Highlights from

Climate Change 2007
Climate Change Impacts, Adaptation and Vulnerability
Summary for Policy Makers

Contribution of Working Group II to the
Fourth Assessment Report of the Intergovernmental Panel on Climate Change

On April 6, 2007, the Intergovernmental Panel on Climate Change released its Summary for Policymakers for the contribution of Working Group II to the Fourth Assessment Report (AR4) on climate change impacts. This document summarizes, in plain language, progress that has been made in understanding impacts of climate change on natural, managed and human systems, their capacity to adapt, and their vulnerability.

Because of a dramatic increase in the number and quality of observations, the AR4 provides the strongest statement to date on the consequences of climate change, concluding that, "*it is likely* [better than 2:1 odds] *that anthropogenic warming has had a discernible influence on many physical and biological systems.*" Particularly obvious are widespread changes in ice and snow cover, earlier spring biological events in natural and managed ecosystems, and changes in water temperature and flows in rivers, lakes, and oceans.

The report presents projections of impacts on policy-relevant sectors, including water, ecosystems, food, coastal systems, industry, settlement and society, and health, and on major regions, including Africa, Asia, Australia and New Zealand, Europe, Latin America, North America, polar regions, and small islands.

In North America, climate change will increase agricultural production in some regions for moderate levels of warming in the next few decades (*high confidence*). Water availability will decrease in the West because of decreased mountain snowpack and earlier spring melt (*very high confidence*). Forests will experience increased stress from insect pests, diseases, and increased wildfire (*very high confidence*). Cities with a history of heat waves will experience more frequent and intense heat waves in the future, with potential adverse health effects (*very high confidence*). Coastal areas are especially vulnerable to the interacting effects of development, pollution, and climate change, and coastal communities are poorly prepared to respond to increasing risks imposed by climate change (*very high confidence*).

Africa, Asia, the polar regions, and small islands are the most vulnerable regions either because of the degree of climate change projected (polar regions) or the vulnerability and lack of resilience of natural and human systems (Africa, Asia, and small islands).

With average global surface warming greater than about 2-3 °C (3.6-5.4 °F), "*it is very likely* [better than 2:1 odds] *that all regions will experience either declines in net benefits or increases in net costs.*"

Information on the following pages is quoted or paraphrased from the Summary for Policymakers for Working Group II of the AR4, released on April 6, 2007. The original document is available at http://www.ipcc.ch/SPM6avr07.pdf.

The following terms have been used to express the assessed likelihood of an outcome or a result: *Virtually certain* > 99% probability of occurrence, *Extremely likely* > 95%, *Very likely* > 90%, *Likely* > 66%, *More likely than not* > 50%, *Very unlikely* < 10%, *Extremely unlikely* < 5%.

The following terms have been used to express confidence in a statement:
Very high confidence At least a 9 out of 10 chance of being correct, *High confidence* About an 8 out of 10 chance, *Medium confidence* About a 5 out of 10 chance, *Low confidence* About a 2 out of 10 chance, *Very low confidence* Less than a 1 out of 10 chance.

OBSERVED IMPACTS IN NATURAL AND MANAGED SYSTEMS

Many natural systems, on all continents and in some oceans, are being affected by regional climate changes, particularly temperature increases.

- **Physical impacts** (*high confidence*): increased sizes and numbers of glacial lakes, with increased risk of floods; increasing ground instability in mountain and other permafrost regions, and ice and rock avalanches in mountain regions; changes in some Arctic and Antarctic flora and fauna, including sea-ice biomes and predators high in the food chain; enhanced run-off and earlier spring peak discharge in many glacier- and snow-fed rivers; lakes and rivers in many regions are warming, with effects on water quality
- **Biological impacts** (*high to very high confidence*): poleward and upward shifts in ranges in plant and animal species on land; poleward shifts and changes in abundance of algae, plankton and fish in high-latitude oceans; earlier timing of spring events, such as leaf-unfolding, bird migration and egg-laying; increased plant production linked to longer growing seasons and increased atmospheric CO_2; increases in algal and zooplankton abundance in high-latitude and high-altitude lakes; earlier fish migrations and range changes in rivers

A global assessment of data since 1970 has shown it is *likely* that anthropogenic warming has had a discernible influence on many physical and biological systems.

