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# Successful adaptation to climate change across scales

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**Abstract**

Climate change impacts and responses are presently observed in physical and ecological systems. Adaptation to these impacts is increasingly being observed in both physical and ecological systems as well as in human adjustments to resource availability and risk at different spatial and societal scales. We review the nature of adaptation and the implications of different spatial scales for these processes. We outline a set of normative evaluative criteria for judging the success of adaptations at different scales. We argue that elements of effectiveness, efficiency, equity and legitimacy are important in judging success in terms of the sustainability of development pathways into an uncertain future. We further argue that each of these elements of decision-making is implicit within presently formulated scenarios of socio-economic futures of both emission trajectories and adaptation, though with different weighting. The process by which adaptations are to be judged at different scales will involve new and challenging institutional processes.


*Keywords:* Adaptation; Vulnerability; Scenarios; Sustainability; Decision making

## 1. Introduction

Climate change is a reality. Observed impacts of climate change on physical and ecological systems over the past century (documented in McCarthy et al., 2001 and Parmesan and Yohe, 2003 for example) are a forerunner of things to come. Along with changes in mean climatic conditions, the earth potentially faces irreversible and catastrophic system feedbacks and impacts associated, for example, with collapse of thermohaline circulation, the melting of the Greenland ice sheet (Gregory et al., 2004), or other singular events (Alley et al., 2003). Societies, organisations and individuals have adjusted their behaviour in response to past climatic changes, and many are now contemplating adapting to altered future climatic conditions. Much of this adaptation is reactive, in the sense that it is triggered by past or current events, but it is also anticipatory in the sense that it is based on some assessment of conditions in the future.

Adaptation is made up of actions throughout society, by individuals, groups and governments. Adaptation can be motivated by many factors, including the protection of economic well-being or improvement of safety. It can be manifested in myriad ways: through market exchanges (Smit et al., 2000), through extension of social networks (Adger, 2003), or through actions of individuals and organisations to meet their own individual or collective goals. It can be undertaken by an individual for their own benefit or it can be made up of actions by governments and public bodies to protect their citizens.

These levels of actions take place within hierarchical structures such that the levels interact with each other.

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Thus, individual adaptation actions are not autonomous: they are constrained by institutional processes such as regulatory structures, property rights and social norms associated with rules in use. The hierarchical structure extends beyond the nation state: Article 3 of the UN Framework Convention on Climate Change encourages governments to adapt to climate change, and the Delhi Ministerial Declaration on Climate Change and Sustainable Development, issued at the Eighth Conference of the Parties of the Framework Convention on Climate Change in 2002, stated that adaptation 'is of high priority for all countries' and that 'adaptation requires urgent attention and action on the part of all countries'. The scales of appropriate adaptation also extend to lower elements of the political and jurisdictional scale. Municipalities, cities, firms and markets are all adapting within the bounds of available technologies, regulatory systems and knowledge of future climate risks (e.g. Lindseth, 2004; Næss et al., 2005).

If, as we argue, adaptation is an issue relevant at local, national and international levels, then it is possible to characterise effective or successful adaptation both independent of the scale and in its scalar context. In the broadest terms, the success of an adaptation strategy or adaptation decision depends on how that action meets the objectives of adaptation, and how it affects the ability of others to meet their adaptation goals. Crucially, an action that is successful for one individual, organisation or level of government may not be classed as successful by another. Success therefore depends on scale of implementation and the criteria used to evaluate it at each scale. This paper explores criteria for measuring the success of adaptation, taking into account explicitly the effect of scale. First, however, it is necessary to clarify the definition of adaptation and review who adapts to climate change and why.

## 2. Adaptation to climate change: scale matters

### 2.1. Defining adaptation: purpose and outcome

We define adaptation to climate change, in a manner similar to the IPCC (2001), as an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities. Adaptation can involve both building adaptive capacity thereby increasing the ability of individuals, groups, or organisations to adapt to changes, and implementing adaptation decisions, i.e. transforming that capacity into action. Both dimensions of adaptation can be implemented in preparation for or in response to impacts generated by a changing climate. Hence, adaptation is a continuous stream of activities, actions, decisions and attitudes that informs decisions about all aspects of life, and that reflects existing social norms and processes. There are many classifications of adaptation options (summarised in Smit et al., 2000) based on their purpose, mode of implementation, or on the institutional form they take. In this paper, to better explain adaptation, we have focussed on the intention of the adaptation and the impact of the adaptation.

