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Chapter 20: Perspectives on Climate Change and Sustainability

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Executive Summary

Conclusions about the ability of nations and the globe to integrate issues of sustainability into their considerations of climate change *and* to integrate climate change into their deliberations about sustainable development can be offered with high confidence in the sense of being established though incomplete.

First of all, the vulnerability of any system depends on exposure and sensitivity and that both depend on its adaptive capacity. Recent work suggests that adaptive capacity is explained, in many instances, by the weakest of these determinants. The prerequisites for (sustainable) development match the determining factors that influence adaptive capacity relative to climate change and climate variability

The relative efficiency of adaptation options and sustainable development programs are site-specific and path-dependent empirical issues.

Equity, access to resources and technology, social and human capital, and access to risk-spreading mechanisms all function simultaneously as determinants of adaptive capacity and as prerequisites to sustainable development.

Development paths, and the choices that define them, affect the impacts of climate change not only through changes in exposure and sensitivity to external stresses, but also through changes in the capacities of systems to adapt.

Sustainability is a concern for development planners in developed and developing countries, alike; but issues of sustainability can be fundamentally different in developing countries than they are in developed countries.

Most of the sustainable development literature that recognizes climate change as an issue sees only the climate change literature that focuses on mitigation.

Millennium Development Goals and the Agenda 21 process focus on mitigation (protecting atmosphere) and are not motivated by adaptation to climate change.

Uncertainty in aggregate global and/or regional estimates of net impacts is expanding.

Reducing vulnerability to the hazards of current climate variability contributes to reducing vulnerability to climate change, but it is not in itself necessarily sufficient.

Participatory processes, carried out as part of climate change research, can facilitate the integration of biophysical and socio-economic aspects of climate change adaptation and development.

Programmatic preferences across adaptation options depend upon the relative weights given to equity and efficiency within the valuation criteria as well as the analytic decision framework that is actually applied in the decision process.

20.1 Introduction

The fundamental nature of an effective societal response to questions of sustainable development was given by the international statesman Maurice Strong (Secretary General of the 1961 UN Conference on the Human Environment in Stockholm and the 1992 UN "Earth Summit in Rio de Janeiro) in accepting the prestigious Public Welfare Medal from the U. S. National Academy of Sciences in 2004. He remarked on that occasion, that "… the main lesson I have drawn from my own experience in dealing with this complex of issues is the need for a major shift in the motivational basis of our current behaviour. People and nations are motivated not only by their immediate self-interest but by their deepest moral, ethical and spiritual values."

The fundamental conclusions of IPCC (2001a) that spoke to the intersection of climate change and sustainable development were summarized in the Executive Summary of Chapter 18: *Enhancement of adaptive capacity is a necessary condition for reducing vulnerability, particularly for the most vulnerable regions, nations, and socioeconomic groups.* Activities required for the enhancement of adaptive capacity are essentially equivalent to those promoting sustainable development. (pg. 879). These fundamentals still ring true. The effects of climate change and climate variability, net of adaptation responses but including the cost of adaptation, are still thought to play a significant role in determining the sustainability of a community's, a society's, a nation's, and even the globe's development trajectory. Moreover, it is still widely believed that the choices that communities, societies, nations, and global institutions make about their development paths are critical in determining the future of climate change.

This chapter will provide evidence from both the relevant literatures and from case studies drawn from earlier chapters to support twelve separate conclusions that support and extend the conclusions published in the TAR. In particular, this chapter will argue, in the sections highlighted in italics, that:

1 IPCC (2001a) argued that the vulnerability of any system depends on exposure and sensitivity and that both depend on adaptive capacity. IPCC (2001a) also argued that adaptive capacity, in turn, depends on a collection of site-specific and path dependents. More recent work suggests that adaptive capacity is explained, in many instances, on the weakest of these determinants. The prerequisites for (sustainable) development match the determining factors that influence adaptive capacity relative to climate change and climate variability, and the development literature supports a parallel dependence of success in many instances on the weakest prerequisite. (Sections 20.3.3, 20.3.4 & 20.3.5).

2 Since adaptive capacity and support for sustainable development of any specific socio-economic-political system are both site specific and path dependent (as is its mitigative capacity), determining the relative efficiency of adaptation options and the relative efficiency of development programs are essentially empirical questions whose answers cannot be predicted a priori. (Sections 20.3.3, 20.3.4, 20.3.5 & 20.6).

3 Equity, access to resources and technology, social and human capital, and access to risk-spreading mechanisms all function simultaneously as determinants of adaptive capacity and as prerequisites to sustainable development. They also are goals for sustainable development programs. (Sections 20.6.4 & 20.8).

4 A two-way causality between sustainable development and adaptive capacity exists. Development paths, and the choices that define them, affect the impacts of climate change not only through changes in exposure and sensitivity to external stresses, but also through changes in the capacities of systems to adapt. There continue to be questions regarding the sequence of

policy implementation to meet climate change adaptation and sustainable development objectives. (Section 20.3.6).

5 Sustainability is a concern for development planners in developed and developing countries, alike; but issues of sustainability can be fundamentally different in developing countries than they are in developed countries. Climate change is seldom included in the list of stressors that these decision-makers take to be sources of serious threat to sustainability. (Sections 20.3.7 & 20.6).

6 Most of the sustainable development literature that recognizes climate change focuses on mitigation. This is reinforced by climate change policy literature where discussions of sustainable development are motivated by emissions reductions. (Sections 20.3.8 & 20.6)

7 Millennium Development Goals and the outputs of the Agenda 21 process focus on mitigation (protecting atmosphere) and are not motivated by adaptation to climate change even though achieving their goals can be beneficial for enhancing adaptive capacity. (Section 20.6.3).

8 Uncertainty in aggregate global and/or regional estimates of net impacts is expanding in part because global coverage of robust net impacts is incomplete (Section 20.6).

9 Environmental impact assessments and/or development policies are beginning to include climate change as a focus of attention in locations where the issues have gained prominence, but this practice is not yet widespread. (Section 20.3.7 & 20.4)

10 Reducing vulnerability to the hazards of current climate variability contributes to reducing vulnerability to climate change, but it is not in itself necessarily sufficient. (Sections 20.3.6 and 20.5.2).

11 Participatory processes, carried out as part of climate change research, can facilitate the integration of biophysical and socio-economic aspects of climate change adaptation and development by creating opportunities for shared experiences in learning, problem definition, and solution design, appropriate to the context of decision making (Sections 20.8.3 & 20.8.4).

12 Programmatic preferences across adaptation options depend upon the relative weights given to equity and efficiency within the valuation criteria as well as the analytic decision framework that is actually applied in the decision process. Risk-management approaches to mitigation and adaptation offer new contexts through which mitigation and adaptation responses to climate change can be integrated and mainstreamed into development programs. (Section 20.8.4).

Counterexamples exist for each of these subsidiary conclusions, so none of them can be advance with “very high confidence”. Still, the do hold across a sufficient set of applications that they can be offered to researchers and policy-makers alike as “well established” methods with which to engage policymakers in discussions about how to bring climate change to bear on issues of sustainable development *and* how to bring sustainable development to bear on issues of climate change (both on the adaptation side and on the mitigation side).

20.1.1 Defining sustainable development

Kates, *et al.* (2000) argue that the world’s present development path is not sustainable, and therein lies a fundamental challenge for all of humanity. Policy makers and scientists are wrestling with how to balance economic growth with environmental conservation, and they have support in their efforts from the highest levels. The recent World Summit on Sustainable Development (WSSD) made it clear that sustainable development is a widely held social and political goal.

Consistent with the IPCC (2001a), sustainable development is defined here to mean “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*”. Enhancing adaptive capacity is consistent with promoting sustainable development because both have similar underpinnings and parallel goals (for example, improved access to resources, reduction of poverty, improved infrastructure, and so on). Notwithstanding the possibility that some decisions might work at cross purposes at the intersection of sustainability and reducing vulnerability to climate change, this working definition focuses attention immediately on making development more sustainable by increasing the ability of systems and societies to adapt to multiple stresses of which climate change and climate variability are but two. It can also highlight the practical truth that sustainable development is an issue confronting developed and developing countries, alike, though perhaps in profoundly different ways. UN (1992) offered “Agenda 21”. Because it focuses attention on economic growth *and* social development (including promoting equity as well as both protecting and enhancing the environment toward the end of promoting human development), it represents to a large degree the practical manifestation of this truth.

In recent years, scientists from all over the world representing a wide array of disciplines have banded together to find ways in which the science and technology communities could exert more influence in promoting sustainable development. The Mexico City Workshop (2002) is evidence that both communities have increasingly recognized that they will play central roles in promoting understanding of both the origins of sustainability challenges and the prospect of successfully dealing with them. This has led to the emergence of what has been called “sustainability science” – an effort to improve on the substantial but still limited understanding of nature-society interactions. Kates, *et al.* (2000) argue that sustainability science is premised on the need for a better understanding of the complex and dynamic interactions between society and nature. As such, it will require fundamental advances in our ability to address such issues as the behaviour of complex self-organizing systems as well as the responses of the nature-society system to multiple and interacting stresses across a full range of scales from local to global.

20.1.2 A wide range of interested parties

The non-governmental organizations (NGO’s) have played a major role in identifying agendas for sustainable development. Indeed, over the past 20 years, NGOs have become a politically important voice in a wide range of international negotiations and discussions over sustainable development, and its link to a wide range of environmental issues. International negotiations among governments on climate change, biodiversity loss, and desertification now routinely offer opportunities for the voices of NGO’s to be heard, and NGO’s have often helped to organize the governments of smaller state actors so as to maximize their voice in international negotiations.

The scientific community has also become entrained in discussions about sustainability. Within the US, for example, the publication of *Our Common Journey* by the National Research Council (1999) marked a significant effort to define as a series of scientific and technological challenges the social, scientific, economic, and technological transitions that would enable the world to make progress towards the goals of sustainable development. The establishment of the InterAcademy Panel as an organization of national academies of science dedicated to capacity building and sustainability issues marks another institutional move forward by the scientific community in promoting a sustainability agenda. International scientific assessments, like the Millennium Ecosystem Assessment (2005), take the sustainable use of natural resources as an imperative, and explore the tradeoffs inherent in emphasizing any particular service provided by ecosystems over other services that those systems provide.

The business community has equal concerns over sustainability in the long term, although there is great variability among individual firms and organizations as to how that concern is expressed. The World Business Council for Sustainable Development (WBCSD), for example, was created in the year leading up to the Rio Conference of 1992. The WBCSD provides a forum for discussion and comparison of best practices for many businesses concerned with the international dimensions of sustainability. The Coalition for Environmentally Responsible Economies (CERES) includes more than 70 large and small corporations that subscribe to the nine overarching principles: protection of the biosphere, sustainable use of natural resources, reduction and disposal of wastes, energy conservation, risk reduction, safe products and services, environmental restoration, and informing the public. Many individual firms have also made their own commitments to sustainability, both through their existing structures for environment, health, and safety, and through creating new offices responsible specifically for sustainability within their organizations. A growing number of companies, like Rio Tinto, British Petroleum, and Dupont to name just three, routinely produce sustainability reports that outline specific environmental and sustainability goals for the company and track progress towards them. Some firms that have not yet made a commitment to reporting on sustainability nonetheless have multiple activities that promote sustainability within particular divisions or product lines. Many firms have joined in partnerships with both NGO's and governments to promote sustainability within a large and growing network of voluntary actions.

Box 20.1: "A case study of Time, Incorporated"

Time Inc. is the publishing unit of Time Warner, a global media conglomerate with headquarters in New York City. The company is one of the world's largest consumers of coated paper and altogether buys about 600,000 tons of paper a year from mills in the U.S., Canada, Finland, Scotland and Germany. The company, which is a member of the World Business Council for Sustainable Development, sees sustainability as crucial not only to environmental protection, but also to financial success and social responsibility, since only sustainable practices can insure a long-term supply of needed raw materials, continued employment for workers and reliable returns for shareholders.

Time is rapidly increasing the proportion of paper it buys that comes from forests that are certified as sustainably managed by independent organizations such as the Forest Stewardship Council. Current goals call for Time's European suppliers to get 80% of their pulp from certified forests by the end of 2005 and for North American suppliers to meet the 80% mark by the end of 2006. Time teamed with International Paper, a global paper supplier based in Connecticut, and the National Recycling Coalition, a non-profit group based in Washington, D.C., to sponsor two pilot projects to promote magazine and catalogue recycling. The projects are underway in Boston and in Prince Georges County, Maryland. In Boston, magazine and catalogue recycling is up more than 20% since the beginning of the project. In Maryland, preliminary data showed a 13% increase and subsequent figures are expected to show greater gains.

Making paper is among the most energy-intensive manufacturing businesses in the world. For that reason, Time joined with Stora Enso, Home Depot (an American retailer) and Canfor (a Canadian pulp supplier) to sponsor a yearlong study of the "carbon footprint" of the magazine business. One important finding of the study is that the biggest source of carbon emissions from the magazine industry is not the transportation of materials and products, as one might expect in a global enterprise, but the use of energy in the paper manufacturing process and their suppliers are meeting desired sustainability benchmarks.

So far, Time Inc. has focused primarily on the environmental aspects of sustainability. But several of the company's initiatives have had important social benefits. For example, Time's promotion of sustainable forestry in Maine has helped preserve vulnerable logging jobs in that state. Time's promotion of magazine recycling in Boston and Maryland has created jobs and helped local governments reduce garbage-disposal costs and increase revenues from recycling companies. With its work on the EPAT and other projects, Time hopes to help establish benchmarks for corporate responsibility that go beyond the environmental arena.

