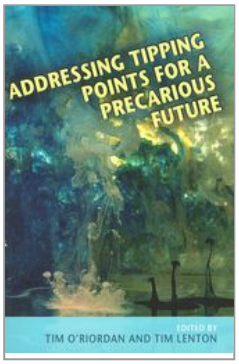


Addressing Tipping Points for a Precarious Future
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# Exploring Adaptive Governance for Managing Tipping Points

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## [−] Abstract and Keywords

Adaptive governance explains processes of reaction and social learning through leadership, experience, and experimentation. Much of this is set in frameworks of culture, power, social relations, social justice, and vulnerability. Adaptive governance stipulates cooperative management, collective action to help prepare society, business, markets, and civil organizations for the characteristics of tipping points: convulsive and unpredictable change and outcomes, and huge uncertainty over the effectiveness of initial responses. Resilience comes about when resources are released by sudden events, or by social value shifts, leading to overall transformation. Examples are offered from drought in Amazonia and the Sahel and urban flooding in Mumbai. Adaptivity is neither easy nor assured and always unpredictable. Local to global institutional fits are required but often wanting. Yet resilience can be found even in the most adverse circumstances, so we need to discover more about its character and adaptiveness.

*Keywords:* tipping points, resilience, adaptation, social learning, panarchy, institutional fit, Amazonian drought, Sahelian drought, Mumbai flooding

A tipping point – a process that starts off slowly and rapidly speeds up leading to cascading effects – was identified in the 1970s in the context of neighbourhood race relations and the spread of group behaviour through social networks. In more recent years the concept has gained traction in the frameworks of development planning, climate change, and ecological resilience. Resilience theory suggests that to anticipate better and avoid tipping points or thresholds in social-ecological systems will require adaptive governance. This is where adapting institutions, networks, and processes generate social learning about changes in social ecological systems. This chapter considers how governance in the context of tipping points differs from conventional forms of adaptation governance. While there are an increasing number of networks and partnerships underway, it appears that governance institutions are on the whole unable to integrate local-level adaptation solutions with large-scale ecological governance approaches.

In this companion piece to that by Joe Smith (7.1), I examine how adaptive institutional responses to climate shocks may act as proxies for institutional responses to tipping points. I offer a number of illustrative examples of how adapting institutions can offer positive coping mechanisms through learning feedbacks that avoid maladaptation following climate shocks. The illustrative examples presented are of systems that are in the phase of reorganization (the 'back loop' in the adaptive cycle). The idea is that a shock may result in a reorganization that maintains the system within the desired state, yet shifts thinking to new ways of governing and adapting to climate change. Examples of institutional reorganization following shocks are given from the Mumbai floods of 2005, dieback in Amazonia in 2005–10, and the Sahel drought in 2012. In the discussion, I **(p.259)** reflect on the weak linkages that exist between local-level adaptations and large-scale environmental change problem-framing, and current barriers to adaptive governance.

## The context

Environmental change is increasingly interpreted in terms of urgent, abrupt, and large-scale transformations, or tipping points. It is also conceived in the context of biophysical limits, as outlined by Tim Lenton in Chapter 2.1. Tipping points feature prominently in the literature addressing: climate change (Lenton *et al*. 2008; New *et al*. 2011); Amazonian forests (Nepstad *et al*. 2008; Nobre and De Simon Borma 2009, Mahli *et al*. 2009; Betts *et al*. 2008; and Toby Gardner (4.3)); and ecological resilience (Rockstrom *et al*. 2009). The idea of tipping points first originated with Tom Schelling (1971) who applied a dynamic model of segregation in the racial composition of neighbourhoods in the United States. Others have used the concept to model the spread of behaviour and innovation through social networks (e.g. Granovetter 1978; Gladwell, 2000; Watts 2002, 2003).

Where there is a tipping point, a threshold condition is overstepped and cascades into a runaway set of events. This could be a rapid U-turn in a policy, which is driven by protests expressing fundamental societal preferences. The Arab Spring – a wave of revolutionary protests across the Arab world which began in December 2010 – is an example of such a runaway process whereby critical masses in people lead to the rapid collapse of existing political regimes. Other chapters in this volume – Paul Ekins (6.2), Joe Smith (7.1) – and commentaries – Paul Brown (7.3) and Jonathan Sinclair-Wilson (7.5) – comment on the social interpretations of this urgency. In this chapter I examine what is new about coping with environmental tipping points by looking at the ways in which governments, businesses, and civil society are building strategies at all scales to respond, adapt, and transform as we enter the Anthropocene. It is the first time in human history that a complex array of global, national, and local institutions and networks are preparing with foresight to govern the Earth system for an uncertain future. The challenge for these institutions is that there is limited knowledge about what types of social, political, and economic enabling conditions need to be met to enable the successful handling of anticipated response strategies in a timely manner.

**(p.260)** One challenge to governance institutions involves accounting for biophysical threshold conditions, e.g. how a flood might trigger a change in institutional learning. History shows that society is not always successful in the ways that it manages change. Trade-offs, maladaptations, and externalities are all risks that result from taking action in one arena that may have unintended negative consequences elsewhere in space and/or time. For example, managing water supply in one part of a river basin may result in people downstream losing out on the benefits of improved water availability for their upstream neighbours. Another example in the global south is where trees and forests are protected to act as carbon sinks, resulting in the

social exclusion of entire communities, including women and the elderly who have limited access to natural resources under traditional land-tenure regimes. In the global north, an example would be building an eco-village on a floodplain, which is exposed to flood risk, and is insured currently but may not be in the future, as climate change alters the timing and ferocity of flooding. The introductory chapter (1.1) explains why such malfunctions in governance occur and may be becoming even more brittle.

