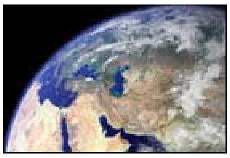

Scientific Facts on

Climate Change

2007 Update

Source document:
IPCC (2007)

Summary & Details:
GreenFacts

Context - In the last few years, scientific research and knowledge on climate change have progressed substantially, confirming that the current warming of the Earth's climate is very likely to be due to human activities such as the burning of fossil fuels. The Earth's warming is already having measurable consequences and future impacts are expected to be wide-ranging and costly.

How can we adapt to those changes? Is it possible to limit the extent of climate change and its impacts through mitigation efforts?

In 2007, the Intergovernmental Panel on Climate Change has provided new answers in its up-to-date assessment of the current state of knowledge on climate change, summarised below.

Part 1: The physical Science Basis

Part 2: Climate change impacts, adaptations and vulnerabilities

Part 3: Mitigation of climate change

This Digest is a faithful summary of the leading scientific consensus report produced in 2007 by the Intergovernmental Panel on Climate Change (IPCC): *"Fourth Assessment Report (AR4)"*. More specifically, it is a summary of the reports by the three Working Groups: "The Physical Science Basis" (WGI), "Impacts, Adaptation and Vulnerability" (WGII), and "Mitigation of Climate Change" (WGIII).

The full Digest is available at: https://www.greenfacts.org/en/climate-change-ar4/

This PDF Document is the Level 1 of a GreenFacts Digest. GreenFacts Digests are published in several languages as questions and answers, in a copyrighted user-friendly Three-Level Structure of increasing detail:

- Each question is answered in Level 1 with a short summary.
- These answers are developed in more detail in Level 2.
- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

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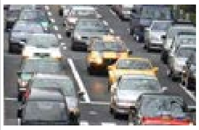
1. What makes the climate change?

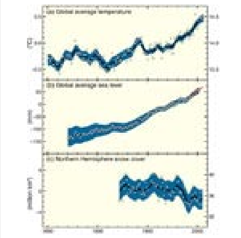

Greenhouse gases are produced mainly by the burning of fossil fuels

The Earth's climate is influenced by many factors, mainly by the amount of energy coming from the sun, but also by factors such as the amount of greenhouse gases and aerosols in the atmosphere, and the properties of the Earth's surface, which determine how much of this solar energy is retained or reflected back to space.

The atmospheric concentrations of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have significantly increased since the beginning of the industrial revolution. This is mainly due to human activities, such as the burning of fossil fuels, land use change, and agriculture. For instance, the atmospheric concentration of carbon dioxide is now far higher than in the last 650 000 years and has been growing faster in the last ten years than it has been since the beginning of continuous measurements around 1960.

It is *very likely* *[see Annex 8, p. 14]* that, overall, human activities since 1750 have had a global warming effect on the Earth.

2. How is climate changing and how has it changed in the past?


Changes in temperature, sea level and snow cover since 1850
[see Annex 3, p. 10]

2.1 The warming of global climate is now unequivocal. There are many observations of increasing air and ocean temperatures, widespread melting of snow and ice, and rising sea levels.

More specifically, eleven of the last twelve years (1995-2006) rank among the 12 warmest years ever recorded since global surface temperatures are measured (1850). Over the last 100 years (1906–2005), global temperature has increased by 0.74°C. Global sea level has risen by 17 cm during the 20th century, in part because of the melting of snow and ice from many mountains and in the polar regions. More regional changes have also been observed, including changes in Arctic temperatures and ice, ocean salinity, wind patterns, droughts, precipitations, frequency of heat waves and intensity of tropical cyclones.

2.2 The temperatures of the last half century are unusual in comparison with those of at least the previous 1300 years. The last time that the polar regions remained significantly warmer than now for a very extended period (125 000 years ago), the sea level rose by 4 to 6 meters.

2.3 Most of the increase in global temperature observed over the past fifty years is *very likely* *[see Annex 8, p. 14]* due to human emissions of greenhouse gases.

3. How is the climate going to change in the future?

From 1980 to the end of the 21st century, temperatures are projected to increase by 1.8°C to 4.0°C.

3.1 The global average temperature is expected to increase by about 0.2°C per decade over the next two decades. Continuing greenhouse gas emissions at or above current rates would cause a further increase in global temperatures and many other climatic changes during the 21st century.

The best estimates for projected global temperature increases from the 1980s to the end of the 21st century range from 1.8°C (1.1 - 2.9°C) to 4°C (2.4 - 6.4°C) for the IPCC scenarios that do not consider additional mitigation measures apart from those already in place in 2000.