In parallel, the faith communities have recognized the need for a global ethic to guide humanity. Kung (1991) remarked that "the world's human population has been growing at an every-increasing rate, and the more people there are on this finite globe, the more space we occupy, the more resources we consume, the more waste and pollution we produce and the more damage we do to the planet's natural system when w indulge in civil, political and religious conflict." His work led to the 1995 report, *A Global Ethic: The Declaration of the Parliament of the World's Religions* produced at a 1993 parliament in Chicago. It dealt with the human values, attitudes, and behaviour that need to be embraced by all cultures and religions to cope with the challenges (including "abuses of earth's ecosystems") in the twenty-first century.

20.2 A synthesis of new knowledge relating to impacts and adaptation

Chapter 17 assesses the state of knowledge about adaptation, noting once again that societies have been adapting to the impacts of weather and climate for a very long time. Still, it must be emphasized that adaptation measures are seldom undertaken in response to climate alone. They have, rather, been part of responses designed to address a range of socio-economic and environmental considerations. Brown (2002) sees this integration in terms of a maturing of the environmental movement from a single-issue focus to one that recognizes environmental quality as one fundamental component of sustainability – a context within which employment, social justice, equity and other dimensions of social and political life are considered simultaneously with environmental issues. How, he asks, can a development path that degrades the environment be sustainable? And how can an environmentally benign path be sustainable if it does not achieve some measure of social justice?

Chapter 17 is in concert with Brown's observation when it notes that the capacity to adapt is linked fundamentally to other indicators of development: education, health, governance, and the distribution of income. It is also clear, however, that a high generic capacity to adapt need not necessarily translate into real action even in developed countries. Different societies and groups within societies are vulnerable to diverse sets of multiple stresses to which adaptation can be prevented by violent conflict, infectious diseases, and other factors. Adaptive capacity can be enhanced by appropriate planning that recognizes climate variability and by mechanism that manage risk through social learning and adaptive management. While examples of mainstreaming adaptation to climate change into development plans can be identified in water management, infrastructure development, and some community development programs, Chapter 17 concludes that it is still too early to assess the sustainability of these initiatives.

On a global level, recent initiatives have begun to support what Burton (2004) calls Type II adaptation (adaptation to climate change itself whose international support is borne from the global public goods nature of the climate problem). These initiatives are meant to support and expand Type I adaptation (existing adaptation to past and current climate conditions and variability), but Burton and van Aalst (2004) argue that this approach will work only if its design becomes part of mainstream (sustainable) development initiatives through a systematic management of risks derived from multiple sources. Much of what follows will, in its assessment of a broad range of literature, support their conclusion.

20.3 Impacts and adaptation in the context of multiple stresses

This section begins with a catalogue of the multiple stresses that nations and communities currently face before offering a review of our current understanding of the determinants of adaptive capacity. Key, here, is the connection between those determinants and what might be termed the "precursors of sustainable development". While this connection makes enormous sense on an abstract level, the devil is certainly in the confounding details; these are reviewed before the discussion turns to a consideration of aggregate indicators, some synthetic reflections on the insights offered by earlier chapters on adaptation and mitigation, and the identification of gaps in our understanding of how best to "mainstream" climate into the development planning.

20.3.1 A catalogue of multiple stresses

While climate change has been recognized for several decades as a major risk factor both for ecosystems and more generally for sustainable development, many early analyses of potential impacts and adaptation options have considered climate changes alone. It has become clear, however, that climate change will occur in a broader context of multiple stresses on ecological and social systems. It follows that analyses of potential impacts, adaptation options, and mitigation options should be conducted within that broader context.

The challenge of considering global and regional environmental changes within a context of multiple stresses has now been documented in several different ways. The Pilot Analysis of Global Ecosystems prepared by the World Resources Institute (2000) conducted literature reviews to document the state and condition of forests, agro-ecosystems, freshwater ecosystems, and marine systems. Since then, the Millennium Ecosystem Assessment (MEA, 2005) has comprehensively documented the services that ecosystems provide and the stresses that they face. For example, the MEA reports that cultivated systems in 2000 cover 25% of Earth's terrestrial surface, that more land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850, that 20% of the world's coral reefs have been lost, that another 20% have been degraded in the past several decades, and that 35% of mangrove areas has been lost. Withdrawals from rivers and lakes have doubled since 1960, keeping pace with the overall growth in human population. Biogeochemical cycles have been substantially altered: in addition to the increase in atmospheric carbon dioxide concentrations, flows of biologically available nitrogen in terrestrial ecosystems have doubled since 1960, and flows of phosphorus have tripled in the same time period. Humans now produce as much biologically available nitrogen globally as all natural pathways combined, and the human component is expected to continue to grow during the 21st century. In spite of the fact that there are some ecosystems whose condition has improved over the past several decades, land-use conversion rates remain high, and the biological consequences include raising the species extinction rate by as much as 1,000 times typical background rates. At least 25% of major marine fish stocks have been over-fished, and global fish yields have actually begun to decline. Major changes in land-cover have been identified in the MA and by Lepers *et al.* (2005), and the consequences of rapid land-cover change explored by Foley *et al.* (2005).

These multiple stresses have occurred in part because both direct and indirect drivers of change have themselves increased, especially over the past 40 years. The world's population has doubled from 3 to more than 6 billion people, and the global economy has increased more than six fold. Food production has increased 2 ½ times, water use doubled, wood harvests for pulp and paper have tripled, timber production doubled, and installed hydropower capacity has doubled. The basic demands for food, energy, materials and freshwater are being met in many places, but as documented elsewhere in this chapter, the divergence between wealthy and poor countries and populations has also grown. So even though there are important increases in human well-being in many places around the globe, they have also brought with them tradeoffs in terms of reductions in the extent and condition of the ecosystems and the services they provide.

Figure 13 of the Synthesis Report for the Millennium Ecosystem Assessment (MEA) (2005) provides an extraordinarily concise presentation of the multiple sources of stress that have confronted the planet's ecosystems and natural resources over the past 50 years. These are, of course, the resources upon which sustainable development pathways will be constructed over the next 50 years and beyond. A version of that figure is replicated in Table 20.1, and all of the caveats expressed in the MEA still apply. In particular, the current and anticipated levels of stress from various drivers in the future are the result of expert judgment of the rigorous assessment of current trends and conditions conducted by the Condition and Trends Working Group of the MEA. They are, therefore, extrapolations of the past and do not necessarily incorporate adaptive and mitigative interventions. Moreover, Table 20.1 reports global impacts and trends that may be extraordinarily different from place to place around the globe.

Recognizing diversity from place to place, both in the manifestation of a specific stress and the potential of human intervention, brings a variety of other sources of stress to the table – sources on sustainability borne of human activity. Socio-economic conditions and trends are critical; for example, changes in population levels and distributions, rates of technological change and other sources of productivity growth, etc… can effect sustainability directly and indirectly through the drivers indicated in Table 20.1. So can the evolution of governmental and other institutional structures such as changes in property rights, redistributive initiatives, a wide range of economic incentives that may or may not be mutually consistent, and so on. Since the manifestations of these conditions and trends are so site-specific, however, it is perhaps best simply to offer a brief description of anthropogenic sources of stress for one region of the world as an illustration.

Table 20.1: *Direct Sources of Stress on Ecosystems and Natural Resources **

Ecosystem / Resource	Habitat Change	Climate Change	Over Exploitation	Pollution
Boreal Forest	L / faster	L / rapid	L / the same	M / rapid
Temperate Forest	M / slower	L / rapid	M / the same	M / rapid
Tropical Forest	VH / rapid	L / rapid	H / faster	L / rapid
Temperate Grassland	VH / faster	L / rapid	L / the same	VH / rapid
Mediterranean Grassland	M / faster	L / rapid	M / the same	L / rapid
Tropical Grassland & Savannah	M / faster	M / rapid	VH / the same	M / rapid
Desert Grassland	L / the same	M / rapid	L / the same	L / rapid
Inland Water	VH / rapid	L / rapid	M / the same	VH / rapid
Coastal Zones	VH / faster	M / rapid	H / faster	VH / rapid
Marine Systems	M / rapid	L / rapid	VH / faster	L / rapid
Islands	M / the same	L / rapid	H / the same	L / rapid
Mountain Regions	M / the same	M / rapid	L / the same	L / rapid
Polar Regions	L / faster	H / rapid	H / faster	M / rapid

** Each entry was taken from Figure 13 in MEA (2005, pg. 16); it records an assessment of current conditions (L, M, H and VH for "low", "moderate", "high", and "very high", respectively) as well as an assessment of whether or not the observed trend will accelerate as the future unfolds.*

To that end, consider the stresses that can be documented across African continent. As described in Chapter 9, for example, Africa's growing urban population, largely fuelled by rural-urban migration, has produced strong negative consequences. Murkirwa (----) documented the decline of rural agricultural production (the result of a contracting labour supply) and rural incomes. He can thereby explain why rural poverty escalated while investment opportunities diminished. Elsewhere, this migration produced largely unplanned urban and semi-urban centres and slums, with their attendant pressure on infrastructure, services and energy consumption. Ogbonna (----) noted that this pressure has turned viciously cyclical since increased demand for biomass sources of energy from the growing urban areas was confounded by increased demand for construction materials to build those areas. Meanwhile, rural-rural migration from marginal to more resource-endowed areas also produced heightened competition for scarce environmental resources. Fiki and Lee (2005) see this as a source of several violent conflicts. Amin, *et al.* (2005) concur in their chronicle of the international humanitarian crisis in the north Dafur region of the Sudan.

It is not difficult to see how these issues might be exacerbated by climate change. Oyebande, *et al.* (2002) report that West Africa has experienced a significant decline in freshwater availability (the region's major river systems have dropped by 40 to 60%). This sharp decrease in water availability, which may be the norm in a world where the climate has changed, was accompanied by greater uncertainty in the spatial and temporal distribution of rainfall and surface water resources; but its largest legacy might be the associated escalation in trans-boundary tensions even when potentially effective adaptations are implemented.

Niasse (2005) chronicles the story of the Sengal River Basin, for example, where eight of the ten driest years from 1904 through 1984 occurred in the 1970s and 1980s. It was in this context that the Senegal River Basin Development Authority (OMVS) was created in Mali, Mauritania and Senegal with the mandate of developing and implementing a major water infrastructure program – a program that eventually included the construction of the downstream Diama Dam and the upstream Manantali Dam. These two dams were meant to reduce the vulnerability of these three countries to drought and climate variability. In 1988, two years after the commissioning of the Diama Dam and few months after the completion of the Manantali Dam, a conflict erupted between Senegal and Mauritania. The tension began when the river started to recede from adjacent floodplains. Senegalese farmers who went to the right bank of the river to prepare their fields were chased away by Mauritanian border guards. Senegalese authorities retaliated by sending back to Mauritania camel herds which used to spend most of the dry season in the northern part of Senegal. A few months later, in April 1989, after a dispute between Senegalese farmers and Mauritanian herders, Mauritanian border guards killed two Senegalese farmers and held 13 others in custody. Tensions grew, border communities were raided and looted, and retaliatory raids took hundred of lives. By the end of June 1989, 75,000 Senegalese and 150,000 Mauritanians were repatriated. Thousands of black Mauritanians, whose nationality was denied by Mauritania, were deported to Senegal to become refugees. The two countries severed their diplomatic relationships, deployed troops along the river, and exchanged of heavy artillery barrages. Although both countries restored diplomatic relationships in 1992, the wounds of the crisis linger on. Since IPCC (2001c) reports that climate models cannot agree on whether precipitation will increase or decrease as climate change progresses over the next century, it is impossible to guarantee that similarly inspired hostilities will not again erupt in West Africa.

20.3.2 The role of the determinants of adaptive capacity

Some of the critical boundaries that define vulnerability are defined by physical properties, but others are determined by social-economic context and social preferences. Even across this bifurcation, though, a fundamental IPCC (2001a) conclusion carries weight: it is worthwhile to recognize from the start that any system's vulnerability to climate change and climate variability will be determined initially by *its exposure to the impacts of climate and its baseline sensitivity to those impacts,* but then focus attention on the point that *its adaptive capacity will determine its ability to cope.* This approach exploits its recognition that all three of these factors, but perhaps most fundamentally the role adaptive capacity in defining social-economic thresholds of tolerance to climate-related stress, clearly depend on path dependent and site specific circumstances.

To sort through the implications of this insight, Yohe and Tol (2001) suggested that a list of the determinants of adaptive capacity should include:

1 the range of available technological options for adaptation,
2 the availability of resources and their distribution across the population,
3 the structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed,
4 the stock of human capital including education and personal security,
5 the stock of social capital including the definition of property rights,
6 the system's access to risk spreading processes,
7 the ability of decision-makers to manage information, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers, themselves, and

8 The public's perceived attribution of the source of stress and the significance of exposure to its local manifestations.

This second tier list of critical factors identifies some of the fundamental sources of diversity across paths and locations. Other recent attempts to describe overall adaptive capacity include those of Brooks and Adger (2005), who list at least eight questions that must be answered for the purpose of identifying appropriate indicators:

1 What is the nature of the system/population to be assessed?
2 What are the principal hazards faced by this system/population?
3 What are the major impacts of these hazards and which elements/groups of the system/population are most vulnerable to these hazards?
4 Why are these elements/groups particularly vulnerable?
5 What measures would reduce the vulnerability of these elements/groups?
6 What are the factors that determine whether these measures are taken?
7 Can we assess these factors in order to measure the capacity of the system/population to implement these measures?
8 What are the external and internal barriers to the implementation of these measures?

