CHAPTER 13

MULTI-LEVEL GOVERNANCE AND RESILIENCE OF SOCIAL-ECOLOGICAL SYSTEMS

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Belief structures get transformed into society and economic structure by institutions – both formal rules and informal norms of behaviour. The relationship between mental models and institutions is an intimate one. Mental models are the internal representation that individual cognitive systems create to interpret the environment; institutions are the external (to the mind) mechanisms individuals create to structure and order the environment (North 1996: 348).

1. INTRODUCTION

The last half of the twentieth century witnessed major efforts on the part of developed countries to assist developing countries in speeding up the process of economic and political development and, within their own borders, to improve natural resources management. While enhancing economic development and protecting the environment do not at first appear closely related, the underlying beliefs of many policy analysts in both fields have notable similarities. Initiatives in each policy area have been based on mental models which hold that solutions to difficult and complex problems can only be generated by scientifically trained analysts and implemented by impartial, national-level officials. However, both policy areas have been subject to considerable failure. Although initiatives based on these shared mental models have been undertaken and funds allocated to correct perceived problems, in many cases little or no improvement has been achieved, even after vast sums were spent. Or worse, the problems increased in magnitude.

This chapter first reviews the belief structures, or mental models, of the policy analysts who have been influential in recommending government strategies to achieve sustainable economic development and sustainable resource development. The dominant mental models used in both policy areas rely primarily on command and control (see Ostrom 1989 for a critique). The chapter then explores the concept of social-ecological systems as complex adaptive systems that differ with regard to their

predictability and their level of resilience to internal and external shocks or weaknesses. The adaptive cycle is described as well as how disturbances at one scale may trigger problems at the same or other scales, particularly if no experimentation has occurred or repertoire of adaptive responses been developed. Section four looks at some long-established institutions and examines why they may have been more resilient than other institutions. Neither policy field has paid much attention to the course of institutional development during the past millennium which facilitated the immensely productive economic development of Western Europe and the United States, or to successful long-term resource regimes throughout the world that have avoided ecological surprises for centuries. The chapter concludes by urging scholars to move beyond the dominant approach and draw on research conducted with various forms of a complex, adaptive systems perspective.

2. THE BELIEF IN THE EFFICACY OF TOP-DOWN SOLUTIONS

2.1 Development Assistance Policies

Major efforts to reconstruct economies after World War II were initiated at the Bretton Woods Conference in July 1944 when the World Bank and the International Monetary Fund were established. After Harry S. Truman declared his "point four" programme of technical assistance to developing nations in early 1949, the United States and many European countries began to focus on the "Third World". In reflecting on the perspective of those asked to implement the point four programme, Stone (1992: 36) indicated that development was viewed as a 'process in which "modernization," industrialization, and GNP growth, achieved largely by means of public investments and comprehensive national planning, would lead to increasingly prosperous and contented free society'.

During the early 1960s, many scholars subscribed to the gap theory of the development process. 'The "gap theory" stressed the lack of certain vital resources as the main stumbling blocks on the road to development. There was a lack of capital, caused by inadequate savings, and a lack of foreign exchange, but also of knowledge, of entrepreneurial spirit and of leadership qualities' (Elgström 1992: 46). Bauer summarised the beliefs of those who invested their professional lives in development assistance:

> The advance of LDCs depends on ample supplies of capital to provide for infrastructure, for the rapid growth of manufacturing industry, and for the modernization of their economies and societies. The capital required cannot be generated in the LDCs themselves because of the inflexible and inexorable constraint of low incomes (the vicious circle of poverty and stagnation), reinforced by the international demonstration effect, and by the lack of privately profitable investment opportunities in poor countries with their inherently limited local markets.
>
> General backwardness, economic unresponsiveness, and lack of enterprise are well-neigh universal within the less developed world. Therefore, if significant economic advance is to be achieved, governments have an indispensable as well as a comprehensive role in carrying through the critical and large-scale changes necessary to break down the formidable obstacles to growth and to initiate and sustain the growth process (Bauer 1984: 27).

The obvious solution to many western scholars, given the theories that were in vogue in the 1960s, was to recommend generous amounts of foreign assistance that could provide the missing capital, create new infrastructure and provide technical assistance. For some, aid was also seen as a way of "stabilising" and rewarding countries that were allies of the West. The relative success of the Marshall Plan in Western Europe played a role in the belief that pumping capital into an economy leads to a recovery. Western Europe had been through a devastating but short war. It had not suffered the loss of long-established and slowly evolving institutions that colonialism had imposed on much of the developing world. Europe had lost massive amounts of physical capital, but retained much of its social capital.

During the 1960s, billions of dollars of grants and loans to developing countries were accompanied by copious advice on organising and reforming governments. The dominant academic thinking of the day was that centralised regimes were most effective for achieving rapid national unity, effective public administration and extensive economic growth (see Ostrom 1999, Peluso 1992). Scholars and policymakers paid little attention to the need to establish transparent procedures, accountable regimes, effective local government, fair and open court systems and an active civil society. Nor was much attention given to stimulating private enterprise and providing the public policies needed to support a dynamic market economy.

In the 1960s, many developing countries enjoyed relatively high growth rates and optimism abounded. By the early 1970s, however, not only were economic growth patterns unstable and uneven across countries, even more disturbing was that the process of growth often adversely affected the poorest. Corrupt regimes diverted foreign aid into private goods rather than making public investments. Mauro (1995) found, for example, a strong inverse relation between the level of corruption in a country during the 1960s and 1970s and its level of spending on education and health.

