

Box**Climate Change: Impacts, Adaptation and Vulnerability**

The report from Working Group II of the Intergovernmental Panel on Climate Change (IPCC) is the second of three working group parts of the Fourth Assessment Report. It describes current scientific understanding of the impacts of climate change on natural, managed and human systems, the capacity of these systems to adapt and their vulnerability. In the following a short summary of this report is given.

Climate change today: observed impacts and vulnerabilities

Observations from all continents and in most oceans show that many natural systems are being affected by regional climate changes, particularly temperature increases:

- *Physical systems:* Global ice melt leads to enlargement and increased numbers of glacial lakes, with increased risk of outburst floods. There is increasing ground instability due to thawing in permafrost regions, and a growing risk of rock avalanches in mountain regions. There is an increased 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 thermal structure and water quality.
- *Biological systems:* Spring events – such as leaf unfolding, bird migration, egg-laying – are occurring earlier. Ranges of plant and animal species are shifting polewards at the global level and upwards at local levels. Arctic and Antarctic flora and fauna are changing, which leads to far-reaching disruptions of the food chain.

The *anthropogenic component of warming* over the last three decades has had a discernible influence on many physical and biological systems. Over 89 percent of the more than 29,000 data series from different locations document changes in the direction expected as a response to warming.

Evidence of effects from regional increases in temperature on managed and human systems include the following:

- *Agriculture and forestry:* Effects on management at higher latitudes in the Northern Hemisphere, such as earlier spring planting of crops, alterations in disturbance regimes of forests due to fires and pests,
- *Health:* Increased mortality in Europe and Asia during prolonged heat waves, changed distribution and infectious potential in some regions of infectious disease vectors, such as mosquitoes and ticks, increase of allergenic pollens in Northern Hemisphere high and mid-latitudes,
- *Human activities:* Aspects of indigenous livelihoods in the Arctic, such as hunting and travel over snow and ice. Winter sports in lower-elevation alpine areas are adversely affected.

Future climate change: estimated impacts and vulnerabilities

Assuming that climate change will not be mitigated and that adaptive capacity is not enhanced through resolute action, for the 21st century scientists expect far-reaching key impacts for different systems and sectors which will be relevant for humans and the environment alike. For the first time, the IPCC has evaluated climate impacts in relation to expected future temperature increases. Examples of the impacts of a further increase in the global mean temperature (as compared to 1980–99) follow:

- Global mean temperature changes *of up to 1.5°C* would exacerbate current key vulnerabilities and cause others, such as negative health effects caused by heat waves, floods and droughts, as well as malnutrition and infectious diseases, millions more people exposed to increased water stress, increased damage from storms and floods and increased coral bleaching.
- Global mean temperature changes *of 1.5 to 3.5°C* would result in an increasing number of key impacts at all scales, such as many million more people at risk from coastal flooding, widespread loss of biodiversity, and commitment to widespread deglaciation of the Greenland and West Antarctic ice sheets with associated sea level rise.
- Global mean temperature changes *greater than 3.5°C* would exceed the capacity of all systems – physical, biological and social, in particular of human societies – to adapt to this extent of warming, especially since it can be even more pronounced regionally. As examples, about 30 percent loss of global coastal wetlands and widespread mortality of corals.

Some *systems* will experience particularly severe impacts: Ecosystems such as tundra, boreal forests, alpine and Mediterranean ecosystems, mangroves, coral reefs; low-lying coasts, water resources in middle and dry low-latitude countries, agriculture in low-latitude regions, human health.

Regions that will be particularly affected are, for example, the Arctic, Africa, especially southern Africa, small islands and Asian mega-deltas, such as the Ganges-Brahmaputra and the Zhujiang.

Specifically, scientists expect the following impacts of climate change for individual climate-sensitive systems and sectors:

- *Water:* There is high confidence^{a)} that runoff and availability will increase at high latitudes and in some wet tropical areas, whereas they will decrease over some dry regions at mid-latitudes and in dry tropical areas, in some of which water is already scarce. Water volumes stored in glaciers and snow cover will decrease and, with them, water availability in regions that are currently home to more than one billion people (one sixth of the world's population).
- *Ecosystems:* There is high confidence that the resilience of many ecosystems will be exceeded in the 21st century due to an unprecedented combination of climate change and associated disturbances (e.g. flooding, drought, wildfire, insects, ocean acidification) and other global change drivers, such as land use change, pollution and over-exploitation of resources. If the global mean temperature increases by more than 2 to 3°C above pre-industrial levels, it is expected that the functioning of some ecosystems will be impeded to such an extent that negative impacts on the products and services that they provide, e.g. water and food supply, are to be expected. Roughly 20–30 percent of plant and animal species (assessed so far) are expected to be at increased risk of extinction if global temperature exceeds 2 to 3°C above pre-industrial levels. Coral reefs are vulnerable to thermal stress and to progressive acidification of the oceans and have low adaptive capacity. Coastal wetlands, such as salt marshes and mangroves, will be negatively affected by sea level rise.
- *Food:* In temperate regions, increases in local mean temperature of up to 1.5 to 3.5°C above pre-industrial levels can have small beneficial impacts on crop yields, which subside in some regions if the temperature increase is greater. At lower latitudes, even moderate temperature increases are projected to have negative impacts on crop productivity, and increased droughts and floods will compromise agriculture especially in subsistence sectors.
- *Industry, settlement, society:* The costs and benefits of climate change will vary widely by location and scale. Some of the effects in temperate and polar regions will be positive and others elsewhere will be negative. In the aggregate, however, net effects will tend to be more negative the larger or more rapid the change in climate. The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, i.e. those whose economies are closely linked to climate-sensitive resources. Poor communities are especially vulnerable, in particular those concentrated in high-risk areas. They tend to have more limited coping capacities and are more dependent on climate-sensitive resources such as local water and food supplies. Many million more people are projected to be at risk from coastal flooding due to