Adaptations are not isolated from other decisions, but occur in the context of demographic, cultural and economic change as well as transformations in information technologies, global governance, social conventions and the globalising flows of capital and (to a lesser extent) labour (see O'Brien and Leichenko, 2000). It can therefore be difficult to separate climate change adaptation decisions or actions from actions triggered by other social or economic events. Some adaptations can be clearly identified as being triggered by climate change, and those adaptations are often purposeful and directed, as can be seen in the UK government's creation of a UK Climate Impacts Programme and the widespread implementation of that programme. Adaptations can also arise as a result of other non-climate-related social or economic changes: a householder deciding to move from an area at increasing risk of flooding to an area at lower risk, for example, may not be primarily motivated by climate change, but rather by other demographic or economic factors. Clearly, attributing adaptations to climate change is not a simple process.

Irrespective of motivation for adaptation, both purposeful and unintentional adaptations can generate short-term or long-term benefits. But they may also generate costs when wider issues or longer timeframes are considered. Adaptations may amplify the impacts of climate change by ineffectual and unsustainable anticipatory action, as can be seen in the changing demand for air conditioning in cars and homes following a series of hot summers in the UK over the past ten years. Adaptations to non-climate drivers can increase vulnerability to climate change stress. For example, demand for riverside and coastal properties in the UK has increased over the past 30 years as these properties are associated with higher quality of life; hence, they can also command higher prices (Hertin et al., 2003).

More recent awareness of the heightened flood risk associated with living in flood prone areas may change the price signals that currently place a premium on coastal or riverside properties. The success of climate-related adaptation actions may therefore be negated by reactive adjustments by economic actors, governments, individuals, and biota that form part of the process of continual adjustment to social and ecological change driven by multiple factors. A further example of this can be seen in the UK construction industry. Instead of incorporating new technology or approaches into new

home construction to build more 'adaptive homes', i.e. that are better suited to the changing climate, the current bidding processes for housing construction contracts seem to be constraining the capacity of the construction industry. The bidding processes tend to favour lowest cost bidders—which then leads to least-cost construction as opposed to most-appropriate construction (Sorrell, 2003).

### 2.2. Who makes adaptation decisions?

Adapting to climate change involves cascading decisions across a landscape made up of agents from individuals, firms and civil society, to public bodies and governments at local, regional and national scales, and international agencies. As mentioned above, a broad distinction can be drawn between action that often involves creating policies or regulations to build adaptive capacity and action that implements operational adaptation decisions. The latter will often be constrained and influenced by a higher-level adaptation framework as well as the institutions that define all aspects of activity in that society. For both public and private agents, where objectives of adaptation are explicit, they are often diverse.

Actions associated with building adaptive capacity may include communicating climate change information, building awareness of potential impacts, maintaining well-being, protecting property or land, maintaining economic growth, or exploiting new opportunities. The objectives associated with implementing adaptation decisions are more likely to focus on reducing the cumulative impacts of climate change, ensuring that adaptive measures taken by one organisation do not adversely impact upon others, avoiding anticipated adverse impacts of climate change, and ensuring that the distributional impacts of adaptation are minimised. Reilly and Schimmelpfennig (2000) point out that some adaptation occurs without explicit recognition of changing risk, while other adaptations incorporate specific climate information into decisions. Since unintentional adaptation has the capacity to reduce the effectiveness of purposeful adaptation, the integration of adaptation actions and policies across sectors remains a key challenge to achieve effective adaptation in practice.

