The Problem of Fit between Ecosystems and Governance Systems – Insights and Emerging Challenges

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Humans and biophysical systems are closely interconnected. Yet not only do we fall short to recognize the tight coupling between these systems, but the stakes of failing to harness the dynamic behaviour of social-ecological systems are getting higher. Two clear signals of this failure is the loss of vital ecosystem services at a global scale (Millennium Ecosystem Assessment 2005), as well as the far-reaching challenges posed by global environmental change (Steffen et al. 2004). Hence, there is a need to elaborate how the attributes of governance at all levels shape and match the dynamics of ecosystems from local to global scales. This is what has been denoted "the problem of fit" (Folke et. al. 1998, Young 2003, Brown 2003, Cummings et. al. 2006).

The following chapter elaborates on the problem of 'fit' between governance systems and the dynamic behaviour of ecological systems. We discuss this issue through a "resilience lens", i.e. by focusing on the capacity of social-ecological systems to deal with environmental and societal change, and to reorganize after shocks and surprises. In this sense, the governance challenge lies not only in developing multilevel institutions and organizations for multiscale ecosystem management, but also to be in tune with the interplay between periods of incremental change when things move forward in roughly continuous and predictable ways, and abrupt change when experience is often insufficient for understanding, consequences of actions ambiguous, and the future of system dynamics often uncertain (e.g. Adger et al. 2005). We are particularly interested

in avoiding pathways of social-ecological misfits that lead to social traps (e.g. Costanza 1983) and constrained options for societal development and future capacity for adaptations (Gunderson and Holling 2002, Berkes et al. 2003).

While the subject has been elaborated in detail by Carl Folke and colleagues earlier (1998), the following chapter intends to provide a transdisciplinary update linking insights from research on social-ecological systems, with advances in the social sciences related to governance theory.

The outline of this chapter is the following. In the first section, we discuss the tight connection between social and ecological systems. The human dependence on the capacity of ecosystems to generate essential services, and the vast importance of ecological feedbacks for societal development suggest that social and ecological systems are not merely linked, but rather *interconnected*. We also present insights concerning the social processes and institutional structures that seem to build resilience in social-ecological systems – that is a capacity for living with and learning from, change and unexpected shocks. In the second section, we examine world wide changes in the socio-political landscape such as decentralization, public-private partnerships, and the emergence of network-based governance. Here we highlight the need to recognize the dynamic nature of not only social-ecological but also governance systems, as well as the notion and features of adaptive governance.

In the third part we analyze how the combined dynamics of social and ecological systems lead to a number of emerging governance challenges that will become important as a consequence of the increased interconnectedness of social, economic, technical and ecological systems (Young et. al. 2006, Held 2000), the non-linear nature of interconnected social-ecological systems, and the challenges posed by global environmental change (Steffen et al. 2004). In the last section, we elaborate what we call "the anatomy of misfits", illustrate their underlying mechanisms, and present suggested strategies to cope with the identified mismatches.

I. From Linked to Interconnected Social-Ecological Systems

Why are social-ecological systems not just social and ecological systems, with some links in between (Westley et al. 2002)? Conventional understanding suggests that the socio-economic system extracts natural resources from the ecological system, which in turn receives disturbances (such as pollution and resource

extraction) from the socio-economic system. As we discuss in the following section, this demarcation between social and ecological systems is seriously flawed.

Berkes and Folke (1998) coined the term "social-ecological system" to emphasize the integrated concept of humans-in-nature to avoid reducing the social aspects to a prefix (i.e. 'socio-'), and to stress that the delineation between social and ecological systems is artificial and arbitrary. They addressed the interplay and problem of fit between social and ecological systems by relating management practices based on ecological understanding to the social mechanisms behind these practices, in a variety of geographical settings, cultures, and ecosystems.

The need to fully understand the interconnected character of social-ecological should not be underestimated. Although certainly illuminating in a number of senses, conventional natural resource management studies tend to have a strong focus on investigating processes *within* the social domain only, treating the ecosystem largely as a "black box". A bold and often incorrect implicit assumption is that if the social system performs adaptively, or is well organized institutionally, it will also manage the environmental resource base in a sustainable fashion.

The flaw of this assumption is illustrated by the mobilization of collective action among coastal fishermen in Belize into cooperatives. This social initiative seemed to have led to a number of socially desired outcomes such as increased revenue for the fishermen. Although the strategy was initially economically successful, the increase of collective action combined with technological development (i.e. fuel-based technology) led ultimately to excessive harvesting of stocks of lobster and conch and in the end worse economic conditions (Huitric 2005). In a similar vein, Allison and Hobbs (2004) describe how natural resource users' and political decision-makers' responses to environmental degradation in agricultural systems in Western Australia can result in a "lock-in" pathological trap (Holling and Meffe 1996) leading to a continued erosion of the resource base, and continued social decline in the region. A third example is the conservation of biodiversity. Although the loss of biodiversity often is argued to be strongly interrelated with endemic corruption in developing countries (Laurance 2004), data shows that even countries with transparent, effective, and non-corrupt institutions have low levels of species richness (Katzner 2005).

Hence human society may show a great ability to mobilize collective action, design institutions and adapt to changing circumstances, but such an adaptation may be at the expense of changes in the capacity of ecosystems to sustain societal development. In fact, recent reviews highlight that human adaptation has caused loss of resilience and pushed many ecosystems close to thresholds or into alternate states with lower capacity to generate ecosystem services for society (e.g. Scheffer et al. 2001, Folke et al. 2004). At worst such adaptations may generate traps and breakpoints in the resilience of a social-ecological system that triggers abrupt undesired change (Gunderson and Holling 2002).

Similarly, focusing on the ecological side alone to understand environmental change or to provide policy recommendations is likely to lead to similarly flawed analysis. As an example, Berkes and colleagues (2006) bring to light the societal and market processes that generate changes in large-scale ecological systems by showing how the sequential exploitation of marine resources is triggered by highly mobile "roving bandits", and rapidly developing world markets. Basing policy recommendations on ecological knowledge alone without recognizing the fundamental impact of social actors and institutions on ecological systems, is a simplistic approach that fails to appreciate the complexity of governance processes, mental models (Adams et. al. 2003) and the social features that enable management of dynamic ecosystems (Folke et al. 2005).

