Lessons Learned for Adaptation to Climate Change

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All disasters have certain features that can be compared: The event itself, the immediate response of the community and government and the long-term response that is aimed at reducing the impact of any future similar events. The previous chapters have provided accounts of eighteen very different extreme events (summarised in Table 24.1). All, with the exception of the tsunami in south-east Asia (Hettiarachchi and Dias, Chapter 16), are directly tied to climate and weather extremes. Each presents its own unique challenges – dependant on the nature of the extreme event, how it unfolded (timing and location) and the existing vulnerability and adaptive capacity of the affected communities. Yet across the case studies, there emerge a number of common and recurring themes: First, there is a certain amount of luck or chance that determines the severity of an event (e.g. the timing or location of landfall of a cyclone determines if it is a human catastrophe or not); second, community awareness of risk plays a role (e.g. understanding that you live in a flood plain and the implications for your safety); third, communication channels play a vital role in successful management of disasters, but the infrastructure and technologies may be vulnerable; and, finally, the time factor – time can be a blessing (e.g. time to develop post-disaster adaptation) or a curse (e.g. time can erode corporate and community knowledge of risks).

In this chapter, we consider the commonalities and points of difference among the case studies in order to think about what lessons may be identified from disaster management and response to enhance our understanding of climate change adaptation.

24.1 The Events (and Before)

The scale of impact of an extreme event relates not only to its type and severity but also to its geographical location and spread, timing and location. In terms of the human impact, the existing vulnerability and preparedness of the affected community are also factors.

Table 24.1. *Summary of the extreme event case studies presented in this book*

Event	Deaths & injuries	Economic cost	Key impact	Historical context	Worsening factors	Saving grace
Hurricane Katrina (New Orleans, 2005)	1,464	Approx. US\$40 billion	Flooding; breakdown of social structure	Hurricane Betsy 1965	Incomplete levee system around New Orleans	'Doomsday scenario' avoided: overtopping or breach of Pontchartrain levees could have worsened flooding; weakening of hurricane before landfall
Flooding of the Mississippi River (central United States; 1812–2005)	246 (in 1927); 385 (1937); 32 (1993)	Hundreds of millions	Flooding	Regular floods	Increasing urbanisation; levees constricting water flow	None
Wildfire in North America (southern California, 2003 and 2007)	24 (2003); 7 (2007)	US\$3 billion	Property destruction, loss of forests	Nine mega fires since 1889 500 homes per year lost to fire	Exponential population growth and vulnerability of settlement lessons	Effective evacuation
Heatwaves in Kansas (US, 1980)	236 (excess deaths)	Unknown	Health, morbidity and mortality	Yes – not specified	Vulnerable community members	Development and refinement of Extreme Heat Programs
Drought in the Murray-Darling Basin (Australia)	Unknown	Unknown	Lost agricultural productivity	1895–1902 – Federation; 1937–1945 – WWII; 1997–2008 – Big Dry	Market forces; water policy	Changing policy

(cont.)

Table 24.1 (cont.)

Event	Deaths & injuries	Economic cost	Key impact	Historical context	Worsening factors	Saving grace
Victorian bushfires (Australia, 2009)	173	AU\$4.4 billion (Teague et al., 2010)	Burning of houses and forested regions	1983 – Ash Wednesday; 1939 – Black Friday	Heatwave, drought, low fuel moisture, extremely low relative humidity, very strong northerly winds (forest fire danger index highest ever record – 170) Land use planning, emergency services preparedness	Effective evacuation in some areas
Cyclone Tracy (Darwin, Australia, 1974)	71 deaths; 650 injured	AU\$500–600 million (1974)	94% of housing no longer habitable; 75% of population evacuated	1897, 1937	Slow translational speed of cyclone, landfall on township	Did not coincide with high tide, which would have created flooding
Queensland floods (Mackay and Charleville, 2008)	No deaths	>AU\$400 million	Property and infrastructure damage	Charleville – 10 floods since 1910; Mackay floods recorded since 1884	Flash flood in Mackay	Charleville – community awareness Mackay – good emergency management support
Windstorm (Europe)	Not stated	Not stated	Property and infrastructure damage	Frequent events	Large geographic scale	Building regulations
Floods in Central Europe (Czech Republic, Poland and Germany, 1997, 2002 & 2010)	114 (1997)	€6.5 billion (1997); €15 billion (2002); US\$3 billion (2010)	Flooding and inundation	Long history since 1342	Land use, changing demography and increased development; dike failure	Advance warning in Germany

