Governance in a 'Wired World' – Emerging Issues for Governance Theory

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Abstract

Unexpected epidemics, abrupt catastrophic shifts in biophysical systems and economical crises that cascade across national borders and regions are events that challenge the steering capacity of governance at all political levels. Departing from works on complex systems in other disciplines, this paper seeks to extend the applicability of governance theory by developing hypotheses about how different governance types can be expected to handle processes of change characterized by nonlinear dynamics, threshold effects, cascades, and limited predictability. The first part of the paper argues the relevance of complex change for social science, and goes on to review how well governance theory acknowledges the intriguing behaviour of complex adaptive systems. In the second part, we develop a typology of governance system based on their adaptive capacity. Finally, we investigate how combinations of governance systems on different levels buffers or weakens the capacity to govern complex adaptive systems.

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Introduction

Processes such as climate change, technological innovations, the spread of pandemic diseases, and rapid fluctuations in world markets all challenge a linear, scale-free, and static worldview that has guided large parts of the scientific study of society and politics (Hall 2003). Furthermore, these processes also have immense impact on present and future levels of human well-being, political stability, and democratic vitality. What's more, the speed of interactions and multiplication of linkages among elements in biophysical, technical, and human systems at a number of spatial scales seems to be increasing creating a global "time-space" compression. (Held 2000; Young et. al. 2006).

While these processes have been portrayed and acknowledged by a number of political science scholars (e.g. Held 2000, Pierre and Peters 2005, Young et. al. 2006), we often fail to recognize that these and other cross-level drivers of change do not add up in a linear, predictable manner. On the contrary, insights from the last decades of empirical and theoretical research on complex adaptive systems clearly shows that biophysical as well as man-made systems are characterized by both positive and negative feedbacks operating over a range of spatial and temporal scales. This results in developments over time characterized by periods of incremental change followed by fast and often irreversible change and "surprises" with immense consequences for economies, vital ecosystems and human welfare (Moench and Dixit 2004; Peters, Pielke, Beltesmeyer et. al. 2004; Schneider and Root 1995).

The purpose of this paper is to elaborate how advances in governance theory can, and should contribute to our understanding of the capacity of governing the intriguing behaviour of complex adaptive biophysical and human systems.

Departing from works on complexity theory in other disciplines, we seek to extend and sharpen the applicability of governance theory by exploring how different governance models handle processes of multilevel, uncertain and non-linear change.

I. What's so Special about Complex Adaptive Systems?

Research on the characteristics and components of complex adaptive systems (CAS) has made substantial progress in the last decades, particularly within the natural sciences. There is not one all encompassing complexity theory, but rather a number of different research traditions and agendas (Manson 2001), ranging from computer simulations, multivariate analysis of empirical data (Liljeros et. al. 2001), to field-based case studies, and combinations (Cederman 1997; Gunderson and Holling 2002; Janssen 2002). There have also been a number of parallel attempts in the social sciences to analyze the non-linear nature of social, political and economical behaviour (Arthur 1999; Jervis 1998; Levin 1999; Pierson 2003)

Key Features of Complex Adaptive Systems

Though difficult to summarize, complexity theory starts from the assumption that there are large parts of reality in which changes do not occur in a linear fashion. Small changes do not necessarily produce small effects in other particular aspects of the system, nor in the characteristics of the system as a whole. Complex adaptive systems (CAS) are special cases of complex systems. They are *complex* in that they are diverse and made up of multiple interconnected elements and *adaptive* in that they have the capacity to change in response to external pressures. These system involve a dynamic network of many agents (e.g. cells,

species, social actors, firms, nations) acting and reacting repeatedly to what the other agents are doing (Holland and Miller 1991), as well as localized selection processes that create novel patterns at higher levels (often denoted emergent properties) (Levin 1998).

Taking complexity theory seriously does not imply assuming that the world is inherently chaotic and unpredictable (Byrne 1998:16), but rather that the systems-to-be-governed seem to display non-linear behaviours due to their interconnectedness. The features of these systems can in a very simplified manner be summarized under two main headings:

THRESHOLD EFFECTS. Complex adaptive systems do not respond to gradual change in a smooth fashion. The reason is that these systems imbed what has been denoted “threshold behaviour”, “tipping points” or “abrupt change”. The main point is that small events might trigger changes, which are difficult or even impossible to reverse. In some cases the transition is sharp and dramatic. In others, though the dynamics of the system have shifted from one state to another, the transition itself may be slow but definite. Hence seemingly stable systems can suddenly undergo comprehensive transformations into something entirely new, with internal controls and characteristics that are profoundly different from those of the original (Gunderson and Holling 2002; Kinzig et. al. 2006).

Threshold effects have attracted wide interest and empirical validation for a number of real-world systems, such as within physics (Goldenfeld and Kadanoff 1999) and ecological theory (e.g. Scheffer and Carpenter 2003; Folke et al. 2004). Granovetter’s classic article of threshold effects in collective action (1978;1983) as well as Pierson’s elaboration of how abrupt social change can be triggered by minor disturbances in political systems (2003) are two parallel explorations in the same tradition. Kranser’s notion of a punctuated equilibrium is another example (Krasner 1994).

SURPRISES AND CASCADING EFFECTS**.** Another property of CAS is their interconnectedness (Gibson, Ostrom and Ahn 2000; Gunderson and Holling 2002). The point is that interconnected systems imbed poorly understood interactions, predominated by both positive and negative feed-backs, and processes operating over a range of spatial and temporal scales. These interactions often result in "surprises" with potential immense consequences for human welfare if they cascade across scale (e.g. from local-regional-global), time (e.g. delayed impacts), and/or system (e.g. from the technical to the economical or political system). For example, extreme weather events in South Asia such as flash floods or droughts tend to spread across interconnected systems, i.e. from the biophysical to the social and economical system. As case studies in Gujarat (India) demonstrate, while no families in the studied communities were below the poverty line in a normal year, drought periods pushed almost 69% of the households below this line. This increase in poverty had major impact on vulnerable populations, particularly on the health of women and children (Moench and Dixit 2004:90-98). Similar notions can be found in Pierson's account of "causal chains" (Pierson 2004) and Mahoney's notion of "reactive sequences" (Mahoney 2000).

Finally, it should be noted that these features obviously are much more dynamic and strongly interconnected with each other in field settings –surprises can trigger threshold behaviour that in turn cascade across systems and spatial scales.

How Common are Complex Adaptive Systems?

The real-world features of complex adaptive systems presented above have mostly been elaborated systematically by transdisciplinary scholars (e.g. Berkes, Colding and Folke 2003; Gunderson and Holling 2002). In Table 1, we present a number of empirical examples of systems that seem to imbed the features of CAS,

i.e. thresholds, surprises and cascading effects. Although fully aware that the theoretical and empirical applicability of complexity theory is likely to be a highly controversial topic in the social sciences (Byrne 1998), we nevertheless argue that there is enough evidence to highlight the need of political scientists to elaborate the implications of complex adaptive systems.

The main reason for this is not theoretical, but has to do with the behavior and characteristics of the systems that societies try to govern. Threshold behaviour and surprises in biophysical or technical systems might seem like marginal issues for governance scholars, yet our assumption is that this sort of non-linear behaviour can spark off political crises that need to be dealt with within existing governance systems. These crises-triggers can, for example, be present if the impact of passing critical biophysical or technical thresholds has large-scale spatial effects; if it is combined with other compounded economical, political or biophysical perturbations; if it emerges in already vulnerable political systems; or if the impact triggers changes in interconnected social or economical systems. As an example, passing irreversible thresholds in soil degradation might look like a minor political problem, yet if this abrupt irreversible shift is experienced on a large spatial scale affecting the food-producing capacity of a nation or region, governance will have to find strategies to buffer the worst impacts and ascertain that the impacts do not undermine the social fabric of society. Oran Young and colleagues (2006) provide a number of examples of the societal implications that follow from the “time-space compression” resulting from the increasing speed of interactions, and multiplication of the linkages among elements in biophysical and human systems. Most important here is that in a strongly interconnected and ‘‘wired world’’, disturbances such as epidemics, ecological, political or economical crises can spread rapidly across biophysical systems, markets and societies (Held 2000).

