Lecture 11 – Impacts of climate change - 4

Adaptation to climate change

- Many of the options listed are presently employed to cope with current climate variability and extremes; their expanded use can enhance both current and future capacity to cope.
- But such actions may not be as effective in the future as the amount and rate of climate change increase.
- To make a list of possible adaptation options is relatively easy.
- If they are to be applied effectively, much more information needs to be generated regarding the detail and the cost of their application over the wide range of circumstances where they will be required.

Table 7.2 Selected examples of planned adaptation by sector

Sector	Adaptation option/ strategy	Underlying policy framework	Key constraints and opportunities for implementation	
			Constraints	*Opportunities*
Water	Expanded rainwater harvesting; water storage and conservation techniques; water use; desalination; water use and irrigation efficiency	National water policies and integrated water resources management; water-related hazards management	Financial, human resources and physical barriers;	*integrated water management, synergies with other sectors*
Agricul-ture	Adjustment of planting dates and crop variety; crop relocation; improved land management, e.g. erosion control and soil protection through tree planting	R & D policies; institutional reform; land tenure and land reform; training; capacity building; financial incentives, e.g. subsidies and tax credits	Technological and financial constraints; access to new varieties; market;	*Longer growing season in higher latitudes; revenues from 'new' products*

Table 7.2 Selected examples of planned adaptation by sector

Sector	Adaptation option/ strategy	Underlying policy framework	Key constraints and opportunities for implementation	
			Constraints	*Opportunities*
Infrastructure/ settlement (including coastal zones)	Relocation; seawalls and storm surge barriers; dune reinforcement; land acquisition and creation of marshlands/ wetlands as buffer against sea level rise and flooding; protection of existing natural barriers	Standards and regulations that integrate climate change considerations into design; land-use policies; building codes; insurance	Financial and technological barriers; availability of relocation space;	*integrated policies and management; synergies with sustainable development goals*
Human Health	Heat-health action plans; emergency medical services; improved climate-sensitive disease surveillance and control; safe water and improved sanitation	Public health policies that recognise climate risk; strengthened health services; regional and international cooperation	Limits to human tolerance (vulnerable groups); knowledge limitations; Financial capacity;	*upgraded health services; improved quality of life*

Table 7.2 Selected examples of planned adaptation by sector

Sector	Adaptation option/ strategy	Underlying policy framework	Key constraints and opportunities for implementation	
			Constraints	*Opportunities*
Tourism	Diversification of tourism attractions and revenues; shifting ski slopes to higher altitudes and glaciers; artificial snowmaking	Integrated planning (e.g. carrying capacity; linkages with other sectors); financial incentives, e.g. subsidies and tax credits	Appeal/ marketing of new attractions; financial and logistical challenges; potential adverse impact on other sectors (e.g. artificial snow-making may increase energy use);	*revenues from 'new' attractions; involvement of wider group of stakeholders*
Transport	Realignment/relocation ; design standards and planning for roads, rail and other infrastructure to cope with warming and drainage	Integrating climate change considerations into national transport policy; investment in R&D for special situations, e.g. permafrost areas	Financial and technological barriers; availability of less vulnerable routes;	*Improved technologies and integration with key sectors (e.g. energy)*

Table 7.2 Selected examples of planned adaptation by sector

Sector	Adaptation option/ strategy	Underlying policy framework	Key constraints and opportunities for implementation	
			Constraints	*Opportunities*
Energy	Strengthening of overhead transmission and distribution infrastructure; underground cabling for utilities; energy efficiency; use of renewable sources; reduced dependence on single sources of energy	National energy policies, regulation, and fiscal and financial incentives to encourage use of alternative sources; incorporating climate change in design standards	Access to viable alternatives; financial and technological barriers; acceptance of new technologies;	*stimulation of new technologies; use of local resources*
Note: Other examples from many sectors would include early warning systems.				

