CHAPTER 1

Introduction: understanding community-based adaptation

Abstract

This book is an attempt to further understanding of the practice of community-based adaptation. As such, the main body comprises a series of case studies of adaptation projects from some of the poorest regions of the world, placed between an introduction and conclusion that seek to clarify the meaning of adaptation and draw lessons for practitioners and policy makers. More specifically, this introduction has three objectives. The first is to locate the focus of this book – community-based adaptation – in the broader context of ongoing development challenges and the international climate change negotiations. This is the purpose of the following two sections. The second objective is to develop a framework for understanding adaptation. This is the task of the middle five sections, in which attention is drawn to the importance of uncertainty in climate predictions, the role of vulnerability in adaptation, and the components of adaptive capacity and resilience. The importance of an appreciation of the role played by culture in adaptation interventions is also highlighted. The concepts presented in these sections are illustrated with examples from the case study chapters that follow and are drawn together to offer a coherent approach to understanding adaptation. Third and finally, the last section provides an overview of the chapters that make up the remainder of the book.

The development challenge

Climate change first came on to the international political agenda in 1992 at the UN Conference on Environment and Development in Rio de Janeiro. It was regarded as an environmental problem and, accordingly, when the United Nations Framework Convention on Climate Change was agreed in 1995 government delegates were appointed from within environment ministries or meteorology offices. While the environmental movement had been raising the issue since the Intergovernmental Panel on Climate Change (IPCC) first assessment in 1990, climate change did not feature as an issue in mainstream development circles until the early part of the 21st century. Although humanitarian agencies and development organizations with a strong disaster relief focus were finding that they were facing one crisis after another – severe droughts in the Horn of Africa during the 1980s, Hurricane Mitch in Central America in 1998 and catastrophic floods in Bangladesh the same year

– these were not seen as evidence of a trend linked to global warming until the publication of the IPCC's Third Assessment Report in 2001. This indicated that increasingly severe weather events were likely to be a feature of global warming, and that global increases in sea surface temperatures contributed to the drying of the Sahel. What was evident from these disasters was that in each case those worst hit were the poorest people in a country or community, a fact that was brought to the world's attention when Hurricane Katrina struck New Orleans in 2005. It is this disproportionate impact on poor people that makes climate change an issue for development. It also forces us to ask why poor people are more vulnerable than other sections of the community who experience the same climate.

The most basic reason is poverty. Poor people are vulnerable to climate change because they have few assets and little to fall back on after a shock event which calls for resources to address it. They have no savings to replace or repair damaged property, and often no access to credit. Their ability to adapt to changed circumstances and adopt different livelihood strategies is limited, because they have little access to new knowledge or opportunities for learning new skills, and no capital to cover the costs of moving or setting up a new way of life. They also tend to have little access to and influence over the institutions and policies that affect their access to resources. The second reason is that poor people in rural communities depend on natural resources for their livelihoods: most of their income or production is from farming, fishing and livestock rearing. These activities are in turn dependent on soil, water and plant life, all of which are being adversely affected by climate change. Finally, poor people often live in places that are remote from services and information, have poor productivity or are prone to disasters. Better off people can afford to avoid these marginal locations, which include steep eroding hillsides, flood plains and low lying coastal areas. Despite these challenges, people in low productivity or hazard-prone areas have adapted using their own capabilities, skills, knowledge and technologies. For example, pastoralists worldwide have developed livelihood strategies for survival in extremely harsh climates with few resources. They make use of diverse grazing patterns and browse for water resources with livestock breeds that are matched to the subtly different environments available to them. In times of severe environmental stress a web of social norms and kinship ties provide support for survival and recovery.

The small-scale farmers who constitute the majority of the rural poor are the same people who have developed complex production patterns based on seed conservation and breeding and a diversity of crops to act as insurance against unpredictable weather and harvests. Farmers worldwide over millennia have been the custodians of biodiversity, cross-breeding wild varieties of edible plants to develop desirable traits for particular situations – climate, soil, altitude, disease resistance and many other characteristics. Practices to manage soil, conserve water and to use wild plants for food, fuel, medicine and construction continue to provide resilience and self-sufficiency for communities with few cash resources and who are remote from markets and sources of external knowledge. Here, people rely predominantly on their local knowledge, unique to their culture or society. Also known as indigenous knowledge or traditional wisdom, these practices and customs have been passed from generation to generation, usually by word of mouth and cultural rituals. This knowledge forms the basis for agriculture, food preparation, health care, education, conservation and the wide range of other activities that have sustained rural societies and their environment in many parts of the world for centuries. A key element of this knowledge is a variety of risk management strategies to cope with uncertain situations, such as growing certain crops as a form of insurance. Drought resistant millet and sorghum, for example, are planted in some areas so that if the main maize crop fails the low yielding but resilient crops still provide some food. Diversifying the crops grown and having multiple sources of food including wild plants thus reduces risks of food insecurity. Maintaining strong social networks and exchange relations with others in the local community is also an insurance strategy based on reciprocity in times of need.

The new challenge facing poor people is that climate change brings a further threat to a natural resource base that has become severely diminished in its ability to support an ever-increasing human population. As the Millennium Ecosystem Assessment (2005) revealed, ecosystems are facing severe decline in species diversity and resilience to shocks, through a combination of population growth, groundwater extraction for intensive agriculture, deforestation for timber and agricultural expansion, and widespread intensification of agriculture that has led to soil erosion and loss of biodiversity. All plants have a range of conditions they can tolerate, and many flourish in quite a narrow range of rainfall and temperature conditions. As climate changes emerge critical points will be reached where, in a particular locality, certain species fail to reproduce and become scarcer. In the Sahel and the Horn of Africa, for example, some pasture species valuable for their nutritive qualities for livestock are disappearing as a result of recurrent severe droughts, being replaced by opportunistic but less nutritious species. Extreme weather – be it wind, heat or rain – erodes soils, reducing the productivity of harvest and grazing lands and forest resources. The livelihoods that rural communities depend on have often developed over generations and are based on an intimate knowledge of their local environments. These livelihoods are now becoming less secure because of these factors. The ability to find new livelihood strategies, alternative crops or breed livestock that are more productive on poorer quality grazing is in many cases beyond the experience contained within traditional knowledge and requires access to outside expertise and information on what is happening to the climate. Poor people do not have access to these resources.