3.2 Global average sea level is expected to rise by 18 to 59 cm by the end of the 21st century. Warming is expected to be greatest over land and at high northern latitudes and smallest over the Southern Ocean and parts of the North Atlantic Ocean. Other projected changes include acidification of the oceans, reduced snow cover and sea ice, more frequent heat waves and heavy precipitation, more intense tropical cyclones, and slower oceanic currents.

3.3 Warming and sea level rise caused by human activities will continue for centuries, even if greenhouse gas concentrations were to be stabilized. If warming persists over many centuries, it could lead to a complete melting of the Greenland Ice sheet, increasing global sea levels by about 7m.

4. What impacts of climate change have already been observed?

Glaciers are melting in many places across the world.

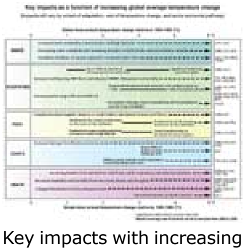
see also our Arctic Climate Change Digest [see https://www.greenfacts.org/en/arctic-climate-change/index.htm]

Regional climate change is already affecting many natural systems. For instance, it is increasingly being observed that snow and ice are melting and frozen ground is thawing, hydrological and biological systems are changing and in some cases being disrupted, migrations are starting earlier, and species' geographic ranges are shifting towards the poles.

Despite remaining gaps in knowledge, it is likely that these effects are linked to human influence on climate. At the regional level, however, responses to natural variability are difficult to separate from the effects of climate change.

Some previously unanticipated impacts of regional climate change are just starting to become apparent. For instance, melting glaciers can threaten mountain settlements and water resources, and damage associated with coastal flooding are increasing.

5. What impacts are expected in the future?



Key impacts with increasing temperatures
[see Annex 1, p. 8]

5.1 Over the course of the 21st century, many impacts are expected to occur in natural systems. For instance, changes in precipitation and the melting of ice and snow are expected to increase flood risks in some areas while causing droughts in others. If there is significant warming the capacity of ecosystems to adapt will be exceeded, with negative consequences such as an increased risk of extinction of species.

5.2 The most vulnerable people are in general the poor, since they have less capacity to adapt, and their livelihoods are often dependent on resources that are linked to climate.

5.3 Africa is found to be particularly vulnerable to climate change, because of existing pressures on its ecosystems and its low capacity to adapt. On all continents, water supply and the threat to coastal areas will be an issue. Overall future impacts are expected to be negative, although some positive effects are also expected initially, such as an increase in agricultural productivity at high latitudes accompanying a moderate warming, or decreased heating needs in cold regions.

5.4 Impacts will depend on the magnitude of the temperature increase. For instance, some crops at mid- to high latitudes will have higher productivity if local temperature increases by 1-3 °C, but will be negatively affected beyond that (see Table [see Annex 9, p. 15]). If higher temperatures persist after the 21st century it could result in very large impacts. For instance, the large sea-level rise that would result from the melting of the Greenland and Antarctic ice sheets would have major repercussions on coastal areas. The cost associated with the effects of climate change is projected to increase over time with rising temperatures.

5.5 A projected increase in the severity and frequency of droughts, heat waves, and other extreme weather events is expected to cause major impacts over the course of this century (see Table [see Annex 10, p. 15]).

6. How do people adapt to climate change?

Changes in consumption habits can help address climate change.

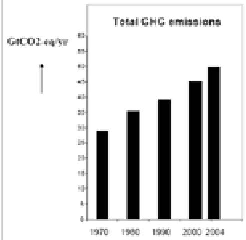
6.1 Humans need to adapt to the impacts of climate change, for instance through technological solutions such as coastal defences and changes in consumption habits. Humans are already adapting to climate change, and further adaptation efforts will be necessary during coming decades. However, adaptation alone is not expected to be able to cope will all projected effects since the options diminish and the costs increase with rising temperatures.

6.2 Vulnerability of human populations to climate change and its consequences can be affected by other factors, such as pollution, conflicts, or epidemics such as AIDS. An emphasis on sustainable development can help human societies reduce their vulnerability to climate change. However, climate change itself can become an impediment to their development.

6.3 Mitigation measures that aim to reduce greenhouse gases emissions can help avoid, reduce or delay impacts, and should be implemented in order to ensure that adaptation capacity is not exceeded.