Negative assessments have repeatedly been made of the results of international assistance to many developing countries based on extensive reviews of the empirical evidence.[2] In *Improving Aid to Africa* (1996: 2), Van de Walle and Johnston noted that 'aid has not succeeded in fostering economic growth and poverty alleviation in most African countries. From 1980 to 1993, the continent's rate of economic growth was actually negative.' The problem of poverty has generally grown worse around the world. In 1996, for example, approximately 1.3 billion people in developing countries subsisted on less than one US dollar a day (World Bank 1996a). Even in Latin America, 'the number of poor, now 33 per cent of the total population, has failed to fall despite economic recovery' (Birdsall and Londoño 1997: 32). Despite some notable achievements many practitioners and observers now view development aid as ineffective at best, and counterproductive at worst (Edgren 1995, Elgström 1992, White 1992, 1998, 1999). Research has confirmed this conventional wisdom (Boone 1996, Dollar and Easterly 1999, Dollar and Svensson 1998).

While there are important exceptions (such as the overall national record of economic and social welfare in Botswana and Taiwan and smaller projects throughout the world), the performance of development assistance is not strongly positive. In an effort to assess the impact of aid on economic growth, for example, Burnside and Dollar (1997) examined the growth rate of per capita GNP (averaged over four-year

periods) for 56 developing countries beginning in 1970–73 and ending in 1990–93. They found that overall levels of aid had *no* independent effect on GNP growth (see also Boone 1994). Further, many projects and programmes have turned out to be unsustainable in the sense that the recipient government is unable or unwilling to continue the effort after development loans or grants are discontinued. When the funds stop, so does the project.

In recent years, particular focus has been on the perverse incentives generated by some forms of development assistance. Rather than emphasising the lack of material or human resources, a number of analysts have pointed to ways in which the incentives of development aid undermine its effectiveness (Bates 1998, Catterson and Lindahl 1999, Killick et al. 1998). Their work indicates that no matter how well-intentioned the assistance, or how many resources are transferred, development will occur only if political and economic institutions generate incentives that facilitate individuals' achievement of development goals.

Many reasons can be cited for this lack of effectiveness and sustainability. One is the excessive faith in the neutrality of centralised governments. Another is the delivery of aid to authoritarian regimes through naïveté or Cold War strategic thinking (Ertman 1997). Still another is that the aid process itself creates a series of perverse incentives within recipient governments and within agencies responsible for disbursing large volumes of funds (Bräutigam 2000).[3] Levels of corruption grew dramatically, with high costs both in terms of achieving an open, fair and effective government administration and in terms of opportunities lost.[4] The most general factor affecting the success or failure of development aid, however, appears to be the lack of effective institutions at all scales to generate incentives enabling development actors – donors; national, regional, and local governments; NGOs; contractors; investors and the citizens of recipient governments – to cope effectively with diverse collective-action problems.

Collective-action problems exist whenever multiple actors are needed to obtain a jointly beneficial outcome but each actor has a short-term incentive to hold back a full contribution to the joint endeavour. Collective-action problems pervade all aspects of development and resource management. The mental models used in advising policymakers (and in teaching generations of graduate students), however, have yet to focus on the wide array of these problems, which nonetheless must be solved at diverse scales in order for economic agents to gain the trust and assurance they need to sustain economic growth. Indeed, a wide variety of institutional arrangements are needed to encourage economic development.

The centralised state has failed throughout Africa due to its overlooking the self-organising and self-government capabilities of African peoples (Wunsch and Olowu 1995). Instead of focusing on the diversely structured collective-action problems that exist in any complex, dynamic political economy, the predominant mental model used until recently in development assistance was that problems of development should be articulated and tackled by national-level governments of donor countries dealing directly with the sovereign national governments of recipient countries (see Ostrom et al. 2002 and Martens et al. 2002 for recent analyses of the role of institutions and incentives in development). This is particularly paradoxical since

many of the scholars involved are economists who recognise the importance of multiple independent actors in a market setting. However, their theory has not addressed how institutions are developed to enhance the emergence of a free, open, competitive market. North stated it well:

> There is no mystery why the field of development has failed to develop during the five decades since the end of the Second World War. Neoclassical theory is simply an inappropriate tool to analyze and prescribe policies that will induce development. It is concerned with the operation of markets, not with how markets develop. How can one prescribe policies when one doesn't understand how economies develop? (North, 1996: 342)

2.2 Natural Resource Policies

During the past half century, a similar set of mental models has dominated the thinking of policy analysts examining a diverse set of problems related to natural resources. The early work of Gordon (1954: 124) focused attention on the problem of over-harvesting from an open access natural resource:

> Wealth that is free for all is valued by no one because he who is foolhardy enough to wait for its proper time of use will only find that it has been taken by another… The fish in the sea are valueless to the fisherman, because there is no assurance that they will be there for him tomorrow if they are left behind today.

When Hardin (1968) dramatised this logic in his famous article *The Tragedy of the Commons*, scholar after scholar proclaimed the necessity of "the" government stepping in (see e.g. Clark 1976, Dales 1968, Ehrenfield 1972, Ophuls 1973). The actual policies varied, but the uniform recommendation was that the initiative for change would come from a national government. Stillman (1975: 13) was among the early commentators to point out the puzzling inconsistency of those who recommended a strong central ruler and thus presumed 'the ruler will be a wise and ecologically aware altruist', while at the same time presuming that the users of natural resources were myopic, self-interested and ecologically unaware hedonists. But somehow, these 'wise and ecologically aware altruists' have repeatedly subsidised the over-extraction of forests and other resources under a diversity of regime structures (Repetto and Gillies 1988).