The mentioned examples illustrate why the delineation between social and ecological systems is artificial and arbitrary, and motivates why the intersection between the social and ecological systems must be addressed in its full complexity and not just as a link between two systems. In short, these systems intersect and co-evolve in such a degree, that we prefer to denote them *interconnected* rather than linked.

Interconnected Social-Ecological Systems and the Problem of Fit

Lack of an integrative perspective on social-ecological systems is only a part of the story; these problems are exacerbated by the mismatch of scales between management and ecosystems. A number of studies show how blue-print, command and control approaches for managing natural resources often fail to embrace the diversity of different local settings and the complexity of

ecosystems (Holling and Meffe 1996, Wilson 2006). As a consequence, this management approach has pushed many ecosystems into degraded vulnerable states (Scheffer et al. 2001, Folke et al. 2004).

The mechanism behind this management failure lies in the attempt to control a few selected ecosystem variables in their efforts to deliver efficiency, reliability, and optimality of ecosystem goods and services (Holling and Meffe 1996). However, stabilizing a set of desirable goods and services can lead to an increased vulnerability of the system to unexpected change (Folke et al. 2002, Gunderson and Holling 2002). For example, Wilson (2006) argues that this mismatch of ecological and management scale makes it difficult to address the fine-scale aspects of ocean ecosystems, and leads to fishing rights and strategies that tend to erode the underlying structure of populations and the system itself.

The shift from approaching social and ecological systems as two separate systems to truly interconnected complex social-ecological systems, characterized by non-linear relations, multiple basins of attraction and the potential for threshold behavior and qualitative shifts in system dynamics (Levin 1998, Arthur 1999, Jervis 1997), has triggered the emergence of analytical frameworks like *social-ecological resilience, adaptive co-management* and *adaptive governance*. The first two are dealt with in this section, while adaptive governance is dealt with later in the chapter.

Enhancing the Fit through Adaptive Co-management

One discussed strategy to enhance the fit between ecosystems and governance is adaptive co-management. Adaptive co-management refers to the multilevel and cross-organizational management of ecosystems. Such multilevel governance systems often emerge to deal with crisis, and can develop within a decade (e.g. Olsson et. al. 2004a). It combines the dynamic learning characteristic of adaptive management with the linkage characteristic of collaborative management (Wollenberg et. al. 2000, Gadgil et. al. 2000, Ruitenbeek and Cartier 2001, Folke et. al. 2003, Borrini-Feyerabend 2004). The motive behind this combination is related to the analytical and managerial shortcomings of both adaptive management and co-management. While adaptive management addresses the humans-in-nature perspective and learning-by-doing (Holling 1978) the approach has been criticized for not incorporating other knowledge systems (McLain and Lee 1996). Co-management on the other hand, addresses institutional and

epistemological aspects, multi-stakeholder processes and the sharing of power in natural resource management, but often neglects fundamental ecosystem feedback and dynamics (as well as the governance dimension which we explain later in this chapter).

Olsson et al. (2004) discuss the role of adaptive co-management for building resilience in social-ecological systems. Resilience in social-ecological systems, or social-ecological resilience (as defined by Folke 2006), emphasizes the reorganization, learning and adaptive capacity of actors in response to ecosystem change (Table 1). For *ecosystem resilience,* the challenge is to sustain the capacity of ecosystems to generate valuable ecosystem services and this depends on ecological dynamics as well as the adaptive management of this dynamics and the capacity to handle surprise. S*ocial-ecological resilience* endorses this challenge but explores further into the institutional arrangements as well as the organizational and governance processes that enable adaptive co-management of ecosystems (Folke et al. 2005).

[TABLE 1 HERE]

The notion of adaptive co-management hence recognizes the fact that ecosystem management is an information-intensive endeavour and requires knowledge of complex social-ecological interactions in order to monitor, interpret, and respond to ecosystem feedback at multiple scales (Folke et. al., 2003). Due to this complexity it is difficult if not impossible for one or few people to possess the range of knowledge needed for ecosystem management (Berkes 2002, Brown 2003, Gadgil et al. 2003, Olsson et al. 2004). Instead, knowledge for dealing with social-ecological systems dynamics is dispersed among individuals and organizations in society and requires social networks that span multiple levels in order for actors to draw on dispersed sources of information (Imperial 1999, Olsson et al. 2006).

Crisis, perceived or real, can trigger learning and knowledge generation (Westley 1995) and open up space for new interactions and combinations of knowledge and experiences, and new management trajectories of resources and ecosystems (Gunderson 2003). For example, mobilization of different knowledge systems may take place in a *social learning process* (Lee 1993), i.e. “learning that occurs when people engage one another, sharing diverse perspectives and experiences to develop a common framework of understanding and basis for joint

action" (Schusler et. al. 2003). Hence, social learning integrates issues of knowledge generation, working out objectives, solving conflicts, and action.

The Social Foundations of Adaptive Co-management

Yet coordinating such complicated institutional and organizational landscape to enhance the fit between ecosystems and governance is far from being a simple task. Three issues do however seem stand out as critical for success in this context; the first is the need to link organizations across levels, the second is the role of bridging organizations, and last the importance of leadership.

Organizing linkages between relatively autonomous, but interdependent actors and actor groups becomes of crucial importance for avoiding fragmented and sectoral approaches to the management of ecosystem services and for enhancing the fit between governance systems and ecosystems. Scholars have pointed out that linking different levels requires an active role of individuals or organizations, for example for linking local communities to outside markets (Bebbington 1997, Ribot 2004, Pomeroy et al. 2006). Crona (2006) refers to such individuals that link fishers to markets in coastal communities of Eastern Africa as middlemen. As pointed out by Gonzales and Nigh (2005) intermediaries are no guarantee for more democratic decision-making but can be part of hierarchical command-and-control structures where policies are implemented in a top-down fashion. Another example is the role of NGO's as coordinators and facilitators in co-management processes (for example Halls et. al. 2005).