7. What are the current trends in greenhouse gas emissions?

Global greenhouse gas emissions have grown markedly since pre-industrial times, with a 70% increase from 1970 to 2004 alone (see Figure [see Annex 6, p. 13]). Over this period, emissions from the transport and energy sectors have more than doubled. Policies put in place in some countries have been effective in reducing emissions in those countries to a certain degree, but not sufficiently to counteract the global growth in emissions.



Global greenhouse gas emissions
[see Annex 6, p. 13]
Source: IPCC

Without additional measures to mitigate climate change, global green house gas emissions will continue to grow over the coming decades and beyond. Most of this increase would come from developing countries, where per capita emissions are still considerably lower than those in developed countries.

8. What actions can be taken to reduce greenhouse gas emissions?

8.1 Mitigation measures to reduce greenhouse gas emissions have a certain cost. However, they also constitute an economic benefit by reducing the impacts of climate change, and the costs associated with them. In addition, they can bring economic benefits by reducing local air pollution and energy resource depletion.


Public transport can help reduce greenhouse gas emissions.
Source: GreenFacts

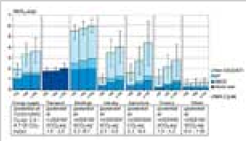
If the benefits of avoided climate change are taken into account and a “carbon price” is established for each unit of greenhouse gas emissions, this could create incentives for producers and consumers to significantly invest in products, technologies and processes which emit less greenhouse gases. The resulting mitigation potential is substantial and could offset the projected growth of global emissions over the coming decades or reduce emissions below current levels.

Mitigation measures could contribute to stabilizing the concentration of greenhouse gases in the atmosphere by 2100 or later. To achieve low stabilization levels, stringent mitigation efforts are needed in the coming decades. This could reduce global GDP by up to a few percent.

8.2 Changes in lifestyle and behaviours that favor resource conservation can contribute to climate change mitigation.

8.3 Mitigation measures can also have other benefits for society, such as health cost savings resulting from reduced air pollution. However, mitigation in one country or group of countries could lead to higher emissions elsewhere or effects on the global economy.

8.4 No one sector or technology can address the entire mitigation challenge. All sectors including buildings, industry, energy production, agriculture, transport, forestry, and waste management could contribute to the overall mitigation efforts, for instance through greater energy efficiency. Many technologies and processes which emit less greenhouse gases are already commercially available or will be in the coming decades.


Mitigation potential for different sectors as a function of carbon price
[see Annex 4, p. 11]

8.5 In order to stabilize the concentration of greenhouse gases in the atmosphere, emissions would have to stop increasing and then decline. The lower the stabilization level aimed for, the more quickly this decline would need to occur. World-wide investments in mitigation technologies, as well as research into new energy sources, will be necessary to achieve stabilization. Delaying emission reduction measures limits the opportunities to achieve low stabilization levels and increases the risk of severe climate change impacts.

9. How can governments create incentives for mitigation?

9.1 A wide variety of policy tools can be applied by governments to create incentives for mitigation action, such as regulation, taxation, tradable permit schemes, subsidies, and voluntary agreements. Past experience shows that there are advantages and drawbacks for any given policy instrument. For instance, while regulations and standards can provide some certainty about emission levels, they may not encourage innovations and more advanced technologies. Taxes and charges, however, can provide incentives, but cannot guarantee a particular level of emissions. It is important to consider the environmental impacts of policies and instruments, their cost effectiveness, institutional feasibility and how costs and benefits are distributed.

Although the impact of the Kyoto protocol’s first commitment period 2008-2012 on global carbon emissions is expected to be limited, it has allowed the establishment of a global response to the climate problem as well as the creation of an international carbon market and other mechanisms that may provide the foundation for future mitigation efforts.

9.2 Switching to more sustainable development paths can make a major contribution to climate change mitigation. Policies that contribute to both climate change mitigation and sustainable development include those related to energy efficiency, renewable energies, and conservation of natural habitats. In general, sustainable development can increase the capacity for adaptation and mitigation, and reduce vulnerability to the impacts of climate change.

10. Conclusion

Current warming trends are unequivocal. It is very likely that greenhouse gases released by human activities are responsible for most of the warming observed in the past fifty years. The warming is projected to continue and to increase over the course of the 21st century and beyond.