## Adaptive governance

Adaptive governance theory explains change processes as being driven by feedbacks mediated through leadership, networks, and social learning (Folke *et al*. 2005; Boyd and Folke 2012). The overarching feature of adaptive governance is the 'adaptive' dimension of governance. In order to buffer change, resilience provides insights into the importance of diversity, modularity, and feedbacks in governing complexity in social-ecological systems. It is defined by Folke *et al*. (2005) as global in scale, in terms of the converging trends of rapid, interconnected global change (Duit *et al*. 2010), and in relation to how institutional responses and constraints interact between scales and levels (Termeer *et al*. 2010), and it is inherently a response to uncertainty and vulnerability of social and biophysical systems. These features make adaptive governance an interesting framework for considering how to manage tipping points. It is inherently about the function of networks (and shadow networks) as mechanisms of learning and building adaptive capacity. Adaptive governance stipulates co-management and collective actions across scales (interdependence). It is a way of thinking about preparing societies, businesses, and governments **(p.261)** for large-scale and fast onset change; thus it has a temporal dimension of great importance to managing tipping points.

### Resilience and panarchy theory

Resilience and 'coupled social ecological systems' thinking offers ideas for understanding the adaptive nature of change in institutions, organizations, and groups in the context of tipping points. Resilience may be introduced here as the ability of a system to absorb disturbance and reorganize while undergoing change, and without losing its identity, function, structure, and feedback. It can be considered as the way that communities respond to crises and progress their pathways of development (Folke *et al*. 2010). Olsson *et al*. (2008) drew on resilience theory to explain how the management of the Great Barrier Reef in Australia reached a tipping point, fuelled by a sense of urgency about the increased pressure from terrestrial runoff, overharvesting and global warming so that the reef, as a coupled social ecological system, was transformed into a sustainable and integrated management model. The transformation process included a shift in governance from a focus on chosen individual reefs to a broader stewardship of the large-scale reef system. In theory, the closer a system is to a tipping point, the lower its resilience and the smaller the shock needed to shift the regime. Resilience can also therefore be thought of as 'the capacity of a linked social-ecological system to absorb recurrent disturbances, such as hurricanes or floods, so as to retain essential structures, processes and feedbacks' (Adger *et al*. 2005).

Panarchy theory (see Chapter 1.1) explains that the basis for change lies in the adaptive cycle (Gunderson and Holling 2002). The adaptive cycle contains four phases:

- Rapid growth (r) – typically characterized by pioneer species, innovators or entrepreneurs;
- Conservation (K) – where resources are increasingly available and locked up in existing structures;

• Release (omega) – that is often triggered by a disturbance (e.g. fire, flood, disease) which exceeds the system's resilience;

• Reorganization and renewal (alpha) – where invention, experimentation and re-assortment are common.

The adaptive cycle has two ways of responding to change. The r and K phases operate together and are called the 'front loop', and the omega and **(p.262)** alpha phases are considered the 'back loop'. The front loop characterizes the development phase and it features things like the accumulation of capital, stability, conservation, and development. Empirical studies of complex adaptive systems often focus on the front loop, which are systems that are undergoing gradual change, such as forest conservation (but see Ashlin 2009). In contrast, this chapter considers systems that are in the phase of reorganization (the back loop) following a fast and abrupt change. The idea is that a shock may result in a reorganization that maintains the system within the desired state, yet shifts thinking to new ways of framing, adapting to, and governing, climate shocks (Ashlin 2009). Thus, given the fast and abrupt change generated in the adaptive cycle, new forms of governance are emerging, which navigate the barriers to sustainability via networks and multi-sector learning platforms (e.g. see Ashlin 2012).

### Adaptive governance and institutional fit

One emerging framework developed from the observation of several hundred cases of ecosystems management over the past twenty years is 'adaptive governance', which emphasizes complexity, rather than the steady-state equilibrium, as a pre-determinant of successful governance. The concept of adaptive governance focuses on the organizational and institutional flexibility for dealing with uncertainty and change (Dietz *et al*. 2003; Folke *et al*. 2005). Fundamental to this framework is a multi-scalar approach, which acknowledges and integrates the knowledge of a diversity of stakeholders to inform resource allocation decisions (Folke *et al*. 2005). Adaptive governance requires the formation of social networks, formal or informal, which create opportunities for collective action, engagement, and learning (Olsson *et al*. 2006). Adaptive processes within networks are then fostered by learning mechanisms, which generate and disseminate information (Folke *et al*. 2005; Olsson *et al*. 2006).

Adaptive governance is an 'ideal' form of environmental governance that consists of four principles: (1) explicit understanding of the system; (2) monitoring; (3) flexibility in management and administration through networks; and (4) strategies that prepare for 'surprise'. Adaptive governance requires adapting institutions:

> The capacity of people, from local groups and private actors, to the state, to international organisations, to deal with complexity, uncertainty and the interplay between gradual and rapid change.
>
> (Boyd and Folke 2012: 3)

**(p.263)** Adapting institutions are evident at the local level in self-organized institutions and networks, and leaders, in public institutions that are responding to uncertainty and complexity, and in multilevel, hybrid institutions that are coping with environmental crisis (Boyd and Folke 2012). The adaptation processes are normative in as far as principles of fairness and effectiveness are embedded in co-management regimes. In theory one could have an adaptive system that is not equitable but still capable of adjusting to surprise: however there is limited empirical work on this.