- The vast majority (greater than 89%) of observed changes worldwide are in the direction expected in response to global warming.
- The spatial agreement between regions of significant regional warming across the globe and the locations of significant observed changes in many systems is consistent with warming and is *very unlikely* due solely to natural variability.
- Several studies have explicitly linked anthropogenic forcings to specific impacts in some physical and biological systems using modeling methods that identify specific causes of climate change.

Other effects of regional climate changes on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers. Examples include: earlier spring planting at northern higher latitudes for forestry and agriculture; heat-related mortality in Europe and Asia; infectious disease vectors in some areas; allergenic pollen in northern latitudes; shorter vehicle travel seasons in the Arctic; mountain sports affected in lower-elevation regions; increased risk of flooding from melting glaciers in mountain regions, drier conditions in parts of Africa that harm agriculture

FUTURE IMPACTS

More specific information is now available across a wide range of systems and sectors concerning the nature of future impacts, including for some fields not covered in previous assessments.

Magnitudes of impact can now be estimated more systematically for a range of possible increases in global average temperature.

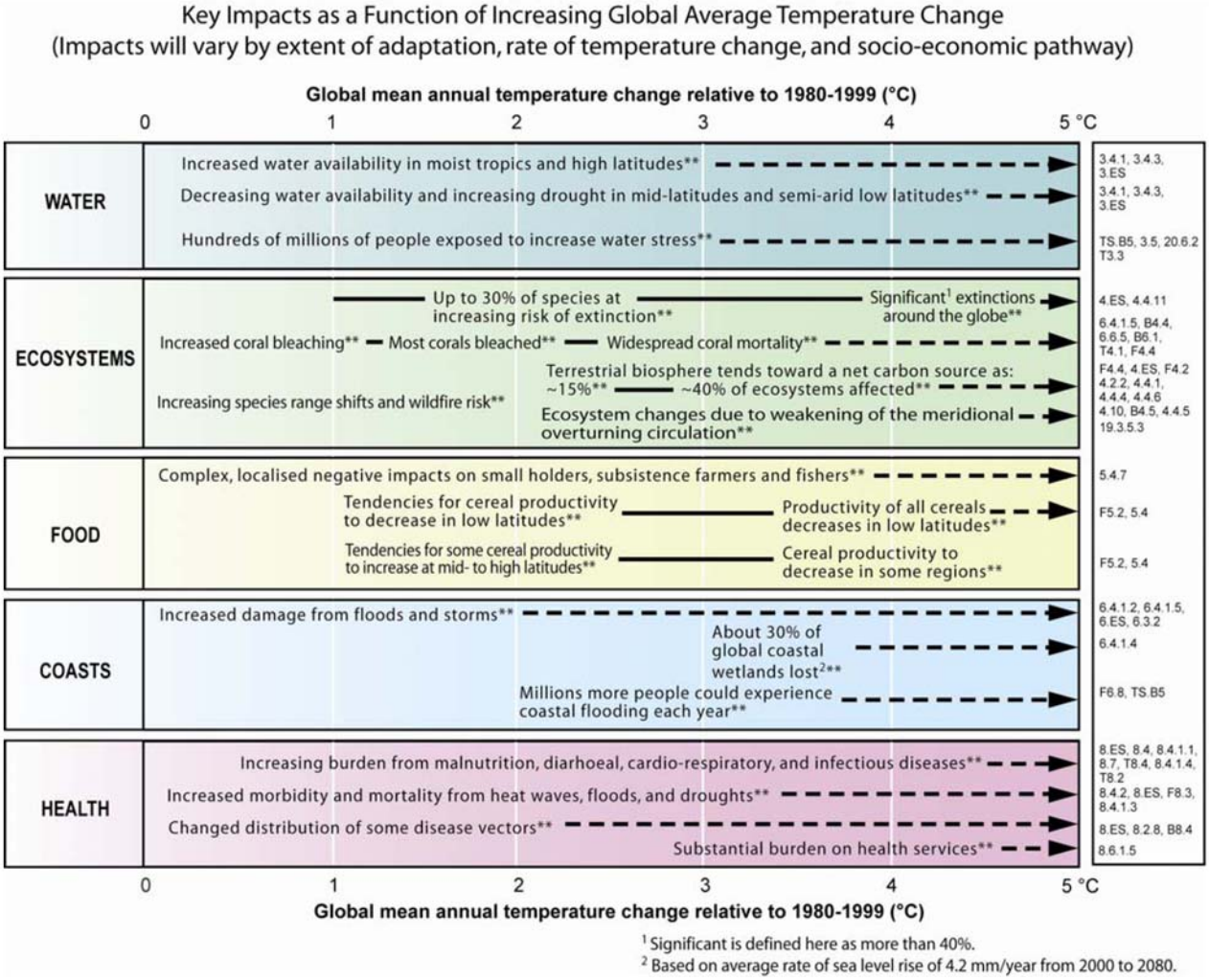

Table SPM-1. Illustrative examples of global impacts projected for climate changes (and sea-level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left hand side of text indicates approximate onset of a given impact. Quantitative entries for water scarcity and flooding represent the additional impacts of climate change relative to the conditions projected across the range of SRES scenarios A1FI, A2, B1, and B2. Adaptation to climate change is not included in these estimations. All entries are from published studies recorded in the chapters of the Assessment. Sources are given in the right hand column of the Table. Confidence levels for all statements are *high*.

Impacts due to altered frequencies and intensities of extreme weather, climate, and sea level events are *very likely* to change. Since the IPCC Third Assessment, confidence has increased that some weather events and extremes will become more frequent, more widespread, and/or more intense during the 21st century; and more is known about the potential effects of such changes. A selection of these is presented in the following table:

Phenomena[a] and direction of trend [WGI SPM]	**Likelihood of future trend based on projections for 21st century using SRES scenarios** [WGI SPM]	**Examples of major projected impacts by sector**			