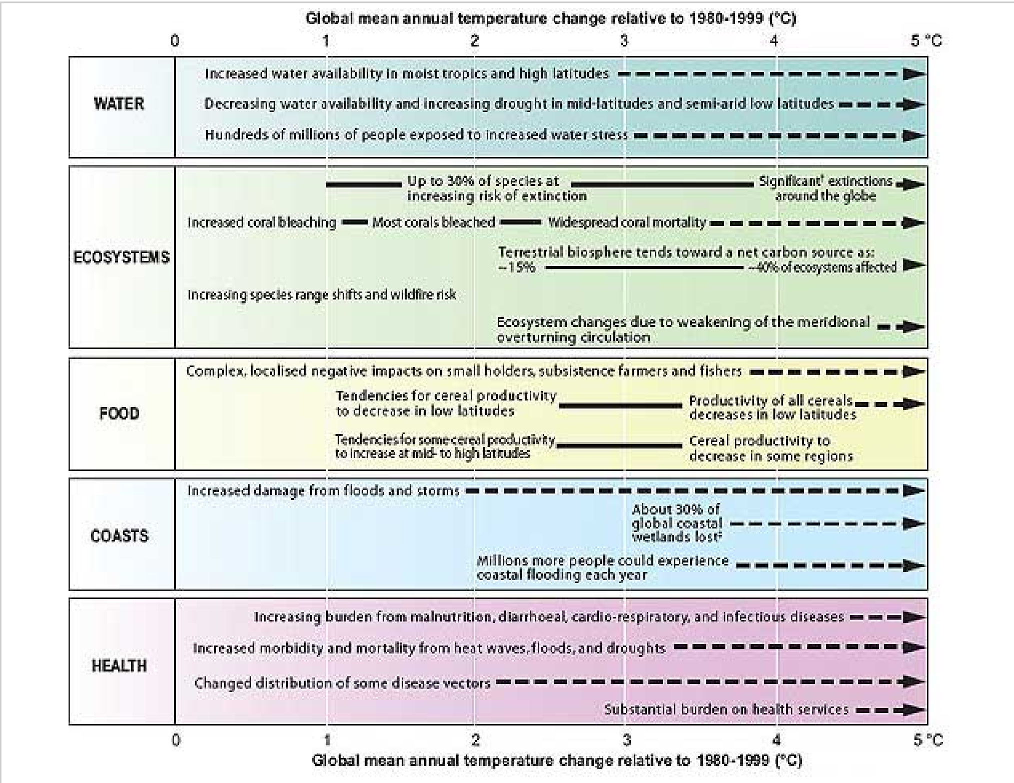
Climate change already has a measurable impact on many natural and human systems. Effects are projected to increase in the future and to be more severe with greater increases in temperature. Adaptation measures are already being implemented, and will be essential in order to address the projected consequences. There is, however, a limit to adaptation; mitigation measures will also be needed in order to reduce the severity of impacts.

Mitigation measures that aim to reduce greenhouse gas emissions can help avoid, reduce or delay many impacts of climate change. Policy instruments could create incentives for producers and consumers to significantly invest in products, technologies and processes which emit less greenhouse gases. Without new mitigation policies, global greenhouse gas emissions will continue to grow over the coming decades and beyond. Rapid world-wide investments and deployment of mitigation technologies, as well as research into new energy sources will be necessary to achieve a stabilization of the concentration of greenhouse gases in the atmosphere.

Additional research addressing gaps in knowledge would further reduce uncertainties and thus facilitate decision-making related to climate change.

Annex

Annex 1:
Figure SPM-2. (WGII) Key impacts as a function of increasing global average temperature change



The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature.

