

Are there social limits to adaptation to climate change?

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Abstract While there is a recognised need to adapt to changing climatic conditions, there is an emerging discourse of limits to such adaptation. Limits are traditionally analysed as a set of immutable thresholds in biological, economic or technological parameters. This paper contends that limits to adaptation are endogenous to society and hence contingent on ethics, knowledge, attitudes to risk and culture. We review insights from history, sociology and psychology of risk, economics and political science to develop four propositions concerning limits to adaptation. First, any limits to adaptation depend on the ultimate goals of adaptation underpinned by diverse values. Second, adaptation need not be limited by uncertainty around future foresight of risk. Third, social and individual factors limit adaptation action. Fourth, systematic undervaluation of loss of places and culture disguises real, experienced but subjective limits to adaptation. We conclude that these issues of values and ethics, risk, knowledge and culture construct societal limits to adaptation, but that these limits are mutable.

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1 Introduction

Individual and societal adaptation to climate is nothing new, neither as an empirical reality nor as a theoretical construct. The resource irregularities offered by different climates and the precariousness which emerges from the vicissitudes of climate have both acted as significant stimuli throughout human history for social and technological innovation. Irrigation, insurance and weather forecasting are just three of the many human institutions which have been prompted and shaped by the interactions between our physical and imaginative encounters with climate. They are examples of how we have adapted our social practices in the face of variable climates.

In a new, deliberative and self-conscious way, however, adaptation to climate change has now become part of the contemporary discourse about the politics and economics of global climate change. It has been enshrined in the policy debate through its appearance in Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), where the ultimate objective of the Convention concedes that adaptation to climate change in relation to food production, ecosystem health and economic development can and will occur. Although much of the earlier international climate policy debate in the 1990s and early 2000s was pre-occupied with mitigation, the past decade has seen a growing attention given to adaptation—both its practice and its politics (e.g. Parry et al. 1998; Pielke et al. 2007).

Notwithstanding the potential insights offered by historical antecedents of change in human societies and their environment (e.g. from Huntington 1915, 2001; to Diamond 2005), the contemporary discourse of climate change adaptation has two quite distinctive foci. First, how can adaptation to climate change be facilitated and enhanced, given that there are at least several generations in the twenty-first century which will experience progressively changing climates? Second, given that efforts at mitigating further global climate change are contested (in desirability, effectiveness and feasibility), are there limits to adaptation by society beyond which politically or ethically undesirable outcomes occur? This latter question is bound up in the discourse of ‘dangerous climate change’, where the implication is that adaptation by society is limited, in some way, once climate change crosses some danger threshold.¹ Schellnhuber et al. (2006), Stern (2007) and Schneider et al. (2007) are three recent high profile reviews which have followed this line of reasoning. An important policy discourse, explicit for example in the policy position of the European Union, suggests that such a threshold is 2°C of global warming above pre-industrial levels. This target is in effect chosen to induce urgent action, given the high likelihood that this threshold will be crossed in coming decades (Schellnhuber et al. 2006).

The purpose of this paper is to examine the assumptions that underlie current notions of limits to adaptation and the associated concept of thresholds. We review underlying assumptions and empirical evidence from a range of perspectives, contending that many previous analyses have considered adaptation from narrower standpoints: predominantly ecological, physical, economic or technical. We put forward our case by articulating four propositions around ethics, knowledge, risk and

¹There are, for example, real and increasingly identified thresholds in the impacts of climate change such as non-linear changes in ecosystems and physical systems brought about through transitions in ecosystem function and process, often exacerbated by feedbacks at global and local scales (e.g. Vaughan et al. 2003; Scheffer et al. 2006).

culture which are designed to interrogate present understanding of adaptation, but also to challenge the existing research in this area. We believe it is more important that these propositions open up a much broader debate about what we mean by the limits of adaptation to climate change, than that they are true in any objective or empirical sense. Yet we suggest that these propositions are defensible and justifiable.

2 The nature of adaptation limits and four propositions

Within the climate change literature, adaptation is generally ‘adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities’ (McCarthy et al. 2001, p. 982). In essence, adaptation describes adjustments made to changed environmental circumstances that take place naturally within biological systems and with some deliberation or intent in social systems (Gallopín 2006; Nelson et al. 2007).

The discourse around limits to adaptation is frequently constructed around three dimensions—ecological and physical limits, economic limits, and technological limits. These dimensions offer various analytical capabilities for investigating adaptation to climate change and allowing adaptation to be present in various forms of policy assessment. Attention to ecological or physical limits to adaptation offers the prospect of investigating of such limits through physical modelling of, for example, agriculture and biodiversity under changing climates. Consideration of economic limits to adaptation lends itself to investigation through the use of cost-effectiveness analysis or cost–benefit analysis. Approaching limits to adaptation through an appreciation of technology suggests value in various types of technology mapping and innovation analysis, for example as applied to coastal defence or building design.