### The challenge of institutional fit

The challenge of institutional fit is the trade-off between robustness/ efficient approaches to existing problems and the flexibility and redundancy required to meet new challenges. In essence, organizations have developed responses for one problem set and are not readily adapted for other problems. This is the key to 'the challenge of the fit' (Folke *et al*. 2005). Olsson *et al*. (2006: 29) highlight the problem of fit in the example of the management of watersheds, which have specific area/system boundaries, but where the administrative boundaries and the area of the watershed do not correspond. The mismatch of boundaries could be across national borders or at the local county and municipal level. They suggest that it is often the case that the jurisdictional, administrative, and institutional responses are not well matched with the biophysical system boundaries, due to historical reasons of national security or ethnic specificity. This suggests a need for flexibility in governance structures (Dietz *et al*. 2003) to allow for ecosystem-based management and stewardship of multifunctional landscapes and seascapes (Folke *et a*l. 2005), while incorporating diverse features of governance that allow for ecosystem stewardship and relationships to multiple and cross-scale complex social-ecological interactions (Duit and Galaz 2008).

## From principles to practice of adaptive governance

The illustrative examples presented here are of systems that are in the phase of reorganization (the back loop). The idea is that a shock may result in a reorganization that maintains the system within the desired state, yet shifts thinking to new ways of governing and adapting to climate change.

### **(p.264)** Amazon dieback

Peter Cox and colleagues (Cox *et al*. 2000) were among the first scientists to make predictions about the collapse of Amazonian rainforest by 2050. They presented a scenario that climate change impacts on the region of Amazonia would risk climate-induced forest dieback converting large areas of tropical forests to savannah by the end of the twenty-first century. While many were sceptical at first, two consecutive droughts in 2005 and 2010 (discussed by Toby Gardner (4.3)) have caused scientists to ask questions about the potential irreversible damage of the combination of deforestation, changing precipitation patterns, fire, and rising global temperatures. Forecasting and monitoring of Amazonia has become more integral to detecting early warning signals since then. A report by the World Bank (Vergara and Scholz 2011) suggests that dieback in Amazonia – one of several major, non-linear, positive-feedback responses to global warming – has the potential to create major disruptions in global climate systems (see also Patricia Howard (4.2)). It also calls for governance of deforestation (despite a notable decrease since 2005). Deforestation is largely driven by cattle ranching, large-scale soybean cultivation, and commodity markets, opening up roads and access for small-scale farming settlements.

The experience of the 2005 Amazonian drought provides important lessons about the adaptive governance response capacity. Brazil experienced one of the worst droughts in thirty years, compounded by extensive forest fires. The cause appears to have been warmer global temperatures, which led to measurable increases in ocean surface temperatures in the Atlantic and, ultimately, lower rainfall across several regions of the country (Aragão *et al*. 2008). The drought impacted the northeast, as well as southwest and western Amazonia. A state of emergency was called, and the Brazilian government mobilized its army to provide water and medical supplies to isolated communities and contend with the intense forest fires in Brazil's western state of Acre. The resulting smoke pollution affected more than 400,000 people, and the

fire damaged more than 300,000 ha of rainforest; direct costs amounted to more than US $50 million (Brown *et al*. 2006). The true monetary and health costs could be far higher as the widespread damage caused to forest cover has made the area more susceptible to repeated burning.

What was particularly important about the 2005 Amazonian drought was the speed and magnitude of the events that unfolded. An important insight is that ecological systems do not respond to stress (such as high **(p.265)** temperatures or extreme weather events) in a linear or predictable manner. In fact, even small disturbances can bring about large and sometimes irreversible changes. In the case of forest dieback it is still debated whether a small change can bring about large-scale change. Nevertheless, the governance system that tackled the 2005 crisis was unconventional both in its rapid response and in the establishment of a situation room, extensive networks, and reliance on available information on the internet. One may wonder whether such a 'flexible' governance system can be institutionalized, strengthened, or replicated to cope with the future climate-related surprises.

Elsewhere I have explained that critical to the disaster response was the availability of the adaptive governance ingredients of early warning, effective actors, and rapid self-organizing action, with strong feedback data-gathering (Boyd 2008). This process included satellite imagery, hot-spot data and meteorological data, which first persuaded the Governor of Acre to act by prohibiting fires. Near-real-time data on hot-spot distributions, derived from MODIS (moderate resolution imaging spectro-radiometer) images and custom-designed analysis software, were voluntarily made available to state government officials by a team of NASA-supported scientists working on the large-scale biosphere– atmosphere experiment in Amazonia (http://lba.cptec.inpe.br/lba/site/). The Acre government in turn established a 'situation room' staffed by two civil defence coordinators, three state employees from INPE (the national space agency) and several researchers and students from the LBA-ECO team. Using both satellite imagery and on-the-ground information, the team provided daily briefings by email on the locations of fires to the local authorities and the Brazilian army, helping to coordinate and focus state and national efforts. Following the successful response to the crisis, access to the China Brazil Earth Resources Satellite (CBERS) second-generation satellite imagery is now granted to Brazilian institutions and more widely across South America. The CBERS has been successfully up-scaled by the provision of free-of-charge CBERS data (www.dgi.inpe.br/CDSR). CBERS has also launched a CBERS project for Africa (Epiphanio 2008). The Environmental Institute of Acre has also since established a permanent situation room that incorporates the use of multiple satellite sensors to monitor the extent of fire and drought conditions (Berkes and Seixas 2004).