The last four questions focus attention on the underlying determinants of the capacity of a system to adapt within the specific path-dependent and site-specific context described in the answers to the first four. Given the likelihood that no two contexts will ever be identical, it is clear that future research has a long way to go if it were to come to grips with the diversity of the socio-political-economic environments that produce wide ranges of sensitivities and imply enormous variances in adaptive capacity. Perhaps more importantly, though, strength across the determinants of adaptive capacity does not necessarily mean high adaptive capacity. A society, be it developed or developing, can have everything in place and still be vulnerable until its capacity is actually utilized either at the local/household or the national level. In short, as noted in Brooks and Adger (2005), societies have to move beyond rhetoric into action.

20.3.3 The implications of diversity

Adger and Vincent (2004) confront the implications of the diversity noted by the IPCC (2001a) directly. They observe that uncertainty is pervasive and that adaptive capacity essentially describes the adaptation space within which decision-makers might find feasible adaptation options. They continue to argue that diversity in context makes it easier to anticipate changes in generic adaptive capacity than changes in adaptation, *per se*, so that linking the determinants of adaptive capacity to drivers and therefore perhaps to the available policy levers can help explain why certain responses to fundamental identical stressors work sometimes in some places, but not at other times in other places. Their argument conforms well with a "weakest link" hypothesis authored earlier by Yohe and Tol (2001): the overall capacity of a system to adapt to an external stress (be it climate-related or not), is a function of the weakest of the underlying determinants of adaptive capacity.

Yohe and Ebi (2005) observed that the public health sector also recognizes that the ability to influence a public health problem (i.e., to adapt to a perceived level of vulnerability) depends on a number of factors that are equally path dependent and site specific; and it also recognizes the validity of a weakest link approach. Indeed, the health sector understands that it is not possible to influence a public health problem when any of the following "prerequisites for prevention" are missing:

1 An awareness that a problem exists *(8)*;
2 A sense that the problem matters *(7 & 8)*;
3 Understanding of what causes the problem *(4, 5 & 7)*;
4 Capability to intervene *(1, 2 & 6)*; and
5 Political will to influence the problem *(3, 4 & 5).*

It is not difficult to see that this list of prerequisites provide support for the IPCC (2001a) description of the determinants of adaptive capacity; the links are indicated by the numbers in italics that refer directly to the determinants of adaptive capacity listed above. The matches are not necessarily precise, of course, in large measure because the scales at which risks can be spread vary by health outcome and by disease determinant. For example, the risk of a heat-related event during a heat-wave can not be shared amongst individuals, but not vaccinating a particular child for measles increases the risks of that child contracting measles and of the community experiencing a measles epidemic. Nonetheless, experience in the public health context offers evidence that IPCC (2001a) recorded a workable list of determinants, especially with its emphasis on public infrastructure (governance, social capital), human capital (education and behaviour) and the ability to manage information.

Ebi, K., et al. (2005a) used this mapping of the two sets of determinants as an organizing template in a collection of explorations into adaptation at the intersection of health and climate. Case studies included gradual long-term changes in public health (disease rates changing over decades), stimuli with severe consequences across short time scales (disease outbreaks), and intervention programs that have been in place for decades. The two sets of determinants provide a different lens though which to identify the weakest link for adaptive capacity. For some case studies, each set of determinants reaches similar conclusions. For example, Githeko and Shiff (2005) map epidemic malaria control in Africa and conclude that the limiting factor is social capital when framed from the lens of adaptive capacity, or the capability to deal with the problem when framed from the public health lens.

The case studies also highlight that one set of determinants may more efficiently identify the weakest link. For example, Kovats and Koppe (2005) rank the determinants of adaptive capacity for heat-related deaths in the United States and identify the availability and distribution of resources and the structure of critical institutions as the weakest links, whereas ranking of the requirements for public health prevention identify political will. In this case, lack of political will is the more fundamental issue, because with political will, both resources and institutions could be resolved in the United States. Note that this conclusion is unlikely to apply to diseases in developing countries, where the political will may exist but human and financial resources limit implementation of adaptations.

In another example, Gubler and Wilson (2005) rank the determinants of adaptive capacity for the resurgence of vector-borne diseases, particularly yellow fever, dengue fever, and malaria, in the Americas. This case study identifies risk spreading as the weakest link because resources for public health interventions are less available to the poor and require financial assistance from developed countries. Gubler and Wilson (2005) conclude that a greater commitment is needed from foundations and international funding agencies to address the serious problems that these vector-borne diseases represent. This weakest link is not directly identified through the requirements for public health prevention.

A difference between the two sets of determinants is that the adaptive capacity lens assumes a basic understanding exists of the causes of a problem. For example, Ebi *et al.* (2005b) explored the consequences of the installation of tube wells in Bangladesh in an effort to provide a "safe" source of drinking water to a population that was experiencing high morbidity and mortality from water-related diarrhoeal diseases (e.g., cholera, dysentery, and other intestinal diseases). In many regions of Bangladesh, the groundwater accessed by these wells has naturally occurring high concentrations of arsenic, a known carcinogen, resulting in possibly 30 million out of the 125 million inhabitants of Bangladesh drinking arsenic-contaminated water. The determinants of adaptive capacity identify a number of limitations to address this problem, but a key problem is the lack of an understanding of why arsenic concentrations vary over short temporal and spatial scales, along with a limited understanding of methods to address this problem.

Notwithstanding this growing body of evidence on a commonality of critical determinants for adaptive capacity and/or sustainable development, research on multivariate analysis suggests that, although a configuration of variables may be necessary to produce an effect, there may be many such configurations that produce the effect. Moreover, different configurations may have few or no variables in common. Charles Ragin (2000) describes an example where aggregate data about the occurrence of race riots in the United States masked two very different situations in the northern and southern states. In the north, the economic gap between whites and blacks played a major role; in the south, lack of black representation in the political sphere was the most important factor. This methodological finding parallels the game theoretic and economic finding that multiple equilibria – even equilibria where most people are well off – are possible under a given set of conditions. That is, outcomes are remarkably open-ended; see, for example, DeCanio (2003) for a discussion of the general issue and how it applies to economic models of climate change.

Literature on vulnerability emphasizes the interactions of specific societies in specific places. There may be a core set of determinants and a "weakest link," but these may apply only in one situation. Cross comparisons of case studies, perhaps Ragin (1987) method or the approach of Kasperson and Kasperson (1995) might shed some light on the generalizability of such sets. Thus, it is hard to identify all the relevant factors much less what might be the "weakest link." In some situations, for instance, aggressive leadership might more than compensate for weaknesses (or strengths, in the case of destructive leadership) elsewhere in the social fabric. Diamond (2005) has made a scholarly attempt to determine the causes of civilization collapse and presents five factors, or "input variables," where the "output" is collapse (not all of which need to be present): environmental damage inflicted by humans (e.g., deforestation), climate change, hostile neighbours, decreased support by friendly neighbours, and other components of the political-economic-social-cultural setting that influences societal responses. In the past civilizations that Diamond studies, there are different "weakest link(s)." As Meyer *et al.* (1998) point out, it is important to dig beneath the first analysis – the climate changed and civilization died out – to the next question: the climate changed, civilization died out, but why?

20.3.4 Factors that support sustainable development

The factors that determine a country's ability to promote sustainable development coincide with the factors that influence adaptive capacity relative to climate change, climate variability and climatic extremes. Moreover, success in achieving sustainability can be explained at least to a large measure by a parallel "weakest link" approach. Indeed, the match between the list of characteristics upon which success in promoting long-term growth, site-specific productivity gains, and improved equity and the determinants of adaptive capacity inspired by IPCC (2001a) is strong. Both include references to strong and skilled governance, appropriate distributions of resources and access to resources, strong stocks of human capital, and overall stability. Whether or not the links between an economic intervention (or an adaptation) and its desired outcomes are strong, weak, or actually run in a direction that is opposite to that predicted by theory or process analysis is essentially an empirical question in nearly every instance. A brief review of some very recent literature is sufficient to make this point.

Lucas (1988) argued, for example, that human capital externalities are large enough to explain differences between the long-run growth rates of poor and rich countries. Moretti (2004) also concentrated attention on human capital by showing that plants located in cities where the fraction of college graduates grew faster experienced larger increases in productivity and that increases in wages generally followed observed increases in productivity. Guiso, *et al.* (2004) expanded the scope of analysis when they explored the role of social capital in supporting successful application of financial structures; they found that social capital matters most when education levels are low and law enforcement is weak. Meanwhile, Rozelle and Swinnen (2004) looked across transition countries across central Europe and the former Soviet Union and observed that countries which grew steadily a decade or more after their reforms have managed to create macroeconomic stability, reform property rights, harden budget constraints, *and* create institutions that facilitate exchange and develop an environment within which contracts can be enforced and new firms can enter. Order and timing did not matter, but success depended upon on meeting all of these underlying objectives. Winters, *et al.* (2004) reviewed a long literature to conclude that the ability of trade liberalization to reduce poverty depends on the existence and stability of markets, on the ability of actors to handle changes in risk, on access to technology, resources, on competent and honest government, *and* on policies that promote conflict resolution and promote human capital accumulation; shortfalls in any of these underpinnings makes it extremely difficult for the gains to trade to reach the most disadvantaged citizens. Finally, Sala-i-Martin, *et al.* (2004) apply new Bayesian estimation techniques to popular data to find robust power in explaining economic growth residing in a nation’s level of participation in primary school education (human capital), other measures of human capital (e.g., health measures), the relative prices of investment goods (available options), and the initial level of per capita income (access to resources); interestingly, though, they find that public consumption and, in some cases, public investment are negatively correlated to growth (deficiency in governance determinants).

20.3.5 Two-way causality between sustainable development and adaptive capacity

There is two-way causality that is path dependent: sustainable development influences adaptive capacity and adaptive capacity influences sustainable development. It follows that development paths, and the choices that define them, affect the impacts of climate change not only through changes in exposure and sensitivity to external stresses, but also through changes in the capacities of systems to adapt.

Swart, *et al.* (2003) argue convincingly that sustainable development policies can influence climate impacts and the design and implementation of climate change response measures and that the reverse can occur, as well. Although linkages between sustainable development and climate change policies have been primarily defined as mitigation measures, this need not leave out adaptation. Measures that build or improve institutional capabilities to address domestic and international socio-economic problems, including enhancement of ‘social capital’ would lead to improvements in adaptive capacity and adaptive response. Agricultural policies addressing options to reduce vulnerability to current drought risks could also reduce vulnerabilities to future climate change. Promoting alternative development pathways as a means of achieving sustainable development could include measures to reduce construction of residential or industrial infrastructure in high risk areas (e.g. areas prone to flooding), thereby providing a 'soft' contribution to an adaptation portfolio for a region or country. Environmental programs directed at protecting biodiversity (e.g. 12% land area target for establishing parks) would make it easier for ecosystems to adapt or migrate where corridors could be protected.

Adaptation measures within climate change policies would be directed at reducing vulnerabilities and enhancing the adaptive capacity of communities and economies. This would be consistent with sustainability goals. Indeed, future linkage between sustainable development and climate change will evolve from current development frameworks. These are regionally unique, and have influenced the relationship between climate and place. Throughout history, societies have adapted to changing economic, technological, social and environmental conditions, creating a range of measures that have become part of their lifestyles, cultures and laws. Yet despite the growth of knowledge about development, and the management of risks from various forces (e.g. extreme climatic events), hazard-related financial losses continue to increase, and loss of life in developing countries continues to be high.

Mileti (1999) shows that losses from hazards, and lack of progress at loss reduction, result from assumptions that technology can be used to control nature and protect people. Growing losses are partly the result of an expanding capital stock, but they are also evidence of increasing complexity in how nature systems interact with development choices to create new vulnerabilities for communities and regions; and climate change, which is expected to produce changes in frequencies of climatic events, would be superimposed on a moving platform of development paths. A few examples make this point. Population growth, particularly in low income regions, means greater exposure of vulnerable communities to many hazards. Migration into marginal areas for agriculture has created new exposures for vulnerable populations, resulting in the phenomenon dubbed by Glantz (1994) as "drought follows the plough". The built environment is growing in density thereby increasing the probability of losses from extreme events. Settlement of hazardous areas (e.g. floodplains, steep slopes) has altered local ecosystems that could have provided protection. Certain measures designed to protect against extreme events, such as levees for flood protection, can destroy riparian habitat and heighten downstream floods. Such measures may also serve only to postpone damages until a larger magnitude event occurs, and this loss could be compounded by additional development dependent on that specific protective measure.

Increases in costs of hazards and the prospects of cumulative environment – economy threats have been described as non-sustainable trajectories of development, or *syndromes*, borrowing a term from the medical sciences to describe concurrent symptoms of a disease. Schellnhuber *et al.* (1997) identify three categories: i) utilization (e.g. Sahel over cultivation of marginal land), ii) development (e.g. urban sprawl and associated destruction of landscapes), and iii) sink (e.g. large scale diffusion of long-lived substances). Schellnhuber *et al.* (2002) and Lüdeke *et al.* (2004) describe the potential future global distribution of some of these syndromes, suggesting how mechanisms of mutual reinforcement, including climate change and development drivers, can help to identify regions where syndromes may expand. Examples of development decisions resulting in cumulative threats include extensive water resource development in the Columbia River Basin (Hamlet, 2003), and potential implications for achievement of basin management objectives within scenarios of climate change (Payne, *et al.*, 2004).

20.3.6 From unsustainable exploitation to sustainable environmental management

"Sustainability" is not just about encouraging sustainable development – often seen as a developing country issue. It is also about adjusting existing environmental management and resource exploitation practices to manage environmental resources more sustainability. This is relevant in both developed and developing countries, although arguably the drivers are currently greatest in the developed world (e.g., development agencies for provinces and states in Canada and the US). Huq and Reid (2004) and Agrawala (2004) have noted that climate change is being increasingly recognized as a key factor that could affect the development (sustainable development) of developed and developing countries alike. For example, the Philippine Country Report (1999) identified 153 sustainable development indicators of which a number pertain to climate change such as level of GHG emissions.

