armitage et al., (2009: online) describe how adaptive co-management additionally encourages the key ingredients of adaptive capacity by encouraging flexibility and innovation.

Perhaps most pointedly, Pelling et al., (2008: 870) observe that "seeing adaptation in terms of learning highlights both material adaptation and institutional modification as valid adaptive strategies. If learning itself is considered a kind of adaptive behavior, then this opens up questions surrounding the process through which actors can learn to learn (or learn to be adaptive)". A central line of inquiry for those studying adaptive co-management is about learning, and in particular the functioning of social or multiple loop learning (Plummer and FitzGibbon, 2007; Armitage et al., 2008; Berkes 2009; Plummer, 2009). Specific attention to learning and knowledge within co-management in relation to adapting to climate change comes from work in the Arctic (Berkes and Armitage, 2010; Armitage et al., 2011). This work

examines linkages among knowledge, learning and adaptation in relation to three co-management cases. Insights gained through the analysis draw attention to how knowledge co-production may trigger or act as a mechanism for learning, which emerged in the cases as a key type of adaption.

Second, adaptive co-management as governance strategy offers a novel institutional arrangement to generate adaptive responses to climate change. Institutions are fundamental to the capability of society for adaptation, and the manner by which trade-offs among adaptation options occur (Gupta et al., 2010; Armitage et al., 2011). As Adger (2003: 33) points out, "adaptive capacity is only potential until there are governance institutions that make it realizable". In returning to the context of the Canadian Arctic, Berkes and Armitage (2010) identify co-management institutions such as the Fisheries Joint Management Committee established under the Inuvialuit Final Agreement and the Nunavut Wildlife Management Board as new institutional processes which are adaptations to the impacts of climate change. Although such co-management arrangements were not intended to address climate change per se, they document that "these arrangements provide emerging networks, or horizontal and vertical linkages that give rise to new social practices and stakeholder interactions, and thus a greater ability to cope with variability and build longer-term adaptive responses to minimize risk and uncertainty" (Armitage et al., 2011: 995). Adaptive co-management thus offers an institutional arrangement which may support climate change adaptation and a pathway to generate adaptive responses. The timing of the adaptive response in the example is concurrent and the intent autonomous, as the arrangements was not initially aimed at climate change.

Adaptive co-management may also be introduced as an anticipatory and planned response to purposefully provide adaptive pathways and mechanisms. In one of the few applied examples connecting adaptive co-management and climate change, Locatelli et al. (2008) argue that adaptive co-management is a good example for forestry because it builds upon three prongs crucial for climate change adaptation. These include the need to: understand diverse views of many stakeholders; develop better mechanisms for learning from experiences; and, address power inequities. The possibility of crossing adaptive co-management with conventional risk management approaches to climate change adaptation is attractive. In this regard, May and Plummer (2011) pioneer the idea of 'adaptive collaborative risk management' (ACRM) by arguing that conventional risk management can benefit greatly by incorporating collaborative and adaptive spirit of adaptive co-management. They illustrate this possibility by adapting the risk management standard CAN/CSA-ISO 31000, which Canadian communities are being encouraged to follow regarding climate change adaptation (Noble et al., 2005; Bruce et al., 2006). In this way "ACRM brings together technical and social aspects and ensures collaboration, as opposed to consultation and communication, and co-development of knowledge and shared learning, as opposed to monitoring and review" (May and Plummer, 2011, online).

The two main ways adaptive co-management supports climate change adaptation are closely related. Initiating an adaptive co-management process, designed with the explicit intent of climate change adaptation, to gain further insights into these two contributions is an intriguing possibility. With this intent, an adaptive co-management approach was initiated in the Niagara Region of Canada in 2010 with the aim of community climate change adaptation. While it is premature to offer results or in-depth insights because the research is still underway, the

following paragraphs succinctly set the context for the case and share experiences thus far to establish the prospect of introducing adaptive co-management as an anticipatory response and platform for adaptive pathways.

The Niagara Region has unique physical and ecological features of the Niagara Escarpment (recognized in 1990 with a UNESCO Biosphere Reserve designation) and is home to approximately 425,000 people. Manufacturing, agriculture and tourism (largely associated with Niagara Falls) are important sectors of the economy; the latter is often highlighted as 30 million people visit the area and are expected to spend $2.3 billion (NEDC, 2010).