The gravity of the drought in 2010 has led experts to renew their interest in Amazonia. For example, in 2011 the EU 7th Framework research programme and various national organizations funded a new €4.7 million **(p.266)** research project called AMAZALERT to establish a multilevel early warning system for the whole region. This project includes fourteen European and Latin American institutions under the leadership of Dr Bart Kruijt, of Wageningen University, and Dr Carlos Nobre, of the Brazilian National Space Research Institute (INPE). They plan to design a data-retrieval procedure to detect the signs of widespread forest degradation, and to enable early warning if irreversible forest loss appears plausible. The project will also assess the impacts and effectiveness of public policies and mechanisms to prevent further deforestation. Over three years, scientists and decision-makers will engage in dialogue to develop the models and to contribute to a blueprint for an early warning system. The project aims to provide tools for decision-makers on future management and monitoring of Amazonia

(Wageningen University and Research Centre 2011). What is unclear with the emergence of large-scale early warning systems is how local adaptation arrangements are factored into the system. If the governance of early warning is predominantly at global and national scales, is there a risk that important local sources of risk knowledge and collective memory will be overlooked? Taking a cue from Chapter 1.1, this response could lead to maladaptations by legitimizing a 'one size fits all' policy, such as Reduced Emissions from Deforestation and Forest Degradation (REDD), which does not account for complex and diverse ecosystems and may penalize activities that help to restore ecosystems (Hurteau 2008; cf. Ostrom 2010) and which could lead to potential implementation problems with negative impacts on local communities. In other words, 'solving problems through centralized controls and global blueprints tends to create its own vulnerabilities in the long term' (Boyd 2009: 3; cf. Ostrom 2010). If new mechanisms such as REDD are to work in practice they will also have to consider lessons on the barriers to local engagement (Hall 2012: 22).

### The Sahel drought

The Horn of Africa is currently experiencing one of the most severe droughts in 60 years. In addition to the 30-year trend of declining precipitation, there is evidence that variability in amount and timing of rainfall from year to year is increasing, which would further compound food insecurity in the region (UNEP 2011). An accompanying trend of higher temperatures – estimated to be equivalent to an additional 10 to 20 per cent reduction in rainfall in its impact on crops – has exacerbated the reduced **(p.267)** and increasingly variable rainfall. Air temperatures in the area have increased by over 1 ºC since the 1970s. As with rainfall, there is evidence that average annual temperatures have become more variable as well. During roughly the same time that these trends in temperature and rainfall have made rain-fed agriculture less secure, the combined population of Darfur and South Sudan has roughly tripled (UNEP 2011).

Research conducted by Sendzimir *et al*. (2011) on the 're-greening of the Sahel' illustrates an example of the solutions to the problems that are currently facing East Africa through adaptive institutions in the Niger region. They found in their study that a massive reforestation of 5 million hectares has taken place in the past 20 years in the Maradi and Zinder regions of Niger. They explain that these solutions emerged from interactions between multiple actors, institutions, and processes that were operating at different levels, times, and scales, and which contributed to this recovery in terms of biophysical, livelihoods, and governance challenges. The key finding of their study shows that 'reversing the direction of reinforcing feedbacks in existing processes' can break 'bad' patterns of interaction and poor management of natural resources. Bad practice began with the colonial structures that weakened rural governance structures and redirected the economy for export. This was followed by a period (1935 to 1970) when resources and institutions were centralized, and large-scale tree clearance for land use occurred. Conditions were exacerbated by the 1970s drought conditions, resulting in large-scale famine. A reversal of interactions started in the 1980s with a push from the international community for better management of natural resources and a political vacuum which emerged following the death of a highly respected political leader, President Kountché. A 'window of opportunity' opened up for local-level communities to take action at this time.

The adaptive response emerged through a co-evolution of local village committees with improved functional ties to regional and national organizations. Ties were built between institutions and across scales, thus breaking the 'pathological dominance from the national government' (Sendzimir *et al*. 2011: 12). The study shows that the assistance of international NGOs helped to establish direct linkages to national governments in ways that built new healthy

relations, thus breaking down old power relations that had been institutionalized by corrupt forest officers. New local organizations were supported and rebuilt by international projects and programmes. Similarly to the case of Amazonia, external funding and support played a role in creating the response capacity. Currently Niger is **(p.268)** resilient enough to sustain itself under normal conditions and withstand drought better than many other countries in the region, but it remains at risk from growing demographic pressures (doubling its population since 1920) (Sendzimir *et al*. 2011).