sea-level rise during the 2080s, especially in densely populated and low-lying areas where adaptive capacity is relatively low and which already face other challenges such as tropical storms or local coastal subsidence. The numbers affected will be largest in the mega-deltas of Asia and Africa while small islands are especially vulnerable.

- **Health:** Researchers consider that the health status of millions of people will be affected by global warming, particularly in regions with low adaptive capacity. In these regions, malnutrition will increase, leading to negative impacts on the growth and development of children. Generally, more deaths, diseases and injuries are expected due to heat waves, floods, storms, fires and droughts. Cardio-respiratory diseases will increase due to higher concentrations of ground level ozone but some mixed effects are also expected, for example, the decrease or increase of the range and transmission potential of malaria in Africa.

Global warming: impacts on Europe

For the first time, wide ranging impacts of changes in current climate have been documented: retreating glaciers, longer growing seasons, shift of species' ranges, and health impacts due to a heat wave of unprecedented magnitude. The observed changes are consistent with those projected for future climate change.

In an *overall balance* for Europe, nearly all regions will be negatively affected by some future impacts of climate change and these will pose challenges to many economic sectors. Climate change is expected to magnify regional differences in Europe's natural resources, e.g. water availability.

- In *Northern Europe*, climate change is initially projected to bring mixed effects including some benefits for small changes in temperature: Reduced demand for heating, increased crop yields, increased forest growth. However, as climate change continues, its negative impacts (more frequent winter floods, endangered ecosystems, increasing ground instability) will outweigh any benefits.
- In *Central and Eastern Europe*, summer precipitation is projected to decrease causing higher water stress. Health risks due to heat waves are projected to increase. Forest productivity will decline and the frequency of peatland fires will increase.
- In *Southern Europe*, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability: increased risk to health due to heat waves, more wildfires, reduced water availability and hydropower potential and lower crop yields.

Further impacts:

- **Flooding** will increase as a result of increased ice and snow melt, flash floods will become more frequent throughout Europe, winter floods and flooding will become more frequent in coastal areas and erosion will increase.
- **Health risks** (heat waves, flooding, diseases) will increase without adaptation measures.
- **Biological diversity** will change dramatically, especially in alpine communities, as the great majority of organisms and ecosystems will have difficulties adapting.
- The challenges for many *sectors of industry* (agriculture and forestry, tourism, energy production) will grow.
- The region has substantial *adaptive capacity* but there are considerable constraints to implementation and major challenges from changes in extreme events.

Responses: Adaptation and climate protection measures

The IPCC scientists expect the impacts of climate change to intensify in line with the rise in the average global temperature. As the temperature rises, the adaptive capacity decreases and adaptation costs increase. The limits of adaptation and its concrete costs remain unclear because effective instruments are highly dependent on specific geographical climate risk factors as well as on the policy environment. Researchers consider the following fundamental assumptions to be likely:

- Unmitigated climate change is, in the long term, likely to exceed the adaptive capacity of natural, managed and human systems. The impacts will vary from region to region. Calculated globally they will cause high costs, and these costs will increase more and more over time as global temperatures increase, outweighing possible benefits of climate change. Net effects are more likely to be strongly negative with greater or more rapid warming.
- A number of impacts, in particular those projected beyond 2020, can be delayed or reduced by decreasing the release of climate-damaging gases. The earlier and more ambitious emission reductions are the higher the probability that the impacts of climate change will be milder.
- Adaptation will be necessary to address impacts resulting from the warming that is already unavoidable due to past emissions.
- Further adaptation measures are crucial in order to reduce the vulnerability of physical, biological and human systems to future climate change, but there are barriers, limits and costs involved. The risk-reducing potential is either very limited or very costly for some key vulnerabilities, such as loss of biodiversity, melting of mountain glaciers or disintegration of major ice sheets.
- Vulnerability to climate change is exacerbated by environmental pollution and poverty. It is also dependent on the development path of a society.
- Sustainable development can reduce vulnerability to climate change by strengthening the adaptive and regenerative capacity of ecosystems.

The IPCC scientists point out that the *array of potential adaptive responses* available is very large, ranging from purely technological (e.g., sea defences), through behavioural (e.g., altered food and recreational choices) to managerial (e.g., altered farming practices) and policy decisions (e.g., planning regulations, emission reduction targets). Yet there remain formidable environmental, economic, informational, social, attitudinal and behavioural barriers to the implementation of adaptation measures.

^{a)} 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.

Reference

Fourth Assessment Report of the IPCC (2007) on Climate Change, Part II. Summary by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Federal Ministry of Education and Research and the German IPCC Liaison Office.