		Agriculture, forestry and ecosystems [4.4, 5.4]	**Water resources [3.4]**	**Human health [8.2]**	**Industry/settlement/ Society [7.4]**
Warmer and fewer cold days and nights; warmer/more frequent hot days and nights over most land areas	Virtually certain[b]	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snow melt; increased evapo-transpiration rates	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves: frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; wild fire danger increase	Increased water demand; water quality problems, e.g., algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially-isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on elderly, very young and poor.
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	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries, infectious, respiratory and skin diseases, post-traumatic stress disorders	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures
Area affected by drought: increases	Likely	Land degradation, lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water- and food-borne diseases	Water shortages for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; windthrow (uprooting) of trees; damage to coral reefs	Power outages cause disruption of public water supply	Increased risk of deaths, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers, potential for population migrations
Increased incidence of extreme high sea level (excludes tsunamis)[c]	Likely[d]	Salinisation of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection *versus* costs of land-use relocation; potential for movement of populations and infrastructure; also see tropical cyclones above

Some events have the potential to cause very large impacts, especially after the 21st century [*medium confidence*].

- There is *medium confidence* that both the Greenland and West Antarctic ice sheets would be committed to partial deglaciation for a global average temperature increase of 1-4°C (1.8-7.2°F), causing sea-level rise of 4-6 m (13-20 ft) over centuries to millennia. Such sea level rise implies major changes in coastlines and ecosystems, and inundation of low-lying areas, with greatest effects in river deltas. Relocating populations, economic activity, and infrastructure would be costly and challenging.
- It is *very unlikely* that the Meridional Overturning Circulation (MOC; sometimes called the North Atlantic conveyor belt) will undergo large or abrupt change during the 21st century. Slowing of the MOC this century is *very likely*, but temperatures over the Atlantic and Europe are projected to increase nevertheless. Large scale changes in the MOC (in future centuries with continued warming) are likely to include changes to marine ecosystem productivity, fisheries, ocean carbon dioxide uptake, oceanic oxygen concentrations, and terrestrial vegetation.