Classifications of purposeful adaptations based on objectives of adaptation strategies frequently focus on measures which share the loss, bear the loss, modify the event, prevent effects, change use or change location (Burton et al., 1993). This classification is an expansion of the three cornerstones of adaptation: reduce the sensitivity of the system to climate change; alter the exposure of the system to climate change; and increase the resilience of the system to cope with changes. *Reducing the sensitivity* of the effected system occurs by, for example, increased reservoir storage capacity, planting hardier crops that can withstand more climate variability, or ensuring that new buildings in flood plains are constructed with a floodable ground floor. *Altering the exposure* of a system to the effects of climate change can be achieved, for example, by investing in hazard preparedness and undertaking climate change mitigation activities. *Increasing the resilience* of social and ecological systems (Adger, 1999; Turner et al., 2003; Luers et al., 2003; Tompkins and Adger, 2004) can be achieved through generic actions which not only aim to enhance well-being and increase access to resources or insurance, but also include specific measures to enable specific populations to recover from loss.

The spatial scale over which these three dimensions of adaptation can be implemented varies, as does the role of international and national policy, individual and collective action. All dimensions of adaptation can be implemented at any scale. In some cases, reducing exposure to impacts and changing the physical characteristics of impacts may only generate individual benefits if others collectively invest in these adaptations too. This may be the case in coastal communities where there may be a need for sea defences. In other cases, individual action will be adequate and specific public policy intervention may not be required to generate individual benefits from adaptation, although the adaptation actions are clearly reliant on permissive regulatory frameworks. In general, efforts to improve the ability of whole populations to recover from loss are more often tackled through public policy intervention at the national scale.

The scales of adaptation can be illustrated with the example of anticipatory adaptation decisions in the context of public water supply in England and Wales. Arnell and Delaney (2004) map out the competing imperatives of adaptation across the scales involved. The UK national government requires water supply companies to take climate change 'seriously' and put in place plans that allow them to deal with a changing climate without specifying the detail of these plans. The broad aim of the policy advice is to ensure reliability of supply and the sustainable use of water resources at the national level. At the next tier of regulation, the environmental regulator (Environment Agency) and the economic regulator (Ofwat) both require companies to consider climate change, and provide some more specific rules to aid decision-making. The Environment Agency's aim is to ensure the sustainable use of the water environment and to maintain a reliable supply, while the aim of the economic regulator is to safeguard the interests of customers whilst ensuring that companies remain commercially viable.

At the fine-grained local scale individual private-sector water supply companies make decisions to ensure security of supply under climate change by changing the way they manage water resources or through demand management to encouraging individual consumers to

alter their behaviour. Their aim is to continue to meet service standards specified in their licence to operate whilst providing appropriate returns to their owners. Individual customers adapt their water consumption habits, partly for altruistic reasons ('to protect our rivers') and partly for economic reasons, responding to price signals in metered domestic water supply.

There are three major lessons from the literature on cross-scale dynamics for implementing adaptation actions across regulatory and stakeholder landscapes (e.g. Adger et al., 2004; Wilbanks, 2002; Rotmans and Rothman, 2003). First, the issue of adaptation can become a crucible for amplifying existing conflicts over objectives between private and public agents. Second, the institutional interactions in adaptation to climate change at different scales are not some natural pattern dependent on the physical risk. Rather, they are the outcome of interactions between the benefits of action or the costs of inaction. Environmental issues are defined by society to be appropriately tackled at a particular scale: ultimately the choice of how an environmental governance problem is handled within a jurisdiction is a reflection of the strength of the interests and power of the actors who define the problem. Understanding adaptation therefore requires consideration not only of different scales of human action, but also of the social construction of appropriate scales by institutions to further their own aims.

The third lesson from the literature on cross-scale dynamics is that adaptation across scales in ecological systems adds complexity, since different biological and ecosystem processes dominate at different levels. The resilience of systems is defined by their ability to self-organise and is emergent from cross-scale and within-scale interactions (Peterson, 2000). At the same time, cross-scale linkages (crossing boundaries from local to global levels) are commonly asserted to be important in social processes. Yet in examining adaptation, the dynamic nature of linkages between levels of governance is not well-understood, and the politics of the construction of scale are often ignored. In examining the potential for adaptation in the management of Pacific salmon fisheries, for example, Miller (2000) demonstrates that various organisations choose to emphasise trans-boundary management issues in jurisdiction, while others choose to ignore those cross-scale issues.