### Urban mega-cities flood risk

A key social ecological tipping point that is currently overlooked is the risk of urban exposure to climate change. The IPCC (2001) and more recently the IPCC (2012) Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) warn of climate risks to low-lying coastal cities like Mumbai, which are likely to face the brunt of sea-level rise and salt-water intrusion into underground aquifers. Moreover, some models indicate that the intensity of heavy rainfall events may increase, whilst the number of rainy days may decrease along India's coastal zones (Challinor *et al*. 2006). Mumbai-Pune, located on the west coast of Maharashtra, has the highest number of people (50 million) exposed to coastal flooding, with unprecedented growth and development of all the Asian mega-cities (Nicholls *et al*. 2008). Mumbai is occasionally hit by cyclones and by frequent periods of heavy rainfall. The main concern for Mumbai is that much of the vulnerable poor live in the low-lying parts of the city most at risk from flooding (Huq *et al*. 2007).

In 2005 the city of Mumbai experienced severe flooding across 100 $km^2$, resulting in the death of over a thousand people and significant damage to property. In the space of 24 hours the city received 95 cm of rainfall – a 'once in a 100 year' event. The event caught city residents unaware. Revi (2005) recalls that the majority of the city services were shut for five days, a first in the history of the city. The unprecedented rainfall affected both wealthy and poor Mumbaikars, with people trapped away from their homes, telephone landlines and mobile phone services cut, and city transport halted for up to 24 hours. The most affected area of the city was the densely populated area of the northwest, inhabited by a mixture of social groups. The main cause was inundation, which was brought about by the accumulation of heavy local rainfall and draining congestion; the drainage process was unable to match the rate of rainfall coupled with the high tide (Kelkar 2005).

Efforts to address climate change at the city level are largely driven by NGOs, activists, and university groups, and include urban 'greening', conservation area protection, and local pollution-prevention campaigns. **(p.269)** Some call for engagement of politicians and elites in helping to address climate change in urban planning (Revi 2008). De Sherbinin *et al*. (2007) suggest that because Mumbai's formal institutions are too many and too weak, hope for climate change adaptive action is most likely to come from strong civil society organizations, such as the national slum-dwellers federation, with support from the overseas diaspora. Yet, the Municipal Corporation of Mumbai plays an important bridging role in the city, and points out that it lacks funds to support city-level change to prepare for long-term climate change.

In the aftermath of the floods a variety of government-supported actions sprang up, indicating that some level of institutional learning had taken place. The response to the crisis was almost immediate, with NGOs and civil society joining forces to launch the Concerned Citizens' Commission (CCC) only three weeks after the event on 4 August 2005 (CCC 2005). The CCC acted as a bridging organization between local humanitarian organizations, families, and

individual slum-dwellers, which in turn acted collectively and cooperatively in response to the crisis, while the official response was less effective, despite the existence of city disaster risk management plans. Although the city's officials have come under scrutiny from the CCC for ineffective institutional responses, since 2005 officials from the Municipal Corporation of Mumbai have introduced thirty early warning rain gauges across the city that are able to monitor rainfall every 15 minutes and update every hour during heavy rainfall (Chatterjee 2010), and new satellite technology is anticipated to help monitor rainfall. A new project is underway, funded by the local authorities, which aims to tackle sewage and waterways, as well as map the city, using aerial photography. Local government funds have also been provided to support interdisciplinary scientific research at the India Institute of Technology into the impacts and solutions to flooding impacts in Mumbai.

Following the floods, a change in opinion among some of the elite, the decision-makers, and organizations that govern Mumbai has been observed, indicating a shift in perception about the risks of climate change. For example, a Climate Action Plan for Mumbai has been announced, financed by the state of Maharastra, which aims to examine projected climate change impacts on hydrology and water resources, agriculture, coastal areas, marine ecosystems, and livelihoods, including impacts on migration in Mumbai (Ghoge 2010). More recently, the city has been putting in place coastal defences to protect the city from breaches from the sea, based on a longer-term adaptation perspective. While these large-scale **(p.270)** infrastructural and engineering solutions are important for the citizens of Mumbai, the CCC also provided the government with recommendations for a broader multi-layered approach to adaptation and mitigation. Nevertheless, the Municipal Corporation of Mumbai has opted for a narrower technical and infrastructural development approach to flood risk and adaptation predominantly, which does not consider flood risk as one of unequal distribution of resources (Chatterjee 2010). Plans and strategies for Mumbai are similar to those developed for many other cities in that they tend to focus on large-scale technological solutions. To build long-term resilience and sustainability Mumbai will also need to think about issues of risk mitigation, risk sharing and risk redistribution and about how marginalization is linked to risk governance and vulnerability (Chatterjee 2010).

## Patterns and limits of adaptive governance

This chapter now draws on the resilience lens and the metaphor of the adaptive cycle of change to reflect on three examples of how institutions reorganize following rapid and sudden shocks. Sendzimir and colleagues (2011) lend three important insights to help us to think through what the examples show. First, crises can result in the formation of rapid communication and reactive policy responses that are single-issue explanations, often with narrow technical framings: these often lead to failure (as was the case in the management of the Sahel crises in the 1970s). Secondly there is no silver bullet: in the case of the Sahel, NGOs stepped in where the state was weak, and the lack of centralized control opened up an opportunity for local small-scale adaptations through agro-ecological experimentations to take shape. The platform and local networks were supported by outside (NGO) ideas, knowledge, and funds. Thirdly, what is most important is the reversibility of the reinforcing feedbacks in adjustment processes. For example, the incidence of farmer-led natural regeneration in the Sahel was a result of sufficient time passing for this type of innovation to become more familiar, backed by the appropriate knowledge and resources from international organizations.