National governments are seen as needed to devise new rules, impose them on users and enforce new definitions of rights and duties. One of the major shared belief systems in natural resource conservation and management has been the acceptance of the single-species growth curves and the capacity to use scientific investigation to determine the maximum sustainable yield (MSY) of a fishery or other renewable resource. A governmental scientific agency is delegated authority to determine the MSY for a fishery or forest resource and then to assign permits to a level of harvesting that is as large as possible while assuring sustainable yields over the long term (Dolšak 2000, Tietenberg 2002).

In addition to presuming that resource users are themselves helpless to overcome the temptation to over-harvest resources, several other mental models have been widely adopted by those concerned with natural resources. The ecosystem

management approach, which is widely taught and applied, urges policymakers to do their analysis at the highest feasible level in order to capture all of the inter-connections. Somehow a national government elected by a general public is implicitly presumed to represent society and thereby is seen as able to do analyses that consider all the effects of its decisions!

Another policy prescription frequently recommended to cope with natural resource problems is total government ownership or control. Thus, governments throughout the world have created various kinds of reserves in areas thought to be suffering from resource depletion or other types of environmental degradation. State agencies have been assigned responsibility for managing natural resources themselves or for contracting out such management under concession arrangements. One of the aims of these agencies has been to reduce the level of disturbance stemming from both human and non-human threats to the resource.

In a cogent critique of policies adopted in the name of increasing the sustainability of natural resources, Ascher (2001) identified a number of perverse processes that occur in the day-to-day implementation of these policies:

- *short-term considerations* stemming from multiple sources, such as short election cycles;
- *perverse learning patterns* arising 'because of oversimplification in the face of complexity, or because the lessons run counter to institutional interests';
- *increased depletion* stemming from a lack of monitoring and control after a national government has declared its ownership of a natural resource, such as a forest, but lacks the resources needed to protect what it has declared that it owns (see Bromley et al. 1992);
- *truncated approaches* serving agency interests by 'enshrining simple strategies at the cost of sustainable protection' (Bromley et al. 1992: 745).

Unfortunately, clearly wrong policies have been adopted in regard to many natural resource systems. In spite of repeated warnings by Newfoundland fishers that the size of the cod they were catching was steadily decreasing, the Canadian agency responsible for management of the extensive eastern coastal zone insisted that its "scientific" data showed evidence of a fishery that could withstand the high levels of withdrawals (Finlayson and McCay 1998). Thus, "scientific information" at a highly aggregated level trumped detailed information about the contents of catches by local fishers (National Research Council 1998). When the collapse in the cod fishery came, it came suddenly (as so many other environmental disasters have occurred) and led to the closure of the entire fishery for years with little evidence of a rebound.

Wilson et al. (2001) questioned the presumption made by many officials that large-scale fisheries should be managed only at a large scale. Recent studies have demonstrated the existence of sub-species of fish at smaller scales than that usually managed by national or international authorities. Ignoring these metapopulations can lead to a different form of overfishing than is usually discussed in contemporary textbooks. 'In particular, rather than overfishing simply by harvesting too many fish, it may be possible to overfish by inadvertently destroying the spatial structure of a

population' (Wilson et al. 2001: 60). In a similar vein, many models of natural resources do not address space explicitly.

Multiple studies document the perverse effect of over-reliance on one level of government – usually a large, central regime. As Berkes (2002) documented, over-reliance on central regimes is not confined to centrally planned economies. It occurs in almost all countries where 'resource management functions have been taken over by a managerial elite' (Berkes 2002: 296). Berkes provided typical examples of the types of impacts that central institutions have had on local-level institutions around the world. In Canada, for example, he described the management strategies of the aboriginal hunters from the Arctic and Subarctic who have monitored caribou distributions and migration patterns for many centuries. He pointed out a fundamental difference between the mental models used by the Canadian government and those used by the aboriginals. Users of the aboriginal system do not search for a way of controlling the caribou by developing a self-conscious estimate of herd size and hunting limits. Rather, the hunters pay close attention to the fat content of the caribou they harvest. This provides them with a reliable, qualitative model of the trends – increasing or decreasing – of caribou health over time. When the caribou are seen as less healthy, the normative system of the hunters is to reduce hunting until the fat content of the caribou appears to rise. By using this qualitative model, the hunters learn the direction of change in which a population of wild animals is headed and can respond accordingly (see also Berkes 1999). Furthermore, the cost of this method is dramatically less than the cost of conducting a head count of a widely dispersed population.

Unfortunately, many indigenous knowledge systems and related institutions have been destroyed as a result of new rules imposed by external authorities (see e.g. Mwangi 2003). It is certainly not the case that all indigenous systems are as effective as modern systems based on extensive data collection and analysis. However, many of these systems are being destroyed in the name of protecting natural resources, without due consideration of whether the indigenous system contains mental models and low-cost heuristics worthy of further investigation.

2.3 Underlying Similarities in Policy Analysis Belief Systems

The belief structures underlying a substantial amount of the scholarly literature and policy advice related both to economic development and to natural resources management share several core assumptions. Both fields share a fundamental commitment to the use of scientific approaches to help elucidate the core variables involved in a process and how they are related. Analysts in both fields have developed relatively simple models of the underlying problems of interest.