These ways of conceiving limits to adaptation are attractive because they offer analytical functionality, a functionality which sits easily alongside other key dimensions of climate change analysis: modelling changes in the Earth system and energy-economic modelling of mitigation policy. Indeed, the framing of Article 2 of the UNFCCC points in this direction, suggesting that there are independent, objective measures and thresholds of danger (Dessai et al. 2004; Oppenheimer 2005). On the other hand, these conceptions of adaptation limits imply that such limits can be defined predominantly in either exogenous or analytical terms. The conceptions give great weight to limits imposed from ‘outside society’ or limits where the risk can be quantified.

In this technological discourse, adaptation limits become synonymous with ecological thresholds, where a threshold refers to a state in sensitive ecological or physical systems beyond which change becomes irreversible. Such thresholds are beginning to be identified in ecological literature and refer to habitat ranges, ecosystem functions and threats of extinction of particular species (Parmesan and Yohe 2003; O’Neill and Oppenheimer 2002; Fischlin and Midgeley 2007). In addition, adaptation limits may also emerge from analyses of the economic costs of adaptation (e.g. Agrawala and Fankhauser 2008) or from the prospects for technological innovation for adaptation. These limits to adaptation are absolute and objective.

In contrast to the above caricature of adaptation limits as exogenously or analytically defined, we approach the question of limits to adaptation differently. We

start by thinking about the ways in which societies are organised, the values that they hold, the knowledge that they construct and the relationships that exist between individuals, institutions and the state. These organisational arrangements and social values are likely to vary widely within and between societies and are likely to change significantly over time (Inglehart 1997; O'Brien 2009). Values in this context refer to the personal or societal judgement of what is valuable and important in life. Values translate into action because they frame how societies develop rules and institutions to govern risk, and to manage social change and the allocation of scarce resources (Ostrom 2005). Indeed values, in some philosophical positions, are manifest in the processes and institutions that regulate behaviour rather than in the outcomes of resource allocations *per se* (Norton 2003).

In our approach to thinking about adaptation, limits are endogenous and emerge from 'inside' society. In this reading, what is or is not a limit to adaptation becomes a contingent question. It all depends on goals, values, risk and social choice. These limits to adaptation are mutable, subjective and socially constructed. How limits to adaptation become constructed, rather than how they are discovered, becomes the operative question.

This alternative conception of limits to adaptation suggests to us four meta-domains whose roles need to be explored in this social construction of adaptation limits: ethics (how and what we value), knowledge (how and what we know), risk (how and what we perceive) and culture (how and why we live). Each of these four domains interacts with the realities and constraints introduced by the physical world—including the weather and climate we experience, the consequences of changes to the climate system and the material impacts these changes cause. But our approach to the limits of adaptation places the locus for their construction inside society rather than outside it.

We offer four propositions about limits to adaptation each of which draws upon one of these four domains. And it is these propositions—relating to ethics, knowledge, risk and culture—which the rest of this paper elaborates and defends. It is through these propositions that we offer answers to the question of whether there are limits to societal adaptation to climate change.

Ethics: Our first proposition is that any limits to adaptation depend on the ultimate goals of adaptation, which are themselves dependent upon diverse values. This proposition on the centrality of values demonstrates that limits are defined by ethical principles. We see an important distinction between (1) approaches that seek to define risks of climate change that are tolerable, and hence that avoid system failure and unacceptable cost, and (2) other approaches that see adaptation as part of a wider process to enhance the well-being of society. Whatever the social goals of adaptation, the existence of diverse, and sometimes incommensurable, values held by the actors involved in decision-making around adaptation can act as limits if these values are not deliberated. The values that underpin adaptation decisions become more diverse and contradictory as one moves from small-scales and single agents to larger-scales and multiple agents. Values in society are not held in isolation and are different for different stakeholders with levels of influence and power over their own destinies. The normative issues of whose values count, the prevalence of externalities and the changing preferences over time for well-being and risk avoidance need to be made explicit.

Knowledge: *The second proposition is that adaptation need not be limited by uncertainties associated with foresight of future climate change.* Uncertainties in the context of climate change may relate to the provisional nature of scientific knowledge about future climates or about the contested nature and status of such scientific foresight. Different social and organisational cultures, and sub-cultures, approach foresight in different ways. These differences in the status of knowledge claims about future climate reveal differences in values and make problematic the delineation of any limit to adaptation to climate change but can have an important bearing on the way in which adaptation decisions are made. We argue, however, that methods of assessing robust adaptations can provide opportunities for overcoming any perceived limits imposed by uncertainties in future foresight.

Risk: *The third proposition is that social and individual factors limit adaptation action.* Factors such as perception of risk, habit, social status and age operate at individual decision-making levels but also constrain collective action. Individual adaptation hinges on whether an impact, anticipated or experienced, is perceived as a risk and whether it should (and could) be acted upon. At the policy level, adaptation policies, like many other areas of public policy, are constrained by inertia, cultures of risk denial, and other phenomena well known in policy sciences. We suggest that individual and social characteristics, in particular risk perception, interact with underlying values to form subjective and mutable limits to adaptation that currently hinder society's ability to act. Such limits could preclude adaptation at societal scales.