Boundary organizations and bridging organizations are two forms of intermediaries that have been described in this context. Boundary organizations can provide an array of important functions for linking researchers and decision-makers (Guston 1999, Cash and Moser 2000). Although similar in some aspects, bridging organizations have a broader scope than boundary organizations, and addresses resilience in social-ecological systems. A bridging organization provides an arena for trust-building, social learning, sense-making, identification of common interests, vertical and/or horizontal collaboration, and conflict resolution (Folke et al. 2005). Malayang (2006) show how bridging organizations perform essential functions in crafting effective responses to change in social-ecological systems. Bridging organizations create the space for institutional innovations and the capacity to deal with abrupt change and surprise. For

instance in Kristianstads Vattenrike, Sweden, most of the activities are coordinated, but not controlled, by Ecomuseum Kristianstads Vattenrike, a small municipal organization acting as a bridging organization (Hahn et al 2006). They have developed an explicit approach to conflict resolution and dealing with disturbances. Bridging organizations, like the one in Kristianstads Vattenrike, seem to play a central role in stimulating, facilitating and sustaining adaptive co-management and adaptive governance (Folke et al. 2005). They can have a key role in collective learning processes that builds experience with ecosystem change and evolves as a part of the social memory. Such a process of social learning is linked to the ability of management to respond to environmental feedback and direct the coupled social-ecological system into sustainable trajectories (Berkes and others 2003). Bridging organizations therefore are essential in fostering sources of resilience in social ecological systems.

Leadership is another critical feature for increasing the fit through adaptive co-management. For example, key individuals can provide visions of ecosystem management and sustainable development that frame self-organizing processes (Agranoff and McGuire 2001, Westley, 2002). Key individuals are important in establishing functional links within and between organizational levels and therefore facilitating the flow of information and knowledge from multiple sources to be applied in the local context of ecosystem management. Leadership has been showed to be of great significance for public network management. Network leadership and guidance is very different from the command and control of hierarchical management (Agranoff and McGuire 2001). It requires steering for holding the network together (Bardach 1998) and balancing social forces and interests that enables self-organization (Kooiman 1993). However, social-ecological systems that rely on one or a few key stewards might be vulnerable to change as exemplified by Peterson (2002) in the case of long-leaf pine forest ecosystems in Florida.

An important lesson is that it is not enough to create arenas for dialogue and collaboration, nor is it enough to develop networks to deal with issues at a landscape level. We have to understand and actively manage the underlying social structures and processes for ecosystem management. A challenge in such governance systems is to support social mechanisms and enabling institutional arrangements for accessing and combining knowledge to respond to ecosystem feedbacks at critical times (Olsson et al. 2006). However comprehensive the combined knowledge might be, there is always an element of surprise when

dealing with complex social-ecological dynamics (Gunderson 1999, 2003). Linking different actors groups in networks and creating opportunities for new interactions is important for dealing with uncertainty and change and critical factors for learning and nurturing integrated adaptive responses to change (Stubbs and and Lemon 2001, Hahn et al. 2006).

II. From Institutions to Dynamic Governance Systems

Institutional theory has made substantial advances in clarifying the importance and social mechanisms behind the emergence of self-organized institutions for natural resource management (Ostrom et. al. 2002, Ostrom 2005). But the last decade displays other important insights that all highlight the dynamic and multilevel nature of governance systems. As we intend to elaborate in this section, these shifts have important implications for our understanding of the problem of fit.

From Government to Governance

Parallel to research advances in the field of institutions and natural resource management, the last two decades display a number of world wide shifts in the organization of society and politics to a less centralized command-and-control style of governing (Pierre 2000, Stoker 1998). The driving factors behind this change are several.

Decentralization initiatives are one cause. As argued by (Bahrdan 2002), decentralization has been one of the most fundamental policy experiments globally. Part of logic behind this shift is related to the alleged failure and lost legitimacy of the centralized state (Bardhan 2002, Mayntz 1993). Another motive is the expectation that a fragmentation of central authority will make government more receptive and efficient in its attempt to solve complex societal problems, such as chronic poverty (Datta and Varalakshmi 1999) and overextraction of natural resources (Ostrom 2005).

The growth of public-private partnership arrangements – i.e. the cooperative ventures between the state and private business - is another trend in the same trajectory (Evans 1996, Osborne 2002). The motive in this case is the expectation that collaborative interagency partnerships can offer fruitful means of achieving public policy goals, and afford a more attractive alternative to full privatization,

or large-scale bureaucratic public service organizations (Lowndes and Skelcher 1998). This trend is highly visible in the field of natural resource management (Ostrom 1996), and advanced by a number of prominent international organizations in water governance (Global Water Partnership 2000, Batley 1996), biodiversity conservation (Stoll-Kleeman and O'Riordan 2002, Hilty 2003), capacity building for ecosystem management (Berkes 2002, Olsson et al. 2004a, Folke et al. 2005), biotechnological research (Rausser et. al. 2000).

Another point often made by governance scholars is the augmented influence of non-governmental organizations and epistemic communities on policy processes at a number of political levels. Climate change policy (Gough and Shackley 2002), biodiversity policy (Fairbrass and Jordan 2001) and decision-making in the European Union, all provide interesting cases in point. The existence of numerous access points into the institutional process, and the large number of officials and organizations that have a role in the process, all support the increased influence of non-state political entrepreneurs such as NGO's and epistemic communities (Zito 2001, Sabatier 1998).

Lastly, the increased impact of multilateral agreements on domestic policy (Cortell and Davies 1996, Bennett 1991), and the spread of policy innovations across different nations (Busch and Jörgens 2005) also illustrate the change away from the command-and-control nature of governing of central governments, and the increased influence of actors and policy-making beyond the centralized state.

The Dynamics of Governance Systems and the "Problem of Fit"

The discussed perspective of governance of complex social-ecological systems have fundamental implications for our understanding of the "problem of fit". Natural resource users trying to preserve ecosystem services and build resilience find themselves not only facing potential collective action problems with other users (Ostrom 1990), but also a plethora of interlinked local, national and international institutions and a diversity of actors and decision-makers.

The case of property rights provides a good example. Much attention has been devoted at common-property regimes as alternatives to government property or private property regimes (e.g. Ostrom 1990, Bromley 1992). Within each of these property rights regimes, use rights, capital rights (rights to sell), management authority, and excludability may be distributed differently for different ecosystem services. Yet as the ecological scale of management

concerns increases, for example to a catchment or a landscape scale, we generally find a mix of property rights regimes and the need to coordinate management in order to reduce the spill-over effects (external costs) among stakeholders – private landowners, communal land representatives, governmental agencies at different levels, and various NGO. Due to their interdependence, no stakeholder can fulfil its objectives in isolation from actions of other stakeholders (Imperial 2005). On this larger ecological scale, the challenges are shifting from designing property rights to agreeing on goals and strategies for responding to environmental change and hence to develop a more dynamic governance system.