Benefit-cost analyses are repeatedly used to demonstrate that the benefits to a developing country of building a road, electric power project or major waterworks will be greater than the costs involved. Models of the economic costs and benefits of various harvest levels are also often used in analysing the relative efficiency of taxes, permits or transferable quota systems.

Scholars in both fields are committed to a determination of an *optimal* policy intervention – frequently a technological fix – and its implementation by a unified regime (even when that regime allocates private, transferable rights). Finding an optimal policy intervention is consistent with a presumption that most of the relevant processes involve a single beneficial equilibrium that is calculable through analysis and achievable through clear policy interventions. The problem identified for policy analysis is to develop a model of the system, determine the variables that affect its performance, determine which variables can be positively affected by a policy change and then develop and implement policies that induce the system to perform at optimal levels. To do this requires the advice of an expert.

Scott (1998) characterised as "seeing like a state" the belief system underlying many efforts to solve problems centrally through expert advice while ignoring the interests, information and capabilities of others involved. Scott attributed the gross failure of much such problem-solving to a belief system that he calls "high modernism".[5] When governments with strong powers adopt this belief system where citizens have a weak voice, the results have been massive tragedies in the twentieth century:

> High modernism must not be confused with scientific practice. It was, as the term ideology implies, fundamentally a faith which borrowed, as it were, the legitimacy of science and technology. It was, accordingly, uncritical, unskeptical, and thus unscientifically optimistic about the possibilities for the comprehensive planning of human settlement and production. The carriers of high modernism tended to see rational order in highly visual aesthetic terms. An efficient and rational city, village, or farm was, to them, a city that looked regimented and orderly in a geometric sense (Scott 1997: 4).

Many policy analysts argue that Scott is not criticising them but rather the authoritarian rulers of Communist Russia and many African countries. Extraordinary faith in the capacity of simple models to be used as the foundation for policies in widely diverse environments bears a striking similarity to Scott's concept of high-modern ideology (see also Ostrom 1989, 2002). The belief is so widespread that Holling, Gunderson and Ludwig (2002), after extensive review of many natural resource failures, refer to this as 'the trap of the expert'. They ask, 'Why does expert advice so often create crisis and contribute to political gridlock? Why, in many places, does science have a bad name?' (Holling et al. 2002: 7).

3. SOCIAL-ECOLOGICAL SYSTEMS AS COMPLEX ADAPTIVE SYSTEMS

During the same era in which the approach to develop natural resources outlined earlier in this chapter rose to dominance, another approach slowly evolved as more and more scholars and practitioners became disillusioned with the performance of policies based on the dominant views. Following in the steps of Simon (1989, 1996), Holling (1973), Axelrod (1984, 1997) and Holland (1995), this approach views a variety of social-ecological systems as complex adaptive systems.

In complex adaptive systems the components and the structure of interactions between the components are able to adapt themselves to internal and external disturbances. From this perspective, the simple models used by many resource

managers are not all wrong. Rather, they are only partial models of much more complex interactions. In some cases, the partial models have been sufficiently useful as to form a good mental model for policy recommendations. In systems that are indeed more complex, there is a further need to understand processes of organisation and reorganisation including collapse and what is likely to happen after collapse. Does a system have one and only one equilibrium to which it returns after a major shock and temporary collapse? Or are there multiple equilibria with different characteristics? How easy is it for a system to flip from a desirable equilibrium to an undesirable one? These are crucial questions.

Order in complex systems is emergent as opposed to predetermined. The system's history is irreversible and future behaviour is path-dependent. The system's future is often unpredictable due to the non-linearity of many basic causal relationships. The variables that affect performance move both fast and slow. If information about slow-moving variables is not recorded for a long period of time, substantial surprises can occur when such a variable reaches a threshold. In social-ecological systems the social components are individuals and institutions. Individuals may change their relations with other individuals, may change their strategies and may change the rules they abide by. In fact, individual strategies and institutional rules interact and co-evolve, sometimes in unpredictable ways.

The complex adaptive systems perspective provides the view of individuals within a variety of situations structured by the biophysical world, institutional rules and the community in which they interact. Boundedly rational individuals trying to do as well as they can in uncertain situations continuously tinker with their strategies including trying to change the rules that affect particular situations. Within ongoing structures, individuals search out perceived advantageous strategies given the set of costs and benefits that exist and the strategies that others adopt. They may look for loopholes in the law – particularly if they think others are doing the same. They may check the level of enforcement by breaking rules occasionally. Those responsible for changing the rules of an institution also experiment with new rules and try to learn from others why some other institutional arrangements appear to work better than their own.

One of the concepts that can be used to evaluate the dynamics of complex adaptive systems is resilience (Gunderson and Holling 2002, Holling 1973). Resilience is defined as the amount of disruption needed to transform a system from one stability domain (characterised by a configuration of mutually reinforcing processes and structures) to another. The concept of resilience originates from ecology. Ecological resilience may be measured 'as the width of the desirable attractor' in a multi-equilibria system 'measured in units of the fast variable' (Carpenter et al. 2002). Resilience has been used to understand how to improve management of systems so as to reduce ecosystem vulnerability. Many examples have been documented where ecosystems have shifted from desired configurations (e.g. a productive rangeland or clean lake) to undesirable configurations (e.g. degraded rangelands or eutrophic lakes) (Scheffer et al. 2001). Human activities have reduced the resilience of these managed ecosystems over time, making them vulnerable to disturbances.

