

Adaptation to climate change in the developing world

W. Neil Adger,^{a,b,*} Saleemul Huq,^c Katrina Brown,^{a,d} Declan Conway^{a,d} and Mike Hulme^a

^aTyndall Centre for Climate Change Research, University of East Anglia, UK

^bCSERGE, University of East Anglia, UK

^cInternational Institute for Environment and Development, London, UK

^dSchool of Development Studies, University of East Anglia, UK

Abstract: The world's climate is changing and will continue to change into the coming century at rates projected to be unprecedented in recent human history. The risks associated with these changes are real but highly uncertain. Societal vulnerability to the risks associated with climate change may exacerbate ongoing social and economic challenges, particularly for those parts of societies dependent on resources that are sensitive to changes in climate. Risks are apparent in agriculture, fisheries and many other components that constitute the livelihood of rural populations in developing countries. In this paper we explore the nature of risk and vulnerability in the context of climate change and review the evidence on present-day adaptation in developing countries and on coordinated international action on future adaptation. We argue that all societies are fundamentally adaptive and there are many situations in the past where societies have adapted to changes in climate and to similar risks. But some sectors are more sensitive and some groups in society more vulnerable to the risks posed by climate change than others. Yet all societies need to enhance their adaptive capacity to face both present and future climate change outside their experienced coping range. The challenges of climate change for development are in the present – observed climate change, present-day climate variability and future expectations of change are changing the course of development strategies – development agencies and governments are now planning for this adaptation challenge. The primary challenge, therefore, posed at both the scale of local natural resource management and at the scale of international agreements and actions, is to promote adaptive capacity in the context of competing sustainable development objectives.

Key words: adaptation, climate change, environmental policy, uncertainty, vulnerability.

*Corresponding author at: Tyndall Centre for Climate Change Research and CSERGE School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK. E-mail: n.adger@uea.ac.uk
Word count

I Introduction

Negotiators from many of the world's industrialized and developing countries meet each year in an ongoing evolution of one of the most contentious and critical international environmental agreements, the UN Framework Convention on Climate Change. This convention encapsulates the major dilemmas of development, equity, marginalization and globalization within its remit and is likely to have far-reaching consequences across the world in matters as wide-ranging as energy use and settlement patterns. Climate change is arguably the most persistent threat to global stability in the coming century. The convention itself has learned the lessons from existing international environmental agreements in building legitimacy through a large-scale significant international scientific effort funded by governments through the UN, known as the Intergovernmental Panel on Climate Change (IPCC) (see Jäger *et al.*, 2001). In Marrakech in Morocco in November 2001, at the Seventh Conference of the Parties, delegates focused their minds on both adaptation to climate change and mitigation measures and, for the first time, formally recognized the dilemmas of adaptation for the developing nations. This recognition took the form of funding mechanisms to assist countries to adapt. The Delhi Declaration from the Eighth Conference of the Parties in November 2002 reinforced the importance of adaptation. The Delhi Declaration, in effect, has linked the participation of the developing world in mitigation of emissions to action and funding on adaptation to the impacts of climate change.

The IPCC proclaims that there is now little doubt that human-induced climate change is happening. All societies consequently need to learn to cope with the changes that are predicted — warmer temperatures, drier soils, changes in weather extremes and rising sea levels. Although it remains difficult to unambiguously distinguish human-induced change from natural variation in climate at small scales, evidence of long-term geophysical and biological changes is now apparent in many parts of the world, such as the retreat of mountain glaciers, the earlier arrival of spring (IPCC, 2001a) and changes in primary productivity (Lucht *et al.*, 2002). But research in this area necessarily encompasses insights from social as well as natural sciences and from policy analysts even outside the IPCC process that, by its nature, cannot be all-encompassing. Participants at a meeting in London in October 2001, hosted by the Tyndall Centre and the International Institute for Environment and Development, including climate scientists, humanitarian relief and international development agencies,¹ argued that new priorities for research and policy in this area are required, reflecting the lived experience of resource-dependent societies in the developing world in coping with climate variability, and even with observed climate change in the recent past. And these lessons, they argued, should feed upwards into the actions of international development agencies and to the whole notion of adaptation within the processes and mechanisms of the UN Framework Convention on Climate Change.

The IPCC in its Third Assessment published in 2001 (IPCC, 2001b) has assessed the capacity of the world to cope with and adapt to the inevitable impacts that climate change will bring. Whilst this assessment was far from comprehensive, it finds, not surprisingly, that the impacts of climate change are not evenly distributed — the people who will be exposed to the worst of the impacts are the ones least able to cope with the associated risks (e.g., Smit *et al.*, 2001). But the meeting in London highlighted that

people of developing nations are not passive victims. Indeed, in the past they have had the greatest resilience to droughts, floods and other catastrophes. Pastoralists in the West African Sahel have adapted to cope with rainfall decreases of 25–33% in the twentieth century, while resilience in the face of changing climate has been documented for smallholder farmers in Bangladesh and Vietnam, and indigenous hunting communities in the Canadian Arctic (e.g., Cross and Barker, 1992; Mortimore, 1998; Huq *et al.*, 1999; Huq, 2001; Berkes and Jolly, 2001; Adger *et al.* 2001b; Roncoli *et al.*, 2001).

Given this apparent paradox – the discrepancy between the conclusions of a global assessment and the past experience of societies living with environmental change – a new and agreed research agenda is clearly required. What are the parameters of risk and vulnerability in developing countries? How can people in developing countries enhance their capacity to adapt to changes in climate that are now both more persistent and more extensive?

II Are developing countries at risk from the impacts of future climate change?

1 Elements of vulnerability

Nearly all human societies and activities are sensitive to climate in some way or other. This is because in large measure where people live and how they generate a livelihood and wealth is influenced by the ambient climate. Since climate is inherently variable for quite natural reasons, human societies have always and everywhere had to develop coping strategies in the face of unwelcome variations in climate or weather extremes – for example migration and transhumance in semi-arid pastoralist societies or financial insurance mechanisms in the case of industrial societies. Some of these coping strategies are more technologically dependent, better resourced, or more robust or resilient than others – compare coastal communities in the Netherlands with those in Bangladesh – and therefore populations today are differentially vulnerable to existing variations in climate and weather based on structural factors.