So while common pool resource or multilevel institutions undoubtedly play a fundamental role in the sustainable management of ecosystem services, the fact that these are embedded in a highly dynamic multi-sectoral and multilevel governance landscape with a variety of actors and interests, forces us to acknowledge the changing nature of governance, and its implications for the problem of fit. More precisely, it forces us to acknowledge not only the potential misfit between institutions and ecosystems (Folke et. al. 1998, Cummings et. al. 2006), but also the lack of fit between ecosystem dynamics and *governance systems*.

By governance systems we mean the interaction patterns of actors, their sometimes conflicting objectives, and the instruments chosen to steer social and environmental processes within a particular policy area (c.f. Pierre 1999, Pierre and Peters 2005, Stoker 1998, Jordan et. al. 2005). Although institutions certainly are a central component in governance (Pierre 2000), our ambition is to put a stronger emphasis on both the patterns of interaction between actors, as well as the multilevel institutional setting under which they interact repeatedly, hence creating complex interactions between structure and agency (Klinj and Teisman 1997, e.g. de la Torre Castro 2006, Bodin et. al. 2006).

One fundamental assumption is that differing multilevel institutional settings, combined with different interaction patterns (c.f. Scharpf 1997), will produce a diversity of outcome related to the problem of fit. To be more precise, different institutional settings (not necessary related to natural resource management alone), and differing constellations of actors (i.e. type, bargaining resources and number of actors) lead to different outcomes in social processes vital for harnessing the behaviour of complex adaptive systems such as social-

ecological system (e.g. high or low adaptive capacity; proficient or non-existing leadership; trust-building or propagation of conflict).

Harnessing Complexity through Adaptive Governance

Adaptive co-management seems to be a step in the right direction for analysing and coping with social-ecological dynamics. On the other hand, it also faces analytical limitations associated to the multilevel character of both social and ecological change (Folke et. al. 2005). How to create governance that is able to "navigate" the dynamic nature of multilevel, and interconnected social-ecological systems becomes a crucial issue in this context.

The notion of "adaptive governance" discussed by Dietz et al. (2003) and Folke et. al. (2005) is interesting since it can address the possibilities and need to draw on the multilevel changing nature of governance systems. Adaptive governance conveys the difficulty of control, the need to proceed in the face of substantial uncertainty, and the importance of dealing with diversity and reconciling conflict among people and groups who differ in values, interests, perspectives, power, and the kinds of information they bring to situations (Dietz et al. 2003). Such governance fosters social coordination that enables adaptive co-management of ecosystems and landscapes. For such governance to be effective it requires joint understanding of ecosystems and social-ecological interactions. This approach also recognizes both the need to govern social and ecological components of social-ecological systems, as well as building a capacity to harness exogenous institutional and ecological drivers that might pose possibilities, or challenges to social actors (Folke et. al. 2005, see also Dietz et. al. 2003. Folke et al. (2005) highlights the following four interacting aspects of importance in adaptive governance of complex social-ecological systems:

a. Build knowledge and understanding of resource and ecosystem dynamics to be able to respond to environmental feedbacks;
b. Feed ecological knowledge into adaptive management practices to create conditions for learning;
c. Support flexible institutions and multilevel governance systems that allow for adaptive management;
d. Deal with external perturbations, uncertainty and surprise;

Polycentric institutional structures – i.e. institutions with multiple and overlapping centres (McGinnis 2000) – are crucial in this notion. It has been proposed that these sort of institutions can address environmental problems at multiple scales and nurture diversity for dynamic responses in the face of change and uncertainty. The argument is that large-scale, centralized governance units do not, and cannot, have the variety of response capabilities that complex, polycentric, multi-level governance systems can have (Ostrom 1998). Similarly, Imperial (1999) argues that polycentric governance creates an institutionally-rich environment that can "encourage innovation and experimentation by allowing individuals and organizations to explore different ideas about solving [complex] problems". Such arrangements allow for self-organization and if efficiently linked across scales, they can increase the complexity of those systems and therefore the variety of possible responses to change (Ostrom 1998).

A number of critical questions remain nonetheless. One is elaborating the type of institutional structures that enable and facilitate people to self-organize, collaborate, learn, innovate, reorganize and adapt in response to threats or opportunities posed by environmental change. Accumulation of social-ecological understanding and experience in a "social memory" – the arena in which captured experience with change and successful adaptations embedded in a deeper level of values is actualized through community debate and decision-making processes into appropriate strategies for dealing with ongoing change (McIntosh 2000) – seems critical for dealing with change. Furthermore, social networks can serve as storage of social memories for ecosystem management, memories that can be revived and revitalized in the regeneration and reorganization phase following change (Folke et al. 2003). There is also a need to understand the governance attributes that support and build social memory and hence resilience in the face of disturbance.

Within this notion and related to the increase of public-private partnerships discussed earlier, Evans (1996) links public-private synergies to building the social capital important for economic development. He argues that social capital is often built in the intermediate organizations and informal policy networks, in the interstices between state and society. In the same issue of the journal *World Development*, Ostrom (1996) explore the constructability of such synergies between governments and groups of engaged citizens. An important research question is under which conditions such synergistic relations can be most easily be constructed.