3.1 The Adaptive Cycle

The adaptive cycle is a heuristic model useful to understand the dynamics of complex adaptive systems (Gunderson and Holling 2002, Holling 1986). Figure 1 provides a stylised picture of the adaptive cycle. Although the adaptive cycle originated from ecology, it has also been applied to social-ecological systems (Gunderson et al. 1995, Gunderson and Holling 2002, Walker et al. 2002). Specific adaptive cycles will vary substantially in terms of temporal and spatial scale, the number of relatively stable domains that exist and the structure of fast-moving and slow-moving variables. The adaptive cycle involves the movement of a system through four phases: a period of rapid growth and exploitation (r); leading into a long phase of accumulation, monopolisation and conservation of structure, during which resilience tends to decline (K); a very rapid breakdown or release phase (Ω); and finally a relatively short phase of renewal and reorganisation (α). If, in this final phase the system is resilient and still sufficiently retains its previous components, it can reorganise to remain within the same configuration as before. This is also a time when novelty can enter – new species, new institutions, ideas, strategies, policies and industries – and the "new" emerging system, whether it is in the same or a different configuration, gains some degree of resilience.

The "forward" (r to K) and "backloop" (Ω to α) dynamics of the adaptive cycle correspond to managing for production and managing for innovation: both are important objectives. They can be likened, in the area of investment, to the part of the portfolio aimed at maximising income (r to K) and the part aimed at maximising flexibility to cope with and adapt to unexpected change in the market (Ω to α). Just as there are costs and benefits involved in diversifying an investment portfolio, so there are costs and benefits involved in building resilience. There are trade-offs and synergies between production and resilience. Achieving both objectives requires an understanding of when it is appropriate to try to increase production efficiency and when (and where) it is appropriate to work to ensure sustainability.
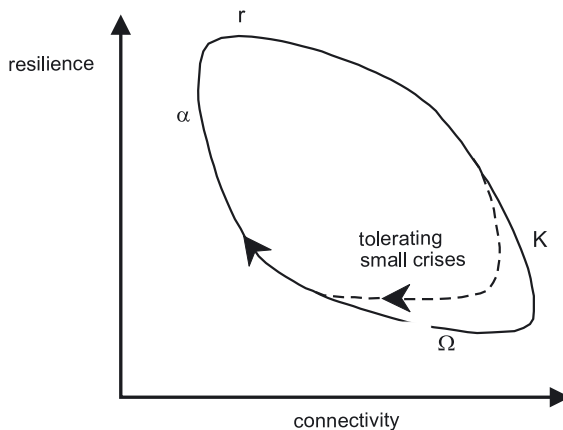

Figure 1. *The Adaptive Cycle*

The stages can be summarised as follows:

- *r to K*. There are strong controls and the system changes slowly. Regulatory policies and efforts to increase efficiency may be appropriate, although careful experimentation is sometimes critical. Application of techniques such as optimal control can be useful in this stage. However, resilience can be lost through gradual changes in underlying slow variables.

- *Ω to α*. The system changes rapidly. In this phase, no equilibria exist, there is turbulence and consequently novelty can enter. What is the appropriate approach to research and management? How can creative and potentially resilient new practices be discovered? The system is susceptible to loss of resources (soil erosion, species, human and financial capital) and measures to conserve capital are appropriate. It is also vulnerable to entering a potentially undesirable configuration. Guidance is needed. Influential ideas ("good" and "bad") can become entrenched and guide subsequent evolution of the system.

In the *r* to *K* phase, the connectivity increases, but resilience decreases and the system becomes vulnerable to disturbances. All systems face small to large disturbance from external or internal sources. Very few systems can be "controlled" and disturbance-free for long periods of time. In fact, efforts to control small disturbances may reduce a system's resilience to large disturbances. However, it is not always possible to judge whether a disturbance is small or large. Like immune systems are not perfectly able to attack all harmful invasions, and we might sometimes get ill, resiliency of systems is also determined by the ability to cope with the errors we make in judging the type of disturbance. A system trained in dealing with disturbances is more likely to anticipate when a disturbance is severe than systems that suppress disturbances.

A risk of decreasing resilience is that a crisis will render the system unable to recover into the same configuration; the system then flips into an alternative stability domain. For example, suppressing forest fires causes an accumulation of fuel on the forest floor and an accumulation of tree biomass. When a fire finally occurs, it will be hot and intense, affecting soil conditions and the capacity of the forest to recover from fire events. The system has flipped. Management can reduce the risk of flipping into an undesirable stability domain by tolerating small crises in order to prevent a big one. The draconian fire-suppression doctrine of the US Forest Service, the Smokey the Bear programme, was a clear and understandable mission to fight all fires in national forests. Tragically, it was a clear policy, but one that was clearly wrong (see Pyne 1982, 1996). A political example of losing resilience is an authoritarian regime which represses all contestation and debate at an early point and then finds itself embroiled in a full-scale civil war.

During the *Ω* to *α* phase institutional innovation can be significant. This is the phase when public entrepreneurs may be able to find new combinations of inputs so as to move the entire system to a more productive functioning and broaden the range of the attractor for positive system performance (or the resilience of the system) (Kuhnert 2001, Schneider et al. 1995).