The purpose of this book is to increase understanding of how rural communities can be supported as they struggle to face the new challenges that climate change brings to their environment.

The international context

The United Nations Framework Convention on Climate Change has as its goal the stabilization of greenhouse gases to prevent dangerous interference with the climate system. Recognizing the need for actions to address the impacts of climate change, Article 4 of the convention places an obligation on developed countries to assist developing countries with adaptation. The targets for global emissions reductions determine the climate context in which adaptation takes place: the most recent science confirms that, as the global temperature rises, increasingly serious impacts will be experienced in food production, water resources, human health and the rate of extinction of plant and animal species (IPCC, 2007: 16). It is at the international climate change negotiations where an agreement will determine whether climate change will be contained through concerted international action on emissions reduction. Mechanisms for raising funding for adaptation and the amounts of money to be allocated will also be decided. While there is a growing level of understanding of the imperative for adaptation as well as mitigation, as of late 2008 there is still no firm commitment on the part of wealthy countries to contribute significant sums of money to help those in developing countries to adapt. However, it is clear that a prerequisite for any agreement on large-scale adaptation funding will be an understanding of how the money will be spent within developing countries and methods for measuring its effectiveness at improving the adaptive capacity of the poorest and most vulnerable communities. There can be no measure of the effectiveness of programmes for adaptation without a common understanding of what adaptation to climate change encompasses.

At the time of writing, there is little more than a year before a new international agreement should be reached during negotiations in Copenhagen in 2009. There is a strong group of informed development, environmental and research organizations working together to further understanding on adaptation at multiple levels: to implement effective projects and programmes, to influence the negotiators, and to influence governments. While there is extensive experience of development and disaster preparedness in areas of harsh climate or subject to extreme weather events, the vast majority of this work has not taken explicit account of climate change – of the fact that future change is certain, but that the direction and pace of change is not known; that extreme events will become more frequent, but as yet their timing cannot be predicted with certainty. While not focused on the policy context, this book supports the search for an international agreement by contributing to the building of an understanding of adaptation, with a specific focus on rural communities.

Early research efforts suggest that costs of adaptation will be substantial, ranging from between US$9 bn and $41 bn per year (World Bank, 2006a; based on an assessment of the vulnerability to climate change of current investments) to at least $50 bn per year (Oxfam, 2007; based on scaling-up the costs of recent community-based adaptation projects, the urgent needs identified in National Adaptation Programmes of Action (NAPAs), and an estimate of hidden costs such as capacity building and measures against desertification). The most recent UN Human Development Report suggests an even higher figure, estimating that a total of $86 bn will be needed by 2015 (UNDP, 2007: 194, to climate-proof existing development investment, adapt poverty reduction to climate change, and to strengthen disaster recovery). In stark contrast to the scale of these figures, the total funds pledged under the UNFCCC are very small, with around $149 m received for adaptation and a further $65 m pledged (Müller, 2008: 7). Under the UNFCCC, money is collected by voluntary contributions to a series of funds established under the Marrakesh Accords at the Conference of the Parties to the UNFCCC in 2001. A study published in 2007 by the Stockholm Environment Institute concludes that these global funds are not only inadequate in terms of funding, but also in terms of efficiency, fairness and in responding to developing countries' needs. The application procedures are complex, and inadequate support has been given to developing countries trying to apply for funds (Möhner and Klein, 2007). Also under the UNFCCC is a new fund, whose governance was finally agreed at the 13th Conference of the Parties in Bali in 2007. The Adaptation Fund is the only fund designed to support 'concrete' adaptation projects, raised by a market mechanism independent of donor governments. The Fund currently relies on a 2 per cent levy applied to Clean Development Mechanism (CDM) trading, yet the World Bank anticipates that this will only generate between $100 m and $500 m by 2012 (World Bank, 2006b). As we go to press, the future architecture, sources and scale of adaptation financing remain unclear beyond an apparent acceptance of the scale of funds needed.

Funding to undertake pilot programmes on adaptation and for action research is still extremely limited, despite the urgency and scale of the need to develop workable solutions to help people adapt. For example, the World Bank has established the Climate Investment Funds, most of which is for funding clean technology in developing countries. Of the approximately $6 bn pledged, the UK's Department for International Development has allocated £800 m, part of which is intended for adaptation under a new Pilot Programme on Climate Resilience. It remains unclear how much of the funding that is currently available is additional to official development assistance (ODA), as required under the UNFCCC. Yet climate change adds to the cost of achieving the Millennium Development Goals and therefore funding for adaptation must be over and above that promised for development. As will be seen in the following chapters, in order to implement successful adaptation projects with extremely poor and marginalized communities, it will be necessary to first undertake activities that are part of basic development as laid out within the Millennium Development Goals.

Despite the current inadequacy of funding, this book is written on the assumption that the Copenhagen agreement will see the commitment of large sums of money for adaptation to enable the scaling up of the kind of community-based interventions described in the following chapters.

Much more work is needed to assess the likely costs of adaptation under different levels of greenhouse gas concentration: the costs of ensuring that infrastructure and government services are resilient to climate change; the costs of prevention of and recovery from climate-related disasters; and the costs for communities and households. Whatever agreement is achieved in 2009, work on these issues will be ongoing, yet important discussions on how to enable adaptation (issues of process, capacity building and technology) and how to ensure effective delivery (issues of governance, decentralization and empowerment) must also run in parallel. These political and institutional challenges are at the heart of community-based adaptation and are returned to in the conclusion to this book.