North Sea tidal surge (Netherlands, 1953)	1,835 deaths, 1,916 injured	€0.7 billion (1953)	Flooding and inundation	Below sea level	Dike failure (inadequate maintenance; diffuse governance – many different small water boards were responsible for maintenance)	Further large dike on the brink of failure and saved by a ship plugging a breach
Sahel drought (North Africa, 1972–74 and mid 1980s)	Unknown	Unknown	Famine, loss of agricultural productivity, reduced growing season	Abrupt change in rainfall from 1960s	Government failure to act	In the 1980s, improved preparation by farmers and government
Indian Ocean tsunami (Sri Lanka, 2004)	Approx. 40,000	US\$1 billion	Flooding, inundation, property damage, loss of life	1883 Tsunami relatively small, little damage	Flooding and inundation, building collapse. Population density, economic development and transport infrastructure concentrated along the coast. Topography and gaps in coral reef created by illegal mining. No capacity for warning.	None

(cont.)

Table 24.1 (cont.)

Event	Deaths & injuries	Economic cost	Key impact	Historical context	Worsening factors	Saving grace
Cyclone Sidr (Bangladesh, 2007)	3,406 deaths, 55,000 injuries	US\$1.7 billion	Property damage, loss of life, loss of agriculture, loss of employment and income	One of 10 most devastating cyclones to hit Bangladesh between 1876 and 2007	Loss of shelter extremely high. Poverty.	Some evacuation
Hurricanes in Mexico and Guatemala (Mesoamerica)	Approx. 500	US\$1.7 billion	Crop damage, loss of transport and infrastructure, loss of income	Mitch 1998, Stan 2005, Agatha 2010	Poverty, terrain	Community-based adaptation
Floods in the Nile Basin (Africa, 1997/1998)	Not stated	Not stated	Loss of crops and livestock, destruction of homes	1878, 1947, 1961, 1988, 1997, 1998, 2006, 2007 and 2010	Increased population since previous event	Community-based leadership, adaptation and diversification of income
Floods in China (1998, 2010)	5,500 (1998), 3,200 (2010)	US\$30.7 billion (1998), US\$51 billion (2010)	Flooding, inundation, loss of lives	1860, 1870, 1931, 1935, 1954, 1998	Development and urbanisation	Development of flood protection mechanisms

Across the case studies considered here, some by their nature have a widespread immediate geographical impact (e.g. flooding of the Mississippi River, heatwaves in the US and Europe and drought in Australia), while others are restricted in their impact area but with equally devastating results (e.g. cyclone Tracy in far north Australia and hurricane Katrina in the US). The timing of events can influence their impact and the actions of community members. For example, in hurricane Katrina, the call for evacuation occurred shortly before payday, and this has been cited as a reason many poorer members of the community were unable to evacuate (Garcia, Chapter 3). In the case of cyclone Tracy, the landfall early on Christmas morning meant many people were safe in their houses or away from the city for the holidays, potentially reducing the death and injury rate (Mason et al., Chapter 9). It also meant, however, that many officials were on leave, reducing the response capacity of local and regional government.

All case studies demonstrate that a community's response to and experience of an event are tied very strongly to its characteristics – demographics, economic wealth, social condition and political influence (see Huq and Ayers, Chapter 24, for further discussion of this point). Some argue that prior experience of an extreme event enhances resilience, whereas others contend that it can lead to over-confidence: Dealing with a bushfire in your 20s can be very different from coping 30 to 40 years later. Response and experience are also linked to the availability of early warning systems and whether action strategies have been developed and practiced.