Culture: *The fourth proposition is that systematic undervaluation of involuntary loss of places and culture disguises real, experienced but subjective limits to adaptation.* This proposition is based on the observation that cultural assets are unique in place and time. Hence many impacts result in loss of assets sometimes irreversible that individuals value. This proposition also raises the issue of values that are largely independent of material assets, but rather rely on perceptions and representations of the world around us. This issue is under-researched and needs to be explored further, not least because culture is not static—all cultures and places change over time—and because what is deemed to have intrinsic social value also changes over time.

These four propositions are explored in detail in the following sections.

3 Proposition 1: any limits to adaptation depend on the goals of adaptation, which are themselves dependent on diverse values

Our first proposition about the limits to adaptation emerges from considerations about the goals of adaptation and the nature of decision-making around climate change adaptation, in particular considerations about the diversity and often incommensurability of values which adaptation agents possess that underpin these goals. This diversity of values may often lead to a paralysis of adaptation actions, such as failure to introduce or change regulatory incentives, or lead to contradictory outcomes, such as actions which simultaneously yet differentially enhance and reduce resilience in communities. We address the question of values, and hence understand the origin of the problem, by first looking at the scale and agency of adaptation decision-making and then by exploring the goals of adaptation.

3.1 The scale and agency of adaptation decision-making

Adaptation to climate change, and hence the limits to adaptation, can only be understood in context. This implies an appreciation of the nature of the operational, managerial or strategic decision that is at stake. This in turn requires the scale and agency of decision-making to be defined. Understanding the values that drive an adaptation decision is usually easier for decisions made at the micro-scale and by well defined agents than at the macro-scale and by diffuse agents. This perspective also requires some appreciation of the differences between adaptation decisions seen as private (e.g. the individual farmer or business) or public (e.g. a government agency). The values that are brought to bear on adaptation decisions become more diverse and contradictory as one moves from small-scales and single agents to larger-scales and multiple agents. If one of the roles of government is to resolve conflicts between agents to engender collective action, then the importance of governance in adaptation decisions becomes increasingly important as one moves along this continuum (Cash et al. 2006).

The problem of scale, value and governance in adaptation decision-making is manifest in the case of coastal management in the UK. Here, increased sea level and changing coastal morphology are increasing the exposure of coastal communities, from the erosive south and east coasts, to the storm-exposed Atlantic coasts (Tsimplis et al. 2005). The desirable adaptation strategy to rising sea-levels as perceived by an individual householder perched on an eroding cliff-line seems clear-cut: invest in beach replenishment or in hard defence structures. For each coastal local authority, responsible for 100 km or more of shoreline, a different set of values and governance issues come into play. For central government with a responsibility for the public purse and a national perspective, the values and the means for resolving value-conflicts are different again. Although all parties tend to appeal to principles of sustainability, the residents directly affected articulate victimhood and vulnerability, while central government priorities centre around fairness, cost-effectiveness and integrated and long-term planning (Few et al. 2007; Tompkins et al. 2008).

Similarly, when thinking about the inter-generational aspects of adaptation decisions, the diversity of goals of adaptation complicates attempts to define limits. The ways in which societies live with climate risks changes over time as values, lifestyles and technologies change (Toman 2006). Adaptation decisions taken today may impose negative environmental and social impacts on a future generation. The values of future generations are most often explicitly incorporated into today's decisions through formal discounting methods in economics. But issues around critical natural capital, the non-material aspects of choice and culture, are effectively excluded from economic analysis.

The dependency of adaptation decisions on scale and agency may point to hidden limits to adaptation in an increasingly complex and inter-connected society. McIntosh et al. (2000) have argued from a study of the ebb and flow of earlier civilisations that as societies become increasingly complex (e.g. divergent in values and with increasingly intricate forms of governance), investment in problem-solving activities (e.g. technical approaches to managing environmental risks) is subject to a law of diminishing return. Sobel and Leeson (2006) suggest that the impacts of Hurricane Katrina on New Orleans may be an example of complexity leading to failure. Here society was exposed to an environmental shock, to which its weakening

ability to resolve or reconcile divergent values through a complex governance structure induced catastrophic failure.

3.2 The goals of adaptation

Understanding the scale and unit of adaptation decision-making reveals the diverging goals of adaptation to climate change that exist. These goals will differ within a sector, a society, between nation states and, most intractably, between different generations. However, the goals of adaptation are rarely stated explicitly. For example, for some agents adaptation concerns conservation of status quo, while for others the current situation is undesirable and hence adaptation is about progress. The goal of adaptation will likely depend on who or what is adapting. For example, well developed institutions and wealthier societies or individuals may seek to maintain their current state or standard of living through adaptation, whilst developing countries may be aiming to continue developing and enhance the standard of living of their citizens. For those on the margins of society, the immediate priority may be to secure livelihoods or protect assets from climate and other risks. In ecosystems, successful adaptation is demonstrated by survival of the species in a changing environment, but not necessarily the survival of an individual (Rappaport 1977).