The remainder of this introduction develops a framework for understanding adaptation that depends on two key parameters: the clarity or uncertainty of existing climate predictions and the vulnerability of a community or household to a given climate change hazard. After examining uncertainty and vulnerability in more detail, the elements of adaptation are considered, with particular emphasis given to the role played by social networks in enabling knowledge sharing, access to resources and influence over policy. The principal adaptation activities are identified as vulnerability reduction, building adaptive capacity and strengthening resilience. These actions are presented in a setting that illustrates how clarity and vulnerability determine the appropriate mix of activities in a particular context. The aim is to provide a mechanism for understanding adaptation that ensures the actions to support communities facing climate change are selected only after their particular circumstances have been assessed. By drawing attention to the uncertainty that is inherent in predicting climate change impacts, adaptation is presented as a process through which communities become increasingly able to make informed choices about their lives and livelihoods.

Climate predictions: understanding uncertainty

Advances in climate science have enabled climate modelling to provide an unprecedented view of the future of the Earth system. The impact of greenhouse gas emissions is now beyond doubt, as is warming of the global climate throughout the coming century. However, the precise implications remain unclear: predictions of rainfall rates, the likely frequency of extreme weather events and regional changes in weather patterns cannot be made with certainty. This uncertainty is of central importance to adaptation. While mitigation activities are rightly driven by the need to avoid dangerous climate change, adaptation planning cannot proceed without first understanding what climate change means in a particular location. Indeed, it is all too easy to assume that adaptation can and should follow climate change predictions. This can be the case where the message from current observations and predictive models is clear and unambiguous, such as for glacial melting or sea-level rise (and even here, the rate of change is a subject of debate). But clear-cut cases are in the minority. In many contexts there is no agreement whether, for example, rainfall is likely to increase or reduce. What, then, should adaptation to climate change mean in these circumstances? This question is addressed in the following two sections of this chapter (see 'Vulnerability and adaptation' and 'Adaptive capacity and resilience', below). First, it is necessary to consider the limitations of climate predictions so that the different aspects of uncertainty can be absorbed into adaptation thinking.

The Intergovernmental Panel on Climate Change (IPCC) provides the most well known and authoritative assessments of the current scientific understanding of climate change. The body was established in 1988 with a mandate 'to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature' relevant to climate change (IPCC, 1988). A creation of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), it conducts no new research of its own, but instead employs the services of around 400 scientists to compile reports on the 'policy relevant'[1] aspects of climate science, impacts and adaptation, and mitigation. Each report examines data from previously published peer-reviewed literature (and selected non-peer-reviewed reports) and is itself subjected to two rounds of expert review and one of government challenge and approval prior to publication. This approach removes controversial or spurious data and establishes a high degree of confidence in the content of the IPCC's publications. However, when relying on the IPCC's conclusions it is important to note that the approach to knowledge gathering and sharing has the potential to be conservative. Consensus building and time constraints mean that some evidence is excluded. For example, the IPCC's fourth report only considers temperature projections that fall within a 90 per cent confidence interval, excludes dynamic melting of the Greenland and Antarctic ice sheets, and excludes non-linear events that might result in higher or more rapid temperature or sea-level rise (Lemons, 2007). These decisions prevent the IPCC from reporting speculative data and allow scientifically plausible statements of certainty to be made in one report – but they also mean that low probability, high-impact events are not drawn out for public consideration. The periodic release of the IPCC assessment reports is also an important limitation: the time taken by the IPCC review process means that the evidence relied on in the reports is restricted to that published well in advance of the IPCC release date, while the 5 to 6 year periodicity of reports means that the most recent IPCC assessment lags behind current scientific thinking.

Rather than undermining the IPCC conclusions or the importance of the process, these observations highlight the need to understand the limits that inevitably exist to even the most authoritative statements of knowledge. Indeed, a 2008 review of the climate science literature illustrates the constraints of the IPCC process (Hare, 2008: 5–6):

> Literature published in the past two years has identified several specific cases of higher risk than that assessed in the IPCC's AR4 [Fourth Assessment Report] ... this literature is sufficiently important, credible and robust to justify presenting a view that adds to, and in some cases differs from, the IPCC assessment. The reader should be aware, also, that this paper presents the science of climate change from a risk perspective, in terms of which low-probability, high-consequence events merit the attention of policymakers at the highest level.

For adaptation, the issue of interest is our ability to use science to predict the future. This is an obvious area for uncertainty to arise, and it does so in many forms. Fundamentally, the relationship between human activity and climate change means that assumptions must be made about the pattern of future emissions in order to generate climate predictions. Climate change predictions are mainly dependent on the greenhouse gas composition of the atmosphere in the future (predominantly carbon dioxide, methane and nitrous oxide). To address this problem, projections are made for a range of reasonably foreseeable future emissions. For example, the IPCC's best estimate for the increase in global average temperature by the end of this century is 1.8°C assuming a low rate of emissions (referred to by the IPCC as the B1 scenario), while the highest foreseeable increases in greenhouse gases would yield a 4.0°C temperature rise (the A1F1 scenario) (Meehl et al., 2007: 749).