The vulnerability or security of individuals and of societies is determined, not only by the likely responses of the resources on which individuals depend, but by the availability of resources and, crucially, by the entitlement of individuals and groups to call on these resources. This is well documented across a wide range of political and economic circumstances and development processes (e.g., Sen, 1981, 1999; Hewitt, 1983, 1997; Watts and Bohle, 1993; Ribot *et al.*, 1996; Adger, 1999). Vulnerability is therefore a socially constructed phenomenon influenced by institutional and economic dynamics. The vulnerability of a system to climate change is determined by its exposure, by its physical setting and sensitivity, and by its ability and opportunity to adapt to change. To illustrate these categories, sensitivity will be high where the system in question includes, for example, settlements built on flood plains, hill slopes or low-lying coastal areas. In terms of action, adaptation may take the form of reducing dependence on vulnerable systems such as diversifying food production away from a limited number of drought-prone crops, of decreasing sensitivity by avoiding building settlements and infrastructure in high-risk locations, or by strengthening existing systems so that they are less likely to be damaged by unusual events.

These emerging conceptualizations of vulnerability and adaptation clearly draw on insights from risk and natural hazards, vulnerability to hunger and famine, and ideas

of entitlement and autarchy in development (e.g., Sen, 1981, 1999; Hewitt, 1983, 1997; Ribot *et al.*, 1996). But vulnerability to climate change, as with vulnerability to hazards, is not strictly synonymous with poverty. Although poverty and marginalization are key driving forces of vulnerability and constrain individuals in their coping and long-term adaptation (see Cannon, 1994), vulnerability to future climate change is likely to have distinct characteristics and create new vulnerabilities. This is not to say that those most marginalized are not most at risk. Indeed both vulnerability and adaptation processes to climate change, it has been argued, are likely to reinforce unequal economic structures (Kates, 2000).

How will the underlying vulnerability change in the future as climate changes? Or does the vulnerability 'map' of today's world simply project forward in time? Just as there is differential vulnerability to today's climate, is there differential vulnerability to future climate change? Answering these questions requires some understanding of the broad characteristics of future climate change as well as an understanding of the sensitivity and exposure of different communities and activities to climate.

Global climate is already warming at a rate unprecedented in the past 1000 years (IPCC, 2001a) and is therefore inevitably altering the character of local and regional weather around the world. A different global climate must by definition induce different experiences of local weather. Although we cannot lay out a simple cause-and-effect chain from a severe weather episode back to human-induced climate change, we can begin to identify those parts of the world where we are already measuring rather different weather characteristics from those that have been experienced in earlier decades. Thus the frequency of intense precipitation events is increasing over many northern mid-latitude regions (Easterling *et al.*, 2000); instances of extreme summer heat, often combined with high humidity, have increased in most world regions; El Niño/Southern Oscillation (ENSO) episodes over the last two decades have been both unprecedentedly large (e.g., 1997/98) and prolonged (e.g., 1991/94; Trenberth and Hoar, 1997); and severe hurricanes (e.g., Mitch) and extensive riverine (e.g., Mozambique) and coastal flooding (e.g., Orissa) have led to many tens of thousands of premature deaths.

That the global climate is changing is undisputed. The trend in climate over the past century – a globally averaged change of nearly 1°C has occurred concurrently with changes in some extreme event regimes as shown in Table 1, based on the summaries of the IPCC (2001a). This suggests that future climate change will bring about further extension of many of these trends. Of course, some of the projections, and some of the observed historical trends, are known with more confidence than others. So although data from around the world show very evident patterns in reduced diurnal temperature ranges and higher minimum temperatures and frost-free days, there is little or no consensus on whether tropical cyclones have been becoming more damaging than in the past, let alone whether the regimes will alter significantly in the future (e.g., Diaz and Pulwarty, 1997; Henderson-Sellers *et al.*, 1998).

None of the historically observed extreme weather events, such as the ENSO events mentioned above, on their own represent particularly convincing evidence that humans are altering global climate. Taken collectively, however, and placed in the context that at a global-scale there is strong evidence of a human fingerprint on climate (Mitchell *et al.*, 2001), a wise inference from these data is that historical statistics and experiences of local weather are *unlikely* to provide a sound basis for economic planning and resource

Table 1 Estimates of confidence in observed and projected change in extreme weather and climate events

Changes in climate phenomenon	Confidence in observed changes (latter half of twentieth century)	Confidence in projected changes (during twenty-first century)
Higher maximum temperatures and more hot days over nearly all land areas	Likely	Very likely
Higher minimum temperatures, fewer cold days and frost days over nearly all land areas	Very likely	Very likely
Reduced diurnal temperature range over most land areas	Very likely	Very likely
Increase of heat index over land areas	Likely over many areas	Very likely over most areas
More intense precipitation events	Likely (northern hemisphere mid–high lat. areas)	Very likely over many areas
Increased summer continental drying and associated risk of drought	Likely in a few areas	Likely over most mid-latitude continental interiors
Increase in tropical cyclone peak wind intensities	Not observed in few analyses available	Likely over some areas
Increase in tropical cyclone mean and peak precipitation intensities	Insufficient data for assessment	Likely over some areas

Source: IPCC (2001a).

management for the future. We can illustrate this past and future change in climate using annual average temperature at a country level as an indicator. We do this for Brazil, Tanzania and Bangladesh in Figure 1. All three countries have experienced a warming of their climate over the last 100 years – between 0.4°C and 0.8°C – and this warming is likely to continue, if not accelerate, in the decades ahead. For this particular model calculation these countries warm by a further 1–2°C over the next 50 years, the rate of warming partly depending on the future growth rate in global greenhouse gas emissions. In either assumed world, however, further warming is substantial and easily exceeds natural variability within the next two decades (after 2015 vertical line in each part of Figure 1).