These divergent goals for adaptation emerge, in part, from different attitudes to risk (risk-takers versus the risk-averse), to disposition (a progressive versus conservative ethos) and to the adaptive capacity of future generations (optimistic versus pessimistic). This divergence in goals can be illustrated by the differing adaptation decisions made even within one business sector in one region. In a study of several house construction firms in England, Berkhout et al. (2006) showed radically different adaptation strategies adopted by different firms in the face of the same apparent risk—increased flooding of flood plains. Some firms withdrew entirely from such construction ventures, while others benefited from falling land values and compensated by investing in engineering solutions to increase infrastructure resilience. If such diversity in goal-setting applies across all sectors and societies it becomes problematic to talk about generic ‘limits to adaptation’.

While there are different perspectives on the goals and objectives of adaptation there is, however, little discussion in the adaptation literature on the role of social and cultural values in defining these goals and objectives (Camfield and McGregor 2005). The risk management literature focuses on adaptation to natural hazards, including both climate and non-climate related hazards (Burton et al. 1993). Adaptations, adjustments or coping strategies are used to respond to the perceived risk of, or experienced impact of, a hazard. These strategies have been classified by Burton et al. (1993) as: share the loss, bear the loss, modify the events, prevent the effects, change use or change location. These various strategies reveal different objectives of adaptation, although the overarching goal remains that of reducing the negative effects and increasing any benefits resulting from a hazard (Burton et al. 1993).

Within the context of the climate change debate, the purpose of adaptation is often seen as to reduce vulnerability or to enhance resilience to climate change and climate variability (Smit and Pilifosova 2001). Other perspectives on adaptation see it as closely related to sustainable development. Adaptation can be viewed as providing broader benefits, not just specifically to cope with climate impacts but as part of

the development process (Apuuli et al. 2000). The resilience approach, as applied to linked social and ecological systems, views learning and adaptation as important processes that improve system resilience to a range of shocks, achievable through adaptive management (Folke 2006; Nelson et al. 2007). Adaptation actions can be used either to build resilience to prevent collapse of a system or to reorganise the system and recover once a shock has caused a collapse.

There are trade-offs between the goals of building resilience and reducing vulnerability. Adaptive management approaches that promote resilience seek to learn from failure and promote the ongoing structures and functions of overall systems. Vulnerability approaches, by contrast, focus on the most endangered individuals or ecosystems and seeks adaptations that protect those, perhaps at the expense of robustness and resilience of the overall system (see for example Plummer and Armitage 2007; Dow et al. 2006; Eakin et al. 2009). Hence there are a range of possible goals of adaptation. The choice between them is taken by institutions of collective response based on the underlying values of society. This divergence of objectives in effect sets different ‘limits’ to adaptation where trade-offs and incommensurabilities mean that not all objectives can be met.

4 Proposition 2: adaptation need not be limited by uncertain knowledge of future climate change

Many scholars have argued that the effectiveness of adaptation responses is dependent on the level of certainty associated with climate change and impact projections (see Füssel 2007; Gagnon-Lebrun and Agrawala 2007). If so, and given that climate and impact projections at the regional and local level are subject to deep uncertainties, one would expect this lack of certainty—this lack of accurate and precise foreknowledge—to act as an important limit to adaptation efforts. This proposition suggests, however, that we should not consider uncertainties associated with foresight of future climate change a limit to adaptation.

The goals and processes of adaptation cannot be separated from the nature, status and legitimacy of knowledge claims about the future. Whilst knowledge about many areas of future development is relevant, here we focus this discussion around the future of climate. Science has claimed a greater degree of predictability for the climate system than it has offered for other, adaptation-relevant, dimensions of social change relating to economics, technology, demography and culture. How knowledge claims about future climate are assimilated into adaptation decision-making therefore becomes of great importance. Indeed more fundamental still, when thinking about the role of climate knowledge in adaptation is the way in which the agents of adaptation—individuals, institutions, governments—view knowledge about weather and climate from the deep past through the present to the long future.

When making a decision for which future climate is relevant a mental map of knowledge about possible future climates is required. Put simply, this mental map can be influenced by the deep climatic past (such as the idea of social memory of past weather extremes; Harley 2003), the present or recent experience of weather (e.g. derived from intuitive perceptions and guided by historical weather data; see case studies in Strauss and Orlove 2003), and the anticipation of future climate (such as

scenarios of climate change constructed from model simulations based on predictive science; Mearns et al. 2001; Hulme et al. 2002; Parson et al. 2007).

The weights given to these three influences in shaping expectations of future climate, and hence the imperative for adaptation decisions and their nature, will depend on many factors. Social and organisational culture will be important, as will social and behavioural psychology and the credibility, saliency and legitimacy of climate scenarios (Cash et al. 2003; see Hulme and Dessai 2008 in the context of the construction of UK climate scenarios). Credibility may mean quite different things in different cultures. The assumed hegemony of predictive scientific models of the climate system as the basis for scenario making (e.g. as presented by the IPCC), is not borne out by historical surveys of scenario exercises (e.g. Pulver and VanDeveer 2007).