There is, however, abundant evidence provided by UNEP (2000) and others that many human activities are currently resulting in degradation of the natural environment , at a range of scales and across all environments. Usmanova (2003) confirmed, for example, that Glantz, *et al.* (1993) were correct in concluding that over-abstraction of water for irrigation has led to the virtual destruction of the Aral Sea. Aparicia, *et al.* (2000) saw the same pattern when they looked at a much more local scale degradation of freshwater ecosystems in catchments affected by land use change and upstream interventions.

In many countries managers of activities which use natural resources or are susceptible to variations in resource availability and hazard over time are currently seeking to revise practices and procedures to make their actions more "sustainable". These managers include individual farmers, small businesses and major international corporations (Hilson (2001), for example, points to the mineral extraction industry) as well as public agencies from local to national and international scales. Definitions of "sustainable" vary across managers, but their common theme is to change the way resources are exploited or hazards managed in order to lessen adverse impacts "downstream" or for subsequent generations. However, climate change is seldom included in the list of stressors that might influence sustainability. Arnell and Delaney (2005) do note, though, that the water management industry in the United Kingdom is an exception; climate change is seen there as one of the reasons for increasing the sustainability of water abstractions.

The published literature on the links between sustainable management of natural resources and the impacts of and adaptation to climate change is very sparse, but what does exist tends to focus on the following areas:

1 Engineering and management techniques which achieve management objectives, such as degree of protection against flood hazard or volume of crop production, whilst having smaller impacts on the environment. Harman, *et al.* (2002) and Turner (2004) speak to this point, but very few of the studies of engineering methods consider explicitly how the performance of these measures is affected by climate change or how suitable they would be in the face of a changing climate. Kundzewicz (2002) demonstrates how non-structural flood management measures can be sustainable adaptations to climate change. On the other hand, as shown in Clark (2002) and Kashyap (2004), much of the literature on integrated water management in the broadest sense emphasizes adaptation to climatic variability and change through the adoption of sustainable and integrated approaches.

2 The benefits to the organization of adopting more sustainable practices, in terms of reduced costs, increased efficiency, or financial performance more broadly interpreted. Johnson &

Walck (2004) offer an example from forestry while Epstein & Roy (2003) is illustrative of the more expansive context. Again, none of these studies consider the effects of climate change on the benefits of adopting more sustainable practices.

3 The development of mechanisms for incorporating sustainable behaviour into organizational practice and monitoring its implementation Jasch (2003) as well as Figge and Hahn (2004) are examples of discussions of ISO certification or the use of environmental management accounting techniques. Still, none of these studies consider how to incorporate the effects of climate change into mechanisms or monitoring procedures.

Clark (2002) and Bansal (2005) have identified several drivers behind moves to become more "sustainable". First, altered legal or regulatory requirements may have an effect. Many governments have adopted legislation aimed at encouraging the sustainable use of the natural environment, but these rarely explicitly include reference to climate change. Heiskanen, *et al.* (2004) report how the European Union's Water Framework Directive, for example, requires agencies responsible for managing water resources across the EU to reduce the environmental impacts of their actions, but the Directive does not explicitly require agencies to adapt to climate change. Secondly, as highlighted by Ramus (2002) and Thomas, *et al.* (2004), internally-generated desires to do things "better", either following an ethical position held by an influential champion or in order to reduce costs or reputational risk and enhance attractiveness to potential employees, can push systems toward sustainability. Finally, customer and/or stakeholder expectations may change. While these drivers may encourage a shift towards sustainable management, they may not in themselves be directly related to concerns over the impacts of and adaptation to climate change.

20.3.7 The sustainable development focus on mitigation

Growing interest in the linkages between climate change and sustainable development is evident in a series of recent publications: Collier and Löfstedt (1997), Jepma and Munasinghe (1998), Toth (1999), Munasinghe and Swart (2000), Abaza and Baranzini (2002), Markandya and Halsnaes (2002), Kok *et al.* (2002), Swart *et al.* (2003), Yamin (2004) are all prime example. A number of themes recur in this literature, particularly the need for equity between developed and developing countries in the delineation of rights and responsibilities within any climate change response framework, particularly with regard to mitigation. Beg *et al.* (2002) outlines such challenges as well, but also identifies potential synergies between climate change and other policies that could facilitate adaptation such as those that address desertification and biodiversity. Masika (2002) specifically outlines gender aspects of differential vulnerabilities. Swart *et al.* (2003) identify the need to describe potential changes in vulnerability and adaptive capacity within the SRES storylines.

Although these linkages should appear to be self evident, direct linkages within the climate change and sustainable development literatures have emerged only recently. Cohen, *et al.* (1998) suggest why. These fields have had different research and policy traditions, the former originating from physical science studies of natural systems and the latter emerging from social policy concerns associated with poverty and degradation of resources particularly in developing countries.

This separation has been felt within the climate policy context. Initial framing of climate change as a problem of atmospheric disruption to be solved only by stabilization of greenhouse gases, as in Article 2 of the UNFCCC (1992), has led to a strong focus on mitigation of greenhouse gases, while adaptation objectives have not been well defined. Burton and May (2004) have described the “adaptation deficit” as the gap between sustainable use of resources and present practice, and that climate change will lead to an increased future adaptation deficit. While mitigation within the UNFCCC includes clearly defined objectives, measures, costs, and instruments, this is not the case for adaptation.

Similarly, within sustainable development community, climate change is seen primarily as a greenhouse gas stabilization challenge. The United Nations (2004) review of progress toward attaining the eight Millennium Development Goals notes that climate change is identified as a fundamental stressor only within Goal 7: “Ensure Environmental Sustainability”. Tracking indicators of protected areas for biological diversity, changes in forests, and access to water all appear in the Goals, but they are not linked to climate change impacts or adaptation; nor are they identified as part of a country’s capacity to adapt to climate change. The climate change component is represented solely by indicators of changes in energy use per unit of GDP, and by total and per capita emissions of CO2.

This does not mean that the linkage between development and climate change adaptation remains unrecognized within the development community. Climate change is identified as a serious risk to poverty reduction in developing countries, particularly because these countries have a limited capacity to cope with climate variability and extremes. The World Bank (2003) has indicated that adaptation measures will need to be integrated into strategies of poverty reduction to ensure sustainable development, and that this will require improved governance, mainstreaming of climate change measures into poverty reduction strategies and strategies for sustainable development, and the integration of climate change impacts information into national economic projections.

Recent negotiations within the Conference of the Parties of the Framework Convention (the COP) have led to the establishment of new mechanisms to support adaptation including the LDC Fund, Special Climate Change Fund, and the Adaptation Fund. This has provided visibility and opportunity to mainstream adaptation into local/regional development activities. However, there are technical challenges associated with defining adaptation benefits for particular actions within UNFCCC mechanisms such as the Global Environmental Facility (GEF). For example, Huq and Reid (2004) and Burton (2004) all note that the calculation of costs of adapting to future climate change (as opposed to current climate variability) as well as the local nature of resulting benefits are both problematic *vis a vis* GEF requirements for defining global environmental benefits.

To avoid misunderstanding, statements about GEF funding requirements must be read carefully and with a clear recognition of the date of publication of this Fourth Assessment Report. As of the summer of 2005, the COP has not yet defined how funding of adaptation activities will be costed. The LDC Fund is currently the one adaptation fund that is operational in its support of National Adaptation Programs of Action (NAPAs) in LDCs; and the COP and GEF are in the process of defining how the implementation of adaptation activities defined in NAPAs will be funded.

The last paragraph will requires updating as the writing process continues over the next year.

20.4 Implications for environmental quality

Climate change is widely recognized as a major environmental challenge. The latest global climate assessments have provided additional valuable data and information that led to greater understanding of climate change and its impacts (IPCC-TAR, 2001) on different human and natural systems. Climate change also affects other environmental issues such as loss of biodiversity, freshwater availability, and water and air quality. The United Nations Framework Convention on Climate Change (UNFCCC) recognizing this fact, included such concern into Article 4, which states that "All Parties…shall…take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessments, formulated and determined nationally, with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, or projects or measures undertaken by them to mitigate or adapt to climate change." (UNFCCC, 1992)

Environmental management occurs at two vastly different scales: locally, in response to individual development projects, programs or plans (e.g., through Environmental Impact Assessments and local management plans) and at very large scales through international agreements (Intergovernmental Panel on Climate Change, Convention on Biological Diversity, and others). It is also largely process-based, concentrating on improving practices through environmental assessments, the use of protected areas, or by limiting exploitation, degradation and pollution. Another approach is to focus on the accumulated outcome of many management efforts over different spatial and temporal scales of action through the use of different environmental indicators or indices.

20.4.1 Mainstreaming climate change into environmental impact assessments

Considering the central role of people in development and recognizing that a development plan or project could produce effects detrimental to the welfare of the same people it intends to benefit, it is essential that the environmental assessment of a proposed project include an analysis of the critical role environmental and social aspects of the design and implementation interventions for sustainable development. Physical structures used to exploit natural resources (e.g. mining operations or hydroelectric developments) or to enhance convenience (e.g. bridges) are examples of projects that have a projected lifetime of several decades or more and may be subject to climate change. Some countries have recognized this concern and have initiated the incorporation of climate change during the environmental assessment (EA) process so that the impact of climate on such projects may be reduced. The Canadian Environmental Assessment Agency, for example, explores new sources of knowledge on climate change that can assist in assessing potential impacts on projects. It also presents a generic guide for incorporating climate change and climate scenarios into EAs in Canada (Barrow, 2000). In the United Kingdom, the Department of Environment, Transportation and the Rural Affairs (DETR) conducted a study (Thomson, 2001) to explore the implications of the potential impacts of climate change across the whole range of its policy and operational responsibilities, and to advise on the next steps for taking forward consideration of the issues arising. One of the significant findings is the need to explore how to incorporate into environmental appraisal guidance clear messages about taking into account potential future climate change.

In developing countries, inclusion of climate change consideration into the environmental impact assessments for project developments is very limited and to a large extent, donor driven, as most development projects are externally funded, Within the development co-operation agencies or multi-lateral banks, addressing climate change and the associated potential vulnerabilities seldom figures among the top priorities (OECD, 2004), (Sohn *et al.*, 2005), particularly in sectors that will impact the long-term climate footprint of a national economy. Environmental safeguards such as Environmental Impact Assessment address the impacts of projects on the environment but not the impact of environmental changes on projects (e.g. due to global climate change).

20.4.2 Institutional, social, economic and cultural factors (capacity determinants)

Environmental vulnerability, together with vulnerabilities of social and economic systems is made up of more than just the risk of disasters and good or bad management. It is not just about climate change, or globalization, or trade agreements. It must also include an understanding of how well any system (environmental, social and economic) can cope with any hazards that may come its way and that might harm it. It would be impossible to work towards good quality of life and growth for countries under a sustainable development model if no account were made of the potential harm that can occur from internal and outside influences and the capacities to overcome them.

One approach to monitor environmental change is to focus on the accumulated outcome of many management efforts over different spatial and temporal scales of action through the use of different environmental indicators or indices. Environmental quality indicators are used to assess the environment's capacity for supporting human and ecological health. They can warn of impending environmental problems and enhance policymakers' and regulators' ability to manage and resolve these problems. They may also be used to gauge progress in meeting short- and long-term environmental goals. The development of useful environmental indicators requires not only an understanding of concepts and definitions, but also a good knowledge of policy needs. The key determinant of a good indicator is the link from measurement of some environmental conditions to practical policy options. Environmental indicators can be used at international, national and local levels as a tool for state-of-the-environment reporting, measuring environmental performance, and reporting on progress toward sustainable development. Some of these indicators are presented in Table 20.2.

Table 20.2: *Examples of environmental quality indicators*

Environmental Quality Indicator	**Proponent**	**Description**
Environmental Indicators	US-EPA	Track environmental conditions over time and help measure the state of air, water, and land; the pressures on those resources; the status of human health; and the integrity of the nation's ecosystems.
Environmental Vulnerability	South Pacific Applied Geo-	The EVI is among the first of tools now being developed to focus on environmental

Index (EVI), (Pratt, et al, 2001)	science Commission (SOPAC)	management at the same mesoscale that decisions are made (economies and social systems), and focus them on outcomes. The EVI is a method seen to provide a relatively quick and inexpensive way of characterizing the vulnerability of natural systems at the level of a region, state, province or island.
Environmental Sustainability Index (ESI, 2005)	Center for International Earth Science Information Network (CIESIN), Columbia University, the Yale Center for Environmental Law and Policy (YCELP), Yale University, and the World Economic Forum's Environment Task Force.	A single meaningful index quantifies the progress towards environmental sustainability. Environmental sustainability is defined through five dimensions, described by 68 variables, which are synthesized into 20 indicators. The environmental stresses dimension reflects how much pressure is currently exerted on the environment; the environmental systems, social and institutional capacity, and human vulnerability dimensions capture the status of ecosystems and a societal notion of carrying capacity, while the global stewardship dimension extends the sustainability concept by adding a social responsibility function.
Biodiversity Indicators - Climate Change Impacts (http://www.ecn.ac.uk/CCI/cci.asp)	UK Environmental Change Network (ECN), funded by DEFRA	Indicator to measure changes in abundance in climate sensitive species. A single, composite indicator has been developed, based on a substantial core of common butterfly, moth and carabid species.