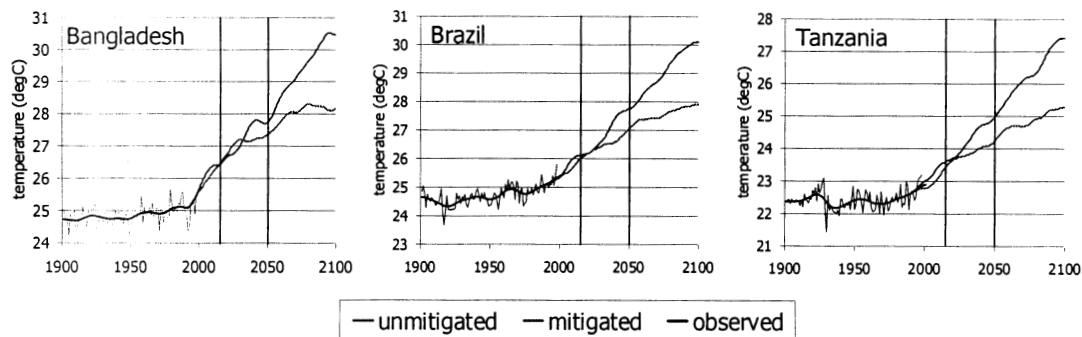


Figure 1 Past and future changes in annual average temperature for Brazil, Tanzania and Bangladesh

Notes

Figures from 1900–2000 are observed. 2000–2100 estimates are calculated using the Hadley Centre model (HadCM2) assuming two different global greenhouse gas emissions scenarios – unmitigated and mitigated. Vertical lines mark 2015 and 2050

2 Uncertainty and its characteristics

These estimates of temperature for three developing countries in Figure 1 show widening ranges the further into the future we look. Quantifying this uncertainty has been the subject of the greatest efforts among climate scientists, teasing out how much is due to our inability to model precisely the physical climate system and how much is due to our inability to foresee the evolution of the human system and its production of greenhouse gases.

Part of the reason why there are diverging estimates of temperature and other variables into the future is associated with not knowing accurately how the climate system reacts to unprecedented emissions of greenhouse gases or knowing how clouds, forest, grasslands and particularly the world's oceans react to climate perturbations and how they feed back into the system. This uncertainty surrounding future climate projections is often manifest in ranges of estimates for particular climate parameters. Table 2 highlights inter-model disparities in future rainfall change in Africa (from IPCC, 2001a) for the key rainfall seasons in West Africa (June to August) and Southern Africa (December to February). In Southern Africa the rainfall signal in December, January and February is inconsistent between models and in West Africa the coherence of the signal in June, July and August is affected by the level of the emissions scenario, with low emissions producing an inconsistent signal and high emissions suggesting no change in rainfall. Similar levels of uncertainty in future rainfall apply elsewhere in Africa and the developing world, although inter-climate model differences in future temperature changes are much smaller, particularly in the Northern Hemisphere (IPCC, 2001a). For the agricultural and water sectors, however, inter-climate model differences in rainfall change often remain a barrier to the effective use of climate change information by managers and stakeholders.

Uncertainties to do with the evolution of societies are of a different nature. The rate

Table 2 A summary of inter-climate model consistency regarding future rainfall change for Africa caused by scientific uncertainty and future emissions rates of greenhouse gases

Region	December to February		June to August	
	High emissions scenario	Low emissions scenario	High emissions scenario	Low emissions scenario
West Africa	Small increase	Small increase	No change	Inconsistent
Southern Africa	Inconsistent	Inconsistent	Small decrease	Small decrease

Source: adapted from IPCC (2001a).

of growth of the world's population into the coming century, the rate of development of low or zero carbon technologies and their global uptake, are fundamentally unknown. Yet these properties of our future world will increasingly determine the future emissions of greenhouse gases into the global atmosphere. For these parameters, the uncertainty stems less from the various methods for their estimation than from the contested and political nature of the changes implied (Carter and La Rovere, 2001; O'Neill *et al.*, 2001).

Some recent efforts have been made to reconcile these two sets of uncertainties – physical modelling and social forecasting – or at least to characterize and distinguish between them (Schneider, 2001; Wigley and Raper, 2001). Although projections of climate change into the future remain fundamentally uncertain, and are even less clear for any specific location within a country, climate change will nevertheless present a significant challenge for developing countries. Climate change is likely to feed through to societal impacts through changes in water, natural resources, food systems, marine ecosystems and through the need to cope with a changing regime of weather extremes. The need to adapt to these changes remains an inescapable conclusion. Following from these observations, we argue that there are two further key research areas – understanding adaptation processes and understanding the international political economy of response to the threat.

III Adaptation in developing countries: past, present and future?

Given the potential risks associated with climate change, a serious effort on characterizing and understanding adaptation is therefore now underway. Analogues of adaptation in the past are complemented with policy and social science research on the present adaptive capacity of governments, civil society and markets to deal with climate perturbations. The economic costs of future adaptations are being derived by examining the differences between the economic losses associated with scenarios of technology uptake and diffusion. Among these approaches, a key issue is the identification of successful adaptations in the developing world where the greatest risk and

physical vulnerability persists. But within examples of success, from indigenous strategies for resource management, to large-scale infrastructure and irrigation, there will still be winners and losers.

First of all it is necessary to distinguish adaptation by who is undertaking it and the interests of the diverse stakeholders involved. It is clear that individuals and societies will adapt and have been adapting to climate change over the course of human history – climate is part of the wider environmental landscape of human habitation. Thus individuals and societies are vulnerable to climate risks and other factors and this vulnerability can act as a driver for adaptive resource management. There are various geographic scales and social agents involved in adaptation. Some adaptation by individuals is undertaken in response to climate threats, often triggered by individual extreme events (Ribot *et al.*, 1996). Other adaptation is undertaken by governments on behalf of society, sometimes in anticipation of change, but, again, often in response to individual events.

But these levels of decision-making are not independent – they are embedded in social processes that reflect the relationship between individuals, their networks, capabilities and social capital, and the state (Adger, 2001). Sometimes a distinction is drawn between planned adaptation, assumed to be undertaken by governments on behalf of society, and autonomous adaptation by individuals (summarized in Smit *et al.*, 2001). But this distinction obfuscates the role of the state in providing security, or in using security as a weapon of coercion when faced with an environmental risk. The nature of the relationship between individuals and agents of government in handling risk is a fraught but under-researched area (Adger, 2001). Political ecology approaches demonstrate that, for example, when faced with a flood risk, residents of marginalized but risky areas of Georgetown, Guyana, have only a limited set of adaptation options – and the state allows such risks to exist as part of the politicized nature of urban planning and control (Pelling, 1999).