3.2 Multiple Scales

A social-ecological system does not consist of just one kind of cycle at one scale. It functions as a nested, hierarchical structure, with processes clustered within subsystems at several scales (e.g. the farm, region and state). Different subsystems, at different scales, may be in different phases and may change at different rates (Gunderson and Holling 2002). The subsystems are semi-autonomous, but cross-scale interactions do occur. Particular attention needs to be paid to these cross-scale interactions.

Connections between the different levels of scale can be labelled as "trigger" and "remember". In the original ecological description of the adaptive cycle at different scales, the term "revolt" was used to convey the suggestion that fast and small events overwhelm slow and large ones, and the term "remember" was used to indicate that the experience accumulated at the larger level can be used to stimulate renewal at the smaller level (Gunderson and Holling 2002). However, we argue that in social-ecological systems the two connections can affect both the smaller and the larger scale systems. Therefore, instead of "revolt", we use the term "trigger" to denote a destabilising factor from one scale to another.

Figure 2 shows the adaptive cycle for three scales. Crisis at a smaller scale may trigger collapses on a larger scale. For example, the Asian financial crisis started in 1997 when some Thai companies could not pay the interest on their debts, leading to a cascading fall-down of financial institutions. The more than 200 unfinished skyscrapers in Bangkok are still visible monuments of the fast rate and large scale of the crisis. On the other hand, disturbances can also be triggered by developments at a larger scale, as we see in the globalised world of today. The *Human Development*
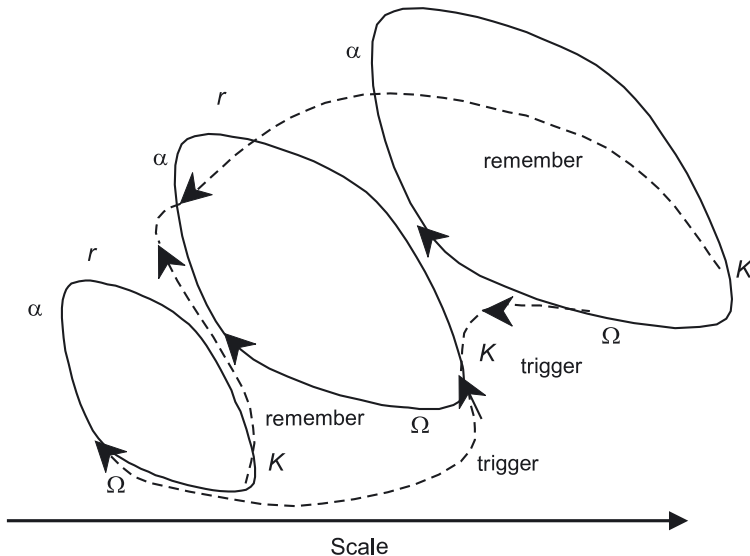

Figure 2. *The Adaptive Cycle at Three Scales*

Report (UNDP 2002), for example, stresses that while many national governments in developing countries have formally become democracies, they have not yet overcome major problems of political favouritism and corruption. Tragically, over 60 countries had lower mean per capita incomes in 2002 than they had in 1990 and more than 3.6 million lives have been lost in the same era due to civil wars. As Mark Malloch Brown of UNDP indicated in an interview with Barbara Crossette in the *New York Times* of 24 July 2002, 'The concern is that one multiparty election does not a democracy make.' He reflected that '[t]he international cheerleaders for democracy have underestimated what it takes to build a functioning, properly rooted democracy'.

Once a major disturbance occurs, memory from higher and lower scales may speed up and direct recovery. Memory is particularly important, since most complex adaptive systems are structured by at least three to five major interacting components that change at a fast, moderate or slow pace. Surprises and unpredictability are endemic in these systems. Responding to rapid change may become routinised, and may or may not improve the ability of a system to respond to moderately or slowly changing variables. Without effective memory at some level, however, responding to slow changes may involve experiencing a major disaster before an adequate set of responses is found anew. Thus, the importance of having relatively independent response capabilities and stored memories at multiple levels is one of the key lessons of recent research on multi-scale, human-ecological systems. Opening management systems to gain information and perspectives from multiple sources – in addition to scientific experts – is another important lesson (Gunderson and Holling 2002).

4. MULTI-SCALE ADAPTIVE PROCESSES IN THE HISTORY OF POLITICAL-ECONOMIC DEVELOPMENT

In an effort to understand how development may be enhanced by multi-level (or polycentric)[6] governance involving the capacity to initiate or veto action at multiple scales, we turn to two examples from Dutch history. The first is the role of waterboards in the historical development of the Netherlands. The second is the importance of smaller scale indigenous irrigation institutions in Bali and how "experts" working for both the Dutch and Indonesian governments during the past century misunderstood the operation of these institutions.

4.1 Dutch Water Management Through the Ages

A typical Dutch institution, namely the waterboards, serves to illustrate the evolution of successful multi-level governance.[7] Before 800 A.D. the inhabitants of the precursor of the Netherlands used non-structural measures to keep their feet dry. Such measures, like manmade hills or abandoning areas when there was danger of flooding, were the result of decisions made by individual households. Increased population pressure, technological know-how and finance led to the development of more structural water-control measures after 800 A.D. These measures, including dikes and sluices, required cooperation within a community to construct and maintain. Farmers

whose lands bordered directly on the dikes agreed to commit themselves to the construction work and to maintenance activities afterwards.