A related example is the increasing attention given to individuals' and communities' knowledge and experience of past and recent climate, and the way this shapes their perceptions of future climate (Cruikshank 2001; Huntington and Fox 2005). The relevance and validity of local knowledge in climate change studies have been demonstrated by a number of studies (Orlove et al. 2000; Riedlinger and Berkes 2001; Berman and Kofinas 2004). However, many have been critical of the integration of local knowledge narrowly as decontextualised data within a scientific framework (Cruikshank 2001; Berkes 2002), and discussions remain over whether and how to overcome differences in epistemology as well as methodological, institutional and political challenges.

Central to an understanding of how scenarios of future climate are used in adaptation decision-making is to appreciate the ways in which they characterise uncertainty. Scenarios constructed from predictive scientific models of the climate system may be contested on epistemological grounds—scientific predictions as socially constructed simulations (e.g. Petersen 2006). But even where an epistemology is shared, resulting scientific uncertainties may limit their usefulness for adaptation decision making. Thus different approaches to characterising such uncertainty—narratives, quantitative alternative scenarios, or probabilistic descriptions (e.g. Dessai and Hulme 2004)—can have quite different effects on the types of adaptation decisions that are made, or not made.

Many commentators have argued that the lack of reliable predictions of future climate pose a major limit for effective adaptation to climate change. Often this argument is used to justify further investment in climate modelling capabilities in order to improve predictions of future climate. In an assessment of climate prediction and adaptation to climate change, Dessai et al. (2009) argue that society can (and indeed must) make adaptation decisions in the absence of accurate and precise climate predictions. They suggest that the limits to accurate and precise foreknowledge of future climate has been falsely constructed as an absolute limit to adaptation.

The accuracy of climate predictions is limited by fundamental, irreducible uncertainties. For climate prediction, uncertainties can arise from limitations in knowledge (e.g., cloud physics), from randomness (e.g., due to the chaotic nature of the climate system), and also from human actions (e.g., future greenhouse gas emissions, population, economic growth and development). Some of these uncertainties can be quantified, but many simply cannot, leaving some level of irreducible ignorance in our understandings of future climate uncertainty (Dessai and Hulme 2004).

Future prospects for reducing these large uncertainties remain limited for several reasons: widening uncertainties (as we gain more knowledge of how the climate system operates, some uncertainties remain irreducible), lack of objective constraints (with which to reduce the uncertainty of predictions) and the problem of model identifiability (different models can give the same prediction based on different physics). Furthermore, there is much evidence that shows that climate is only one of many uncertain processes that influence society and its activities. This suggests that climate prediction should not be the central tool to guide adaptation to climate change. We therefore argue that adaptation efforts are not likely, in effect, to be limited by the lack of reliable (accurate and precise) foresight about future climate conditions. An approach focused more on robust decision-making is less likely to be constrained by epistemological limits and therefore more likely to succeed than an approach focused on optimal decision-making predicated on the predictive accuracy of climate models.

Robust decision-making comprises a variety of analytic approaches proposed to identify and assess robust strategies (Lempert et al. 2006). Robust strategies perform well compared to the alternatives over a wide range of assumptions about the future. In this sense, robust strategies are “insensitive” to the resolution of the uncertainties. Decision makers developing such robust strategies systematically examine the performance of their adaptation strategies over a wide range of plausible futures driven by uncertainty about the future state of climate and many other economic, political and cultural factors. In this framing, they should choose a strategy that they find sufficiently robust across these alternative futures. Such an approach can identify successful adaptation strategies without accurate and precise predictions of future climate.

Differences in how social, organisational or individual understandings of future weather and climate are constructed can therefore lead to contrasting types of adaptation decision-making, or indeed can determine whether or not adaptation occurs. These epistemological and cognitive differences will inter-play (e.g., Knopman 2006) with the complex landscape of the scale and agency of adaptation decision-making and with the different goals of adaptation, as discussed previously. This inter-play will reveal—implicitly if not explicitly—different sets of values at work in the way societies adapt to climate change and make problematic the delineation of any limit to adaptation to climate change.

5 Proposition 3: social and individual characteristics act as limits to adaptation

Behaviours at the individual and social levels are contingent upon a wide variety of factors. As argued in proposition 1, underlying values determine decisions about whether and how to adapt to climate change. For individuals, and the societies they are members of, actions are shaped in part by deeply-embedded (but not static) cultural and societal norms and values. Some characteristics operate at the individual level and include beliefs, preferences, perceptions of self-efficacy and controllability. These, together with perceptions of risk, knowledge, experience, and habitual behaviour, norms and values determine what is perceived to be a limit to adaptation—at both individual and social levels in any particular society—and what is not. These limits are therefore not absolute and insurmountable but rather socially

constructed, subjective and mutable. It depends on individuals' underlying values and their enacting by societies whether a limit is perceived as such. This proposition is therefore firmly grounded in the sociology and psychology of risk. We argue that an insightful appreciation of individual and social actions—and conversely the limits to such actions—needs to be discussed and understood in terms of the characteristics of individuals and the societies that they compose, and how these affect perceptions of risk and related behaviours.