The argument is not a theoretical construct. Crises and risk researchers make the same point when elaborating the anatomy of “modern crises” related to

technology, health hazards or environmental catastrophes that seldom confine themselves to a particular policy area (say health or energy) but rather “jumps from one field to the other, unearthing issues and recombining them into unforeseen “megathreats” that not only have physical and physical implications, but also threaten the legitimacy of the state (Boin 2004; c.f. Pidgeon, Kasperson and Slovic 2003).

Table 1. Non-linear Behaviour in Human, Technical and Biophysical Systems

System	Example	Non-linear behaviour type	Description	Reference
Social-ecological	Freshwater	Surprise	Climate warming combined with agricultural runoff in the Great Lakes and Upper Mississippi basins leads to spread of subtropical cyanobacterium, making loss of water supplies permanent rather than sporadic.	St. Armand (2002) Chorus et. al. 2000
	Soil degradation	Threshold	Soil degradation can reach a threshold which leads to economically irreversible shifts in productivity.	Antle et. al. 2006
	Extreme weather events	Cascade	Floods and droughts in Asia tend to have both short- and long-term livelihood health impacts i.e. spread to the social and economic system.	Moench and Dixit (2005)
Social-technical	Infrastructure	Surprise, cascade	WTC infrastructural collapse cascaded across infrastructure systems and magnified damages in NYC (e.g. water infrastructure, transportation, electric power systems, phone lines and IT systems)	Zimmerman (2001:100f)
	Urban rail-way systems	Surprise, cascade	Hong Kong's Mass Transit Railway experienced a spontaneous and unpredictable crisis situation in 1996. A smaller incident was magnified through positive feed-backs, which resulted in a complete system break-down.	Ellis (1998)
Social-health	Epidemic	Surprise	Pathogenic H5N1 avian influenza found in domestic birds in northern Nigeria. The influenza spread quickly within the country due to slow and ineffective government response.	WHO (2005a), WHO (2005b).
	Epidemic Threshold	Threshold	The existence of epidemic thresholds in certain types of social networks has been identified using both computer modelling and empirical data. The threshold consists of a critical value that defines whether a disturbance will propagate and infect the whole network.	Eguiluz and Klemm 2002
	Cholera outbreaks	Surprise, cascade	Serious cholera outbreaks in Latin America and Southern Asia are triggered by temporal variability related to El Niño- Southern Oscillation, with serious health and livelihood implications.	Pascual et. al. (2000), Patz (2002)
Socio-economical	Poverty traps	Threshold	Chronic or persistent poverty can be understood as "poverty traps" into which people may fall and have difficulty escaping. These traps depend on the existence of multiple self-reinforcing dynamic equilibria.	Barrett and Swallow (2006)
Political-economical	Financial crash	Surprise, cascade	Financial crash in Argentina 2001-2002 with endogenous political-economical origin triggered by exogenous shocks. Crises cascaded to the social and economical systems, i.e. increased mistrust of government institutions, and resulted in an explosion of poverty.	Sornette (2002:2526-8), Servén and Perry (2005).
	Institutions	Threshold	Existence of "deep equilibria" in institutional development which imply that once arrangements settle on that point, they are highly likely to endure for an extended period of time, example proportional representation party systems.	Pierson (2003:157f)
	Social capital	Threshold	Societies can end up in "social traps" which are difficult to escape as it would require actors to abandon deep mutual mistrust developed over a long time.	Rothstein (2005)

II. Does Governance Theory Contribute? Present Understanding and Complexity Blind Spots

Does governance theory have the analytical tools necessary for addressing the non-linear behaviour of complex adaptive systems? In the following section, we intend to review advancements in governance theory and the emerging field of multilevel governance, and discuss to what extent these insights can be integrated with our increased understanding of complex adaptive systems. Rhodes finds no less than seven distinct usages of the term 'Governance' within the contemporary literature. Among those, our understanding of the term is similar to what Rhodes denotes as 'Governance as a Socio-Cybernetic System' (Rhodes 2000:58), insofar that we view governance as the sum of hierarchies, processes, practices, and institutions involved in the making of public policy. We do not intend to review nor discuss all scientific literature related to governance, but rather to focus on a few key publications that link models of governance with societies' ability to solve or cope with uncertainty and complex societal problems.

The Difference between Governing Complexity and Complex Adaptive Systems

It would be a mistake to disregard attempts by governance scholars to address issues of societal complexity. Pierre and Peters (2005), Kickert and colleagues (1997) and Kooiman (2003) all present interesting insights related to governance systems' ability to cope with change and uncertainty.

Pierre and Peters for example, develop five governance models based on how the governance system induce and respond to information from society

(denoted “feedback”), and the system’s capacity to respond effectively to them (“adaptability”). One point is that state-dominated governance models (what they denote the “étatiste model”, the “liberal-democratic state”, and “state-centric governance”) are likely to provide poor, or strongly biased feedback due to distorted information flows from lower to higher levels caused by multiple veto points and strong institutional structures.

The adaptability of these systems is also considered low due to information deficiencies and low capacities for reaching consensus with organized societal interests. Governance were the state has a weak role (denoted “Dutch governance” and “Governance without Government”) are argued to suffer from information deficiency, but this time due to lack of incentives to provide information from societal interests. On the other hand, adaptability is assumed to be high as a result of organizational flexibility (Pierre and Peters 2005:2-48).

Kooiman (2003) also recognizes the highly dynamic and non-linear nature of governance, society, and governability, and maps out a number of analytical schemes. Governance issues related to societal complexity, diversity and dynamics are discussed in detail, and linked to different governance modes. For example, self-governance and co-governance modes are suggested to be poor in dealing with complexity due to their tendency “to ignore the intended and unintended consequences of their behaviour for others” (Kooiman 2003:206). Hierarchical governance on the other hand is implicitly suggested to have a higher capacity to deal with complexity as a result of this modes ability to more effectively monitor and steer unexpected non-linear developments (ibid, 206ff).

The point we want to make is that there is a vast difference in governing complexity, and in governing complex *adaptive systems*. While “complexity” defined in a general sense, implies change, uncertainty and limited

predictability, complex adaptive *systems* have common features that result from their emergent properties. This implies that the governance systems that seem to be best fit to deal with uncertainty and change (complexity) as hypothesized by Pierre and Peters (2005) and Kickert and colleagues (1997), *are not necessarily those best fit to tackle the non-linear, multilevel properties of complex adaptive systems*, i.e. thresholds (as defined in Walker and Meyers 2004), surprises (as defined in Gunderson 2003:36) and cascading effects (as defined in Kinzig et. al. 2006). This has wide implications, something that becomes clear in for example of Pierre and Peters (2005). Even though adaptability and the use of feed-back from society is likely to be poor in state dominated governance, a potent state with wide autonomy might be what is needed to assume a quick unilateral response to events that risk pushing vital systems across critical thresholds, or buffer potential and harmful cascading effects in the social system.

Consider the devastating impacts of the Hurricane Katrina in New Orleans in 2005. These cascading impacts were not the result of a lack of scientific information or failed meteorological predictions (Science 2005), but rather the failure to achieve the collective political and administrative action needed to 1) mobilize the social actors needed to mitigate the worst impacts of extreme weather events; and 2) mobilize and coordinate evacuation and assistance with short notice (Schneider 2005, Burns and Thomas 2006; Greenberger 2005; Waugh 2006). So although the Dutch governance model might be flexible and adaptable to changing circumstances as hypothesized by Pierre and Peters (2005), it might also be too weak and too slow to cope with fast Katrina-like cascading effects.

Kooiman (2003) does include a detailed discussion of the linkages between the problem-solving capacities of governance types in the face of unexpected non-linear change. For example, Kooiman argues that laws and

planning are likely to be ineffective in highly dynamic contexts and in coping with unexpected events, and that instruments harness the capacity of interdependent and adaptive societal actors, will do a better job (pp. 57, 72ff, 206f).

On the other hand, Kooimans analysis fails to acknowledge that the capacity of governance scales at one level (say local) to deal with unexpected events (say a sharp unexpected decrease in vital freshwater resources), or the irreversible effects of reaching a threshold (say a collapse of a fish stock, or rigid poverty traps), can be compensated for by the actions of social actors at other higher levels (say by initiatives realized by government policy-makers or international actors). This buffering capacity in multilevel governance is two-sided as the inability of central actors to deal with surprises and cascading effects (e.g. the Argentinean financial and social collapse) can be partly buffered by the features of social organization at lower levels (e.g. the existence of social networks, coping strategies, and reciprocal behaviour, c.f. Adger 2003; Bohle et. al. 1994).