The 2005 Mumbai floods are revealing because of the magnitude of coupled social-ecological risks facing urban areas. Mumbai shows how extreme poverty co-exists with environmental risk

in a resilient city where there is a burgeoning middle class and financial centre with property prices **(p.271)** equivalent to London, Paris, and New York. However, given that the whole cityscape of Mumbai persists on the poverty margins with little or no buffering capacity, it requires that the introduction of complex adaptation strategies be implemented through the leadership of the Municipal Corporation of Mumbai. In this regard, the public institution is providing adaptation arrangements, but there are problems over who should fund this provision, given that the benefits fall to individuals and private entities. Moreover, in India the risks of climate change are linked to its aversion to accept external interference in its adaptation strategies and policies. The events of 2005 illustrate that institutional responses in India can be reactive and self-organizing among civil society, but are limited due to the presence of too many uncoordinated government institutions. De Sherbinin *et al*. (2007) suggest that a more radical transformation is necessary which involves moving the low-lying old city of Mumbai to the suburbs. This introduces normative and ethical questions about whether this is a desirable strategy. This example shows that reorganization in the back loop of the adaptive cycle cannot be about structural and technological fixes alone, but also needs to incorporate reorganization of social and ethical considerations (Chatterjee 2010). Adaptive governance challenges in a highly human-dominated system like Mumbai encompass basic infra-structure impediments, as the city is historically located on a delta that is unable to absorb the multiple shocks induced by today's societal needs. What is certain, however, is that Mumbai's city officials and citizens will have to engage in changing urban planning practices and factor neigh-bourhood integration for adaptation into everyday life (Revi 2005).

In Amazonia, it is evident that the governance and management strategies have in the past fallen short of adequately protecting both people and ecosystems. To blame are both global economic demand for raw materials, minerals, and agricultural commodities and weak enforcement of policies at the national level. In Brazil, federal command and control structures have failed to deliver forest conservation (Fearnside 2005), and state-level administration has failed to enforce the law relating to forests and land-use change or to provide incentives to reduce deforestation (Chomitz *et al*. 2006). More recently, scientists have shown that establishing and implementing protected areas in zones under a high level of current or future anthropogenic threat in Amazonia offers high payoffs in reducing carbon emissions and as a result should receive special attention in planning investment priorities for regional conservation (Soares-Filho *et al*. 2010). It seems that Brazilian environmental policy has created a **(p.272)** sustainable core of protected areas in the Amazon that buffers against potential climate-tipping points and protects the drier ecosystems of the basin (Walker *et al*. 2009).

As in the case of the Sahel, it is perhaps a window of opportunity that international scientific institutions and funding are stepping up to the plate. While the 2005 drought response illustrated a particularly important role for the state, future integration of international funds and national/regional organizations in adaptation measures is likely to occur. Any attempt to manage Amazonia will require a suite of approaches and mechanisms, such as local innovations and scientific research, coupled with national regulation and markets. National institutions will need to provide better extension support, agricultural implements and technology to farmers, regulate medium and large agribusinesses, and prioritize those areas most threatened and vulnerable in the 'crescent of deforestation' covering the regions south and east (see also Toby Gardner (4.3)).

## Limits to adaptive governance

Some say that historical reflections are a limited guide to the future. Davis (2004) gives the example of urban areas, which he points out are 'evolving with "extraordinary" speed and in directions that are unpredictable'. He explains that in this rapid process the accumulation of poverty undermines security and poses vast challenges to the survival mechanisms of the poor. While it is not necessarily appropriate to rely on past understandings to predict climate futures, it is also not possible to predict the future with certainty. We can use existing metaphors to think about the possible outcomes. The adaptive cycle and tipping points as metaphors help to illustrate, in the case of climate-related shocks, how institutions and social systems respond to rapid and shock events. The limitations lie in the need to draw on historical references of 'what happened' in the period of 'creative destruction' in the adaptive cycle. Moreover, the practical application to what this means for buffering future events to save lives needs further thought. The adaptive cycle specifically is a useful metaphor as it allows us to think about ways in which societies reorganize and respond to uncertainty. As these cases show, there are old and new cross-sectoral climate partnerships and networks that mobilize across scales. Nevertheless, while examples are informative to begin our discussions, our collective understanding of how to reorganize on a global scale remains a much greater challenge.

**(p.273)** References

Bibliography references:

Adger, W.N., Hughes, T.P., Folke, C., Carpenter, S.R., and Rockström, J. (2005), 'Social-Ecological Resilience to Coastal Disasters', *Science*, 309 (5737): 1036–39.

Aragão, L.E.O.C., Malhi, Y., Barbier, N., Lima, A., Shimabukuro, Y., Anderson, L., and Saatchi, S. (2008), 'Interactions Between Rainfall, Deforestation and Fires During Recent Years in the Brazilian Amazonia', *Philosophical Transactions of the Royal Society B, Biological Sciences*, 363 (1498): 1779–85.

Ashlin, A. (2009), 'Biodiversity and Natural Disasters: Opportunities for Change in Post-Tsunami Sri Lanka' (unpublished D.Phil. thesis, University of Oxford).

Ashlin, A. (2012), 'Adaptive Governance and Natural Hazards: The 2004 Indian Ocean Tsunami and the Governance of Coastal Ecosystems in Sri Lanka', in E. Boyd and C. Folke (eds), *Adapting Institutions: Governance, Complexity and Social-Ecological Resilience* (Cambridge: Cambridge University Press), 216–39.