Realizing that action is required to enhance the adaptive capacity of the most vulnerable societies and groups, the emerging research agenda is focused on identifying generic determinants of resilience. This is being undertaken in part through learning the lessons from present and past adaptations. These determinants include the social capital of societies, the flexibility and innovation in the institutions of government and the private sector to grasp opportunities associated with climate change, and the underlying health status and wellbeing of individuals and groups faced with the impacts of climate change (Adger, 2001). Agricultural communities in northern Nigeria have demonstrated resilience in continued increases in per capita agricultural production and stability in the last three decades of the twentieth century at a time of increasing aridity and population growth. In Bangladesh, new local government investments in shelters have helped to reduce mortality from cyclones. The key is to pick out the characteristics of the institutional and technological conditions that promote broad-based and equitable adaptation.

So the role of collective action in facilitating adaptation is a key issue where lessons can be learned from political ecology, and other theoretical insights, for present day adaptation processes. From research on collective action (Agrawal, 2001) it is clear that the size of the group undertaking the collective action, the boundaries of the resource at risk, the homogeneity of the decision-making group, the distribution of benefits of management and other factors are all important in determining the ultimate success of

collective management. Research is required on how collective action is central to adaptive capacity at various scales of decision-making. At present, insights about responses to climate change as collective action are primarily used to examine national-level cooperative action to reduce greenhouse gas emissions under the UN Framework Convention on Climate Change (Müller, 2002), rather than on how the process of adaptation evolves.

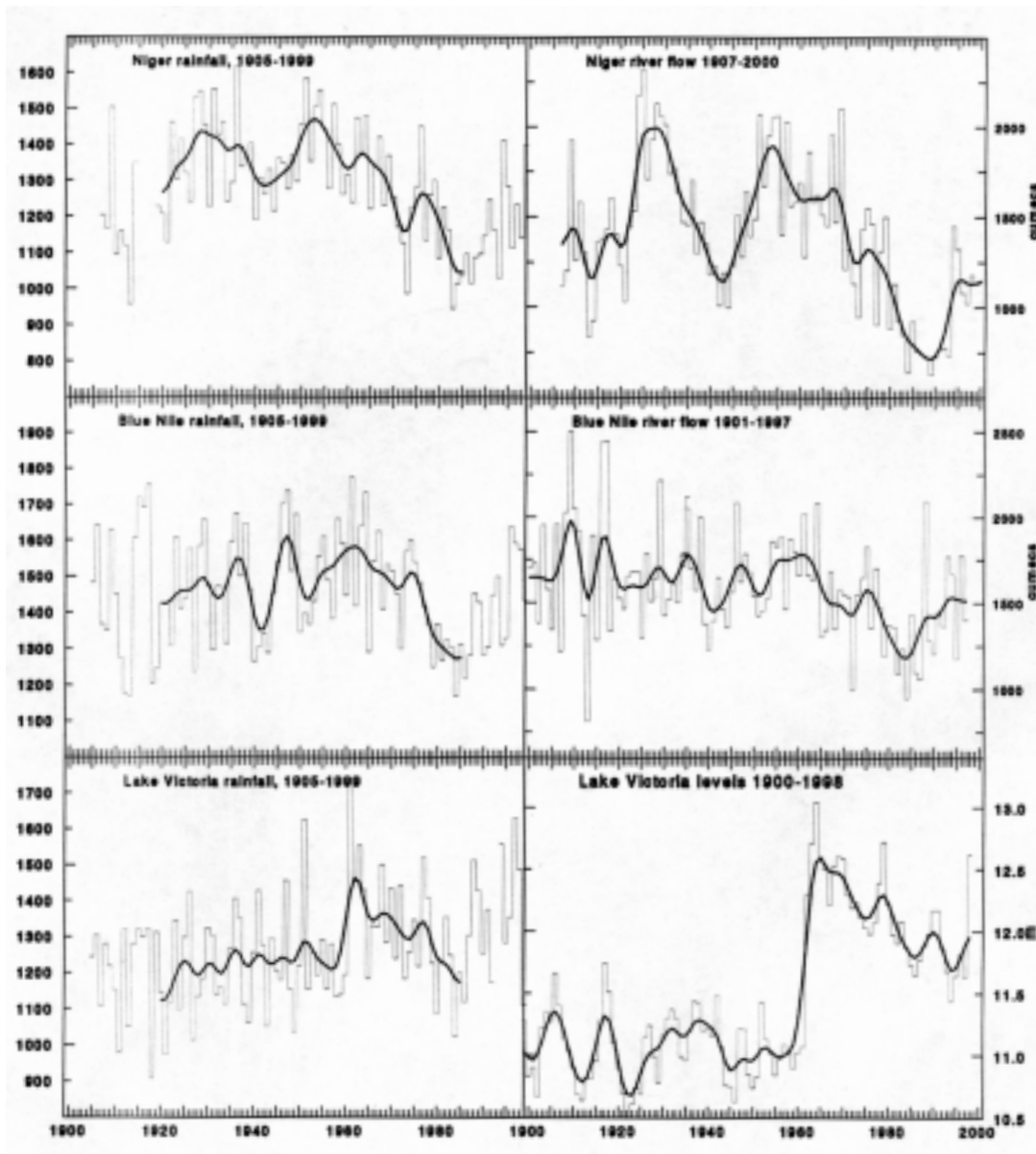
Analogues of past climate change contrast with scenarios derived from climate model experiments in the search for adaptation insights. The analogue approach involves taking detailed case studies of past responses to climate variability and extremes (temporal analogues) or present-day behaviour in regions with climate conditions similar to those that might possibly develop in the region of interest (spatial analogues). The aim is to establish how individuals and institutions anticipate or respond to reduce the risks of different types of climate variability and how policy has influenced these actions. Understanding the present-day effects and response to climate variability at all levels of social organization is a prerequisite for studying the effects and responses to future climate change and for identifying the key determinants of successful adaptation in the future.

