



UNITED  
NATIONS



Framework Convention  
on Climate Change

Distr.  
GENERAL

FCCC/TP/2008/3  
20 November 2008

ENGLISH ONLY

**Physical and socio-economic trends in climate-related risks and extreme events, and their implications for sustainable development**

**Technical paper\***

*Summary*

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change concludes that warming of the climate system is unequivocal, as evidenced by increases in global average temperatures, widespread melting of snow and ice, and rising sea levels as a consequence of climate change. These physical trends in the climate are projected to intensify into the future. This paper, prepared in the context of the Nairobi work programme on impacts, vulnerability and adaptation to climate change, draws on the information provided by the IPCC in outlining the physical and socio-economic trends in climate-related risks and extreme events for developing countries, particularly for the least developed countries and small island developing States, and the implications for sustainable development. Physical and socio-economic trends are compounding each other to undermine sustainable development and the ability to achieve the Millennium Development Goals in the poorest regions of the world through increased poverty, loss of livelihoods, and compromised health and education.

Parties may use the information contained in this technical paper as they consider implementing adaptation action under the Convention, including in the work under the Nairobi work programme, particularly on its work area on climate-related risks and extreme events, and in the work of the Ad-hoc Working Group on Long-term Cooperative Action under the Convention on enhanced action on adaptation. The information could also be considered by Parties and organizations in their actions to enhance resilience to the impacts of the adverse effects of climate change.

\* Much of information and data presented in this document are drawn from the Third and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change.

## CONTENTS

	<i>Paragraphs</i>	<i>Page</i>
I. EXECUTIVE SUMMARY .....	1–39	3
A. Introduction .....	1–6	3
B. Physical trends in climate-related risks and extreme events ..	7–12	4
C. Socio-economic trends .....	13–27	5
D. Implications for sustainable development.....	28–34	7
E. Final remarks .....	35–39	8
II. INTRODUCTION .....	40–58	9
A. Mandate .....	40–41	9
B. Objective .....	42–44	9
C. Background.....	45–56	9
D. Scope .....	57	13
E. Structure of this report.....	58	13
III. PHYSICAL TRENDS IN CLIMATE-RELATED RISKS AND EXTREME EVENTS .....	59–80	14
A. Overview of observed trends in developing countries .....	60–68	14
B. Future projections for physical trends in developing countries	69–80	20
IV. SOCIO-ECONOMIC TRENDS .....	81–144	25
A. Climate risks and general socio-economic trends .....	82–83	26
B. Least developed countries .....	84–110	26
C. Small island developing States.....	111–144	34
V. IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT.....	145–179	43
A. Introduction .....	145–149	43
B. Key sectors .....	150–151	44
C. The interaction of physical climate changes and socio-economic vulnerabilities: implications for sustainable development....	152–177	45
D. Climate change and the Millennium Development Goals.....	178–179	51
VI. FINAL REMARKS .....	180–188	53
<u>Annex</u>		
List of references .....		55

## I. Executive summary

### A. Introduction

1. This technical paper was mandated by the Subsidiary Body for Scientific and Technological Advice (SBSTA) at its twenty-eighth session (FCCC/SBSTA/2008/6, para. 48) as part of the activities under the Nairobi work programme on impacts, vulnerability and adaptation to climate change. It aims to promote further understanding and assessment of impacts of, and vulnerability and adaptation to, climate change, current and future climate variability and extreme events, and the implications for sustainable development, paying particular attention to the vulnerable developing countries, especially least developed countries (LDCs) and small island developing States (SIDS).
2. The paper can be used to provide information for decision-making by Parties to the Convention, with a view to facilitating adaptation action in the context of sustainable development and as background to the in-session workshop on risk management and risk reduction strategies under the Ad-hoc Working Group for Long-term Cooperative Action under the Convention (AWG-LCA) to be held during the fourth session of the AWG-LCA in Poznan.
3. This paper is closely related to the technical papers on integrating climate risk assessment and management and disaster risk reduction strategies into national policies,<sup>1</sup> and on mechanisms that can be used to manage financial risks from direct impacts of climate change.<sup>2</sup> While this paper illustrates the current conditions and issues regarding climate-related risks and extreme events, the other two papers aim to provide inputs for possible policy solutions and mechanisms to address the adverse effects of climate change.
4. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) concludes that warming of the climate system is unequivocal, as evidenced by increases in global average temperatures, widespread melting of snow and ice, and rising sea levels. These changes are impacting on, and are projected to continue to impact on, humans in a variety of ways. Increases in disasters linked to climate-related risks and extreme events such as hurricanes, cyclones, floods, landslides, wildfires and drought, heat waves and cold spells, are having a marked impact on human populations.
5. Developing countries, particularly LDCs and SIDS feel acutely the impacts of these changes, and are projected to suffer disproportionately from future climate changes and variability. These countries tend to be located in areas where threats from extreme events are often the greatest, and they rely heavily, in economic terms, on climate-sensitive sectors. Developing countries suffer the most when a disaster hits – more than 95 per cent of all deaths caused by disasters occur in developing countries; and losses from natural disasters are 20 times greater (as a percentage of GDP) in developing countries than in industrialized countries.
6. Furthermore, these countries already face huge gaps in infrastructural development, human resources and technological capacity, which constrain their integration into the global economy and render them perpetually vulnerable to both socio-economic and climate-linked stresses. The ensuing impacts threaten to derail efforts for sustainable development and the long-term achievement of the Millennium Development Goals (MDGs).<sup>3</sup> For example, the United Nations Development Programme (UNDP) 2006–2007 Human Development Report (HDR) concludes that failure to address climate

---

<sup>1</sup> FCCC/TP/2008/4.

<sup>2</sup> FCCC/TP/2008/9.

<sup>3</sup> In 2000, world leaders adopted the United Nations Millennium Declaration, committing to reduce extreme poverty by 2015 through a set of targets known as the Millennium Development Goals.

change will “consign the poorest 40 per cent of the world’s population – some 2.6 billion people – to a future of diminished opportunities.” (UNDP, 2008)

### **B. Physical trends in climate-related risks and extreme events**

7. The AR4 describes the global changes in climate as well as physical systems that have been observed until 2006, including increases in surface temperatures, decreases in glaciers and ice caps, rising sea level, increased precipitation in many regions and drying in others, more intense and longer droughts, increased frequency of heavy precipitation events, and increases in the intensity of tropical cyclones.

8. The following changes are likely to continue to occur: warming is projected to increase; sea ice is projected to shrink; sea levels are projected to rise; it is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent; it is likely that tropical cyclones will become more intense; and increases in the amount of precipitation are very likely in high latitudes, while decreases are likely in most subtropical land regions. These physical changes are projected to result in decreased water availability, decreased crop productivity in many parts of the world, and loss of plant and animal species and associated ecosystem services.

9. Physical and climate trends are projected to intensify in the future in many parts of the world due to climate change. Physical trends include increasing and accelerating levels of risk. The increase in the risk of physical trends associated with climate change is additional to the risks associated with climate variability.

#### *Projections for Africa, including African LDCs*

10. Africa, which accounts for the majority of LDCs in the world, is highly vulnerable to climate change and variability. This continent is projected to experience increased warming, decreased rainfall, and increased intensity of droughts and floods as a result of climate change. The impact on human populations, particularly the most vulnerable, will be extensive – populations will be exposed to increased water stress; agricultural production will be affected leading to increased food insecurity; and the transmission of disease will change, with diseases such as malaria, diarrhoea and dengue expanding and becoming more prevalent.

#### *Projections for Asia, including Asian LDCs*

11. Asia, which includes eight LDCs located in South and Southeast Asia, is highly vulnerable to extreme weather events. Asia is home to 11 mega deltas which are highly susceptible to sea level rise and extreme events. Climate change is projected to impact South and Southeast Asia through increased warming, increased precipitation, and an increase in the frequency of intense precipitation events and extreme rainfall and winds associated with tropical cyclones.

#### *Projections for SIDS*

12. SIDS are highly vulnerable to the impacts of climate change because of their exposure to sea level rise and vulnerability to tropical storms and cyclones. Ten of the SIDS are also LDCs. SIDS are likely to experience increased sea levels, warming, and increased intensity of extreme events under climate change. Water resources are projected to be severely compromised to the point where they become insufficient to meet demand during low rainfall periods.

### C. Socio-economic trends

13. Socio-economic trends show that developing countries are highly vulnerable to climate risks. LDCs are characterized by extreme poverty, weak economies, inadequate institutional and human resources, and lack of physical and financial infrastructure. Their economies are dominated by climate- and water-sensitive sectors such as agriculture, timber and non-timber products, tourism and the hydropower industry. The physical characteristics of SIDS (small size and remote geographical location surrounded by sea along zones of complex climate activity) combined with socio-economic factors result in SIDS suffering from an exceptionally high level of exposure to climate change and climate variability.

#### *Socio-economic trends for LDCs*

14. A large number of people in the LDCs are living in extreme poverty. In 2005, approximately 277 million people lived in extreme poverty in all LDCs (206 million in African LDCs, 71 million in Asian LDCs and 1 million in island LDCs). The noted high vulnerability of Africa to climate change (IPCC 2001 and 2007) is partly reflected by the fact that the continent houses most of the world's LDCs.

15. Furthermore, although a high rate of economic growth (exceeding 7 per cent) was registered among LDCs since 2000, the number of poor people has been growing. This is because economic growth has been spatially and temporally variable and is not uniform across economic sectors. The growth has been driven mainly by enclaves of capital-intensive sectors supported by foreign direct investment (FDI) and is often oriented to primary products, such as extraction of minerals. Such investments are highly dependent on commodity prices, are often not well integrated into the rest of the economy and generate limited employment. While official development assistance (ODA) to LDCs doubled between 1999 and 2004 to USD 24.9 billion, the total debt burden also increased to a record USD 158.9 billion in 2003.

16. The economies of LDCs are highly dependent on climate- and water-sensitive sectors such as agriculture, tourism and hydropower. While agriculture is an important form of livelihood for the majority of people in LDCs, agricultural productivity has been declining as a result of low investment in this sector and of climate variability. At the same time, most LDCs are failing to absorb rural labour outside the agriculture sector, leading to accelerated migration to cities, creating immense challenges in the delivery of services and in unemployment. By 2006, nearly 140 million people in LDCs lived in slums. Food insecurity has increased and the proportion of the undernourished in the total LDCs population rose from 34 per cent to 41 per cent between the 1995–1997 and 2002–2004 periods.

17. Limited investment in the social sector among LDCs has contributed to lack of access by a large part of the population to basic socio-economic infrastructure and services such as clean water, sanitation, roads, schools, and health facilities, contributing heavily to levels of vulnerability, and impeding progress towards sustainable development.

18. A significant number of LDCs are facing critical water shortages, and lack of clean water is likely to be a key factor limiting economic growth in the LDCs in this century. Only 58 per cent of the population in all LDCs have access to improved water facilities. Agriculture is the largest consumer of water among LDCs, consuming over 90 per cent. Water shortages will be exacerbated by climate change and climate variability, leading to further decline in food production and health.

19. Investment in the health sector among LDCs is low, resulting in numerous health problems linked to climatic and non-climatic factors, such as poor hygiene, sanitation and provision of clean water (causing up to 75 per cent of diseases in some LDCs). Malaria is also one of the biggest health threats, and is influenced by both climate and socio-economic factors.

20. Furthermore, LDCs face long-term health problems and loss of productivity due to the HIV/AIDS pandemic, further increasing vulnerability to climate-related health problems through increased poverty and reduced immunity. Sub-Saharan Africa, where most of Africa's LDCs are found, is the most affected, accounting for 77 per cent of all AIDS deaths in 2007. The interaction of HIV/AIDS with recurrent drought in Sub-Saharan Africa has contributed to food insecurity.

#### *Socio-economic trends for SIDS*

21. SIDS are characterized by high population densities relative to their size, and many face economic stagnation, growing economic inequalities, difficulties in integrating into the global economy, weakening social capital and rising poverty. However, there are large differences in demographic patterns, resource endowment, and development status. Levels of human development and growth rates vary significantly across islands. Some SIDS are dealing with a growing burden of debt, such as Jamaica where the average public debt was nearly 145 per cent of GDP in 2005.

22. The economies of SIDS are dominated by agriculture, fisheries, tourism, and international transport (air and sea). These industries are sensitive to climate and to external market forces over which SIDS have little control. Owing to their small and narrowly defined economies, SIDS are typically import dependent. As a result, SIDS are highly vulnerable to external shocks and pressures, such as unpredictable trends in terms of trade and other impacts of globalization.

23. Agricultural exports have often relied on preferential access to major developed-country markets, which are slowly eroding and the GDP contributions from agriculture from many SIDS have been decreasing, partly due to the drop in the competitiveness of cash crops, high subsidies in the agriculture sector in developed countries, and numerous protectionist mechanisms restricting entry of agricultural exports from developing countries. In addition, increased agricultural inputs and competing uses for water resources have also contributed to the decline in this sector.

24. Although there is large diversity, most SIDS are experiencing rapid urbanization linked partly to the decline in agricultural productivity. These large population concentrations have introduced problems of waste management including: limited sanitary landfills; a large proportion of industrial and hazardous waste being disposed of in the municipal solid waste stream; scarce facilities for treating wastewater; inadequate legislation and enforcement measures; and a lack of sufficient qualified personnel to deal with waste issues. This has resulted in pollution of limited fresh water resources which are already in short supply in most SIDS.

25. In low-lying SIDS, strategic infrastructure is located in coastal zones and, for instance, more than 50 per cent of the population live by the coast in the Caribbean and Pacific islands. These areas are subject to high land-use pressure leading to pollution of limited water sources and degradation of natural resources, which increases susceptibility to climate extremes such as tropical cyclones. These areas are also highly susceptible to sea level rise which will lead to shortages of land and exacerbate further human pressure on limited land resources.

26. Health in SIDS is greatly threatened by numerous climate related diseases, further exacerbated by socio-economic conditions. Although less acute, HIV/AIDS is also a growing problem among SIDS, particularly given their relatively small populations. HIV/AIDS has impacted severely on SIDS' economies as productivity declines, income levels are reduced and the social fabric is eroded leading to loss of resilience even to mild social and environmental stresses.

27. Tourism is a major source of revenue for SIDS. The willingness of tourists to visit a holiday destination is strongly linked to the state of preferred environmental attributes, including warm temperatures, clear waters, beach features and low health risks, followed by marine wildlife attributes

such as coral and fish diversity and abundance. Changes in these attributes due to land use pressure and climate variability have been observed, and future impacts of climate change, including the threat of natural disasters, may have negative effects on tourism.

#### **D. Implications for sustainable development**

28. Climate change and socio-economic trends are compounding each other to undermine sustainable development and the ability to achieve the MDGs in the poorest regions of the world, through increased poverty, loss of livelihoods, and compromised health and education. While it is not within the scope of this paper to discuss all of the possible interactions and consequences, some key areas of concern are highlighted.

29. The impact of climate change in developing countries sits in sharp contrast to that in developed countries, where economic losses as a percentage of GDP are much lower (despite sustaining high levels of direct property losses), and the ability to recover is much stronger. The combination of socio-economic vulnerability and climate shocks in developing countries tends to lock them into a cycle of poverty.

30. The poorest communities are disproportionately affected by extreme events because their socio-economic characteristics and physical location on the most marginalized lands make them most vulnerable and least able to recover. Increases in the intensity and frequency of extreme events have the potential to significantly undermine efforts for development, as they set back GDP and agricultural production and divert resources from efforts to improve areas such as education and health. Many countries are exposed to multiple or sequential extreme events, compounding vulnerability and creating poverty traps as poor households struggle to cope and recover. For example, Ethiopia suffered sequential droughts between 1999 and 2004, and it is estimated that poverty in 2004 would have been 14 per cent lower had households been able to smooth consumption (Dercon, 2005, cited in UNDP, 2008, p.85). Furthermore, women are often more economically and socially vulnerable in poor nations and hence feel the impacts of extreme weather events more acutely.

31. The number of people living under severe water stress is likely to increase substantially, as factors such as increased water demand and decreased water quality converge with changes in water availability and increased salinity due to climate change. This has wide-reaching impacts for sustainable development. Constraints on water supply will disproportionately affect women and children as they have to travel further to gather water for household use, thus compromising education and livelihood opportunities. Almost all of the 50 river basins in Africa are transboundary, and hence increased water scarcity could result in conflict in many African LDCs, placing even greater stress on sustainable development.

32. About 75 per cent of the world's poor live in rural areas and are involved in farming, and agriculture represents a significant fraction of GDP in developing countries, particularly those in Africa. Agricultural production and food security are likely to be severely compromised in many developing countries as trends in global and national food markets and changes to precipitation and temperature patterns converge. This poses serious implications for nutrition and livelihoods, making them more susceptible to climate-linked diseases.

33. The interaction of poor public health and waste management practices, inadequate infrastructure, and changing disease patterns due to climate change and changes in lifestyle will be a key stressor on sustainable development. According to the World Health Organisation (WHO), climate change was estimated to be responsible for 154,000 deaths and 5.5 million disability adjusted life years (DALYs)<sup>4</sup> in

---

<sup>4</sup> DALYs are used to measure the burden of disease. One DALY can be thought of as one lost year of "healthy" life.

2000, and much of this was attributable to the LDCs. In Africa, the economic burden of malaria is already estimated at an average annual reduction in economic growth of 1.3 per cent for those African countries with the highest burden (Gallup and Sachs, 2001, cited in the contribution of Working Group II to the AR4, p. 437).

34. Efforts to improve industry and associated livelihood opportunities, and expand infrastructure that delivers important economic and public services are threatened by the impacts of sea level rise, extreme events and other climate changes. Almost without exception, key infrastructure, such as international airports, roads and capital cities in the Indian Ocean, the Pacific Ocean and the Caribbean are situated along the coast (IPCC 2007d).

#### **E. Final remarks**

35. The impacts of climate change, including those associated with climate-related risks and extreme events, are already occurring, and are projected to intensify in many parts of the world, particularly for the most vulnerable developing countries including LDCs and SIDS. Current and projected physical and socio-economic trends in climate-related risks and extreme events have significant implications for sustainable development and its associated goals, including the MDGs, with the most vulnerable developing countries, including but not limited to LDCs and SIDS, being most affected.

36. Physical trends in the climate are projected to intensify in the future and are an additional burden to those risks associated with climate variability. Socio-economic trends indicated that vulnerability to climate change impacts is increasing, particularly for the most vulnerable countries including LDCs and SIDS.

37. Together, physical and socio-economic trends are self-reinforcing. Increasing climate-related risks and associated losses are exacerbating the adverse socio-economic trends. And these adverse socio-economic trends are in turn increasing vulnerability and exposure to the risks. If progress towards sustainable development is to be achieved, steps need to be taken to break this vicious cycle.

38. Without vigorous and enhanced efforts, many developing countries, especially LDCs and SIDS, are at risk of becoming trapped in a downward spiral that is both self-reinforcing and self-perpetuating. The current low level of adaptation efforts needs to be redressed urgently within the context of sustainable development. Previous piecemeal and fragmented or relatively uncoordinated efforts have not been able to break this cycle and will not suffice. Broader strategic action on adaptation to climate change within the context of sustainable development is needed within the framework of the Convention.

39. The information presented in this technical paper, detailing the relevant issues regarding climate related risks and extreme events faced by developing countries, particularly the LDCs and SIDS, and the implications for sustainable development as well as for the MDGs, could provide inputs to:

- (a) The further work under the Nairobi work programme on its focus area of climate-related risks and extreme events;
- (b) The in-session workshop under the AWG-LCA on risk management and risk reduction strategies, including risk sharing and transfer mechanisms, to be held at the fourth session of the AWG-LCA in Poznan, as well as the negotiations of the Bali Action Plan (decision 1/CP.13) on its pillar on enhanced action on adaptation towards an agreement during the fifteenth session of the Conference of the Parties (COP) in Copenhagen;
- (c) The work by Parties and organizations on physical and socio-economic trends in climate-related risks and extreme events, and their implications for sustainable development.

## II. Introduction

### A. Mandate

40. This technical paper was mandated by the SBSTA at its twenty-eighth session (FCCC/SBSTA/2008/6, para. 48). The SBSTA requested the secretariat, in the context of the Nairobi work programme under its work area on climate-related risks and extreme events, to prepare a technical paper on physical and socio-economic trends in climate-related risks and extreme events in the context of their implications for sustainable development, paying particular attention to the most vulnerable developing countries, especially LDCs and SIDS.

41. The SBSTA suggested that this paper could provide valuable input to the in-session workshop under the AWG-LCA on risk management and risk reduction strategies, to be held during the fourth session of the AWG-LCA in Poznan.

