1 The past, present and future of adaptation: setting the context and naming the challenges

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1.1 The purpose of this book

This book seeks to expose and debate key issues in climate change adaptation, and to report the current state of knowledge on adaptation. Adaptation is often the poor cousin of the climate change challenge – the glamour of international debate in metaphorically smoke-filled rooms is around mitigation, whereas the bottom-up activities of adaptation carried out in community halls and local government offices are often overlooked. Yet as international forums increasingly fail to deliver against mitigation targets, the realisation is dawning that effective adaptation will be essential across all sectors to deal with the unavoidable impacts of climate change.

Many challenges surround the definition and implementation of successful adaptation, which this book seeks to address. To explore these challenges, we have taken a selection of papers from the First International Conference on Climate Change Adaptation 'Climate Adaptation Futures', held on the Gold Coast, Australia, in June 2010. This three-day meeting of over 1000 researchers and practitioners in adaptation was the first of its kind.

What are these challenges? We begin this chapter with a discussion of five principal challenges for adaptation. We then outline the content of this book. We map the chapters of the book onto the five challenges, so that those who wish to explore in greater depth can do so.

1.2 What are the five principal challenges for adaptation today?

1.2.1 Challenge 1: Understanding the balance of actions to adapt and actions to mitigate

We tend to assume that the wisest course of action in confronting climate change involves a mix of two actions: (a) reducing emissions as much as we can afford so as to keep impacts and adaptation costs to the minimum over the long term, (b) adapting to most of the remaining impacts so as to minimise damage to society and the environment. Then, thirdly, we bear the costs of the unavoidable residual damage (which includes impacts that we cannot adapt to or we judge not worth adapting to). Figure 1.1 is a

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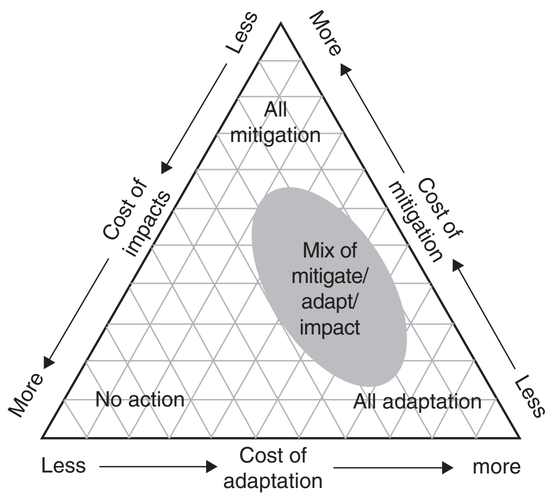

Figure 1.1 Schematic on interconnection between climate change impacts, mitigation and adaptation. With kind permission from Springer Science and Business Media: *Climatic Change*, 96, 2009, 23–27, Closing the loop between mitigation, impacts and adaptation, Parry, M., Figure 1.

schematic of the trade-offs between these three with, in the example shown, the mix being located to the right of the triangle, the predominant actions being roughly equal amounts of mitigation and adaptation, with less being spent on remedial damage. A less optimistic picture (more 'realistic' say those dismayed at the slow progress of international climate policy) would be to locate the mix of actions more to the left of the triangle, with less action on mitigation and adaptation leading to more damage from impacts.

Schemas such as this suggest that we know the relationship between action and outcome, whether it be mitigation or adaptation. In theory we might, but in practice we do not. Even if we did, it is not clear whether an 'optimal' mix of actions exists even in theory (i.e. one where actions along each of the three lines give the most reward). However, this schema is a fair reflection, in outline, of how our current actions are premised: that if we take one line of action we will ultimately reduce costs along another. If this is the case, what task is being left to adaptation given the current effort (and expected outcome) from mitigation?

Adapting for 'overshoot and recover'

It is widely accepted that the threshold for dangerous climate change is a warming of 2 °C above pre-industrial levels. It is increasingly unlikely that emissions of greenhouse gases can be held at a level that will ensure global temperatures remain below this threshold (Rogelj et al. 2011): it would require stabilisation at about 450 ppm CO_2 equivalent (CO_2e) and we are already at 430 CO_2e. Therefore, we need to explore scenarios in which atmospheric concentrations of greenhouse gases, and possibly even global temperatures, overshoot their targets and then recover to stabilise below dangerous levels.

Since the 2007 Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC), partly in response to gaps in the Assessment and also driven by the need to answer urgent questions from policymakers, a number of analyses have been completed of the climate outcomes for varying strategies of emissions reductions (e.g. Hansen et al. 2008; Van Vuuren et al. 2008; Allen et al. 2009a; Meinshausen et al. 2009; Parry et al. 2009b; Schneider 2009; Sanderson et al. 2011; Tomassini et al. 2010).

Figure 1.2 shows the projected global temperature increases using a simple Earth-system model (Lowe et al. 2009). Here we assume that rates of global emissions, which are currently increasing at about 3% per year, are transformed to a 3% annual reduction. The emissions peak or downturn is at varying dates (Parry et al. 2009b):

- immediate action with an emissions downturn in 2015 would lead to a global mean temperature peak at about 2 °C (above pre-industrial) around 2065
- delayed action leading to an emissions downturn in 2025 gives temperature peak at about 2.5 °C around 2080
- a further delay in action with a 2035 downturn points to peak temperatures at about 3 °C around 2100.

Calculations such as these (and there is broad agreement among the estimations referenced above) led to the view voiced at the Copenhagen summit in 2009 that almost immediate action was needed to avoid warming by more than 2 °C (Allen et al. 2009b).

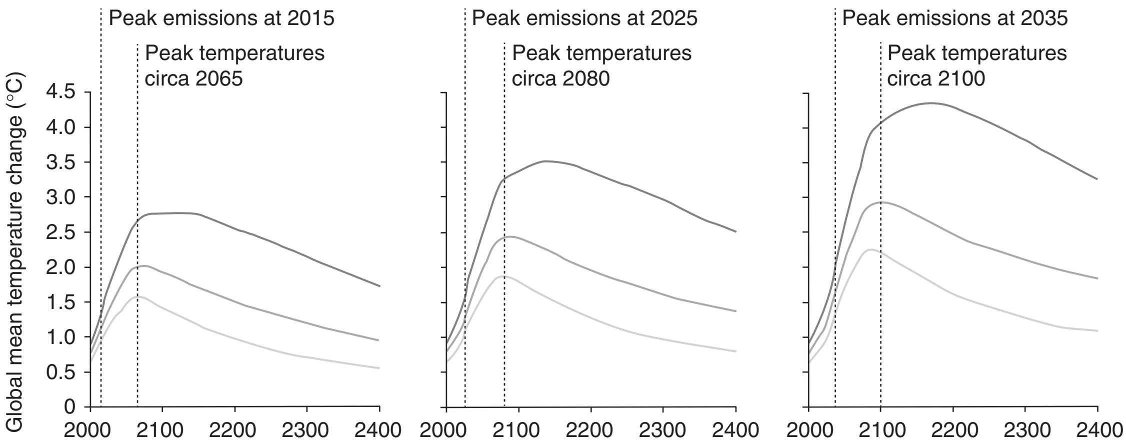

Figure 1.2 Global average surface temperature scenarios of peak emissions at different dates (2015, 2025 and 2035) with 3%-per-year reductions in greenhouse gas emissions. Reprinted by permission from Macmillan Publishers Ltd: *Nature* (Parry et al. 2009b), copyright (2009). For a colour version of this figure please see Plate 1.

It was agreed at the 2011 Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in Durban, that action will not be immediate but is planned to be implemented by 2020 – and will still be intended to avoid exceeding 2 °C warming. To achieve this would require more substantial emissions reductions, levels which many find difficult to envisage (Anderson and Bows 2011; New et al. 2011).

The likelihood, from the analysis above and others similar to it, is that we will exceed 2 °C of warming, and realistically we should be planning to adapt to at least 3 °C. We should assume that very substantial adaptation will be needed, in combination with an annual 3% per annum emissions reduction over two centuries (i.e. until 2200). This would bring global temperatures back to about 1.5 °C above pre-industrial levels by 2200 and 1.0 °C by 2300, a state advocated by some as being the highest temperature at which the biosphere could be sustained over the long term (Hansen et al. 2008).

The adaptation 'need' implied by mitigation

As discussed with respect to Figure 1.1, there is a balance to be achieved between adaptation and mitigation. Thus, even if we are successful at limiting warming to just 1.5 °C through mitigation, we will still have to adapt to the impacts we have failed to avoid. This concept is explored further in Figure 1.3.

When the climate outcomes discussed in the previous section are superimposed on the table of impacts from the 2007 Working Group II Fourth Assessment of the IPCC (Parry et al. 2007, Table TS.3), as shown in Figure 1.3, we can explore the impacts avoided (or not) by mitigation, as well as the amounts of adaptation needed to keep residual impacts to an acceptable level. The vertical lines represent projected median temperature outcomes, so that impacts to the right of the lines are as likely as not to be avoided by mitigation, and vice versa for impacts to the left. The area to the left is thus the 'adaptation field', the area of potential impacts that either must be borne or adapted to.

From Figure 1.3, we can see that, even assuming the strongest possible mitigation action (giving an even chance of exceeding 2 °C) the potential impacts are substantial; for example, 1 to 2 billion people are estimated to become short of water. The consequences for delayed or reduced action can also be inferred from Figure 1.3.