What about Multi-Level Governance?

Emerging in the early 1990s, the term “multilevel governance” has been adapted to several academic traditions and has been applied to a variety of policy areas such as European policy-making (Schout and Jordan 2005), environmental governance (Jordan and Lenshow 2000), and economic policy (Eising 2004). The rationale for this field is that governance takes place through processes and institutions operating at, and between varieties of spatial scales involving a range of actors with different levels and forms of authority. As in conventional governance theory however, how the characteristics of, and

changes in, governance affect societies' ability to deal with complex adaptive systems is a non-issue.

As an example, Fritz Scharpf's (1997) illuminating analysis of differences in the problem-solving capacity national and European bodies is devoid of a discussion of how well multilevel governance is able to tackle the problems presented in our first table. In a similar vein, Hooghe and Marks (2003) analysis of types of multilevel governance, van Kersbergen and van Vaarden's synthesis of varieties of governance research (2004), Lowndes and Skelchers' (1998) analysis of multi-organizational partnerships, and Yee's (2004) framework of modes of multilevel governance makes no mention of how complex processes of change might have an impact.

It is interesting to note that even scholars in the field of multilevel governance of global environmental change – probably one of the clearest examples of the non-linear nature of change - seem to overlook the fundamental governance challenges posed by the behaviour of complex adaptive systems (e.g. Eckerberg and Joas 2005; Lundqvist 2005; Winter 2006). For instance, none of the chapters in the 630 page volume on multilevel governance of global environmental change deal explicitly with the governance challenges posed by the dynamic behaviour of interacting human, biophysical and technical systems (e.g. Winter 2006).

Oran Young's later work on cross-scale interactions provides an important exception here, although Young actually never unpacks the components of multi-level governance systems that are able to deal with the features of complex systems such as surprises and non-linear change (Young 2006; Young et. al. 2006).

III. The Anatomy of Adaptive Capacity in Multilevel Governance Systems

So how could governance theory approach issues of complexity? As we discuss in the following sections, two notions are central for this question. The first builds on the observation that different governance models might co-exist and interact over societal levels, and that the combination of different governance systems will be decisive for the impact of disturbances and surprises. In order to understand the effects of a disturbance, buffering and amplifying capacity of the entire system must therefore be taken into account. We explore the consequences of this notion by mapping out possible cross-scale interaction effects between different types of governance systems on two levels. Second, the notion of an *adaptive capacity* of governance systems is developed through making a conceptual distinction between "exploitation", i.e. the capacity to benefit from existing forms of collective action, and "exploration", i.e. the capacity of governance to nurture learning and experimentation (March 1991; March and Olsen 2006).

Adaptive capacity – balancing exploitation and exploration.

Being a relatively new concept within social science (yet often encountered in studies of development policy, natural resource management, and climate change policy), multiple definitions of adaptive capacity are currently in circulation (cf Brooks 2003). Moreover, concepts with similar connotations are also frequent in the contemporary scholar debate about vulnerability (Turner et. al. 2000), resilience (Gunderson and Holling 2002), the role of redundancy (Low and Ostrom 2003), and institutional robustness

(Anderies et. al. 2004). We suggest that AC can be seen as a function of two underlying capacities: *exploitation* and *exploration.* This distinction is primarily motivated by the fact that, in many of its contemporary usages (e.g. Adger 2000; Turner et. al. 2003; Walker et. al. 2000), the concept of adaptation obscures the conflict between the stability-inducing role of institutions, and communities' capacity to experiment and learn from changing circumstances

In an 1991 article, 'Exploration and Exploitation in Organizational Learning", James G. March argues that organizations face a fundamental tension between *exploration* "captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation " and *exploitation*, that is "refinement, choice, production, efficiency, selection, implementation, execution." The tension arises from the fact that "adaptive systems that engage in exploration to the exclusion of exploitation are likely to find that they suffer the costs of exploration without gaining many of its benefits" and, "Conversely, systems that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibria" (March 1991:71, cf. March and Olsen 2006: 12f).

March's distinction can be applied to issues regarding governance systems' capacity for dealing with complex adaptive systems, and that the adaptive capacity of a governance system can be understood as a function of the trade-off between exploration and exploitation. However, in doing so, the meaning of the two concepts has to be defined more precisely. In short, exploitation has to do with the institutional foundation and collective action-inducing features within a governance system, whereas exploration primarily rests in the network structures and information processing side of governance systems.

Exploitation

In order for actors within a governance system to be able to engage in the activities associated with exploitation (refinement, choice, production, efficiency, selection, implementation, execution), problems of collective action must be resolved or at least controlled. The reason for this is that all such activities are either impossible or severely un-efficient in a context of high transaction costs (cf. North 1990a). Some authors claim that the problem of collective action is the most fundamental societal problem (Ostrom 1998; Taylor 1998), and that many other forms of social predicaments (e.g. poverty, famine, and environmental degradation) are generated through failures of addressing collective action problems on various levels (North 2005; Ostrom 2005; Rothstein 2005; Sandler 2004,).

Force and hierarchy, third party-enforcement (G. Hardin 1968), generalized trust, network structures, (Putnam 1993), institutional trust (Levi 1997; Rothstein and Stolle 2003), norms of reciprocity (Ostrom and Walker 2003), perceptions, beliefs, taboos (R. Hardin 2002), and the creation of institutional rules (Ostrom 2005), are all examples of mechanisms that can be called upon to ensure cooperation among actors in a governance system, as well as for keeping transaction costs on an acceptable level. Consequently, the strength of these mechanisms also determines the governance system's capacity for exploitation.

Exploration

Unlike exploitation, March's concept of exploration has no obvious counterpart within governance theory, although theories on policy learning (Beland 2006; Busenberg 2000, 2004; Sabatier and Jenkins-Smith 1999) and policy diffusion

(DiMaggio and Powell 1983; Meseguer 2005) can be understood as comprised by several components related to learning and experimentation. First, exploration involves the capacity for gathering, analysing, and accumulating *information* about ongoing processes in the community's environment. Learning also implies self-monitoring, or the process of extracting and computing information about the state of the community itself (Gunderson and Holling 2002, North 2005). Second, exploitation also involves *experimentation*; i.e. processes of testing, evaluating, refining, and reapplying new forms of governance, institutional configurations, policies, and practices within a given policy area. Such processes of trial-and-error are highly useful for coping with changing circumstances under high uncertainty, but are also likely to be costly. In practical settings, the explorative capacity of a given community is reflected in the quality of its educational system and informational infrastructures such as the existence of independent universities, research institutes and "think tanks", as well as in arenas for public debate and science-policy dialogues, and unbiased mass media. Third, exploration also entails having sufficient resources, such as physical, monetary, human capital. Learning processes, experimentation, and gathering information is often costly, and capacity for exploration might therefore be limited by insufficient resources.

In sum, humans erect institutions and establish norms of cooperation and reciprocity in order to achieve predictability, stability, and low costs for social interactions (North 2005). This is in turn essential for engaging in exploitive activities, i.e. to raise overall welfare through cooperation and interaction. But with stability comes rigidity. Institutions are path dependent, sticky, and products of circumstances and power struggles present at the time of construction (Mahoney 2000; Pierson 2004; Thelen 1999, 2003). Norms and networks of cooperation are slow changing and have a tendency to grow

stronger with increased actor homogeneity (“bonding” vs. “bridging” social capital, cf. Woolcock and Narayan 2000). In contrast to March’s original account of the opposition between exploration and exploitation in organizations—which focused on the seemingly less complicated problem of allocating organizational resources on either exploration or exploitation—the trade-off between exploration and exploitation in governance systems is rooted in a much more fundamental tension between the dual needs for institutional stability and change.

IV. Four Governance Typologies

The balance between exploration and exploitation determines the adaptive capacity of governance systems. The interaction between exploitation and exploration can be further investigated by placing them as orthogonal dimensions in a conceptual space. First, communities combining high levels of exploitation with low levels of exploration can be viewed as ideally equipped for the task of steady state governance. As long as no surprises (external or internal) occur, or circumstances do not change, this is the most efficient form of governance as it maximizes the capacity for exploitation through a dense set of social mechanisms (e.g. institutions, norms, and hierarchies) that ensure stability and predictability necessary for keeping transaction costs low. This form of governance can thus be characterized a ***rigid***, as it maximizes stability while lacking flexibility vis-à-vis changing circumstances. Peters and Pierre argues that these are the characteristics of the state dominated “étatiste”, “liberal-democratic state”, and “state-centric governance” models of governance, in which coordination and cooperation are high but

responsiveness to external changes is slow and incremental due to either biased or weak feedback (Pierre and Peters 2005).