At almost the same time, drainage activities were developed as well. These made lowland areas habitable by getting rid of superfluous water. Small dams and sluices were built and maintained, based on agreements similar to those for the flood-protection systems. The noticeable difference with the inputs for dike maintenance was that from the beginning all beneficiaries had to pay for the benefits received from the drainage activities.

Originally, the local communities in the countryside were in charge of all general collective interests and took responsibility for water management. Around 1100 A.D., however, a new adaptation occurred when water management tasks gradually began to be separated from the general public tasks. The reason was probably increased occurrence and severity of flooding as well as a growing interdependence and complexity of the hydraulic works that began to stretch out beyond the local scale.

At the end of the eleventh century and the beginning of the twelfth century the first public bodies for local and regional water management appeared on the scene and the phenomenon of the waterboards was born. The purpose of these boards was to ensure safety from flooding through the construction and maintenance of dikes and dry feet through drainage by means of the necessary hydraulic structures. The establishment of the waterboards was recognised by the higher, regional authorities who still held themselves responsible for water management but resigned from their administrative water management duties.

Each of the waterboards differed in design and the way it implemented physical structures as well as rules. They were also confronted with different problems. They were not always successful in preventing floods or draining areas effectively. During the Republic of the United Provinces of the Netherlands there were severe floods, and extensive peat-digging caused unintended artificial lakes and other management problems. Still, the waterboards survived. Dolfing (2000) argued that the main reason for the waterboards' long-term adaptation and survival is the institutional arrangements. The rules for the waterboards were designed based on the shared norms and values of the population. Although the boards were not always successful in maintaining safety and dry feet, preserving the institutional arrangements that they were familiar with and could adapt was seen as more important than switching to new and unfamiliar institutional arrangements. Perhaps the roots of the shared norms in contemporary Dutch society go back to those people who found ways to make the land inhabitable by developing institutions based on reciprocity (see Toonen 1996).

The history of the waterboards shows a continuous tinkering with the rules at different scales. Disturbances like floods and the results of peat digging triggered new rules and structures. The Dutch waterboards illustrate how local-level governments can evolve into a resilient collaboration of multi-level governance when national institutions recognise the importance of smaller governance units and work with them rather than destroying them.

Does the Dutch tradition of water management help the country's engineers and officials to manage water elsewhere? An illustrative example where national officials for some time did not recognise the value of local institutions is the recent history of

rice production in Bali, a small island east of Java of the former Dutch colony Indonesia.

Bali's complex irrigation system has existed for more than a thousand years. Irrigators in Bali face a coordination problem. On the one hand, control of pests is most effective when all rice fields have the same planting schedule. On the other hand, the terraces are hydrologically interdependent, with long and fragile systems of weirs, tunnels, canals and aqueducts. To balance the need for coordinated fallow periods and use of water, a complex calendar system has developed which states what actions should be done on specific dates. These actions are related to offerings to temples: the small temples at the rice terrace level, the temples at the village and regional levels, up to the *Pura Ulun Swi*, the "Head of the Rice Terraces" temple of the high priest Jero Gde, the human representative of the Goddess of the Temple of Crater Lake. This crater lake feeds the groundwater system which is the main source of water for irrigation. These offerings were to reciprocate for the use of water that belonged to the gods.

Bali consisted of many kingdoms before its conquest by the Dutch around 1900. The Dutch saw these offerings in a different light, namely as a royal irrigation tax. The fact that during the nineteenth century there were a number of kingdoms in Bali was a sign to the Dutch that the institution of kingship had weakened over time, with one powerful kingdom disintegrating into a number of little kingdoms. The Dutch wanted to restore centralised government; in particular they wanted to use a revived royal irrigation tax to improve the irrigation system. The Dutch administrative reorganisation failed, partly due to lack of funding, but also, as a historical analysis conducted during the 1930s demonstrated, because there was no tradition of a centralised government from the past. After World War II, Indonesia became independent from the Netherlands, though the colonial bureaucratic systems were taken over by the new independent government.

During the late 1960s the Indonesian government made self-sufficiency in rice a major national development goal. In the same period the Green Revolution began in Asia, the spread of new rice-growing technologies that promised a dramatic increase in rice production. Bali was one of the first targets of the Green Revolution. In contrast to the earlier Dutch attempts to modernise rice production, this time the engineers were well-funded.

The function and power of the water temples were invisible to the planners involved in promoting the Green Revolution. They regarded agriculture as a purely technical process. Farmers were forced to switch to the "miracle" rice varieties, which would lead to three harvests a year instead of the two of the traditional varieties. Farmers were stimulated by government programmes that subsidised the use of fertilisers and pesticides. The farmers continued performing their rituals, but now they no longer coincided with the timing of rice farming activities. Soon after the introduction of the miracle rice, a plague of plant-hoppers caused huge damage to the rice crop. A new variety was introduced, but then a new pest plague hit the farmers. Furthermore, there were problems of water shortage.

During the 1980s an increasing number of farmers wanted to switch back to the old system, but the engineers interpreted this as religious conservatism and resistance to

change. Lansing quoted a frustrated American irrigation engineer, 'These people don't need a high priest, they need a hydrologist!' (Lansing 1991: 115). It was Lansing who unravelled the function of the water temples and was able to convince the financers of the Green Revolution project on Bali that irrigation was best coordinated at the level of the water temples. Lansing built a computer model of the artificial ecosystem and showed that for different levels of coordination, from the farmer level up to central control, the temple level was the scale at which decisions could best be made to maximise rice production (see also Lansing and Kremer 1994).