## 3. Defining successful adaptation

### 3.1. Criteria for success

We have argued above that adaptation actions are undertaken with different objectives. Defining success simply in terms of the effectiveness of meeting objectives, however, is not sufficient for two reasons. First, whilst an action may be successful in terms of one stated objective, it may impose externalities at other spatial and temporal scales. What appears successful in the short term turns out to be less successful in the longer term. The rush to install domestic and commercial air-conditioning in western Europe following summer heat waves, for example, represents an effective adaptation for its adopters, but is based on energy- and emissions-intensive technologies and therefore may not be sustainable in the long term. Second, whilst an action may be effective for the adapting agent, it may produce negative externalities and spatial spillovers, potentially increasing impacts on others or reducing their capacity to adapt. Much coastal planning for increased erosion rates, for example, involves engineering decisions that potentially impact neighbouring coastal areas through physical processes of energy dissipation and sediment transport (Pethick and Crooks, 2000).

The definition of success clearly, therefore, depends on both the spatial and the temporal scale, and should not simply be assessed in terms of the stated objectives of individual adaptors. The issues of governance and the wider effectiveness of adaptation are also critical, and can be assessed through reference to equity, legitimacy and the economic efficiency of adaptation. Adaptation to climate change, therefore, can be evaluated through generic principles of policy appraisal seeking to promote equitable, effective, efficient and legitimate action harmonious with wider sustainability (see de Löe et al., 2001; Fankhauser et al., 1999; Burton et al., 2002). In the following sections, we address first the issue of effectiveness and efficiency, before examining the equity and legitimacy of adaptation actions.

It is, however, important to note that these criteria of efficiency, effectiveness, equity and legitimacy are contested and context specific, and are based on competing values (Adger et al., 2003a). The relative importance attached to each criterion will vary between countries, between sectors within countries, and over time as attitudes and expectations change. Most importantly, the relative weight placed on these values varies between actors engaged in adaptation processes, depending on their world view and perceived limits to responsibility (Haddad, 2005). Arguably, conflicts over the allocation of resources, for adaptation and other purposes, reflect different perceptions of progress as a central dilemma of development (Low and Gleeson, 1998). Private-sector decisions are often assumed to focus on economic efficiency, particularly when the outcomes of the decisions are judged by share performance in capital markets. Decision-making by public bodies are also driven by economic efficiency—seeking to implement objectives such as those termed 'best value', for example in UK public expenditure. Nonetheless, the distributional effects and the legitimacy of the decision are also important.

Less obviously, the relative importance attached to different criteria will vary with the perceived limits to an agent's area of responsibility. A public sector agency may, for example, ignore the environmental or developmental effects of an action because they can be externalised in the decision-making process so that they become "somebody else's problem". The spatial scale over which the action will be evaluated, therefore, also influences the weighting given to different criteria.

### 3.2. Effectiveness in adaptation

Effectiveness relates to the capacity of an adaptation action to achieve its expressed objectives. Effectiveness can either be gauged through reducing impacts and exposure to them or in terms of reducing risk and avoiding danger and promoting security (see for example Jones, 2001). The effectiveness of adaptation can sometimes be directly measured—for example, the number of houses removed from high hazard locations can be counted—but more often the effectiveness of an adaptation measure is more elusive: effectiveness depends on the sequence and interaction of adaptations over time. The impacts of interventions in public health to reduce the risks from extreme temperatures or epidemics, for example, can be estimated through standard techniques such as estimating the avoided impact of disease burden, and dose–response estimates of projected cases associated with particular risks (McMichael et al., 2004). Yet the complex causal chain of behavioural feedbacks makes any such estimation of the effectiveness of public health interventions and the effectiveness of individual actions problematic (McMichael and Githeko, 2001; Kahn, 2003).

There are a number of issues surrounding measurement of the effectiveness of adaptation. First, there may be uncertainty over how a particular adaptation option will work even under defined conditions. The effectiveness of physical flood defences in reducing inundation is relatively well-known, for example, whilst the effectiveness of 'softer' engineering approaches—such as creation of coastal wetlands, river channel restoration or managing farmland to reduce flood runoff—may be equally effective. Yet this effectiveness is rather more difficult to predict or evaluate.