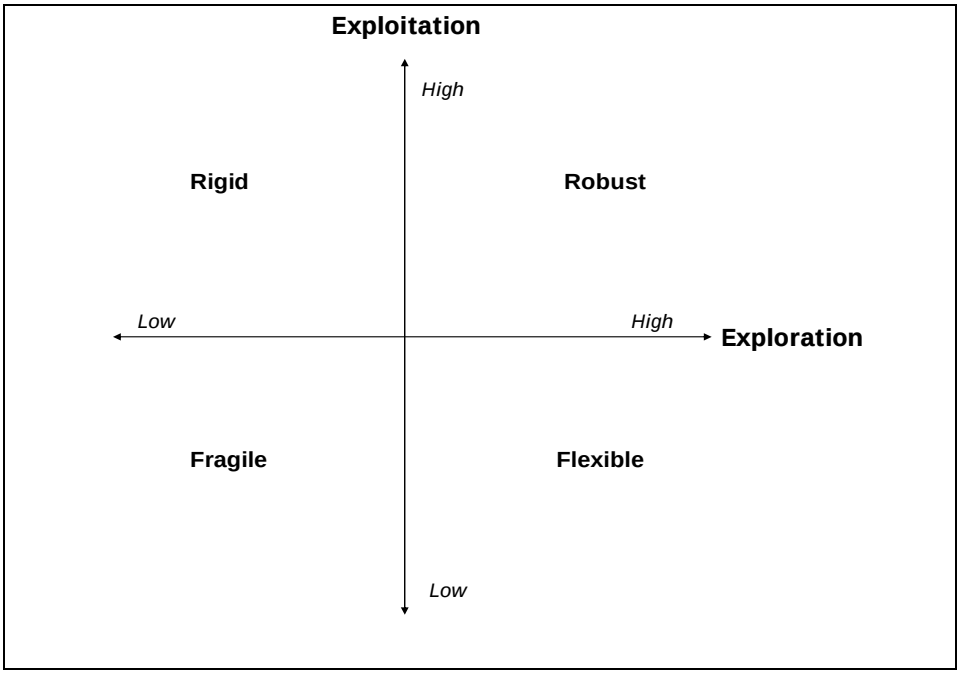
The ***robust*** governance type combines a high capacity for exploration with an equally high level of capacity for exploitation, and is thus well-equipped for handling steady-state governance, long-term transformation processes, and sudden changes alike. This is of course an ideal state in which the rigidity-inducing effects of institutions are kept from obstructing necessary processes of exploration. It is an empirical matter if this ideal-type has any real-world counterparts, but as we will show, the robust governance type is the only governance type that has a sufficiently high level of adaptive capacity to be able to respond to all sorts of complex processes.

In contrast, real-world examples of the ***fragile*** governance type can be found in abundance throughout the world. In this type, weak capacities for exploitation and exploration form a vicious circle where difficulties of accumulating knowledge and capital due to high transaction costs also inhibits the capacity to adapt to new circumstances and to buffer the effects of chocks, which in turn makes it even harder to achieve collective action. Much of earlier work within development issues have emphasized the role of collective action-related factors such as badly functioning institutions, non-existing property rights (De Soto 2000), corruption (Rothstein 2003; Zak and Knack 2001) or low levels of social capital (Knack and Keefer 1997; Putnam et al. 1993) for understanding why many countries fail to achieve even moderate levels of economic development and human well-being. Less focus have been put on the role of exploration when explaining why some countries are dealing more effectively with external changes such as fluctuations in world market prices, natural disasters, and epidemics.

Finally, the ***flexible*** governance system denotes a condition in which the governance system has well-developed capacities for exploration (e.g.

learning processes, feedback loops, monitoring schemes, resources, and capital) but is lacking in the capacity transform the gains from exploration into objects of exploitation. Adaptation will therefore be incremental, haphazard, and without an institutional foundation, but might nevertheless be sufficient for long-term adaptation, albeit at the expense of a lower level of overall well-being. The flexible governance system bears some resemblance with the "Dutch governance" and "Governance without Government" models suggested by Pierre and Peters (2005) and can essentially be seen as the governance counterpart to evolutionary or market-based selection processes. Exploration is non-directed, non-hierarchical, and carried out independently by multiple actors trying to maximize individual utility through mutual non-coordinated adjustment and exploration of emerging niches.

Figure 1. Adaptive capacity of four governance types



The Efficacy of Governance Models – Defining the Mechanisms

An assessment of how well different governance models cope with the dynamic behaviour of complex adaptive systems must specify the mechanism to be able to credibly link models (e.g. network governance) with outcomes (say, ability to cope with cascading effects). As argued above, change takes many forms but for the purpose of outlining some general hypotheses we intend to rely on two simple distinctions. The first distinction has to do with the rate of change. Here the endpoints are processes characterized by either states of slow change and continuous events (e.g. demographical change, environmental degradation), or conditions of rapid change and rare events (e.g. extreme weather events, natural disasters, economical shocks). The former corresponds to steady-state conditions, and the latter to change processes containing thresholds and cascading effects.

The other dimension is the predictability of change, which runs from high (such as constitutional change and cultural change) to low (such as climatic change, international relations). In this context, the term predictability includes both predictability of outcomes (effects) of change and occurrence of change (i.e. the probability of a change taking place) (cf. Pierson 2003). Figure 2 displays these two dimensions, along with hypothetical plots of the capacity of the four governance types to handle the effects of complex systems (adaptive capacity).

Fragile and Robust Governance Systems

The robust governance type, with its combination of high explorative and exploitive capacity, is assumed to perform equally well regardless of the predictability and rate of changes. Slow changes and predictable changes are handled equally well as rapid unpredictable change. Similarly, the fragile

governance type performs badly across all forms of change, simply because any form of change is difficult to handle with low capability for exploration in combination with equally low capacity for exploitation.

Network Based Governance

The strength and weaknesses of network-based governance (NBG) has been widely debated (Kickert et. al. 1997, Pierre and Peters 2005). The optimistic image displays network governance as a model that is able to promote a high learning capacity and adaptability in multilevel governance systems due to the flexibility created by informal cooperative arrangements in combination with higher levels of actor diversity and opportunities for repeated interaction (Jones et. al. 1997, Kickert et. al. 1997). The argument is that network based governance is able to harness changes in social, political and ecological context by making informal flexible multi-actor, multi-level and multi-sectoral coordination possible, as well as combining diverse sources of knowledge to cope with uncertainty (Kickert et. al. 1997).

As a consequence of limited capacity for exploitation, the flexible network-based governance type produces suboptimal levels of overall welfare in times of stability and predictability. The lack of exploitive capacity means that the production of public goods will be difficult, and flexible governance will therefore be less effective in reaping the benefits from a condition of slow and gradual change. However, as change becomes faster and more uncertain, the flexible governance type performs better than the state dominated alternative. The reason is that actors can adapt to changing circumstances without central coordination drawing on a much richer set of knowledge, institutional diversity and policy alternatives as compared to state dominated systems (c.f. Folke, Hahn, Olsson and Norberg 2005; Koppenjan and Klijn 2004:90-99).

Fast Large Scale Disturbances in Network Governance

The benevolent capacity of NBG for coping with fast uncertain change will however depend strongly on the spatial impacts of change. The reason for this is that NBG relies heavily on social coordination and control, collective sanctions, and reputations, rather than on legal and authority recourse. These mechanism are 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 , Hesterley and Borgatti 1997; Larson 1992).

As social, political and ecological processes propagate through spatial scales and systems, the problem solving capacity of NBG will be highly limited as these sorts of effects of complex adaptive systems often require quick unilateral response at other spatial scales, or in other policy arenas than those targeted by participants of existing social networks. The critical lack of time to form shared understandings between actors, the absence of a “history of play” (Ahn, Ostrom, Schmidt et. al. 2001) due to earlier limited encounters, and hence the limited possibilities of applying collective sanctions is pivotal in this context.