The mechanisms involved in producing predictions also introduce uncertainty. Climate predictions are significantly different from their more established cousin, weather forecasting. Climate is fundamentally different from weather in that climate refers to long-term (conventionally 20 to 30 year) average weather conditions. Weather, on the other hand, refers to short-term (hourly and daily) changes such as in temperature, rainfall and wind. Weather is hard to predict as its dynamics are chaotic: small changes in the current weather conditions can create large changes in the weather at a later time. Despite this, well-established scientific understanding and measurement infrastructure allows predictions up to about 15 days ahead. Seasonal forecasting has emerged more recently than weather forecasting, and is based on an improved understanding of slowly changing phenomena that have a significant impact on the weather, such as the El Niño Southern Oscillation (ENSO). Measuring these important but slowly changing phenomena allows seasonal trends to be predicted up to around two years in advance, although confidence is greater for shorter timescales of up to around three months. Seasonal forecasts are not weather forecasts, but are more similar to climate models in that they offer a view of weather statistics, but over shorter timescales. A typical seasonal forecast may predict daily rainfall for a particular three month period. An expression of confidence is normally included: for example, a forecast may predict with 90 per cent confidence that daily rainfall will be between 150 mm and 200 mm. The confidence captures and communicates the uncertainty in the forecast, and varies significantly with geographical location: the more the weather is dominated by El Niño, for example, the more accurate the seasonal forecast. Generally speaking, predictability reduces the further a location is from the equator and from the ocean, and temperature is usually easier to predict than precipitation (Harrison et al., 2007a: 10).

Beyond seasonal timescales, climate models are relied on to provide information on long-term trends. While they are able to establish with high confidence that global average temperatures will continue to increase (not least because of the levels of greenhouse gases currently in the atmosphere), more detailed changes, such as the impact of warming on wet and dry seasons, remain unclear. The IPCC's calibrated expressions of confidence draw attention to the inherent uncertainty in climate models, which by definition are only approximations of reality, offering an incomplete representation of the full complexity of the Earth's systems. Uncertainty – meaning that more than one plausible future can be asserted – is unavoidable. Even for a fixed rate of future emissions there is uncertainty as to the exact impact on temperature. While the highest emission scenario produces a most likely average temperature increase of 4°C by the end of the 21st century, it is also possible that the increase might be as high as 6.4°C or as low as 2.4°C (Meehl et al., 2007: 749). Currently, the impact of uncertainty can be seen most clearly in the failure of climate models to provide good agreement at the regional scale, and in particular on future levels of precipitation.

Table 1.1 illustrates the extent of the problems with predicting precipitation changes from climate models. The table summarizes the climate change predictions for East Africa for the period 2080 to 2099, published in the IPCC's Fourth Assessment Report. They were generated by running 21 different climate models for a fixed increase in greenhouse gases.[2] The table compares the model responses to the data for 1980 to 1999, reporting the predicted change in temperature and percentage change in precipitation. The 21 models generate a spread of predictions as a result of the differences in assumptions and computational methods used. This diversity is captured in the following ways:

- The table shows the minimum (min), maximum (max), median (50 per cent) and quartile (25 per cent and 75 per cent) values from the 21 models for both temperature and precipitation change. Half of the 21 model predictions lie between the 25 per cent and 75 per cent figures. For example, half of the distribution of winter (December, January, February) temperature increases lie in the region 2.6 to 3.4°C, while the median (or middle) value from the 21 model outputs was a rise of 3.1°C. It is noteworthy that, while for all seasons the median precipitation change prediction suggests an increase, one or more models predict a decrease (demonstrated by the negative minimum values for this response).
- The quantity 'Tyrs' gives an estimate of when a clearly discernible trend emerges in the data. It gives the time, in years, before the 20 year average change in temperature or precipitation predicted by the models is greater

than the annual or seasonal variability generated by the models. For the temperature responses, the increasing trend is visible for all seasons after 10 years: in other words, it can be said with 95 per cent confidence that the average temperature in the period 1989 to 2009 will be greater than the average between 1980 and 1999.

- The predictions for precipitation are much less clear cut than for temperature: even during the winter season it is 55 years before there is 95 per cent confidence that the average precipitation will have increased. For the spring season the figure is greater than 100 years, indicating that even the predicted change at the end of the century cannot be expressed with confidence. During June, July and August no figure is given as half of the models have failed to agree on whether there will be an increase or decrease in precipitation by the 2080 to 2099 period.

This example demonstrates that timescales of a generation or more can be required before a clear pattern emerges from a suite of precipitation models, reflecting the uncertainty associated with predictions at the regional scale. The shortcomings of regional climate projections are well recognized in the scientific community. The World Climate Research Programme's Modelling Panel has concluded that 'regional projections from the current generation of climate models [are] sufficiently uncertain to compromise [the] goal of providing society with reliable predictions of regional climate change' (World Climate Research Programme, 2008a). As a result, attention is now turning to the possibility of large increases in computing power, with a proposal for a new billion dollar facility now on the table (Heffernan, 2008: 268). Following a summit meeting of international climate scientists in May 2008, a statement called for the establishment of an international 'Climate Prediction Project', the goal of which is to improve climate information to underpin 'regional adaptation and decision making in the 21st century' (World Climate Research Programme, 2008b). The hope is that improved computing power combined with investment in national research centres and improvements in scientific understanding will allow more precise regional data to be developed. However, such an initiative will have to overcome fundamental concerns that

Table 1.1 Temperature and precipitation predictions for East Africa

East Africa	*Temperature change °C*						*Precipitation change %*					
Season *2080–2099*	Min	25	50	75	Max	Tyrs	Min	25	50	75	Max	Tyrs
Dec–Feb	+2.0	+2.6	+3.1	+3.4	+4.2	10	–3	+6	+13	+16	+33	55
Mar–May	+1.7	+2.7	+3.2	+3.5	+4.5	10	–9	+2	+6	+9	+20	>100
Jun–Aug	+1.6	+2.7	+3.4	+3.6	+4.7	10	–18	-2	+4	+7	+16	
Sep–Nov	+1.9	+2.6	+3.1	+3.6	+4.3	10	–10	+3	+7	+13	+38	95
Annual	+1.8	+2.5	+3.2	+3.4	+4.3	10	–3	+2	+7	+11	+25	60

Source: adapted from Christensen et al. (2007: 854)

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remain among climate scientists. Problems with current models include their inability to reproduce tropical rainfall patterns, simulate the Arctic cycle, or mimic Atlantic hurricanes or European droughts (Pearce, 2008b). Moreover, the confidence that exists in current predictions is predominantly due to agreement being found between the predictions of several different climate models – such as where there is close agreement between the 25 per cent and 75 per cent columns in Table 1.1. However, this notion of multimodel consensus is itself open to question, the more so following studies that reveal the possibility of 'systematic error common to all models' – in essence, biases within the entire suite of models that undermine the reliability of the consensus (Palmer, 2008; see also Pearce, 2008a). Improvements are therefore necessary in the science behind climate modelling: massive investment in computing power alone will not be enough.