### B. Objective

42. The Nairobi work programme aims to assist all countries, in particular developing countries, including LDCs and SIDS, to improve their understanding and assessment of the impacts of, and vulnerability and adaptation to, climate change and to make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical and socio-economic basis, taking into account current and future climate change and variability.

43. This technical paper can be used to provide input for decision-making by Parties to the Convention, with a view to facilitating adaptation action in the context of both sustainable development and the work by Parties and organizations towards achieving the objective of the Nairobi work programme to promote their understanding of impacts of, and vulnerability to, climate change and climate variability.

44. This paper illustrates the current conditions and issues regarding climate-related risks and extreme events. It is closely related to two other technical papers: the first on integrating practices, tools and systems for climate risk assessment and management and strategies for disaster risk reduction into national policies and programmes;<sup>5</sup> and the second on mechanisms that can be used to manage financial risks from direct impacts of climate change in developing countries, including consideration of the unique circumstances of the most vulnerable developing countries, especially LDCs, SIDS and countries in Africa.<sup>6</sup> These two papers aim to provide inputs for possible policy solutions and mechanisms to address the adverse effects of climate change discussed here.

### C. Background

45. The AR4 concludes that warming of the climate system is unequivocal, as evidenced by increases in global average temperatures, widespread melting of snow and ice, and rising sea levels. These changes are impacting on, and are projected to continue to impact on, humans in a variety of ways, for instance through changes to water availability, agricultural production, health impacts, loss of ecosystem resources, and changes to human settlements and industry. Increases in disasters linked to climate-related risks and extreme events such as hurricanes, cyclones, floods, landslides, wildfires and drought, heat waves and cold spells are having a marked impact on human populations. Estimates show that about 90 per cent of natural disasters worldwide are related to weather, climate or water, and that weather-related disaster is growing (World Meteorological Organization, 2006).

---

<sup>5</sup> FCCC/TP/2008/4.

<sup>6</sup> FCCC/TP/2008/9.

46. Physical and socio-economic trends related to climate risk are complex. A wide range of models has been used to project possible climate trends, and these models use a range of scenarios depending on levels of emissions and socio-economic pathways. Hence the range of estimates for physical changes in the climate system can vary significantly.

47. Generally accessible climate models are not yet efficient at projecting changes at a regional or sub-regional level. Modelling at smaller scales requires high-resolution models, with good historic data on climate variables, and an ability to incorporate local features, such as mountain ranges and complicated coast lines, which impact climate variability. In most developing countries, especially LDCs and SIDS, modelling capability and the availability of necessary data are limited.

48. Developing countries, particularly LDCs and SIDS, feel acutely the impacts of these changes, and are projected to suffer disproportionately from future climate changes and variability. These countries tend to be located in areas where threats from extreme events are often the greatest, and they rely heavily, in economic terms, on climate-sensitive sectors. Furthermore, these countries already face huge gaps in infrastructural development, human resources and technological capacity, which constrain their integration into the global economy and render them perpetually vulnerable to both socio-economic and climate-linked stresses.

49. Socio-economic trends that predispose countries to climate risk can be extensive – anything that makes a country less resilient financially, socially or technologically will impact the ability of that country to respond to changes in the climate. Socio-economic trends are often characterized by the complex interaction of a number of factors at different scales. Climate change has the ability to create or amplify existing socio-economic vulnerabilities that have the potential to lock countries in a cycle of poverty and deepening vulnerability. It is worth noting that poverty and vulnerability to climate hazards are highly correlated but do not completely overlap. The poor are generally more exposed to climate variability and change, and have a lower capacity to cope and recover. Furthermore, climate changes can increase vulnerabilities and induce greater levels of poverty. In addition, developing countries, some SIDS and most LDCs in particular, often lack the quantitative data required on local and national scales to assess socio-economic trends.

50. Nonetheless, a significant amount of work has been undertaken to provide a more comprehensive understanding of physical and socio-economic trends relating to climate risk.<sup>7</sup> In particular, the IPCC assessment reports have brought together a wide body of information and expertise in order to understand and refine projections, and much of the data reported in this paper draws on the AR4.

---

<sup>7</sup> Reports from other United Nations related bodies such as the World Meteorological Organisation, United Nations Conference on Trade and Development, UNDP and the United Nations Economic Commission for Africa also provide a wealth of information on LDCs and SIDS, and have been referenced here, as appropriate.

### 1. Least developed countries<sup>8</sup>

51. Box 1 describes the criteria used to designate countries as least developed. In 2005, about 277 million people lived in extreme poverty in all LDCs (UNCTAD, 2008). It is projected that the total number of those living in extreme poverty in LDCs will reach 470 million by 2015 and that the majority of these will be in Africa (UN-OHRLLS, 2006). The noted high vulnerability of Africa to climate change (IPCC, 2001; IPCC, 2007b) is partly reflected by the fact that most of the world's LDCs are located in that continent.<sup>9</sup>

#### **Box 1. Criteria to designate a least developed country**

The Economic and Social Council of the United Nations used the following three criteria for classifying a country as a least developed country (LDC):

- Low-income criterion, based on a three-year average estimate of the gross national income per capita (under USD 745 for inclusion, above USD 900 for graduation from LDC category);
- Human resource weakness criterion, involving a composite Human Assets Index based on indicators of: (a) nutrition; (b) health; (c) education; and (d) adult literacy;
- Economic vulnerability criterion, involving a composite Economic Vulnerability Index based on indicators of: (a) population size; (b) remoteness; (c) merchandise export concentration; (d) share of agriculture, forestry and fisheries in gross domestic product; (e) homelessness owing to natural disasters; (f) instability of agricultural production; and (g) instability of exports of goods and services.

Source: <<http://www.unohrlls.org/en/lcd/related/59>>.

52. The Brussels Declaration and the Programme of Action (POA) for the Least Developed Countries for the Decade 2001–2010 contains specific goals and targets in the form of the following seven action-oriented commitments which, if fully addressed, will lead to sustainable development pathways and the realization of the MDGs <<http://www.un.org/ohrlls>>:

- Commitment 1: Fostering a people-centred policy framework;
- Commitment 2: Good governance at national and international levels;

<sup>8</sup> The recognition in the United Nations system that there were groups of countries under extreme poverty and with structural handicaps that require special international attention dates as far back as the 1960s. More recently, in May 2001, a consolidated plan of action under the Brussels Declaration and the Programme of Action (POA) for the Least Developed Countries for the Decade 2001–2010 was adopted by the Third United Nations Conference on the Least Developed Countries.

<sup>9</sup> There are 30 LDCs in Africa: Angola, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Togo, Uganda, United Republic of Tanzania, Zambia. There are 8 LDCs in Asia: Afghanistan, Bangladesh, Bhutan, Cambodia, Lao People's Democratic Republic, Myanmar, Nepal, Yemen. There are 11 SIDS LDCs: Comoros, Guinea-Bissau, Haiti, Kiribati, Maldives, Samoa, Sao Tome and Principe, Solomon Islands, Timor-Leste, Tuvalu, Vanuatu.

- Commitment 3: Building human and institutional capacities;
- Commitment 4: Building productive capacities to make globalization work;
- Commitment 5: Enhancing the role of trade in development;
- Commitment 6: Reducing vulnerabilities and protecting the environment; and
- Commitment 7: Mobilizing financial resources.

53. Climate-related risks are a major threat for all LDCs because of the socio-economic stresses that these countries are already experiencing, such as increasing levels of poverty, food insecurity, land degradation, water shortages and declining water quality, rapid urbanization, health epidemics and difficulties in integrating into the global market. These socio-economic stresses predispose LDCs to being more vulnerable to the physical impacts of climate change. An extreme event has the potential to significantly undermine development, as was the case with Samoa where two cyclones struck in 1990 and 1991, setting back the country's development by 20 years and wiping out 15 per cent of its GDP (WMO, 2006).

## 2. Small island developing States<sup>10</sup>

54. SIDS are small land masses surrounded by vast expanses of ocean with large, exclusive economic zones (for mid-Pacific States, these zones are around 1,000 times larger than the land area). SIDS constitute about one fifth of all politically independent countries.

55. SIDS are experiencing sea level rise and an increase in the intensity and frequency of various extreme events, such as heavy rainfall, drought, high air and ocean temperatures, strong winds and storm surges (IPCC, 2001; UNFCCC, 2005). The capacity of SIDS to cope with these events is being increasingly exceeded.

56. SIDS deserve special attention with respect to vulnerability to climate change (box 2). The negative effect of climate-related risks and extreme events on sustainable development among SIDS was recognized fully under the 1994 Barbados Programme of Action (BPOA) for the Sustainable Development of Small Island Developing States, the 2005 Mauritius Strategy for the Further Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States, and the MDGs. It was noted that the unusually high susceptibility of SIDS to climate risk is directly linked to their socio-economic and cultural context, including limited resource endowments, low development marked by inadequate data on climate risks and technical capacity, weak human and institutional capacity and limited financial resources. The level of vulnerability of SIDS is further increased by their rapidly growing populations relative to the small country size, growing poverty, problems with health, including HIV/AIDS, remoteness from global markets, and geographical location (e.g. some are surrounded by ocean in areas of complex climate activity). In addition, the vast majority of infrastructure and industry in SIDS tends to be located close to the coast; hence SIDS face higher costs per capita from climate-related risks and extreme events (Binger, 2000; Briguglio et al., 2008; document FCCC/SBI/2007/11).

---

<sup>10</sup> SIDS may comprise a single island as in Barbados and Nauru; a few islands as in Tuvalu (nine islands) and Cape Verde (15); or numerous islands as in the Seychelles (115) and Tonga (180).

**Box 2. Special characteristics of small island developing States that increase their vulnerability to climate change**

- Limited physical size, which effectively reduces some adaptation options to climate change and sea level rise (e.g. no retreat options; in some cases entire islands could be eliminated, so abandonment would be the only option);
- Generally limited natural resources, many of which are already under heavy stress from unsustainable human activities;
- High susceptibility to natural hazards such as tropical cyclones (hurricanes) and associated storm surges, droughts, tsunamis and volcanic eruptions;
- Relatively thin fresh water lenses that are highly sensitive to sea level changes;
- In some cases, relative isolation and great distance to major markets;
- Extreme openness of small economies and high sensitivity to external market shocks, over which they exert little or no control (low economic resilience);
- Generally high population densities and, in some cases, high population growth rates;
- Often poorly developed infrastructure (except for major foreign exchange-earning sectors such as tourism);
- Limited funds and human-resource skills, which may severely limit the capacity of small islands to mitigate and adapt to the effects of climate change.

*Source:* <IPCC, 2001; UNFCCC, 2005>.

**D. Scope**

57. This paper focuses specifically on likely changes to the climate system, and the implications for developing countries, particularly LDCs and SIDS given their current and probable socio-economic conditions. Key socio-economic characteristics that have the greatest impact on the vulnerability of LDCs and SIDS to climate risks were selected for analysis. It is not within the scope of this paper to report on trends associated with a range of future development scenarios and all the socio-economic issues that face particularly vulnerable developing countries.

**E. Structure of this report**

58. The report is structured as follows:

- (a) Chapter III reviews physical trends in climate-related risks and extreme events, and the impact that these changes will have on selected sectors, including water, agriculture and food security, human health, ecosystems, settlements, infrastructure and industry;
- (b) Chapter IV reviews socio-economic trends that predispose particularly vulnerable countries to the adverse effects of climate change and links this to impacts of climate risks where required;
- (c) Chapter V examines where and how these physical and socio-economic trends interact, and discusses the implications for sustainable development and the consequences for addressing the MDGs;
- (d) Chapter VI draws key observations and provides additional remarks.

### III. Physical trends in climate-related risks and extreme events

59. This chapter describes the physical trends in climate-related risks (temperature, precipitation and sea level rise) and extreme events, and how they could be exacerbated by climate change. The chapter describes the current conditions and recent projections. Trends for developing countries in general, as well as for LDCs and SIDS, are discussed, and a description is provided of the impacts that these changes will have on human populations. It is important to note that these trends will vary according to country, and micro-variation will occur within areas (e.g. although, in many places, total rainfall is increasing, the rainfall pattern is changing, which therefore has an effect on agriculture).

#### A. Overview of observed trends in developing countries

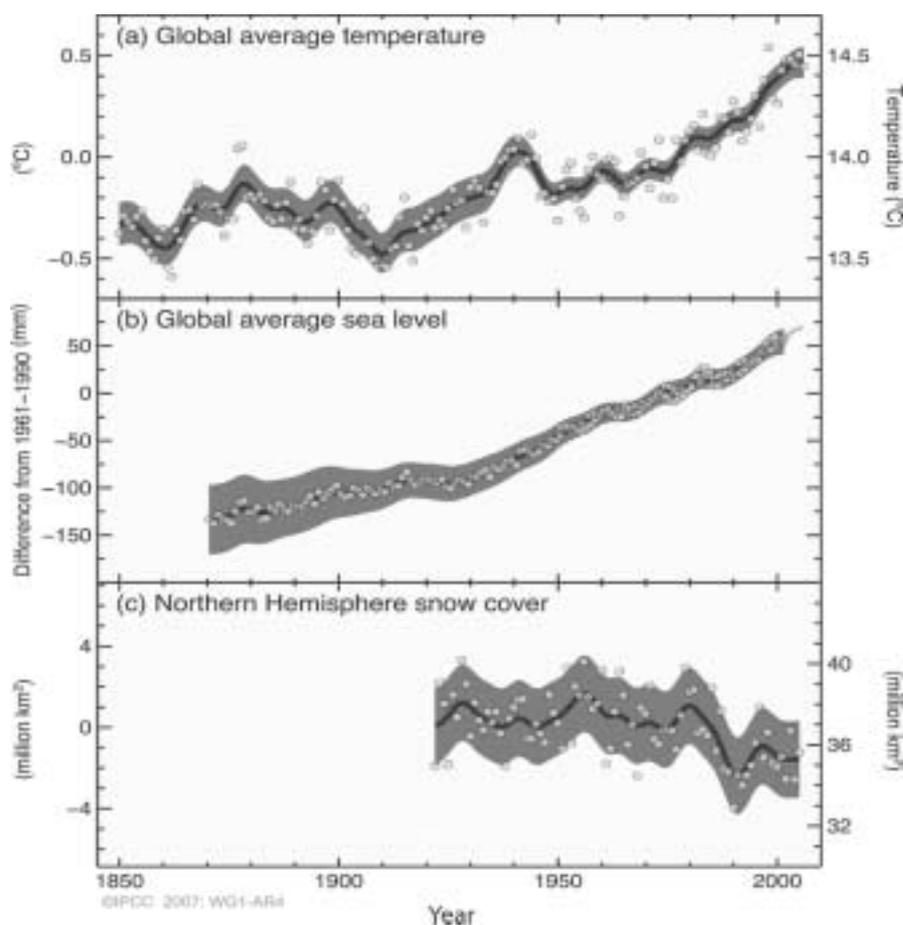
60. The AR4 affirms that the consistency between observed and modelled changes in several studies is sufficient to conclude that anthropogenic warming over the last three decades has probably had a discernible influence on many physical and biological systems. Moreover, the AR4 concludes that there is increased evidence that low-latitude and less-developed areas generally face greater risk, for example in dry areas and mega-deltas. New studies confirm that Africa is one of the most vulnerable continents owing to the range of projected impacts, multiple stresses and its low adaptive capacity. Substantial risks due to sea level rise are projected, particularly for Asian mega-deltas and for small island communities (IPCC, 2007a).

##### 1. Observed trends in climate-related risks

61. The summary for policymakers in the contribution of Working Group I to the AR4 describes the changes in climate that have been observed up to 2006; an overview of these global trends is as follows (see figure 1):

- (a) At the time of publication of the AR4, 11 of the previous 12 years (1995–2006) ranked among the 12 warmest years in the instrumental record of global surface temperature (since 1850);
- (b) Mountain glaciers and snow cover have declined on average in both hemispheres and widespread decreases in glaciers and ice caps have contributed to sea level rise;
- (c) The global average sea level rose at an average rate of 1.8 mm per year between 1961 and 2003. The rate was faster between 1993 and 2003, at about 3.1 mm per year. Whether the faster rate between 1993 and 2003 reflects decadal variability or an increase in the long-term trend is unclear. The total rise in sea level in the twentieth century is estimated to be 0.17 m;
- (d) There have been significant increases in precipitation in eastern parts of North and South America, northern Europe and northern and central Asia over the time period 1900–2005. Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia over the same time period.

**Figure 1. Changes in temperature, sea level and northern hemisphere snow cover, 1850–2000**



Source: IPCC. Fourth Assessment Report, contribution of Working Group I. Figure SPM.3.

62. These recent changes are beginning to affect many other natural and human systems. While these impacts have not yet become established trends, the following observations have been made:

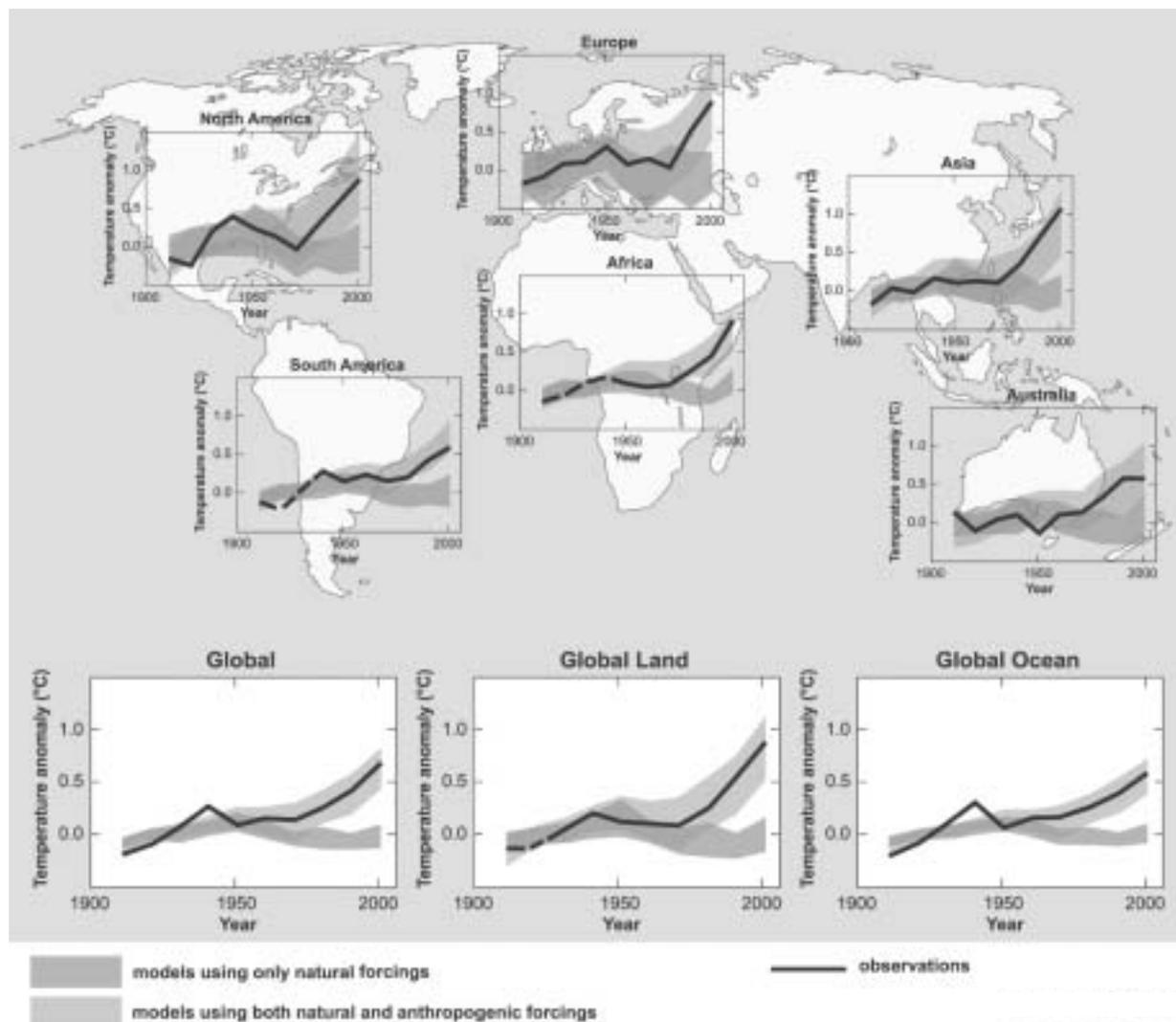
- (a) Settlements in mountain regions are at greater risk of glacial lake outburst floods caused by melting glaciers;
- (b) In the Sahel region of Africa, warmer and drier conditions have led to a reduction in the length of the growing season, with detrimental effects on crops. In southern Africa, longer dry seasons and more uncertain rainfall are prompting adaptation measures;
- (c) Sea level rise and human development are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas (IPCC, 2007b).