Warnings are often critical in reducing the impact of extreme events. Effective capacity to warn and communicate risk often depends on community awareness that systems exist, knowledge of how to access them and the sophistication of detection and prediction systems. However, the warning in itself is insufficient – the community must also take heed and respond. In the case of hurricane Katrina, clear and accurate predictions of the storm's landfall and impact did not prevent a catastrophic human disaster (Garcia, Chapter 3). Some sectors of the community did not have the capacity to respond to the warning (e.g. the poor and disenfranchised), while the emergency management response was poorly coordinated and largely inadequate. In the case of cyclone Tracy, prior to the event, a number of false-alarm cyclone warnings appeared to dilute the community perception of risk and therefore response (Mason et al., Chapter 9). Following the horrific and catastrophic outcome of the Black Saturday wildfires in Victoria, a community alert program and warning system was adopted to prevent a reoccurrence. Yet when the warnings were activated under severe fire weather conditions, many residents did not respond (Whittaker et al., Chapter 8). Here, the perception was that the risk was insufficient to merit action, with the 'believability' of the warning linked to a need to see or smell fire. In fact, in the circumstances of this type of fire, being able to see or smell fire means it is too late to evacuate.

Even adequate warning systems and a responsive community may be overwhelmed by unprecedented conditions, leading to catastrophic disaster (e.g. Black Saturday

bushfires, Australia, Chapter 8). Governments/authorities may fail to recognise a disaster unfolding, and this can be a problem both with slow-creeping events (e.g. drought) and very rapid-onset events (e.g. flash flooding, bushfire). This highlights the need to select the right indicators or triggers for warning, which, in the case of bushfires, is the type of weather conditions. Emergency management and community response need to be designed to work within the effective time frames of forecasting. Among case studies of developed nations, there appears to be a tacit reliance by communities on personal warnings – almost an expectation that someone will knock on my door if I need to evacuate.

In almost all the case studies documented here, there had been experience of historically analogous events (similar type and scale; Table 24.1), and in some cases actions to mitigate future impacts of similar events had been undertaken. In some instances, these prior 'adaptation' actions were very successful and this was clear in the outcome. For example, ongoing adjustment to heatwave events in Kansas City is continually improving the response (Mills and Snook, Chapter 6). In other cases, they were not. Despite the increasing channelisation of the Mississippi River, through increasing the height and extent of levees, these levees continue to be overtopped or breached in flood events (Kusky, Chapter 4).

24.2 Vulnerability and Resilience

Case studies of natural hazards and of community exposure demonstrate the role of vulnerability in understanding the impacts of extreme events and, in turn, in climate change adaptation planning. High vulnerability is clearly demonstrated in many of the eighteen case studies presented here, and for a variety of reasons ranging from geographical location through to population age structure. From these we can identify three broad categories of vulnerability related to socio-economic characteristics of a community, awareness and planning and preparation.

Socio-economic status of a community is often considered a key indicator of vulnerability. Certainly among the case studies, poor and disenfranchised members of a society or poorer nations in general experience high loss of life, housing and subsistence as natural hazard impacts. This is not, however, a simple developed versus developing nation division; even in the richest society, there are poorer members and areas, and poverty was a key factor in the impact of hurricane Katrina (Garcia, Chapter 3). Other socio-economic factors include political change. So, for example, in Poland a new political regime preceded the 1997 flood, and the transition of legislative structures meant that the systems in place for issuing warnings were inappropriate and cumbersome (Kundzewicz, Chapter 13).

Vulnerability will be extremely high where awareness of the risk of a particular event is low or absent, particularly among community and emergency management authorities. In the case of the 2004 Indian Ocean tsunami, while there may have

been some scientific understanding of the risk, the limited history and absence of experience of such events meant that, despite a warning period, the response was limited (Hettiarachchi and Dias, Chapter 16). In the case of cyclone Tracy, building standards were not regulated for the domestic market and houses were built to meet day-to-day conditions rather than extreme events (Mason et al., Chapter 9).