Climate change is a concern in the Region and this issue provided a window of opportunity to initiate an adaptive co-management approach. The window of opportunity opened when a planner from The Regional Municipality of Niagara who was charged with the task of developing a climate change adaptation plan requested a meeting with researchers at Brock University and Environment Canada who were conceptualizing the application of adaptive co-management to climate change. Recognizing that many individuals and organizations were active on the landscape, a social-ecological inventory was undertaken. A social-ecological inventory is a technique to identify active individuals/organizations, gain insights about their activities and values, understand the social-ecological system and 'prime' it for engagement. A total of 38 individuals representing 33 organizations were interviewed to gain an enriched picture of the existing activities and network.

These individuals were then brought together in an interactive and learning orientated process. Gaining knowledge about climate change projections and impacts were identified as an important first step. In an initial workshop local climate changes scenarios were described and potential impacts were detailed. This information provided the basis for much discussion as the participants reflected upon the implications. Over the course of the next several meetings information was shared from the social-ecological inventory, through other initial inquires about climate change knowledge, and experiences from other places. Interaction among the participants increased as they engaged with this information and each other in person at the meetings as well as through an electronic portal, which served as a repository for all materials.

In time, the individuals began to coalesce and a group identity emerged with the name Niagara Climate Change Network as a response to climate change. The group felt it was imperative to come to a shared understanding and expression of concern about climate change. A tremendous amount of effort was therefore put into crafting a climate change charter which individuals and organizations could sign. The group also created an administrative structure in the form of a steering committee to more efficiently and effectively develop and implement responses to climate change tailored to the Region.

Conclusions

The title of this paper provocatively posed an ambitious question to adaptive co-management scholarship: can it help to foster governance and build capacity for climate change adaptation? In exploring this question, adaptive co-management was positioned as a governance strategy and two substantive ways in which it supports climate change adaptation were identified. First, it

builds generalized adaptive capacity. Second, it offers a novel institutional arrangement to generate adaptive responses to climate change.

Although the question posed in the title was answered in the affirmative, the following key questions for moving forward with adaptive co-management for climate change adaptation emerged from the exploration.

Can further insights be gained about how adaptive co-management as a governance strategy builds general adaptive capacity and generates adaptive responses?

Developing a more full understanding of adaptive co-management is a critical challenge. While efforts to synthesize knowledge of the adaptive co-management process and the influences of exogenous and endogenous variables offer some advancement (Plummer, 2009), the findings from a recent systematic review and analysis of adaptive co-management literature (Plummer et al., under review b) reveal that existing research is insufficient in terms of definitional clarity, measurement and findings to answer: the extent to which variables (e.g., social and political context, properties of networks, assets employed by agencies, organizations, and individuals, attributes of organizations and individuals, key functions of individuals) can be traded off; which variables always need to be present; and, the variables that can improve its quality. Gaining insights specific to variables associated with adaptive co-management (e.g., learning, knowledge, networks, leadership) is also required and will be beneficial. These are formidable challenges for adaptive co-management scholarship at present. Pursuing a fuller understanding of adaptive co-management in a systematic and rigorous manner raises the prospects of developing theory to help guide human-environment interactions (Plummer et al., under review b).

How does the context of climate change influence adaptive co-management?

Since knowledge and experience of adaptive co-management in the specific context of climate change adaptation is limited, an underlying assumption of this paper is that scholarship on adaptive co-management in other environmental contexts is transferable to some degree. Determining the degree to which such knowledge and experience is indeed transferable as well as understanding how this context shapes the adaptive co-management process is essential. For example, Armitage et al., (2009: 100) derive 'ten conditions for successful adaptive co-management' from a variety of empirical cases which must be present to some extent for a successful outcome. Conditions of success they identify which present immediate challenges in regard to climate change include: well-defined resource system, small-scale resource use contexts, reasonably clear property rights, and national and regional policy environment. In reflecting upon research experiences with Niagara, the context of climate change seems to add a level of 'abstraction' and a lack of immediacy that often precipitate stakeholders to act in other adaptive co-management situations. Being aware of how adaptive co-management manifests in different situations is also critical. Plummer and Hashimoto (2011) offer a framework for researchers and policy makers in this regard. They argue that adaptive co-management can thus be tailored to a context, and in turn, the adaptability and fit enhanced.