2. Observed trends in extreme events and their impacts

63. The summary for policymakers in the contribution of Working Group II to the AR4 describes the changes in extreme events that have been observed up to 2006 and an overview of these global trends is as follows (see figure 2):

- (a) More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and sub-tropics. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. Changes in sea surface temperatures, wind patterns and decreased snowpack and snow cover have also been linked to droughts;
- (b) The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour;
- (c) Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent;
- (d) There is observational evidence suggesting an increase in intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures. There are also suggestions of increased intense tropical cyclone activity in some other regions where concerns over data quality are greater. There is no clear trend in the annual number of tropical cyclones.

**Figure 2. Global and continental temperature change, 1900–2000**



Source: IPCC. Fourth Assessment Report, contribution of Working Group I. Figure SPM.4.

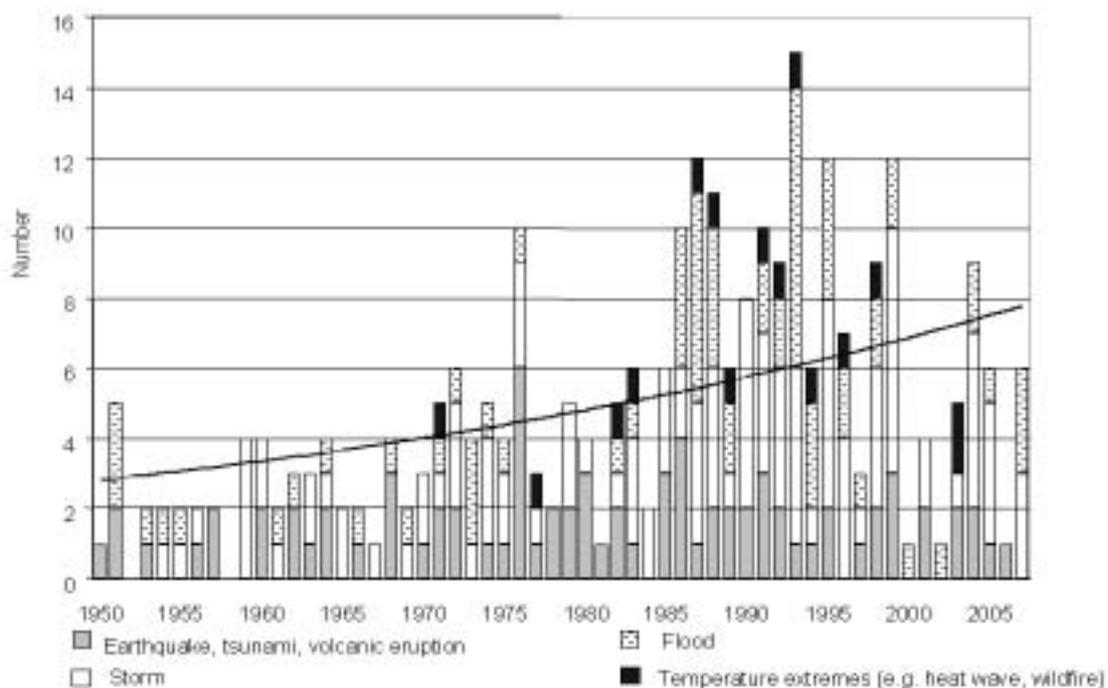
64. The AR4 concludes that there is now higher confidence in the projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation and some aspects of extremes and ice. The impacts from altered frequencies and intensities of extreme weather, climate and sea-level events are very likely to change, with projected impacts including increased water stress and wild fire frequency, adverse effects on food production, adverse health effects, increased flood risk and extreme high sea level, and damage to infrastructure.

65. Figure 3 shows an increase in climate and weather-related disasters over the last five decades compared with a relatively constant level of geological and geophysical disasters. The figure shows a clear distinction between geological disasters, which have remained fairly constant in number, and climate-related disasters, which have increased decade after decade. One possible explanation is that climate change has influenced the increase in climate-related disasters, and it is certainly set to be a more powerful force as it continues and accelerates.

66. Figures 4 and 5, from the Centre for Research on the Epidemiology of Disasters (CRED), show trends in hydro-meteorological disasters for LDCs and SIDS, respectively. The steady long-term upward trend in such disasters is confirmed by both sets of data.

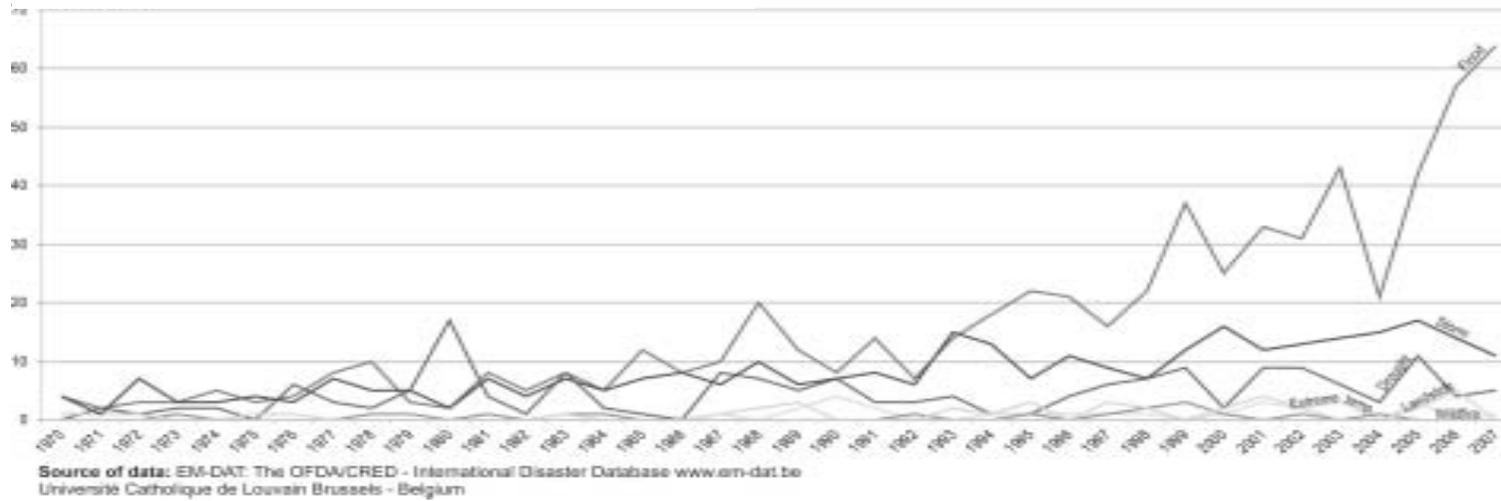
67. These statistics measure the occurrence of disasters and not simply the hazard events themselves. The increase in weather-related and hydro-meteorological disasters cannot be attributed only to climate change on the basis of this information. The information shows that losses from climate-related weather events have been increasing. This trend may also explain difficulties that developing countries, especially LDCs and SIDS, have been experiencing in adapting well to climate variability and extremes, most probably due to a lack of adaptive capacity. This observation reinforces the need for strengthening adaptive capacity in order to manage increasing climate change risks as a consequence of climate change.

**Figure 3. Great natural disasters, 1950–2007**

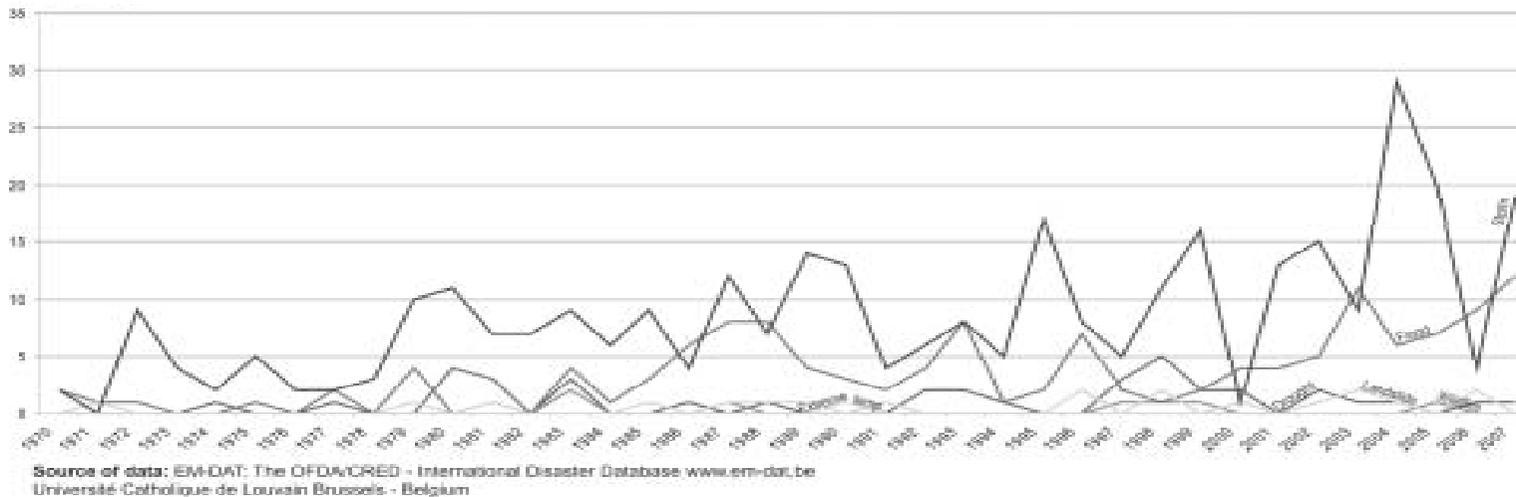


Source: Münchener Rückversicherungs-Gesellschaft Geo Risks Research, NatCatSERVICE

**Figure 4. Trends in hydro-meteorological disasters in least developed countries, 1970–2007**



**Figure 5. Trends in hydro-meteorological disasters in small island developing States, 1970–2007**



68. Furthermore, developing countries suffer the most when a disaster hits – more than 95 per cent of all deaths caused by disasters occur in developing countries; and losses from natural disasters are 20 times greater (as a percentage of GDP) in developing countries than in industrialized countries.<sup>11</sup> These disasters significantly undermine efforts for development, as they set back GDP and agricultural production and divert resources from efforts to improve areas such as education and health. For example, annual damages from climate disasters for the Pacific islands of Fiji, Samoa, and Vanuatu are estimated at 2–7 per cent of GDP (UNDP, 2008). In Mozambique, torrential rainfall in 2000 led to the worst flooding in 50 years. It directly affected two million people and forced 650,000 to leave their homes. It cost USD 600 million and reduced economic growth from a target of 10 per cent to below 4 per cent (Mozambique National Disaster Management Institute, cited in DFID, 2006).

### **B. Future projections for physical trends in developing countries**

69. The observed physical trends in the climate described in the previous section are projected to intensify in the future. The magnitude of change in climate-related trends will depend on a variety of factors, including natural processes (such as volcanic eruptions), as well as anthropogenic forcing through GHG emissions. As concern over changes in climate has grown, so have the number and variety of models for understanding future trends in climate-related risks. The AR4 brings together these efforts and summarizes future projections.

70. This section provides an overview of trends in climate-related risks in developing countries, and also presents a more detailed analysis for LDCs and SIDS. As LDCs are spread across a large and diverse geographical region, it is not possible to summarize projected climate changes for LDCs as a single region. Rather, because LDCs can be classified as African, Asian or SIDS, climate projections are reported below according to these three categories, including projections as given in the United Nations Conference on Trade and Development (UNCTAD) Least Developed Countries Report (UNCTAD, 2008).

#### 1. Global projections

71. The summary for policymakers in the contribution of Working Group II to the AR4 summarizes the following physical trends related to climate change are projected (see figure 6 for the summary of key impacts as a function of increasing global average temperature change):

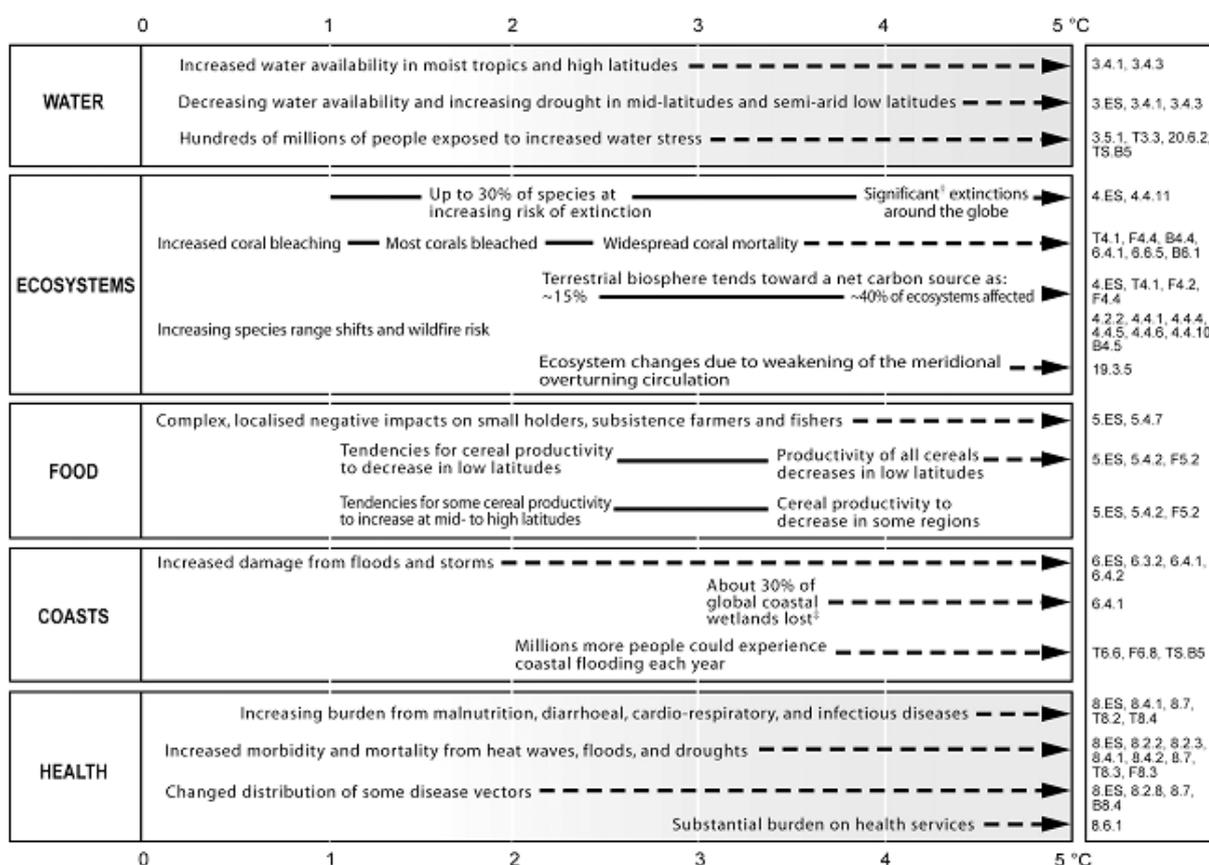
- (a) For the two decades following the release of the IPCC report in 2007, a warming of about 0.2°C per decade is projected for a range of scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected;
- (b) The estimates for projected global average surface warming at the end of the twenty-first century range from an increase of 1.8°C in the low emissions scenario (B1) to an increase of 4.0°C in the high emissions scenarios (A1F1) (with the entire likely range falling between 1.1 and 6.4°C);
- (c) Sea ice is projected to shrink in both the Arctic and the Antarctic under all scenarios;
- (d) Sea levels are projected to rise, and this rise would continue for centuries even if greenhouse gas concentrations were to be stabilized;

---

<sup>11</sup> World Bank. 2008. Disaster Risk Management, available at: <http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEVELOPMENT/EXTDISMGMT/0,,menuPK:341021~pagePK:149018~piPK:149093~theSitePK:341015,00.html>.

- (e) It is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent;
- (f) Based on a range of models, it is likely that future tropical cyclones will become more intense, with larger peak wind speeds and heavier precipitation associated with ongoing increases of tropical sea surface temperatures;
- (g) Increases in the amount of precipitation are very likely in high latitudes, while decreases are likely in most sub-tropical land regions;
- (h) Snow cover is projected to contract and widespread increases in thaw depth are projected over most permafrost regions.

**Figure 6. Global mean annual temperature change relative to 1980–1999 (°C)**



<sup>†</sup> Significant is defined here as more than 40%.  
<sup>‡</sup> Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080.

Source: IPCC. Fourth Assessment Report. Summary for policymakers in the contribution of Working Group II. Figure SPM.2

72. The projected changes in key climate parameters, sea level rise and extreme weather events would cause further impacts on economic sectors, inter alia, water, agriculture and food security, health, ecosystems and industry. The summary for policymakers in the contribution of Working Group II to the AR4 highlights some of the impacts that are projected for these sectors:

- (a) *Water:* By the middle of the twenty-first century, annual average river runoff and water availability are projected to increase by 10–40 per cent at high latitudes and in some wet tropical areas, and decrease by 10–30 per cent over some dry regions at mid-latitudes and in the dry tropics, some of which are presently water-stressed areas. The extent of drought-affected areas will likely increase. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk;
- (b) *Agriculture and food security:* Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1–3°C, depending on the crop, and then decrease, beyond that temperature, in some regions. At lower latitudes, particularly in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1–2°C), which would increase the risk of hunger. The potential for food production is projected to increase with increases in local average temperature over a range of 1–3°C; above this, however, the potential is projected to decrease;
- (c) *Health:* Projected climate change-related exposures are likely to affect the health status of millions of people with low adaptive capacity, through: increases in malnutrition and consequent disorders, with implications for child growth and development; increased death, disease and injury due to heat waves, floods, storms, fires and droughts; the increased burden of diarrhoeal disease; the increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change; and the altered spatial distribution of some infectious disease vectors;
- (d) *Ecosystems:* Approximately 20–30 per cent of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in the global average temperature exceed 1.5–2.5°C relative to 1980–1999. If global average temperature increase exceeds about 3.5°C, model projections suggest a significant level of extinction (40–70 per cent of species assessed) around the world;
- (e) *Settlements, industry and infrastructure:* The costs and benefits of climate change for industry, settlements and society will vary widely by location and scale. Poor communities can be especially vulnerable, in particular those concentrated in high-risk areas. Such communities tend to have more limited adaptive capacities and are more dependent on climate-sensitive resources such as local water and food supplies. The most vulnerable industries, settlements and societies are generally those located in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanization is occurring;

## 2. Projections for Africa, including African LDCs

73. Africa is highly vulnerable to climate change and has some of the most variable climates in the world. Of its 54 countries, 30 are classified as LDCs, most of which are in Sub-Saharan Africa. The study of the regional climate projections in the Working Group I contribution to the AR4 gives the following projections for physical changes related to climate change in Africa:

- (a) Warming is very likely to be larger than the global annual mean warming throughout the continent and in all seasons, with drier subtropical regions warming more than the moister tropics;
- (b) Annual rainfall is likely to decrease in much of Mediterranean Africa and the northern Sahara, with a greater likelihood of decreasing rainfall closer to the Mediterranean coast.

Of particular relevance to the LDCs, rainfall in southern Africa is likely to decrease in much of the winter rainfall region and western margins. There is likely to be an increase in annual mean rainfall in East Africa. It is unclear how rainfall in the Sahel, along the Guinean Coast and in the southern Sahara will evolve;

- (c) A general increase in the intensity of high-rainfall events, associated in part with the increase in atmospheric water vapour, is expected in Africa, particularly southern Africa and many of the LDCs;
74. These physical changes are projected to have the following impacts (IPCC, 2007b):
- (a) *Water:* By 2020, between 75 million and 250 million people are projected to be exposed to increased water stress for the full range of IPCC SRES scenarios;
  - (b) *Agriculture and food security:* Areas suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. Projected reductions in yield in some countries could be as much as 50 per cent by 2020 and crop net revenues could fall by as much as 90 per cent by 2100, with small-scale farmers being affected the most. This would further adversely affect food security and exacerbate malnutrition in the continent. Already compromised fish stocks will be depleted further by rising water temperatures and a decline in water availability for freshwater fish;
  - (c) *Health:* Changes in temperature will alter the spatial and temporal transmission of disease vectors, introducing malaria, dengue fever and other diseases to new areas;
  - (d) *Ecosystems:* Between 25 and 40 per cent of mammal species in national parks in sub-Saharan Africa may become endangered. Degradation of the coral reefs off of East Africa is projected;
  - (e) *Settlements, industry and infrastructure:* Inundation along coasts and in many major cities is projected due to sea level rise, coastal erosion and extreme events, with the potential to wipe out infrastructure and affect human settlements. Much of the tourism industry relies on climate sensitive sectors, including national parks (see para. 74 (d) above on ecosystems) and coastal resources.