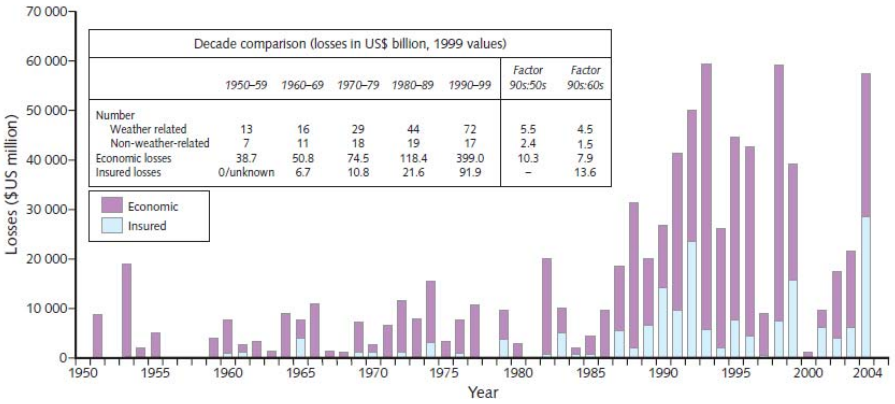
Costing the impacts: extreme events

- In the previous paragraphs the impacts of climate change have been described in terms of a variety of measures; for instance,
  - the number of people affected (e.g. by mortality, disease or by being displaced),
  - the gain or loss of agricultural or forest productivity,
  - the loss of biodiversity,
  - the increase in desertification, etc.
- However, the most widespread measure, looked for by many policymakers, is monetary cost or benefit.

Table 7.3 Fatalities, economic losses and insured losses (both in 1999 US dollars) for disasters in different regions as estimated by the insurance industry for the period 1985–99.

Fatalities & losses	Africa	America: South	America: North, Central, Caribbean	Asia	Australia	Europe	World
Number of events	810	610	2260	2730	600	1810	8820
Weather-related	91%	79%	87%	78%	87%	90%	85%
Fatalities	22990	56080	37910	429920	4400	8210	559510
Weather-related	88%	50%	72%	70%	95%	96%	70%
Economic losses ($US billion)	7	16	345	433	16	130	947
Weather-related	81%	73%	84%	63%	84%	89%	75%
Insured losses ($US billion)	0.8	0.8	119	22	5	40	187
Weather-related	100%	69%	86%	78%	74%	98%	87%

Figure 1.2 The total economic costs and the insured costs of catastrophic weather events for the period 1950 to 2004 as recorded by the Munich Re insurance company



Decade comparison (losses in US$ billion, 1999 values)

	1950–59	1960–69	1970–79	1980–89	1990–99	Factor 90s:50s	Factor 90s:60s
Number							
Weather related	13	16	29	44	72	5.5	4.5
Non-weather-related	7	11	18	19	17	2.4	1.5
Economic losses	38.7	50.8	74.5	118.4	399.0	10.3	7.9
Insured losses	0/unknown	6.7	10.8	21.6	91.9	–	13.6

The insurance industry and climate change

- The impact of climate on the insurance industry is mainly through extreme weather events.
- In developing countries there may be very high mortality from extreme weather but relatively small costs to the industry because of low insurance penetration.
- In developed countries the loss of life may be much less but the costs to the insurance industry can be very large.
- Some idea of the types of disaster that cause the largest economic loss can be gleaned from Table 7.4 .

Table 7.4 Individual events included in the aggregates in Table 7.3 that incurred over $US5 billion of economic loss and over $US1 billion of insured loss

Year	Event	Area	Economic losses ($US billion)	Ratio: insured/ economic losses
1995	Earthquake	Japan	112.1	0.03
1994	Northridge Earthquake	USA	50.6	0.35
1992	Hurricane Andrew	USA	36.6	0.57
1998	Floods	China	30.9	0.03
1993	Floods	USA	18.6	0.06
1991	Typhoon Mireille	Japan	12.7	0.54
1989	Hurricane Hugo	Caribbean, USA	12.7	0.50
1999	Winterstorm Lothar	Europe	11.1	0.53
1998	Hurricane Georges	Caribbean, USA	10.3	0.34
1990	Winterstorm Daria	Europe	9.1	0.75
1993	Blizzard	USA	5.8	0.34
1996	Hurricane Fran	USA	5.7	0.32
1987	Winterstorm	W. Europe	5.6	0.84
1999	Typhoon Bart	Japan	5.0	0.60

Costing the total impact

- Modelling the monetary impacts of climate change requires quantitative analysis connecting environmental, economic and social issues.
- The main tool for such studies is the Integrated Assessment Model (IAM) (see box in Chapter 9 on page 280) which includes all the elements illustrated in Figure 1.5 .