High levels of interannual rainfall variability and their effects on water resources in Africa can provide illustrative examples of climate–environment–society interactions. A commonly cited drawback to the analogue approach to climate change assessment is that the characteristics of future climate change are likely to be very different to past climate variability, particularly in terms of the rate and magnitude of change. Examples exist for Africa, however, where the observed rainfall variability is *greater* than changes suggested by climate models for the next 50–100 years (Hulme, 1998).

Figure 2 shows three patterns of rainfall variability together with examples of the high level of variability in African water resource systems primarily in response to rainfall conditions during the twentieth century. The panels on the left depict catchment average rainfall series and the panels on the right depict the river discharge or lake levels of the corresponding catchments that generally exhibit similar temporal characteristics to rainfall. The three locations highlight examples of long-term *trend* (Niger river, Sahel), *periodic fluctuations* (Blue Nile, Ethiopian Highlands), and long-term *change* and short-term *extremes* (Lake Victoria, East Africa).

The most pronounced example of variability has been the multi-decade decline in rainfall over the Sahel where the 1961–90 average is about 25% drier than earlier decades (Hulme *et al.*, 2001) with dramatic consequences for river flows in the region (e.g., the Niger; Figure 2). Local long-term studies of agricultural practices and the social and economic conditions during this dry period highlight the dynamic nature of individuals' capacity to successfully adapt to change (see, for example, Mortimore and Adams, 1999) and the complex interplay of other, nonclimate factors. Benson and Clay (1998) illustrate the complexity of relating drought shocks to macroeconomic indicators in some African countries, highlighting highly differentiated, economy-wide impacts and the importance of national economic structure, resource endowments and other short-term economic factors.

The second example in Figure 2 shows periodic fluctuations in Blue Nile river flows that have led to significant water resource management problems in Egypt. During the past two decades conditions have moved from a prolonged period of low flows with the very real threat of water shortage in Egypt (only alleviated by a timely high flood



Source: adapted from Conway (2002).

Figure 2 Three examples of rainfall and river systems in Africa exhibiting high levels of temporal variability: the Niger, Sahel; the Blue Nile, Ethiopian Highlands; and lake levels in Lake Victoria, East Africa. Left-hand panels: catchment average rainfall series (1905-99), the decadal filter is not shown for the early and later parts of the rainfall series because for these periods the series are less reliable as they are based on low numbers of rain gauges. Right-hand panels: river discharge and lake levels

in 1988) to a series of relatively high flows that have brought the High Aswan Dam reservoir to record levels and enabled the Egyptian government to pursue a major expansion programme of irrigated agriculture into the Western Desert and Sinai. The resultant increase in demand for water may, from a climatic perspective, be maladaptive in that it is likely to increase Egypt's vulnerability to climatically induced future changes in water supply.

The third example in Figure 2 shows long-term change and rapid fluctuations in Lake Victoria levels due to the combined effects of rainfall variability and a large hydrological system with complex and delayed response to climate events (Conway, 2002). The immediate hydrological impacts of such events include disruption and damage resulting from temporary inundation of lakeside and wetland areas and river flooding. Longer-term management implications revolve around the dynamic nature of water resources over time and the need for flexible management systems that consider the inherent uncertainty in the resource base. This undermines traditional assumptions of reliable yields for planning water supply projects, in the case of Lake Victoria, for example, fluctuating water levels have generated controversy surrounding the feasibility of two major hydro-power installations (Waterbury, 2002). Fluctuating lake levels and wetland extent also present challenges and opportunities for agriculture, fishing and other lakeside activities (e.g., Sarch and Allison, 2002).

In all these cases isolating the effects of climate from other factors of change during the analogue period is an extremely complex undertaking. Nevertheless, detailed study of their impacts and responses including the influence of nonclimatic factors is a prerequisite for understanding the importance of future climate change and for identifying effective adaptation strategies. Indeed, an interesting test of our ability to do this for future climate change would be to step back into the 1960s and ask: what would be the impacts of a 25% reduction in rainfall sustained over the Sahel during the next 30 years? Whether this would produce answers similar to what actually happened is a moot point, but it certainly underscores the enormity of the challenge to predict the impacts of what remains highly uncertain change in future climate.

The limits to many adaptation options are already apparent in areas such as population movement and migration, in the ability to bring new agricultural land under irrigation when rainfall is threatened, or to bring about large-scale infrastructural changes to minimize the impacts of sea-level rise on coastal areas. Migration, for example, is a coping mechanism used throughout history by societies as part of their resource utilization strategies and as a means of coping with climate variability. Indeed migration, including to urban centres, continues to play an important role in livelihood resilience to the present-day in many parts of the developing world. There is a substantial degree of certainty that areas of the present day developing world will face greater incidence of extreme weather events in the future. If desirable migration is not available to those affected, it may ultimately increase the necessity of displacement migration, typically undertaken as a last resort when other coping strategies are exhausted.

There is emerging evidence from Brazil, Vietnam and the small island developing nations that new migrants to frontier areas build up knowledge of the local environments to promote sustainable utilization of resources (Connell and Conway, 2000; Adger *et al.*, 2002; Muchagata and Brown, 2000). Migration would appear to be a feasible climate adaptation strategy in particular circumstances. But the right to

migration, particularly international migration at a time when there are increasing inequities in international labour flow practice, is likely to be increasingly contested (O'Neill *et al.*, 2001). This implies that migration may be a limited option in many parts of the world; thus other means of supporting adaptive capacity and enhancing resilience are required. These may build on existing coping strategies or may attempt to introduce innovation in terms of technology or institutional development. This then is the current focus on some of the most recent international developments in climate change policy.

This review suggests that there are critical limits as to how far analogues of past and present adaptation experiences are relevant for adaptation to future climate change as a result of two inter-related phenomena. First, there may well be nonlinearities, or critical thresholds, in the climate change impact or response function of natural and social systems. And, secondly, the magnitude and rate of the change in climate in many parts of the world may turn out to be unprecedented in human history. Taking these factors together, human societies may experience what is already hypothesized in emerging ecosystem science – that smooth change and adaptation can be interrupted by sudden and drastic switches to another state, resulting in the inability to cope with new circumstances. These sudden shifts can be seen in forest, coral reef, grassland and other ecosystems as a result of apparently gradual climate change (e.g., Scheffer *et al.*, 2001). There is also the reverse situation where climate change is not gradual – i.e., a sudden discontinuity in climate or more than one extreme weather event coming in close sequence which may also undermine the inability to cope. Indeed, this characteristic of the sequencing and recovery time from weather-related hazards is well understood within the hazards research area. Blaikie *et al.* (1994) suggest that the timing of hazardous discrete events in nature constitutes a building of pressure on the vulnerability of marginalized populations. The vulnerability of populations is both event-based and a product of political and economic structural factors (Mustafa, 1998; Adger, 1999; Pelling, 1999). As with ecosystems, interventions to facilitate societal adaptation in the developing world, and the developed world, require new priorities to maintain individual and social resilience.