Berkes, F. and Seixas, C.S. (2004), 'Lessons from Community Self-Organization and Cross-Scale Linkages in Four Equator Initiative Projects' (Winnipeg: Centre for Community-Based Resource Management Natural Resources Institute, University of Manitoba).

Betts, R.A., Malhi, Y., and Roberts, J.T. (2008), 'The Future of the Amazon: New Perspectives from Climate, Ecosystem and Social Sciences', *Philosophical Transactions of the Royal Society B, Biological Sciences*, 363 (1498): 1729–35.

Boyd, E. (2008), 'Navigating Amazonia under Uncertainty: Past, Present and Future Environmental Governance', *Philosophical Transactions of the Royal Society B, Biological Sciences*, 363 (1498): 1911–16.

Boyd, E. (2009), 'Governing the Clean Development Mechanism: Global Rhetoric Versus Local Realities in Carbon Sequestration Projects', *Environment and Planning A*, 41 (10): 2380–95.

Boyd, E. and Folke, C. (eds) (2012), *Adapting Institutions: Governance, Complexity and Social-Ecological Resilience* (Cambridge: Cambridge University Press).

Brown, I.F., Schroeder, W., Setzer, A., De Los Rios Maldonado, M., Pantoja, N., Duarte, A., and Marengo, J. (2006), 'Monitoring Fires in Southwestern Amazonia Rain Forests', *Eos, Transactions, American Geophysical Union*, 87 (26).

CCC (2005), 'Mumbai Marooned: An Enquiry into the Mumbai Floods' (Mumbai: Conservation Action Trust).

Challinor, A., Slingo, J., Turner, A., and Wheeler, T. (2006), 'Indian Monsoon: Contribution to the Stern Review', http://www.hm-treasury.gov.uk/d/Challinor_et_al.pdf (accessed 8 June 2012).

Chatterjee, M.L. (2010), 'Resilient Flood Loss Response Systems for Vulnerable Populations in Mumbai: A Neglected Alternative' (unpublished D.Phil. thesis, Rutgers University).

Chomitz, K.M., Buys, P., de Luca, G., Thomas, T.S., and Wertz-Kanounnikoff, S. (2006), 'At Loggerheads? Agricultural Expansion, Poverty Reduction, and Environment in the Tropical Forests' (Washington DC: World Bank). **(p.274)**

Cox, P.M., Betts, R.A., Jones, C.D., Spall, S.A., and Totterdell, I.J. (2000), 'Acceleration of Global Warming Due to Carbon-Cycle Feedbacks in a Coupled Climate Model', *Nature*, 408: 184–87.

Davis, M. (2004), 'Planet of Slums: Urban Involution and the Informal Proletariat', *New Left Review*, 26: 5–30.

de Sherbinin, A., Schiller, A., and Pulsipher, A. (2007), 'The Vulnerability of Global Cities to Climate Hazards', *Environment and Urbanization*, 19 (1): 39–64.

Dietz, T., Ostrom, E., and Stern, P.C. (2003), 'The Struggle to Govern the Commons', *Science*, 302 (5652): 1907–12.

Duit, A. and Galaz, V. (2008), 'Governance and Complexity – Emerging Issues for Governance Theory', *Governance*, 21 (3): 311–35.

Duit, A., Galaz, V., Eckerberg, K., and Ebbesson, J. (2010), 'Governance, Complexity, and Resilience', *Global Environmental Change*, 20 (3): 363–68.

Epiphanio, J.C.N. (2008), 'CBERS: Remote Sensing Cooperation between Brazil and China', *Imaging Notes*, 23: 16–19.

Fearnside, P.M. (2005), 'Deforestation in Brazilian Amazonia: History, Rates, and Consequences', *Conservation Biology*, 19 (3): 680–88.

Folke, C., Hahn, T., Olsson, P., and Norberg, J. (2005), 'Adaptive Governance of Social-Ecological Systems', *Annual Review of Environment and Resources*, 30: 441–73.

Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T., and Rockström, J. (2010), 'Resilience Thinking: Integrating Resilience, Adaptability and Transformability', *Ecology and Society*, 15 (4): 20.

Ghoge, K. (2010), 'Climate Change Action Plan for Mumbai in Two Years', *Hindustan Times*, 1 April.

Gladwell, M. (2000), *The Tipping Point: How Little Things Can Make a Big Difference* (New York: Little Brown).

Granovetter, M. (1978), 'Threshold Models of Collective Behavior', *American Journal of Sociology*, 83 (6): 1420–43.

Gunderson, L.H. and Holling, C.S. (eds) (2002), *Panarchy: Understanding Transformations in Human and Natural Systems* (New York: Island Press), 493.

Hall, A. (2012), *Forests and Climate Change: The Social Dimensions of REDD in Latin America* (Cheltenham: Edward Elgar Press).

Huq, S., Kovats, S., Reid, H., and Satterthwaite, D. (2007), 'Editorial: Reducing Risks to Cities from Disasters and Climate Change', *Environment and Urbanization*, 19 (1): 3–15.

Hurteau, M.D., Koch, G.W., and Hungate, B.A. (2008), 'Carbon Protection and Fire Risk Reduction: Toward a Full Accounting of Forest Carbon Offsets', *Frontiers in Ecology and the Environment*, 6 (9): 493–98.

