Understanding and Measuring Human Vulnerability to Climate Change

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Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of GHGs have increased.

Total radiative forcing is positive, and has led to an uptake of energy by the climate system.

The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO2 since 1750.
Global Temperature Changes from the 20th Century Average (degrees C)

"Scientific evidence for warming of the climate system is unequivocal."
- Intergovernmental Panel on Climate Change
Mean temperature and degrees above average during the 2003 European heat wave, which killed over 70,000 people.
Russian Heat Wave, Summer 2010, 56-60000 deaths
Heat wave in the United States, June 2012
Grand Rapids flooding, Huffington Post, April 2013
U.S. Climate Extremes Index

Contiguous U.S.
Excluding Tropical Cyclone Indicator

July
1910–2012

Percentage values correspond to the average spatial extent of extremes observed across the Contiguous U.S. during a given season and year.
Major Weather Events in the 2000s (Connor, 2011)

- **US 2011**: A series of storms moved across the south-eastern US spawning a record number of tornadoes and killing hundreds of people, including nearly 100 in Joplin, Missouri.
- **CANADA 2005**: The warmest summer on record in Canada.
- **UK 2000**: Widespread flooding in October and November during the wettest autumn in England and Wales since records began in 1766.
- **EUROPE 2003**: Record heatwave in France and other parts of Europe. Some 35,000 people are estimated to have died from heat-related causes.
- **CHINA 2010**: Torrential rain in China causes landslides. Some 1,500 people killed in one mudslide in north-west China.
- **RUSSIA 2010**: Extreme heatwave sees temperatures soaring in Moscow, which was badly affected by surrounding wildfires.
- **US 2005**: Most active hurricane season on record. Hurricane Katrina hits New Orleans causing extensive flooding and killing more than 1,300 people.
- **BRAZIL 2005**: Worst drought in 60 years in Brazil caused by lowest Amazon flow in 30 years.
- **ARGENTINA 2009**: An exceptional heatwave in northern and central Argentina sees record temperatures of 40°C over large areas.
- **HORN OF AFRICA 2006**: Long-term drought followed by torrential downpours produce worst flooding for 50 years.
- **PAKISTAN 2010**: Worst floods in Pakistan’s history affecting some 20 million people. Many hundreds die.
- **AUSTRALIA 2010**: Worst floods in more than 50 years affect north-eastern Australia, causing devastation across area the size of France and Germany combined.
Estimated Deaths Attributed to Climate Change in the Year 2000, by Subregion*

Mortality per Million Population

- 0 - 2
- 2 - 4
- 4 - 70
- 70 - 120
- no data

*Change in climate compared to baseline 1961-1990 climate

Data Source:

Maps produced by the Center for Sustainability and the Global Environment (SAGE)
Climate change impacts — exposure to flood risk under the climate change scenario A2

European Environmental Agency, 2010
Heat waves — both a low share of green and blue urban areas and high population densities can contribute to the urban heat island effect in cities.
Changes in water availability

Change in water availability compared with average 1961–1990 (%) 2050 based on IPCC scenario A1

- more than 20
- 20 to 0
- 0 to -20
- -20 and more

Farming in a Warmer World

Crop forecasts show that some countries farther from the Equator could benefit from a warmer world, but others would be worse off by 2080 if global warming were to proceed unchecked. Long-range forecasts vary widely; the following is a synthesis of available forecasts by country or region.

Note: These figures assume that crops grow faster because of higher levels of carbon dioxide in the air. But some scientists say that the actual effects of global warming could be worse than shown here, because the benefits of extra carbon dioxide may not appear if crops lack proper rainfall, proper soil and clean air.

Grain productivity is likely to benefit from

- warmer winters,
- longer growing season,
- less frosts and possibly
- Possibly CO$_2$ fertilization and water-use efficiency increase caused by CO$_2$.

Grain productivity is threatened by

- increase in summer temperatures and PET,
- decrease in summer precipitation and soil moisture
- possibly increase in fall precipitation.
- more frequent and longer droughts,
- possibly more crops diseases and pest infestations.
Projected impacts from climate change in different EU regions

Adapting to climate change: the European Union must prepare for the impacts to come
European Commission - IP/09/519  01/04/2009
Multi-AOGCM mean of surface air temperature anomalies (mean base years: 1980-1999)
Radiative Forcing of the Representative Concentration Pathways

Risk Level with Current Adaptation

Potential for Additional Adaptation to Reduce Risk

Risk Level with High Adaptation

Present
Near Term (2030-2040)
Long Term 2°C (2080-2100)
Long Term 4°C

Risk Level
Very Low
Low
Med
High
Very High

Increased Flood Losses and Impacts
Increased Drought-Related Water and Food Shortage
Increased Losses and Impacts from Extreme Heat Events

Increased Water Restrictions

Increased Flood Damage to Infrastructure, Livelihoods, and Settlements
Heat-Related Human Mortality
Increased Drought-Related Water and Food Shortage
Increased Risks from Wildfires