### 3. Projections for Asia, including Asian LDCs

75. Asia covers a vast area with a range of climatic zones and is home to eight LDCs located in South and Southeast Asia. It is highly vulnerable to extreme events and is already facing formidable environmental challenges, including land degradation and deterioration in water and air quality. The coastal areas of 11 Asian mega-deltas cover an area greater than 10,000 km<sup>2</sup> and contain unique ecosystems. These areas, which are home to millions of people and are important to the economies of the region, are threatened by sea level rise and extreme events.

76. The study of the regional climate projections in the Working Group I contribution to the AR4 of the IPCC presents the following projections for changes in physical trends in the South and Southeast Asia:

- (a) Warming is likely to be above the global mean in East and South Asia, and similar to the global mean in Southeast Asia;
- (b) Precipitation is likely to increase in South and Southeast Asia, in both boreal winter and summer; there is very likely to be an increase in the frequency of intense precipitation

events in parts of South Asia, and extreme rainfall and winds associated with tropical cyclones are likely to increase in Southeast and South Asia.

77. These physical changes are predicted to have the following impacts (IPCC, 2007c):
- (a) *Water:* Glacier melt in the Himalayas is projected to increase flooding and rock avalanches from destabilized slopes, and affect water resources within the next two to three decades. This will be followed by decreased river flows as the glaciers recede;
  - (b) *Agriculture and food security:* It is projected that crop yields could increase by up to 20 per cent in East and Southeast Asia while they could decrease by up to 30 per cent in South Asia by the middle of the twenty-first century. Taking this into consideration, as well as the influence of rapid population growth and urbanization, the risk of hunger is projected to remain very high in several developing countries. Food insecurity and loss of livelihood will be exacerbated by the loss of cultivated land and areas for fisheries;
  - (c) *Health:* Changing patterns and an increased occurrence of epidemics of vector-borne diseases are expected. Illness and death are expected to increase from diarrhoeal diseases, due to drought and flooding, as well as from higher levels of cholera bacteria in coastal waters;
  - (d) *Ecosystems:* Increased risk of extinction for many species is likely as a result of the synergistic effects of climate change and habitat fragmentation. Stability of wetlands, mangroves and coral reefs is likely to be increasingly threatened;
  - (e) *Settlements, industry and infrastructure:* Coastal inundation is likely to affect aquaculture and infrastructure, especially in heavily populated mega-deltas. Substantial socio-economic activities and populations are currently highly concentrated in the coastal zones in Asia, particularly in the mega-deltas where many of the LDCs are located, and settlements, industry and infrastructure in these areas are at risk from sea level rise and extreme events.

#### 4. Projections for SIDS

78. SIDS are highly vulnerable to the impacts of climate change, owing to their susceptibility to sea level rise and vulnerability to tropical storms and cyclones. Among the SIDS, 11 are categorized as LDCs.

79. The study of regional climate projections in the Working Group I contribution to the AR4 presents the following projections for changes in the physical climate for SIDS:

- (a) Sea levels are likely to rise on average during this century around the small islands of the Caribbean Sea, Indian Ocean and the North and South Pacific Oceans. The rise is not likely to be geographically uniform, but large deviations among models make the regional estimates across the Caribbean, Indian and Pacific Oceans uncertain;
- (b) All Caribbean, Indian Ocean and North and South Pacific islands are very likely to warm during this century. The warming is likely to be somewhat less than the global annual mean;
- (c) Summer rainfall in the Caribbean is likely to decrease in the vicinity of the Greater Antilles, whereas changes elsewhere are uncertain. Annual rainfall is likely to increase in the northern Indian Ocean and the equatorial Pacific, with seasonal variations;

- (d) An increased intensity of tropical cyclones, storm surges, coral bleaching and inundation is projected.
80. These physical changes are projected to have the following impacts (IPCC, 2007d):
- (a) *Water*: Water sources will likely be seriously compromised due to rising sea level, changes in rainfall and increased evapotranspiration. For example, in the Pacific, a 10 per cent reduction in average rainfall (by 2050) would lead to a 20 per cent reduction in the size of the freshwater lens on Tarawa Atoll, Kiribati. By the middle of the century, climate change is projected to reduce water resources in many small islands (e.g. in the Caribbean and Pacific) to the point where they become insufficient to meet demand during low-rainfall periods;
  - (b) *Agriculture and food security*: Agricultural land will very likely be affected by sea level rise, extreme events, and a decline in freshwater supply. The relative magnitude of loss is likely to differ between islands. Fisheries may be affected by increasing sea surface temperature, rising sea level, and damage from tropical cyclones;
  - (c) *Health*: Increases in the intensity of tropical cyclones cause considerable losses to life and property. Heat stress and changing patterns in disease vectors will affect health;
  - (d) *Ecosystems*: Mid- and high-latitude islands are virtually certain to be colonized by non-indigenous invasive species, previously limited by unfavourable temperature conditions. Forests affected by extreme events are often slow to regenerate; however, forest cover may increase on some high latitude islands. Accelerated beach erosion, degradation of coral reefs and bleaching will be caused by sea level rise and increased sea water temperature;
  - (e) *Settlements, industry and infrastructure*: The concentration of large settlements and economic and social activities on or near the coast is a recognized feature of small islands. Coastal resources are a significant contributor to livelihoods and industry, with tourism also playing an important role. Changes in sea level and any changes in the magnitude and frequency of storm events are likely to have serious consequences for these land uses.

#### IV. Socio-economic trends

81. This chapter reviews socio-economic trends that predispose developing countries to the adverse effects of climate change, with particular attention given to LDCs and SIDS. The review takes into account, inter alia, international action plans such as the Brussels POA for LDCs 2001–2010, the Johannesburg Plan of Implementation of the World Summit on Sustainable Development, the 1994 Barbados Programme of Action BPOA for the Sustainable Development of SIDS and the Mauritius Strategy for the Further Implementation of the Programme of Action for the Sustainable Development of SIDS. The additional burden caused by climate change is addressed through the assessments made. The aim is to provide information on current and potential sources of socio-economic vulnerabilities<sup>12</sup> in addressing climate-related risks and extreme events, including their expected increase caused by climate

---

<sup>12</sup> The review relies on the definition of vulnerability as given in IPCC AR4, chapter 17: “Vulnerability to climate change refers to the propensity of human and ecological systems to suffer harm and their ability to respond to stresses imposed as a result of climate change effects. The vulnerability of a society is influenced by its development path, physical exposures, the distribution of resources, prior stresses and social and government institutions.”

change, that have a bearing on sustainable development in particularly vulnerable countries, especially LDCs and SIDS.

#### **A. Climate risks and general socio-economic trends**

82. Particularly vulnerable developing countries, including LDCs and SIDS, are generally characterized by certain socio-economic trends that make them more vulnerable to the impacts of climate change. These include: high rates of population growth (especially in hazard prone areas); urbanization; food insecurity; high levels of poverty; conflicts; and mismanagement of natural resources (IPCC, 2007b; IPCC, 2007e; Dilley et al., 2005). Many such vulnerable countries also suffer from weak institutional frameworks, policies and governing systems, all of which combine to lower their capacity to manage climate risk. The increase in the scale and frequency of climate extremes in these low-development regions is devastating and impedes recovery before the next event; this is causing greater long-term damage as compared with the more immediate impacts of disasters that make headline news.

83. In most developing countries, climate risk management is not integrated into the development process, resulting in countries applying a reactive approach to these events. Although there are ongoing efforts to change this, they are still in the early stages. A reactive approach undermines further the ability to cope with similar stresses in future. For example, governments, donors and development agencies tend to fund disaster relief and rehabilitation by reallocating resources from existing development programmes, thus creating a multiplicity of negative effects, further constraining and reversing development and increasing vulnerability.

#### **B. Least developed countries**

84. LDCs are characterized by extreme poverty, weak economies, inadequate institutional and human resources, and a lack of physical and financial infrastructure. Their economies are dominated by climate and water sensitive sectors such as agriculture, timber and non-timber products, tourism and the hydropower industry. These countries have the lowest resilience of all to climate-related risks and extreme events.

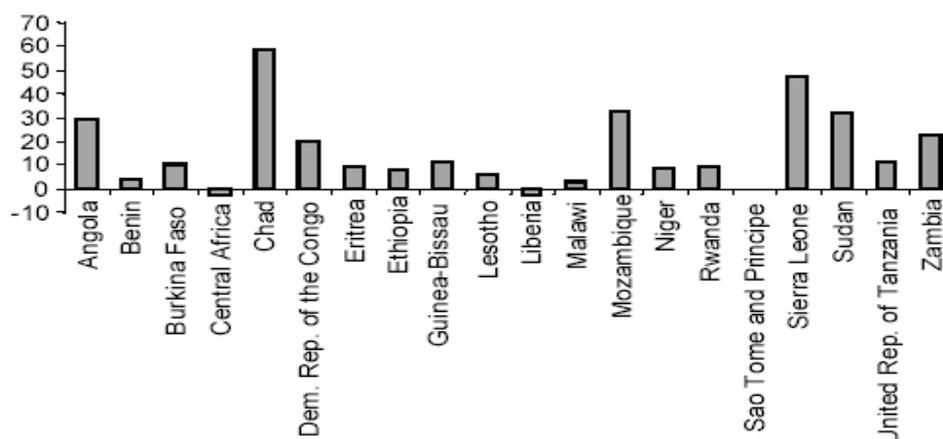
85. This section reviews the socio-economic trends in LDCs that predispose these countries to climate risks. It includes an analysis of the economic performance of these countries in terms of progress in basic development infrastructure, technology development, economic diversification and generation of domestic wealth, trade and globalization and the role of foreign direct investment (FDI) and official development assistance (ODA). The review includes sectors that are instrumental in the socio-economic development of LDCs, such as agriculture and food security, water, ecosystems and energy. These are assessed in terms of their role in human well-being and poverty reduction. In this context, issues such as education, health, migration and urbanization, and general labour productivity are also covered. Climate risk monitoring and response and governance, which are considered an important facilitating factor in sustainable development, are also covered.

##### **1. Economic growth and poverty**

86. During the late 1970s and 1980s, the majority of LDCs experienced growth reversal. ODA fell by 45 per cent in real per capita terms between 1990 and 1998. In contrast, LDCs, on the whole, have shown a strong positive trend in economic growth since 2000, reaching a peak in 2005 and 2006 when their average growth rate exceeded 7 per cent – a target set by the LDCs and their development partners as a key goal in the Brussels POA. The highest average GDP for two decades was registered in 2004. This growth was achieved through high capital inflows, mainly in the form of grants and FDI associated with higher growth in merchandise exports, although this was not uniform across all LDCs (figure 7). FDI increased from USD 6.8 billion in 2001 to USD 10.7 billion in 2004. However, this accounted for only 1.6 per cent of global FDI inflows, and 70 per cent of this total went to six countries, all of which

were oil producing (Angola, Chad, Equatorial Guinea, Mauritania, Sudan and Yemen) (UN-OHRLLS, 2006). Many of these countries have engaged in significant economic reforms over the last two decades, including extensive trade liberalization, financial liberalization and privatization, in order to access the global economy.

**Figure 7. Growth rate of exports in selected least developed countries in Africa, 1997–2006**  
(per cent)



Source: Economic Report on Africa. 2008. *Development Challenges for Africa in 2007. Chapter 3. Africa and the Monterrey Consensus: Tracking Performance and Progress*. Available at <<http://www.uneca.org/era2008>>.

87. ODA doubled between 1999 and 2004 to USD 24.9 billion; however, the total debt burden increased by USD 20.8 billion in 2001 to a record USD 158.9 billion in 2003 (UN-OHRLLS, 2006). Most of the ODA received was diverted to debt relief and humanitarian needs (box 3).

88. As a result, despite positive economic trends, poverty remains entrenched in LDCs. In 2005, 36 per cent of the total population of LDCs lived in extreme poverty (under USD 1 a day), and the actual number of poor people was larger in 2005 compared with 2000 (UNCTAD, 2008). For the period between 2001 and 2004, only 6 out of 46 LDCs (for which sufficient information was available) met or exceeded the POA target growth of 7 per cent per annum; of those same 46 LDCs, 18 were unable to achieve growth rates per capita of more than 1 per cent per annum (this is considered too low to have any effect on extreme poverty).

89. When a longer-term view of the growth trends is used (i.e. between 1980 and 2003), where data are available, real GDP per capita grew at only 0.72 per cent per annum for the LDCs as a whole; and of the 41 LDCs, 17 had negative average annual GDP per capita growth rates (UNCTAD, 2006).

**Box 3. Factors accounting for the lack of sustainability in the recent economic growth among least developed countries**

The economic growth registered among least developed countries (LDCs) is having a limited role in poverty reduction, leaving LDCs exposed to high levels of vulnerability. Numerous factors account for this situation, including:

- Economic growth is based on the dominance of foreign direct investment (FDI)-driven enclaves of capital intensive sectors (e.g. extraction of minerals), which generate limited employment, are not integrated into the rest of the economy, and are highly dependent on commodity prices (higher oil prices were influential in the high growth rate in 2004);
- There is a differential access to external finance, particularly FDI inflows (84 per cent of FDI inflows in 2004 was absorbed by only 10 LDCs) and official development assistance (ODA) grants (30 per cent of the noted increase in ODA during 1999 and 2004 was absorbed by Afghanistan and the Democratic Republic of the Congo);
- A significant proportion of the increase in ODA is attributable to debt relief and emergency assistance rather than development; however, while that is so, the overall debt burden of the LDCs continues to increase. For example, in 2003, interest payments and profit remittances were equivalent to about 60 per cent of the value of grants received (excluding technical cooperation);
- External capital inflows have failed to have a catalytic role in stimulating domestic capital accumulation, for example ODA directed to production sectors such as agriculture, industry, and tourism constituted only 6.8 per cent of total aid commitments in the period 2000–2003, while for the banking and financial services it constituted only 1 per cent;
- Financial liberalization has failed to promote productive investment; for example, the delivery of credit to the private sector and to small and medium enterprises (SMEs) is poor due, in part, to the weak capacity of local entrepreneurs;
- There is a low rate of economic diversification, as shown, for example, by limited growth in the manufacturing sectors. Where growth has occurred, it has been concentrated in only a small number of LDCs. For example, Bangladesh constituted half of the total increase in manufacturing value added for all LDCs between the 1990–1993 and 2000–2003 periods, while for other LDCs that experienced progress, low-skill labour-intensive products dominated;
- The current level of integration into international trade and investment flows has not included a growth in the domestic knowledge and skills required for promoting technological capacities for development;
- There has been a low level of development in major physical infrastructure;
- LDCs have the lowest and poorest quality stock of transport and energy infrastructure in the world, while energy infrastructure deficiency constitutes one of the crippling factors in the process of capital accumulation. For example, limited access to electricity results in high production costs and hence diverts funds away from productive investments. Climate change will exacerbate this situation through an increased shortage of water and this will have an adverse effect on many LDCs that rely on hydropower generation.

*Sources:* UN-OHRLLS, 2006; UNCTAD, 2006, 2007 and 2008.

90. A year-to-year analysis shows that, since they achieved political independence, LDCs have experienced short periods of rapid growth which have been followed by economic crises, and recovery has been variable. Only 7 out of 40 have maintained steady sustained growth, including Bangladesh, Bhutan, Burkina Faso, Cape Verde, the Lao People's Democratic Republic, Lesotho and Nepal. Of the 33 LDCs that have experienced major economic crises, only 12, including Mozambique and Uganda, have real GDP per capita that is now higher than it was at its peak in the 1970s or early 1980s (UNCTAD, 2006).

91. It can be concluded that the rapid economic growth that is being registered among LDCs as a group is spatially and temporally variable, and is not uniform across economic sectors. There are gross inequalities in the distribution of the wealth that is generated (box 3). This growth has had only a limited contribution in terms of increasing the adaptive capacity of LDCs to climate change.

## 2. Agriculture and food security

92. Agriculture is a significant source of livelihood for the majority of people in LDCs. For example, in Ethiopia 85 per cent of the population was employed in the agriculture sector by 2004 (UNDP, 2005). Women are directly dependent on subsistence agriculture; in 1990 less than 30 per cent of the total wage employment outside of agriculture was female in LDCs as a group, leaving the rest directly dependent on agriculture (Department of Economic and Social Affairs, 2004; Koroma, 2007). Estimates show that in Uganda, for example, 75 per cent of the country's food is produced by women alone and that they form 80 per cent of the agricultural labour force (UNDP, 2005), highlighting the significant role that women are playing in this sector.

93. Productivity of agriculture has been declining in the LDCs. In Uganda, for the 1990–1991 and 2003–2004 periods, agriculture had the slowest growth rate among major sectors (3.8 per cent per annum), while in Bangladesh, agriculture as a percentage of GDP declined from 25.6 per cent in 2000 to 21.9 per cent in 2005, and its growth rate (excluding fisheries) was negative (Ahmed, 2006; Enyimu, 2006). The agriculture sector in LDCs is mostly undercapitalized and subjected to the vagaries of weather and climate. LDCs generate low returns for intensive labour investments due to low inputs and reliance on obsolete technologies. In cases where sufficient outputs are realized, the lack of access to markets may be an obstacle. Recurrent droughts, for instance, in the Sahel region and in Southern Africa, have also contributed to the declining trend in the agriculture sector. Rural poverty in most LDCs has been accentuated by climate variability and climate change, increasing food insecurity and reducing the scope of benefits from the export of agricultural products. Agricultural productivity has also been heavily reduced by the HIV/AIDS pandemic, particularly in Africa (see also the section on human health below).

94. The above factors combined give rise to food insecurity, which further affects human health and increases susceptibility to current and future climate risks. The number of people in LDCs who are undernourished rose from 196 million in the 1990–1992 period to 246 million in the 1998–2000 period. About 44 per cent of the population in Ethiopia is food insecure (UNDP, 2005); in Uganda 39 per cent of children in 2001 were stunted due to poor nutrition while, in Bangladesh, maternal malnutrition was noted at a rate of 45 per cent per 100,000 live births in 2006 and is a major cause of maternal mortality (Enyimu, 2006; Ahmed, 2006).

## 3. Water resources and food security

95. A significant number of LDCs are facing critical water shortages, and a lack of clean water is likely to be a key factor limiting economic growth in the LDCs in this century. In Bangladesh, groundwater forms 73 per cent of the total amount of water used; however, most of this is contaminated with arsenic (UN-OHRLS, 2003). There are large variations in terms of the quantity and quality of

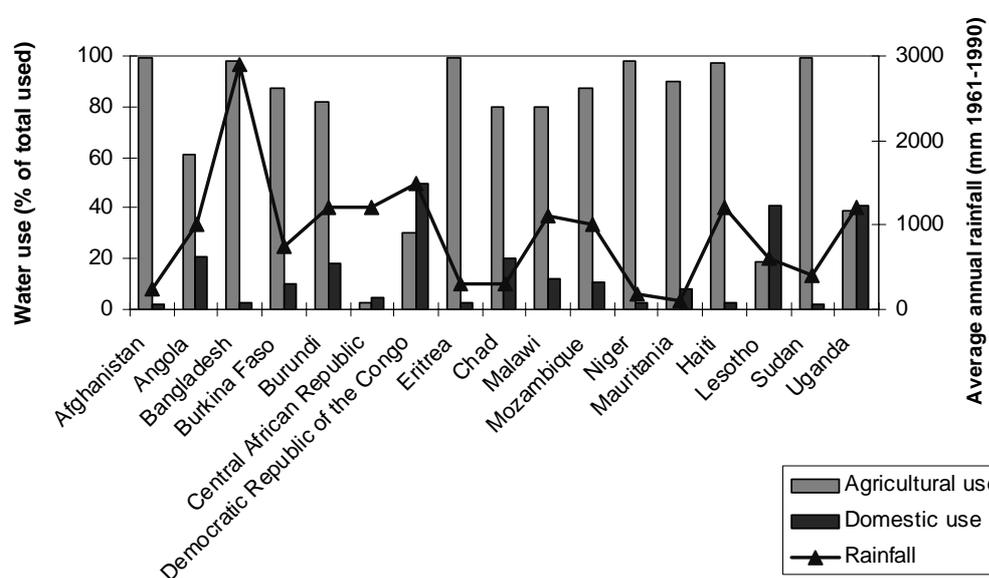
water resources among LDCs. In Africa, average annual internal renewable water resources range from 935 km<sup>3</sup> in the Democratic Republic of the Congo to 0.4 km<sup>3</sup> in Mauritania (UN-OHRLLS, 2003).