There is a substantial range of uncertainty surrounding the temperature outcomes for different courses of mitigative action, shown by the upper horizontal bars in Figure 1.3, and these

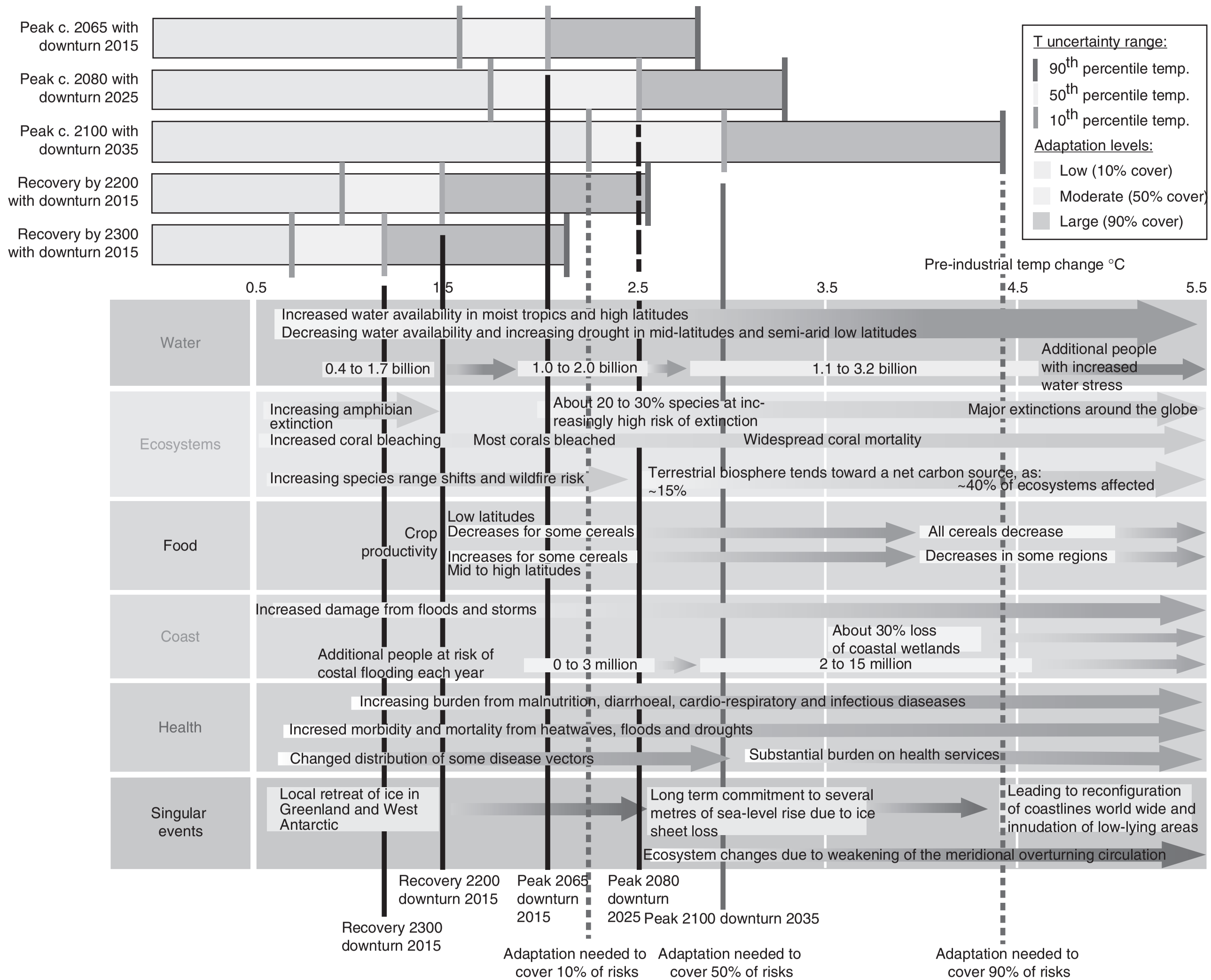

Figure 1.3 Selected global impacts from warming associated with 3% p.a. global emissions reduction, and with global emissions downturns in 2015, 2025 and 2035. Black vertical lines show (a) median projected global temperatures at their peak for different emissions downturn times, and (b) median temperatures at recovery times in 2200 and 2300. Red vertical lines show different adaptation needs for emissions downturn in 2035 and peak temperature c. 2100. Horizontal bars indicate uncertainty range for temperature, and adaptation needs for 10, 50 and 90% coverage of expected climate risk. With kind permission from Springer Science and Business Media: *Climatic Change*, 96, 2009, 23–27, Closing the loop between mitigation, impacts and adaptation, Parry, M., Figure 3. For a colour version of this figure please see Plate 2.

represent a major challenge for adaptation. Since adaptation costs increase steeply, sometimes even quadratically, with climate change there are difficult decisions to be made about the extent of cover to plan for.

In Figure 1.3 we assume that high levels of adaptation are needed to cover 90% of impacts, moderate levels of adaptation would cover 50%, and low levels would cover only 10% of impacts. On this basis, for example, if global emissions did not peak until 2035 and if we wished to cover 90% of expected impacts, then we should be planning to adapt to at least 4 °C of warming.

The challenge left to adaptation by the UNFCCC

What does the analysis so far imply in terms of what has been achieved by the UNFCCC? The accords achieved so far in the UNFCCC process call for all countries to commit to emissions reductions to avoid a global temperature rise of more than 2 °C, and aim to mobilise US$100 billion annually by 2020 for developing countries to fund mitigation and adaptation (UNFCCC 2010).

The pledges put forward by nations so far have, for the most part, been accepted domestically – with one notable exception. The US promise to cut emissions to 14–17% below 2005 levels by 2020 has yet to be approved by the US Senate and for now remains unconfirmed. The outcome of the current pledges, both those officially announced and those under consideration would, if fully implemented, lead to a temperature peak of 3.5 °C (Hohne et al. 2011).

The funding for implementation by developing countries (adaptation and mitigation) agreed to in the UNFCCC Cancún Adaptation Framework is US$100 billion per annum. Assuming that about one half of this US$100 billion is used for adaptation, this is likely only to address the impacts resulting from 1.5 °C of warming (Parry 2009). The food and health sectors, for example, might be able to adapt and thus avoid impacts of up to a 1.5 °C rise by 2030, the water sector up to a 2 °C rise by 2050 and coasts up to a 2.5 °C rise by 2080 (Parry et al. 2009a). But for ecosystems and some singular events, such as Greenland ice melt, most impacts simply cannot be avoided whatever the scale of funding available.

Consequently there is currently a gap of 1.5 °C between the adaptation covered by present funding targets (1.5 °C) and the mitigation pledged within the UNFCCC negotiations (3 °C). If this gap is not closed the unavoided impacts will likely be substantial. This is shown in Figure 1.4.

Moreover the UNFCCC figures for adaptation (to 1.5 °C) could be substantial underestimates. The financial assistance needed by developing nations may be two to three times higher overall and many more times higher for certain sectors (Parry et al. 2009a). The UNFCCC estimates do not, for example, include any costs for ecosystem adaptation, which alone have been valued at US$65–80 billion annually by 2030 for protected areas and almost US$300 billion annually for non-protected areas (Fankhauser 2010). Even the latter figure covers mainly protection of forests and biodiversity in farmed areas and does not include the ecosystem damage in unmanaged areas that is simply unavoidable, such as the loss of warm-water coral reefs.

To conclude, there are currently plans (possibly themselves underestimates) to fund adaptation to 1.5 °C of warming, but the peak of warming from projected emissions, assuming current efforts on mitigation, is likely to be 3 °C or more. Closing this 1.5 °C gap presents a huge challenge to adaptation.

1.2.2 Challenge 2: Adaptation as transformation, adaptation as incremental change

A key challenge for adaptation is knowing when to adapt and how much to adapt. Humans have always adapted to climate variability and change, usually in a reactive, autonomous way, with varying degrees of success (Fagan 2008). However, as we start to gain a better understanding of future climate change in relation to anthropogenic greenhouse gas emissions, we are in a better position to recognise that we need to be more proactive in adaptation planning. Stafford Smith et al. (2011) characterised adaptation decisions according