Furthermore, how people and societies respond to periods of abrupt change and reorganize following change are not well understood in relation to the problem of fit (Gunderson and Holling 2002). The bulk of the governance literature is no exception and poses a challenge for future research (Duit and Galaz 2006). Explorative work, based on several case studies, suggests that four critical factors, interacting across temporal and spatial scales, seem to be required for resilience of social-ecological systems during periods of rapid change and reorganization (Folke et al. 2003):

- Learning to live with change and uncertainty
- Combining different types of knowledge for learning
- Creating opportunity for self-organization toward social-ecological resilience
- Nurturing sources of resilience for renewal and reorganization

Lost Opportunities? Two Alternative Stories

Broadening the scope to study governance forces us to ask how the shifts in the socio-political landscape discussed earlier affect the misfit between governance and ecosystems. There are at least two alternative stories worth elaboration here. The first is that these changes in the organization of society provide a fertile ground for an enhanced fit between ecosystem dynamics and societal governance. More precisely, the shift away from the command-and-control nature of governing creates a higher diversity in institutions, an increased involvement of actors with complementing knowledge at a number of political levels, and polycentric institutions with noticeable multiscale linkages. In the end, these changes might lead to an increased diversity and redundancy that enhances the resilience of social-ecological systems (Dietz et. al. 2003, Folke et. al. 2005). Arguments in favour of redundancy focus on increased system reliability in the face of environmental or operational uncertainty (Streeten, 1992). For instance, independent planning teams may develop alternative management plans based on complementary observations and knowledge, enhancing the diversity of response options. Low et al. (2003) suggest that diversity and redundancy of institutions and their overlapping functions across organizational levels may play a central role in absorbing disturbance and in spreading risks. For vital components and functions redundancy can be

economically efficient; the costs of redundancy should be weighted against the costs of designing components and functions that "never" fail and the costs of failure and correcting failures when these occur anyway. Streeter (1992:99) has referred to the back-up function of redundancy as "failure absorption rather than failure correction."

The second less optimistic picture highlights the risks of a decreased controllability/governability of complex modern societies. Put bluntly, an increased diversity and complexity in governance systems could result to decreasing levels of compliance among social actors (Mayntz 1993), to higher policy–intervention uncertainty resulting from more complex cause-effect relations (Kooiman 2003), and increased deficits of efficiency and legitimacy of central institutions and decision-making due to the enhanced autonomy of societal actors at diverse scales (Hirst 2000:20f). Arguments against redundancy in addition, focus on avoiding policy inconsistencies – fragmentation, duplication, and overlaps – as well as the potential conflicts and high operational and transaction costs that may result when more people are involved in decision-making (Imperial 1999).

It is of course impossible to give a clear answer to which of the two stories that best describe the impacts of current socio-political shifts. We do however like to highlight the risk that the story is one of lost opportunities. The number of global initiatives that push for a greater diversity and complexity of governance systems seems to be increasing. Examples here are political and expert driven processes that promote Integrated Water Resources Management (IWRM), a shift towards more participatory international development strategies (Ellis and Biggs 2001, Schneider 1999), the acknowledgement of stakeholder participation, traditional knowledge and innovations in ecosystem management by the Convention on Biological Diversity (CBD), and approaches that promote sustainable development by building partnerships across scales and between stakeholder groups (e.g. UN's Partnerships for Sustainable Development).

Yet if these networks and emerging cross-scale social interactions do not promote a systematic understanding of the non-linear behaviour of social-ecological systems and do not intentionally build a capacity to cope with change and surprises, there is an obvious risk that we simply are adding more complexity to governance rather than increasing the fit between ecosystems and governance.

The role of social or policy networks is an illuminating example of our argument. Social networks can play a crucial role in the dynamic relationship between key individuals and organizations (Westley 2002). It has also been argued that social networks can lead to an enhancement of social-ecological resilience by improving the fit between ecosystem dynamics and institutions (Olsson et. al. 2004a, Folke et. al. 2005, Hahn et. al. 2006).

On the other hand, social networks can provide a conservative force that benefits from the existing misfit and therefore tries to block needed changes. One reason is that the structure of social networks - i.e. the patterns of actor interactions in governance - are fundamental for whether they are able to promote adaptation and learning, or instead create vulnerable and maladaptive collaboration patterns (Fürst et. al. 2001, Bodin and Norberg 2005, Janssen et. al. 2006). As stated by Newman and Dale (2005), not all social networks are created equal; networks composed of "bridging" links to a diverse web of resources strengthen a community's ability to adapt to change, but networks composed only of local "bonding" links which impose constraining social norms and foster group homophily, can reduce adaptability.

Another challenge is the fact that social networks rely rather heavily on the voluntary coordination and control (Jones et. al. 1997), which implies that these are created and robust only when they are able to promote the joint interest of all parties. As a result, social networks might resist needed governing attempts by central actors by using their joint capacity as veto power; fail to reach obviously needed agreements (Pierre and Peters 2005, Mayntz 1993:19); fall short on coping with ecosystem change due to imbedded power relations (Galaz 2006); or lack the incentives to deal with the direct and indirect effects of their actions on actors outside the network (Kooiman 2003).

The point we want to stress here is that there is an obvious risk that ongoing global sustainable development policy initiatives are missing the opportunity to explore the resilience building potentials of decentralization, partnership arrangements and the evolution of network-based governance. On the contrary, we might simply be doing nothing more than adding more diversity and complexity to existing governance systems, a trap experienced in other cultures (Tainter 1997).

There is a need to increase the understanding of the role of networks in facilitating cross-scale interactions, dealing with uncertainty and change, and enhancing ecosystem management (Scheffer et al. 2002, Bodin and Norberg

2005). There is also a need to further investigate the role of social networks and their cross-scale linkages in creating flexibility and resilience and in providing response options in times of social-ecological change. We also need to understand in what ways such cross-scale dynamics can widen desirable social-ecological stability domains and make systems more robust to change and surprises.

III. Emerging Challenges

Governance systems are just as dynamic as ecological systems. The patterns of interactions between state and non-state actors tends to change over time (Pierre 2000), existing social or policy networks oscillate between latency and activism (Mayntz 1993), societal actors adapt and sometimes divert external governing attempts (Kooiman 2003), institutional development might imbed path-dependent or positive feed-backs (Pierson 2003), and political support might erode and recover after extreme events (Dalton 2004). What is interesting from our perspective is that the combined dynamics between governance and social-ecological systems poses a number of unexplored, yet fundamental questions related to the problem of fit. In the following part we explore three such challenges. The first deals with the recognition that large scale crises might trigger political events that push governance systems towards more rigidity and hence greater vulnerability. The second stems from the drastic governance challenges posed by cascading effects in social-ecological systems. Third and lastly, we elaborate the possibilities of tackling these cascades by promoting governance that builds on managing "networks of networks" within existing yet diverse subpolicy fields.