State Dominated Governance

State dominated governance is characterized by the heavy involvement and control of state actors in decision-making and implementation. The drawbacks of this model have been widely acknowledged in terms of its limited capacity to

588 deal with information deficits (Ostrom 1999), biased information (Pierre and
589 Peters 2005), or lack of incentives to provide public goods (Ostrom, Wynne and
590 Schroeder 1993).

591 State dominated governance hence seems to perform well when
592 change is slow and predictability is high. This model is able to use existing
593 institutions and norms in such a way that actors are mobilized to reach
594 predetermined goals. Collective action and public good creation are facilitated
595 by lowered transaction costs. Douglass C. North's analysis (1990b, 2005) of
596 the importance of institutions and political order in providing stable structure of
597 exchange relationships in both political and economic markets for economic
598 growth, is one example of the mentioned mechanism.

599 But due to limited capacity for exploration, performance drops rapidly
600 compared to NBG as change becomes more rapid and uncertain. The reason
601 for this is twofold. First, the lower capacity for exploration limits the perceived
602 set of available alternative policies and institutional arrangement. Hence
603 although the capacity to promote coordination among actors still remains high,
604 central decision makers might lack the understanding of which actions can and
605 needs to be taken. Second, what used to be the rigid governance type's
606 foremost asset –strong and stable institutions and norms—is now turned into a
607 liability. Path dependency and high sunk costs invested in institutional
608 structures obstructs fast and optimized rearrangement of institutional rules and
609 practices.

610

611 Fast Large Scale Disturbances in State Centric Governance

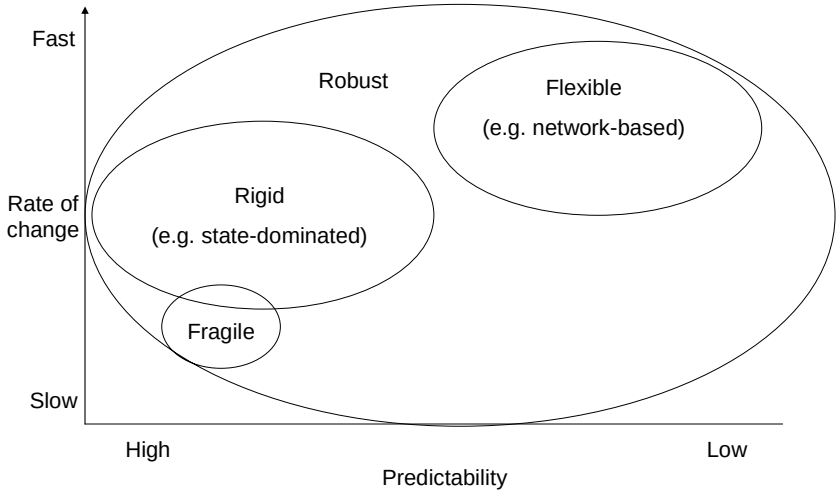
612

613 The story is likely to be different for fast irreversible changes, and
614 cascades across large spatial scales. Compared to network based governance,
615 a potent central state might have an advantage in achieving fast coordination in

complex actor settings hence being better apt in coping with multilevel and cross-system type of changes, as exemplified in the case of Hurricane Katrina in New Orleans.

The argument is that the democratic nation state is the only actor capable of perform three key roles simultaneously necessary to cope with fast change. First, in its capacity as a source of constitutional ordering, the state is capable appropriately 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 demotic 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).

Figure 2 Adaptive capacity and different types of complex change (NB: Large scale shocks not included)



Note: Circles illustrate the adaptability domain of governance types, i.e. the area of change in which each governance type is expected to have maximum adaptive capacity.

Amplifiers and Buffers - Interaction Effects in Multilevel Governance Systems

However, the hypotheses illustrated in Figure 2 presuppose that governance systems are scale-free and unitary for a given community. By allowing for interaction effects between different governance systems nested within each other, a somewhat different picture emerges (c.f. Young 2006; Cash et. al. 2006). This point has been – although not explicitly - made by a number of scholars of natural resource management (Berkes et. al. 2003; Ostrom 2005). Concepts such as “institutional redundancy” (Low ,Ostrom, Simon and Wilson 2003) and “polycentric institutions” (McGinnis 2000) are based on similar recognitions of the interplay between institutions on different social levels. India’s strategy to cope with climate change provides an example of cross-scale buffering effects: While initiatives from the central government to reduce underprivileged communities’ vulnerability to the effects of climate change allegedly has been slow and ineffective (Science and Development Network 2005), a number of adaptation and risk reducing strategies are promoted by a number of actors (e.g. farmers, NGO’s, international aid organizations, the business community) which are likely to buffer some of the worst social impacts of projected extreme weather events (Moench and Dixit 2004, Mendelsohn and Dinar 1999).

Figure 3 shows how a combination of governance systems on different levels can sometimes produce cross-scale interaction effects. For the sake of simplicity we use the terms national and local to denote two different organizational levels, although much more complex interactions between

multiple spatial and temporal scales is likely to encountered in an empirical setting. The first interaction effect is illustrated by the area labelled ‘Rigid + flexible’ and refers to the combination of local level flexible governance and national level rigid governance. An example of this combination is identified by Pierre and Peters (2005) in the case of Belgium and Germany where sub-national governments seem to have modernized more rapidly and effectively than have central governments (Pierre and Peters 2005:85).

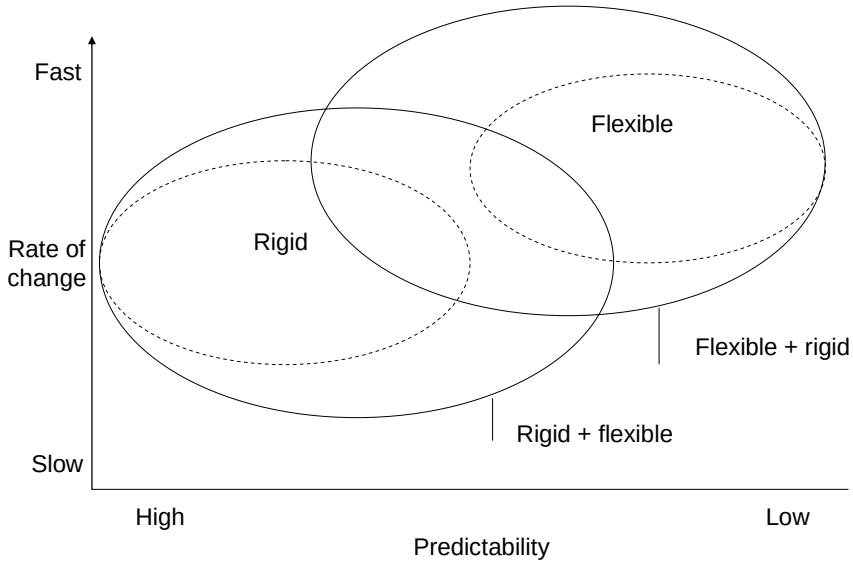
In comparison with level-free rigid governance, this combination produces higher adaptive capacity for unexpected shocks without sacrificing performance in situations of slow and local change. The buffering effect resulting from local initiatives following the devastating earthquake in Mexico city is another example (Gavalya 1987).

In a similar fashion, the combination of rigid local level governance and national level shows overall better adaptive capacity (illustrated in figure 3 by the area labelled ‘Flexible + rigid’), as compared to the scale-free performance of flexible governance. Specifically, by virtue of a stronger capacity for collective action, rigid local governance buffers the weak performance of flexible governance in times of slow and gradual change.

On the other hand, if rigid governance systems at the national level are combined with fragile local communities, the drawbacks associated with the first system can be seriously amplified. The reason for this is that shocks and unexpected events that undermine problem solving capacity at the national level might trigger collapses on the local level (ecological, economical or social) that risk to cascade back to the national level and seriously undermine the legitimacy of the state. A number of examples of this amplifying mechanism can be found in the literature dealing with the vulnerability of political regimes in the face of external and internal stresses and shocks (Jenkins and Bond 2001; Migdal 1986).

A similar amplifying effect can be found in the case where the advantages of a flexible governance type at the national level can be undermined by the failure of local communities to cope with crises triggered by unexpected and/or fast change. So although flexibility at the national level might promote learning and uncoordinated adaptation to slow change, the vulnerability of fragile local communities might trigger events such as political crises that bring to light the national systems poor ability to promote collective action.