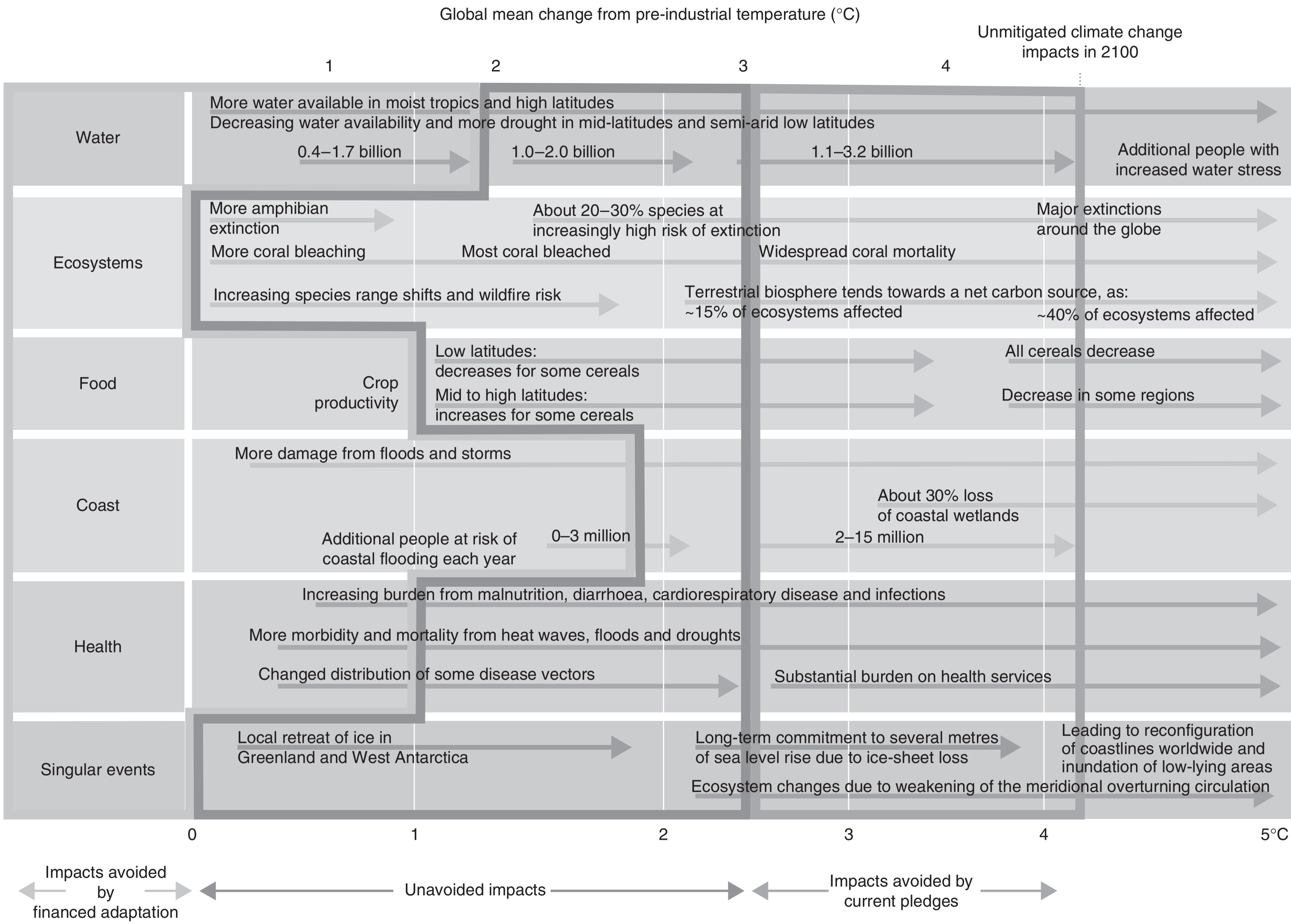

Figure 1.4 Potential impacts currently covered by UNFCCC adaptation targets (blue) and not covered (red). Green shows the impacts avoided by mitigation pledges as part of the UNFCCC process. The global climate impacts are taken from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Reprinted by permission from Macmillan Publishers Ltd: *Nature* (Parry, 2010), copyright (2010). For a colour version of this figure please see Plate 3.

to the lifetime of those decisions. Decisions with a short lead time and a short consequence period, such as in annual planting of crops, can be adjusted regularly, whereas decisions with a short lead time but with a long consequence period, such as building a bridge, really need to consider climate change risks now. Decision lifetime also interacts with confidence in the climate projections e.g. sea-level rise benchmarks for planning decisions in coastal areas can be set on 2030, 2050 and 2080 timeframes to account for the uncertainty in the projections and their interaction with the asset life of the planned infrastructure. Other non-climate drivers such as demographic change or economic change will also interact with decision-making for these longer timescales, reinforcing the need to take account of interdependencies and not make climate adaptation decisions in isolation.

The amount of adaptation required depends on how well greenhouse gas emissions are curbed through mitigation at the global level (see previous section) and at the local level the vulnerability that arises from exposure, sensitivity and the adaptive capacity of individuals, communities and institutions. As indicated in the previous section, greenhouse gas emission targets to limit warming to 2 °C have been widely agreed in principle but in practice the current pledges from various countries suggest that a warming of at least 3.5 °C is more likely (Hohne et al. 2011).

Bringing together these two aspects of decision timelines and the amount of adaptation required leads to thinking about responses in terms of *incremental* or *transformational* adaptation. Incremental adaptation implies essentially business as usual with some manageable changes to deal with climate change which can usually be addressed by adopting an adaptive management approach. In contrast, transformational adaptation requires fundamental changes in systems that are qualitatively and quantitatively different from incremental adaptation. For example, a farmer can adjust incrementally by amending crop planting dates, varieties and management practices but if there is insufficient water in the future to irrigate then a major change in farming system or location may be required.

Adaptation responses that range from incremental to transformational have been classified in different ways: routine – non-routine – complex unbounded (Dovers 2009); coping – more substantial – system transformation (Moser and Ekstrom 2010); preservation – restoration – transformation (Craig 2010); resist – transform – move (Ruhl 2010); incremental – transitional – transformational (Howden et al. 2010). Despite these fairly consistent approaches to thinking on the nature of adaptation responses, definitions of incremental and transformational adaptation, until recently, have proved elusive. Park et al. (2012) have provided definitions:

> Incremental adaptation – 'maintaining the essence and integrity of an incumbent system or process at a given scale'.
>
> Transformational adaptation – 'a discrete process that fundamentally (but not necessarily irreversibly) results in change in the biophysical, social or economic components of a system from one form, function or location (state) to another, thereby enhancing the capacity for desired values to be achieved given perceived or real changes in the present or future environment'.

Their interpretation is scale dependent: for example, a transformational challenge for an individual farmer may be an incremental challenge at the level of maintaining food production systems nationally. As you move from incremental to transformational adaptation, complexity and risk increase but the benefits are also greater (see Figure 1.5 and Howden et al. 2010).

To date, most attention has focused on incremental adaptation with emphasis on short-term tactical decisions, though increased thinking on transformational adaptation is now going beyond the literature and into policy and on-ground actions (Park et al. 2012). The framing of adaptation by the IPCC may have contributed in part to the focus on incremental adaptation. Firstly, adaptation has been framed as the residual response required after mitigation with, to date, overly optimistic assessments of the likely level of mitigation. The residual impacts are consequently becoming much greater because of this

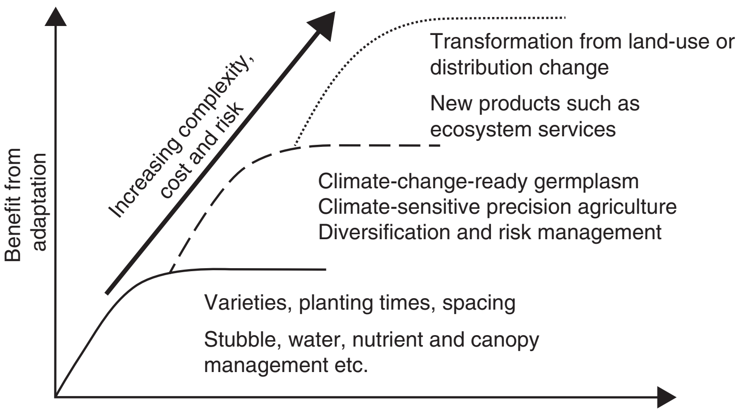

Figure 1.5 Hypothesised relationship between incremental and more transformational adaptations as climate change increases, indicating possible types of adaptations and the likely increasing complexity, cost and risk associated with the more transformative adaptations. From Howden et al. (2010b, Fig. 9.7, p. 109) with permission.

lack of action on mitigation. Additionally, the impacts do not increase linearly with increasing temperature but rather exponentially or abruptly where thresholds are crossed. Coupled with this is the widely used framing of adaptation as the actions needed to fill the vulnerability gap left after intrinsic adaptive capacity has responded to potential impacts derived from exposure and sensitivity. This tends to focus attention on incremental adaptation at the very local level and tends to ignore the cross-scale and systems nature of thinking required for many adaptation responses.

That is not to say that incremental adaptation is not important – proactive and well planned incremental adaptation will be vitally important in dealing with many of the impacts of climate change in the coming two decades. There is much that can be done to modify existing practices, industries, institutional arrangements and policies to adapt to modest amounts of climate change. One area in particular that warrants more attention than it is currently receiving is investment in development of new technologies specifically for climate adaptation. This can take the form of new materials and designs for infrastructure, or breeding new plant cultivars that can both take advantage of rising CO_2 concentrations and be productive under higher temperatures. At the same time, care is needed to ensure that these technologies are not maladaptive or have other unintended and undesirable consequences (Mendelsohn 2011).

Although much incremental adaptation is likely to occur autonomously; it will likely have better outcomes if it is planned proactively. Adopting an adaptive management approach to incremental adaptation provides flexibility and builds adaptive capacity (Tompkins and Adger 2004).

Thinking on transformational adaptation has been strongly influenced by resilience literature and in particular the social-ecological resilience framework (Walker et al. 2004). Social-ecological systems have distinct phases and evolve and transition through adaptive cycles. In the context of climate adaptation Park et al. (2012) have modified the adaptive action-learning cycle to reflect the differences between incremental and transformational adaptation in terms of scale, resources required, and actors involved (Figure 1.6). Important to this conceptual approach are linkages between incremental and transformational adaptation even though the decision types, policy needs and resources required are quite different. Consistent with this thinking, Horrocks and Harvey (2009) proposed 'continuous transformation' characterised by adaptive cycles of incremental and transformational adaptation that are continually evolving along an adaptive pathway.

How well are these concepts of transformational adaptation penetrating actions and/or policies on climate adaptation? Evidence is emerging that some transformational adaptation