In all of the case studies described in this book, weather or environmental conditions are central in shaping the experience of the hazard. But in most cases, human factors or activities act to increase or decrease risk (see Table 24.1 for 'worsening factors' and 'saving grace'). This is vulnerability, for example, the increasing risk of flooding in the Mississippi, US (Kusky, Chapter 4), Australia (King et al., Chapter 10), Europe (Kundzewicz, Chapter 13) and China (Kundzewicz et al., Chapter 20) and relates, at least in part, to increasing development. The geographical risk of floods always existed, but development, groundwater extraction and channel straightening changes to run-off pathways all change the flood risk. If the response is to build hard engineering structures such as levees, this may increase the risk, at least downstream of the flood protection. Softer solutions, for example, maintaining wetlands into which flood water can be pumped, may be more effective.

24.3 Adaptation Actions Following the Event

All the case studies described here demonstrate some level of adaptation following the event – even if these responses might be classified as 'maladaptations'. They are of two types: Immediate actions (e.g. heat warning systems, heat-stress prevention plans) and long-term change (e.g. changes and building regulations, building or retrofitting resilient infrastructure, changes to land use zoning).

Immediate Responses

In both the Black Saturday bushfire (Whittaker et al., Chapter 8) and Kansas heatwave (Mills and Snook, Chapter 6), the need for proactive emergency responses through assisted evacuation (bushfires) and intervention or physical assistance for vulnerable community members (heatwave) was identified. These adaptations recognise that community education is sometimes insufficient to evoke an appropriate community response in the face of the emergency and those people with the highest vulnerability may be unable to undertake the necessary action themselves and should be identified for physical assistance once an alert is issued.

In Sri Lanka, following the devastation of the tsunami, an all-hazards approach has been adopted as part of extreme event planning (Hettiarachchi and Dias, Chapter 16). This acknowledges that it may be difficult or even impossible to anticipate the scale of the risk of an extreme event, so that implementing a more flexible approach increases the preparedness for and resilience to the unknowns.

Long-Term Responses

Long-term responses to natural disasters may worsen existing or create new vulnerabilities, maintain the status quo or reduce the risk from future events. Following cyclones Sidr and Tracy, active policies to 'build back better' were adopted by the governing bodies. In the case of cyclone Tracy, this required an allowance of time to firstly assess the cause of building failure and then develop new building standards designed to withstand future cyclones (Mason et al., Chapter 9). The capacity for long-term recovery, however, may be stalled by pre-existing challenges. This is the case in Bangladesh, where transport and communication failures are hampering the recovery process (Paul and Rahman, Chapter 17). The experience of cyclone Tracy also highlighted that response actions can have their own risks, with the long-term evacuation necessitated by the slow start to rebuilding creating social and psychological problems and resettlement issues.

In the aftermath of a disaster, it is not uncommon for a government to undertake a process of formal or informal enquiry to determine the successes and failures of preparation and response at both government and community levels, the adequacy of forecasts and early warning systems and future actions that might reduce the damage and loss of life in future events. Examples of formal instruments include the Royal Commission following the Black Saturday fires in Australia (Whittaker et al., Chapter 8) and the Deltaworks report following the North Sea storm surge in the Netherlands (Vellinga and Aerts, Chapter 14). These are often important political instruments and facilitate the implementation of large-scale and expensive adaptations that may otherwise be politically unpalatable.

Determining the success of long-term recovery responses requires a method of evaluation. Time and repeat events are the most reliable tests of planned adaptation. In Kansas, efforts to improve the responses to severe heat events have meant an overhaul of the management by the local authorities (Mills and Snook, Chapter 6). In this case, incremental learning and testing of policies and adaptation responses in subsequent events (with a moderate frequency of reoccurrence) have been possible. A planning exercise was able to identify existing systems that could be modified or incorporated into heatwave response planning to quickly improve the response without the need for fundamental change or great expectations.