Figure 3 Two examples of buffering cross-scale interaction effects



V. Conclusions: Can Complex Systems be Governed?

Contrary to what is often assumed by policy scholars and policy makers, large parts of the world are not characterized by linear and predictable social, economical or ecological processes. Instead, chocks and disturbances are much more common features than previously acknowledged. At the same time, a fundamental shift is on the way in how we govern ourselves: from command-and control management performed by Weberian bureaucrats within centralized national bureaucracies towards a plethora of different schemes of

715 self-government, public-private partnerships, collaborative efforts, policy
716 entrepreneurs, and participatory initiatives usually gathered under the umbrella
717 term of ‘governance’.

718 For the Weberian bureaucracy, a high premium was put on the capacity
719 for instigating collective action. Implementing large-scale policies through a
720 centralized and formal administrative apparatus requires the ability to secure
721 large-scale cooperation among citizens (cf. Levi 1997). In addition, the
722 argument advanced by institutional economists such as North (1990b) is also
723 based on the key role played by stability–inducing and transaction cost-
724 lowering institutions for economic development. But the combined processes of
725 diminishing strength of the nation state and an increasingly complex,
726 interlaced, and rapidly changing world has heightened the need for adaptation
727 and flexibility in order to reduce vulnerability and secure vital resources of
728 communities (Young et. al. 2006).

729 Throughout this paper, we have argued that there is a need to shift the
730 focus from studying the character of new patterns of governance (e.g. Kooiman
731 1993; Pierre and Peters 2000) to a research agenda that elaborates the
732 problem solving capacity of existing governance systems in the face of
733 multilevel change characterized by nonlinear dynamics, threshold effects, and
734 limited predictability. We have also suggested that our understanding of
735 governance of complex systems must account for the problem solving capacity
736 of interacting higher and lower levels of social and organisational levels. In
737 short, although governance theory certainly has much to offer, the need to
738 elaborate the implications of the interconnectedness of systems and their non-
739 linear behaviour should be obvious.

740 The number of research fields that have taken on this challenge is
741 impressive ranging from scholars of vulnerability (e.g. Turner, Kasperson,
742 Matson et. al. 2003), crisis management (e.g. Boin 2004), and resilience

743 theory (cf. Folke et.al. 2005). We believe that governance theory with its
744 detailed focus on the behaviour of political actors in governance systems has
745 much to offer to this debate.

746 This however raises the question of whether it is at all possible to govern
747 the messy and unpredictable nature of complex adaptive systems. As we have
748 tried to show, only governance types that combine high capacities for
749 exploration *and* exploitation can be expected to perform well regardless of the
750 certainty and rate of change. A full-blown example of the robust governance
751 type is dependent upon resolving the fundamental tension between institutional
752 stability and flexibility (Pierson 2004; Thelen 1999, 2003), at the same time as
753 the problem solving capacity is maintained in multilevel governance systems.

754 Designing institutions that simultaneously produce high levels of collective
755 action and learning often means overriding basic institutional traits such as
756 path dependency and stickiness – a feat which is not likely to be accomplished
757 easily and without conflict. This means that we are left with less-than-optimal
758 governance systems for governing complex systems. How to get a better
759 analytical grip of the limits and possibilities of governance in a world were
760 change is non-linear, uncertain, and imbedded in a diversity of multilevel
761 systems ranging from the natural to the social world, remains a matter of great
762 concern for the future for governance theory.

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765 ## References
766
767
768 Adger, Neil W. 2003. “Social Capital, Collective Action and Adaptation to
769 Climate Change.” *Economic Geography,* 79(4): 387-404.
770 Ahn, T., E. Ostrom, D. Schmidt et. al. 2001. “Cooperation in PD Games –
771 Fear, Greed and History of Play”, *Public Choice*, 106:137-155.
772 Anderies, J. M., M. A. Janssen, and E. Ostrom. 2004. “A Framework to
773 Analyze the Robustness of Social-Ecological Systems from an Institutional
774 Perspective.” *Ecology and Society* 9(1): 18. [online] URL:
775 http://www.ecologyandsociety.org/vol9/iss1/art18/

776 Antle, J.H., J. J. Stoorvodel and R.O. Valdivia. 2006. “Multiple Equilibria, Soil
777 Conservation Investments, and the Resilience of Agricultural Systems.”
778 *Environment and Development Economics*, 11: 477-492.
779 Arthur, B. W. 1999 “Complexity and the Economy”, *Science*, 284: 107-109
780 Barrett, C.B. and B.M. Swallow. 2006. “Fractal Poverty Traps.” *World*
781 *Development*, 34(1): 1-15.
782 Beland, D. (2006). "The Politics of Social Learning: Finance, Institutions, and
783 Pension Reform in the United States and Canada." *Governance - an*
784 *International Journal of Policy and Administration* 19(4): 559-583.
785 Berkes, Fikret, Johan Colding and Carl Folke. (2003). *Navigating Social-*
786 *Ecological Systems – Building Resilience for Complexity and Change.*
787 Cambridge: Cambridge University Press.
788 Berkes, Fikret, Terry P. Hughes, R. S. Steneck et. al. 2006. "Globalization,
789 Roving Bandits, and Marine Resources", *Science*, 311:1557-1558.
790 Bohle, HG, Tom E Downing and M.J. Watts. 1994. “Climate Change and
791 Social Vulnerability. Toward a Sociology and Geography of Food
792 Insecurity”. *Global Environmental Change*, 4 (1):37-48.
793 Boin, Arjen. 2004. “Lessons from Crises Research”, *International Studies*
794 *Review*, 6: 165-174.
795 Brooks, N. 2003. “Vulnerability, Risk and Adaptation: A Conceptual
796 Framework” *Tyndall Centre Working Paper No. 38.*
797 Burns, P. and M.O. Thomas. 2006. “The Failure of the Nonregime – How
798 Katrina Exposed New Orleans as a Regimeless City”, *Urban Affairs*
799 *Review*, 41(4): 517-527.
800 Busenberg, G. J. 2000. "Innovation, Learning, and Policy Evolution in
801 Hazardous Systems." *American Behavioral Scientist* 44(4): 679-691.
802 Busenberg, G. J. 2004 "Adaptive Policy Design for the Management of Wildlife
803 Hazards." *American Behavioral Scientis*t 48(3): 314-326.
804 Byrne, David. 1998. *Complexity Theory and the Social Sciences*. London:
805 Routledge.
806 Cederman, Lars-Erik. 1997. *Emergent Actors in World Politics – How States*
807 *and Nations Develop and Dissolve*. Princeton: Princeton University Press.
808 Chorus, I., I.R. Falconer et. al. 2000. “Health Risks Caused by Freshwater
809 Cyanobacteria in Recreational Waters“, *Journal of Toxicology and*
810 *Environmental Health* (Part B), 3, 323-347.
811 De Soto, H. 2000. *The Mystery of Capital: Why Capitalism Triumphs in the*
812 *West and Fails Everywhere Else.* New York: Basic Books.
813 DiMaggio, P. J. and W. W. Powell 1991. *The New Institutionalism in*
814 *Organizational Analysis.* Chicago: University of Chicago Press.
815 Eckerberg, Katarina and M. Joas. 2004. ”Multi-Level Environmental
816 Governance: A Concept under Stress?” *Local Environment,* 9(5): 405–412.
817 Eguiluz, V.M. and K. Klemm. 2002. “Epidemic Threshold in Structured Scale-
818 Free Networks.” *Physical Review Letters*, 89(10):’108701-1’-‘108701-4’.
819 Eising, R. 2004. “Multilevel Governance and Business Interests in the
820 European Union”, *Governance*, 17(2): 211-245.
821 Ellis, Paul. 1998. “Chaos in the Underground: Spontaneous collapse in a
822 Tightly-Coupled System.” *Journal of Contingencies and Crisis*
823 *Management*, 6(3):137-152.
824 Folke, C., S. Carpenter, B. Walker et. al. (2004). ”Regime Shifts, Resilience,
825 and Biodiversity in Ecosystem Management”, *Annual Review of Ecology,*
826 *Evolution, and Systematics*, 35, 557-581.