96. For surface water sources, LDCs face issues over the shared management of watersheds. For instance, there are 10 Nile countries and eight Zambezi river basin countries, which include a number of LDCs (United Nations Environment Programme (UNEP), 2006; IPCC, 2007b). Effective water-resource management is challenged by the significant number of competing uses, such as for hydropower and industry, irrigation and drinking water (UN-OHRLLS, 2003). The construction of dams in response to the high demand for hydropower also has far-reaching consequences on food production in LDCs. For example, the 795,000 km<sup>2</sup> watershed of the Mekong serves three LDCs (Cambodia, Lao People's Democratic Republic and Myanmar) where dams constrain fish migration and threaten fisheries downstream thus reducing protein intake for over 52 million people. Furthermore, diverting the river interferes with the protection that it provides as a barrier to saltwater penetration into the rich Mekong delta soils used for crop production (UN-OHRLLS, 2003). It also has impacts on freshwater ecosystems (marshes and wetlands) that are rich in biodiversity, affecting the livelihoods of the poor who are usually highly dependent on these systems for food production, natural water purification, fish and other services.

97. Deforestation and general watershed degradation is widespread among LDCs and this affects water quality and availability (figure 9; Bates et al., 2008). It is estimated that the Congo River watershed has lost more than 1,000,000 km<sup>2</sup> of its original forest cover, and the Ganges and the Mekong have each lost between 500,000 and 1,000,000 km<sup>2</sup> (UN-OHRLLS, 2003).

98. The agriculture sector uses the largest amount of water, accounting for over 90 per cent in most LDCs (UN-OHRLLS, 2003) (figure 8). Irrigation is a major source of river pollution, with agricultural nutrients or chemicals from leaching fertilizers, pesticides, and manure reaching waterways (Bates et al., 2008). The water use efficiency of most agricultural systems in LDCs is low, at around 30 per cent (UN-OHRLLS, 2003).

**Figure 8. Average rainfall and water consumption in the agricultural and domestic sectors of selected least developed countries, 1961–1990**



Source: UN-OHRLLS, 2003.

99. Lake Chad shrunk to nearly a twentieth of its original size in 1963, partly due to the high demand for agricultural water but also due to low rainfall. This led to a shortage of water for domestic and agricultural use, resulting in crop failures, livestock deaths, collapsed fisheries, soil salinity, and increasing poverty throughout the region, contributing to socio-political instability (UN-OHRLLS, 2003; Bates et al., 2008).

#### 4. Population growth, land use pressure, poverty and urbanization

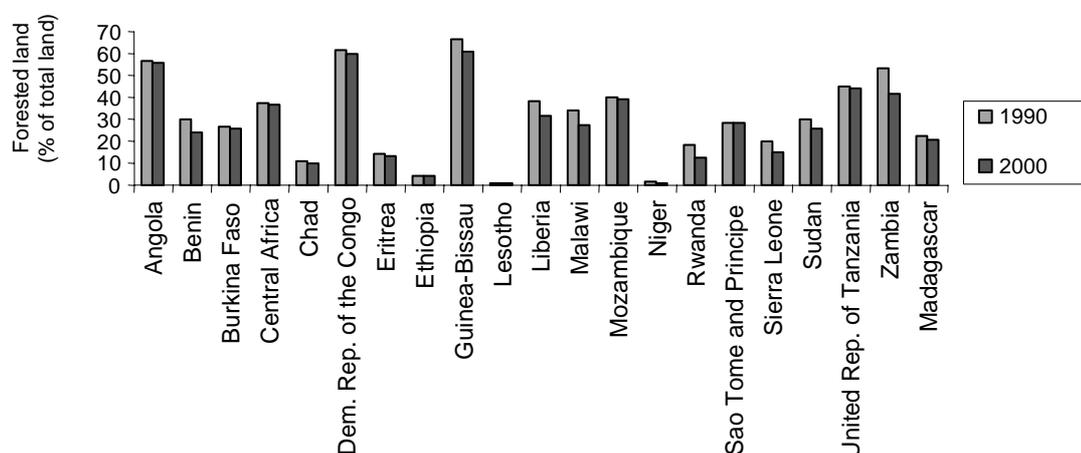
100. LDCs constituted approximately 767 million people in 2005 and, while projections are difficult owing to the effects of HIV/AIDS, it has been estimated that the total population of the current LDCs as a group may reach 1.04 billion by 2020 (UN-OHRLLS, 2006; UNCTAD, 2004). LDCs as a group have one of the fastest growing populations and over 40 per cent of the population is under 15 years, as compared with 28 per cent in other developing countries. Rapid population growth is putting great strain on limited resources for the provision of basic human development infrastructure such as education.

101. Rapid population growth also poses a major challenge to poverty eradication. Most LDCs now have poverty reduction strategies in place; however, their implementation remains a significant challenge. Some of the factors accounting for continued growth in the number of people living in poverty include: political insecurities (e.g. in Uganda and Sudan); widespread HIV/AIDS prevalence in African LDCs in particular; climatic variability and low productivity in the agriculture sector; poor access to basic infrastructure; and the high vulnerabilities of LDCs to external shocks (UNDP, 2005). For example, in Uganda, while overall GDP growth averaged 6.5 per cent per annum for the 1990–1991 and 2002–2003 periods and the rate of per capita GDP growth was 2.7 per cent per annum, this was lower than the population growth rate of 3.4 per cent per year.

102. LDCs have experienced rapid growth of the labour force; it comprised 312 million people in 2000 and is predicted to rise to 401 million people between 2000 and 2010 (although 22 per cent of this increase is expected to occur in Bangladesh alone) (UNCTAD, 2006). In the meantime, LDCs are

largely failing to absorb labour outside the traditional agriculture sector and the role of agriculture continues to decline. In 31 LDCs, over 30 per cent of the population lives on fragile lands, and the livelihoods of these people are highly vulnerable to climate risks (UNCTAD, 2006). Rising populations combined with poor agricultural practices have led to deforestation, increased salinity of soil and accelerated problems of land degradation, leading to desertification in many parts of LDCs in Africa (UN General Assembly Economic and Social Council, 2006). Deforestation occurred at a rate of about 2 per cent annually between 1990 and 2000, affecting Benin, Burundi, Comoros, Guinea-Bissau, Liberia, Malawi, Sudan, Togo, Uganda and Zambia in Africa, as well as Haiti, Myanmar, Nepal and Samoa (figure 9) (Department of Economic and Social Affairs, 2004). Deforestation contributes to food insecurity, owing to the importance of timber and non-timber forest products in food security in these countries. Declining livelihood alternatives in rural areas is a factor in the accelerated migration to cities, creating huge challenges in delivery of service, unemployment problems, high incidence of crime and the potential for civil unrest, therefore rendering LDCs less attractive to foreign investors. By 2006 nearly 140 million people in LDCs lived in slums (UNDP, 2005).

**Figure 9. Decline in forested land in selected least developed countries in Africa between 1990 and 2000**



Source: United Nations Department of Economic and Social Affairs. Millennium Indicators database <<http://millenniumindicators.un.org>>.

## 5. Human health

103. LDCs face a range of climate and non-climate related health issues. Health problems among LDCs are linked to the fact that, despite economic growth, investment in the health sector is not increasing. In Uganda, for example, over 75 per cent of the disease burden is linked to poor hygiene and inadequate sanitation practices (Enyimu, 2006). Provision of safe water is a major threat to health in LDCs as a lack of clean water can lead to diseases such as diarrhoea – across the LDCs as a whole, only 58 per cent of the population have access to improved water facilities (UN-OHRLLS, 2006; Economic Report on Africa, 2008). Africa (excluding North Africa) is estimated to be losing about 5 per cent of GDP annually on health problems linked to water and sanitation deficits (Economic Report on Africa, 2008). Water-related health problems linked to water scarcity will be exacerbated by increased rainfall variability and high temperatures as most LDCs experience poor water harvesting and management policies. These health problems will further compound nutritional deficits as a result of the food insecurity discussed in the previous section on agriculture.

104. Congested housing in cities, combined with a deficiency in the supply of services, is a threat to human health in LDCs. High population concentration in cities predisposes the population to the rapid spread of disease, particularly during periods of climate extremes, which lead to outbreaks of infectious diseases (Economic Report on Africa, 2008). Outbreaks of cholera in Djibouti, Somalia and Mozambique were associated with excessive flooding during the 1997–1998 El Niño events. These threats to human health lower productivity and predispose these countries to a greater vulnerability to additional health risks posed by climate change.

105. One of the biggest health threats in LDCs is malaria. By 2006 it was estimated that, while 15 LDCs had managed to control the disease, the situation was deteriorating in 13 others, mostly in Africa (UN-OHRLLS, 2006). The high death rates associated with malaria are linked to complex interactions involving climatic conditions, land-use systems that create favourable conditions for mosquitoes to breed, a lack of capacity to establish and maintain a malaria early warning system, and limited access to medical facilities and other preventive measures such as insecticide-treated bed nets, all of which relate to poverty, a low level of public education and development.

106. In addition to health risks that are directly linked to climate, LDCs face huge long-term health problems and loss of productivity due to the HIV/AIDS pandemic. Southern African LDCs, such as Zambia, Malawi and Lesotho, where HIV/AIDS is most prevalent, accounted for 77 per cent of all AIDS deaths in 2007, with women accounting for 61 per cent of those living with HIV and AIDS and life expectancy having been reduced from 62 years in 1990–1995 to 39–48 years in 2000–2005 (CHGA, 2008; UNDP, 2005). The spread of HIV/AIDS in LDCs is linked to complex socio-economic factors including a lack of economic opportunity which results in migration and disruption of the family structure. HIV/AIDS disproportionately impacts women, raising their vulnerability to climate-related health problems. LDCs have high numbers of female-headed households, the majority of which face crippling shortages of resources, food insecurities, and limited access to education; they are therefore very prone to HIV/AIDS and its negative impacts, such as increased poverty and vulnerability to other stresses.

107. Current indications are that the decline in prevalence rates is faster among the wealthier and educated groups than among the poor for whom there is limited change, although numerous efforts are being made in public education prevention and access to medication (UNDP, 2005). The HIV/AIDS pandemic increases further vulnerability to climate-related health problems through increased poverty and reduced immunity.

#### 6. Climate risk assessment capability as a source of vulnerability

108. The limited capacity to undertake an assessment of climate risks and provide timely weather information required in order to plan adaptive responses is a source of vulnerability in developing countries. The majority of the population in LDCs depends on climate-sensitive sectors, such as agricultural and forest products, for livelihood and sustenance. They are more likely to be severely affected by climate-related diseases such as influenza, diarrhoea, cholera, meningitis, dengue and malaria, as noted above. The ability to provide timely advice on climate and early warning is hampered by weak infrastructure, lack of basic services such as communication networks and electricity, a less educated public and an overall lack of resources. Without such information, a proactive approach to risk management cannot be fully addressed.

109. Nonetheless, some LDCs have demonstrated progress in climate risk assessment. For example, flood-related deaths in Bangladesh are gradually decreasing. This has been attributed partly to substantial efforts to improve early warning systems and undertake adaptation activities based on climate risk assessments. Attempts are also ongoing in association with the World Meteorological Organization to develop and strengthen national meteorological and hydrological services (NMHSs) among LDCs.

## 7. Governance

110. Addressing governance is one of the commitments under the Brussels POA for LDCs. LDCs often experience a lack of human capital, limited public expenditure and management skills, and limited local governance infrastructure (Keuleers, 2004). This is more the case given the weakened traditional governing frameworks. There are usually limited resources and efforts to mobilize the participation of civil society, local communities and the public at large in governance in order to promote more effective service delivery. Poverty and a low level of public education also have a role in effective participation of the public in governance. Weak governance at the local level is a contributing factor in political instability and the mismanagement of natural resources, which enhances poverty and increases susceptibility to climate variability (World Resources, 2002–2004; UNEP, 2006). In addition, a weak governance system limits the ability of countries to proactively assess and manage climate risks (Keuleers, 2004; Yohe et al., 2007). A number of LDCs are working with the United Nations Population Fund (UNFPA), under the United Nations Capital Development Fund (UNCDF) Business Plan 2005–2007, to address issues of governance at the local level.

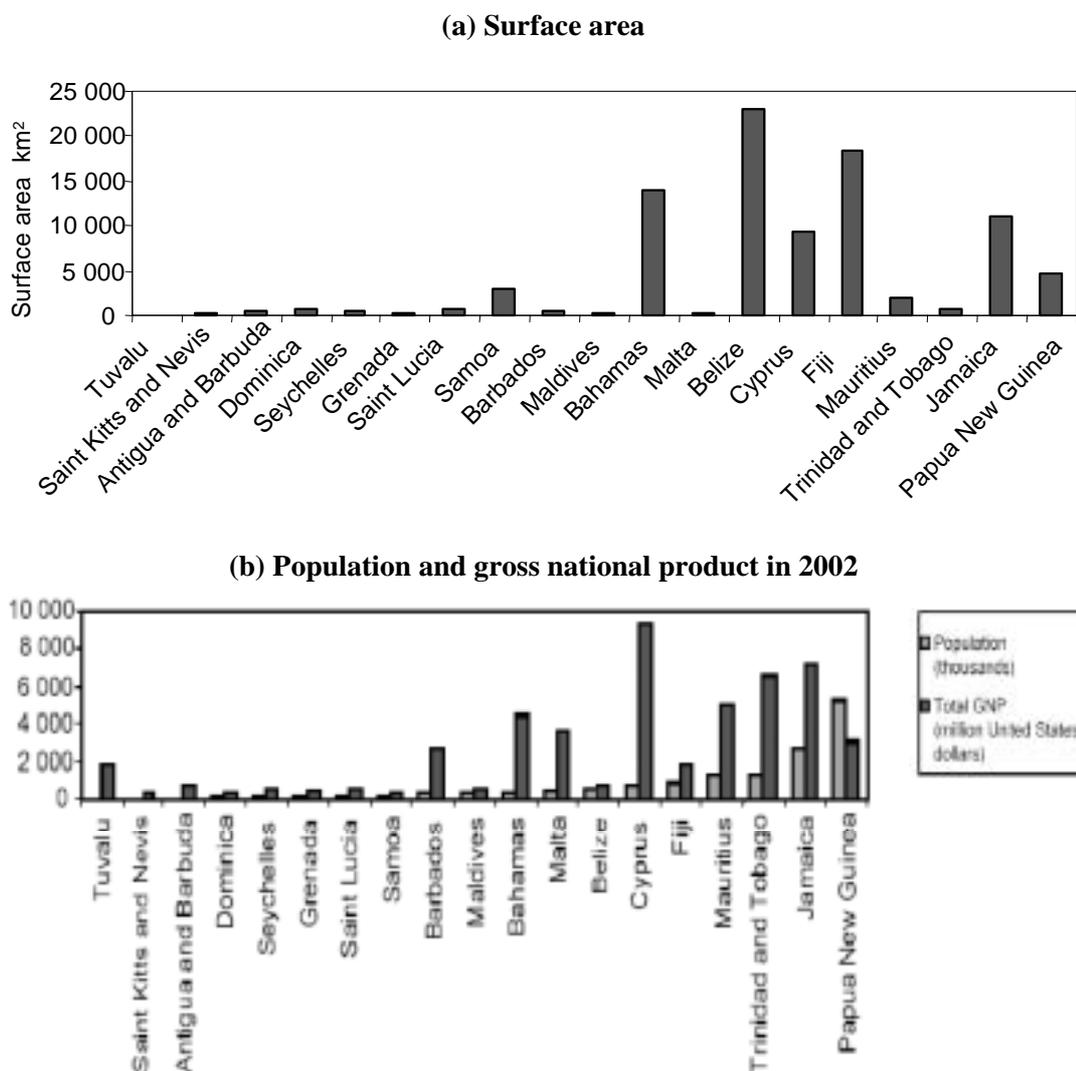
### **C. Small island developing States**

111. This section presents socio-economic trends that, when combined with physical trends, put SIDS at a unique level of vulnerability to climate risk. In contrast to LDCs, SIDS as a group are defined by their physical characteristics and location. Attention has therefore been given to socio-economic factors that have a greater link with climate and other physical trends in the context of SIDS, such as settlement patterns, urbanization and human health, as well as the main sectors of SIDS' economies that are climate sensitive: water, agriculture, fisheries, ecosystem resources, tourism (with some reflection on transport), and energy. Links between the integration of SIDS' economies into the global economy and implications on vulnerability are also discussed. The section ends by briefly reflecting on the overall capacity of SIDS to respond to climate risk, highlighting issues of governance and capacity for climate monitoring and early warning systems.

112. There is great diversity among SIDS, in terms of surface area and geography, population and GNP (figure 10). Low-lying SIDS such as the Maldives and Papua New Guinea have nearly 50–80 per cent of their land area less than one metre above mean sea level, whereas others such as Haiti have diverse terrain (UNFCCC, 2005). Furthermore, there are large differences in demographic patterns, resource endowment, development status (figure 10), and hence, human well-being (e.g. the mortality rate per births can be used as a measure, see table 1). The human development index (HDI) also varies significantly; Saint Kitts and Nevis and Seychelles had a high HDI of 1 and 2 respectively in 2002, in contrast to Papua New Guinea and Comoros with 133 and 137, respectively.

113. In terms of economic growth in the Caribbean, the average annual growth rate between 2000 and 2005 was –0.2 per cent in Haiti which is one of the largest islands, and 7.6 per cent in Anguilla which is one of the smallest. Some SIDS are faced with a growing burden of debt, such as Jamaica where the average public debt was nearly 145 per cent of GDP by 2005 (Witter, 2008).

**Figure 10. Diversity among small island developing States in terms of (a) differences in surface area, and (b) population and gross national product**



Source: Based on 2002 data from the Commonwealth Secretariat, <<http://www.thecommonwealth.org/Internal/151766/151767/countries>>.

**Table 1. Mortality rate of children under five in selected small island developing States, per 1000 live births**

	Bahamas	Barbados	Belize	Guyana	Jamaica	St. Lucia	St. Vincent and the Grenadines	Suriname	Trinidad and Tobago
<b>1990</b>	27.3	17.0	46.8	81.6	31.7	22.0	24.5	41.9	24.0
<b>2000</b>	25.1	12.0	43.0	72.5	25.6	20.5	19.2	30.8	18.3

Source: Witter M 2008. *Current Socio-Economic Trends and Medium Term Prospects for the Caricom Caribbean*. (unpublished report). Data extracted from Mung K and Hospedales JC. 2005. p.65.

114. It follows that there will be great variability among SIDS with respect to the impacts of climate change. For instance, in high islands such as Viti Levu in Fiji, the overall cost of damages on the economy by different climate change risks is expected to be lower, at 2–3 per cent of GDP by 2050, in contrast to low-lying islands such as Tarawa, Kiribati, where estimated damages could be as high as 17–18 per cent of GDP by 2050 (under the SRES A2 and B2 emissions scenarios) (IPCC 2007d). However, it is not within the scope of this paper to provide socio-economic trends specific to each of the SIDS. Instead, the focus is on the underlying socio-economic factors in the context of the overall physical characteristics (i.e. geographical location) that accentuate the vulnerability of SIDS as a group to climate risk. Individual cases are used as necessary and where data are available in order to support the noted overall trends.

#### 1. Settlements, migration and urbanization among SIDS

115. Despite the variability, SIDS are generally characterized by high population densities relative to their size (figure 10) and they generally face economic stagnation, growing inequalities, weakening social capital and rising poverty. The indigenous population groups are affected further, and in some cases this is linked to unequal land rights (Republic of Suriname, 2004; UNFCCC, 2007b; Witter, 2008). These socio-economic factors, compounded by geographical location, reduce the capacity of SIDS to cope with climate risks, making them vulnerable to climate change stresses.

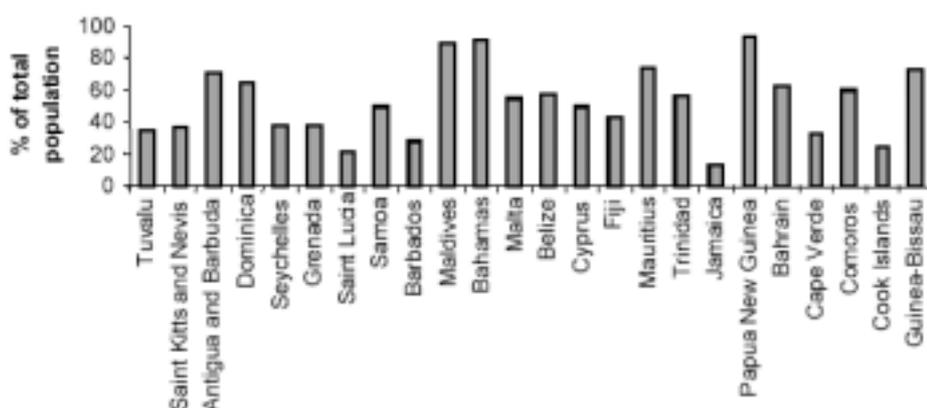
116. In most SIDS, in particular those that are low-lying, major cities or towns hosting strategic infrastructure such as airports, seaports, industrial and central business areas and government activities are located in coastal zones which, among other factors, are exposed to sea level rise. More than 50 per cent of the population in the Caribbean and Pacific islands live within 1.5 km of the shore (IPCC, 2007d). Along the north coast of Jamaica and the west and south coasts of Barbados, continuous corridors of development occupy nearly all of the prime coastal land.