Using climate and forecasting information

Inevitably, all models will harbour uncertainty. Desai et al. (2008: 52) go as far as to suggest that models can only be 'heuristic tools which help our understanding of what we observe, measure or estimate' and should not be treated as 'truth machines'. If this is the case, then relying on climate models to provide information of sufficient precision to drive adaptation may always be a mistake. However, for the present, the question does not arise as model predictions remain either too contradictory or too broad to provide sufficient detail for a purely impacts-driven approach to adaptation. Indeed, it should be noted that moving from climate model outputs to a prediction of the likely impacts of climate change requires a further layer of modelling and therefore uncertainty. Impact models are a separate area of study from climate science that rely on physical and socio-economic models to translate a climate future (changes in temperature, rainfall and length of growing season, for example) into human impacts (such as health implications, flooding and food supply).

The aspects of uncertainty presented here should not be confused with a lack of knowledge: the issue is to develop a clear understanding of what climate science is currently offering. Changes in the Earth's systems are beyond doubt and as time passes the emerging science continues to suggest that the changes may be more profound and with us sooner than first thought. Climate change is already being experienced in many parts of the world, not least through rising sea levels, and climate predictions are clear in anticipating change at an unprecedented pace and scale. Yet the uncertainties associated with predictions are multifaceted and complex. If adaptation is to respond to the challenges of climate change, both these aspects of climate knowledge – the process of change and the degree of uncertainty – must be understood. Some level of understanding of what climate change may bring in a particular setting and how uncertain those predictions are will be essential if informed decisions are to be taken.

It follows that short-term forecasting and climate predictions both have a role in adaptation. This is reinforced in the case study chapters that follow, where it is found that local knowledge, which traditionally underpins community responses to changes in the weather and seasons, needs increasing support in the face of unprecedented climate variability. The different challenges that climate change presents are best addressed through different approaches to forecasting or prediction. Extremely fast onset events, such as flash floods or cyclones, require weather forecasting (looking at the days or weeks ahead); fast onset events, such as drought, need seasonal forecasting (at a timescale of weeks and months); and slow onset events, such as changes to seasons or sea level, can to an extent be predicted through climate modelling (looking at multiple years into the future) (R. Ewbank, personal communication, 26 September 2008). Yet there are also important links across these timescales, as changes to the climate place short-term events in a new context. Forecasting underpins the early warning that is necessary to ride out extreme weather events, be it through temporary relocation, securing property or ensuring adequate food supply. Climate change model predictions, on the other hand, may indicate the future likelihood of, for example, high rainfall or temperatures. This allows current unexpected events to be understood as part of an emerging trend (rather than as an anomaly) and offers a new context for infrastructure investment or livelihood decision making. This holds equally for incremental changes (such as gradual changes in temperature, sea level or rainfall), which can go unnoticed, be perceived as anomalous, or be disguised in or misdiagnosed as part of cyclical climate variations. Such changes may be foreseeable through seasonal forecasting but must also be recognized as part of a new long-term trend if they are to be understood and planned for.

Thus it is through short-term and seasonal forecasting that adaptation actions are able to engage with the variable conditions that are superimposed on emerging climate trends. However, a risk remains that simple climate change messages can disguise the complexity that is inherent in climate modelling. This applies to uncertainty (where similar outcomes can be equally asserted) and the statistical nature of predictions (in that climate only offers a view of the average conditions over a long period). If the uncertainty in climate messages is overlooked or underplayed then actions may be driven towards maladaptations focused on predicted impacts that fail to materialize. Equally, however, complexity and uncertainty must not divert adaptation from addressing threats to livelihoods if such impacts are known and imminent. These challenges are reflected in the Kenya case study reported in Chapter 6. In a context dominated by reductions in annual rainfall, the need for information was met through efforts to translate seasonal forecasting into locally relevant agricultural information. While the need to inform the community about long-term climate change was recognized, specific predictions were at the time judged to be too uncertain to have a role in adaptation actions.

In short, relevant and appropriate dissemination of climate change-related information, encompassing weather forecasts, seasonal forecasts and climate change predictions, is an important – if not defining – feature of adaptation.

Vulnerability and adaptation

Vulnerability underpins adaptation: it is the perception of vulnerability to some aspect of climate change that motivates and defines the objectives of adaptation activities. However, this observation raises two questions. First, how is this perception arrived at? As indicated above, the generation and communication of climate change knowledge plays a significant role in how we understand the conclusions of climate science, and this topic will be considered further in the following section (see 'Adaptive capacity and resilience', below). The second question is more fundamental: what do we mean by vulnerability? This question is the subject of the following paragraphs, in which alternative perspectives on vulnerability are shown to differ in their treatment of the uncertainty in climate change predictions, and yield different approaches to adaptation.

Before moving to consider vulnerability in detail, it is first necessary to ask 'vulnerability to what?' An answer of 'climate change' is only a starting point, as climate change will bring very different impacts in different places. However, three qualitatively different phenomena can be identified, offering a categorization that can help with understanding the challenges of climate change (Brooks, 2003: 9):

- *Category 1.* Discrete recurrent hazards, as in the case of transient phenomena such as storms, droughts and extreme rainfall events.
- *Category 2.* Continuous hazards, for example increases in mean temperatures or decreases in mean rainfall occurring over many years or decades.
- *Category 3.* Discrete singular hazards, for example shifts in climatic regimes associated with changes in ocean circulation.