Attempts to produce indicators of environmental *sustainability* (ESI 2005, World Economic Forum 2002, Levy 2002, Prescott-Allen 2001, Consultative Group for Sustainable Development Indicators 2001) have succeeded at aggregating these individual indicators so that they respond to demands for measures of sustainability trends. However, environmental indicators directly associated with climate change are expressed in terms of greenhouse gas (GHG) emissions such as: carbon economic efficiency expressed in CO^2 emissions per GDP, and carbon lifestyle efficiency expressed in CO^2 per capita. The environmental sustainability index (ESI, 2005) particularly noted the diversity of national priorities and circumstances between developed and developing countries. Developed countries are likely to put more emphasis on longer-term challenges such as climate change, waste treatment and disposal, clean and sustainable energy supply, and the protection of biodiversity. Developing nations underscore more urgent and short-term issues such as access to drinking water and sanitation, environmental health problems, and indoor air pollution. Aside from GHG emissions, ESI accounted for the ability to reducing environment-related natural disaster vulnerability in terms of the average number of deaths per million inhabitants from floods, tropical cyclones and droughts, and other environmental hazard exposure.

20.4.3 Adaptive capacity, environmental quality and the feedback to sustainability

Healthy, productive and protective environments, social systems and economies are the basis of sustainable development and human welfare. The environment is the source of most raw materials and absorbs the pollution from human activities. In turn, while going about its daily business, communities use the environment and convert its resources and natural services into those that directly support them. The problem is that all of these systems can be damaged, overloaded, or prevented from meeting the communities' needs. By their own choices, communities can determine their own quality of life to a certain extent, the condition of lands and opportunities for future generations.

20.5 Implications for risk, hazard and disaster management

The management of the risk from "natural" hazards and disasters is a special case of environmental management. In the most general terms, it has two components. The first is preparing for and reducing exposure to potentially hazardous events (such as floods, droughts, hurricanes or earthquakes), and the second is developing mechanisms to aid recovery after an event strikes. The literature on hazard and disaster management is huge, ranging from studies into the mechanisms which generate hazards, engineering and management responses to hazard and the factors which determine vulnerability to hazard. There is also a large and expanding literature on hazards and climate change (e.g. for drought and crops (Richter & Semenov, 2005), landslide (Schmidt & Glade, 2003), avalanche hazard (Stethem *et al.*, 2003), storm surge (Danard *et al.* (2003), and floods (Mirza *et al.*, 2003, Hunt, 2002; Bronstert, 2003)), and a growing literature on the linkages between hazard management and sustainable development (see below). The literature linking hazard management with sustainable development *and* climate change, however, is small.

20.5.1 Hazard management and sustainability

"Pre-event measures" include measures to alter the physical manifestations of the hazard event, reduce exposure to loss and facilitate subsequent recovery from loss. They include engineering works to, for example, alter river channels, building works to reduce susceptibility to damage, land use planning to encourage wise use of hazard-prone areas, the development of warning and forecasting systems, and the development of insurance to pay for losses. "Sustainable" pre-event measures would (i) not lead to an increase in exposure (e.g. by encouraging development in risk zones), (ii) not differentially benefit or harm particular sectors of the community, (iii) not increase exposure to other hazards and threats, and (iv) not increase exposure to "downstream" communities. Examples of reviews of sustainable hazard-focused management include Hooijer *et al.* (2004), Harman *et al.* (2002), Yin (2001) and Penrose & Fry (2000): all examine how different measures can reduce the impact of flooding whilst maintaining and enhancing the physical environment. A different perspective is taken by those following a vulnerability approach to hazard management, who examine how enhancing adaptive capacity (e.g. Tompkins & Adger, 2004; Ford & Smit, 2004; Liverman & Meredith, 2002; Finan *et al.*, 2002) can reduce the impacts of hazardous events.

"Emergency measures" are those actions taken immediately after onset of a disaster, and include the provision of disaster relief and assistance. "Sustainable" disaster relief should not increase vulnerability to subsequent events or other hazards, and should be implemented equitably. Wisner *et al.* (2004) give examples of disaster relief which sought to increase resilience to drought in Orissa, India. However, inappropriately targeted disaster relief can enhance inequalities in an impacted society (by concentrating effort on relatively wealthy victims, for example: Morris & Wodon., 2003), and can encourage a cycle of dependency (Wisner *et al.*, 2004). Reconstruction of damaged property in the same exposed locations will also, obviously, maintain and possibly enhance exposure to subsequent hazards.

Climate change is just one of the drivers behind an increasing interest in "sustainable" hazard management approaches (and is not necessarily the most important), but it does affect the performance and benefits of sustainable measures. Few studies have explicitly addressed this issue, although O'Hare (2002) suggested that incorporating climate change and its uncertainty into measures to reduce vulnerability to hazard was essential in order for them to be truly sustainable, and Kundzewicz (2002) showed how non-structural flood management measures, such as flood forecasting and warning, land use planning, and property-scale flood proofing, were not only more sustainable than traditional measures but were also more robust to climate change uncertainty.

20.5.2 Reducing vulnerability to current climatic variability and adapting to climate change

Burton, *et al.* (2002), Davidson, *et al.* (2003) and Kashyap (2004) all recently reported that reducing vulnerability to current climatic variability can go a long way towards reducing vulnerability to increased hazard risk associated with climate change; Robledo, et. al (2004) emphasized the extra value to be gleaned if measures designed to reduce vulnerability are also sustainable. To a large extent, adaptation measures for climate variability and extremes already exist. Measures to reduce current vulnerability by capacity building rather than distribution of disaster relief, for example, will increase resilience to changes in hazard caused by climate change (Mirza, 2003). Similarly, the implementation of improved warning and forecasting methods and the adoption of some land use planning measures would reduce both current and future vulnerability. However, many responses to current climatic variability would not in themselves be a sufficient response to climate change. For example, a changing climate would alter the design standard of a physical defence, such as a realigned channel or a defence wall. It could alter the effectiveness of building codes based on designing against specified return period events (such as the 10 year return period gust). Finally, it could alter the area exposed to a potential hazard, meaning that development previously assumed to be "safe" was now located in a risk area. Burton and van Aalst (1999) in their assessment of the World Bank Country Strategic Programs and project cycle identify the need to assess the success of current adaptation to present day climate risks and climate variability, especially as they may increase with climate change.

Coping with current changes in climatic variability and extremes will build learning in dealing with future climate changes and will enhance coping abilities of communities. Since climate change will likely manifest itself through changes in variability as well as in overall trend, methods used to cope with past and emerging patterns in climatic variability will be a useful starting point for the design of future adaptations. In LDC NAPA, there is emphasis on enhancing local coping mechanisms and indigenous knowledge systems as a way to build adaptive capacity at the community level. This is done in several ways. Approaches used to deal with emerging shifts in growing season conditions (shifts in start of rains, length and quality of growing season) such as diversifying crops planted, staggered planting, and increased use of water harvesting techniques (Desanker and Mushove, 2005), will increase community resilience and enhance their coping abilities to future changes in climate. Areas that are facing new or increased climatic threats such as drought or floods, can learn from areas that have traditionally been exposed to frequent droughts and floods. This is highlighted in the NAPA Primer (Desanker, 2004) as an important area for regional synergies in adaptation planning.

20.6 Global and aggregate impacts

20.6.1 Review of global and regionally aggregate estimates of impacts

There are essentially two ways of estimating the global or regional impacts of climate change. The first aggregates detailed case studies to infer impacts for a given global temperature change. This approach underpins the "damage functions" used in many integrated assessments of the impacts of climate change such as Tol (2002a & 2002b) and Tol *et al.* (2004).

The integrated assessment models which take this approach can then be used to calculate the aggregate impacts of any scenario of greenhouse gas emissions, such as the SRES scenarios reported in Nakicenovic and Swart (2000). Regional climate changes from the scenario are combined with one or more damage functions, and the resulting impacts are aggregated across regions and, sometimes, over time, applying discount rates to bring them back to a present day equivalent; see Hope (2005) for a recent illustration. The outputs can also include estimates of the impacts of climate change across the regions of the world and over time, and the models can show how these impacts change if measures are taken to cut back the emissions of greenhouse gases, or adapt to changes in climate. They perform a useful service by taking the best information from the detailed scientific and economic research, and revealing its policy implications. They can also highlight just how much we still have to learn about the economic implications of climate change, and enable different views on economic and scientific parameters, such as discount rates, equity weights and climate sensitivity, to be rigorously explored.

Tol (2002b), Tol, *et al.* (2004) and Pearce (2003) identify some key problems associated with this approach. Most involve the difficulties in comparing studies that apply different approaches, assumptions and scenarios, particularly in the different ways that they, themselves, aggregate across both sectors and countries. Aggregation across countries requires assumptions about equity weighting, whilst aggregation across sectors requires impacts to be expressed in a common metric (usually dollars). Tol, *et al.* (2004), for example, estimated the global annual welfare impacts of a doubling of CO_2 concentrations at 2.3%, -2.7% or 0.2% of GDP, depending on whether aggregation weighting done in terms of output, world average prices or equity.

Box 20.2: "Social-ecological resilience to coastal disasters"

Adger, *et al.* (2005) assessed the sources of social and ecological vulnerability to disasters and the outcomes of various extreme events in the context of coastal zones. They argue that hazards in coastal areas often degenerate into disasters "waiting to happen" because the sources of resilience are eroded through environmental change and/or human action. Resilience is, today, increasingly correlated with large scale processes like globalization, increased human mobility, and emerging new economic sectors. As a result, it becomes easier to ignore or even dismiss sources of resilience to make way for development that is, by virtue of continued or expanding natural risk, unsustainable. This trend can be reversed by incorporating diverse mechanisms for coping with change and crisis. For ecosystems, this means promoting biodiversity and functional redundancy by, for example, exploiting spatial patterns. For social systems, this means installing governance and management frameworks that can spread risk through similarly diverse patterns of resource use, human activity, and lifestyles. The authors offer some specific ideas, reflected in the table below; but they can all be understood with reference back to the determinants of adaptive capacity, connections to the potential to reduce exposure or sensitivity to externally generated risk, and reference to an analogy to the way individuals construct their financial portfolios to eliminate "diversifiable risk".

Box 20.2 Table 1: *Examples of local and regional scale actions to enhance resilience*

Elements of Vulnerability	Local Action	National & International Action
Exposure & sensitivity	Maintaining/enhancing ecosystem function through sustainable use Maintaining local memory and promoting learning	Mitigation of human-induced causes of hazard Avoid perverse incentives Promote early warning Enhance disaster recovery
Enhance adaptive capacity	Diversify ecological systems Diversify livelihood portfolios Create legitimate and inclusive governance structures and social capital	Bridge organizations for integrated response Create horizontal networks in civil society for social learning

Despite these difficulties, this aggregation is the only feasible method of producing an estimate for the social cost of carbon; that is the extra impacts caused by the emission of one extra ton of carbon emissions – i.e., the benefit of reducing carbon emissions by one ton. These estimates are the product of summing the discounted value of the extra impacts generated by an extra ton of emissions for as long at it remains in the atmosphere. They are worth the effort, though, if the social cost calculations are complete, because economic efficiency holds that efforts to cut back the emissions of greenhouse gases should continue as long as the marginal cost of the cutbacks is lower than the social cost of the impacts they cause. If taxes are used as the policy tool, they should be set at the social cost. If tradable permits are used, then their price should be the same as the social cost. In any case, the ratio of these (marginal) social costs is the correct approach for any comparison between greenhouse gases.

After surveying the literature, Clarkson and Deyes (2002) proposed a value of £70 per ton of carbon (in year 2000 prices) for the social cost of carbon. They also proposed using upper and lower values of £35 and £140 per ton. These values are higher than most other estimates in the literature such as Tol (1999) where the FUND model finds marginal costs of $9-23/tC, depending on the discount rate. If the aggregation of impacts over countries accounts for inequalities in income distribution or for risk aversion, though, then marginal costs would rise by about a factor of 3; but they would still fall short of £70. Hope (2003) reports results from the PAGE model for which the mean social cost of carbon was US$19 (or about US$5 per ton of CO2), US$105 per ton for methane, and US$200 000 per ton for SF6. For each gas, the range between the 5^{th} and 95^{th} percentiles was about an order of magnitude. Tol (2005) found that studies that are peer-reviewed have lower estimates and smaller uncertainty ranges. The results depend strongly on the discount rate used, and are still highly uncertain; but they do provide enough information to start a rational discussion about sensible cutbacks of the emissions of CO2, methane and other greenhouse gases, and the appropriate trade-off between gases.

The second approach to aggregation applies a "top-down" perspective across geographically-distributed impacts model with consistent climate and socio-economic scenarios. Recent examples, here, include Arnell *et al.* (2002), Levy, *et al.* (2004), Arnell (2004), Parry, *et al.* (2004), Nicholls (2004), van Lieshout, *et al.* (2004), Leemans and Eickhout (2004), and Vorosmarty *et al.* (2000). Such studies ensure consistency in approach across a large geographic domain and, when they are multi-sectoral, across sectors. They can also give global or regional estimates of impact using a range of numeraires. The "Fast Track" studies, for example, estimate climate change impact in terms of millions of adversely affected people, while Leemans and Eickhout (2004) estimate changes in ecosystem extent and Levy, *et al.* (2004) index impact in terms of changes in carbon flux. Some of these studies have calculated impacts for specific GCM-based scenarios; Table 20.3 shows the numbers of people impacted by climate change by the 2080s, under different socio-economic futures and climate change as estimated by the HadCM3 climate model. Hitz & Smith (2004) constructed damage functions from a set of such studies, showing considerable variability in shape of damage function between studies and sectors, with uncertainty due to model and impact formulation being greatest for water, health and energy impacts.