Although many of the long-term responses to disasters are engineering and planning solutions, some focus on changes to community and social structures. In the coffee-growing districts of Guatemala and flood plains of the Nile, empowering local communities through self-organisation has built resilience. While traditionally there has been separation of disaster preparedness from social-ecological development, Eakin and colleagues (Chapter 18, adaptation to tropical storms by coffee producers in Guatemala and Mexico) and Goulden and Conway (Chapter 19, floods in the Upper White Nile) demonstrate that significant gains can be made in disaster preparation by

building social capital. In the case of Sahel, communities have deliberately adapted to climate variability and therefore reduced their vulnerability (Chapter 15, Batterbury and Mortimore). In this situation, adaptation can be facilitated by external actors but essentially takes place from within rather than being driven from the outside as was the case with cyclone Tracy (Mason et al., Chapter 9). An increase in GDP often follows a disaster. The investment in recovery has a positive impact on economic growth.

It often appears that political and public will is driven by the horror of an event (e.g. cyclone Tracy, Victorian bushfires, North Sea storm surge), but this must be accompanied by the capacity to act if effective outcomes are to be achieved. In the case of cyclone Sidr and the Indian Ocean tsunami, international shock and horror were reflected in the willingness to donate to the recovery, but limitations in capacity have hampered recovery efforts.

One of the greatest challenges to implementing responses to disasters is maintaining the lessons or policies developed following an extreme event in the face of day-to-day operations (e.g. see discussion in Eakin et al., Chapter 18, and the example of relaxed setback zoning in the tsunami-affected areas of Sri Lanka, Chapter 16). This problem is particularly acute where events are infrequent (e.g. tsunami) and the corporate and community knowledge of the risk potential can be lost, particularly in the face of other economic interests (e.g. urban development and population pressure) or simply as a result of migration (e.g. new residents in Queensland flood-affected areas were unaware they lived in a floodplain; King et al., Chapter 10).

24.4 Reflections on Historical Adaptation to Climate (as Different from Future Planning for Climate Change)

Recognising Change – Disaster Versus Variability

While all the case studies discussed in this book had disastrous outcomes, some were more clearly irregular extreme events while others were more regular and strongly tied to climate variability. If an extreme is identified as a risk management issue in a highly variable climate rather than an exceptional event unlikely to be repeated in the near term, the emphasis will be on building resilience and adaptive capacity rather than on disaster preparedness. Part of this may be community recognition that the presumed status quo (e.g. a stable climate) needs to be changed.

Community acceptance of change may require recognition of past mistakes (e.g. never should have built on a floodplain), which need to be addressed. Post-disaster recovery activities may provide the opportunity to correct these mistakes. For example, in the tsunami in Sri Lanka, new development boundaries were set in the immediate aftermath (although it should be noted that they were subsequently partly relaxed; Hettiarachchi and Dias, Chapter 16), and cyclone Tracy was the impetus for the development of building regulations.

In Australia's Murray-Darling Basin region, dry or drought conditions have been accepted as part of the normal climate variability in the region (Chapter 7). A shift in policy, from one of disaster response to one of building resilience and adaptive capacity, has been shaped by this growing awareness of the reality of climate variability.

Where Does Risk Lie? – Avoiding ‘Maladaptation’

Actions taken in the immediate aftermath of a disaster are often directed at returning to the status quo as quickly as possible. The case studies highlight a few examples in which a clear policy to tackle failures that worsen a disaster is undertaken (e.g. building moratorium in Darwin following cyclone Tracy; ‘build back better’ approach following cyclone Sidr). If the recovery approach does not pause to reflect on future risks and other potential risks (e.g. the risk of a heatwave in a cyclone-prone district), then adaptive actions can create new or different risks in future events (maladaptation) or can fail to account for other threats or future changes (e.g. change in frequency or intensity). A clear example of the latter case was demonstrated in the Queensland flood chapter (Chapter 10). In both Charleville and Mackay, levee systems were constructed following earlier floods, but in the 2008 events, the floodwaters came from alternative flood sources to the river protected by the levees. In the case of Charleville, flooding came from a second tributary and, in the case of Mackay, from overland flow (i.e. flash flooding).