While climate modelling makes clear that the possibility of major environmental changes is real, category 3 hazards are currently poorly understood and their possible impacts for communities unknown. Examples of the first two hazard categories, however, are found in the case studies examined in this book. The challenge for adaptation is very different for each of these classes of hazard. Category 1 hazards, for example, may demand early warning or disaster risk reduction approaches, category 2 the adoption or evolution of new livelihood practices, while category 3 may demand the abandonment of existing lifestyles. In any particular case, however, it remains necessary to consider vulnerability to a particular hazard or category of hazards.

Climate change hazards yield two forms of impact: biophysical impacts, such as the physiological effects on crops, changes in disease vectors, or changes to land, soil and water quality and quantity; and livelihood (or socio-economic) impacts, including damage to infrastructure or changes in crop production or trade patterns (Orindi and Murray, 2005: 5–6; FAO, 2007: 2). Crucially, livelihood impacts arise as a result of the interaction of biophysical impacts with existing social systems. For example, mortality rates following the emergence of new diseases are dependent on factors such as access to health care and nutritional intake. Similarly, a change in land quality (a biophysical impact of climate change) interacts with a community or household's existing social and economic systems to be translated into livelihood impacts such as a fall in income from crop production, reduced food security or human migration. The case of Bangladesh, examined in Chapter 2, illustrates this interaction: persistent flooding and high river flow rates erode the fertile land that local people depend on for their livelihoods, while relocation to islands created by the change in river flow is restricted by local landowners. Clearly, it is the prospect of livelihood impacts that is central to motivating adaptation, yet differences in how livelihood impacts are understood generate two quite different versions of vulnerability.

The first approach to vulnerability arose from a desire to estimate the potential costs of climate change (Burton et al., 2002). In this view, vulnerability refers to the 'end-point' livelihood impacts of climate change after an adaptation option has been adopted (Kelly and Adger, 2000: 327). Rather than assessing context, end-point vulnerability seeks to measure the effectiveness of an adaptation option in reducing the damage brought about by a particular hazard. For example, the difference in yield between two proposed crop varieties after flooding quantifies relative vulnerability. This approach facilitates the assessment of competing adaptation interventions based on the outcome of an anticipated climate hazard: the introduction of the crop with the highest yield would be the chosen adaptation. By contrast, the second approach – the 'starting-point' interpretation – focuses on understanding the processes that pre-exist within a system (Kelly and Adger, 2000: 327; O'Brien et al., 2004: 2). It seeks to examine the characteristics of communities to identify those elements that make them susceptible to climate change: in this sense the approach considers vulnerability to exist independently of the external climate hazard. Thus rather than suggesting the introduction of the highest yielding crop, an assessment of starting-point vulnerability should address the breadth of issues that play a role in vulnerability to flooding (such as the lack of watershed management cooperation between upstream and downstream communities, illegal logging or degraded soils with poor moisture retention). Alternative crop varieties would also be subject to this analysis (for example, whether the seeds can be stored and reused on farm, and the cost and availability of the inputs necessary to obtain high yields). This explicit focus on the broad social and environmental context, rather than on a particular adaptation intervention, distinguishes starting-point from end-point vulnerability.

The starting point definition of vulnerability is assumed throughout this book. Understood in this way, vulnerability is determined by the environmental and human characteristics of the community, revealing the process through which climate change hazards generate livelihood impact. Human factors such as food entitlements and access to health care will play an important role in determining the outcome of several hazards, while others, such as the quality or location of housing, may only assume significance for a particular hazard (for example, flooding). Environmental variables, such as topography, biodiversity or groundwater reserves are key to mediating climate hazards, moderating changes in all aspects of weather including temperature, precipitation and extreme events. These variables are also influenced by human activities as communities strive to manage and exploit the environment (Brooks, 2003: 5). Methods for assessing starting point vulnerability are explored in several of the following chapters. For example, in Sri Lanka (Chapter 5) the project team engaged in several activities with the community including resource mapping, risk mapping, and field observations and transect walks. Each of these approaches yielded different information about context in which risks and threats to the local resource base, environment and livelihoods have emerged. The Pakistan case study (Chapter 4) notes the importance of gender analysis in the process of assessing vulnerability, as women's livelihoods often have different characteristics from those of men. Women also offer a different insight into the local threats and risks.

There are several reasons for adopting the starting point definition of vulnerability. Starting-point vulnerability recognizes that ongoing livelihood activities, coping mechanisms or broader issues (such as the emergence of conflict) can generate changes in the human and environmental factors that underpin vulnerability (Smit and Wandel, 2006: 287). This dynamic aspect of vulnerability – the possibility of change to the social, political, economic and environmental characteristics of a community – is only captured in the starting point description. Yet capturing changes to vulnerability over time is essential when considering climate hazards. Category 1 (discrete recurrent hazards) and category 2 (continuous hazards) both draw attention to climate change as an ongoing phenomenon (with impacts experienced either intermittently or progressively). A meaningful representation of vulnerability to climate change must therefore capture the incremental changes to vulnerability that result from multiple or progressive impacts over time. Moreover, there are inherent difficulties with end-point analysis that are not immediately obvious. End-point vulnerability is forward looking in the sense that it tries to anticipate the outcome of climate hazards. It therefore relies on social and economic models to translate *predicted* biophysical impacts into *predicted* livelihood impacts following some *anticipated* adaptation: at each stage uncertainty is introduced and compounded. Moreover, the reliance on social and economic models inevitably increases as the analysis moves further into the future and climate hazards extend beyond the realm of experience. As Burton et al. (2002: 8) state, '[a]nalysis of the choice of adaptation measures at some future time to an uncertain future climate in an unknown socio economic context is bound to be highly speculative'.