IPCC (2001), *Climate Change 2001: Impacts, Adaptation and Vulnerability* (Cambridge: Cambridge University Press).

IPCC (2012), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*, ed. C.B. Field *et al*. (Cambridge: Cambridge University Press). **(p.275)**

Kelkar, R.R. (2005), 'Understanding the Extreme Weather Events', *IWRS News Letter November 2005*, http://rrkelkar.files.wordpress.com/2007/08/kelkar-understanding-extreme-weather-events.pdf (accessed 21 June 2012).

Lenton, T.M., Held, H., Kriegler, E., Hall, J., Lucht, W., Rahmstorf, S., and Schellnhuber, H.J. (2008), 'Tipping Elements in the Earth's Climate System', *Proceedings of the National Academy of Sciences USA*, 105 (6): 1786–93.

Malhi, Y., Aragao, L.E.O.C., Galbraith, D., Huntingford, C., Fisher, R., Zelazowski, P., *et al*. (2009), 'Exploring the Likelihood and Mechanism of a Climate-Change-Induced Dieback of the Amazon Rainforest', *Proceedings of the National Academy of Sciences USA*, 106: 20610–15.

Nepstad, D.C., Stickler, C.M., Filho, B.S., and Merry, F. (2008), 'Interactions among Amazon Land Use, Forests and Climate: Prospects for a Near-Term Forest Tipping Point', *Philosophical Transactions of the Royal Society B, Biological Sciences*, 363 (1498): 1737–46.

New, M., Liverman, D., Schroder, H., and Anderson, K. (2011), 'Four Degrees and Beyond: The Potential for a Global Temperature Increase of Four Degrees and its Implications', *Philosophical*

*Transactions of the Royal Society A, Mathematical, Physical and Engineering Sciences*, 369 (1934): 6–19.

Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., *et al*. (2008), 'Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes Exposure Estimates' (OECD Environment Working Papers No. 1 ENV/WKP (2007)1).

Nobre, C.A. and Borma, L.D.S. (2009), '"Tipping Points" for the Amazon Forest', *Current Opinion in Environmental Sustainability*, 1 (1): 28–36.

Olsson, P., Gunderson, L.H., Carpenter, S.R., Ryan, P., Lebel, L., Folke, C., and Holling, C.S. (2006), 'Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems', *Ecology and Society*, 11 (1): 18.

Olsson, P., Folke, C., and Hughes, T.P. (2008), 'Navigating the Transition to Ecosystem-Based Management of the Great Barrier Reef, Australia', *Proceedings of the National Academy of Sciences*, 105 (28): 9489–94.

Ostrom, E. (2010), 'A Polycentric Approach for Coping with Climate Change', *Policy Research Working Paper* (Washington DC: World Bank).

Revi, A. (2005), 'Lessons from the Deluge: Priorities for Multi-Hazard Risk Mitigation', *Economic and Political Weekly*, 40 (36): 3911–16.

Revi, A. (2008), 'Climate Change Risk: An Adaptation and Mitigation Agenda for Indian Cities', *Environment and Urbanization*, 20 (1): 207–29.

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E.F., *et al*. (2009), 'A Safe Operating Space for Humanity', *Nature*, 461 (7263): 472–75.

Schelling, T. (1971), 'Dynamic Models of Segregation', *Journal of Mathematical Sociology*, 1: 141–86.

Sendzimir, J., Reij, C.P., and Magnuszewski, P. (2011), 'Rebuilding Resilience in the Sahel: Regreening in the Maradi and Zinder Regions of Niger', *Ecology and Society*, 16 (3): 1. **(p.276)**

Soares-Filho, B., Moutinho, P., Nepstad, D., Anderson, A., Rodrigues, H., Garcia, R., *et al*. (2010), 'Role of Brazilian Amazon Protected Areas in Climate Change Mitigation', *Proceedings of the National Academy of Sciences*, 107 (24): 10821–26.

Termeer, C.J.A.M., Dewulf, A., and van Lieshout, M. (2010), 'Disentangling Scale Approaches in Governance Research: Comparing Monocentric, Multilevel, and Adaptive Governance', *Ecology and Society*, 15 (4): 29.

UNEP (2011), 'Food Security in the Horn of Africa: The Implications of a Drier, Hotter and More Crowded Future', *Global Environmental Alert Service* (Nairobi: UNEP).

Vergara, W. and Scholz, S.M. (eds) (2011), 'Assessment of the Risk of Amazon Dieback' (New York: World Bank, Latin America and Caribbean Region).

Wageningen University and Research Centre (2011), ‘New EU-South America Research on Amazon Dieback, Climate and Deforestation Starts in October’, *ScienceDaily*, 26 September, http://www.sciencedaily.com/releases/2011/09/110926081904.htm (accessed 25 February 2013).

Walker, R., Moore, N.J., Arima, E., Perz, S., Simmons, C., Caldas, M., Vergara, D., and Bohrer, C. (2009), ‘Protecting the Amazon with Protected Areas’, *Proceedings of the National Academy of Sciences*, 106 (26): 10582–86.

Watts, D. (2002), ‘A Simple Model of Global Cascades on Random Networks’, *Proceedings of the National Academy of Sciences*, 99 (9): 5766–71.

Watts, D. (2003), *Six Degrees: The Science of a Connected Age* (New York: Norton).