117. Coastal zones are associated with unique socio-cultural developments in a number of SIDS (Briguglio et al., 2008). They are zones of centres of attraction; however, when this is combined with population growth, the result is high land-use pressure, which leads to the destruction of the very resource that sustains these settlements. In the Maldives, where more than 70 per cent of the inhabited islands have buildings located less than 30 m from the shoreline, nearly 50 per cent of all the inhabited islands are suffering from beach erosion (Becken and Hay, 2007).

118. Most SIDS are experiencing rapid urbanization linked partly to the decline in agricultural productivity. The percentage of the population living in urban areas grew by 5.6, 7.2 and 12.4 per cent in Barbados, Grenada and St. Vincent, and the Grenadines islands, respectively, over a ten-year period from 1995 (figure 11). Large population concentrations have introduced problems of waste management. For a number of SIDS, sanitary landfills are limited; a large proportion of industrial and hazardous waste is disposed of in the municipal solid-waste stream; facilities for treating wastewater are scarce; and there are inadequate legislative and enforcement measures in place and a lack of sufficient qualified personnel

to deal with waste issues. This has resulted in the limited freshwater resources becoming polluted, especially on low islands. Pollution is also a threat to ecosystems (e.g. to coral cover and health) and has been linked to outbreaks of diseases such as ciguatera fish poisoning (IPCC, 2007d).

**Figure 11. Urbanization among small island developing States: the status in selected States**



Source: United Nations Department of Economic and Social Affairs, Statistics Division, 2003.

119. In areas of large population concentration, exposure to climate hazards, such as tropical cyclones, results in greater material losses and can quickly give rise to outbreaks of water- and vector-borne diseases. Given the small size of SIDS, this can spread rapidly over entire islands, threatening their populations. An outbreak of dengue fever in Fiji linked to El Niño in 1997–1998 affected 24,000 people out of a total population of approximately 856,000 (IPCC, 2007d). Damage from hurricanes was estimated at USD 2.2 billion for the 2004 hurricane season alone in the Bahamas, Grenada, Jamaica and the Dominican Republic (UNFCCC, 2007a).

120. The vulnerability of coastal cities is also exacerbated by the ongoing shift away from traditional housing styles, techniques and materials that were resistant to damage and could be repaired quickly. This is particularly the trend in Pacific and Indian Ocean SIDS. The new western style housing in the Pacific SIDS, for instance, is increasing vulnerability to thermal stress as well as the need to rely on air conditioning, which is costly to maintain. These houses are also more costly and slow to reconstruct after storms and flooding, which may result in more people, particularly low-income groups, finding it difficult to recover between extreme events (IPCC, 2007d).

121. Current indications (figure 11) suggest that, unless greater effort is invested in developing rural areas, rural–urban migration is projected to grow, further increasing the degree of susceptibility of most SIDS to climate-related risks brought about by high population concentrations in complex urban infrastructure, much of which is located along shore lines. In the Pacific islands region, cyclones accounted for 76 per cent of the reported disasters between 1950 and 2004, with an average cost relating to damage caused per cyclone of USD 75.7 million at 2004 value (World Bank, 2006).

## 2. Human health

122. Climate-related diseases cost societies in terms of lost lives, cost of care and negative impacts on production. Climate hazards such as tropical cyclones and storm surges have both short- and long-term effects on human health and general livelihoods in SIDS, inter alia, malnutrition resulting from

disturbances in food production or distribution, and the destruction of residential areas, which may lead to displaced people to concentrate in certain centres with limited services.

123. Owing to the fact that many SIDS are found in tropical or sub-tropical regions, they are conducive to the transmission of diseases such as malaria, dengue, filariasis, schistosomiasis, and food- and water-borne diseases. The rate of increase in these diseases has been exacerbated further by poor public health practices, inadequate infrastructure, poor waste-management practices, increasing global travel, land-use change as well as changing climatic conditions (IPCC, 2007d). Increase in malaria incidence in Suriname has been linked to gold mining in the hinterland in the last decade (Republic of Suriname, 2004).

124. Threats to health posed by extreme weather events in the Caribbean include: insect- and rodent-borne diseases (such as dengue and malaria); water-borne diseases (such as cholera); food-borne diseases (such as diarrhoea); respiratory diseases (such as asthma and bronchitis); and malnutrition resulting from disturbances in food production or distribution (IPCC, 2007d).

125. For some SIDS, declining water quality due to land-use activities is negatively affecting human health, through increasing water-borne diseases and pollution (UNFCCC, 2007b). Sea level rise, owing to the intrusion of saltwater, will significantly increase health problems that are linked to low water quality.

126. There is evidence of increasing incidences of climate and non-climate related ailments and epidemics, such as HIV/AIDS, tuberculosis, drug-resistant strains of malaria, dengue fever, severe acute respiratory syndrome, West Nile Virus, and avian influenza. Other diseases that are on the rise include nutritional disorders, diabetes and other non-communicable diseases. The five leading causes of death between 1985 and 2000 in the Caribbean SIDS were found to include heart diseases, cancers, cerebro-vascular diseases, diabetes, and HIV/AIDS; among communicable diseases, HIV/AIDS accounted for 59 per cent of deaths (Witter, 2008).

127. HIV/AIDS is particularly devastating given the relatively small population and high poverty levels in some SIDS. The poor are generally more vulnerable to HIV/AIDS and in some SIDS a large proportion of the population lives in poverty. The pandemic poses a serious threat to the limited skilled human-resource base on these islands; HIV/AIDS was shown to be primarily responsible for a loss of 22 per cent of "potential years of working life" (15–64 years) between 1985 and 2000 in men aged 20–44 years (Witter, 2008). As a result, both health and general productivity will decline further when the consequences of HIV/AIDS and other socio-economic factors combine with climate-related diseases that are increasing in SIDS due to climate change, leading to loss of resilience even to mild social and environmental stresses.

### 3. Natural resources and livelihood activities

128. The economies of SIDS are dominated by agriculture, fisheries, ecosystem resources, tourism, and international transport activities (air and sea) (UNFCCC, 2005). In 2004, total tourist arrivals to SIDS was around 27 million persons compared to 11 million in 1988; this translated to a 9 per cent increase per annum in comparison with a 6 per cent growth rate for the total global tourist arrivals over the same period (Craigwell, 2007). Export of fossil fuels is also an important source of revenue for some SIDS, for example Bahrain and Trinidad and Tobago (UNFCCC, 2005). All of these sectors are sensitive to climate and to external market forces, over which SIDS have little control.

129. *Water:* SIDS have limited options for developing freshwater resources. Owing to their geophysical settings, many are vulnerable to unpredictable periods of low water recharge, and have few or no permanent streams or lakes and a limited capacity for water storage. This is partly due to steep topography, short river channels and easily erodible soils, which cause the siltation of reservoirs

(United Nations Department of Economic and Social Affairs, 1998). Owing to population growth, urban migration, and economic developments, the supply of high-quality, potable water is already a problem for most SIDS. Where groundwater is used, extraction mostly outstrips supply. For example, in the Bahamas, where freshwater lenses are the only exploitable groundwater resource, over-pumping results in salinity intrusions that reduce the quality of the water. Pollution from land-use related activities is further threatening freshwater availability in a number of cases.

130. Water shortages will become more acute with future climate change. Dominica in the Caribbean, and Seychelles in the Indian Ocean, which are almost entirely dependent on surface water from ephemeral and perennial streams, suffered serious water shortages during the 1997–1998 El Niño event. Marshall Islands also suffered the same problem when rainfall over the 1982–1983 period for many parts of the Western Pacific was within only 10–30 per cent of the long-term average (Becken and Hay, 2007).

131. *Agriculture:* Agriculture is important for subsistence needs and accounts for a large section of the labour force in SIDS. The availability of arable land varies across islands, ranging from, for example, 0.5 per cent in the Bahamas to 50 per cent in Mauritius (Binger, 2000). Agriculture for export is also important; cash crops such as sugar cane, bananas and forest products are a source of foreign exchange and economic growth. In Mauritius, the sugar cane industry contributes to the diversification of the economy through links with tourism and other industries (IPCC, 2007d).

132. However, the overall contribution of agriculture to the economic performance of the majority of islands has been declining. Historically, agricultural exports have relied on preferential access to major developed-country markets, which is slowly eroding. For example, the GDP contributions from agriculture in some Caribbean islands has decreased from 9.5 per cent to 7.6 per cent in 2004, partly due to the drop in the competitiveness of cash crops, high subsidies in the agriculture sector in developed countries, and numerous protectionist mechanisms restricting entry of agricultural exports from developing countries (Witter, 2008). Another important factor is increased and competing uses for water resources (e.g. from tourism) (Rosalie and Campling, 2004).

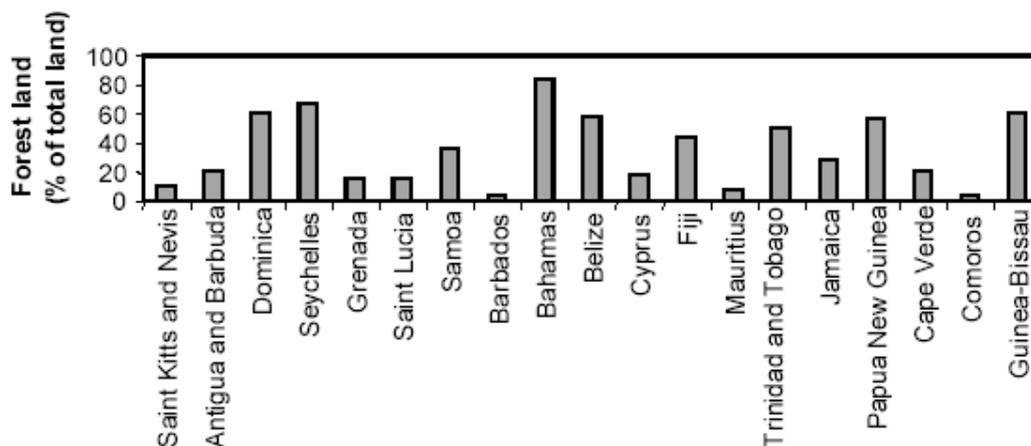
133. Agricultural production is already stressed due to high population densities and growth rates, and a lack of appropriate agricultural inputs. In several SIDS, unsustainable agricultural practices contribute to deforestation, leading to the loss of soil fertility, and agrochemical pollution of soils, freshwater and coastal resources. It further reduces the prospects for agricultural productivity in the long term and renders land and crops more susceptible to the impacts of climate change.

134. *Fisheries:* Fisheries play a significant role in the economy of many SIDS and are an important source of protein for human consumption. Fisheries are negatively affected by degradation of coral reefs and coastal ecosystems as a result of human activity, and these impacts will be exacerbated by climate change. For example, climate-induced changes in patterns of El Niño Southern Oscillation (ENSO) may lead to a decline in total stock, migratory shifts and changes in the reproduction patterns of different species of economic value. However, SIDS lack resources and infrastructure for assessing such changes. Currently, they lack the capacity for monitoring and managing fish stocks and for enforcing appropriate measures to minimize illegal and unregulated fishing and overharvesting. A combination of these factors makes fisheries more susceptible to climate stresses.

135. *Terrestrial:* Overall biodiversity in SIDS is rich, with a significant degree of endemism (Binger, 2000), though this does vary by island (e.g. 84 per cent of land is under forest cover in the Bahamas, as opposed to less than 10 per cent in Barbados, Mauritius and Comoros) (figure 12). The general trend is towards increased deforestation due to agricultural expansion and overharvesting, which has impacts not only on the immediate environment, but also on downstream marine resources. Mangroves may suffer reductions in geographical distribution due to either sea level rise or change in rainfall (IPCC, 2007d). The consequences of the unsustainable use of natural resources, combined with the effects of climate

change, will be the rapid loss of biodiversity leading to reduced food security, a decline in human well-being and a greater susceptibility to climate risks such as flooding.

**Figure 12. Proportion of forested land in selected small island developing States**



Source: United Nations Department of Economic and Social Affairs, Statistics Division, 2003.

136. *Tourism*: Evidence has shown that the willingness of tourists to revisit a holiday destination is strongly linked to the state of preferred environmental attributes, including the following characteristics that are more relevant for SIDS: warm temperatures, clear waters and beach features, low health risks, and marine wildlife attributes such as coral and fish diversity and abundance (Becken and Hay, 2007). This has led to a high concentration of tourism activities around coastal areas, which also makes this industry highly vulnerable to sea level rise and other climate-related risks (Briguglio, 2008). For example, in the Commonwealth Caribbean, of the 77,000 hotel rooms available, over 65 per cent are located in coastal areas. In Barbados, over 90 per cent of its 6000 hotel rooms are located within 1 km from the high-water mark and less than 20 m above sea level. As a result, over 50 per cent of rooms are at risk from a category 3 hurricane, with estimated replacement costs of up to USD 550 million if they are damaged (Becken and Hay, 2007). Degradation of environmental features either due to land-use pressure and/or the climate will negatively affect tourists' destination choice.

137. The tourism industry is further characterized by high water demand, increasing stress on already overdrawn water supplies in many small islands. Energy consumption is also an important factor in the tourism industry. Energy is a major cost factor in the operation of accommodation services for most SIDS; more so when energy is derived from fossil fuels either for transport or for electricity generation. Air conditioning constitutes about 50 per cent of overall energy consumption in hotels (Bohdanowicz and Martinec, 2001 in Becken and Hay, 2007) and increased warming due to climate change will cause demand for cooling systems to escalate, eventually reducing the profitability of hotels.

#### 4. Trade and globalization

138. Owing to their small and narrowly defined economies, SIDS are unable to produce all of the goods and services required to meet domestic needs and, as a result, they are import dependent (Tompkins et al, 2005). Furthermore, they tend to have a narrow range of resources, over-specialization and inefficient economies of scale. They are faced with serious difficulties in competing in international trade, which leads to a high vulnerability to external shocks and pressures, such as unpredictable trends in terms of trade and impacts of globalization (Binger, 2000; Rosalie and Campling, 2004; Mauritius, 2005) (box 4). The majority of SIDS are experiencing serious capacity constraints in meeting World Trade Organization (WTO) obligations to integrate fully into the global multilateral trading system.

#### **Box 4. Trade and vulnerability of small island developing States**

A number of factors limit the full integration of small island developing states (SIDS) into the global market, including:

- Open and small-scale economies of SIDS with limited resources, resulting in high production costs and non-competitive prices;
- High transportation costs due to geographical remoteness;
- A heavy reliance on export earnings along with the fact that several SIDS are single commodity exporters, leading to high vulnerability to external economic threats and shocks;
- Difficulty in accessing capital, including from multilateral financial institutions.

In general, the international trade negotiations at the World Trade Organization, pursued under the Doha Development Agenda, have not been adequately addressed, particularly those relating to the preferential treatment of SIDS, access to markets and agricultural subsidies.

*Source:* Rosalie and Campling, 2004; UNFCCC, 2005.

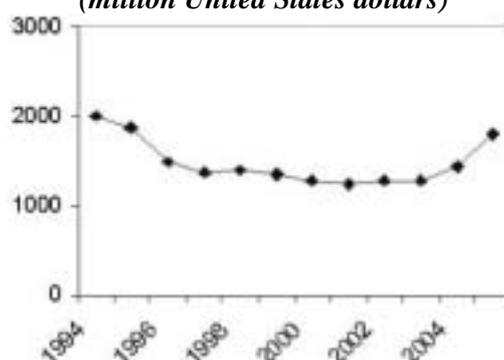
139. Although most SIDS have had a long history of colonialism and have been exposed to numerous forms of global market forces, recent decades have seen more intense globalization in the form of multinational corporations, global communications networks and international regulatory agencies. While these changes have had positive impacts, for instance, through stimulating the economies of SIDS and providing employment, they have also created vulnerabilities, for example through:

- Loss of the social cohesion that provides social security for coping with climate stresses;
- Change in diet, resulting in greater reliance on food imports and weakening of rural agricultural economies (Witter, 2008);
- Exposure to fluctuating international prices for key commodities such as food and energy;
- Intense extraction of already limited natural resources, for example fisheries and forest products, especially in areas of high population concentration, leading to degradation of environmental resources, including coastal erosion that increases vulnerability to climate-related risks such as flooding.

140. ODA is an important factor in the development of SIDS. Indications show that overall ODA to SIDS fell between 1990 and 2002, and remained below 1990 levels of USD 22 million in 2003

(figure 13). The Seychelles experienced a 50 per cent decline in ODA and responded to this financial gap by increasing levels of borrowing (Rosalie and Campling, 2004). Very high debt is a major source of vulnerability among a number of SIDS. According to the World Bank (2005), seven Caribbean states were among the 10 most indebted countries in the world in 2005. In the most affected states, Guyana and St. Kitts and Nevis, public debt as a percentage of GDP was 155.3 per cent and 152.6 per cent, respectively, by 2005. Eventually these stresses combined with other factors to give rise to high rates of unemployment. In St. Lucia, an average of 18.5 per cent was registered for 2000–2005 and the informal sector, formed by low-income rudimentary jobs, accounted for approximately 42 per cent and 60 per cent of GDP in Jamaica and Guyana (Witter, 2008).

**Figure 13. Total official development aid to small island developing States, 1994–2005**  
(million United States dollars)



Source: United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and the Small Island Developing States.

141. According to the IPCC (IPCC 2007d), increased loss of resilience to climate risks in SIDS is linked to externally driven pressures, including energy costs, population movements, financial and currency crises and increasing debt. Other factors, such as the high cost of transportation and communication networks, linked in part to the remoteness of SIDS from major markets, are a further barrier, although rapid development of information and communications technology offers the potential to reduce this isolation. Climate change will make it even more difficult for SIDS to compete in international markets, through reduction of productivity in economic sectors such as agriculture and fisheries, as well as loss of biodiversity and damage to development infrastructure.

##### 5. Vulnerability and response capability to risks

142. Most SIDS lack comprehensive environmental legislative and policy frameworks and skilled human resources to deal with climate risk. Financial constraints also pose a significant limiting factor in environmental management in SIDS, making projects such as adaptation to sea level rise beyond the resource capacity of most SIDS (Binger, 2000). A lack of economic and human resources, as well as appropriate institutions, limits access by most SIDS to some of the standard international initiatives put in place to assist developing countries in responding to climate change, for example the clean development mechanism (CDM) under the Kyoto Protocol. The small size of SIDS means that only small-scale CDM projects can be organized and coordinating these will require large resources (UNFCCC, 2005). The scarcity of skilled labour is shown by the high proportion of expatriate personnel and by the level of technical assistance provided by aid programmes.

143. As in the case of other developing countries, limited investment in climate observation systems and climate change science constrains effective and consistent risk assessment in SIDS.

These assessments are required in order to plan appropriate adaptation measures; although steps are being taken by the international community (e.g. the Caribbean region has developed sea level rise and climate monitoring systems in 12 countries), there is still a lot to be done in developing a robust early warning system for most SIDS. Where assessments of climate risk exist, there is limited capacity and resources to implement appropriate adaptation measures.

144. Furthermore, the combination of factors, such as the high risk of occurrence of extreme weather events, limited economic assets, small population and geographical size, and relative isolation to global markets, makes SIDS less attractive to the conventional insurance industry, contributing to their increased vulnerability (Rosalie and Campling, 2004).

## **V. Implications for sustainable development**

### **A. Introduction**

145. “The consequences of climate change will depend on how the physical impacts interact with socio-economic factors” (Stern, 2006). As highlighted in the previous two chapters, developing countries, in particular LDCs and SIDS, face a multitude of socio-economic stresses and are more vulnerable to projected changes and variability in the climate system. Economies in these countries rely on climate-sensitive sectors such as agriculture and fisheries. They have limited resources for coping with and recovering from climate and socio-economic shocks and stresses, and tend to be located in marginalized areas where threats from extreme events are often the greatest.