Second, the effectiveness of an adaptation option introduced by an organisation may be reliant on actions taken by others. Demand reduction as an adaptation option in the water supply industry, for example, relies on individual consumers to reduce their consumption of water; the effectiveness of flood warning schemes depends on whether and how floodplain occupants respond to warnings. The individual uptake of adaptation options is highly uncertain, but there is considerable empirical evidence (often from hazard research: Wilbanks and Kates, 1999) that there are many constraints on individual adaptation. The effectiveness of adaptation measures which rely on individual actions may therefore be very difficult to assess.

Third, the effectiveness of an adaptation action may depend on the future—unknown—state of the world. The effectiveness of a measure to reduce sensitivity to a physical hazard will depend on future climate. For example, the degree to which a new reservoir provides future security of water supply will depend on the extent of climate change, and the standard of service provided by a flood protection embankment will depend on the future flood regime. Effectiveness of an action may also depend on future social and economic conditions. Declining incomes, for example, may reduce the effectiveness of measures which rely on individuals taking adaptation actions themselves, and changes in attitudes towards regulation may influence the effectiveness of adaptation measures based on rules and regulations. Two key indicators of the effectiveness of an adaptation action are therefore *robustness to uncertainty* and *flexibility*, or ability to change in response to altered circumstances. Some adaptation measures are inherently more robust and less sensitive to changing conditions than others. For example, the future technical effectiveness of flood protection embankment depends on the future relationship between flood frequency and flood magnitude (in other words, its design standard may be significantly reduced in the future). In contrast, the effectiveness of a flood warning scheme would be unaffected by future changes in climate (as long as the climate change did not change the physical nature of the hazard).

Fourth, whilst an adaptation measure may be effective at reducing the impacts of climate change or increasing opportunities in one location or time period, it may increase pressures "downstream", or lessen the abilities of others to adapt to climate change. A flood embankment, for example, often simply increases flood hazard downstream.

Potentially, any adaptation action can create unintended impacts on other natural and social systems. Measures to reduce exposure and sensitivity to a climate hazard have the greatest potential to impact on other elements of the physical and ecological environment. Measures to increase resilience are less likely to have an environmental impact, although clearly they can if they focus solely on achieving short-term objectives without taking into account wider sustainability considerations. In practice, there may be considerable uncertainty over the impact of an adaptation action. In some cases the impact may be clear and immediate, and past experience may be a very useful guide. In other cases, for example where the action is innovative, the consequences may not be known. The adverse effects of traditional 'concrete' engineering approaches to flood management, for example, are well-known, but the adverse and

beneficial effects of soft engineering approaches (such as river channel restoration) are very uncertain.

Significantly, however, the assessment of the effectiveness of an adaptation action may be dependent on the spatial and temporal scales over which the change is viewed. Longer time scales may reveal greater change as the natural and social systems adjust to altered circumstances; larger spatial scales may reveal "downstream" impacts of an action.

### 3.3. Efficiency in adaptation

Adapting to climate change entails costs, but should also yield significant benefits. At the scale of the individual organisation the costs will be those of implementation, including transaction costs and the costs of inaccurate prediction (see also Ingham and Ulph, 2003), and the benefits, those of reduced impacts or enhanced opportunities. There is, however, at any scale of analysis far more to economically efficient adaptation than a simple comparison of quantified costs and benefits.

Any assessment of the economic efficiency of adaptation actions requires consideration of, first, the distribution of the costs and benefits of the actions, second, of the costs and benefits of changes in those goods that cannot be expressed in market values, and, third, the timing on adaptation actions. The distributional issue in adaptation has itself two specific dimensions: the balance between private and public costs and benefits of adaptation actions, and the regulatory system that determines the 'publicness' of benefits. Some elements of adaptation to climate change response are, in effect, public goods. These include conservation of nationally or internationally important habitats, conservation of common cultural heritage and the conservation of resources for future use. Other types of adaptation effectively involve private goods. If private firms in the water industry invest in knowledge of climate change risks, the costs and the benefits of this response are largely private.