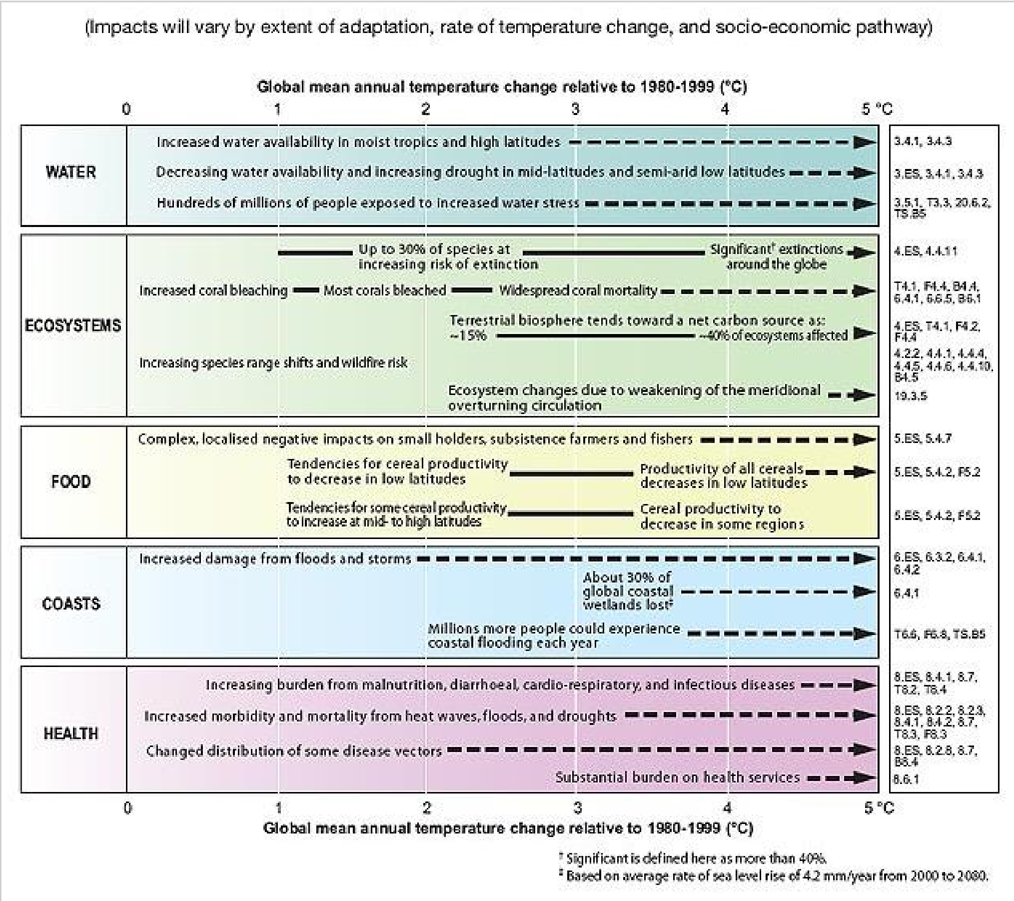
Entries are placed so that the left hand side of text indicates approximate onset of a given impact.

See full Figure SPM-2 (WGII) [see Annex 2, p. 9]

Source: based on IPCC Climate Change 2007: Impacts, Adaptation and Vulnerability, Summary for Policymakers (2007) [see http://www.gtp89.dial.pipex.com/spm.pdf], p16

Annex 2:

Figure SPM-2. (WGII) Key impacts as a function of increasing global average temperature change



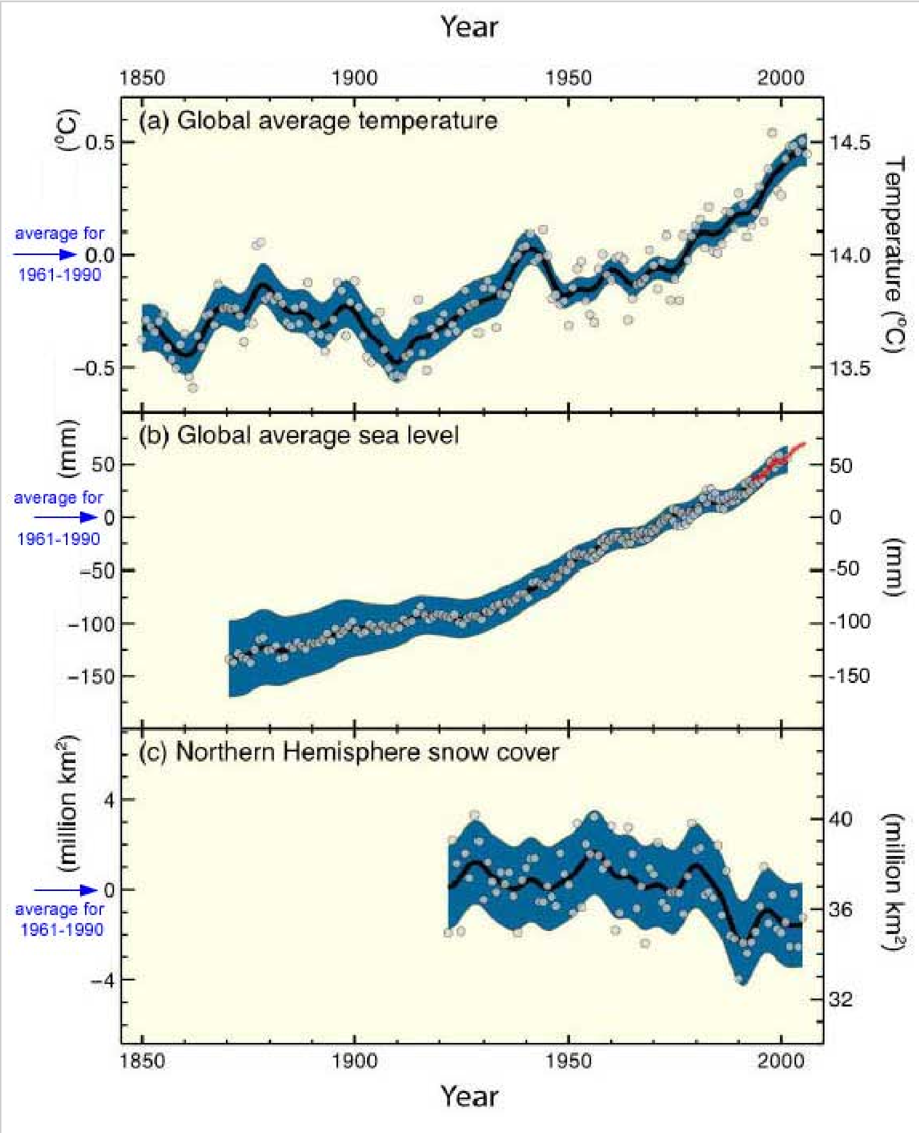
Illustrative examples of global impacts projected for climate changes (and sea-level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. [T20.7] The black lines link impacts, dotted arrows indicate impacts 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 (see Endbox 3). 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.