146. The ensuing impacts threaten to derail efforts for sustainable development and the long-term achievement of the MDGs. For example, the UNDP 2006–2007 Human Development Report concludes that failure to address climate change will “consign the poorest 40 per cent of the world’s population – some 2.6 billion people – to a future of diminished opportunities” (UNDP, 2008).

147. The United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) and Care International undertook a study to map the humanitarian implications of climate change, the overlaying factors influencing human vulnerability (socio-economic trends) and specific hazards associated with climate change (physical trends). They found that several parts of the world are hotspots for more than one of three hazard types (flood, drought, and cyclone or hurricane). These hotspots include much of Sub-Saharan Africa and much of South Asia, precisely those areas that are least developed within these continents. (UNOCHA and Care International, 2008).

148. This chapter examines where and how these physical climate trends and socio-economic trends converge or interact. It begins by describing the importance of each of the sectors discussed in chapters 3 and 4 (water, agriculture and food security, health, ecosystems, and settlements, industry and infrastructure) for sustainable development.

149. The chapter then presents a number of areas of concern, where climate and socio-economic factors are compounding each other to undermine sustainable development and the ability to achieve the MDGs in the poorest regions of the world, through increased poverty, loss of livelihoods, and compromised health and education. None of these observations can be considered independently; socio-economic vulnerabilities and climate changes compound each other, and impacts in one area of sustainable development often permeate other areas. It is not within the scope of this paper to provide a comprehensive list of the connections between climate trends, socio-economic trends, and sustainable development, but rather to draw attention to some of those areas where this convergence is projected to have the greatest impact in the most vulnerable countries. Adaptation strategies will be particularly critical in these areas, and are aimed at moderating the adverse effects of climate change by reducing vulnerability to climate and socio-economic impacts through a wide range of interventions.

## B. Key sectors

150. Sustainable development refers to development pathways that meet the needs of the present without compromising those of the future. It is vital to poverty reduction, both in the short term and in providing ways that enable people to stay above the poverty line in the longer term. In the context of the most vulnerable developing countries, five sectors are often discussed in relation to sustainable development: water; agriculture and food security; human health; ecosystems; and settlements, industry and infrastructure. The impacts of the projected physical changes in climate on each of these sectors were discussed in chapter 3, and socio-economic aspects were discussed in chapter 4. In turn, the relevance of each of these selected sectors to sustainable development is summarized below:

- (a) *Water*: Sustainable development is often undermined in vulnerable countries through a lack of water for drinking, loss of opportunity that can be dedicated to work or education due to collection of water, illness from water-borne diseases such as diarrhoea, and limited scope for improving livelihoods where water is unavailable for irrigation.
- (b) *Agriculture and food security*: The vast majority of people in vulnerable countries are dependent on agriculture or fishing for their lives and livelihoods. In nearly all developing countries, women are the dominant labour force, and in most cases they are limited to subsistence agriculture, which is becoming increasingly marginalized due to poverty and rising population. The contribution of agriculture to GDP in both LDCs and SIDS has been falling. In addition to human pressure, food production is increasingly undermined by a lack of water for irrigation, and increased frequency of droughts and floods that damage and destroy crops as well as deplete fish stocks.
- (c) *Human Health*: Poor health restricts people from work and education and therefore impinges on livelihood and advancement opportunities. Furthermore, poor health can be costly, putting pressure on household finances, and can drive people further into poverty, and hence greater vulnerability, particularly in LDCs and some SIDS where health facilities are limited as shown in chapter 4.
- (d) *Ecosystems*: Natural resources form the basis for sustainable development, particularly in LDCs and SIDS where much of the population is heavily reliant on natural resources and ecosystem services for livelihoods. For example, soil and seeds are used for agricultural opportunities, fish and coastal resources provide sustenance and a basis for tourism, and forests are essential for fuelwood and livelihoods through the sale of forest products.
- (e) *Settlements, industry and infrastructure*: Economic growth provides jobs, as well as the infrastructure that brings access to services, such as electricity, water and sanitation, and education, which all contribute to sustainable development. Poor human settlements are typically located in marginalized areas, which are the most susceptible to impacts of climate change such as sea level rise and extreme events. Furthermore, as highlighted in chapter 4, LDCs and SIDS often lack the industry and infrastructural development that allow for service delivery and livelihood opportunities.

151. The following section discusses areas of concern, providing evidence of the association between the impacts of climate and socio-economic factors and the implications for sustainable development, where available. However, documenting evidence of the links between socio-economic trends, climate trends and sustainable development is not straightforward; it is rarely possible to isolate the causes and effects of economic and climate shocks on sustainable development. Nonetheless a number of measures are often used to assess the impacts that shocks have on development, and a variety of these measures are reported below:

- **Losses to GDP:** GDP is often used as a measure of the economic development of a country. Where shocks or stresses cause GDP to contract, a variety of follow-up economic impacts can occur, undermining development. For instance, decreased economic opportunities and loss of jobs undermine industry and livelihoods, and decreases in public finance or tax revenues can restrict development of infrastructure and public services, and hence the delivery of energy, water and sanitation, and health and education facilities;
- **Direct financial or infrastructure losses due to extreme events:** Events such as floods and cyclones drain government finances, as money that could otherwise have been spent on sustainable development is deferred to relief and rehabilitation costs. Furthermore, these events can destroy infrastructure that delivers services for sustainable development, such as transport, schools and hospitals, as well as hotels that provide tourism-based livelihoods. The financial value of loss of crops is also sometimes reported, demonstrating the direct financial impact on food security and production;
- **Changes to HDI:** The HDI combines measures of life expectancy, literacy, educational attainment and GDP per capita for individual countries as a means of measuring and comparing human development. As a result, although it is based on limited indicators, it provides a standardized measure that can be used across different countries to assess human well-being, which is a critical component in sustainable development and poverty reduction.

### **C. The interaction of physical climate changes and socio-economic vulnerabilities: implications for sustainable development**

152. The poorest communities are disproportionately affected by the adverse effects of climate change, as their socio-economic characteristics and physical location in the most marginalized areas make them most vulnerable and least able to recover from the impacts. For example, increases in the intensity and frequency of extreme events have the potential to wipe away important sustainable development gains in these communities.

153. Climate-related extreme events cut across each of the sectors for sustainable development described above. A single event tends to have an accumulative effect that damages the capacity for recovery and for responding to future events, halting the process of sustainable development almost indefinitely if no aggressive interventions are made. Extreme events are therefore directly linked to socio-economic factors, which make human populations more vulnerable to their impacts. For example flooding can result in the contamination of drinking water supplies, triggering water-borne diseases such as cholera and reducing labour productivity; cyclones wipe out crops, reducing food production, which may lead to malnutrition and disease; drought renders agricultural livelihoods unviable, therefore threatening food security; waterlogging from heavy rains and floods brings vector-borne diseases such as malaria as stagnant water attracts mosquitoes; cyclones wipe out infrastructure as well as the services that play a significant role in development; and further destroy ecosystems that sustain fisheries and tourism, which are important sources of livelihood.

154. Many countries are exposed to multiple or sequential extreme events, compounding vulnerability and creating poverty traps as poor households struggle to cope and recover. For example, Ethiopia has suffered successive cycles of drought; survey data show that, between 1999 and 2004, more than half of all households in the country experienced at least one major drought shock. These shocks are a major cause of transient poverty: had households been able to have constant or predictable level of consumption, then it is estimated that poverty in 2004 would have been at least 14 per cent lower, a figure that translates into 11 million fewer people living below the poverty line. These poverty traps thwart efforts to build up assets and increase income, and therefore undermine development (Dercon, 2005, cited in UNDP, 2008).

155. Women constitute two-thirds of the world's poor and are often disproportionately affected by extreme events. For example, floods frequently claim more women as victims as they often have not been taught to swim (UNDP, 2008). Furthermore, women are often more economically and socially vulnerable in poor countries and hence feel the impacts more acutely, finding it difficult to recover. The impacts of extreme events can have knock-on effects on other aspects of development; for example, Indian women born during a flood in the 1970s were 19 per cent less likely to have attended primary school (UNDP, 2008).

156. Climate hazards such as tropical cyclones and storm surges have both short- and long-term effects on human health and general livelihoods in SIDS and LDCs, including drowning, injuries, sudden change in family composition, increased disease transmission, decreases in agricultural productivity and increased incidence of mental disorders as a result of stress (IPCC, 2007d).

157. The number of people living under severe water stress is likely to increase substantially, as factors such as increased water demand and decreased water quality converge with changes in water availability and increased salinity due to climate change, which has far-reaching impacts for sustainable development.

158. The adverse effects of climate change on freshwater systems will aggravate the impacts of other stresses, such as population growth, changing economic activity, land-use change and urbanization. Importantly, the interaction of physical and socio-economic stresses can create conflict over water use, as competing priorities over water for drinking and household use, irrigation and industry collide. Sectors that are already under stress will especially suffer, such as agriculture where 70 per cent of global water use is already dedicated to sustaining agricultural production.<sup>13</sup> Furthermore, constraints on water supply will disproportionately affect women and children, as they have to travel further to gather water for household use, thus compromising education and livelihood opportunities.

---

<sup>13</sup> United Nations Food and Agriculture Organization of the United Nations, available at: [http://www.fao.org/nr/water/aquastat/water\\_use/index6.stm](http://www.fao.org/nr/water/aquastat/water_use/index6.stm).

**Box 5. Case study on the impacts of hurricane Ivan on sustainable development in Grenada**

A Category 4 hurricane system hit Grenada in September 2004, accompanied by sustained winds of approximately 140 mph, with gusts exceeding 160 mph. The hurricane had the following impacts:

- A total of 28 persons were killed;
- A total of 90 per cent of hotel rooms were damaged or destroyed, amounting to a total cost of USD 108 million or 29 per cent of GDP;
- Heavy damage was caused to ecotourism and cultural heritage sites, accounting for 60 per cent of job losses in this sub-sector;
- A total of 90 per cent of housing stock was damaged, with a total cost of USD 517 million or 38 per cent of GDP;
- Telecommunication losses were equivalent to 13 per cent of GDP; with damage to schools and education facilities amounting to 20 per cent of GDP;
- Losses in the agriculture sector were equivalent to 10 per cent of GDP – the two main commercial crops, nutmeg and cocoa, are expected to make no contribution to GDP or to earn foreign exchange for at least 6–8 years;
- Damage to electricity installations amounted to 9 per cent of GDP; and overall damages were estimated at USD 824 million, or two times current GDP;
- Before this disaster, an economic growth rate of 5.7 per cent had been forecast in Grenada. By 2005 a negative growth of at least –1.4 per cent had been projected for this island state.

*Source:* Becken and Hay, 2007

159. Freshwater systems cut across administrative boundaries and, as a result, physical and socio-economic stresses in one country will affect water supply in neighbouring countries, requiring integrated water resource management across river basins. This issue is particularly prominent in Africa, where almost all of the continent's 50 river basins are transboundary, and increased water scarcity could therefore result in conflict in many African LDCs, placing even greater stress on sustainable development (IPCC, 2007b).

160. Asia is a major exporter of food and already uses the majority of its arable land for agriculture or grazing, with many of its LDCs reliant on agriculture as a livelihood. A lack of water for irrigation will therefore put pressure on an already constrained food industry, and could restrict economic growth in the region (IPCC, 2007c). Furthermore, Asia dominates world aquaculture, which requires freshwater as an input, presenting another competing priority for scarce water supplies. Asia is also home to at least 14 major international river watersheds, and LDCs such as Bangladesh and Nepal are already witnessing the combination of climate factors and human factors such as deforestation and land conversion that compromise these watersheds (IPCC, 2001).

161. In SIDS, decreasing water supply will limit tourism and associated employment and revenues. Further, SIDS' water supply is already compromised because of the lack of alternatives and growing population and land-use pressure. Several SIDS are beginning to look at other options for water supply, including investing in (expensive) desalinization plans, large storage reservoirs and improved water harvesting (IPCC, 2007d).

162. Agricultural production and food security are likely to be severely compromised in many developing countries as trends in global and national food markets and changes to precipitation and temperature patterns converge, with serious implications for nutrition and livelihoods.

163. Socio-economic trends, including national and international market reform, and changes to global food prices, as well as the prices of inputs such as fertilizer, are compounding the impacts of changing weather patterns on crop yields. About 75 per cent of the world's poor live in rural areas and are involved in farming, and agriculture represents a significant fraction of GDP in developing countries, particularly the LDCs in Africa. Furthermore, the convergence of these stresses will have the greatest impact on the poorest groups, particularly female-headed households, which are playing an increasingly prominent role in rural areas as men migrate to cities for wage labour. The rural poor are often dependent on rain-fed agriculture with limited inputs such as fertilizers or irrigation, and are therefore very vulnerable to changes in climate. The urban poor are also vulnerable, as decreased supply will raise food prices, compromising their ability to purchase food and maintain their nutritional status. The impacts on sustainable development are far-reaching. As food becomes scarce, the nutritional status of the population will be compromised, increasing susceptibility to climate-linked diseases against the backdrop of an escalating HIV/AIDS pandemic. Livelihoods will be undermined, contributing to increased poverty both at a local level and more widely across the economy as GDP is weakened.

164. In Africa, climate change is projected to reduce crop yields in some countries by as much as 50 per cent by 2020, and crop net revenues could fall by as much as 90 per cent by 2100, with small-scale farmers in LDCs being the most affected (IPCC, 2007b). These farmers are more vulnerable to such impacts as market reforms have removed subsidies, resulting in rising fertilizer prices. Furthermore, food security is already a humanitarian crisis in many African LDCs and is likely to be aggravated further by climate variability and change, HIV/AIDS, poor governance and poor adaptation. Losses in crop yields have been shown to have a direct effect on children's health; in Zimbabwe, children aged 12–24 months lost an average of 1.5–2.0 cm of linear growth in the aftermath of the 1994–1995 drought. The impact was most severe among the poorest households with few livestock (World Bank, 2001). In Ethiopia (an LDC) and Kenya, two of the world's most drought-prone countries, children aged five or less are, respectively, 36 and 50 per cent more likely to be malnourished if they were born during a drought (UNDP, 2008).

165. The production losses due to climate change may drastically increase the number of undernourished people in several developing countries in Asia, severely hindering progress against poverty and food insecurity (Wang et al., 2006, cited in IPCC, 2007c). Furthermore, the Asia-Pacific region, where many of the LDCs are located, is also the world's largest producer of fish. The combination of climate changes in oceanic circulation, overharvesting and pollution is decreasing yields.

166. Agriculture in SIDS is important to development not only for subsistence, but also as a source of income through the export of crops such as sugar cane, bananas and forest products. Furthermore, fisheries are an important component of GDP for many SIDS and, as such, they contribute to food security. At the same time, these countries are struggling to access markets, and food production is characterized by limited alternatives and inputs, and declining fish stocks due to unregulated fishing and overharvesting. An example from the Dominican Republic indicates how the convergence of climate and economic shocks can impact sustainable development: headcount poverty increased from 36 to

40 per cent following a combination of drought and terms-of-trade shocks in 1990 (IMF, 2003). In Fiji, a 6.8 per cent increase in annual food prices was attributed to Cyclone Kina in 1993 (Benson, 1997).

167. The combination of a poor level of public health and poor waste management practices, inadequate infrastructure, and changing disease patterns due to climate change as well as changes in lifestyle will be a key source of stress on sustainable development.

168. Human health is already a limiting factor in achieving sustainable development in many developing countries, as it diverts already limited resources to health care, and prevents people from engaging in livelihood and education opportunities that lead to important sources of income for families. The burden is often disproportionately higher on women, as they care for family members. Increased incidence of diarrhoea and vector-borne diseases such as malaria will increase vulnerability, particularly amongst the poorest. Furthermore, the HIV/AIDS pandemic makes families and their countries at large more economically and socially vulnerable to climate-related illness.

**Box 6. Case study on the combined impacts of drought and socio-economic conditions on sustainable development in Zimbabwe**

In 1991–1992, Zimbabwe was hit by a severe drought that devastated production of maize, the staple food crop, as well as cotton and sugarcane. By the end of 1992, real GDP had fallen by 9 per cent and inflation had jumped to 46 per cent, with an increase of 72 per cent in food prices, largely due to the higher prices of imported food. The drought also strongly affected industrial production because of its close links with agriculture. Agro-processing and textiles were badly hit due to a combination of low demand, input shortages, power cuts and tight credit. By the end of 1992, manufacturing output had fallen by about 9 per cent and high interest rates affected sectors in which working capital requirements had increased sharply. Agricultural growth fell by about 23 per cent in real terms in 1992. Moreover, the exchange rate, which had been devalued in the year before the drought, became overvalued in 1992 and 1993 as a result of high inflation.

Few direct measures of the poverty impacts of the 1992 drought are available, but they indicate that there was an appreciable increase in poverty, especially in rural areas. The following indirect indicators also point to a fairly severe poverty impact of the drought:

- Employment was relatively stable over the course of the crisis; however, real wages declined by 23 per cent in 1992 (they declined by 42 per cent in agriculture and by 18 per cent in manufacturing);
- Households cut expenditure on health and education to allow for food purchases. Government expenditure on health and education was also reduced (as a share of the budget), with a particularly high reduction in allocation for primary education. School dropout rates increased;
- Both child malnutrition and the number of children with low birth weight worsened;
- Higher import prices of food were passed on to consumers (although the government continued to subsidize maize);
- Government drought relief programmes substantially increased their distribution and, in light of the severity of the food shortages, free distribution was preferred over food-for-work programmes. However, evidence suggests that such transfers covered only 15–25 per cent of the household food needs at the height of the food shortages and were not well targeted to the poor.

*Source:* IMF, 2003

169. In Africa, the economic burden of malaria is already estimated at an average annual reduction in economic growth of 1.3 per cent for those African countries with the highest burden (Gallup and Sachs, 2001, cited in the contribution of Working Group II to the AR4). Maternal malaria (which is projected to spread with climate change) is linked with higher infection rates of HIV/AIDS (IPCC, 2007b), indicating how women can become more vulnerable. In 2003, 2.2 million Africans died of HIV/AIDS and an estimated 12 million children lost one or both parents to the same. The convergence of this already disastrous scenario with climate change stresses, such as reduced food security and disease, will constrain further attempts by these countries to meet the MDGs.

170. The global burden of diarrhoea and malnutrition attributable to climate change is already the largest in the world in Southeast Asian countries, including Bangladesh, Bhutan, India, Maldives, Myanmar and Nepal in 2000 (UNFCCC, 2007a) (all of these countries, except India, are LDCs). Diarrhoea poses one of the largest threats to sustainable development because of its prevalence and significant impact on education, work, and family expenditure on medical costs. It is very likely that South and Southeast Asia will experience increases in morbidity and mortality from diarrhoea and a high level of cholera as a result of climate changes (IPCC, 2007c). An outbreak of dengue fever in Fiji in 1998 cost over USD 3–6 million (IPCC, 2007d).

171. In SIDS, exposure to climate hazards such as tropical cyclones can quickly result in outbreaks of water- and vector-borne diseases and, given the small size of SIDS, this can quickly spread over an entire island, threatening the whole population. A number of SIDS are also witnessing the spread of HIV/AIDS.

172. According to WHO, climate change was estimated to be responsible for 154,000 deaths and 5.5 million DALYs<sup>14</sup> in 2000. This is a global estimate, and WHO divides their regions on the basis of mortality rates, rather than poverty or other development measures. While it is therefore not possible to attribute a percentage of these deaths to LDCs, 69 per cent of these deaths are attributable to Southeast Asian and African countries that have high mortality rates, many of which overlap with the LDCs (WHO, 2002).

173. Efforts to improve industry and associated livelihood opportunities, and expand infrastructure that delivers important economic and public services, are threatened by the impacts of sea level rise, extreme events and other climate changes.

174. Sustainable development in vulnerable countries often involves the construction of infrastructure for delivering basic services such as healthcare, education, energy, water and sanitation, and the promotion of industry to create jobs and generate revenue, particularly around tourism. At the same time, sea level rise, extreme events and other climate changes threaten to undo these very efforts at sustainable development, as coastal and other natural resources are wiped out and infrastructure is damaged or destroyed. These changes have been documented for their ability to wipe out decades of development and take several percentage points off GDP. The Organization for Economic Co-operation and Development (OECD) estimates that in six developing countries alone, climate change could undermine USD 1.5 billion of ODA (e.g. by damaging infrastructure as sea levels rise) (OECD, 2005).

175. In African LDCs, for example, climate change is interacting with human drivers such as deforestation, resulting in the destruction and degradation of ecosystems that are the backbone of the tourism industry. As a result, between 25 and 40 per cent of mammal species in national parks in sub-Saharan Africa may become endangered (IPCC, 2007b). Tourism, based around these national parks, provides an important industry and source of livelihood, and may be weakened by these changes.