Table 20.3: *Global scale impacts of climate change: millions of people adversely affected by climate change by 2080, compared to situation without climate change.*

	A1FI	A2	B1	B2
Global temperature change (^{o}C from 1961-1990)	3.97	3.21-3.32	2.06	2.34-2.4
Increased risk of hunger (Parry *et al.*, 2004)	290	550-580	50	150-170
Increased risk of water scarcity (Arnell, 2004)	1820	4700-5400	1700	2800-3100
Increased risk of malaria transmission (Van Lieshout *et al.*, 2004)	93	107-157	132	139-215
Increased risk of coastal flooding (Nicholls, 2004)	43	67	27	39

Change in climate derived from the HadCM3 model.

Other studies, including Leemans and Eickhout (2004) and Arnell (2005) as recent examples, estimate impacts for specified global temperature changes by rescaling patterns of change in temperature and precipitation before running impacts models. With increases of temperature of between 1 and 2^{o}C (above 2000), for example, Leemans and Eickhout (2004) show that most species, ecosystems and landscapes would be impacted. Arnell (2005) meanwhile argues that an increase of 2^{o}C above the 1961-1990 mean by 2050 would result in between 550 and 900 million people suffering an increase in water resources stress under the A1 and B1 worlds, 900-2200 million people suffering an increase under A2, and 600-1100 million suffering under B2. For each assumed socio-economic world, the range represents different spatial patterns of rainfall change associated with a 2^{o}C rise in temperature.

Global estimates for impact, however, tend to hide very substantial variations in regional impacts. Table 20.4 shows the regional distribution of millions of people adversely affected by water resources stress from Arnell (2004), coastal flooding from Nicholls (2004) and malaria transmission from van Lieshout *et al.* (2004).

Table 20.4: *Regional impacts of climate change: millions of people adversely affected by climate change by 2080, compared to situation without climate change.*

	Population living in watersheds with an increase in water-resources stress (Arnell, 2004)				Increase in average annual number of coastal flood victims (Nicholls, 2004)				Additional population at risk of malaria, where transmission season increases by at least one month (van Lieshout *et al.*, 2004)			
	A1	A2	B1	B2	A1	A2	B1	B2	A1	A2	B1	B2
Europe	270	380-490	230	170-180	1.6	0.3	0.2	0.3	14	42	27	34
Asia	290	810-1200	300	330-600	1.3	14.7	0.5	1.4	198	341	151	180
North America	130	110-145	110	10-65	0.1	0.1	0	0	9	33	15	13
South America	160	430-470	100	130-190	0.6	0.4	0	0.1	-26	-47	18	15
Africa	410	690-910	400	490-560	2.8	12.8	0.6	13.6	31	44	37	65
Australasia	0	0	0	0	0	0	0	0	1	1	1	1

20.6.2 Interpreting global and regionally aggregate estimates

Great care must be taken in interpreting aggregate estimates of impacts. In addition to the methodological issue raised above (that different authors use different techniques to produce their aggregate indicators), Yohe and Schlesinger (2002) argue that the recognition that adaptive capacity varies fundamentally from place to place and time period to time period leads immediately to the conclusion that aggregation significantly masks the distributional implications of climate change. This is a critical concern, of course, given the UNFCCC's focus on providing assistance for the world's most vulnerable nations and peoples in their attempts to adapt to the site-specific and path-dependent manifestations of locally experienced climate change.

To see this point, one need not sort through the implications of the diversity discusses in Section 20.2, although that would certainly be required to address climate policy in terms of a global cost-benefit problem. It is, for present purposes, sufficient to compare aggregate estimates of impacts estimated from one model with its regionally disaggregated underpinnings; i.e., compare the regional implications of smooth climate change with a global aggregate along a standard baseline emissions trajectory produced by something like the Nordhaus and Boyer (2001) RICE model. Some regions see possible benefits throughout the next century (though these benefits may be exaggerated because the regional "damage functions" in RICE were calibrated to earlier results that overestimate the positive influence of carbon dioxide fertilization on the agricultural sectors). Other regions show significant losses, ranging from 2 to 3 percent of GDP by 2095; and the countries collected in the low income (LI) category could expect losses that would average almost 5 percent of their GDP. The disparity captured by RICE ignores variation across nations within each regional aggregate as well as intra-national disparities of the sort noted by Yohe and Schlesinger (2002). Still, even the limited regional disparity that the RICE results do reflect is hidden entirely from view by a trajectory of global aggregate impacts weighted by income where modest benefits in the early years of this century are followed by damages that amount to no more than 1.8% of global economic activity by 2095.

20.6.3 Consistency and tension across on global policies on CC and SD

Sustainable development is essentially concerned with various aspects of human systems and activities and evolution of the environment, which can be specified in terms of two kinds of relationships: (i) human-human and (ii) human-environment. According to Agenda 21 of the Rio Earth Summit (1992), the human being has to be placed at the centre of the stage within a framework of social transformation that promotes harmonious economic (growth, efficiency, stability), social (equity, empowerment, institutions, poverty alleviation), and environmental (biodiversity, natural resources management, pollution control) processes. Ahmad (2001) reflected on this placement to conclude that the overarching issues guiding these processes towards a sustainable pathway are appropriate technologies, cultural issues, and good governance, underpinned by morality and ethics. The sustainable development pathway is expected to lead to peace, security, and intra-, inter-national and inter-generational equity. The set of human-human relationships would take into consideration the present status and future improvement of equity in all these respects, with a view to promoting social cohesiveness globally and nationally. The human-natural environment relationships focus on interactions between human activities and environmental health, arising from the on-going development pathway and technology regime and pressure on natural environment for eking out a living as a result of high levels of poverty, with a view to improving the policy regime, the institutional framework and program implementation towards enhancement of the environment.

Various protocols and conventions have been signed internationally, which focus on improving both kinds of relationships for achieving sustainable development. These include (with their dates noted in parentheses): International Covenant on Civil and Political Rights (1966); International Covenant on Economic, Social and Cultural Rights (1996); Montreal Protocol on Substances that Deplete the Ozone Layer (1987) and Amendments (June 1990, November 1992, September 1997, December 1999); Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) and Amendment (September 1995); Basel Protocol on Liability and Compensation for Damage Resulting from Transboundary Movements of Hazardous Wastes and their Disposal (1999); United Nations Framework Convention on Climate Change (1992); Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997); Convention on Biological Diversity (1992); Cartagena Protocol on Biosafety to the convention on Biological Diversity (2000); United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (1994); Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (1998); Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998); Stockholm Convention on Persistent Organic Pollutants (2001).

National governments have been developing institutions and policy frameworks for sustainable development, and there have been many national, regional, and international conferences and workshops designed to assess their success. Early work in this regard culminated with the World Summit on Sustainable Development (WSSD) in Johannesburg during the third quarter of 2002. The Summit reviewed the implementation of sustainable development protocols, conventions, policies, programs, and understandings generated through Rio Earth Summit and other conferences at the local, national, and international levels. It was noted that the implementation was extremely limited at all levels, and so a Plan of Implementation (PoI) for promoting sustainable development was adopted.

The PoI identified poverty as the greatest global challenge and reiterated the millennium development goal (MDG) of halving by 2015 the proportion of world's people whose income is less than US$1 a day. Agreement was also reached on the related goals of halving the proportion of people without access to safe drinking water and appropriate sanitary conditions, also by 2015. (UN (2002), para 7). A strong appeal has been issued for changing unsustainable patterns of production and consumption by all countries of the world, particularly the developed countries (UN (2002), para 14). In this context, a strong emphasis has been placed on the management of natural resources in an integrated and sustained manner (UN (2002), para 24). Given that the human beings are at the center of the concerns for sustainable development, they are entitled to healthy and productive lives, in harmony with nature (UN (2002), para 53). A strong call has been issued for the promotion of equitable and improved access to affordable and efficient healthcare services for all segments of society (UN (2002), para 54).

The WSSD PoI also addressed the issue of sustainable development in a globalizing world. In the wake of globalization, there has been tremendous advancement in technology, particularly information technology, and an unprecedented increase in international trade and global wealth, but "there remain serious challenges including serious financial crises, insecurity, poverty, exclusion, and inequality within and among nations." These problems are particularly faced by developing countries and countries in transition. A call has, therefore, been made for globalization to be fully inclusive and equitable. To that end, policies and measures should be formulated and implemented at the national and international levels with full and effective participation of the developing countries and countries in transition and people of respective countries, as the case may be (UN (2002), para 47).

While globalization is proceeding at a fast pace, spearheaded by private companies (particularly multinational and transnational companies) and supported by the national governments and international institutions, the sustainable development process remains more in the realm of discussions and agreements and very little in terms of practical action. It has been recognized that the primary responsibility for promoting sustainable development lies with each country, but developing countries (in particular the least developed countries) need substantial financial and technological assistance to be able to make progress towards achieving sustainable development within an integrated economic, social, and environmental framework. In this context, it has been agreed that the Monterrey Consensus relating to flow of financial resources as well as official development assistance (ODA) of 0.7 per cent of the GDP should be made available by the developed countries to the developing countries to help the latter achieve the goals concerning sustainable development (UN (2002), paras 81 and 85).

The basic thrust would vary from country to country, depending on a country's level of development, its cultural dynamics, whether the economy of the country is primarily agricultural or it has substantial industrial base, whether the economy is large or small, whether the country is landlocked or has access to the sea, whether the country is largely mountainous or low and flat, and the state of its environment. The starting point is a reality check with respect to these and other relevant aspects, on the basis of which policies and program thrusts for promotion of sustainable development may be developed. But, what can be achieved would depend not only on the policies and programs developed but also on the institutional framework and access to resources. The developing countries, particularly the least developed countries, are seriously deficient in both respects. The WSSD has called for transfer of both adequate resources and appropriate technologies from developed to developing countries, as noted earlier, as well as for developing an effective institutional framework at all levels for both full implementation of the outcomes of Agenda 21 and WSSD and also for meeting other sustainable development challenges that may emerge as progress is made (Ahmad 2001; UN (2002), para 137).

20.6.4 Commonality across goals and determinants

The seventh Millennium Development Goal (MDG) asks that the earth's decision makers strive to "ensure environmental sustainability." There are three targets under this goal:

1. integrate the principles of sustainable development into country policy and programs and reverse the loss of environmental resources
2. halve the proportion of people without sustainable access to safe drinking water by 2015 and
3. achieve significant improvement in the lives of at least 100 million slum dwellers by 2020.

Clearly, there is no reflection in concrete in terms about climate change. Nor is their mention of the need for improvement of adaptive capacity and promotion of adaptation activities. It is, therefore, essential that the environment-related MDGs be more relevant to the practical aspects of promoting sustainable development, particularly in the developing countries. In this context, looking to the commonality across the determinants of adaptive capacity and the prerequisites for sustainable development make it clear that both would be enhanced by offering income-poor, resource-constrained developing countries assistance in terms of financial resources and technologies. The link between climate and the MDG process can thus be extraordinarily complementary, especially since the MDGs are currently a high profile initiatives for which the United Nations has recommended increasing support.

Box 20.3: "A case study of the Philippines"

The Philippines being an archipelagic country is vulnerable to the impacts of climate change. The country's initial National Communication to the UNFCCC recognizes the need to formulate adaptation strategies for various sectors (The Philippines Initial National Communication, 1999). Recent studies have also identified potential adaptation options for water resources, forest resources and agriculture, and local communities in watershed areas (Lasco *et al.*, 2005).

In contrast, (sustainable) development plans of the Philippines have practically nothing to say on the need for climate change adaptation. In general, these documents do not recognize climate change as a major issue of concern. If ever it is recognized, the focus is on climate change mitigation and not on adaptation. For example, the Philippine progress report on the Millennium Development Goals noted the increasing trend in CO_2 emissions in the country. In response, several initiatives were cited to help reverse the trend such as the Clean Air Act of 1999 (NEDA, 2003). This is reflective of the emphasis of the Millennium Development Goals (Goal No. 7) on the mitigation of carbon emissions.

The Philippine Medium Term Development Plan (MTDP) for 2004-2010 did not explicitly mention climate change as a concern. There was an indirect reference to climate change mitigation in that 10 Clean Development Mechanism (CDM) projects are targeted for implementation (NEDA, 2004). Direct references to climate change adaptation is lacking. However, there is a very strong focus on natural disaster vulnerability and adaptation which are mainly climate related such as tropical cyclones and the resulting floods and landslides. Among the planned activities include geo-hazard mapping of all regions of the country, and disaster preparedness and management in the development planning process at all levels of governance. Examples of the latter are periodic risk assessments, institutionalizing community-based mechanisms for disaster management, and capacity building. Several major flood control and drainage projects are also scheduled to be built.

All of the above activities geared towards adapting to current climate extremes also increase adaptation to future climate change. For example, under a 2x CO2 scenario, it is predicted that most of the country will experience higher rainfall which could cause more flooding. The flood control infrastructure to be built under the MTDP could help adapt to increased flooding in the future at least partially. Thus while climate change adaptation is not explicitly addressed by existing development plans, there are numerous initiatives that will promote adaptation to climate change.

20.7 Implications for regional, sub-regional, local and sectoral development; access to resources and technology; equity

Section 20.5.1 offered a few of the most current estimates of regional vulnerability to climate change, but they fell short of connecting those estimates to sustainability. Arrow, *et al.* (2004) began to fill this gap by estimating rates of growth of per capita "genuine wealth" – a measure of the rate of change of investment in physical, natural and human capital. The two panels of Table 20.5 display their results. Panel A records estimates of "genuine investment" as a percentage of GDP. This measure begins with domestic net investment in physical capital, adds investment in education (human capital), and then subtracts estimates of resource depletion (disinvestment in natural capital). Note that resource depletion includes damage from carbon emissions, but also notes changes in energy, mineral and forest reserves. These data are the basis of the calculations recorded in Panel B. The first column there matches the last column in Panel A, and a series of adjustments, described in the notes, transform these investment estimates into estimates of the rate of change in per capital "genuine wealth"; the adjustments take population growth and technological change into account.