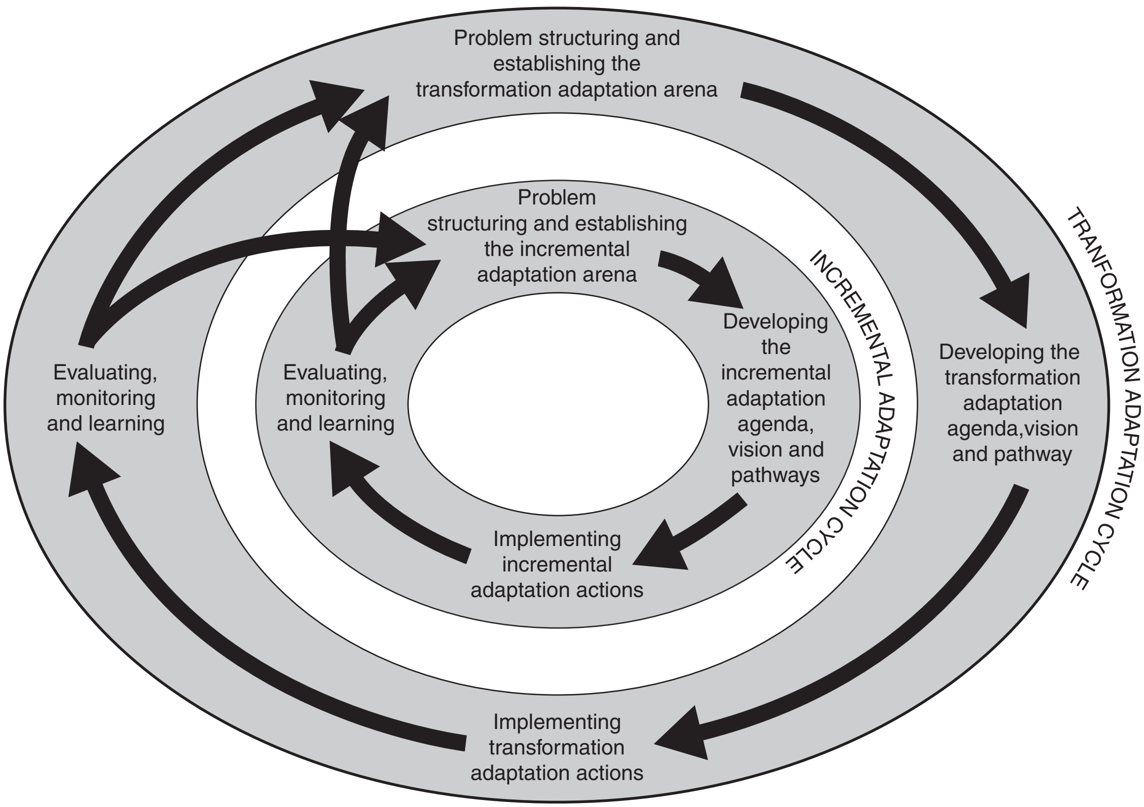

Figure 1.6 The 'Adaptation Action Cycles' framework explored as a basis for analysing the relationships between incremental and transformative adaptation. Park et al. 2012. Reproduced with the permission of Elsevier under the terms of the STM Agreement.

is being practised in terms of on-ground actions; for example, in Australia a large wine company has purchased land in a cooler climate to commence growing varieties currently better suited to a warmer climate (www.brownbrothers.com.au/newsevents/newsdetail.aspx?newsid=53), and some local councils are approaching planning of new residential developments with consideration of significant climate change (SMEC 2010). However, these types of actions are fairly limited, and transformational approaches are likely to be constrained by high-level policies framed in an economic rationalist context that sees adaptation largely driven by market responses with the need for intervention to deal with market failures being rare (Garnaut 2008). Furthermore, there is inadequate thinking on legislative aspects of policy in the context of transformation with current approaches tightly linked to preservation and restoration (Craig 2010; Ruhl 2010).

Both incremental and transformational adaptation will be required as climate change unfolds. It will be common for many industries and communities to be adapting simultaneously across this incremental–transformational continuum even though there will be different needs for information and policies, with scale being a critical driver of these differing needs. Whether it be incremental or transformational adaptation there is an unequivocal need for a proactive and anticipatory approach as it will be more efficient than reacting after significant change has occurred.

1.2.3 Challenge 3: Converting adaptation knowledge into action

The great challenge for adaptation, and indeed for the whole climate change response paradigm, is the conversion of knowledge into action. Despite all the activities of the sceptics, it is still the case that the majority of the general public, and the vast majority of scientists, accept the reality of human-induced climate change (Leviston et al. 2011). However, it is equally true that this acceptance rarely translates into adaptation action, whether by governments, the private sector or the community. This challenge explores why this should be the case, and what remedies are available.

Barriers to adaptation

Knowledge barriers. One of the most obvious reasons why we fail to take action to address climate change may simply be that we may lack, or believe that we lack, sufficient knowledge about future climate, socioeconomic trends and technological developments to allow us to act. As one example, it is common to hear demands for future climate change scenarios at greater spatial and temporal resolutions as a necessary precursor for action. But this implies a fundamental misunderstanding of the nature of scenarios – they are defined by the IPCC as 'plausible … descriptions of how the future may develop' (IPCC 2007). The key word here is 'plausible' – there are a whole host of other, equally likely futures. Thus a scenario, however detailed, cannot and should not be used as a prediction to underpin planning and action.

Scenarios are useful tools to explore our vulnerabilities and sensitivities, and so understand where we need to devote effort in order to enhance resilience. Increasingly sophisticated analyses of multiple simulations of future climate are helping us to develop probabilistic projections of changes (e.g. Jenkins et al. 2011). Even these struggle with some important variables for adaptation such as storminess, and in general speak to the needs of mitigation and impacts, but are insufficient to support adaptation decision-making in terms of the information that they can provide around, for example, thresholds and sensitivities.

Emphasis on the need for information on the future effects of climate change can be a distraction from action. Creating high-resolution climate change scenarios is time consuming and expensive of human and computing resources – it can be seen as taking action, but in fact it makes a limited contribution to our preparedness for climate change.

There are many sectors of human existence where we act in the context of incomplete knowledge and high levels of uncertainty. Defence is a sector that immediately comes to mind. The UK Government's Strategic Defence and Security Review (HM Government 2010) speaks at length of 'growing uncertainty about longer-term risks and threats', but UK Government spending on defence is around £45 billion per year.

Taking all these factors into account, the key is to start from the decision framing rather than from the climate change projections, and to embrace the uncertainty within the decision-making process.

Given that uncertainty is not a barrier to adaptation, then to a great extent we possess the engineering and technological knowledge to adapt. There are gaps, such as around the genetic capacity of plants to acclimatise, which can be bridged through research, but these are not insurmountable. There may also be skills barriers – although the knowledge may exist, it may not be present at the particular place and time required to facilitate adaptation. Training and education programmes, as well as knowledge exchange between developed and developing countries, are the tools which address skills deficits.

Financial barriers. Financial barriers to adaptation exist at all scales, from international through to individual. At the international scale, the UNFCCC has always recognised financing, or lack of it, as a barrier to adaptation in the often highly vulnerable Least-developed Countries (LDCs) (UNFCCC 2007). It has set up the Adaptation Fund, which to date has funded projects to a value of around US$1 billion. This is supported in part by money from the trading of Certified Emissions Reduction credits (2% of their value per annum) (see: www.adaptation-fund.org).

By 2020, the UNFCCC estimates that there will be a need for US$100 billion per annum for adaptation and mitigation activities in the LDCs. One of the actions of the Conference of the Parties in Durban at the end of 2011 (COP17) was to agree the broad design of a Green Climate Fund to address this need, although there was no agreement and little discussion on where the money will be found.

Many arguments support the need for initiatives such as the Green Climate Fund. From a geopolitical perspective, they are an incentive for the LDCs to continue to support actions to reduce greenhouse gas emissions. In the one-country-one-vote forums of the UNFCCC, this continued support is essential for success. From an equity perspective, LDCs are not the author of the problem of global warming, but they are likely to be the most impacted by its effects.

At national, community and individual levels, financial barriers may be perceived to exist. It may be hard to justify allocation of funding to address a problem that won't fully manifest itself for many years, even decades. And such considerations weigh especially heavily, as at present, during economic recession and the global financial crisis. Under these circumstances, financing of actions to address existing adaptation deficits is justifiable, and has the added advantage of building adaptive capacity.

Legislative and regulatory barriers. Legislative and regulatory frameworks can be used to enforce policy change and assist in shifts in social behaviour, and are often used as the 'stick' to persuade other incentive-based forces of change. Legal frameworks already exist for the management of natural resources, biodiversity conservation, planning and development, insurance and emergency management (McDonald 2010), all of which have the potential to contribute, positively or negatively, towards adaptation. Legislation plays a role in allocating agency responsibilities, establishing and empowering institutions and organisations, providing legal authority in decision-making, defining liabilities and defining the process and players of decision-making (Dovers and Hezri 2010; McDonald 2011). It can also provide stability against a background of rapid change and ongoing uncertainty (McDonald 2011). Existing regulatory and governance frameworks will, by necessity, have an important function in adaptation – either in supporting adaptation or as a barrier to be overcome. Existing legislation and regulations that conflict with (counter) adaptation, and those that do not provide the necessary signals to support adaptation, are often seen as key barriers to adaptation.

The law is often perceived as rigid and inflexible. Changes to both statutory and common law take time. Common law relies on precedence and so is tested and shaped as legal challenges arise. Statutory law, on the other hand, is more controllable, but relies on the necessary political and public will, with decisions often based on moral or popular opinion rather than the rational decision-making processes (Inderberg and Eikeland 2009) sometimes depicted in theories of climate change adaptation. The political process is largely influenced by very short funding and governance cycles, far shorter than the planning periods associated with climate change adaptation.

Incremental changes to legislation through amendments to existing statutes will occur in response to emerging adaptation policy, but also in response to extreme events such as floods and droughts. Some authors argue that the unique challenges of adaptation require new legal frameworks and concepts (Inderberg and Eikeland 2009) that allow for greater flexibility (D. Fisher[1], pers. comms. 2010). This is particularly the case for adaptive management pathways, which by their nature invoke a need for flexibility. McDonald (2011) notes that 'environmental degradation caused by creeping or incremental threats may provide more time for legal reform'. However, the very nature of climate change is such that thresholds and shocks may occur, for which existing legal frameworks are inadequate, thus compromising capacity throughout society to adapt.

Failures of communication. Adaptation activities can be seriously undermined by a failure to communicate relevant information in a timely

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and appropriate manner and/or where ineffective communication leads to misunderstanding or misinterpretation of available knowledge (Moser and Ekstrom 2010). Recognising the overarching challenge of communicating complex climate change concepts, failures of communication to support adaptation have included failure to:

- adequately set communication goals
- identify and understand target audiences
- appropriately frame messages and use appropriate language
- make use of 'messengers' most likely to effectively communicate and influence particular audiences
- provide adequate resources (time, funding, expertise) to support communication efforts.

Focusing on developing oversimplified general-purpose 'messages', that are sought as a 'silver bullet' to solve communication challenges, without being developed to address specific communication goals, or targeted at a particular audience, is also unlikely to deliver effective communication outcomes.