---

<sup>14</sup> DALYs are used to measure the burden of disease. One DALY can be thought of as one lost year of “healthy” life.

176. One million people along the coasts of South and Southeast Asia will likely be at risk from flooding and sea level rise (IPCC, 2007c), particularly the poorest, who live in marginalized areas or near coasts for their livelihoods. Coastal inundation will not only threaten lives but also affect the aquaculture industry and infrastructure. Nature-based tourism is a booming industry in Asia and an important part of the pathway to sustainable development. Beach resorts and eco-tourism destinations in poorer countries in South East Asia are especially likely to be vulnerable to climate change.

177. In the Caribbean and Pacific islands, more than 50 per cent of the population live within 1.5 km of the shore. Almost without exception, key infrastructure such as international airports, roads and capital cities in the Indian and Pacific Oceans and the Caribbean are situated along the coast (IPCC, 2007d). Settlements, industry and infrastructure are particularly threatened in SIDS where sea level rise may result in large areas of land being inundated. Sea changes will accelerate beach erosion, degrade coastal environments, damage cultural heritage on coasts and damage ecosystems. Tourism is an important economic sector in SIDS, providing employment and revenue for growth, and is often based around these threatened coastal environments.

#### **D. Climate change and the Millennium Development Goals**

178. The MDGs provide a framework for achieving progress towards sustainable development and, as they have been agreed by many United Nations member States, are widely used to discuss sustainable development in the least developed parts of the world.

179. The following table highlights the potential impacts of the interaction between climate change and socio-economic trends on the achievement of each of the MDGs, and hence progress towards sustainable development. Progress made towards the MDGs will not be sustainable in the long run without effective measures to adapt to climate change and safeguard the progress that has already been made.

**Table 2. Potential impacts of the interaction of climate change and socio-economic trends on the Millennium Development Goals**

<b>Millennium Development Goal</b>	<b>Potential impacts of the interaction of climate change and socio-economic trends</b>
Goal 1: Eradicate extreme poverty and hunger	<ul style="list-style-type: none"> <li>• Damage to livelihood assets, including homes, water supply, health and infrastructure, can undermine people's ability to earn a living, and destroys capital investment in sustainable development.</li> <li>• Reduction in crop yields and changes in international and national markets for food, affect food security.</li> <li>• Changes in natural systems and resources, infrastructure and labour productivity may reduce income opportunities and affect economic growth.</li> <li>• Social tensions over resource use can lead to conflict, destabilizing lives and livelihoods and forcing communities to migrate.</li> <li>• Long-term development funds that would be diverted to relief measures.</li> </ul>
Goal 2: Achieve universal primary education	<ul style="list-style-type: none"> <li>• Natural disasters and the loss of livelihood assets reduce opportunities for full-time education; more children (especially girls) are likely to be taken out of school to help fetch water, earn an income or care for ill family members.</li> <li>• Malnourishment and illness reduce school attendance (particularly when combined with weakened capacity from the HIV/AIDS crisis) and the ability of children to learn when they are in class.</li> <li>• Displacement and migration can reduce access to education.</li> <li>• General decline in investment in education at national levels as monies are diverted to relief.</li> </ul>

**Table 2** (continued)

Millennium Development Goal	Potential impacts of the interaction of climate change and socio-economic trends
Goal 3: Promote gender equality and empower women	<ul style="list-style-type: none"> <li>• Exacerbation of gender inequality, as women depend more on the natural environment for their livelihoods, including agricultural production. This may lead to increasingly poor health and less time to engage in decision-making and earning an additional income.</li> <li>• Women and girls are typically the ones to care for the home and fetch water, fodder, firewood and often food. During times of climate stress, they must cope with fewer resources and a greater workload, and are often the most vulnerable to HIV/AIDS and its impacts.</li> <li>• Female-headed households may increase as families are displaced by climate stresses; these households generally have few assets and are particularly affected by climate related disasters.</li> </ul>
Goal 4: Reduce child mortality Goal 5: Improve maternal health	<ul style="list-style-type: none"> <li>• Deaths and illness due to heat waves, floods, droughts and hurricanes will increase.</li> <li>• Children and pregnant women are particularly susceptible to vector-borne diseases (e.g. malaria and dengue fever) and water-borne diseases (e.g. cholera and dysentery) which may increase and/or spread to new areas; for example, anaemia resulting from malaria is currently responsible for one quarter of maternal mortality.</li> <li>• Reduction in the quality and quantity of drinking water exacerbates malnutrition, especially among children.</li> <li>• Natural disasters affect food security, leading to increased malnutrition and famine, particularly in Sub-Saharan Africa.</li> <li>• Diversion of resources to relief will reduce national investments in maternal health and child care.</li> </ul>
Goal 6: Combat HIV/AIDS, malaria and other diseases	<ul style="list-style-type: none"> <li>• Water stress and warmer conditions encourage the spread of malaria beyond its normal zone, which, combined with lower resources for education campaigns and other prevention measures, will result in greater mortality.</li> <li>• Households affected by HIV/AIDS have lower livelihood assets, and malnutrition accelerates the negative effects of the disease.</li> <li>• Family displacement will increase further incidents of contracting HIV/AIDS, exacerbated by the limited provision of health facilities and a decline in access to education.</li> </ul>
Goal 7: Ensure environmental sustainability	<ul style="list-style-type: none"> <li>• Alterations as well as possible irreversible damage from both climate change and other human activities to the quality and productivity of ecosystems and natural resources will be caused.</li> <li>• Decrease in biodiversity and worsening of existing environmental degradation will occur.</li> <li>• Alterations in ecosystem–human interfaces and interactions lead to loss of biodiversity and loss of basic support systems for the livelihood of many people, particularly in Africa.</li> </ul>
Goal 8: Develop a global partnership for development	<ul style="list-style-type: none"> <li>• Climate change is a global issue and a global challenge. Furthermore, socio-economic trends that predispose countries to vulnerability are often linked to wider international changes and globalization. Responses require global cooperation, especially helping LDCs and SIDS to adapt to the adverse effects of climate change.</li> <li>• International relations may be strained by climate impacts.</li> </ul>

Source: Adapted from UNFCCC, 2007a.

## VI. Final remarks

180. The impacts of climate change, including those associated with climate-related risks and extreme events, are already occurring, and are projected to intensify in many parts of the world, particularly for the most vulnerable developing countries including LDCs and SIDS. Changes in temperature, precipitation, sea level and extreme events are affecting water supply, agriculture and food security, health, ecosystems, human settlements, and trade and industry.

181. Current and projected physical and socio-economic trends in climate-related risks and extreme events have significant implications for sustainable development and its associated goals, including the MDGs, with the most vulnerable developing countries, including but not limited to LDCs and SIDS, being most affected.

182. Physical and climate trends are projected to intensify in the future in many parts of the world due to climate change. Physical trends include increasing and accelerating levels of risk. The increase in the risk of physical trends associated with climate change is additional to the risks associated with climate variability.

183. The socio-economic trends indicate that vulnerability to climate change impacts is increasing, particularly for the most vulnerable countries including LDCs and SIDS. Data for the past several decades indicate that adverse socio-economic trends and the associated lack of adaptation and adaptive capacity have been increasing vulnerability. Thus even without significant climate change, climate variability and extremes have been taking an increasing toll on life and health, economic development and natural ecosystem goods and services. This will be exacerbated by climate change.

184. Examples of socio-economic vulnerabilities of the most vulnerable developing countries include poor levels of human well-being, inefficient labour productivity, widespread unemployment, rapid population growth, mismanagement of resources and often, especially for SIDS, narrowly defined economies leading to import dependency as well as isolation from global markets due to their remote geographical location.

185. The two sets of trends (physical and socio-economic) reported in this paper are clearly seen to be mutually reinforcing. The repeated exposure of LDCs to climate risks has the potential to further exacerbate the socio-economic factors that predispose them to vulnerability to climate hazards. These adverse socio-economic trends are, in their turn, increasing vulnerability and exposure to the risks. Climate-related risks and extreme events have far-reaching implications on sustainable development for nations such as SIDS and LDCs that are already grappling with basic development needs such as provision of clean water, waste management, education, health facilities, transport and communication infrastructure – all of which are requirements for addressing and achieving the MDGs. If progress towards sustainable development is to be achieved, steps need to be taken to break this vicious cycle.

186. Without vigorous and enhanced efforts, many developing countries, especially LDCs and SIDS, are at risk of becoming trapped in a downward spiral that is both self-reinforcing and self-perpetuating. The current low level of adaptation efforts needs to be redressed urgently within the context of sustainable development.

187. A diverse range of specific actions is needed according to particular circumstances. Many of these have been identified in this and other papers relating to the Nairobi work programme. However, piecemeal and fragmented or relatively uncoordinated efforts have not been able to break this cycle and will not suffice. Broader strategic action on adaptation to climate change within the context of sustainable development is needed within the framework of the Convention.

188. The information presented in this technical paper, detailing the relevant issues regarding climate-related risks and extreme events faced by developing countries, particularly the LDCs and SIDS, and the implications for sustainable development as well as for the MDGs, could provide inputs to:

- (a) Further work under the Nairobi work programme, especially in its area of work on climate-related risks and extreme events;
- (b) The in-session workshop under the AWG-LCA on risk management and risk reduction strategies, including risk sharing and transfer mechanisms, to be held during the fourth session of the AWG-LCA in Poznan, as well as in the negotiations of the Bali Action Plan on enhanced action on adaptation towards a Copenhagen agreement during the fifteenth session of the COP;
- (c) The work by Parties and organizations on physical and socio-economic trends in climate-related risks and extreme events, and their implications for sustainable development.

Annex**List of references**

- Ahmed N. 2006. *Case Study on Bangladesh*. Geneva: United Nations Conference on Trade and Development. Available at: <<http://www.unctad.org>>.
- Bates BC, Kundzewicz ZW, Wu S. and Palutikof JP. 2008. *Climate Change and Water*. Technical paper. Geneva: Intergovernmental Panel on Climate Change.
- Becken S and Hay J. 2007. *Tourism and Climate Change*. Toronto: Channel View Publications. p.347.
- Benson C. 1997. *The Economic Impact of Natural Disasters in Fiji*. Working Paper 397. London: Overseas Development Institute.
- Binger A. 2000. *Capacity Development Initiative. Country Capacity Development Needs and Priorities. Report for Small Island Developing States*. Available at: <[http://www.gefweb.org/Documents/Enabling\\_Activity\\_Projects/CDI/documents/SIDS\\_Assessment.pdf](http://www.gefweb.org/Documents/Enabling_Activity_Projects/CDI/documents/SIDS_Assessment.pdf)>.
- Bohdanowicz P and Martinec IM. 2001. Thermal comfort and energy savings in the hotel industry. *In: Proceedings of the 15th Conference on Biometeorology and Aerobiology, Kansas City, Missouri, 28 Oct.–1 Nov. 2002*. Boston: American Meteorological Society.
- Briguglio L, Kosh K, Nurse and Wong P. 2008. Climate change and small island developing states. *In: Strachan J and Vigiliance C (eds). Sustainable Development in Small Developing States: Issues of Challenges*. Economic Paper No. 80. London: Commonwealth Secretariat. pp.65–79.
- Craigwell R. 2007. *Tourism Competitiveness in Small Island Developing States*. Research Paper No. 2007/19. United Nations University, World Institute for Development Economics Research. Available at: <[http://www.wider.unu.edu/publications/working-papers/research-papers/2007/en\\_GB/rp2007-19](http://www.wider.unu.edu/publications/working-papers/research-papers/2007/en_GB/rp2007-19)>.
- Department of Economic and Social Affairs of the United Nations Secretariat. 1998. *Progress in the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States. Report of the Secretary-General*. Commission on Sustainable Development. Sixth session, 20 April–1 May 1998. United Nations Economic and Social Council document E/CN.17/1998/7/Add.8. Available at: <[islands.unep.ch/dd98-7a3.htm](http://islands.unep.ch/dd98-7a3.htm)>.
- DFID (Department for International Development). 2006. *Eliminating World Poverty: Making Governance Work for the Poor. A White Paper on International Development*. London: Department for International Development.
- Dilley M, Chen RS, Deichmann U, Lerner-Lam AL and Arnold M, with Agwe J, Buys P, Kjekstad C, Lyon B and Yetman G. 2005. *Natural Disaster Hotspots: A Global Risk Analysis. Disaster Risk Management Working Paper Series No. 5* Washington D.C.: World Bank.
- Enyimu J. 2006. *Case study on Uganda*. Presentation given at the United Nations Conference on Trade and Development Ad Hoc Expert meeting in preparation for the mid-term review of the programme of action for the least developed countries for the decade 2001–2010. Available at: <[http://www.unctad.org/en/docs/ldcmisc20068\\_en.pdf](http://www.unctad.org/en/docs/ldcmisc20068_en.pdf)>.
- Gallup JL and Sachs JD. 2001. The economic burden of malaria. *American Journal of Tropical Medicine and Hygiene*. 64(1,2): pp.85–96.
- IMF (International Monetary Fund) 2003. *Fund Assistance for Countries facing Exogenous Shocks: A Report by the Policy Development and Review Department*. Washington D.C.: International Monetary Fund. Available at: <[www.imf.org/external/np/pdr/sustain/2003/080803.pdf](http://www.imf.org/external/np/pdr/sustain/2003/080803.pdf)>.

IPCC. 2001. *Asia. Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change.*

IPCC. 2007a. *Climate Change 2007, Synthesis Report. IPCC. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.*

IPCC. 2007b. *Africa in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press. pp.433–467.

IPCC. 2007c. *Asia in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge: Cambridge University Press. pp.469–506.

IPCC. 2007d. *Small islands in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press, Cambridge. pp.687–716.

IPCC. 2007e. *Assessing key vulnerabilities and the risk from climate change in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press, Cambridge. pp.779–810.

Keuleers P. 2004. *Governance in the Least Developed Countries in Asia and Pacific: An assessment of the current situation.* UNDP Sub-Regional Resource Facility for the Pacific, Northeast, and Southeast Asia Bangkok SURF. Available at: <<http://www.undplao.org/whatwedo/bgresource/demogov/GovernanceinLDCAsiaPacific-Keuleers.pdf>>.

Mung K and Hospedales J. 2005. *Caribbean Health Situation Analysis Developed for the Caribbean Commission on Health and Development.*

OECD (Organisation for Economic Co-operation and Development). 2005. *Bridge Over Troubled Waters: Linking Climate Change and Development.* Paris: Organisation for Economic Co-operation and Development.

Republic of Suriname. 2004. *Final National Assessment Report. Barbados Programme of Action (BPOA) + 10 Review.* Available at: <<http://www.sidsnet.org>>.

Rosalie MW and Campling L. 2004. Seychelles in perspective – placing child development in context. Socioeconomic development in Seychelles: an overview. *Seychelles Medical and Dental Journal*. Special Issue: 7 (1), November 2004.

Stern N. 2007. *The Economics of Climate Change: The Stern Review.* New York: Cambridge University Press.

Tompkins EL, Nicholson-Cole SA, Hurlston L, Boyd E, Hodge GB, Clarke J, Gray G, Trotz N and Varlack L. 2005. *Surviving Climate Change in Small Islands: A Guidebook.* Norwich: Tyndall Centre for Climate Change Research. Available at: <[www.islandsonline.org/climatechange.htm](http://www.islandsonline.org/climatechange.htm)>.

Executive Board of the United Nations Development Programme and of the United Nations Population Fund. 2005. *UNCDF Business Plan 2005–2007: Investing in the LDCs to achieve the Millennium Development Goals.* Document DP/2005/22.

UNCTAD (United Nations Conference on Trade and Development) 2008. *The Least Developed Countries Report 2008.* Geneva and New York: United Nations.

UNCTAD (United Nations Conference on Trade and Development). 2007. *The Least Developed Countries Report 2007*. Geneva and New York: United Nations.

UNCTAD (United Nations Conference on Trade and Development). 2006. *The Least Developed Countries Report 2006*. Geneva and New York: United Nations.

UNCTAD (United Nations Conference on Trade and Development). 2004. *The Least Developed Countries Report 2004*. Geneva and New York: United Nations. Chapter 2.

United Nations. 2005. *Report of the International Meeting to Review the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States*. Annex III, "Summaries of panel discussions". United Nations document A/CONF.207/11.

UNDP (United Nations Development Programme). 2007. *Human Development Report 2007/2008. Fighting Climate Change: Human Solidarity in a Divided World*. Available at: <<http://hdr.undp.org/en/reports/global/hdr2007-2008>>.

UNDP (United Nations Development Programme). 2005. *Hoping and Coping: A Call for Action. The Capacity Challenge of HIV/AIDS in Least Developed Countries*. Available at: <[http://www.undp.org/hiv/docs/hoping\\_and\\_coping\\_final.pdf](http://www.undp.org/hiv/docs/hoping_and_coping_final.pdf)>.

United Nations Economic Commission for Africa. 2008. *Economic Report on Africa. 2008. Africa and the Monterrey Consensus: Tracking Performance and Progress*. Available at: <<http://www.uneca.org/era2008>>.

United Nations Economic Commission for Africa. 2008. *Securing Our Future: Report on the Commission for HIV/AIDS and Governance in Africa*. Available at: <<http://www.uneca.org/CHGA/Report>>.

UNEP (United Nations Environment Programme). 2006. *Africa Environmental Outlook 2: Our Environment, Our Wealth*. Division of Early Warning and Assessment. Nairobi: United Nations Environment Programme.

United Nations Department of Economic and Social Affairs, Statistics Division. 2003. *World Statistics Pocketbook: Small Island Developing States*. New York: United Nations.

United Nations Department of Economic and Social Affairs. 2004. *Progress towards the Millennium Development Goals, 1990–2003*. New York: United Nations.

UNFCCC. 2005. *Climate Change, Small Island Developing States*. Bonn: United Nations Framework Convention on Climate Change.

UNFCCC. 2007. *Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries*. Bonn: United Nations Framework Convention on Climate Change.

UN-OHRLLS (United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States). 2003. *Third World Water Forum, Kyoto, Japan 16 to 23 March 2003. Report of the United Nations Office of The High Representative For The Least Developed Countries, Landlocked Developing Countries And Small Island Developing States*. New York: United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States.

UN-OHRLLS (United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States). 2006. *Facts About Least Developed Countries (LDCs)*. New York: United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States.

United Nations General Assembly Economic and Social Council. 2008. *Implementation of the Programme of Action for the Least Developed Countries for the Decade 2001-2010. Report of the Secretary-General*. Third United Nations Conference on the Least Developed Countries. United Nations General Assembly document A/63/77-E/2008/61.

United Nations Office for the Coordination of Humanitarian Affairs and Care International. 2008. *Humanitarian Implications of Climate Change: Mapping Emerging Trends and Risk Hotspots for Humanitarian Action*. Available at: <[http://www.careclimatechange.org/files/MainReport\\_final.pdf](http://www.careclimatechange.org/files/MainReport_final.pdf)>.

Wang XF, Chen and Dong Z. 2006. The relative role of climatic and human factors in desertification in semiarid China. *Global Environmental Change*. **16**: pp.48–57.

Witter M. 2008. *Current Socio-Economic Trends and Medium Term Prospects for the Caricom Caribbean*. Draft. Prepared for the International Federation of the Red Cross and Red Crescent Societies. (unpublished report.)

World Bank. 2006. *Not If But When: Adapting to Natural Hazards in the Pacific Islands Region. A Policy Note, 2006*. Available at: <<http://siteresources.worldbank.org/INTPACIFICISLANDS/Resources/Natural-Hazards-report.pdf>>.

World Bank. 2005. *A Time to Choose: Caribbean Development in the 21st Century*. Report No. 31725-LAC. 7 April 2005. Available at: <[http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2005/11/15/000090341\\_20051115085309/Rendered/PDF/342080ENGLISH0Jun05173EN.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2005/11/15/000090341_20051115085309/Rendered/PDF/342080ENGLISH0Jun05173EN.pdf)> .

World Bank. 2001. *World Development Report 2000/2001: Attacking Poverty*. Washington D.C.: World Bank.

World Health Organization. 2002. *The World Health Report 2002: Reducing Risks, Promoting Healthy Life*. Geneva: World Health Organization.

World Meteorological Organization. 2006. *Weather, Climate and Water Services for the Least Developed Countries*. Geneva: World Meteorological Organization.

World Meteorological Organization. 2006. Preventing and mitigating natural disasters. Available at <<http://www.wmo.ch/pages/publications/showcase/documents/WMO993.pdf>>. p.3.

World Resources Institute. 2003. World Resources, 2002–2004. *Decisions for the Earth: Balance, Voice and Power*. Washington D.C.: World Resources Institute.

-----