An important distinction that should be clarified here is that between 'limits' and 'thresholds'. Thresholds are points at which step changes occur in physical and ecological systems (Gordon et al. 2008). When systems change beyond a certain threshold they are often not likely to retain their original state. In this sense a threshold that is linked to irreversible change in particular, represents an absolute limit to maintenance of the status quo, but only a relative limit to adaptation. This is because adaptation could still be possible when the system in question moves to another state. In this proposition, however, we argue that adaptation is subjectively limited by social and individual characteristics. Therefore whether a threshold is a limit or not is value and perception-dependent (see related discussions in proposition 4 on places and cultures). In other words, it is perceptions, values and norms that either enable or constrain action, thus either encouraging or limiting adaptation. For example, if the possibility of a threshold being reached—and the system changing to a different state as a result—is perceived as unacceptable through a particular individual or societal lens, this perception would identify this threshold as a limit to adaptation. Through a different societal lens, however, the possibility of the same change and adaptation to it could be perceived as acceptable, and in this case reaching the threshold would not be perceived as a limit to adaptation.

O'Riordan and Jordan (1999) have shown that cultural theory is a useful tool in demonstrating that individuals' preferences are attached to different worldviews, and this has implications for adaptation to climate change. The profound differences in attitudes between egalitarians, individualists, fatalists and hierarchists mean that it is difficult if not impossible to agree on how to respond to an issue or problem. It has been suggested that values centred on pro-environmental, ecocentric and altruistic orientations can and do give rise to actions focussed around long-term sustainability (e.g. Fransson and Gärling 1999; Nilsson et al. 2004). However, these values currently neither reflect mainstream worldviews nor underlie present societal structures and institutional arrangements, which in turn act as limits to public engagement in adaptation to climate change (and indeed mitigation of emissions) (Dobson 2003; Horton 2005). A first step toward enabling more communities and individuals to adapt could be to make explicit the underlying values shaping preferences and decisions. Unless the structural aspects of human society that fail to support those values that can lead to proactive adaptation initiatives are changed, the practical implementation of broader adaptation activities remains questionable.

Evidence from community-based initiatives and activities indicates that individuals can feel enabled to responsibly implement behavioural alternatives through programmes that (a) encourage individuals to consider their behaviours in relation to environmental and societal impacts; and (b) provide a supportive environment for individual and community decision-making (e.g. Nye and Burgess 2008; Spaargaren and van Vliet 2000). These examples illustrate a small number of specific initiatives which prove conducive to behavioural change. At present there is little indication

of larger scale initiatives with similar outcomes. Much of the evidence on community initiatives stems from mitigative rather than adaptive actions (e.g. Kates and Wilbanks 2003; Moser and Dilling 2007). However, since it has been argued that the determinants of adaptive and mitigative capacity are essentially the same (e.g. Yohe 2001), we may infer that enabling adaptive initiatives can occur in a similar fashion as enabling mitigative action, from the bottom up. Their effectiveness will depend in part on how individuals' motivation to act can be harnessed. For instance, individuals with low self-efficacy (or an external locus of control) do not perceive themselves as able to act on perceived threats (Bandura 1977; Hines et al. 1987). A study of elderly people's perceptions of heat wave risks suggests that this relatively vulnerable group does not perceive its vulnerability and therefore does little to adapt (Wolf et al. 2009).

Perceptions of risk, knowledge and experience are important factors at the individual and societal level in determining whether and how adaptation takes place. Research in Norway, for example, shows that in situations where no risk is perceived, little if any action to adapt is undertaken a situation described as complacency (O'Brien et al. 2006). Choices are shaped by whether local impacts are known and are anticipated (see proposition 2), and by the cognitive-behavioural gap that exists in individuals between knowledge of impacts, values, beliefs, norms and action (Jackson 2005). Both hazards and adaptation research point to the importance of immediate priorities moulded, for example, by non-climatic impacts (O'Brien and Leichenko 2000; O'Brien et al. 2004) as drivers of behavioural change. To date there are many fewer examples of behavioural change in response to expected climatic impacts, or indeed to future climate change, than there are to experiences of current climate variability. Yet in the context of limits to adaptation, neither the hazards nor the risk literatures can provide an adequate indication of how mutable and constructed limits may be overcome, given the complex interactions between social and individual characteristics, with a view to securing sustainable societal adaptation in the long term. The survey of observed adaptation in the UK by Tompkins et al. (2005), for example, demonstrated that much planning involves building the capacity to deal with future events rather than anticipating and acting on expected specific risks.

Historic and current adaptation is and continues to be informed by perceptions and local knowledge based on previous experience of weather and climate (Vedwan and Rhoades 2001; Thomas et al. 2007). While adaptation activities are inherently local and are necessarily based on contextual knowledge, it is unclear how insights from the past could serve us in the face of future climate changes. Particularly in developed nations, climate change and its impacts, although generating concern, are also generally believed to be removed in space ('not here') and time ('not yet'). This may hamper a current appreciation of the impacts of climate change and how society and individuals could respond to these. Furthermore, individuals' failure to link experiences of extreme weather events to similar climate-related future occurrences (Whitmarsh 2008) can preclude long term behavioural learning, resulting little learning should a similar situation reoccur. In addition, the biased assimilation of knowledge means that only information congruent with pre-existing cognitions will be remembered (Lord et al. 1979; Rachlinski 2000). This implies that even if provided with information about how to adapt, people who do not believe adaptation is necessary are highly unlikely to retain or act on this information.