There has been a tendency to rely on the 'information deficit model' of science communication, which assumes that audiences are empty vessels that information can be transferred to, from expert sources, in order to meet their knowledge deficit (Nerlich et al. 2010). One key issue associated with this response is that the 'language' or terminology commonly used in climate change adaptation research, such as 'scenarios' and 'uncertainty' is not necessarily transferable to different audiences without the risk of misinterpretation or misunderstanding. This approach is also unlikely to appreciate the importance of engagement with audiences to develop and deliver communication strategies, and the value of co-production and co-generation of communication tools and methods. It is also unlikely to value existing knowledge, experiences, information needs or the capacity of audiences to access and use information to adapt to climate change impacts. Failure to recognise the influence of an individual's values (including cultural values) and beliefs when perceiving risk, and considering and using information when taking action in response to the perceived risk, provides a significant communication barrier (O'Neill and Hulme 2009).

Cognitive and psychological barriers. Even where there is sufficient knowledge, appropriate financial and legislative frameworks, and good communication, adaptation is likely to fail if perceptions of vulnerability, risk and urgency are missing. Human cognition is the basis for all other barriers to adaptation, and it presents arguably one of the most vexatious challenges to address in adapting to climate change. We have learnt from psychological research that when human perceptions of risk, individual opinions and values combine with the inherent uncertainty associated with climate change projections, decision-making is affected. In the political realm, decisions often become moral rather than rational. Cognitive barriers – the lack of ability or willingness to deal with the complexity of climate change along with the other issues requiring attention – reduce the ability of decision-makers to turn an awareness of climate change adaptation pathways into action.

One of the greatest challenges is the long time-lags between identifying future changes and the occurrence of those changes. The ability of individuals to have a clear perception of a risk that is decades into the future, sufficient to undertake adaptation, is limited. Generating a sense of urgency is extremely challenging as a result. In addition, lack of experience of climate-related events can be a barrier to an appropriate response, with a tendency to 'prioritise' risks based on what is most significant to an individual at any given time also reducing the urgency to act (Adger et al. 2007).

Public perceptions of the risk of climate change, when empirically tested, can be at great odds with media reporting of 'beliefs' or attitudes (e.g. Reser et al. 2011). This can lead to unwillingness by decision-makers to act against a perceived public will.

One means of dealing with cognitive barriers is to build adaptive capacity by dealing with existing adaptation deficits (e.g. preparation for extreme events, effective management of water resources, etc.).

Barriers to adaptation and lack of adaptive capacity. All these barriers to adaptation contribute to a lack of adaptive capacity. Where they can be overcome, adaptive capacity increases as does the likelihood that there will be action.

In some cases, there is an existing adaptation deficit (e.g. Burton and May 2004). That is, there is a failure to adapt to current climate conditions, insufficient or misdirected adaptation, or maladaptation. This situation may arise for a number of reasons including a lack of resources to adapt (financial constraints), an inadequate understanding of what is being adapted to (knowledge constraints), or a very rapidly changing set of social, economic or demographic circumstances which renders climate variability a secondary consideration (instability constraints). Where an adaptation deficit exists, developing adaptive capacity to manage future climate change will of course be even more of a challenge. Conversely, addressing the adaptation deficit can build adaptive capacity.

In the next section, we discuss some of the approaches to overcoming these barriers.

Overcoming the barriers to successful adaptation

Market-based and regulatory instruments. Economists such as Stern (2007) and Garnaut (2011) describe climate change, and responses to it, very much in terms of markets. Stern (2007) called climate change the greatest market failure the world has ever seen. Garnaut (2011) talks of 'a strong, flexible economy with smoothly functioning markets' as one of the two main building blocks for successful adaptation, the other being sound information about the impacts.

Both Garnaut and Stern would see well-functioning markets as able to deliver successfully-adapted societies, in which industry, business, communities and individuals are incentivised to adapt. The role of government is to create enabling frameworks for the development and maintenance of these markets, and hence for successful adaptation. Carbon pricing is an integral driver of market success, and provision would be made within these markets for maintenance of healthy ecosystems and biodiversity, and for disadvantaged members of society.

However, in reality, and in the absence of Garnaut's sound information, adaptation action generally takes place in response to extreme events (Berrang-Ford et al. 2011). If the frequency and/or intensity of extremes increases in the future then the pace and magnitude of government and community response will increase. This will not be optimal: responses to extremes are often hurried and poorly-considered and provide short-term solutions which are unsuitable or inadequate to address the long-term threat of climate change (and so are, in fact, maladaptations). It is only in an ideal world, with Garnaut's sound information, that we would be able to plan our adaptation strategies in a well-paced and considered manner.

Under the higher end of global warming that we are beginning to envisage (3–4 °C of warming), there are limits to adaptation that market mechanisms cannot address. Sea-level rise under high rates of warming may simply cause some low-lying small island states to disappear. Increased frequency of inundation of communities by flooding rivers (which is beginning to be observed in some areas of central Queensland for example) may render communities initially uninsurable and eventually uninhabitable. Multi-year, even multi-decade droughts may destroy agricultural communities. These will impact not only on local economies and societies, but on international trading patterns and security. Elsewhere in this book (Chapter 22), human migration as an impact and as an adaptation is explored. It is hard to see the responses to such extremes of climate change as ever representing the successful interplay of market forces.

As described above, there are cases where the market will be unable to drive successful adaptation. In these cases governments have a role: to build adaptive capacity and to ensure that the right actions are taken at the right time, that the necessary regulatory frameworks are in place, that ecosystem services are properly recognised and that vulnerable communities are protected.

Role of engagement and communication. The role of engagement and communication is to ensure that robust and informed adaptation decisions and action can be taken by audiences who have access to, and the capacity to consider and use, information to support and achieve effective adaptation outcomes. Ineffective communication has been identified as a significant barrier to climate change adaptation (Moser and Ekstrom 2010). There is growing recognition that in order to be effective, the communication of information, and engagement with target audiences, to support climate change adaptation needs to be participatory, integrated, iterative, outcomes focused, 'made to measure' (Nerlich et al. 2010; Jäger and Moll 2011) and, needs to take into account the scale at which climate change adaptation activities are being undertaken (individual, local, regional or global).

Pursuing clear communication goals, understanding audiences and what motivates them to take action to adapt to climate change impacts, and then planning and framing communications activities and messages accordingly, will go some way towards overcoming communication challenges (O'Neill and Hulme 2009; Nerlich et al. 2010; Pidgeon and Fischhoff 2011). Reliance on traditional methods of science communication must also be reconsidered, with the use of appropriate communication tools and approaches drawn from a wide spectrum of available options more likely to deliver effective communication outcomes. As noted by Pidgeon and Fischhoff (2011), communication of climate science needs to reflect the long-term integrated nature of climate science itself, and must be 'strategic in its analysis, design, implementation and evaluation'. Effective engagement and communication with audiences, particularly at a local level where adaptation action is happening on the ground, is more likely to ensure that local knowledge and expertise is valued and used, and is more likely to support and motivate the conversion of knowledge into action.

Case studies of successful translation of knowledge into action

Having explored the barriers and enablers of adaptation, it still remains difficult to pinpoint examples of present-day adaptation to address the future risks of climate change. Here we explore two examples: the first is a community-level response to an adaptation deficit which nevertheless will deliver long-term benefits in protection against the effects of climate change; the second is a regional action targeted explicitly at long-term climate change.

The Grantham relocation. Grantham, a small rural community in Queensland, experienced a flash flood in January 2011 which took 12 lives and washed away 120 houses. In response, the local council purchased a parcel of 1000 ha of land above the flood level and, on 23 May 2011, announced its relocation policy. Residents were offered serviced plots of land in exchange for their existing plots, using a ballot system, and the first homes were completed close to the first anniversary of the flood (Lockyer Valley Regional Council 2011). Although settlements in Australia have relocated in the past to avoid flooding, the innovative role of the council and the speed of the action were strong contributors to success. Interestingly, throughout the relocation, climate change has never been mentioned; no doubt a response to the strong scepticism among Australian rural communities. This action contrasts nicely with the more usual role of government, to restore damaged goods to their initial state without taking into account changes that may be necessitated by present or future climate change.

Current *flood defences in the North Sea* owe much to planning in the aftermath of the 1953 storm, when over 2500 lives were lost in the surrounding countries. However, greater certainty that sea-levels will rise in response to global warming, compared to the response of other climate variables (Garnaut's sound information), associated with the very long timescales involved in planning, building and maintaining coastal defences, means that this is an area where adaptation action has taken place in response to a future threat, and in a well-paced and considered manner, rather than as a knee-jerk reaction to an extreme event. In the UK, the Thames Barrier opened in 1984, and in the Netherlands the Eastern Scheldt storm surge barrier (Oosterscheldekering) opened in 1986, so some thirty years after the initial impetus of the 1953 storm. Defence levels included sea-level rise as understood at the time of the design, with a 200 year design life for the Eastern Scheldt Barrier and 50 years for the Thames Barrier (Lavery and Donovan 2005; VanKoningsveld et al. 2008).

1.2.4 Challenge 4: Mainstreaming and leapfrogging across organisational scale

The foregoing sections have shown the extent of the adaptation challenge, the degree to which it may increasingly require transformational approaches, and the barriers faced in turning responses into action. Many of these issues invoke cross-level scale concerns – local adaptation being conditioned by provincial or national policies, or transformation at the farm level requiring supporting change from the surrounding region, for example – which were widely evident at the conference but remain challenging to consider (here we adopt the definitions of scale and level as clarified by Cash et al. 2006).