A further problem arises when the class of adaptation activities associated with end-point vulnerability are considered. These are referred to as first generation or standard approaches (Burton et al., 2002: 7) and aim to reduce end-point vulnerability by finding a particular adaptation solution to a particular climate change problem. Typically, first generation approaches have been associated with technological fixes, such as raised bridges, improved levees or new monoculture crop varieties. However, the 'speculative' nature of the analysis can lead to overwhelming uncertainty and ultimately to maladaptations if the reality of climate change turns out to be different from current expectations (O'Brien et al., 2004: 5). Second generation adaptation takes a very different approach, commencing from the premise that it is necessary to address the context in which hazards occur (Burton et al., 2002; O'Brien et al., 2004; Eriksen et al., 2007). Starting-point vulnerability is employed to examine the biophysical, social, economic, political and cultural factors that make up climate vulnerability. By shifting focus in this way, the function of adaptation becomes one of reducing the causes of vulnerability when addressing particular outcomes. The intention is to reduce current vulnerability to the climate change hazard (or hazards) without the risk of maladaptation: activities should simultaneously reduce the impacts of potential climate change and improve the well-being of households or communities in the short term – for example through addressing poor housing, degraded soils or the inequitable distribution of resources. These approaches to adaptation are in essence vulnerability reduction measures, and can be classified as no-regrets strategies – meeting climate change adaptation goals while fulfilling broader development ends even if climate change predictions do not play out. Many of the approaches to adaptation examined in the following chapters employ no-regrets strategies. For example, in Pakistan (Chapter 4), small-scale vegetable farming provided food security and increased income almost immediately, while also being much less water intensive than the local cash crops and thus well suited to the (anticipated) dryer, water scarce climate. Similar approaches were adopted in Nepal, Kenya and Sudan (Chapters 3, 6 and 8).

As the case studies in this book illustrate, the focus on the causes of vulnerability does not mean that second generation approaches cannot address livelihood impacts. Nor does it mean that starting point vulnerability can or should operate independently of climate change predictions. Analysis of vulnerability will need to be with reference to an anticipated hazard (for example, vulnerability to sea-level rise). Moreover, there will be circumstances when climate change predictions are clear or impacts are evident in the short term (such as glacial lake outburst or where sea-level rise leads to flooding). However, starting-point vulnerability should ensure that the chosen response (such as the introduction of saline tolerant varieties or dam building) recognizes the 'existing social, economic and political structures' and thus that adaptations 'may increase inequality in a community and exacerbate vulnerability for some' (O'Brien et al., 2004: 12).

Adaptive capacity and resilience

While starting-point vulnerability can underpin no-regrets approaches to adaptation, investment in these strategies inevitably requires a degree of confidence in climate change predictions. A point will arise when uncertainty about the future climate increases so much that vulnerability assessments start to lose value, eventually becoming meaningless as the real possibility of unforeseen hazards emerges. If increased rainfall is as likely to emerge as increased drought, how then should adaptation proceed? This section focuses on how this challenge can be met through building adaptive capacity, understood as the ability to change in response to climate changes, and resilience, understood as the ability to absorb or cope with the unexpected. However, adaptive capacity and resilience should not be seen as independent of vulnerability: increasing a household or community's resilience or ability to adapt should help reduce vulnerability to the broadest possible range of hazards. As discussed below, adaptive capacity is also related to resilience, as building adaptive capacity is one way to support the ability to cope and recover.

Adaptive capacity refers to the potential to adapt to the challenges posed by climate change, describing the ability to be actively involved in processes of change. It encompasses the ability of actors within a particular human and environmental system to respond to changes, shape changes and create changes in that system (Chapin et al., 2006: 16,641). The tools that make up adaptive capacity therefore include both tangible assets, such as financial and natural resources, and less tangible elements such as the skills and opportunities to make decisions and implement changes to livelihoods or lifestyle. Both the diversity and distribution of these components of adaptive capacity are important. For Chapin et al. (2006: 16,641) adaptive capacity: 'depends on the amount and diversity of social, economic, physical, and natural capital and on the social networks, institutions, and entitlements that govern how this capital is distributed and used'.

Similarly, Smit and Wandel's (2006: 286) review of adaptation literature suggests that the determinants of adaptive capacity include both assets, including financial, technological and information resources, and the context within which these assets are held, including infrastructure, institutional environment, political influence and kinship networks. Thus both Chapin and Smit and Wandel draw attention not just to the availability of assets but also to the prevailing social and political context through which distribution takes place: networks, institutions, entitlements and political influence. Smit and Wandel (2006: 289) note that this context operates at different scales: while some elements of adaptive capacity are local (such as networks of family relationships), it is also important to recognize that broader and sometimes global social, economic and political forces may have the most significant influence on local vulnerabilities, such as where international free trade agreements remove supportive subsidies or price guarantees for a particular local crop. It may not be sufficient to consider only micro-scale relationships if it is 'powerful political and economic vested interests that determine the nature of the adaptation context' (Brooks, 2003: 12).

Diversity supports adaptive capacity by providing communities with options at times of stress or external change. Diversity is an attribute that offers more than simple accumulation of assets: it recognizes that addressing an uncertain future requires access to a range of alternative strategies, some of which will prove viable. However, diversity is also a key pillar of resilience. Where adaptive capacity refers to the ability to influence and respond directly to processes of change, resilience is the ability to absorb shocks or ride out changes. For resilience, diversity of social, economic, physical and natural assets improves the prospects of a socio-ecological system persisting. For example, a farm system dependent on a single crop may have low resilience to disease or climate change compared with one predicated on agricultural biodiversity. Similarly, the Kenyan case study (Chapter 6) reports how a diversity of seeds are planted in response to uncertain seasonal forecast information, ensuring that some crops reach maturity even if the predicted weather patterns do not emerge. In Peru, a diversity of planting altitudes and terrains underpins the conservation of potato varieties from one year to the next, ensuring that crops survive in some locations even if they fail in others (Chapter 9). In the same way, resilience may also take the form of multiple (diverse) livelihoods. While diversity underpins resilience, it is also important to recognize that the scale or degree must be appropriate and that a point can be reached at which assets or skills are spread too thinly to be of benefit. In some circumstances sufficient accumulation of assets may also support resilience: reserves of financial capital, for example, can be enough to ensure a household can cope in many circumstances. Safety nets such as insurance, when available and affordable, can also form an important component of resilience and may play a role in backstopping specialization or compensating for a lack of diversity.