- Adaptation is especially important in the agricultural sector.
- In that sector, under changes in global average temperature of less than about 3 °C, when adaptation is taken into account, estimates of global aggregate economic impact cost vary from the slightly negative (i.e. slightly beneficial) to the moderately positive depending on underlying assumptions (see also Section ‘Impact on agriculture and food supply’, pages 196–202).

- For global average temperature increases of 2–3 °C from pre-industrial levels (i.e. up to a situation of doubled carbon dioxide concentration) which are expected to occur by early in the second half of the twenty-first century, the Stern Review has reviewed recent estimates and concluded that the cost of climate change could be equivalent to a loss of 0 to 3% in global GDP from what could have been achieved in a world without climate change.
- The Stern Review goes on to point out that poor countries will suffer higher costs.

Environmental refugees

- It has been estimated that, under a business-as-usual scenario, the total number of persons displaced by the impacts of global warming could total of the order of 150 million by the year 2050 (or about 3 million per year on average) – about 100 million due to sea level rise and coastal flooding and about 50 million due to the dislocation of agricultural production mainly due to the incidence and location of areas of drought.
- The cost of resettling 3 million displaced persons per year (assuming that is possible) has been estimated at between $US1000 and $US5000 per person, giving a total of about $US10 000 million per year.

- The impacts of the additional climate change that would occur with a second effective doubling of carbon dioxide will be substantially more severe than those of the first doubling.
- The Stern Review has considered these (see box in page 227) and estimated that the total cost of business-as-usual (BAU) climate change to be equivalent to around a 5–20% reduction in current global per capita consumption now and for ever, with a strong likelihood that it will be in the upper part of that range and with disproportionate losses tending to fall on poorer countries.

Table 7.5 Examples of singular non-linear events and their impacts

Singularity	Causal process	Impacts
Non-linear response of thermohaline ciculation (THC)	Changes in thermal and freshwater forcing could result in complete shutdown of North Atlantic THC or regional shutdown in the Labrador and Greenland Seas. In the Southern Ocean, formation of Antarctic bottom water could shut down. Such events are simulated by models and also found in the palaeoclimatic record.	Consequences for marine ecosystems and fisheries could be severe. Complete shutdown would lead to a stagnant deep ocean, with reducing deepwater oxygen levels and carbon uptake, affecting marine ecosystems. It would also represent a major change in heat budget and climate of northwest Europe.
Disintegration of West Antarctic Ice Sheet (WAIS)	WAIS may be vulnerable to climate change because it is grounded below sea level. Its disintegration could raise global sea level by 4 to 6 m. Large sea level rise from this cause is unlikely during the twenty-first century.	Considerable and rapid sea level rise would widely exceed adaptive capacity for most coastal structures and ecosystems.

Table 7.5 Examples of singular non-linear events and their impacts

Singularity	Causal process	Impacts
Positive feedbacks in the carbon cycle	Climate change could reduce the efficiency of current oceanic and biospheric carbon sinks. Under some conditions the biosphere could become a source. Gas hydrate reservoirs also may be destabilised, releasing large amounts of methane to the atmosphere.	Rapid, largely uncontrollable increases in atmospheric carbon concentrations and subsequent climate change would increase all impact levels and strongly limit adaptation possibilities.
Destabilisation of international order by environmental refugees and emergence of conflicts as a result of multiple climate change impacts	Climate change – alone or in combination with other environmental pressures – may exacerbate resource scarcities in developing countries. These effects are thought to be highly non-linear, with potential to exceed critical thresholds along each branch of the causal chain.	This could have severe social effects, which, in turn, may cause several types of conflict, including scarcity disputes between countries, clashes between ethnic groups and civil strife and insurgency, each with potentially serious repercussions for the security interests of the developed world.