As this story suggests, the complex irrigation systems and the role of the temples have evolved over a long history of local adaptations, at different levels of scale. The water temples played a significant role in coordination of the use of water, but also in providing technical advice and mediating conflicts between different *subaks,* or local cooperative groups of farmers, on water use. The offering to the different temples made the farmers aware of the interconnections between the water flows at different levels. Due to Lansing's insight and analysis, some of these systems have evolved still further and avoided the fate of many self-organised systems of this kind when experts declared them defunct and constructed new infrastructures without paying much attention to local property rights, ecology, culture and tradition.

5. CONCLUSION: COPING WITH COMPLEXITY

The last half-century has witnessed scholars from a variety of disciplines adopting a belief system that Scott (1998) calls "high modernism". High modernists try to suppress complexity through the design of unitary governments that rely on the advice of experts to optimise progress towards a preferred social goal. In the developing world, the advice of experts has led to the suppression of indigenous institutions that evolved over centuries, leaving post-colonial governments as virtual monopolists of official power. Without facing independent and strong organisations in the public or economic sphere (except for multinational corporations which frequently bribed their way to autonomous operation), political leaders did what monopolists usually do – maximised their own short-term interests. While chunks of national coffers were transferred to private bank accounts, the majority of their own citizens have been left to live on less than two US dollars per day (UNDP 2002). With regard to the protection of natural resources, the approach has led to creation of parks on paper rather than real-life functioning biodiversity reserves (Brandon 1995). It has also produced major losses of ocean fisheries, increasing vulnerability to drought, and pest control efforts that have paradoxically resulted in chronic pest outbreaks (Holling et al. 2002).

It is time to declare this belief system bankrupt!

Fortunately, we do not need to start over. While proponents have extolled the virtues of high modernism, researchers in multiple disciplines have worked on a variety of approaches to the study of living complex orders. This chapter discussed the fruitful approach of viewing ecological systems as complex, multi-tiered, adaptive systems that vary in their capacity to be resilient in light of diverse temporal and spatial disturbances. A complementary approach is the study of polycentric systems (Toonen 1988). Ostrom's definition of a polycentric order is one 'where many elements are

capable of making mutual adjustments for ordering their relationships with one another within a general system of rules where each element acts with independence of other elements' (Ostrom 1999: 57).[8] Market systems, judicial systems, water management, irrigation systems and many natural resource systems that have evolved over long periods of time – like the irrigation systems of Bali – are polycentric or multi-level in structure.

Polycentric systems are in no way guaranteed to cope successfully with all of the problems of complex human and human-ecological systems. No system of governance is. Substantial research has, however, been conducted on the performance of governing units serving metropolitan areas within the United States. A consistent finding is that metropolitan areas characterised by large, medium and small public and private agencies with considerable autonomy but which also face incentives to seek out opportunities for complementary efforts tend to outperform metropolitan areas served by a few large-scale units (see McGinnis 1999a, 1999b, 2000 and literature cited therein). Frey (1994) and Pommerehne (1990) have undertaken extensive studies providing strong evidence of the performance of complex governance systems.

Ashby (1960) recognised long ago that to achieve any level of regulation in a system, one needs to design in as much variety in the response capabilities as exist in the relevant system. What we have learned is that the hot debates about opposites – small-scale versus large-scale, centralised versus decentralised, top-down versus bottom-up – lead nowhere. Resilient adaptive systems need attributes of all of the above. What we do need is careful empirical research that helps us to better understand how multi-level or polycentric governance systems work, how they adapt over time, what are the major threats to their continued resilience and how we can build even better resilient, learning, complex systems in the future.

NOTES

1. This chapter was prepared for delivery at the ISS Conference on 'Environmental Degradation, Institutions, and Conflict,' 8 and 9 October 2002. An earlier version was presented at the Annual Meeting of the American Political Science Association, Boston, Massachusetts, 29 August to 1 September 2002. The authors appreciate support from the National Science Foundation and the Resilience Alliance. We also appreciate the careful work of Sarah Kantner in preparing this manuscript and of Laura Wisen in helping run down elusive citations.

2. According to World Bank poverty data, the absolute number of individuals subsisting on less than US $1.00 per day has grown, but the percentage of the population living in poverty in developing countries has been slightly reduced since 1987 (World Bank 2000).

3. In examining the problem of aid dependence, Bräutigam (2000: 1) stressed, 'Large amounts of aid delivered over long periods, create incentives for governments and donors that have the potential to undermine good governance and the quality of state institutions.'

4. As reflected in a World Bank report, 'A 10 per cent bribe on the cost of a good public investment project depresses the project's rate of return only slightly. A bribe that saddles the country with a white elephant investment may result in economic costs far exceeding the corrupt payment, particularly if the policy environment causes a value-subtracting investment to appear nominally profitable' (World Bank 1997b: 57).

5. Ostrom (1989) stressed that this type of thinking was responsible for an "intellectual crisis" in the study of American public administration.

6. We are using the terms multi-level and polycentric as having similar meanings. Hooghe and Marks (2001) consider polycentric governance as one or two major forms of multi-level governance.

7. This brief history of the waterboards is mainly based on Dolfing (2000) and Kaijser (2002).

8. Another useful approach undertaken by legal anthropologists is that of legal pluralism. For a recent overview see Meinzen-Dick and Pradhan (2002).

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