Arguably, the initial treatment of drought in Australia's Murray-Darling Basin as a disaster and the payment of disaster relief during drought could be seen as creating perverse outcomes (i.e. supporting continued production on very marginal farming lands) and have been a ‘maladaptation’ (Chapter 7). It is important that disaster responses (as with other adaptation actions) take a holistic approach and consider other interacting stressors and risks.

Acceptable Risk and the Associated Costs

In planning for disasters, most governments, communities and individuals make a decision – albeit a subconscious one in many cases – about what is an acceptable risk. However, what appeared to be an acceptable risk before an event may not seem so acceptable in the face of disaster and the political imperative to respond. The decision ultimately comes down to what (or how much) to invest for what level of risk (usually expressed as the severity of an event with a particular return period such as the 1-in-100-year event). In a number of case studies, it was apparent that the design of houses or levees was for relatively common events of low magnitude rather than extreme events (e.g. European floods, cyclone Tracy, hurricane Katrina). Faced with the aftermath of a disaster that may have a return period in the order of hundreds of years, the decision must be made: Is the cost of moving the risk threshold worth it?

This is particularly the case for centrally funded, high-cost engineered solutions such as coastal protection works (cf. privately funded but centrally regulated actions such as building code). The decision might be that emergency management actions will be relied on for very rare events rather than costly or unpopular adaptive actions.

Cost-benefit analyses of adaptation, compared to bearing the risk, are very rarely undertaken. Following the storm surge of 1953, the Dutch Government invested a staggering €9 billion in building a protection system that was designed to protect all areas against 1-in-4,000-year events, with protection for the most populated areas designed to withstand a 1-in-10,000-year event (Vellinga and Aerts, Chapter 14). These levels were based on a cost-benefit analysis and identified a much higher risk threshold than is generally the case (e.g. 1-in-100-year events for new building standards in Australia following cyclone Tracy). What is interesting to note in the action of the Dutch Government is that additional economic benefits were also gained from the plan.

The decision to undertake adaptation actions or accept an existing risk also brings with it a burden of either cost or risk and then the need to decide who will bear that cost or risk. A failure to invest in adaptation actions will devolve the potential for some risks and costs to the community, including potential loss of life, loss of property and decreased quality of life either through evacuation or temporary shelter arrangements. In the Murray-Darling Basin, a clear decision to assign risk and cost has been established, with a policy of resource users bearing the risk of climate variability and the government the cost of policy change (Botterill and Dovers, Chapter 7).

For almost all the case studies, previous events of similar scale and type had been experienced, yet in many cases, disasters unfolded with flaws in both community and emergency management response. So if history repeats, we might ask, are we failing to learn the lessons or are we tacitly accepting the risk of infrequent extreme events? Identifying how to learn adaptation lessons for climate change and extreme events remains an ongoing challenge. It will be important to maintain a perspective of risk rather than winding back policies in times of 'calm weather' or stable conditions.

24.5 The Future Impact of Climate Change on Disaster Management

Climate change is likely to require a shift in perception of natural disasters if adaptation is to be effective. Recognising the unfolding of a disaster was a problem in the lead-up to the European heatwave (Pascal et al., Chapter 12) and in some way the bushfires in Victoria, Australia (Whittaker et al., Chapter 8). In both these cases, identifying the risk of a disaster involved recognising and responding pre-emptively to climate cues. For other events, their regularity makes them no less disastrous in their impacts (e.g. drought in Australia, floods), but should they continue to be seen as disaster or part of the pattern of climate variability that may be shifting in response to climate change, thus necessitating a change in preparedness and response strategies? This key

question has important political and policy implications. If an event is seen as part of a relatively stable pattern of natural variability, then effort can be focused on how to manage actions for sustainably dealing with future rare events. If, however, it is seen as part of a shift to a new condition, this would imply a new response with, for example, investment in development in areas not prone to flooding or moving existing flood-prone development out of high-risk areas. Expenditure will be channelled into adaptation rather than post-disaster 'clean-up' funding. This demonstrates how a shift in thinking might be undertaken that shifts the 'acceptable risk' boundary.