The psychological literature shows that most individuals tend to respond to issues, risks or concerns they consider as immediately and personally relevant (Moser and Dilling 2004; Paton et al. 2001). Although populations are not homogeneous, there is a tendency to operate myopically, discounting the potential future benefits of current actions (Stoll-Kleemann et al. 2001). Conceptualisations of the future have been linked to personal values, worldviews and religious beliefs (Tonn et al. 2006). There is also emerging evidence that adaptation in practice may be constrained by both perceived and actual adaptive capacity (e.g. Grothmann and Patt 2005). Thus, variations in risk perceptions, the distant nature of climate change, the failure to link current experiences with future events, the difficulty in identifying and implementing adaptation measures all suggest that little adaptation to climate change is occurring at individual levels, other than that driven by non-climatic factors.

At the organisation level, similar factors have been identified as limiting adaptation (Berkhout et al. 2006): lack of knowledge of climate change impacts and their identification; difficulty in assessing and implementing adaptation options. Furthermore, regulation and economic incentives may encourage behavioural change, but evidence for the permanence of behaviours resulting from such measures is not clear cut. For instance, the Water Services Regulation Authority (OFWAT, in England and Wales) requires water companies to consider adaptation in their long term plans, yet there is little evidence this has translated into specific adaptations due to conflicting temporal and other economic considerations (Arnell and Delaney 2006). The importance of policies and non-climatic drivers, in other words, currently play perhaps an even more important role in influencing adaptive behaviours to climate change.

Decisions are made regularly at individual and societal levels that have implications for current and future adaptation. We suggest that individual and social characteristics interact with underlying values to form subjective and mutable limits to adaptation that currently hinder society's ability to act. This could preclude adaptation at societal scales and in the future. These limits can be interpreted as personal and social, mirroring wider debates on the relative dichotomy of agency and structure in determining action (Giddens 1984). As small scale initiatives suggest, these limits are indeed relative and could be overcome, although on a large scale they may necessitate deep cultural and social change. Such changes, however, may imply modifying existing structures and value systems, thus threatening deeply held cultural, historical or ethnic identities. The next proposition turns to discuss these in more detail.

6 Proposition 4: the systematic undervaluation of involuntary loss of places and cultures disguises real, experienced but subjective limits to adaptation

Current climate change discussions frequently focus on biophysical transformation and their economic implications. But such analyses, framed in terms of utilitarian metrics, frequently fail to recognise that the experienced worlds of individuals and communities are bound up in local places and that the physical changes will have profound cultural and symbolic impacts. The Stern Review (Stern 2007), for example, incorporates irreversible catastrophic losses such as sea level rise from loss

of Greenland ice sheet as expected values and weights them with low discount rates. Ultimately, Stern (2007) concludes, however, that ‘we have conceptual, ethical and practical reservations about how non-market impacts should be included, though there is no doubt they are important’ (Stern 2007, p 187). Baer (2007) and Neumayer (2007) argue that this conclusion demonstrates only the limits of using economic calculus when externalities are pervasive. Turner et al. (2008) argue that losses that are indirect and cumulative are more likely to be invisible in environmental decision-making and that such losses typically include cultural and lifestyle losses, loss of identity, self-determination and influence, and changes which for those experiencing it represent ‘loss of order in the world’ (Turner et al. 2008, p.4).

In line with Turner et al. (2008), we argue that specific losses of physical places involve loss of attendant cultural and social significance that is invisible to the prevailing calculus (Adger et al. 2009). In some cases significant physical changes to places from climate change impacts will influence the ways in which individuals interact with the natural and social environments. These impacts are rarely included in the way that adaptation is framed or the subsequent decision making calculus. Proposition 1 addresses the incommensurability of goals and values and how choices must be negotiated. Here we suggest that by undervaluing culture and place we are ignoring certain limits to adaptation, which whilst subjective are real for those experiencing them.

The valuing of places and cultures does not imply that adaptation is the same as conservation. Cultures are never static as individuals and societies initiate change or respond to new sets of external conditions. Whether a result of a changing physical environment, emigrations, the influx of immigrants, or local innovations, cultures are always in flux. Place names in Nunavut, for example, are often descriptive of the environment and are important references for navigation. However, place names are also slow to change and the environmental conditions of the past are not the same as today, leaving a legacy of place names that do not correspond to the current environment (Henshaw 2003). These apparent misnomers highlight that populations in the region have been able to accommodate environmental change and adapt to new conditions. The dynamic nature of culture does not discount the value of a particular culture, especially when change is involuntary and, as in the case of climate change, results from anthropogenic emissions for which others are largely responsible. The projected changes associated with a warming climate will be irreversible and highly significant.