827 Gavalya, A.S. (1987). “Reactions to the 1985 Mexican Earthquake: Case
828 Vignettes”, *Hosp Community Psychiatry*, 38: 1327-1330
829 Gibson, C., E, Ostrom and T.K. Ahn. 2000. “The Concept of Scale and the
830 Human Dimensions of Global Change: a Survey”, *Ecological Economics*,
831 32: 217-239.
832 Goldenfeld, N. and L.P. Kadanoff. 1999. “Simple Lessons from Complexity.”
833 *Science*, 284: 87-89.
834 Granovetter, M. (1978). "Threshold Models of Collective Behaviour." *American*
835 *Journal of Sociology*, 83(May): 420-1443.
836 Greenberger, M. 2005. *The Role of the Federal Government Response to*
837 *Catastrophic health Emergencies: Lessons Leaned from Hurricane*
838 *Katrina*. University of Maryland School of Law, Legal Studies Research
839 paper No. 2005-52.
840 Gunderson, L.H. 2003. “Adaptive Dancing: Interactions Between Social
841 Resilience and Ecological Crises” in Berkes F. et. al. (eds.) *Navigating*
842 *Social-Ecological Systems – Building Resilience for Complexity and*
843 *Change*, Cambridge: Cambridge University Press, 33-52.
844 Gunderson, L.H. and C.S. Holling 2002. *Panarchy – Understanding*
845 *Transformations in Systems of Humans and Nature.* Island Press,
846 Washington D.C.
847 Hall, P. A. (2003). “Aligning Ontology and Methodology in Comparative
848 Politics.” In J. Mahoney and D. Rueschemeyer (eds.). *Comparative*
849 *Historical Analysis in the Social Sciences*. (Cambridge, Cambridge
850 University Press): 373-404.
851 Hardin, G. 1968. "Tragedy of Commons." *Science* 162(3859): 1243-8.
852 Hardin, R. 2002. *Trust and Trustworthiness.*(New York: Russell Sage).
853 Held, D. 2000. “Regulating Globalization? The Reinvention of Politics”,
854 *International Sociology*, 15(2), 394-408.
855 Hirst, P. 2000. “Democracy and Governance.” In Pierre, J (ed.). *Debating*
856 *Governance –Authority, Steering and Democracy.* Oxford, Oxford
857 University Press, 13-35.
858 Holland, J.H. and J.H. Miller. 1991. “Artificial Adaptive Agents in Economic
859 Theory.” *American Economic Review*, 81(2): 365-370.
860 Hooghe, L., and G. Marks. 2003. “Unravelling the Central State, but How?
861 Types of Multi-level Governance.” *American Political Science Review*, 972:
862 233-243.
863 Janssen, M.A. (ed.) 2002 *Complexity and Ecosystem Management: The*
864 *Theory and Practice of Multi-agent Systems*. Cheltenham UK/
865 Northampton, MA, USA: Edward Elgar Publishers.
866 Jenkins, J. C. and D. Bond. 2001.”Conflict-Carrying Capacity, Political Crisis,
867 and Reconstruction.” *Journal of Conflict Resolution*, 45(1): 3-31.
868 Jervis, R. 1997. *System Effects – Complexity in Political and Social Life.*
869 Princeton, Princeton University Press.
870 Jones, C., W.S. Hesterly, S.P. Borgatti 1997. “A General Theory of Network
871 Governance: Exchange Conditions and Social Mechanisms”, *The*
872 *Academy of Management Review*, 22(4), 991-945.
873 Jordan, Andrew and A. Lenshow. 2000. “Greening the European Union? What
874 can be Learned for the Leaders of EU Environmental Policy?” *European*
875 *Environment*, 10(3):109-120.
876 Kickert W.J.M and J.F.M. Koppenjan 1997. ”Public Management and Network
877 Management: an Overview”, in Kickert W.J.M., E-H Klijn and J.F.M.

878 Koppenjan (eds.) *Managing Complex Networks –Strategies for the Public*
879 *Sector,* Sage, London, 35-61.
880 Kickert, W.J.M., E-H Klijn and J.F.M. Koppenjan (eds.) 1997. *Managing*
881 *Complex Networks – Strategies for the Public Sector*. London:Sage.
882 Kinzig, A. P., P. Ryan, M. Etienne, H. Allison, T. Elmqvist, and B. H. Walker.
883 2006. “Resilience and Regime Shifts: Assessing Cascading Effects”,
884 *Ecology and Society*, 11(1): 20. [online] URL:
885 http://www.ecologyandsociety.org/vol11/iss1/art20/
886 Knack, S., & Keefer, P. 1997. “Does Social Capital Have an Economic Payoff?
887 A Cross-Country Investigation.” *The Quarterly Journal of Economics,*
888 112(4):1251-88.
889 Kooiman, J. 2003. *Governing as Governance*. Sage, London.
890 Kooiman, J. (ed) 1993. *Modern Governance – New Government Society*
891 *Interactions*. London:Sage.
892 Koppenjan, Joop and Erik-Hans Klinj (2005). Managing Uncertainties in
893 Networks. London: Routledge.
894 Krasner, S. D. 1984. "Approaches to the State. Alternative Conceptions and
895 Historical Dynamics." *Comparative Politics* 16(2): 223-246.
896 Larson, Andreas. 1992. “Network Dyads in Entrepreneurial Settings: A Study
897 of the Governance of Exchange Relationships.” *Administrative Science*
898 *Quarterly*, 37(1): 76-104.
899 Levi, M. 1998. *Consent, Dissent, and Patriotism*. New York, Cambridge
900 University Press.
901 Levin, S.A. 1999. *Fragile Dominion – Complexity and the Commons*.
902 Cambridge MA: Perseus Publishers.
903 Liljeros, F., C. Edling, L.A. Nunes Amaral et. al. 2001.”The Web of Human
904 Sexual Contacts”, *Nature*, 411, 907-908.
905 Low, B., E. Ostrom, C. Simon and J. Wilson 2002. “Redundancy and Diversity:
906 Do they Influence Optimal Management?” In Berkes, F., J. Colding and C.
907 Folke (eds.). *Navigating Social-Ecological Systems.* Cambridge:
908 Cambridge University Press, 83-114.
909 Lowndes, V. and C. Skelcher. 1998. “The Dynamics of Multi-organizational
910 Partnerships: An Analysis of Changing Modes of Governance.” *Public*
911 *Administration*, 76: 313-333.
912 Lundqvist, L.J. 2001. “Implementation from Above: The Ecology of Power in
913 Sweden's Environmental Governance”, *Governance*, 14(3), 319-337.
914 Mahoney, J. 2000s. "Path Dependence in Historical Sociology." *Theory and*
915 *Society* 29(4): 507-548.
916 Manson, S.M. 2001. “Simplifying Complexity: a Review of Complexity Theory.”
917 *Geoforum*, 32 (3): 405-414.
918 March, J. G. 1991. "Exploration and Exploitation in Organizational Learning."
919 *Organization Science* 2(1): 71-87.
920 March, J.G. and Olsen, Johan P. “Elaborating the “New institutionalism”” In
921 Rhodes, R.A.W., Binder, S.A. and Rockman, B.(eds.) *The Oxford*
922 *Handbook of Political Institutions* (Oxford: Oxford University Press): 3-20.
923 McGinnis, M.D. (ed.) 2000. *Polycentric Games and Institutions*. Michigan:
924 Michigan University Press.
925 Mendelsohn, R. and Ariel Dinar .1999. “Climate Change, Agriculture, and
926 Developing Countries: Does Adaptation Matter?” *World Bank Research*
927 *Observer*, 14(2):277-293.

Meseguer, C. 2005. "Policy Learning, Policy Diffusion, and the Making of a New Order." *Annals of the American Academy of Political and Social Science* 598: 67-82.

Midgal, J.S. 1986. *Strong Societies, Weak States - State-Society Relations and State Capabilities in the Third World*. Princeton: Princeton University Press.

Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well Being – Synthesis*. Washington: Island Press.

Moench, Marcus and Ajaya Dixit. eds. 2004. *Adaptive Capacity and Livelihood Resilience – Adaptive Strategies for Responding to Floods and Droughts in South Asia*. Boulder CO: The Institute for Social and Environmental Transition (ISET).

North, D. C. 1990a. "A Transaction Cost Theory of Politics." *Journal of Theoretical Politics* 2: 335-367.

North, D. C. 1990b. *Institutions, Institutional Change, and Economic Performance.* (Cambridge: Cambridge University Press)

North, D. C. 2005. *Understanding the Process of Economic Change.* Princeton, Princeton University Press.

Ostrom, E. 1998. "A Behavioral Approach to the Rational Choice Theory of Collective Action." *American Political Science Review* 92(1): 1-22.