Conventionally, adaptation is caricatured as mainly local activity within a policy framework, in contrast to mitigation which is caricatured as an activity which is mainly driven by big, broad policy settings such as a price on carbon. Both caricatures are misleading – mitigation still depends intimately on individual behaviour, as the tendency for the 'rebound effect' to (modestly) reduce the efficacy of policy instruments shows (Ackerman and Stanton 2011); and adaptation is in fact a deeply nested process, in which each level of organisation is conditioned by its broader operating environment, but also constrains the options open to higher levels of organisation to set policy. Thus, to take an Australian example, while national industry policy can set the context for whether farmers or other small businesses plan for climate change, complex cross-level feedbacks to do with rural politics and farmer scepticism have hampered the ability of the national government to remove maladaptive aspects of drought 'exceptional circumstances' policy from the operating environment of farmers. Novel approaches to adaptation are needed (e.g. Nelson et al. 2008; Hogan et al. 2011) that allow for cross-level dynamics.

While the cross-level nature of adaptation has long been noted (e.g. Adger et al. 2005, 2009; Juhola and Westerhoff 2011), the caricature continues to underpin much thinking: as noted earlier, both the Stern and Garnaut reports regarded adaptation as a matter of managing modest market failures after providing the information and policy environment within which market-driven action would flow; yet governments have a role in carrying out adaptation as well as setting the policy framework for it, and hence failures of adaptive capacity and barriers to action within government are as important to study as those among local communities. In fact it is more useful to conceptualise adaptation at any given level of organisational scale as having both an action-at-this-level component (including horizontal dependencies among organisations), and a context-setting-for-other-levels component. In general it may be true that the action component dominates more at local levels, and the context-setting/policy component more at national and global levels. Nonetheless, national governments do act to adapt, in managing their own resources, setting up their own structures to coordinate actions across sectors, or establishing specific support institutions at a national scale, such as the National Climate Change Adaptation Research Facility in Australia. At the same time, choices of small businesses set the context within which individuals within the business are then more or less able to carry out their own adaptation actions, such as providing offices which are resistant to heat waves. Thus the dependence of the nature of adaptation responses on the level of organisational scale may be better conceptualised as in Figure 1.7.

This reconceptualisation is important in thinking about how to structure responses to climate change across levels in society. It is a widely touted rubric that adaptation to climate change should be mainstreamed into all relevant organisations' activities as quickly as possible. This rubric is found in policy in developed nations as well as in the rhetoric of development for developing economies. But, as already noted in this chapter, there is a wide variety of types of organisations in terms of their structures and readiness to act (Gardner et al.

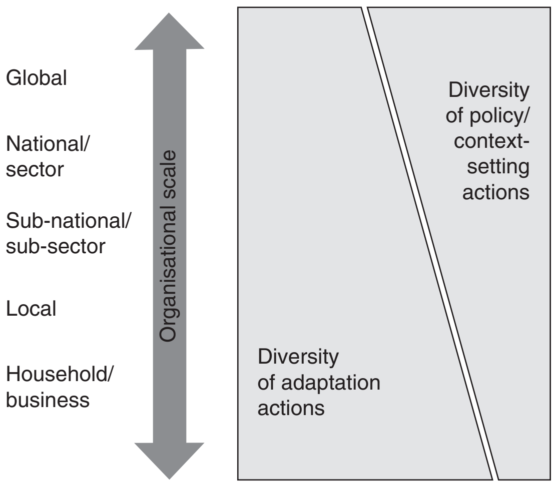

Figure 1.7 Schematic illustrating how the balance between types of adaptation activity may vary across levels of organisational scale, from being dominated by actual adaptation actions at local level, through, at higher levels, to more context-setting policies which set the operating environment for lower levels of organisation. Note that at least some activities in both types occur at all levels, which emphasises the importance of understanding issues such as adaptive capacity and appropriate institutional arrangements at all levels.

2010), and an equally large variety of adaptation challenges and response options that they need to address. The parallels with sustainable development are notable; as with adaptation to climate change, responses need to be across many levels of organisational scale, albeit with more action locally, and in all forms from incremental adjustments to practice to transformational changes in thinking. Awareness of sustainable development in the light of the Brundtland report in the 1980s (Brundtland 1987) has led to the idea being 'mainstreamed' into most policies and boardrooms – triple bottom line reporting has had great value and can be found very widely. However, this mainstreaming has been relatively superficial and reactive, dealing with the more tractable issues, often reinterpreted and watered down. In particular, it singularly failed to deliver the essential transformative changes in consumption and the valuation of our global commons that continue to be an urgent consideration today. We need to learn from this experience for adaptation, and set aside black and white calls for mainstreaming in favour of a more nuanced approach.

The experience of sustainable development would suggest that uncritical devolution of all adaptation thinking into the day-to-day business of organisations is likely to fail to deliver all that is needed. In particular, issues which are more transformative or in other ways far from the business-as-usual mainstream are unlikely to be addressed until too late. Given the argument earlier that adaptation needs to focus increasingly on transformative long-term decisions in the face of uncertainty, mainstreaming these away from the focus of specialist units within organisations and government seems likely to fail.

A parallel concern emerges in relation to the development agenda. The need to converge development and climate change to ensure that development was not maladaptive with respect to the future was discussed in panels at the conference, and it has been said that 'adaptation is development in a carbon constrained world' (Stern 2009). However, the development literature talks at times of a 'development gap' and an 'adaptation gap' as if these are linear and additive – developing countries need to reach the point where they can deal with today's conditions, and then take further action to respond to future climate change (see Figure 1.8). This is a dangerous misconception that suggests that it is sensible to carry out conventional western development until the world reaches a satisfactory level of (GDP-based) well-being before dealing with the future. Since the western world is seeking to change much of that development trajectory itself to decarbonise its economy, this is a pathway to disaster. Worse, it is also one which misses the greatest perverse benefit of being under-developed: that you have not yet invested in undesirable technologies and can leap-frog western development to a climate-adapted state much more easily than developed countries with their massive levels of sunk capital. The classic parallel is mobile telephony, where many African countries have largely skipped the stage of fixed copper wires to go direct

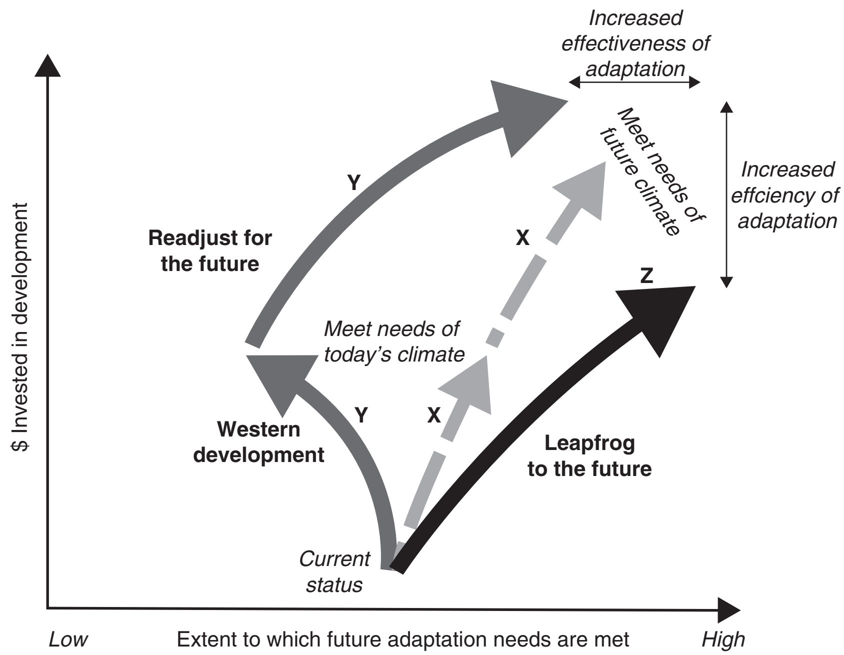

Figure 1.8 Development-adaptation conceptual models: the dotted lines X show the concept of an additive development and adaptation gap, where part of the gap is filled by development to deal with today's climate, then further adaptation meets the needs of a future climate in an aligned and additive way; but this conceptualisation is usually erroneous. This approach is more likely to follow lines Y in practice, where current development pathways may meet today's climate needs but in ways that are maladaptive in terms of climate change mitigation and adaptation, thus necessitating an inefficient readjustment for future conditions. By contrast, line Z seeks to take new green approaches to development today that are pre-adapted to the future, potentially delivering cheaper (more efficient) and better (more effective) outcomes. (Developed from discussions with C. Roth).

to mobile telephones, and are therefore now ahead of many western countries in the innovative uses of those phones for mobile banking, among many other examples. There are obvious opportunities in energy systems (to skip centralised, coal-fired power stations in favour of dispersed renewables which can be more resilient to climate extremes), urban design (half the cities people will live in by 2050 are yet to be built so that opportunities exist to implement designs with lower energy needs but also better adaptation to heat and flood), food systems (better targeted use of water, nitrogen and phosphorus with climate-adapted agro-ecological systems) and many other areas.

All these opportunities have both mitigation and adaptation aspects and all need urgent, imaginative attention to deliver outcomes that are both more efficient and more effective (Figure 1.8). The problem is that, in times of economic stringency, developed world companies are likely to seek new and expanding markets for existing products for which they still need to obtain payback on their sunk investments; the result of mainstreaming development in business-as-usual operations for these markets may be a disastrous additional round of maladaptive (to climate change) sunk investments in the name of development. Once again, such development thinking should not be mainstreamed prematurely; rather, great and imaginative efforts need to be put into 'leapfrogging' options, which may include developed countries agreeing to allow their old technologies to see out their investment days at home while supporting their industries to invest in new, climate adapted technologies in (and in collaboration with) the emerging economies.

In summary, there are strong reasons to imagine that not all adaptation activities should be mainstreamed too quickly in either developed or developing countries. However, there remain challenges in determining what types of activities should be mainstreamed quickly as opposed to those that need continued central attention; and in establishing incentives to ensure that this plays out towards successful climate-sensitive outcomes in the developing world. These issues in turn raise a further challenge, of knowing when adaptation is occurring successfully, to which we now turn.