Table 20.5: *Reflections of Long Term Sustainability across the Globe, source: Arrow, et al. (2004)*

Panel A: Genuine Investment as a Percentage of GDP

Country	Domestic Net Investment	Education Spending	Damage From CO2	Energy Depletion	Mineral Depletion	Net Forest Depletion	Genuine Investment
Bangladesh 1973-2001	7.89	1.53	0.25	0.61	0.00	1.41	7.14
India 1970-2001	11.74	3.29	1.17	2.89	0.46	1.05	9.47
Pakistan 1970-2001	10.92	2.02	0.75	2.60	0.00	0.84	8.75
Nepal 1970-2001	14.82	2.65	0.20	0.00	0.30	3.67	13.31
China 1982-2001	30.06	1.96	2.48	6.11	0.50	0.22	22.72
Sub-Saharan Africa 1974-2001	3.49	4.78	0.81	***7.31***	1.71	0.52	***-2.09***
Middle East North Africa 1976-2001	14.72	4.70	0.80	***25.54***	0.12	0.06	***-7.09***
UK 1971-2001	3.70	5.21	0.32	1.20	0.00	0.00	7.38
USA 1970-2001	5.73	5.62	0.42	1.95	0.05	0.00	8.94

Panel B: Growth Rates in Per Capita Genuine Wealth

Country	Genuine Investment	Unadjusted Genuine Wealth	Population Growth	Per Capita Unadjusted Wealth	Technological Change	Adjusted Genuine Wealth
Bangladesh	7.14	1.07	2.16	-1.09	0.81	0.30
India	9.47	1.42	1.99	-0.57	0.64	0.54
Pakistan	8.75	1.31	2.66	-1.35	1.13	0.59
Nepal	13.31	2.00	2.24	-0.24	0.51	0.63
China	22.72	3.41	1.35	2.06	3.64	8.33
Sub-Saharan Africa	-2.09	-0.31	2.74	-3.05	0.28	-2.58
Middle East North Africa	-7.09	-1.06	2.37	-3.43	-0.23	-3.82
UK	7.38	1.48	0.18	1.30	0.58	2.29
USA	8.94	1.79	1.07	0.72	0.02	0.75

Notes: The last column in Panel A is the result of subtracting estimates of depletion of natural resources from the sum domestic investment and education expenditure (all expressed as a percentage of GDP). The second column in Panel B is obtained by multiplying the first (taken directly from the last column of Panel A) by estimates of GDP/wealth ratios for each country. Subtracting population growth in the third column expresses growth in unadjusted genuine wealth in per capita terms; these are the values in the middle column. Estimates of technological change in the fifth column are then multiplied by the inverse of the output elasticity of capital investment (an estimated factor of 1.72) to obtain a comparable measure of the effects of technological change on wealth. Adding this multiplicative product to the unadjusted growth rates produces the estimates recorded in the last column.

The ultimate results, while clearly approximations derived from data of uneven quality across the globe, suggest that much of the developed world is performing reasonably well in terms of sustainability. Sub-Saharan Africa, the Middle East, and North Africa are, however, serious exceptions to this general conclusion. Driven in large measure by significant depletion of natural resources (particularly energy resources in the Middle East), they display significant depreciation in the “genuine wealth” measure, and therein lies the difficulty in taking the good news for the developed world too seriously. The positive rates of growth in “genuine wealth” that they display are derived significantly by their exploitation of the resources of the world's poorest countries and their exploitation of energy reserves in some of the richest (the oil exporting countries of the Middle East). This conclusion is confirmed by Figure 3.1 in MEA (2005, pg. 55) where the annual decline in savings (i.e., lost contributions to wealth) attributable to the same list of corrective factors listed in Table 20.5 is reported. The reduction in savings relative to a purely economic indicator is greater than 25% for countries like Trinidad and Tobago, Congo, Uzbekistan, Kuwait, Azerbainan, Saudia Arabia, Angola, Kazakhstan, Iran, and Syria; and it is between 10% and 25% for countries like Venezuela, Mauritania, Bahrain, Ecuador, Indonesia, Ethiopia, Burundi, Malaysia, Ukraine, Viet Nam, Mongolia and Bolivia.

20.7.1 The 2003 Heat Wave in Europe

Luterbacher, *et al.* (2004), Schär, *et al.* (2004) and Rebetez (2004) have chronicled the anomalous hot and dry conditions between June and mid-August of 2003 that effected Europe as a whole the southern Mediterranean regions in particular. Stott, *et al.* (2004) have meanwhile argued that the risk of summers as warm as 2003 may increase by two orders of magnitude in the next 40 years. The direct impacts of th2003 event included between 27,000 and 40,000 attributed deaths, a high prevalence of wildfires, a 30% reduction of primary productivity and associated large losses in crops, increases in the demand for electricity and water. The subsequent recovery in European vegetation suggests substantial resilience in some ecosystems, but Gobron, *et al.* (2005) warn that this resilience need not persist if such events become more frequent. Measures to cope with additional electricity and water demand in management may be possible, but their cost has not been estimated. Other systems were not prepared for this additional stresses, and poorly coped with the situation. Preparedness planning and how much of these damages could be actually avoided become essential questions in evaluating the sustainability of climate sensitive sectors even in developed countries, since the heat-wave 2003 was a first signal of the possible early effects of climate change.

20.7.2 etc… other summaries cross chapter case per sustainability.

20.8 Opportunities, co-benefits and challenges for adaptation

This section is devoted to a discussion of some of the opportunities and challenges that can be gleaned from the current state of knowledge. It begins by noting that the identification of both (or either) is sensitive to the decision-analytic approach adopted by either the researcher or the decision-maker; this point is illuminated by comparing two sets competing objectives (sustainability versus optimality and equity versus efficiency) and two alternative analytical methods (cost-benefit analysis and risk analysis). It closes with a discussion of "co-benefits", taken here to mean mitigation benefits from adaptation and adaptation benefits from mitigation.

20.8.1 Optimality versus sustainability

Arrow, *et al.* (2004) offer a clear description of the difference between optimality and sustainability in the context of a social welfare function that is designed to reflect the discounted value of global of the social worth of consumption depicted in a standard utility context. Optimality involves maximizing social welfare through prudent investments in physical, human and natural capital (which can, to some degree, substitute for one another in producing socially worthwhile consumption); optimality, in short, guarantees inter-temporal efficiency. It is well established that the inability to pool risks perfectly, the taxation of capital income, and the under-pricing of natural resources tend to contribute sub-optimally excessive consumption.

Sustainability, meanwhile, can be defined as guaranteeing that social welfare never declines over time from one year to the next. The same factors just noted also tend to undermine efforts to maintain sustainability. As reported in Section 20.6, estimating genuine investment required to sustain social welfare year in and year out can offer empirical evidence that rich countries seem to be avoiding over-consumption relative to this sustainability metric while poor countries and some of the oil exporting regions are falling short of that goal. As was emphasized above, however, countries' consumption patterns are not independent so that some of the success of the rich to be sustainable might be attributable, in large part, to the failure of the poor to do so.

For a discussion of sustainability, climate change, and a global approach to mitigation and adaptation, it is perhaps more important to note that Arrow, *et al.* (2004) clearly articulate reasons why optimality and sustainability are not the same thing. Indeed, they can be mutually exclusive. Since sustainability is concerned with the change in social welfare and not its level, it is possible that a sustainable path would not guarantee that contemporaneous utility at any point in the future would be as high as it is today. Moreover (and unlike optimality), sustainability does not imply a unique consumption path. Indeed, if resources were truly exhaustible and substitution potential were limited, then there may not exist a sustainable path even though it would be possible to characterize an inter-temporally efficient trajectory. As a result, achieving sustainability over some periods of time does not guarantee that it can be maintained forever. Conversely, even if the sustainability criterion could be satisfied for all time, proceeding along that path would not necessarily guarantee optimality. Casting these observations into a regional or national context, it is now easy to see why poorer countries who are trying to move closer to an optimal development pathway might resist calls from richer countries to take the sustainability criterion into account.

20.8.2 Equity versus efficiency

The trade off between equity and efficiency in policy design has been recognized in the economics literature for a very long time. Indeed, coverage of the fundamental conflict between promoting equity and encouraging maximally efficient economic behaviour has made its way into introductory textbooks such as Stiglitz and Walsh (2002). In the climate arena, this trade off is much more complicated than simple textbook treatments would suggest. It is exacerbated by the observation that the problems are being caused by the actions of world's rich countries while the effects are being felt most severely by the world's poor countries. This is why the language of the United Nations Framework Convention on Climate Change (1992) calls for developed countries to support adaptation initiatives designed to help the world's most vulnerable people. Working Group III authors of IPCC (Chapter 1 in 2001b) framed this issue in terms of a contentious dichotomy between contraction and convergence – the notion that rich countries would have to curtail their economic growth to ameliorate the climate problem (contraction) even as the poor countries accelerate their growth to bring their per capita levels of economic activity more in line with the norm set by the rich (convergence).

Working with a fifty year time horizon, Yohe and Van Engel (2004) have suggested that the trade off need not be quite so stark over the long term. They observe that the very transfers of international capital that would promote convergence over the near term between low and high income countries could also work to spread the incidence of achieving any sustainability-motivated climate target more evenly across both types of countries over the long term. However, Manne and Richels (1992 and 1997) added even more complication to the mix by showing that certain emissions and concentrations targets would be impossible to achieve in their modelling framework (which is calibrated to achieve significant convergence in terms of per capita income across regions with minimal contraction for the developed countries) even if enormously stringent mitigation were undertaken immediately. Other modelling frameworks, like the Nordhaus and Boyer (2001) RICE model, can achieve these targets more easily, but their baseline trajectories of economic growth worldwide are far less robust and their underlying rates of convergence are less compelling.

20.8.3 Cost-benefit approaches versus risk management

The cost-benefit approach to evaluating the relative efficacy of various responses to climate change has come under increased scrutiny since the Third Assessment Report IPCC (2001a) and (2001b). With regard to the trade off between equity and efficiency, it is important to note that simply summing the costs and benefits of any particular intervention runs the risk of ignoring its distributional consequences; i.e., an intervention could be evaluated favourably if the sum of its benefits exceeded the sum of its costs regardless of who garnered the benefits and who suffered the costs. Practitioners have responded to this criticism, of course, by inserting "distributional weights" into the calculus. Brent (1996) provides some of the generic details of this methodological adjustment. Fankhauser, *et al.* (1997) add some specifics by considering a case in which impacts that are expressed in monetary terms are spread over a collection of groups.

Profound uncertainty can also create problems for the cost-benefit approach to climate. Tol (2003) and Yohe (2003) examined cases in which a few plausible climate futures produced catastrophic impacts in at least one region or for at least one group of people. In these cases, the standard Ramsey discount rate for the cost-benefit calculus could turn negative for those regions or groups if the catastrophic impacts drove per capita incomes to subsistence levels. Even if this collapse to subsistence happened for only one participant along one plausible climate scenario, the discounted stream of marginal benefits or marginal costs might not be finite. In such cases, policy decisions that were evaluated in terms of expected net benefits would be dominated to the extreme by the perhaps isolated cases where impacts were most severe.

Other efficiency based decision tools exists, of course, and risk management techniques have been designed explicitly to accommodate the uncertainties that can so significantly confound the cost-benefit approach (although Brent (1996) also suggests ways with which the fundamentals of risk-analysis can be brought into the cost-benefit context). In these approaches, both mean outcomes and the variance of outcomes around those means influence the valuations of alternative actions by risk-averse decision-makers. The results include the calculation of risk-premiums, on the one hand, and the willingness to pay for insurance that reduces risk), on the other. As noted in Manne and Richels (1992 and 1997) and Yohe, *et al.* (2004), either calculation adds the variance of outcomes to the valuation procedure and makes hedging against the possibility of intolerable outcomes at the expense of sacrificing some average return an efficient decision in the sense of maximizing expected welfare.

It is critical to emphasize that the risk-management approach to decisions is not simply an application of the precautionary principle to decision analysis under uncertainty. It is, instead, as rooted in the precise definition of economic efficiency as the cost-benefit approach. Hahn and Sunstein (2005) see the growing popularity of the precautionary principle in discussions about climate change, nuclear power, genetically modified food, etc. as a threat to principled decision-making. However, risk-analysis collapses to the precautionary principle only when variance is given exclusive weighting in the context of critical thresholds whose crossings would produce marginal damages that are taken to be infinite. Hahn and Sustein (2005) also see the precautionary principle as paralyzing because the definitions of the critical thresholds can be entirely arbitrary. Yohe, *et al.* (2004) see cost-benefit approaches as equally paralyzing because uncertainty and discounting over the very long-term, especially in the context of a pervasive but not necessarily accurate view that it will decline over time, can be used as a reason not to act; i.e., a reason to wait and see. By way of contrast, a risk-based approach makes uncertainty a reason to act in the near-term; i.e., to purchase some "insurance" that either reduces the likelihood of an intolerable consequence or reduces the cost of responding to that consequence in a less distant and thus less discounted future.