Landscapes are dynamic social constructions which reflect process and change through historical and contextual experience. As a result of the complex interactions of cultural, political, and ecological processes landscapes assume symbolic meaning and may have profound cultural implications (Baker 1992). Historical and contextual experience also leads to the development of rules, norms, and forms of governance to manage and interact with the environment (Young and Lipton 2006). Thus, part of the order and structure of societies is designed to interact with the physical environment and any change in the physical environment will influence these structures as well as the larger social system. The range of this influence varies in accord with the proximity of a society to the natural environment. For example, for some cultures a physical landscape provides social order by helping to define and regulate kinship relationships (Gow 1995). Nevertheless, all societies have affective ties between individuals, communities, and their material environments, and changes

in the environment affect individual and collective constructions of reality (Oliver-Smith 1991; Pretty 2007). The implications of a changing physical environment touch the core of how individuals and cultures may define themselves and their interactions with the world around them.

There is increasing evidence that particular places in the world will be transformed and, in effect, lost through the impacts of a changing climate. In the South Pacific, for example, there are significant concerns that sea level rise will force people to leave their islands (Adger et al. 2009). Migration is an adaptation, but involuntary migration may be undesirable to those leaving their homeland, and the disruptive impacts on economies, social order, cultural identity, knowledge, and traditions belie successful transitions (Adger et al. 2009). Modern history provides numerous examples of peoples who were forced to migrate as a consequence of dam construction, social reorganization, and national security. The outcomes of these movements have been strikingly similar and contain few successes. Amongst other problems, the severing of attachment to place may have devastating repercussions for individuals and societies strongly anchored to a particular region (Trudelle-Schwarz 1996; Oliver-Smith 1991).

For cultures and the physical environment climate change implies irreversible loss. Change is not inherently negative. However, the current metrics of accounting for loss do not include mechanisms for evaluating the cultural and symbolic value of the landscape. These impacts are systematically undervalued and do not enter into the decision making calculus for adaptation responses. Whether slow and incremental or fast and abrupt, climate change is and will continue to modify the relationships of societies with the environment. The loss of physical places and transformed ecological systems will often be irreversible, with associated environmental, cultural, and social implications. These changes are associated with limits to certain possible adaptation pathways. While many of the changes are unavoidable, the way in which we choose to plan for, and respond to, change is subject to discretion.

7 Conclusions

This paper challenges the implicit assumption that successful adaptation to climate change will be bound by limiting factors beyond which adaptation will not be possible. The propositions in effect challenge this view and maintain that societal adaptation is not necessarily limited by exogenous forces outside its control. More often, adaptation to climate change is limited by the values, perceptions, processes and power structures within society. What may be a limit in one society may not be in another, depending on the ethical standpoint, the emphasis placed on scientific projections, the risk perceptions of the society, and the extent to which places and cultures are valued.

The purpose of this paper is to examine the assumptions underlying current notions of limits to adaptation and the associated concept of thresholds. We suggest that four elements inherent in any society contribute to limiting the successful adaptive response of society. The role of *ethics* and its manifestation in the diverse goals of adaptation of different actors is critical. What may be interpreted as a limit or a failure of adaptation may in fact be a successful adaptation for another actor, resulting from the different priorities and values held within society. Lack

of precise *knowledge* about future climate impacts is often cited as a reason for delaying adaptation actions. It becomes a limit in itself, whereas we argue that greater foresight will not facilitate adaptation. Instead, robust decision-making circumvents the need for precise knowledge. Adaptation decisions depend on the perceptions of *risk* held by society, which may act as limiting factors if the society does not believe the risk is great enough to justify action. And fourth, the undervaluing of *places and cultures* may limit the range of adaptation actions. The current methods of valuing loss do not include cultural and symbolic values, leading to an undervaluation in comparison with more easily valued and tangible assets.

What are the implications of this set of observations and propositions for policy and individual action to adapt to climate change? The major implication arises from our observations that diverse and contested values—underpinned by ethical, cultural, risk and knowledge considerations—underlie adaptation responses and thus define mutable and subjective limits to adaptation. Given diverse values of diverse actors, there is, we believe, a compelling need to identify and recognise implicit and hidden values and interests in advance of purposeful adaptation interventions. As a consequence, we suggest that there is a requirement for governance mechanisms that can meaningfully acknowledge and negotiate the complexity arising from the manifestation of diverse values—for example, deliberative platforms for adaptive action involving wide sets of stakeholders. We have argued here that locality, place and cultural icons are likely to loom large in adaptation decisions.

We argue that, notwithstanding physical and ecological limits affecting natural systems, climate change adaptation is not only limited by such exogenous forces, but importantly by societal factors that could possibly be overcome. Based on our review, we suggest that an adaptable society is characterized by awareness of diverse values, appreciation and understanding of specific and variable vulnerabilities to impacts, and acceptance of some loss through change. The ability to adapt is determined in part by the availability of technology and the capacity for learning but fundamentally by the ethics of the treatment of vulnerable people and places within societal decision-making structures. The issues we raise in this paper represent, we argue, the core problems of adaptation decision-making at all institutional and political scales, and across all cultures.

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