Increased Flood Damage to Infrastructure and Settlements
Increased Risks to Coastal Infrastructure and Low-Lying Ecosystems

Reduced Fisheries Catch Potential at Low Latitudes

Unprecedented Challenges, Especially from Rate of Change

POLAR REGIONS
Risks for Ecosystems
Risks for Health and Well-Being
Unprecedented Challenges, Especially from Rate of Change

NORTH AMERICA
Increased Flood Losses and Impacts
Heat-Related Human Mortality
Damages from River and Coastal Urban Floods

Increased Flood Losses and Impacts from Extreme Heat Events
Increased Water Restrictions

EUROPE
Increased Flood Damage to Infrastructure, Livelihoods, and Settlements
Heat-Related Human Mortality
Increased Drought-Related Water and Food Shortage

ASIA
Increased Flood Damage to Infrastructure, Livelihoods, and Settlements
Heat-Related Human Mortality
Increased Drought-Related Water and Food Shortage

AFRICA
Increased Flood Damage to Infrastructure and Settlements
Increased Risks to Coastal Infrastructure and Low-Lying Ecosystems

CENTRAL AND SOUTH AMERICA
Reduced Water Availability and Increased Flooding and Landslides
Reduced Crop Productivity and Livelihood and Food Security
Vector-Borne Diseases

SMALL ISLANDS
Loss of Livelihoods, Settlements, Infrastructure, Ecosystem Services, and Economic Stability
Significant Change in Composition and Structure of Coral Reef Systems
Risks for Low-Lying Coastal Areas

AUSTRALASIA
Significant Change in Composition and Structure of Coral Reef Systems
Increased Flood Damage to Infrastructure and Settlements
Increased Risks to Coastal Infrastructure and Low-Lying Ecosystems

THE OCEAN
Reduced Fisheries Catch Potential at Low Latitudes
Increased Mass Coral Bleaching and Mortality
Coastal Inundation and Habitat Loss

Compounded Stress on Water Resources

Reduced Water Availability and Increased Flooding and Landslides
Reduced Food Production and Quality
Vector-Borne Diseases
Number of 1995-like Chicago Heat Waves. Under the lower emissions scenarios, 1995-like heat waves are projected to occur approximately once every three years. Under the higher scenarios, heat waves are projected to occur on average, three times per year. Source: USGCRP (2009)

Projected changes in the level of the Great Lakes by end of the century.
Source: USGCRP (2009)
This Envisat image covering the area east of Moscow shows several large smoke plumes originating from burning peat fields and forest fires. Source: ESA
(Left) Street in Moscow, June 17th, 2010, 20:22 PM. (Right) August 7th, 2010, 17:05 PM
Floods in Copenhagen, July 2011
Image © Risager, EEA

Flooding in New Orleans after Hurricane Katrina in 2005.
Source: FEMA (2005)
Worldwide, water stress in the 2080s is projected to impact 1.1 – 3.2 billion people.\textsuperscript{1}

The Andean inter-tropical glaciers in South America are expected to disappear in the next few decades, affecting water availability and hydropower generation.\textsuperscript{1}

Worldwide, the decline in calorie availability by 2050 will increase child malnutrition by 20% relative to a world with no climate change.\textsuperscript{3}

In India, women born during a drought or a flood in the 1970s were 19% less likely to ever attend primary school.\textsuperscript{4}

In Bangladesh, 1 meter of sea level rise will flood 20% of the country’s land area.\textsuperscript{5}

In Ethiopia, GDP growth closely tracks rainfall variation.\textsuperscript{2}

Studies project a reduction of 11-28% agricultural production in sub-Saharan Africa by 2050, with wheat expected to disappear entirely by 2080.\textsuperscript{1}

A sea level rise of one meter could lead to crop losses of $500 million of mangos, cashew nuts, and coconuts in Kenya.\textsuperscript{1}

**Thematic dimensions of vulnerability**

* **Social:** refers e.g. to human welfare including mental and physical health, both at an individual and collective level.

* **Economic:** related to potential financial damage and/or disruption of productive capacity.

* **Physical:** refers to the condition of physical assets including built-up areas, infrastructure and open spaces that can be affected by natural hazards. This dimension depicts locations in susceptible areas and deficiencies in the resistance of the exposed elements.

* **Cultural:** related to the meanings placed on artifacts, customs, habitual practices and natural or urban landscapes.

* **Environmental:** refers to all ecological and bio-physical systems and their different functions.

* **Institutional:** refers to both organizational form and function as well as guiding legal and cultural rules.

(Adapted from Methods for the Improvement of Vulnerability Assessment in Europe. Generic conceptual framework for vulnerability measurement, EC-DG Environment 2012)
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<td>Regional land-use and land-cover changes and related hydrometeorological changes</td>
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<td>Access to health care, Mosquito spraying, Drainage improvement, Water treatment and sanitation measures</td>
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