20.8.4 Challenges and opportunities for mainstreaming adaptation into national/regional /local development planning processes

Burton and van Aalst (2004) made the connection to a risk-management approach, but they also offered some concrete steps by which addressing climate-related risk might be mainstreamed into development planning. Using a World Bank context, they proposed, the creation of a Climate Risk Management Knowledge Base, the expansion of institutional support for including climate information into Country Assistance Strategies and other country-level planning documents, and the application of a routine risk-screening tool to identifying climate "hot spots" at the project level. The Knowledge Base would grow over time as his second and third proposals produced a climate-risk evaluation track record. Indeed, creating the risk-screening tool is the lynchpin to their approach as they envisioned each project being allocated to one of three categories:

Category 1 – High Risk: projects in climate-sensitive sectors; projects located in hazard zones; projects related to livelihoods on the margin of climate tolerance; projects with long physical and/or economic lifetimes.

Category 2 – Partial or Moderate Risk: projects with some specific climate vulnerability; projects that increase other vulnerabilities external to the project.

Category 3 – No/Low Risk: projects independent of climate.

Category 1 projects would not go forward until they were subjected to a full climate risk-assessment. Category 2 projects would be subjected to a cursory climate-risk screening, perhaps with a wide range of possible stakeholders; they could become Category 1 projects if the screening uncovered significant risks and/or proximate climate thresholds. Of course, climate would not be part of the assessment process for Category 3 projects.

20.8.5 Participatory processes

Knowledge about climate change and sustainable development can be translated into public policy through processes that generate usable knowledge. The idea of usable knowledge stems from the experiences of national and international bodies (academies, boards, committees, panels, etc.) that offer credible and legitimate information to policy-makers through transparent multi-disciplinary processes. This requires the inclusion of local knowledge with more formal technical understanding generated through scientific research. Ultimately, social learning emerges through consensus that includes both scientific discourse and policy debate.

Climate change adaptation is a local/regional scale challenge linked to larger scale forces. In this case, the learning process will have to include participation of local practitioners in climate-sensitive endeavours (water management, land use planning, etc.) so that past experiences can be included in the study of, and the planning for, future climate change and development pressures. Impacts of changing global climate patterns will lead to biophysical impacts that are regionally unique, depending on the initial state of each region's ecosystems and resources. At the same time, societies have been developing in different ways, and their relationships with their biophysical environments have been influenced by social, political and economic forces that are also regionally unique. There needs to be a process of integration of various dimensions of knowledge about how regional resource systems operate, how they're affected by biophysical and socioeconomic forces, and how they might be affected by future changes of various kinds.

Haas (2004) describes examples of experiences in social learning on sustainable development and climate change, noting the importance of sustaining the learning process over the long term, and maintaining distance between science and policy while still promoting focused science-policy interactions. Lorenzoni, *et al.* (2001) chronicled an agriculture case from the eastern United Kingdom, for example, to show that while there are adaptation options available (e.g. shifting cultivation times, modifying soil management to improve water retention and avoid compaction), there are also questions on how a climate component can be built into the way non-climate issues are currently addressed. Long term strategies may have to include regional acceptance of greater fluctuations in crop yields than is currently the case, and to diversify operations in order to maintain farm incomes and employment. The compartmentalization of regional decision making is seen as a barrier to encouraging more sustainable land management over the periods in which climate change evolves.

Cohen, *et al.* (2004) offers another illustration of this interdependence. Water resources management in the Okanagan region of western Canada will have to plan for population growth and potential increased drought risk due to projected climate change. A future portfolio of adaptation measures could include both supply enhancement and demand reduction. This region has previously had some positive experiences with implementing demand reduction measures, but Shepherd, *et al.* (2005) note a number of institutional and political obstacles. Future adaptation efforts will have to account for financial, political and social elements of water policy, with implications for water related governance and land use planning at the local and regional scales.

Hisschemöller *et al.* (2001) suggest how participatory processes can play an important role in facilitating the integration of biophysical and socio-economic aspects of climate change adaptation and development by creating opportunities for shared experiences in learning, problem definition, and design of potential solutions. Van de Kerkhof (2004) has since observed that a variety of participatory techniques have been tried in the context of climate change mitigation, while Huitema *et al.* (2004) report on a recent exercise on water policy that employed citizen's juries. Cohen *et al.* (2004) also show how participatory processes were an integral part of the Okanagan case; and Summit Environmental Consultants Ltd. (2004) produced an indicator of a successful climate change participatory process is a recent report by regional planners that includes consideration on how to incorporate climate change adaptation into long term water plans.

Two examples from the Canadian Arctic illustrate how participatory processes have been used to incorporate indigenous knowledge into environmental assessments of ongoing and planned development. The Northern River Basins Study assessed the effects of pulp mills and upstream flow regulation on aquatic ecosystems. The traditional knowledge component focused on obtaining local historical knowledge through protocols developed with indigenous communities. Conclusions and recommendations on balancing environment and development included recognition of the implications of climate change on river flows and ice formation important for the ecological integrity of a large freshwater delta (NRBS Board, 1996). More recently, an environmental assessment of the West Kitikmeot / Slave region was prepared as part of a review of proposed expansion of mining. This assessment was produced through a partnership with governments and indigenous peoples, and included traditional knowledge projects. Knowledge to facilitate sustainable development was identified as an explicit goal of the assessment, and climate change impacts were listed as one of the long term concerns for the region, though there were no specific recommendations for managing these impacts (WKSS Society, 2001).

Toth and Hizsnyik (2005) describe how participatory techniques might be applied to inform decisions in the context of possible abrupt climate change. They note explicitly that a comprehensive understanding of the implications of extreme climate change requires an in-depth exploration of the perceptions and reactions of the affected stakeholder groups and the lay public. The project on "Atlantic sea level rise: Adaptation to imaginable worst-case climate change" (Atlantis) has studied one such case, the collapse of the West Antarctic Ice Sheet and a subsequent 5-6 meter sea-level rise. Possible methods for assessing the societal consequences of impacts and adaptation options in selected European regions include simulation-gaming techniques, a policy exercise approach, as well as directed focus group conversations. Each approach can be designed to explore adaptation as a local response to a global phenomenon. As a result, each sees adaptation being informed by a fusion of "top down" descriptions of impacts from global climate change and "bottom up" deliberations rooted in local, national and regional experiences.

20.8.6 Expanding co-benefits

The obvious linkages between mitigation and adaptation present a policy challenge, especially in a development context. Chapter 18 distinguishes two levels at which mitigation and adaptation aspects are interrelated. At highly aggregated, global or multinational levels, these two activities are extent substitutes to some degree: the more mitigation is undertaken, the less adaptation is necessary and vice versa. Accordingly, the larger amount of resources is devoted to mitigation, the less is available for investments in overall socioeconomic development, in specific investments in enhancing adaptive capacity, and for individual adaptation projects. At the national and sub-national levels, though, this trade-off is doubtful because the effectiveness of the mitigation outlays in terms of averted climate change depends on the mitigation efforts of other major emitters of greenhouse gases. It follows that the magnitude of necessary adaptation is disconnected from the nation's mitigation effort. At the level of greenhouse gas emitting and/or climate sensitive sectors where specific mitigation and adaptation projects are to be considered, the relationship can be positive (adaptation reducing emissions as well or mitigation fostering adaptation), negative (adaptation increasing emissions or mitigation inhibiting adaptation) or neutral. Section 18.4.1 summarizes the insights from recent work on these issues.

The approach taken in this chapter can be exploited to uncover two ways by which decision-makers might expand the scope of their attempts to achieve this fundamental integration beyond the narrow confines of searches for win-win options for which co-benefits are easily articulated. In the first, noting that the determinants of mitigative capacity described in Yohe (2001) are almost identical to the determinants of adaptive capacity reveals that working to enhance the precursors for sustainable development can also enhance a country's ability to adapt and to contribute to global mitigation initiatives. More to the point, programs and policies that promote more equitable distributions of resources, more responsive governance structures, more reliable networks of social and human capital, more thorough understandings of the causal links in political, social, economic and climate systems, and so on can complement one another on all three fronts. Moreover, as argued above, these underlying commonalities can bring climate issues, both on the adaptation side and the mitigation side, to the table of the decision-makers who are most critically concerned with development issues.

Incorporating the risk-based approach described above into the decision process offers a second means by which a multitude of co-benefits can be identified and explored. Tol (2003) has argued that mitigation and adaptation cannot be integrated into a common decision-making context because their scales are different. Adaptations work at local scales with horizons that are sometimes very short while mitigation policies work essentially at global scales and very long time horizons. Brown (2005) shows, however, that the benefits of mitigation can be expressed in terms of both reductions in the pace of climate change over the long term and resulting reductions in the variance in the outcomes of climate change. Tol's critique applies well to the first component of benefits, but not to the second. Reductions in the variance of what climate change might bring begin immediately, and so the associated benefits for any mitigation target can be expressed as the "willingness to pay" for this reduction in risk. Moreover, different estimates of the "willingness to pay" can be associated with alternative adaptation programs whose net benefits accrue over a relatively short time horizon. In this context, there may be value to mitigation as a complement to adaptation even in places where climate change itself may be beneficial (at least for a while in terms of expected impacts) and that this phenomenon is not confined to the developed world.

20.9 Uncertainties, unknowns, and priorities for research

Lubchenko (1999) argued forcefully that scientists have highlighted the need for a "new contract" between science and society for sustainable development. As it stands now, though, a large gap exists between what scientists think they can offer and what society has demanded and supported. Several concrete steps, borne of the conceptual framework offered here, can begin to close this gap.

20.9.1 Bringing climate to the development community

Careful analyses of site-specific issues can show academics (in the development field, for example) how assuming a constant climate over even the relatively short-run can be misleading, especially if this assumption is combined with the view that coping with climate variability in a development strategy guarantees that climate change has been accommodated. Practitioners can come to recognize a common set of concerns in underlying determinants of adaptive capacity and prerequisites for sustainable development.

20.9.2 Bringing development and policy to the scientific community

Differentiating the relative contribution of climate variability from that of climate change in impacts and adaptation is difficult if not impossible to achieve, and many policy decisions need to be informed by a clear recognition of this complication. Burton (2004) has argued that every country will need to adapt to climate change even as they cope with other stresses. He concludes, therefore, that the allocation of funds for adaptation between countries is only one critical issue to be confronted. Equally important is determining an equitable distribution of funds across the competing needs of every country eligible for funding. Although climate change can be extraordinarily important to most countries, it is likely that other challenges will be ranked higher at different levels and when considering varying time scales. The science community needs to recognize the development context as it designs its research agenda and, perhaps more importantly, as it communicates its results.

20.9.3 Cataloguing best practices

Because vulnerability is site-specific and path-dependent, it is difficult to cast adaptation in terms of global benefits. Still, as understanding about the mechanisms by which the determinants of adaptive capacity support successful implementation of adaptation strategies across the globe, commonalities will be discovered; and their discovery will have global benefit. The UNFCCC country technology needs assessment reports, for example, identify hard and soft options for mitigation and adaptation, and a careful review of their content can be a first step in compiling catalogues of "best practices" across rural communities in developing countries where indigenous adaptation have been adopted; and this can be a first step in uncovering the valuable understanding of what does or does not work where, and why. Implementing pilot programs, chosen individually only on the basis of maximum benefit but organized collectively on the basis of spanning the maximum amount of contextual diversity, can also facilitate the productive discovery of fundamental commonalities.

20.10 Conclusions

IPCC (2001a) reported that adaptation can contribute to reducing vulnerability of the poor and the most vulnerable – a fundamental conclusion that has been well established. Indeed, several donor agencies are advocating mainstreaming of adaptation in development plans, especially through Poverty Reduction Strategies as reported in Word Bank (2003). As it stands, now, the issue is not one of convincing decision-makers that bringing climate to bear on development deliberations is a good idea; it is, instead, one of suggesting how it might be accomplished when development planners already have so much "on their plates". Nonetheless, the IPCC (2001a) warned that planners that ignore climate at their own risk, especially when long-term investment decisions can lock their economies into specific development trajectories from which it could be expensive to deviate.

This chapter has established the connection between the precursors of sustained support of economic growth and improved well-being, on the one hand, and the determinants of adaptive capacity, on the other. Development planners are, of course, already familiar with the precursors for success in their initiatives, and they are already concerned with seeking ways of strengthening the "weakest links" that support the connections between implementation and success. The first key to bringing climate into their agendas is simply to make it clear to decision-makers in the development ministries that they are already working these problems. Indeed, recognizing climate could provide them more ammunition when they negotiate for claims to scarce economic resources.

This chapter has also highlighted the complexity of trying to predict what will work and what will not at any single site specific and path depend context; but development planners are already experienced in coping with this complexity, as well. They already know that the effectiveness of the programs that they contemplate all the time, like opening trade or imposing environmental restrictions on industrial activity, may or may not work to increase productivity, improve general welfare (including equity considerations) or reduce poverty in a specific sector or across a specific region. Determining which adaptation to climate change will work (and where) is an analogous empirical question, and one with which they have some familiarity. Indeed, noting that the determinants of more mainstream "adaptations" to other external stresses are the same as the determinants for the capacity to adapt to climate stress suggests that they are already confronting exactly the same empirical questions. Climate, therefore, is not a new issue to be added to an already clogged agenda. It is, instead, an additional incentive for the careful examination how and why policies designed to promote productivity in an interdependent world might function

Preparing and planning for adaptation by strengthening the determinants of adaptive capacity can simultaneously work as a hedge against climate impacts and as a means of improving prospects for sustainable development by supporting (for example) productivity growth (or at least adding to the insulation that protects productivity initiatives from external stress). Cast as a risk-reducing tool, improving adaptive capacity can be seen as a tool with which to reduce climate risk, complement mitigation, improve socio-economic stability, widen the range of attractive investment opportunities, and thereby enhance the prospects for developing sustainably.

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