Under climate change, adaptive planning for extremes may require consideration of worsening scenarios. The Victorian Black Saturday bushfires in 2009 were the worst fires ever experienced in Australia and were strongly linked to very extreme climate conditions (Whittaker et al., Chapter 8). Ultimately, existing policies, strategies and responses were inadequate for the escalation of conditions. During an extensive process of enquiry through a Royal Commission, no real consideration was given to climate change and the potential for even worse conditions.

A challenge for climate change adaptation may be the absence of public 'horror' at the incremental rate of increase in severity and frequency of extremes. Lessons from gradual-onset disasters such as drought and heatwaves may offer more profound insights into climate change adaptation.

24.6 Lessons Learned

After a natural disaster, particularly one in which lives are lost, a process of investigation, enquiry and reflection generally occurs. It happens at the level of the individual, the larger community and the government. The purpose of this reflection is usually to ensure the scale of the disaster is not repeated and often results in changes – including to individual actions (e.g. encouraging people to plan their response in advance of an event, including early evacuation), as well as community actions, government policy and infrastructure. It is from this reflection that emergency management builds and refines its policies and actions, builds resilience and reduces risk. The synergies with climate change adaptation are clear, with the key tenets of adaptation being to develop adaptive capacity, resilience and adaptation frameworks/policies. The following are lessons we have derived from the historical case studies in this book, which can be translated into lessons for climate change adaptation.

Community Awareness

In all case studies, there was a considerable potential role for community awareness in addition to any government or authority role for action, enforcement or assistance. Realising this potential has a positive effect on the outcome of an event, saving lives and property. The concept of preparedness is not new in disaster management, but when shifted to the context of climate change adaptation, it has a new character.

Communities that live in an area of, for example, fire risk need to be aware of the risk as well as be prepared through a fire plan and evacuation strategy. Awareness leads to timely implementation of the plan and evacuation. Conversely, as Whittaker and colleagues demonstrate in the 2009 Black Saturday bushfires (Chapter 8), lack of awareness may result in costly inaction or delay.

In adapting to climate change, awareness extends to the realisation that something has changed and that current levels of preparedness and responses may no longer be appropriate. This might mean only minor changes but may extend to fundamental reconsideration of, for example, whether wholesale relocation of a community would be appropriate. In the case of the extraordinary flash flood in the small Australian town of Grantham, there was a post-disaster resolution by the local council to offer at-risk residents a land swap, moving them to higher ground to avoid any risk of a repeat catastrophe (Karoly and Boulter, Chapter 25).

The Whole Picture: All Hazards

In responding to disasters, it is important that actions be pragmatic, realistic and forward thinking. This is equally important for adaptation actions. The key risk of not undertaking a forward-thinking approach is that unintended consequences can result from short-term solutions so that these may not prove to be suitable in the long term (e.g. disaster payments for drought in Australia, Chapter 7). In addition, solutions that look only to the most recent disaster or to one risk factor can result in unintended consequences for future events or other areas. For example, the development of cyclone-resistant housing standards could create housing that is unsuitable for extreme heat conditions. In adaptation terms, this could be considered a maladaptation.

Enabling Adaptation

One of the greatest challenges for public policy in considering climate change is how to make adaptation happen. The case studies discussed in this volume demonstrate quite clearly that there are several pathways to enabling adaptation. In particular, adaptation can be fostered through both incentives and regulation. In the case of cyclone Tracy, the use of regulation was the most expedient approach, changing building regulation to ensure housing met cyclone standards (Mason et al., Chapter 9). For other adaptation actions, incentives may be more appropriate (e.g. buy-backs to encourage people to leave areas of extreme bushfire risk).