IV International institutional policy responses on adaptation to climate change

Adaptation to climate change has increasingly become a focus of policy debates. A number of articles in the UNFCCC and the Kyoto Protocol refer to adaptation. The IPCC recognizes different forms of adaptation, but also states that there is little evidence that efficient or effective adaptations to climate change risks will be taken autonomously (Smit *et al.*, 2001). Thus intervention is necessary to enhance adaptive capacity or the ability to adapt to new or changing conditions without becoming more vulnerable or shifting towards maladaptation. The COP7 meeting of the Climate Change Convention in Marrakech in 2001 expanded the scope of activities eligible for funding, including in the areas of adaptation and capacity-building, and established two new funds under the Convention (plus another fund, the adaptation fund, under the Kyoto Protocol), that will be managed by the Global Environment Fund (GEF) in addition to its climate change focal area: a Special Climate Change Fund will finance projects relating to: capacity building, adaptation; technology transfer; climate change

mitigation; and economic diversification for countries highly dependent on income from fossil fuels. Also a Least Developed Countries Fund will support a special work programme to assist LDCs (least developed countries). The GEF is charged with implementing the provisions of the Marrakech Accords in a manner that respects both procedural fairness and reflects and priorities of developing countries in seeking to adapt to both climate variability and change.

Most of the focus so far has been on assisting LDCs to develop National Adaptation Plans of Action (NAPAs). Contributions to funds were to be voluntary and a number of developed countries pledged to make contributions at the level of over US\$400 million a year that would be channelled to the developing countries through the GEF. The GEF has been supporting work in developing countries on adaptation to climate change through a staged process. Stage I was to support studies and planning, Stage II to support detailed planning and capacity building and Stage III to support actual adaptations. Most developing countries have already carried out the initial assessment (or Stage I) studies on adaptation (many of which are reported in their National Communications to the UNFCCC). A few Stage II studies (for example in the Caribbean, Pacific and Bangladesh) have also been initiated. However, there is a need for the developing countries to prepare more detailed assessments of adaptation to climate change including policies and ensuring their compatibility with action plans under other multilateral, environmental agreements (such as biodiversity and desertification) as well as with other national sustainable development plans or strategies (Huq, 2002).

Within this set of international negotiations there are divergent views as to what constitutes adaptation and the role of development, particularly sustainable development, in the process. Adaptation to climate change is not a costless exercise. We have already highlighted in this paper that it is inextricably intertwined with the political economy of natural resource use. Hence investments in adaptation will inevitably have winners and losers (Kates, 2000). Equally the nature of uncertainty concerning the scope and magnitude of climate changes, as discussed above, suggests that some adaptation strategies may turn out to be redundant. In the worst scenarios, investments in adaptation may be offset by maladaptive policies in other sectors (Burton, 1997). So, within the international negotiations the view is often expressed that sustainable development is required both in terms of managing future climate change risks, as well as weather-related hazards in the present day, and indeed in seeking to promote low-emission-based industrialization. But others argue that the climate threat and the need for adaptation is a not a continuation of what has gone before and that climate change brings new and urgent dimensions to sustainable development. Further, the Kyoto Protocol, and related mechanisms around the international agreements on climate change, has authority only to focus on environmental impacts and adaptation provoked by a narrowly defined human-induced climate change. Hence there is a fundamental dilemma at the heart of international action on this issue – the need for reductionist identification of the ‘climate’-related part of global social and economic trends, versus the desire to see climate change as another important dimension of global environmental threats to development.

These same issues are played out throughout the mechanisms of the international agreements. Projects implemented as part of the Clean Development Mechanism (CDM) of the Kyoto Protocol, one of the so-called flexible mechanisms, have the dual

mandate of reducing greenhouse gas emissions and contributing to sustainable development. The Protocol suggests that a 'share of the proceeds' from the CDM shall be used to assist particularly vulnerable developing countries in meeting the costs of adaptation to the adverse effects of climate change. Ambitious claims have been made about the likely benefits of CDM projects in developing countries without basis in research or observation. Developing countries are unlikely to become fully engaged in implementing the UNFCCC unless they perceive development benefits. At present there are serious risks to developing countries engaging in CDM activities, not least of which is that may distort development priorities, and may also lead to the situation where the only domestic mitigation measures remaining are higher cost activities (Parson and Fisher-Vanden, 1999; Karp and Liu, 2000; de Jong *et al.*, 2000). Thus the implementation of the various mechanisms, including the CDM and associated adaptation funds do not offer the desired but elusive 'win-win' solutions to climate change and development – they always result in winners and losers, and the losers are invariably the most marginalized in terms of resources, new technologies and access to decision-making (see also O'Brien and Leichenko, 2000)

V Conclusions

Adaptation to climate change is the adjustment of a system to moderate the impacts of climate change, to take advantages of new opportunities or to cope with the consequences. Many participants in the meeting in London argued that because of the nature of the new challenges brought about by climate change in natural resource management and other areas of governance, adaptation will inevitably be characterized both by processes of negotiated adjustments involving individuals, civil society and state, and by renegotiation of risk-bearing and sharing between them. This is different to the dominant discourses of adaptation in international negotiations which perceive adaptation as a process that can be smoothed through international development transfers. Global managerialism dominates these policy and international institutions and discourses (Adger *et al.*, 2001a). It creates a distortionary focus in these debates toward 'planned adaptation', either at the global scale through international institutions or at the scale of states through national governments. Of course, the role of international action is critical in this area, if only because of the interaction between planning for adaptation with an emerging scientific understanding of the risks involved as expressed by the IPCC, yet there are serious limits as to what international actions regarding adaptation can achieve. However, a re-alignment to focus on how policy can support the adaptive capacity and resilience of vulnerable communities would also potentially find synergies with more conventional development policy and analysis.