Climate change planning by governments at present tends to concentrate on providing public goods such as scenario information, risk assessments in the public domain and public awareness campaigns (see Callaway, 2004). Hence, many response programmes at present avoid providing subsidies to private adaptation decisions. But the public and private elements of responding to climate change are not fixed: they are shaped by institutional and regulatory features in each sector of the economy. Further, they can change from public to private and back again over time (see Bakker, 2003 on the UK water industry, for example).

The second issue in assessing efficiency of adaptation relates to decisions concerning non-market benefits. Any assessment of the efficiency of an adaptation that incorporates only goods with market proxies (such as property, human health, or economic production) risks seriously underestimating both costs and benefits. Government-led adaptation to climate change often stresses public good elements of the problem such as ecological and aesthetic impacts and non-traded ecosystem goods and services as much as private market impacts (Fankhauser et al., 1999; Azar, 1998; Azar and Schneider, 2003). Environmental economics research demonstrates, however, that estimates of stated or revealed preferences for non-marketed goods are based on reference points of priced marketed goods which themselves are non-sustainable and distorted (e.g. Common and Perrings, 1992; Arrow et al., 2003). In other words, the prices of traded goods which form the basis of valuation of costs and benefits of non-traded goods are the prices which have led to non-sustainable exploitation of resources in the first place. The assessment of the underlying social costs and benefits of adaptation, and their distribution, is therefore problematic.

The timing of the adaptation action in relation to the climate change impact will also affect the perceived economic efficiency of an adaptation action. For organisations or individuals, where planning horizons are short (less than one year), capital turnover rates are high and systems can readily adjust, adaptation to short-term climate variability is all that is required to create an economically efficient response to climate change. A farmer deciding on which crops to plant next year needs to know the likelihood of drought next year rather than the likelihood of drought in 50 years time: long-term events are not relevant. On the other hand, where planning horizons are long, capital turnover rates are low and systems cannot quickly adjust, longer-term climate changes have to be factored in order to avoid costly planning errors. For example, a farmer considering investing in expensive irrigation works with a long life will need to take longer-term climate change into account to ensure that the investment generates net benefits.

### 3.4. Equity and legitimacy in adaptation

The success of an adaptation action can be argued to depend not only on its effectiveness in meeting defined goals, but also on issues of equity and perceived legitimacy of action. It is important to note here that present-day adaptations to the risks from climate change are imposed on present-day society as a result of previous actions in perturbing the climate system. The whole issue of adaptation therefore begins from a sub-optimal and 'unfair' starting position because of the intergenerational nature of the problem.

Equitable adaptations can be evaluated from the perspective of outcome (i.e. who wins and loses from the

adaptation) as well as who decides on the adaptation to take. The distributional consequences of environmental decisions range from the uneven spatial impacts of environmental change to the distribution and consequences of political and social change. The fairness of the rules by which decisions are made is fundamentally determined by the underlying distributions of power within the institutions that manage resources and often create vulnerabilities (Adger et al., 2005).

There are diverse principles of equity in outcome: these include principles of desert (i.e. who deserves to win or lose), equality, or need. Each principle has its own strengths (see Müller, 2001). For adaptation, equity in outcome means identifying who gains and who loses from any impact or adaptation policy decision. Assessments of this nature often demonstrate that many present-day adaptation actions reinforce existing inequalities and do little to alleviate underlying vulnerabilities (see Adger et al., 2003b, 2005; Thomas and Twyman, 2005). Reactive adaptation (such as reinstatement of infrastructure after impacts of extreme events) in particular tends to exacerbate vulnerabilities. Glantz and Jamieson (2000) among others, for example, argue that the impacts and recovery from Hurricane Mitch in Central America reinforced inequalities inherent in social and economic structures of land tenure and entitlement.

On the other hand, anticipatory adaptation actions that seek to cushion the effects of climate on exposed populations and facilitate recovery from impact, i.e. measures to improve the ability to respond to climate impacts, can 'level the playing field'. Measures to reduce poverty and increase access to resources could reduce present-day vulnerability as well as vulnerability to both climatic variability and climate change. Mangrove replanting in Vietnam, for example, is being undertaken to buffer coastal environments to reduce the vulnerability of coastal communities in the present day. Whilst the mangroves provide some physical protection, the greatest benefits come from the increased wealth generated from the ecosystem goods and services provided by mangrove forests on an annual basis (Tri et al., 1998).