Ostrom, E. and J. Walker 2003. *Trust and Reciprocity: Interdisciplinary Lessons from Experimental Research*. New York: Russell Sage

Ostrom, Elinor, S.G. Wynne and L.D. Schroeder. 1993. *Institutional Incentives and Sustainable Development: Infrastructure Policies in Perspective*. Boulder CO: Westview Press.

Ostrom, Elinor. 2005. *Understanding Institutional Diversity*. Princeton: Princeton University Press.

Ostrom, Elinor.1999. ”Coping with Tragedies of the Commons.” *Annual Review of Political Science*, 2: 493-535.

Pascual, M., X. Rodo, S.P. Ellner et. al. 2000. “Cholera Dynamics and El-Niño-Southern Oscillation.” *Science*, 289: 1766-1769.

Patz, J.A. 2002. “A Human Disease Indicator for the Effects of Recent Global Climate Change.” *Proceedings of the National Academy of Sciences*, 99(20):12506-12508.

Perry, G. and L. Servén 2005. “The Anatomy of Multiple Crisis: Why was Argentina Special and What Can We Learn from It?” In Alexander Volbert. (ed.) *Monetary Unions and Hard Pegs.* Oxford: Oxford Scholarship Online Monographs, 231-287.

Peters, D.P.C., R.A. Pielke, B.T. Bestelmeyer et. al. 2004.”Cross-scale Interactions, Nonlinearities, and Forecasting Catastrophic Events”, *Proceedings of the National Academy of Sciences*, 101(42), 15130-15135.

Pidgeon, Nick, Roger E. Kasperson and Paul Slovic. (eds.) 2003. *The Social Amplification of Risk: Assessing Fifteen Years of Research and Theory.* Cambridge: Cambridge University Press.

Pierre, J. (ed.) (2000). Debating *Governance – Authority, Steering, and Democracy*. Oxford University Press, Oxford.

Pierre, J. and G.B. Peters (2005). *Governing Complex Societies – Trajectories and Scenarios*. (Basingstoke: Palgrave McMillan).

Pierson, P. (2003). Big, Slow-Moving, and...Invisible.” In J. Mahoney and D. Rueschemeyer (eds.) *Comparative Historical Analysis in the Social Sciences.* (Cambridge, Cambridge University Press): 177-207.

Pierson, P. 2004. *Politics in Time: History, Institutions, and Social Analysis.* (Princeton: Princeton University Press).

Putnam, R. D., Leonardi, R., & Nanetti, R. 1993. *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton: Princeton University Press.

Rhodes, R. A. W. (2000). “Governance and Public Administration”. In J. Pierre (ed.), *Debating governance. Authority, Steering, and Democracy*. Oxford: Oxford University Press, 54-90.

Rothstein, B. 2000. "Trust, Social Dilemmas and Collective Memories." *Journal of Theoretical Politics* 12(4): 477-501.

Rothstein, B. 2003. "Social Capital, Economic Growth and Quality of Government: The Causal Mechanism." *New Political Economy* 8(1): 49-71.

Rothstein, B. and D. Stolle 2003.” Social Capital, Impartiality and the Welfare State: An Institutional Approach”. In D. Stolle and M. Hooghe (eds.).*Generating Social Capital. Civic Society and Institutions in Comparative Perspective.* Basingstoke/New York, Palgrave Macmillan**:** 191-210.

Rothstein, Bo. 2005. *Social Traps and the Problem of Trust*. Cambridge: Cambridge University Press.

Sabatier, P. A. and Jenkins-Smith, H. 1999. “The Advocacy Coalition Framework. An Assessment”. In Sabatier, P. A. (ed.) *Theories of the Policy Process*. (Boulder: Westview Press).

Sandler, Todd. 2004. *Global Collective Action.* (Cambridge: Cambridge University Press).

Scharpf, Fritz W. 1997. “Introduction: the Problem-solving Capacity of Multi-level Governance.” *Journal of European Public Policy*, 484: 520-538.

Scheffer, Marten and Steve Carpenter. 2003. “Catastrophic Regime Shifts in Ecosystems: Linking Theory to Observation.” *Trends in Ecology and Evolutio*n, 18:648-656.

Schneider S.H. and T.L. Root. 1995. “Ecological Implications of Climate Change Will Include Surprises.” *Biodiversity and Conservation*, 5: 1109-1119.

Schneider, S.K. 2005. “Administrative Breakdowns in the Governmental Response to Hurricane Katrina.” *Public Administration Review*, 65(5):515-516.

Schout, A. and Andrew Jordan. 2005. “Coordinated European Governance: Self-Organizing or Centrally Steered.” *Public Administration*, 83(1):201-220.

Science .2005. “Scientists' Fears Come True as Hurricane Floods New Orleans”, 9 September 2005: 309 (5741), 1656 – 1659.

Science and Development Network. 2005. “India's Pragmatic Approach to Climate Change”, *Science and Development Network*, [online] URL: http://www.scidev.net/dossiers/index.cfm?fuseaction=dossierreaditem&dossier=4&type=3&itemid=518&language=1

Sornette, Didier. 2002. ”Predictability of Catastrophic Events: Material Rupture, Earthquakes, Turbulence, Financial Crashes, and Human Birth.” *Proceedings of the National Academy of Sciences*, 99: 2522-2529.

St. Arman, A 2002. “Cylindrospermopsis and Invasive Toxic Alga.” *Lake Line*, 22(1): 30-34.

Steffen, Will ed. 2004. *Global Change and the Earth System – A Planet under Pressure*. Berlin: Springer Verlag.

Thelen, K. 1999. "Historical Institutionalism in Comparative Politics." *Annual Review of Political Science* 2: 369-404.

Thelen, K. 2003. “How Institutions Evolve”. In J. Mahoney and D. Rueschemeyer (eds.) *Comparative Historical Analysis in the Social Sciences.* (Cambridge, Cambridge University Press):**:** 208-240.

Turner, B.L., Roger E. Kasperson, P.A. Matson et. al. 2003. “A Framework for Vulnerability Analysis in Sustainability Science.” *Proceedings of the National Academy of Sciences*, 100(14):8074-8079.

van Kersbergen, K. and F. van Vaarden 2004). ”Governance as a Bridge Between Disciplines: Cross-disciplinary Inspiration Regarding Shifts in Governance and Problems of Governability, Accountability and Legitimacy”, *European Journal of Political Research*, 43(2):143-171.

Walker, B. and J. A. Meyers. 2004. “Thresholds in Ecological and Social–Ecological Systems: a Developing Database”, *Ecology and Society*, 9(2): 3. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art3/

Walker, Brian and J. A. Meyers. 2004. “Thresholds in ecological and social–ecological systems: a developing database”, *Ecology and Society, 9(2): 3.* [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art3/

Waugh, W.L. 2006. *“*The Political Costs of Failure in the Katrina and Rita Disasters.” *Annals of the American Academy*, 604:10-25.

WHO. 2005a. *Avian influenza - situation (birds) in Nigeria*. Press Release from the World Health Organization, 8 February 2006

WHO. 2005b. *Avian influenza - situation in Nigeria – update*. Press Release from the World Health Organization, 22 February 2006.

Winter, Gerd. (ed.). 2006. *Multilevel Governance of Global Environmental Change – Perspectives from Science, Sociology and the Law*. Cambridge: Cambridge University Press.

Woolcock, M. and D. Narayan 2000. "Social Capital: Implications for Development Theory, Research, and Policy." *World Bank Research Observer* 15(2): 225-249.

Worm, B., E.B. Barbier, N. Beaumont et. al. 2006. "Impacts of Biodiversity Loss on Ocean Ecosystem Services.” *Science*, 314: 787-790.

Young, Oran, Frans Berkhout, Gilberto C. Gallopin et. al. 2006. “The Globalization of Socio-Ecological Systems: An Agenda for Scientific Research.” *Global Environmental Change*, 16(3):304-316.

Young, Oran. 2006. “Vertical Interplay Among Scale-dependent Environmental and Resource regimes.” *Ecology and Society,* 11(1): 27. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art27/

Zak, P. J. and S. Knack 2001. "Trust and Growth." *Economic Journal* 111(470): 295-321.

Zimmerman, R. 2001. “Social Implications of Infrastructure Network Interactions.” *Journal of Urban Technology*, 8(3):97-119.