This review of issues has shown that much adaptation in the developing world will rely on past experience of dealing with climate-related risks. Thus much adaptation by farmers, fishers, coastal dwellers and residents of large cities will be autonomous and facilitated by their own social capital and resources. This will not easily be identifiable among a myriad of social, demographic and economic factors impinging on development trajectories and experiences (O'Brien and Leichenko, 2000). But there is a key role for planning for adaptation in these ongoing processes. International institutions need to appropriate these latest research insights on adaptation from the

developing world and build a global coalition, not only to take action to reduce damaging emissions, but to facilitate the inherent resilience of populations coping with an uncertain future.

Thus competing sustainable development objectives are highlighted by the dilemmas of climate change. We would argue that building adaptive capacity is not synonymous with development. Populations at risk from climate change impacts range from owners of second-home beach-front properties in Europe and north America through to resource-dependent farmers and labourers in Africa and Asia – building adaptive capacity necessarily requires considerations of rights to development and security rather than just avoidance of pertinent risks. It is also becoming clear when considering the nature of global climate change that poverty reduction policies and goals will in themselves not address the risks for the most vulnerable portions of developing societies. Nevertheless climate change and its associated risks give greater impetus for both dematerialization and empowering and institutionalizing sustainable development.

Acknowledgements

We thank the UK Research Councils – NERC, ESRC and EPSRC – for financial support for the Tyndall Centre for Climate Change Research. This paper stems from a meeting hosted jointly by the Tyndall Centre, CSERGE and the School of Development Studies at the University of East Anglia and the International Institute for Environment and Development in London. We thank all the participants for stimulating discussions and feedback. We also thank three referees for constructive comments. We retain full responsibility for this final version.

Notes

1. 'Adaptation to climate change: setting the agenda for development policy and research'. Symposium hosted by the Tyndall Centre for Climate Change Research and International Institute for Environment and Development, Royal Society, London, 25 October 2001.

References

- Adger, W.N.** 1999: Social vulnerability to climate change and extremes in coastal Vietnam. *World Development* 27, 249–69.
- Adger, W.N.** 2001: *Social capital and climate change*. Working Paper 8, Tyndall Centre for Climate Change Research, University of East Anglia, Norwich.
- Adger, W.N., Benjaminsen, T.A., Brown, K. and Svarstad, H.** 2001a: Advancing a political ecology of global environmental discourses. *Development and Change* 32, 681–715.
- Adger, W.N., Kelly, P.M. and Ninh, N.H.,** editors, 2001b: *Living with environmental change: social vulnerability, adaptation and resilience in Vietnam*. London: Routledge.
- Adger, W.N., Kelly, P.M., Winkels, A., Huy, L.Q. and Locke, C.** 2002: Migration, remittances, livelihood trajectories and social resilience. *Ambio* 31, 358–66.
- Agrawal, A.** 2001: Common property institutions and sustainable governance of resources. *World Development* 29, 1649–72.
- Benson, C. and Clay, E.** 1998: *The impact of drought on Sub-Saharan African Economies*. World Bank Technical Paper No. 401. Washington DC:

- World Bank.
- Berkes, F. and Jolly, D.** 2001: Adapting to climate change: social-ecological resilience in a Canadian Western Arctic community. *Conservation Ecology* 5(2), online at: <http://www.consecol.org/Journal/vol5/iss2/> last accessed 19 February 2003.
- Blaikie, P., Cannon, T., Davis, I. and Wisner, B.** 1994: *At risk: natural hazards, people's vulnerability and disasters*. London: Routledge.
- Burton, I.** 1997: Vulnerability and adaptive response in the context of climate and climate change. *Climatic Change* 36, 185–96.
- Cannon, T.** 1994: Vulnerability analysis and the explanation of natural disasters. In Varley, A., editor, *Disasters development and environment*. Chichester: John Wiley, 13–30.
- Carter, T.R. and La Rovere, E.L.** 2001: Developing and applying scenarios. In McCarthy, J.J., Canziani, O., Leary, N.A., Dokken, D.J. and White, K.S., editors, *Climate change 2001: impacts, adaptation and vulnerability. Inter-governmental Panel on Climate Change (IPCC) Working Group II*. Cambridge: Cambridge University Press, 877–912.
- Connell, J. and Conway, D.** 2000: Migration and remittances in island micro-states: a comparative perspective on the South Pacific and the Caribbean. *International Journal of Urban and Regional Research* 24, 52–78.
- Conway, D.** 2002: The hydrological effects of two extreme rainfall events over East Africa: 1961 and 1997. In Van Der Leden, H., editor, *Flow Regimes from International Network Data (FRIEND) 2002 – Regional hydrology: bridging the gap between research and practice*. Proceedings of the Fourth International FRIEND Conference, Cape Town, South Africa. IAHS Publication No. 274, Wallingford: IAHS, 475–82.
- Cross, N. and Barker, R.**, editors, 1992: *At the desert's edge: oral histories from the Sahel*. London: SOS Sahel.
- de Jong, B.H.J., Tipper, R. and Montoya-Gomez, G.** 2000: An economic analysis of the potential for carbon sequestration by forests: evidence from southern Mexico. *Ecological Economics* 33, 313–27.
- Diaz, M.F. and Pulwarty, R.S.**, editors, 1997: *Hurricanes, climate and socio-economic impacts*. New York: Springer Verlag.
- Easterling, D.R., Karl, T.R., Gallo, K.P., Robinson, D.A., Trenberth, K.E. and Dai, A.G.** 2000: Observed climate variability and change of relevance to the biosphere. *Journal of Geophysical Research* 105, 20101–14.
- Henderson-Sellers, A., Zhang, H., Berz, G., Emanuel, K., Gray, W., Landsea, C., Holland, G., Lighthill, J., Shieh, S.-L., Webster, P. and McGuffie, K.** 1998: Tropical cyclones and global climate change. *Bulletin of the American Meteorological Society* 79, 19–38.
- Hewitt, K.**, editor, 1983: *Interpretations of calamity from the viewpoint of human ecology*. Boston: Allen and Unwin.
- Hewitt, K.** 1997: *Regions of risk: a geographical introduction to disasters*. Harlow: Longman.
- Hulme, M.** 1998: The sensitivity of Sahel rainfall to global warming: implications for scenario analysis of future climate change impact. In Servat, E., Hughes, D., Fritsch, J.M. and Hulme, M., editors, *Water resources variability in Africa during the 20th century*. IAHS Publication, No. 252. Wallingford: IAHS, 429–36.
- Hulme, M., Doherty, R., Ngara, T., New, M. and Lister, D.** 2001: African climate change: 1900–2100. *Climate Research* 17, 145–68.
- Huq, S.** 2001: Climate change and Bangladesh. *Science* 294, 1617.
- Huq, S.** 2002: The Bonn-Marrakech agreements on funding. *Climate Policy* 2, 243–46.
- Huq, S., Karim, Z., Asaduzzaman, M. and Mahtab, F.**, editors, 1999: *Vulnerability and adaptation to climate change in Bangladesh*. Dordrecht: Kluwer.
- IPCC 2001a:** *Climate change 2001: the scientific basis*. Contribution of Working Group I to The Third Assessment Report of the IPCC. Cambridge: Cambridge University Press.
- IPCC 2001b:** *Climate change 2001: impacts, adaptation and vulnerability*. Cambridge: Cambridge University Press.
- Jäger, J., van Eijndhoven, J. and Clark, W.C.** 2001: Knowledge and action: an analysis of linkages among management functions for global environmental risks. In Social Learning Group, editors, *Learning to manage global environmental risks: volume 2 a functional analysis of social responses to climate change, ozone depletion and acid rain*. Cambridge, MA: MIT Press, 165–78.
- Karp, L. and Liu, X.** 2000: *The clean development mechanism and its controversies*. Working Paper 903, Department of Agricultural and Resource Economics, University of California, Berkeley.