In terms of equitable outcomes of climate change adaptations, the rules by which decisions are being made and the underlying distributions of power influence the legitimacy of the decisions. Legitimacy is the extent to which decisions are acceptable to participants and non-participants that are affected by those decisions. Legitimacy can be gained as well as compromised through the evolution of adaptation strategies. There are no universal rules for procedures that guarantee the legitimacy of policy responses because cultural expectations and interpretations define what is or is not legitimate (Brown et al., 2002). But again the social acceptability of the procedures for implementation of adaptation actions, such as land use zoning and planning controls or provision of flood shelters, is an important characteristic. Legitimacy and trust are also scale dependent—while individuals consent to adaptation strategies and policies implemented by their governments for the public good, they are less likely to recognise the legitimacy of action by other countries to meet their own adaptation objectives. Further, the legitimacy of adaptation decisions by governments rests on the authority of the information in the political sphere (in this case the perception of climate change risks) and on the legitimacy of the instruments of policy.

In summary, equity of outcome and legitimacy of decision-making are both central to the resilience and ultimately the perceived success of adaptation. Equity is important for instrumental reasons: development which is inequitable undermines the potential for welfare gains in the future (see Boyce, 2002 for example) and developments which lack legitimacy have less chance of full implementation. Equity and legitimacy are also goals in themselves (Low and Gleeson, 1998) in that fair public action defines both our relationships to the natural world and is a component of long-term sustainability. In addition, equity defines the relationship of how individuals relate to and respect other sections of society, locally and globally.

### 3.5. Evaluating success

Successful adaptation that balances effectiveness, efficiency and equity through decision-making structures that promote learning and are perceived to be legitimate is an ideal from which much adaptation inevitably diverges. One major hypothesis implied in the discussion above is that the sustainability of adaptation depends on the heterogeneity of adaptive capacity across different stakeholders. In contrast, in resource management theories, heterogeneity in capacity, benefits and objectives has been shown to be detrimental to sustainable resource management (Agrawal, 2002). The divergence between these two ideas applies as much to future capacities as to present capacities. It is clear from the diversity of development pathways that the success and sustainability of future adaptations will depend on how institutions and social and cultural attitudes change. The IPCC's Special Report on Emissions Scenarios (SRES: IPCC, 2000) presents four different narrative storylines describing the way world population, economies and political structure may evolve over the next few decades. There are, of course, other sets of narrative storylines describing future worlds (e.g. UNEP, 2002; Kemp-Benedict et al., 2002). The SRES storylines are defined along two dimensions, characterising a market versus community orientation, and a global versus local perspective. These narrative storylines demonstrate that both the basis for adaptation and

the weight given to the suggested criteria for successful adaptation change radically (see Arnell et al., 2004 for methods of development of the SRES storylines). Table 1 presents our assessment of the implied weighting of the four success criteria for adaptation discussed above within the main storylines.

These storylines demonstrate that where rapid economic growth over this century is based on global economic integration; the possibility that such pathways create new vulnerabilities in populations that are either excluded from such growth, or whose economic activities suffer as a consequence of such globalising trends are ignored (e.g. O'Brien and Leichenko, 2000; O'Brien et al., 2004). Thus, such scenarios give much greater implicit weighting to efficiency in the capacity to adapt in future, than those storylines associated with locally negotiated (B1)-type worlds.

Finding a balance between these four success criteria can lead to one criteria being completely disregarded, as to achieve success in one criteria may lead to abandonment of another. For example, we can see the inherent trade-offs between effectiveness and efficiency when considering flood defences. Most measures to reduce the physical impact of climate change are designed to provide some level of service or protection, i.e. a prescribed level of effectiveness. A flood protection scheme designed today to protect against the 100-yr return period flood, for example, will continue to provide protection to that physical level as climate changes over time, but the risk of overtopping will change. Clearly, installing such a flood protection scheme today to cope with climatic variability will also serve to lessen the impacts of climate change over the next few decades, but the standard of protection provided will vary over time.