Recognizing the Possibility of Backlash

Perceived crises often open up a window-of-opportunity for learning and change as crises can contribute to overcome inertia and social dynamics which often inhibit learning under "normal" conditions. This is an important insight from studied of organizations (Kim 1998), social-ecological systems (Westley 1995, Gunderson and Holling 2002) and political decision-making (Kingdon 1983, Stern 1997). The crises may be caused by external markets and tourism pressure, floods and flood management, shifts in property rights, threats of acidification,

resource failures, rigid paradigms of resource management, new legislation or governmental policies that do not take into account local contexts (Berkes et al. 2003). Hence ecological crises such as irreversible ecological regime shifts that affect the economy and livelihoods of communities might trigger learning and the possibility of an enhanced 'fit' between ecosystems and institutions.

Yet there are reasons to be aware of possible and destructive backlashes as well. The major governmental reorganization in the U.S. following after September 11, 2001 provides a good illustration of how political systems can behave after a large scale crisis. As elaborated by James Mitchell, public policy had increasingly favoured a broad engagement between civil society and hazard management in the latter part of the 20th century. But in the wake of 9/11, there was a sudden return to governance approaches that favoured trained experts, centralized decision-making, and secrecy over transparent, participatory and decentralized governance approaches (Mitchell 2006, see also Gill 2004).

The intense political debate following after Hurricane Katrina (REF), and in Sweden after the slow ineffective response of Swedish government after the devastating impacts of the Asian tsunami in December 2004 (Swedish Government Inquiry 2005:14), display strong advocates of centralized "man-on-horseback" solutions. By this we mean the promotion of centrally appointed leaders that under times of crises clear the way for centrally controlled, rapid response teams of experts from the military and other action-oriented institutions (from Mitchell 2006:230, c.f. Boin and t'Hart 2003).

The point we want to make here is that the general trends towards more flexible, participatory, redundant and polycentric institutions – and hence a better 'fit' between ecosystems and institutions - might be reversed by political processes triggered by large-scale crises that result from e.g. fast abrupt changes in vital ecosystems (c.f. Scheffer et. al. 2003), or extreme climatic or ecological "surprises" that propagate and cascade through economic and livelihood systems (c.f. Kinzig et. al. 2006, Schneider 2004). A worst case scenario here are fast abrupt ecological crises that propagate through social end economic systems due to the increased interconnectedness of systems (c.f. Young et. al. 2006, Rosenthal and Kouzmin 1997) and social and political processes that as a response to these crises create more rigid, more centralized, less 'fit' and hence more vulnerable governance systems. How to avoid these crises-triggered destructive feedbacks between ecological, economic and political systems should be a

research area of great concern in dealing with the challenges of global environmental change.

Governance Challenges Posed by Cascading Effects

Suggestions to promote network based governance (Kickert et. al. 1997) or adaptive governance (Folke et. al. 2005, Dietz et. al. 2003, Olsson et. al. 2006, Lebel et. al. 2006) provide fruitful starting points in dealing with the complex behaviour of social-ecological systems. Yet relying too heavily on the benign powers of self-organized social networks to cope with the dynamic behaviour of interlinked social-ecological systems might under certain circumstances lead to serious governance failure.

The cases of catchment/river basin management for water resources, or suggestions of basing governance on "bioregionalism" provide good illustrations of this point. The benefits of overcoming the misfit between the "natural" hydrological boundaries and institutions by promoting catchment based management and planning has been widely acknowledged by natural resource management scholars (Lundqvist 2004, Walmsley 2002, McGinnis et. al. 1999). Yet the usefulness of these catchment or region based social networks is nontheless likely to be drastically reduced when shocks to the water system resulting from e.g. global environmental change induced extreme events (Re Munich 2006, Steffen et. al. 2004), risk to cascade and trigger crisis and non-linear behaviour in social, ecological or economical domains that clearly surpass the scale of the river basin or "bioregion".

Kinzig and others (2006) provide a number of illustrations of the governance challenges posed by interacting and cascade effects. Projections of the social, economic and ecological state in the Australian wheat-belt display a number of interacting thresholds. Abrupt shifts from sufficient soil humidity to saline soils and from freshwater to saline ecosystems, might make agriculture a non-viable activity at a regional scale and trigger migration, unemployment and the weakening of social capital. Michael H. Glantz's study of how El Niño-Southern Oscillation-triggered droughts and floods cascade through a number of domains ending up creating massive soybeans plantations in Brazil (Glantz 1990); and El Niño-Southern Oscillation related cholera outbreaks in Latin America and Southern Asia with serious health and livelihood implications (Pascual et. al.

2000) are just two more examples of the tight coupling and large scale surprises and cascades imbedded in social-ecological systems.

The implications of this sort of 'misfit' between existing governance and cascades in coupled social, ecological and economic systems can be devastating for ecosystems and livelihoods if governance is unable to deal with the propagation of crises across scales and domains. This is why we also need to uncover ways to overcome possible inherent limitations embedded in network based governance such as adaptive governance. Allow us to elaborate this argument.

As mentioned earlier, it should be recognized that network based governance relies heavily on social coordination and control, collective sanctions, and reputations, rather than on legal and authority recourse. Hence the "complicated dance of mutual adjustment and communication" (Jones et. al. 1997) between social actors is fundamentally based on the possibilities of repeated interactions (such as those provided by geographical proximity), on restricting the number of exchange actors in the network (to reduce coordination costs), and on the possibility to develop shared understandings, routines and conventions (to be able to cope with change and resolve complex tasks) (Jones et. al. 1997, Larson 1992, Ostrom 2005).

But the mentioned underlying social mechanisms for network based governance also highlight its limitations. As social and ecological processes propagate through scales, the problem solving capacity of network governance will be highly limited when a quick unilateral response requires collective action and institution-building at other scales and in other policy arenas than those targeted by participants of existing social networks. The reason for this is the critical lack of time to form shared understandings between actors, the absence of a "history of play" (Ahn et. al. 2001) due to earlier limited encounters, and hence the limited possibilities of applying collective sanctions.

The implications should not be underestimated. Major drivers of change (e.g. climate change, continued decline in ecosystem services, changes in the dynamics of the Earth System) will trigger surprises at spatial and time scales that might go considerably beyond the problem solving capacity of existing governance systems, network-based or not. The social and ecological effects of events like Hurricane Katrina, the spread of pandemic diseases, and the number of cross-national, cross-system challenges identified by the International Geo-

Biosphere Program (Steffen et al. 2004) clearly surpasses the collective action capacity of social actors at a wide number of scales.