- Kates, R.W.** 2000: Cautionary tales: adaptation and the global poor. *Climatic Change* 45, 5–17.
- Lucht, W., Prentice, I.C., Myneni, R.B., Sitch, S., Friedlingstein, P., Cramer, W., Bousquet, P., Buermann, W. and Smith, B.** 2002: Climatic control of the high-latitude vegetation greening trend and Pinatubo effect. *Science* 296, 1687–89.
- Mitchell, J.F.B., Karoly, D.J., Hegerl, G.C., Zwiers, F.W., Allen, M.R. and Marengo, J.** 2001: Detection of climate change and attribution of causes. In Houghton, J.D., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, S., Maskell, K. and Johnson, C.A., editors, *Climate change 2001: the scientific basis*. Cambridge: Cambridge University Press, 697–738.
- Mortimore, M.J.** 1998: *Roots in the African dust*. Cambridge: Cambridge University Press.
- Mortimore, M.J. and Adams, W.M.** 1999: *Working the Sahel*. London: Routledge.
- Muchagata, M. and Brown, K.** 2000: Colonist farmers' perceptions of fertility and the frontier environment in eastern Amazonia. *Agriculture and Human Values* 17, 371–84.
- Müller, B.** 2002: The global climate change regime: taking stock and looking ahead. In Schram Stokke, O. and Thommessen, O., editors, *Yearbook of international co-operation on environment and development 2002–003*. London: Earthscan, 27–40.
- Mustafa, D.** 1998: Structural causes of vulnerability to flood hazard in Pakistan. *Economic Geography* 74, 289–305.
- O'Brien, K.L. and Leichenko, R.M.** 2000: Double exposure: assessing the impacts of climate change within the context of economic globalisation. *Global Environmental Change* 10, 221–32.
- O'Neill, B.C., MacKellar, F.L. and Lutz, W.** 2001: *Population and climate change*. Cambridge: Cambridge University Press.
- Parson, E.A. and Fisher-Vanden, K.** 1999: Joint implementation of greenhouse gas abatement under the Kyoto Protocol's Clean Development Mechanism: its scope and limits. *Policy Sciences* 32, 207–24.
- Pelling, M.** 1999: The political ecology of flood hazard in urban Guyana. *Geoforum* 30, 240–61.
- Ribot, J.C., Magalhães, A.R. and Panagides, S.S.,** editors, 1996: *Climate variability, climate change and social vulnerability in the semi-arid Tropics*. Cambridge: Cambridge University Press.
- Roncoli, C., Ingram, K. and Kirshen, P.** 2001: The costs and risks of coping with drought: livelihood impacts and farmers' responses in Burkina Faso. *Climate Research* 19, 119–32.
- Sarch, M-T. and Allison, E.** 2002: Fluctuating fisheries in Africa's inland waters: well adapted livelihoods, maladapted management. In *Proceedings of International Institute of Fisheries Economics and Trade ics and Trade*. 1–11.
- Scheffer, M., Carpenter, S., Foley, J.A., Folke, C. and Walker, B.** 2001: Catastrophic shifts in ecosystems. *Nature* 413, 591–96.
- Schneider, S.H.** 2001: What is dangerous climate change? *Nature* 411, 17–19.
- Sen, A.K.** 1981: *Poverty and famines: an essay on entitlement and deprivation*. Oxford: Clarendon.
- Sen, A.K.** 1999: *Development as freedom*. Oxford: Oxford University Press.
- Smit, B. et al.** 2001: Adaptation to climate change in the context of sustainable development and equity. In McCarthy, J.J., Canziani, O., Leary, N.A., Dokken, D.J. and White, K.S., editors, *Climate change 2001: impacts, adaptation and vulnerability*. IPCC Working Group II. Cambridge: Cambridge University Press, 877–912.
- Trenberth, K.E. and Hoar, T.J.** 1997: El Niño and climate change. *Geophysical Research Letters* 24, 3057–60.
- Waterbury, J.** 2002: *The Nile Basin: national determinants of collective action*. London: Yale University Press.
- Watts, M.J. and Bohle, H.G.** 1993: The space of vulnerability: the causal structure of hunger and famine. *Progress in Human Geography* 17, 43–67.
- Wigley, T.M.L. and Raper, S.C.B.** 2001: Interpretation of high projections for global-mean warming. *Science* 293, 451–54.