More specific information is now available across the regions of the world concerning the nature of future impacts, including for some places not covered in previous assessments.

Worldwide, heavily populated and low-lying coastal areas will be at greater risk for flooding and storm damage because of rising sea levels and more frequent and/or intense storms. Inland areas will also be affected in general by increased incidence of extreme weather events. Mountainous regions in general will lose glacier volume, initially causing increased flooding, followed by dwindling river flows and water availability during parts of the year.

Africa & Asia hold the most vulnerable populations and the largest number of people impacted by climate change. Within the next several decades, large numbers of people on both continents will experience decreased water availability due to changes in precipitation patterns, drought, glacier loss, and seawater intrusion into coastal groundwater. Crop production is projected to decline significantly on large portions of both continents. By the end of this century, adaptation to sea level rise in some coastal regions of Africa could cost as much as 5-10% of GDP. Impacted populations will number in the hundreds of millions.

Australia & New Zealand have significant adaptation abilities, but also face severe impacts, mostly associated with decreased water supplies, coastal impacts, extreme weather events, decreased crop and forest production, and large-scale loss of biodiversity.

Europe faces many impacts from climate change, and adaptation capacity varies by climate zone and country. Retreating glaciers, longer growing seasons, shift of species ranges, and health impacts due to a heat wave of unprecedented magnitude are already well documented. Nearly all European regions are expected to be negatively affected by some future impacts of climate change and these will pose challenges to many economic sectors. Negative impacts will include increased inland and coastal flooding, coastal erosion, glacier retreat, reduced snow cover, and extensive species loss, and, in Southern Europe, heat, drought, and decreased water availability.

In **Latin America** some tropical forests will be replaced by more arid savannah ecosystems and many tropical regions are at high risk of species extinctions. Crop and livestock production will

decline in drier areas, although soybean yields will increase in temperate zones. Rising sea surface temperature will damage coral reefs and shift locations of southeast Pacific fish stocks. Changes in precipitation patterns and glacier loss will affect water availability.

North America will see a mix of benefits in some regions (e.g., increased crop yields at some degree of warming and less cold exposure) and negative impacts, such as hotter, drier conditions in the West, leading to reduced mountain snowpack and water availability. Cities that historically experience heat waves will experience more frequent and more intense heat waves in the future.

Polar Regions will experience decreased ice cover, shifts in species ranges and timing of spring biological events, damage to infrastructure, loss of indigenous lifestyles, invasive species with rising temperatures, and the need to relocate communities near eroding coastlines and that rest on soils with melting permafrost.

Small Islands are at high risk for coastal erosion, storm damage, and loss of freshwater.

RESPONDING TO CLIMATE CHANGE

- Some adaptation is occurring now, to observed and projected future climate change, but on a limited basis.
- Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions.
- A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change. There are barriers, limits and costs, but these are not fully understood.
- Vulnerability to climate change can be exacerbated by the presence of other stresses, such as rapid population growth, poverty, pollution, and ocean acidification.
- Future vulnerability depends not only on climate change, but also on development pathway, including trends in regional population, income, and technological development.
- Sustainable development can reduce vulnerability to climate change by enhancing adaptive capacity and increasing resilience, although few development plans explicitly include either adapting to climate change.
- On the other hand, it is *very likely* that climate change can slow the pace of progress toward sustainable development, either directly through increased exposure to adverse impact or indirectly through erosion of the capacity to adapt.
- Many impacts can be avoided, reduced, or delayed by mitigation. Impacts studies based on scenarios with lower future greenhouse gas emissions indicate that damages can be avoided and vulnerabilities reduced.
- Adaptation and mitigation measures are both needed to diminish the risks of climate change.
- Impacts of climate change will vary regionally, but overall are *very likely* to impose net annual costs which will increase over time as global temperatures increase.