1.2.5 Challenge 5: Measuring climate change adaptation and evaluating success

Adaptation will be required in response to the impacts of climate change, even in the presence of mitigation activities. First, the large-scale engineering works that will be required in many cases to implement mitigation initiatives will take many years to bring to fruition. Second, many years of training and development of human capital may be required to precede mitigation action. These timescale issues mean that adaptation is required to the climate change impacts that occur during the time that mitigation actions take to come on stream. Combined with the fact that adaptation is itself a learning process, they demonstrate the necessity for action now to address climate changes taking place now and in the future. Finally, mitigation cannot deal with all the impacts of climate change – there will be residual impacts we will need to deal with by adaptation.

How do we measure the 'success' or 'effectiveness' of an adaptation initiative? We need to understand whether this initiative is sufficient to address the impact, or whether it needs to be enhanced, changed or redirected. If it is successful, we should judge its transferability – adaptation does not necessarily travel well in time or space – measures introduced in one place may not work in other locations and, just because a measure (or portfolio of measures) worked well previously does not mean that it will work today or tomorrow.

In defining 'success', it is likely that the definition will be normative. This normative definition will be set about by considerations of fairness and equity, and of the trade-offs between adaptation for ecosystem well-being and human and community well-being – what is good for one may not necessarily be good for the other (Adger et al. 2005).

Given these considerations of a normative definition of 'success', measuring the success of an adaptation option is clearly not straightforward. Adger et al. (2005) defined a set of normative evaluation criteria based on effectiveness, efficiency, equity and legitimacy. Doria et al. (2009) used expert elicitation to seek a definition of successful adaptation to climate change. Their consensus definition is 'any adjustment that reduces the risks associated with climate change, or vulnerability to climate change impacts, to a predetermined level, without compromising economic, social, and environmental sustainability'. We argue here that considerations of scale are paramount in determining the success of adaptation, whether spatial or temporal scale.

Considerations of time

Adaptation projects which require large-scale, capital intensive and long lifetime structures must be evaluated for success taking into account performance over the total lifetime. Such projects include transport and energy infrastructure and networks, flood defences, and urban development and redevelopment. An adaptation option that appears successful in the short-term may appear less so in a few decades. Engineering solutions to frequent and often catastrophic flooding from the Mississippi River have continued for almost 200 years to build yet higher and longer flood levees following each successive flooding event. These solutions have proved to be breachable or to worsen flooding during subsequent events – the response being to build yet higher or longer levees, with the same outcome (Kusky, in press). It is only relatively recently that, in the Mississippi basin, alternative 'softer' adaptation strategies have been advocated with ecological solutions, such as wetlands that will intercept and hold rainfall *in situ* proposed (Hey and Phillippi 1995; Hey et al. 2009).

Planning very long-term adaptation projects has to take into account the uncertainties associated with projections of future climate change. Up until 2030, future projections suggest that temperature increases at least are broadly the same irrespective of greenhouse gas concentrations (Sanderson et al. 2011). However, after that date the amount and rate of warming is strongly dependent on the emissions pathway of greenhouse gases, and the underlying socioeconomic scenarios (Solomon et al. 2007). It is clear that increasing our knowledge of the processes underlying the enhanced greenhouse effect is not going to reduce these uncertainties. If anything, knowing more is likely to increase these uncertainties. Therefore, adaptation actions to address future climate change must be flexible, incorporating the ability to adjust and modify as knowledge increases, i.e. an adaptive management process. A portfolio of mutually supportive adaptation measures with multiple benefits will deliver to these requirements. The portfolio is likely to involve 'low regrets' actions that address present-day vulnerabilities to climate but also improve resilience to future climate change, irrespective of the nature of that change. An exception is adaptation to sea-level rise, where the timescales for planning and implementation of defence structures are very long, the threat is real and understood, and the level of certainty around at least the sign of change is high.

It is difficult to assess the success of something that is designed to address a problem that won't fully emerge for many decades and/or climate extremes which are, by definition, rare, even if their frequency and intensity are increasing. And, if we are successful, there will no longer be a baseline against which to make a comparison in order to evaluate that success. Some of these slightly esoteric points can be addressed. First, some changes are already happening, and attempts to address these changes through adaptation can be evaluated because action is piecemeal and many no-action baselines do still exist. Second, even decades ahead, not everyone everywhere will adapt, and so baselines will continue to exist although we may need to look further afield to identify them. This implies the need for a well-nested monitoring system, for indicators of adaptation which take into account leads and lags, and a process for continually updating and validating these indicators over time. All of these requirements pose significant challenges.

Considerations of spatial scale

Spatial scale is also relevant. In looking to evaluate the 'success' of an adaptation activity, how widely do we look? What is an adaptation in one location may result in negative impacts elsewhere, i.e. it becomes a maladaptation (Barnett and O'Neill 2010). We have seen this with respect to the enactment of legislation and court cases around weather modification, especially cloud seeding for rainfall, in the United States. No doubt climate change adaptation will lead to the development of a body of legislation to control activities.

It is the actions of many different actors – individuals, communities, local governments through to national governments – that lead to maladaptations when considered in their totality. A good example at the international scale occurred in the (northern) summer of 2010, when Russia experienced its hottest summer on record which, together with a drought which is estimated to be the worst in 50 years, led to devastating forest fires throughout late July and August (MacFarquhar 2010). Wheat yields were reduced by 20–30%, leading the Russian government to ban wheat exports, first until the end of 2010 and, subsequently, until the results of the 2011 harvests were known. Russia is one of the world's top wheat exporters and, in 2009, the third largest. In response to the Russian export ban, grain prices rose on the world market (see Figure 1.9). This action by the Russian government was reminiscent of 2007, when low grain stocks and drought in Australia (also a large wheat exporter) led to record high international prices and, in some hard-hit less-developed countries (for example Mexico and India), food riots. Although an underlying cause of these price rises was climatic, we wouldn't claim that they were forced by climatic change. But as the

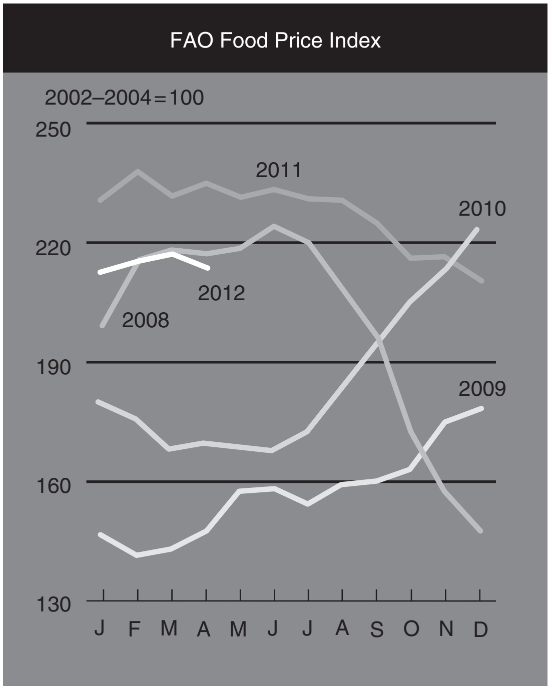

Figure 1.9 FAO Food Price Index. (From Food and Agriculture Organisation of the United Nations website at www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en with permission). For a colour version of this figure please see Plate 4.

effects of climate change begin to make themselves felt, this type of self-protective reaction by governments with far-reaching consequences is likely to become much more common in the absence of recognition of the reality of climate change and a willingness to formulate policy now. Such actions address the immediate impacts of a climate extreme, but in themselves impact widely upon trading partners, food aid and ultimately national and international security.

Who counts?

An activity which supposedly delivers to the needs of adaptation may prove to be unsuccessful when considered from the standpoint of delivery to mitigation or sustainability across the range of spatial and temporal scales. From whose perspective do we evaluate an adaptation activity? Whose needs should be paramount? Are they those of government or of community? If you improve the resilience of a village, will central government care? If central government builds a dam to improve water supplies and displaces ten villages is that a successful adaptation? If market forces rule, and water availability is managed through pricing, who looks after the interests of the poor and disadvantaged? Who maintains environmental flows?

1.3 First International Conference on Climate Change Adaptation, 2010

This book draws on the work of presenters at the First International Conference on Climate Change Adaptation, held in Queensland in 2010. The prime driver for organising this conference was the lack of an international forum focused solely and explicitly on climate change adaptation – providing opportunities to learn about the latest research developments, to network with colleagues and to share and build understanding, expertise and capacity among researchers and decision-makers in this critically important field.

We cannot manage climate change solely through mitigation: the timescales to implement mitigation strategies and reap the benefits are too long, in terms of building expertise, design, implementation and outcome. By the time responses come on stream, serious impacts of climate change will already be felt. Indeed, and particularly among ecosystems, such impacts are already emerging (e.g. Rosenzweig et al. 2008). Both adaptation and mitigation strategies are necessary to manage climate change, but neither is sufficient alone. And yet, in 2010, the spotlight still shone on mitigation actions, and adaptation was the poor cousin – something to be done when everything else failed. That story has changed now, and the 2010 conference was just one of a growing number of initiatives to bring adaptation to the forefront in response to lack of international action on mitigation.

The conference organisers started with three requirements: (1) it should be an international conference, (2) it would be the first of a biennial conference series on climate change adaptation (3) it should be a conference as much for decision-makers and policymakers in adaptation as for researchers.

In all three of these requirements, we were successful. The conference attracted over 1000 participants from 50 countries. By the end of the conference, we had already identified the next venue: the second international Climate Adaptation Futures conference took place in Arizona, USA, in June 2012, and the third is planned for Brazil in 2014. The 2010 conference programme was developed to appeal to the totality of the very diverse adaptation community, with around 40% of participants identifying themselves as practitioners within government and private sector.

1.4 From conference to book

How did we choose the papers that appear in this book? The book was never intended to be simply a proceedings – much more than that, it seeks to reflect on the pressing issues around climate change adaptation today, as addressed by speakers at the conference based on their talks and subsequent activities.