Resilience and adaptive capacity are closely related, not least because both reduce the impact of uncertainty. Fostering adaptive capacity is also a mechanism for building resilience: adaptive capacity expands the options and opportunities for coping with or avoiding the impacts of climate change and thus improves a community or household's prospects of survival. For example, given access to and the ability to employ climate-related information, a pastoralist community may proactively sell livestock prior to a drought, thus yielding the resources necessary to cope (as in the Niger case study in Chapter 7). In this example, resilience – the broad ability to cope and recover – was enhanced through adaptive capacity that enabled the community to engage with and respond to the prospect of drought.

Elements of adaptive capacity

Adaptation requires the accumulation of skills as well as a diversity or accumulation of assets. Principally, utilizing a diversity of assets to expand the range of available livelihood or coping strategies requires the ability to explore ways of employing those assets. Thus attributes of adaptive capacity also include the ability to experiment or innovate, and the capacity to learn (Peterson, 2000: 328; Chapin et al., 2006: 16,641). Indeed, it has been suggested that the most adaptive societies are those with actors who have the capacity to experiment, and institutions in place to support them (Patt, 2008). The involvement of NGOs and institutions in farmer-led research into rice varieties in Sri Lanka, explored in Chapter 5, demonstrates how local adaptive capacity – and in particular the confidence to experiment – can be fostered. A similar experience is reported in the Peru case study (Chapter 9). The provision of technical training is an important element in supporting experimentation and learning, and is present in many of the case studies. For example, training in raft construction in Bangladesh (Chapter 2) allowed local farmers to implement their own changes to the design of floating gardens, ensuring they were suitable for the local conditions. Local extension services can also be key, as demonstrated in the Pakistan case study (Chapter 4) in which the presence of NGO and extension support is identified as part of the difference between success in one site and failure in another. The readiness to experiment and learn is complex and influenced by human, cultural, financial and institutional factors. The ability to put a diversity of resources to productive use may be linked to educational background and prior experience. Cultural attitudes may overlap with attitudes to financial assets to assist or inhibit experimenting and risk taking. For example, evidence suggests that there is no correlation between farmers' wealth and their willingness to adopt new management practices (Phillips, 2003; A. Patt, personal communication, 6 June 2008). On the other hand, the take up of insurance – a method of reducing risk and thereby facilitating experimentation – has been found to be greater among wealthy households. Risk-averse households can in fact be less likely to take insurance, often because of their lack of experience with handling financial products (Gine et al., 2007: 2). Some social norms, if narrowly defined or deeply held, can stand in the way of experimentation. However, culture may equally support or inhibit experimentation: marginalized communities have exhibited both conservatism and experimentation as a strategy to deal with environmental change (Ensor and Berger, 2009; Patt, 2008: 63).

The process of learning and adopting new strategies can be closely linked to the presence of social networks (defined in more detail below). Gine et al.'s (2007: 19) study of insurance take up among rural households in Andhra Pradesh reveals membership of social networks to be important in determining whether a new insurance scheme is adopted, as networks provide opportunities for sharing information and advice. The importance of networks is explained in part by research which suggests that individuals respond differently to information that is gained through 'experience-based reasoning' or 'analytically-based reasoning'. Experience-based information processing is generally dominant in decision making, and relies on experience that is personally held or communicated from others. Analytical reasoning responds to authoritative, externally provided information and generally has a role restricted to moderating the experiential response (Balstad, 2008: 166). Social networks provide an opportunity for sharing experiences and therefore are well placed to be effective in promoting learning, influencing changes to behaviour and stimulating collaborative innovation processes (Cross and Parker, 2004: 9). In the same way, they can help the real and perceived risk of adopting changes to livelihoods to be reduced by observing and understanding the experiences of others. This is evident in many of the case studies examined in this book, including in Nepal (Chapter 3) where the practice of vegetable growing was introduced to demonstration sites in the first year of the project and spread within two years to almost all farmers in the area.

Importantly, adaptive capacity also requires the ability to access and process climate information. Climate change is an emerging phenomenon with the potential to transform environments and challenge traditional expectations of seasonal patterns and climate extremes. As adaptive capacity embodies a household or community's ability to engage with and make decisions about processes of change, some level of understanding of climate change predictions and the associated uncertainty is essential. Indeed, in most of the case study chapters that follow, raising awareness of climate change was a central adaptation activity. As noted, however, there is also the potential for simple climate change messages to disguise the complexity that is inherent in climate modelling. The illusion of certainty and simplicity is attractive. Social scientists and psychologists have found a tendency for people to reduce complexity by focusing on single problems and single solutions even when faced by multiple threats and where a diverse response may be more effective (Balstad, 2008: 167). This poses a problem for the communication of climate change information and raises the prospect of uncertainty being overlooked or underappreciated by either party when information is exchanged. However, an appreciation of complexity and uncertainty is essential if maladaptations or futile efforts at vulnerability reduction are to be avoided.

Some form of institutional support is necessary for information dissemination, as climate change science and predictions will be beyond the reach of most poor communities. It is the responsibility of national governments to assimilate and communicate short- and long-term weather and climate change information, and to identify and facilitate the filling of gaps in knowledge where they exist. Moreover, each of these responsibilities should be grounded in the livelihood context of those who are most vulnerable to climate change: information should be targeted at these groups in a form and with content that is appropriate to their needs. This responsibility can be framed either generally, in terms of social contract between government and citizens, or more specifically in terms of the rights violations that will result from the depletion of resources and loss of lives and livelihoods.