There is also a very clear role for community knowledge and communication. The approach undertaken by the Kansas City Council to manage heatwave exposure demonstrates a very successful communication strategy, supported by proactive actions targeted at protecting the most vulnerable citizens (Mills and Snook, Chapter 6).

Practicality

Vulnerability, while able to be minimised and countered through adaptive capacity, it can be unavoidable. For example, vulnerability can be tied to geography – remote location, exposure to extreme events and so forth. This may sometimes mean a change in community perception or attitude – for example, an acceptance that it is no longer appropriate to build in a particular locality that is regularly flooded. In the case of developing countries, vulnerability is often tied to socio-economic factors such as underdeveloped infrastructure, poverty or limited education. Adaptation actions may therefore need to address some of these issues in order to improve adaptive capacity.

Final Reflections

In observing the actions of some communities or authorities following an extreme event, the question can be asked whether those actions are truly developing resilience or are simply a reflection of stoicism. The concept of resilience embraces an element of change. Returning a community to its pre-disaster state is not always optimal but is sometimes perceived within a community and the popular media as demonstrating worthy resilience. This view can be a barrier to adaptation, as it reinforces the position of those within society who are reluctant to change or implement new strategies. Those who do seek change, for example by selling the farm or relocating their home, can be labelled as 'giving up'. All this militates against positive action and change.

Few of the case studies presented here are unique events, and many share outcomes and critical lessons. So the question can be asked: If we know many of the consequences of these disasters, why don't things change? Although in some case studies there are changes, in fact many of these are incremental, rarely transformational. The response to the 1953 storm surge might be considered an exception, with a massive investment in major infrastructure to protect communities from a repeat disaster (Vellinga and Aerts, Chapter 14). Clearly, there are barriers to translating knowledge into action, particularly transformed action, and these barriers are important to understand and inform planning for adaptation to climate change.

With every disaster comes cost – lost lives, repair or replacement of infrastructure, clean-up costs. With increasing risks of climate change-related impacts, the cost of dealing with disasters is likely to rise further unless a more resilient society and environment can be constructed. Costs will potentially become prohibitive, and ultimately the cost, if government action or preparation is not taken or fails, falls onto the community through loss of life, loss of shelter and loss of income. Most governments are unwilling to be perceived as or to become the 'insurer of last resort'. They are moving towards resilience-building strategies as an approach to disaster management (e.g. Australia's National Disaster Resilience Framework). But this also can be seen as shifting responsibility and costs from governments to communities. In

planning climate change adaptation, costs are inevitably a major consideration: What is considered an acceptable risk; are we willing to pay; is the investment in adaptation worthwhile given the potential cost of not adapting? Government, while reluctant to be the 'insurer of last resort', does arguably have a role in actions that are in the interests of the public good. Government decisions to invest in adaptation may reduce the cost of rectifying damage – be that from a disaster or through a changing climate.

Protection of life is generally through early warning systems, community awareness and action and assistance to the most vulnerable. Protection of property relates to understanding what an acceptable risk threshold is and regulating to ensure structures and development meet that risk level.

Adaptation in a Changing Climate

In this volume of case studies, we have considered the development of adaptation following natural hazards. Climate change will potentially bring with it more disasters but also more gradual but equally difficult changes that must be adapted to. From the response to natural disasters, we begin to understand the process and long-term outcomes of undertaking adaptation actions. It highlights the challenge of developing political and community will to both acknowledge present and future change and implement adaptation actions and policies to address these changes. It demonstrates the potential for 'calm weather' periods to undermine strategic policy – although under climate change, we expect this will be less of a challenge than initiating adaptation policies. It also highlights the important role of cost-benefit analysis in guiding the development of appropriate adaptation strategies.

While the need to invest in adaptation for climate change can be financially challenging and politically unpalatable, disasters demonstrate the great risks that can be associated with failing to adapt. The critical difference under climate change is that a return to normal or stable conditions following an event will not occur under climate change.

Reference

- Teague, B., McLeod, R. and Pascoe, S. (2010). *2009 Victorian Bushfires Royal Commission Final Report: Summary*. Victoria: State of Victoria.