This does not imply a recommendation of "man-on-horseback" solutions based on the re-emergence of centralized one-size-fits-all or command-and-control steering. We do however like to stress the need to elaborate whether it is possible - and in that case how - to manoeuvre "networks of networks" of societal actors in a way that thresholds are avoided, cascading effects are buffered, and a capacity to respond to, and reorganize after crises, is maintained. We elaborate this point in the next section.

There are obvious normative implications. As political systems gradually change from hierarchically organized systems that govern by means of law, rule and order, to more fragmented systems that govern through self-regulated networks, there are reasons to explore the link to democratic theory. As stated by (Sorensen 2002), there is a need to reinterpret and reformulate the basic concepts of liberal democracy – such as "the people", "representation" and "politics" – to make them more useful as guidelines for the promotion of democracy in political systems characterized by network governance (see also Hirst 2000, Held 2000b).

Steering Networks of Networks?

Can social and policy networks really be steered and coordinated temporarily, and swift enough to cope with the non-linear behaviour of social-ecological systems? By steering – or 'directed influencing - "networks of networks" we do not imply conventional approaches to cross-sectoral (e.g. Krott and Hasanagas 2006, Lundqvist 2004) or transnational policy coordination (e.g. Hoel 1997). This sort of coordination seldom acknowledges the dynamic non-linear behaviour of complex social-ecological systems, but is instead created to implement defined targets - say a percentage reduction of some pollutant, or the application of voluntary agreements or eco-labels (c.f. Jordan et. al. 2005). Nor are we talking about the creation of global monitoring or assessment programmes (Young 2002), or a "World Environmental Organization" (Biermann 2002).

What we mean is instead the temporary formation of weak interactions between existing social and policy networks in various subpolicy communities (say water, risk, land, health, environment) to provide fast unilateral response to abrupt changes in social-ecological systems that cascade through domains and

spatial scales. Of interest here is not the creation of new bureaucratic organizations, but rather the development of a capacity to utilize existing - or compensate for non-existing or maladaptive – social networks in diverse policy fields to cope with abrupt non-linear behaviour and cascading effects.

While this might sound as an impossible task, scholars analyzing the features of network-based governance have identified a number of strategies that can be assumed to "manage networks" (Kickert et al. 1997). The strategies summarized in the next table range from promoting mutual adjustment by negotiations and consultation, to more direct interventions such as restructuring relations or the 'selective activation' of networks (Kickert and Koppenjan 1993). We suggest that these strategies are worth exploring in trying to match governance systems with the devastating risks imbedded in cascading effects.

[TABLE 2 HERE]

The issue of leadership and bridging organizations discussed earlier is important in this setting as well, but in a different manner. The reason for this are the coordinating challenges posed by processes at temporal (fast) and spatial scales (large); the difficulties of coordinating a multi-network landscape (both in terms of legitimacy and availability of resources); and the long-lasting ecological and social impacts of this coordination. As a result, dealing with cascades is likely to require the heavy involvement of central state actors. This statement is expected to be controversial, the argument is that state actors in stable democracies are likely to be the only actors in governance with the authority, legitimacy and resources required to coordinate networks of networks.

First, the state is the only actors capable to distribute powers and responsibilities between itself, regional and local governments and civil society. Second, the nation state remains the main institution of democratic legitimacy that most citizens understand and are willing to accept. Effective democratic states thus can represent their populations more credibly than any other body. Third, national governments in stable democracies are strongly legitimate externally, their decisions and commitments are taken as reliable by other states and political entities, and thus their external commitments can provide legitimacy for supra-national majorities and quasi-polities and inter-state agreements (from Hirst 2000, see also Lundqvist 2001, Pierre and Peters 2000). Hence the state in stable democracies is likely to be the only actor that is able to

(more or less successfully) steer networks in such a way that both high adaptability to changing circumstances, and the capacity to promote collective action by binding agreements to steer long term change, is maintained (see however March and Olsen 2006:13ff).

Research on adaptive governance of social-ecological systems illustrate that the management of ecosystem and landscapes is complex to apprehend and implement and, therefore, cannot easily be subject to planning and control by a central organization only, such as a national government (Folke et al. 2005). However, the conditions creating the opportunities for adaptive co-management to self-organize, such as enabling legislation, flexible institutions, and recognition of bridging organization, are good candidates for governmental actions, which can be carefully tested and evaluated. Therefore, the state has an important role to play in the governance of social-ecological systems (in the sense of Hirst and Thompson 1995, Lundqvist 2001, Sorenson and Torfing 2005) but its role might be different and change from "authorative allocation 'from above' to the role of the 'activator" (Eising and Kohler-Koch 2000). Instead of ready-to-use plans for ecosystem management superimposed on local contexts, the role of central authorities and agencies could be to form legislation to enable self-organization processes, provide funding, and create arenas for collaborative learning (Berkes 2002, Olsson et al 2004a, Nickerson and Olsen 2003, Hahn et al. 2006). Folke et al. (2003) refer to such an activator role as 'framed creativity' of self-organization processes.

IV. The Anatomy of Misfits between Ecosystems and Governance Systems

The Earth seems to be moved well outside the range of natural variability exhibited over at least the last half million years. As stated clearly by Will Steffen and colleagues (2004), the nature of changes now occurring simultaneously in the Earth System, their magnitudes and rates of change are extraordinary. The socio-political landscape also displays a number of radical shifts in governance to more decentralized, more coupled to multilevel and multi-sectoral institutional arrangements, less command-and-control focused, and more complex decision-making structures. The question is; how well do these trends match? Is the problem of fit between ecosystems and institutions increasing? And for what type of problems?

The answer depends on whether we are able to couple the increasing diversity and complexity in governance, to learning processes and an increased understanding of the dynamic behaviour of social-ecological systems; to the encouragement of diversity and experimentation; but also to a capacity to mobilize collective action before critical thresholds are reached, or in a way that cascades are buffered. It requires not only a governance structure nested across levels of organizations and with adaptive capacity such as that suggested by scholars of multilevel environmental governance (e.g. Winter 2006), but also a thorough recognition of the ecological processes that operate across temporal and spatial scales (Carpenter et al. 2001).

In the following table, we elaborate different kinds of 'misfits' between governance and social-ecological systems, and their underlying mechanism. As can be seen, the suggested solutions will differ considerably between different sorts of 'misfits'. Our ambition is not to provide a complete or all-encompassing list of solutions, but rather highlight that different solutions deal with different sorts of misfits.