The book is divided into nine sections. In the first, introductory, section, there is this chapter, together with a transcript of the presentation by Steve Schneider on uncertainty, limits to adaptation and adapting to 4 °C of warming – a topic which has become increasingly relevant since 2010. Sadly, Steve died very shortly after giving this presentation, which was one of his last. We are very grateful to Terry Root for giving permission for this transcript to be published here.

The next section is a consideration of advances in adaptation thinking. Ash and Stafford Smith look at the science questions that adaptation research needs to address on behalf of practitioners, and consider the extent to which these questions are being successfully answered. They propose an integrated and coordinated research framework in order to improve the quality and delivery of outputs. Howden et al. look generally at agriculture and food security, but this is a very wide-reaching chapter, insightful on communication of knowledge, uncertainty in projections and their effects, and bridging the science–policy interface. This section on advances also considers equity and economic impacts of adaptation (Adger), adaptation effectiveness (Kay et al.) and maladaptation (Barnett and O'Neill).

The third section examines enabling frameworks and policy for adaptation. Dovers explores the fitness for purpose of existing policies and institutions. Liverman examines the nature of the science–policy interface and, from her own great experience in this arena, looks at how scientists need to adapt in order to be effective at this interface. Mimura looks at processes for government decision-making, taking the example of Japan. Stafford Smith discusses the role of scenarios of the future in engaging stakeholders, and how these scenarios should be designed and delivered. McDonald looks at legislative frameworks for adaptation and Schuster at the role of insurance.

Section four is on engaging with stakeholders, recognising that, firstly, the generators of knowledge are often severely challenged by its communication and, secondly, that knowledge delivery needs to be tailored to the needs and capacity of the audience, even though those needs may be poorly articulated. Waschka and Torok make a comparative study of the mechanisms of communication. This chapter contains three case studies on tailored communication products: for decision-makers (Knauf), through video-based narratives (McCormick) and for Indigenous people (Woodward). Vandenbeld looks at communication around coastal retreat in New Zealand. Prior describes participatory processes to engage stakeholders and build consensus. Cohen et al. examine shared learnings, taking the case of the Columbia basin in Canada. Leonard and Parsons look at the cultural dimensions of adaptation with respect to Indigenous land managers in Australia.

Section five explores key challenges in adaptation and development. Ayers and Huq lead off with an overview of adaptation, development and the community. Dube explores climate change and sustainable development in Botswana. Dodman looks at urban poverty in developing countries, naming it as the biggest challenge for adaptation. Gemenne looks at the role of migration, proposing that, provided it is a considered and timely action by the individual, it can form a useful adaptation strategy. This is followed by a set of case studies in adaptation, development and poverty (Crick et al.).

Section six is the first of three sectoral sections, on natural systems and agricultural production. Hobday and Midgley look at ecosystems impacts and adaptation. Cowan explores the concept of using ecosystem management as an integrating framework for adaptation. On agriculture and adaptation, Conde et al. present a brief case study of coffee farming in Mexico. Batima et al. provide an overview of livestock management in Mongolia. Section seven is on water security and contains three regional case studies: for China (Xia and Tanner), for north-east Brazil (Magalhães) and for the Himalayas (Tiwari and Joshi). Section eight is on urban infrastructure and livelihoods. Mehrotra et al. look at adaptation in cities. Lynam et al. present a case study from Queensland, exploring interrelationships of well-being and adaptation. There are three regional case studies in this section: salinisation in the Mekong Delta and the response of agricultural communities through migration to the cities (Dunn); adaptation in buildings and infrastructure with examples from Australia (Riesz and Gilmore); energy efficiency in buildings, again using examples from Australia (Wang et al.).

Section nine is on extremes, disaster management and adaptation. Woolf et al. look at the knowledge base on extreme event risk and building capacity. Dwirahmadi et al. explore extreme-event management and the links to adaptation.

We have outlined the five principal challenges for adaptation in Section 1.1. How, then, do the papers in this book address these challenges? Here, for the reader who is seeking to understand more about the five greatest challenges for adaptation named in this chapter, we point you to some of the key relevant chapters:

Challenge 1: Understanding the balance of actions to adapt and actions to mitigate. Steve Schneider's talk teaches us much about the perils of a 4 °C warming and the need for immediate action on both adaptation and mitigation. Mark Stafford Smith, in his discussion of new scenarios for adaptation, touches on the challenges faced by adaptation when mitigation activities are insufficient.

Challenge 2: Understanding the necessity for both incremental and transformational adaptation. Stafford Smith, because he starts from the premise that warming can be expected to exceed the 'dangerous' threshold of 2 °C by a considerable margin, explores the necessity for both incremental and transformational change, and the trade-offs and synergies between them. Ash and Stafford Smith touch on this issue as they move to conclude that integrated approaches to adaptation are required to ensure effectiveness.

Challenge 3: Converting knowledge into action. The chapter by Howden et al., although ostensibly about adaptation, agriculture and food security, has much to say about this challenge, the nature of the science–policy interface, the need to create bridges and strategies to do so, and in particular the approaches that the science community needs to take. Liverman also explores the science–policy interface, in an insightful contribution illuminated by her experiences working as a scientist on adaptation policy issues with the US government and in international forums. Finally, Waschka and Torok explore the nuts-and-bolts practicalities of effective communication.

Challenge 4: Mainstreaming adaptation – where, when and how? The argument presented is that mainstreaming may not always deliver optimal outcomes for adaptation. Dovers looks at whether existing institutions are sufficient for successful adaptation, and argues that we should use the capacity that exists in institutional systems and policy processes rather than imagine wholly new institutions.

Challenge 5: Measuring climate change adaptation and evaluating success. Barnett and O'Neill write about frameworks for evaluating adaptation success and the risks of maladaptation. Kay et al. explore the meaning and assessment of adaptation effectiveness. However, there are many different standpoints from which to judge success and failure. From a social justice perspective, Adger looks at equity issues and fairness in adaptation, the role of the market and the need to ensure that the evaluation of success takes social justice into account. Dodman explores issues around equity, adaptation and the urban poor in developing countries. Dube looks at the interactions of adaptation and sustainable development from the particular standpoint of Botswana.

1.5 Now it's 2012, what has changed? Reflections on the future

The Climate Adaptation Futures Conference occurred in mid-2010, and no doubt much of the work reported there dated from 6–12 months earlier again. This volume reports impressions of the authors from soon after the conference, at times updated with more recent work. Therefore we complete this introduction with a brief reflection on what has risen to the fore since the conference, sometimes inspired by its three days of enthusiastic interactions.

The world has seen the ongoing implications of the major economic downturn that started in 2008 and is still playing out in struggling national economies and massive global debt in 2012. One major implication has been a distraction away from long-term issues of climate change towards economic issues that are perceived to be more urgent. Progress on mitigation and carbon prices has been slow, and the scientific community has become ever more unhappily confident that the global economy cannot be decarbonised in time to avoid significant warming – at least 2 °C but quite likely more. At the same time, scientific understanding of the intensely interconnected nature of the many global threats to environmental, social and economic systems has greatly increased. Global environmental changes range from increased occurrence of anoxic zones due to the disrupted nitrogen and phosphorus cycles, through dwindling accessible water supplies in some major regions of the world such as the Indo-Gangetic Plain, to increasing numbers of extreme events (these may or may not be strictly climate change related but their consequences are certainly affected by other global changes such as increasing population and urbanisation).

These challenging issues place much more pressure on good adaptation planning and risk management. Not only must we tackle preparations for higher levels of climate change more realistically and transformatively, but we must start to consider the nature of simultaneous adaptation to the unavoidable impacts of other global environmental changes as well.

On the other side of the ledger, the 2010 Conference emphasised how much activity there is in adaptation around the world, and this activity and the derived literature has continued to expand quickly. In the face of the negative reality that mitigation is proceeding too slowly, the positive news is that there is an immense store of human creativity and innovation being applied to the problem. One result is that attention has shifted much more strongly into the implementation of adaptation. With this shift has come: more thinking about getting beyond impacts and vulnerability to adaptation planning and actions; much greater attention on how to choose between adaptation options; clearer focus on delivering those options in collaboration with diverse users of research; a redirected emphasis on creating the right policy environment to support proactive adaptation; and a growing integration of the different strands of adaptation research. In all these activities, there is much to be done but encouragement to be had.

If these are important trends, what are the important questions that we might hope the next volume such as this will have progressed?

- What is a more deeply validated figure for the potential economic and social benefits of comprehensive, locally resolved proactive adaptation at national level across all sectors and all climate-change-related impacts?
- Can we understand the impacts of climate change in a more holistic way which will allow evaluation of interactions across all scales and all dimensions, so allowing us to devise and implement adaptation strategies which will address the totality of impacts and lessen the chances that the choices we make will lead to maladaptations?

- What governance and social learning arrangements enable a whole society to be resilient and proactive to rapid environmental change, incorporating faster institutional learning responses that can keep up with increasing rates of change?
- What global investment incentives can be put in place by whom, and how to make it advantageous for all involved players in the developing nations to rapidly develop 'green economies' that are deeply climate change ready?
- In recognition of the emerging likelihood that global climate change will take us to +3 °C and beyond, what are the adaptive strategies we will require, and do we have the capacity and the will to deliver them?
- How can we translate adaptation knowledge and adaptive capacity into action?

The adaptation research agenda over the next decade is likely to be driven by the search for answers to these questions. For practitioners charged with making adaptation happen, and with increasing the resilience of communities and ecosystems to climate change, the questions are more likely to lie around the evaluation of adaptation. How can we evaluate the success/effectiveness of adaptation actions? Are societies/ecosystems becoming more, or less, resilient to climate change? What are the underlying causes of these changes in resilience and vulnerability? To address these questions requires the identification of indicators of adaptation (Committee on Climate Change 2011), and programmes of monitoring and evaluation. It is only by taking this two-pronged approach, of researchers seeking to understand the underlying dimensions and interrelationships of adaptation, and of practitioners seeking to evaluate their successes and failures, that we are likely to successfully deliver resilient systems which are well adapted to climate change.

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