Table 7.6 Examples of impacts due to changes in extreme weather and climate events

Phenomenon and direction of trend	Likelihood of future trends based on projections for twenty-first century using SRES scenarios	Examples of major projected impacts by sector. Agriculture, forestry and ecosystems
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	*Virtually certain*	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks
Warm spells/heatwaves. Frequency increases over most land areas	*Very likely*	Reduced yields in warmer regions due to heat stress; increased danger of wildfire
Heavy precipitation events. Frequency increases over most areas	*Very likely*	Damage to crops; soil erosion, inability to cultivate land due to water logging of soils

Table 7.6 Examples of impacts due to changes in extreme weather and climate events

Phenomenon and direction of trend	Likelihood of future trends based on projections for twenty-first century using SRES scenarios	Examples of major projected impacts by sector. Agriculture, forestry and ecosystems
Area affected by drought increases	*Likely*	Land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire
Intense tropical cyclone activity increases	*Likely*	Damage to crops; wind throw (uprooting) of trees; damage to coral reefs
Increased incidence of extreme high sea level (excludes tsunamis)	*Likely*	Salinisation of irrigation water, estuaries and fresh-water systems

Summary

- The main impacts of climate change will be due to sea level rise, increases in temperature and heat waves and a more intense hydrological cycle leading on average to more frequent and intense floods, droughts and storms (see Table 7.6 for a summary of impacts of extreme events).
- There are many ways in which the environment is being degraded due to human activities, for instance, through over-withdrawal of groundwater, loss of soil or deforestation. Global warming will exacerbate these degradations.

- To respond to climate change impacts, it will be necessary to adapt. In many cases this will involve changes in infrastructure, for instance new sea defences or water supplies. Many of the impacts of climate change will be adverse, but even when the impacts in the long term turn out to be beneficial, in the short term the process of adaptation will mostly have a negative impact and involve cost.
- Through adaptation to different crops and practices, first indications are that the total of world food production may not be seriously affected by climate change – although studies have not yet taken into account the likely occurrence of climate extremes. However, the combination of population growth and climate change will mean that disparity in per capita food supplies between the developed and the developing world will become much larger.
- Because of the likely rate of climate change, there will also be a serious impact on natural ecosystems, especially at mid to high latitudes. Forests especially will be affected by increased climate stress causing substantial dieback and loss of production, associated with which there is the positive feedback of additional carbon dioxide emissions. In a warmer world longer periods of heat stress will have an effect on human health; warmer temperatures will also encourage the spread of certain tropical diseases, such as malaria, to new areas.

- Economists have attempted to estimate the average annual cost in monetary terms of the impacts that would arise under the climate change due to a doubling of pre-industrial atmospheric carbon dioxide concentration.
  - If allowance is added for the impact of extreme events, the estimates are typically around 1% to 4% of GDP for developed countries and 5–10 % or more for many developing countries.
  - Later chapters will compare them with the cost of taking action to slow the onset of global warming or reduce its overall magnitude.
  - However, these attempts at monetary costing only represent a part of the overall impact story that must include the cost in human terms, for instance, the large social and political disruption some of the impacts will bring. In particular, it is estimated that there could be up to 3 million new environmental refugees each year or over 150 million by the middle of the twenty-first century. Refinements of all these estimates and the assumptions on which they are based are urgently required.

- Estimates of overall impact need to take the longer term into account. The cost of continuing with business-as-usual (BAU) has been estimated by the Stern Review as the equivalent of 5–20% reduction in per capita consumption now and for ever with a strong likelihood that it will be in the upper part of that range and with disproportionate losses falling on poorer countries.

Reading material

- Climate change in Nepal: Impacts and adaptive strategies by Ajay Dixit, Institute for social and environmental transition-Nepal [http://www.wri.org/our-work/project/world-resources-report/climate-change-nepal-impacts-and-adaptive-strategies]