How does adaptive co-management compare to, and connect with, other governance strategies for climate change adaptation?

Both parts of this double-barreled question require consideration and warrant future investigation. The first part of the question identifies the need to clearly identify the outcomes from adaptive co-management and evaluate its successes or failures. Considerable actual and potential outcomes are apparent in the adaptive co-management literature (Plummer et al., under review b). While evaluation of adaptive co-management is critical, few studies have undertaken such an assessment (Plummer and Armitage, 2007; Cundhill and Fabricius, 2010). Efforts to assess the effectiveness of institutional prescriptions of adaptive co-management based on evidence from the existing literature were inconclusive and led to the call for more empirical and theoretical work (Huitema et al., 2009). The subsequent systematic review of adaptive co-management literature to 2010 found little basis for meaningful comparisons and thus identified evaluating outcomes and establishing generalizable patterns of how components of adaptive co-management relate to goals and outcomes as a critical future challenge (Plummer et al., under review b).

The second part of this question draws attention to the need for multiple governance strategies for climate change adaptation and consideration of their interplay. Climate change is an example of a wicked problem with global to local interdependencies. The very definition of earth system governance offered by Biermann et al. (2009) earlier highlights the interrelations and increasing integration of institutions as well as connections between mitigation and adaptation to environmental change. Duit and Galaz (2008: 318) observe that "…different governance systems might coexist and interact over societal levels" and that "…the combination of different governance systems will be decisive for the impact of disturbances and surprises". Adaptive co-management is one example of an emerging governance strategy and determining how it works with others will be critical. Adaptive co-management works across levels and scales, but usually focuses on an identifiable landscape or small scale. Attention is required as to how changes prompted by adaptive co-management may cascade upwards. Recent work by Galaz et al., (in press) is a reminder that all governance strategies present both opportunities and limitations. Future research is required to better understand what those are for adaptive co-management generally, and specifically in regard to climate change.

What if adaptation is not appropriate and a different system trajectory is required?

Adaptive strategies and capacity for adaptation are essential to dealing with change. However, it is possible that adaptability can 'mask business as usual' and that they may be maladaptive, undermine long term solutions, and cause undesirable consequences (Folke et al., 2003; Scheffer, 2009). An important distinction is required between adaptability, capacity for reconfiguration within a social-ecological regime, and transformability, the capacity to create a fundamentally new social-ecological system and shift to a social-ecological trajectory (Walker et al., 2004; Lebel et al., 2006). Responses, even adaptive ones, which fail to respond adequately to system feedbacks can create lock in or rigidity traps which cause persistence along established paths as well as reduced capacity to innovatively respond to opportunities (see Walker et al., 2009; Olsson et al., 2010). Understanding when and how these situations occur and building capacity to transform conditions at particular scales are essential, and complimentary, processes (Walker et al., 2004; Lebel et al., 2006; Olsson et al., 2010). Despite recognizing the need for transitions and transformations, few examples based on empirical cases exist and "there is still a lack of

understanding on how to transform SES into new, improved trajectories that sustain and enhance ecosystem services and human well-being" (Olsson et al., 2010: 264). Adaptive co-management appears to be an exception to this observation. Building upon work in Kristianstads Vattenrike as well as navigating transitions in other cases (e.g., Olsson et al., 2006; Olsson et al., 2008), Olsson et al. (2010) introduce the idea of transformative capacity. From their experiences, building capacity for transformation requires understanding where you are, determining where to go, and devising ways to get there. They conclude that "important questions for future research on SES transformations are what needs to be transformed and how transformations happen" (p. 281). Adaptive co-management thus seems particularly applicable to deliberative transformational change at lower scales that may cascade upwards (Folke et al., 2010).

Undertaking adaptive co-management to address climate change adaptation will not be an easy task as it is neither a set prescription nor a governance panacea. At the same time, it offers a viable way to foster governance and build capacity to navigate change. As Olsson et al. (2010: 281) argue: "…if we can increase our understanding of SES transformations and provide strategies and guidelines for initiating and navigating SES' transformations we could better prepare for and potentially speed up the responses to the rapidly changes in the capacity of the earth's ecosystems to sustain our development and civilization. The issue is pressing, considering the window of opportunity for transformation towards sustainability that are currently wide open due rapid, pervasive global changes in many dimensions".

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