[TABLE 3 HERE]

We would like to stress that although a number of policy initiatives are strongly promoted to deal with misfits related to the two first categories of misfits, i.e. spatial and temporal scales of ecological system (e.g. river basin management, collaborative natural resource management, participatory natural resources planning) *they do not automatically create a better 'fit' in dealing with abrupt threshold behaviour, or cascades in social-ecological systems*. The importance of this observation should not be underestimated in the face of the multilevel and non-linear character of interconnected social-ecological systems (Folke et. al. 2004, Gunderson and Holling 2002). As a parallel, the promotion of adaptive management to "manage around thresholds" (e.g. Rogers and Biggs 1999), does not automatically lead to a better 'fit' in terms of dealing with large scale cascading effects that spill over to a diverse set of domains and policy fields.

There are of course interactions between the different sorts of misfits, for example both spatial and time scale mismatches in water management, or both threshold and cascading effects in water related vulnerability to climate change. Berkes and collages (2006) analysis of the "roving bandits" discussed earlier for

example, illustrate both spatial (local institutions vs. highly mobile fleets), temporal (rate of ecological and market driven change vs. slow evolution of international institutions) and probable threshold (risk of collapse due to governance failure) misfits. Although these interactions are poorly understood, the examples and mechanisms presented here should be viewed as stylized illustrations developed for heuristic reasons.

It should also be acknowledged that as the type and number of 'misfits' increase (e.g. from local spatial misfits to cross-national cascade effects misfits), so does the governance challenge. This results from the enlargement in the number of actors, spatial scales, and interactions across systems as we recognize the multiscale and cross-system nature of global environmental change.

Concluding Remarks

The challenges posed by the non-linear nature of global environmental change to existing governance at all levels are enormous. During the preparation of this chapter in October and November of 2006, issues of climate change, extreme weather events, and the large scale collapse of ecosystems are reaching a media coverage in Sweden that is impossible to grasp because of its intensity. The state of the problem is however not all doom and gloom as often portrayed in the public debate. We believe that there indeed are ways to cope with the detrimental misfit between ecosystems and governance, and that important insights have been reached the last decades that will prove critical in our attempts to match the interplay between periods of incremental change when things move forward in roughly continuous and predictable ways, and abrupt change when experience is often insufficient for understanding, consequences of actions ambiguous, and the future of system dynamics often uncertain. The insights discussed in this chapter are the following:

- Social and ecological systems are not merely linked, but rather interconnected. Policy prescriptions that fail to acknowledge the tight interconnection between these systems is likely to provide not only poor, but also undesired societal pathways. Both adaptive co-management and adaptive governance provide interesting alternatives worth further exploration.

- Enhancing the fit between ecosystems and governance will require using the increased diversity and complexity of governance systems as a fertile ground for cross-organizational and multilevel collaboration, learning processes,

polycentric and redundant institutions which might provide innovation and enhanced response diversity in the face of shocks and surprises.

- Governance systems are just as dynamic as social-ecological. This implies that current positive shifts in governance might face backlashes in times of crises, and that multilevel governance systems might be moving towards more complexity and less governability, and not towards more adaptive governance.

- Cascading effects pose a serious governance challenge due to the critical lack of time to respond, and their spatial and cross-system character. Whether and how "networks of networks" can be steered to buffer the impacts of cascades is a critical issue for the future.

- Current global initiatives such as participatory natural resource management and integrated natural resource management are only able to cope with certain misfits related to the spatial and temporal scales of ecosystem behavior. How to build on existing initiatives to also match threshold behavior and cascades in ecological systems is a crucial issue.

The fit between ecosystems and governance can be enhanced. Getting a better grip of the mechanisms behind different types of misfits, and finding governance solutions to harness these mechanisms in a highly dynamic and interconnected social, political and ecological world is indispensable in preparing for the challenges of an uncertain and most likely surprising future.

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Table 1. A sequence of resilience concepts, from the more narrow interpretation to the broader social-ecological context (From Folke 2006)

Resilience concepts	*Characteristics*	*Focus on*	*Context*
Engineering resilience	Return time, efficiency	Recovery, constancy	Vicinity of a stable equilibrium
Ecological/ecosystem resilience social resilience	Buffer capacity, withstand shock, maintain function	Persistence, robustness	Multiple equilibria, stability landscapes
Social-ecological resilience	Interplay disturbance and reorganization, sustaining and developing	Adaptive capacity transformability, learning, innovation	Integrated system feedback, cross-scale dynamic interactions

Table 2. Strategies for steering "networks of networks" as a way to match governance with social-ecological system dynamics. Remade from Kickert and Koppenjan (1997, pp. 53).

Strategy	Methods	Description
Game management – steering the interaction processes in existing networks	*Selective activation*	Identifying and activating the parties necessary for tackling a particular problem. This can be assumed by activating links in a network (i.e. people who occupy a nodal position), and the nature and amount of information which need to be sent through these links.
	Arranging	Provide conflict regulating mechanisms which indicate how action should be taken in conflict situations. Arrangements are *ad hoc* and temporary.
	Brokerage	Active participation by policy entrepreneurs (c.f. leadership). Entrepreneurs deal with ideas and solutions and link up actors in networks who would not have found each other by themselves.
	Mediation and Arbitration	Implemented at a time when conflict exist and the interaction process finds itself in a deadlock. Activities range from ensuring that relations are maintained, to calling into question unrealistic claims, and taking into account unrepresented interests.
Network Structuring - modifications of existing networks	*Influencing formal policy*	Influencing the division of resources within the network and thus alter actors' positions. Possible veto points might be either established or removed. Modification of rules that define participation and interaction.
	Influencing interrelationships	Modifying the number of, and interrelationship within participating units to reduce coordination costs.
	Influencing values, perceptions	Steer the value of and interest definitions of a target group in a desired direction through intensive mass information campaigns, or targeted efforts. More drastic methods include "reframing" i.e. challenging actors' frames of reference, especially in times of perceived crises (c.f. Olsson et. al. 2006).
	Mobilization of new coalitions	Existing networks may be broken into new coalitions by e.g. mobilizing new coalitions and putting pressure on maladaptive networks.

Table 3. Types of Misfit between Ecosystem Dynamics and Governance Systems

(See attached document)