When planning for climate change, the degree to which trade-offs can be made between these different success criteria remains unknown. Initial findings from a project exploring long-term coastal planning processes in Christchurch Bay, in southern England (see Few et al., 2004), reveal that the effectiveness of coastal defences, the net costs of the various plans, as well as the distribution of costs and benefits and the legitimacy of the decision-making process are all important to local and national decision-makers as well as the affected communities. Few and colleagues (2004) conclude that these apparent conflicts can be overcome by developing a more effective cross-scalar approach to coastal management and by encouraging new forms of collective involvement in decision processes. Such changes in

Table 1
Interpretations of criteria for successful adaptation implicit under the SRES storylines

| Storyline | Brief characterisation | Implicit interpretations of elements of success in adaptation |
|---|---|---|
| A1 | Very rapid economic growth with increasing globalisation, an increase in general wealth, with convergence between regions and reduced differences in regional per capita income. Materialist-consumerist values predominant, with rapid technological change. | Strong focus on economic efficiency and welfare maximisation at aggregate level and excluding the possibility of welfare losses or increased vulnerability of marginalised sectors.<br>Effectiveness interpreted in local, physical terms.<br>Little attention paid to the equity or legitimacy of societal processes. |
| A2 | Heterogeneous, market-led world, with more rapid population growth but less rapid economic growth than A1. The underlying theme is self-reliance and preservation of local identities. Economic growth is regionally oriented, and hence both income growth and technological change are regionally diverse. | Strong focus on economic efficiency and welfare maximisation at aggregate level—emphasis on nationally agreed objectives.<br>Effectiveness interpreted in local, physical terms.<br>Little attention paid to the equity or legitimacy of societal processes. |
| B1 | Same low population growth as A1, but development takes a much more environmentally sustainable pathway with global-scale cooperation and regulation. Clean and efficient technologies are introduced. The emphasis is on global solutions to achieving economic, social and environmental sustainability. | Strong emphasis on equity and legitimacy – an assumed social contract for sustainability within nations.<br>Effectiveness of adaptations interpreted broadly.<br>Large-scale economic criteria are relevant, with focus on distributional effects. |
| B2 | Population increases at a lower rate than A2, with development following environmentally, economically and socially sustainable locally oriented pathways. | Strong emphasis on equity and legitimacy – an assumed social contract for sustainability and explicit consent for adaptation actions for governments at multiple levels.<br>Effectiveness interpreted broadly, with emphasis on locally agreed criteria for success.<br>Economic efficiency relevant, with focus on distributional effects within local regions. |

Source: Storylines summarised from IPCC (2000).

the process of decision-making might also change the relative weighting that is given to the success criteria.

## 4. Conclusions

We have argued that adaptation to climate change impacts is necessary, that it is already occurring, and will occur with greater urgency in the future at a range of scales. Subsequent papers in this special issue demonstrate that the pathways towards adaptation, the technologies and the institutional forms of collective action are diverse, and that ensuring their sustainability and resilience in the context of uncertain futures represents a major challenge. Since climate change impacts are presently observed, adaptation should also be observable in contemporary society. There have been documented adaptations in markets such as insurance and reinsurance, coastal planning, health interventions, built environment, water resources, and adjustments and adaptations within resource-based livelihoods. The present process of national-level planning for adaptation by developed and developing countries represents a major resource effort in anticipatory planning and provides a first guide to its potential sustainability.

We have argued that adaptation that requires large-scale investment is likely to be episodic and staggered. It is likely to be triggered through extreme events that raise the consciousness of climate change within policy-making and hence giving legitimacy to governmental action. We have also argued that adaptation operates at different spatial and societal scales and that success or its sustainability needs to be evaluated against different criteria at these different levels. Elements of effectiveness, efficiency, equity and legitimacy are important in judging success, but the relative weight allocated to each criterion is not given but rather emerges from societal processes of consent and action. The degree of success critically depends on the capacity to adapt and the distribution of that capacity. The relative importance of success criteria is contested and will vary over time.

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