Source: IPCC Climate Change 2007: Impacts, Adaptation and Vulnerability, Summary for Policymakers (2007) [see http://www.gtp89.dial.pipex.com/spm.pdf], p16

Annex 3:

Figure SPM-3. (WGI) Changes in Temperatures, Sea Level and Snow Cover between 1850 and 2010

Observed changes in (a) global average surface temperature; (b) global average sea level rise from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All changes are relative to corresponding averages for the period 1961-1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c).



Source: based on IPCC Climate Change 2007: The Physical Science Basis, Summary for Policymakers (2007) [see http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm], p6

Annex 4:

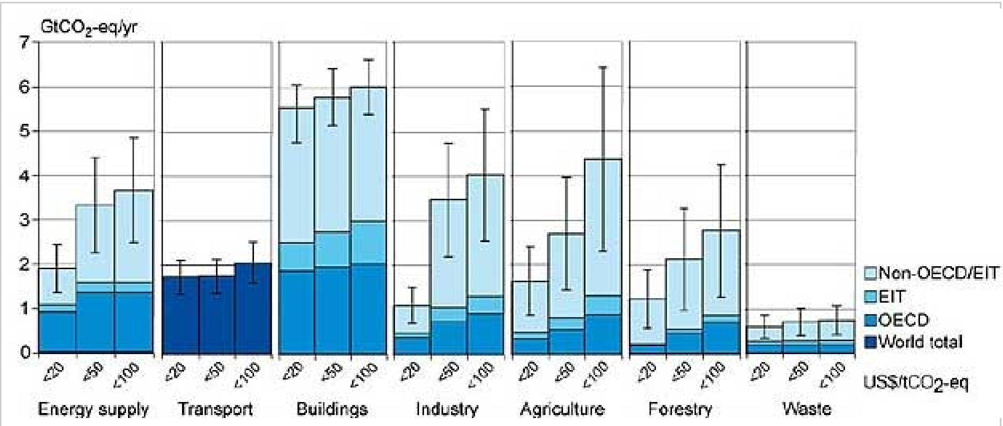
Figure SPM-6. (WGIII) Estimated economic mitigation potential in 2030 as a function of carbon price

Estimated sectoral economic potential for global mitigation for different regions as a function of carbon price in 2030 from bottom-up studies, compared to the respective baselines assumed in the sector assessments.

(GreenFacts note: The mitigation potential is expressed in Giga tonnes of CO_2 equivalent per year.
1 Giga tonne = 1 000 000 000 tonnes.

The economic mitigation potential for a “carbon price” of up to 20 USD, up to 50 USD and up to 100 USD was considered for each sector

EIT stands for Economies in Transition and refers to countries of the former Soviet bloc which are transitioning to a market economy. OECD stands for the 30 Member countries of the Organization for Economic Cooperation and Development.)



See detailed Figure SPM-6 (WGIII) [see Annex 5, p. 12]

Source: IPCC Climate Change 2007: "Mitigation, Summary for Policymakers" [see http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm], p11

Annex 5:

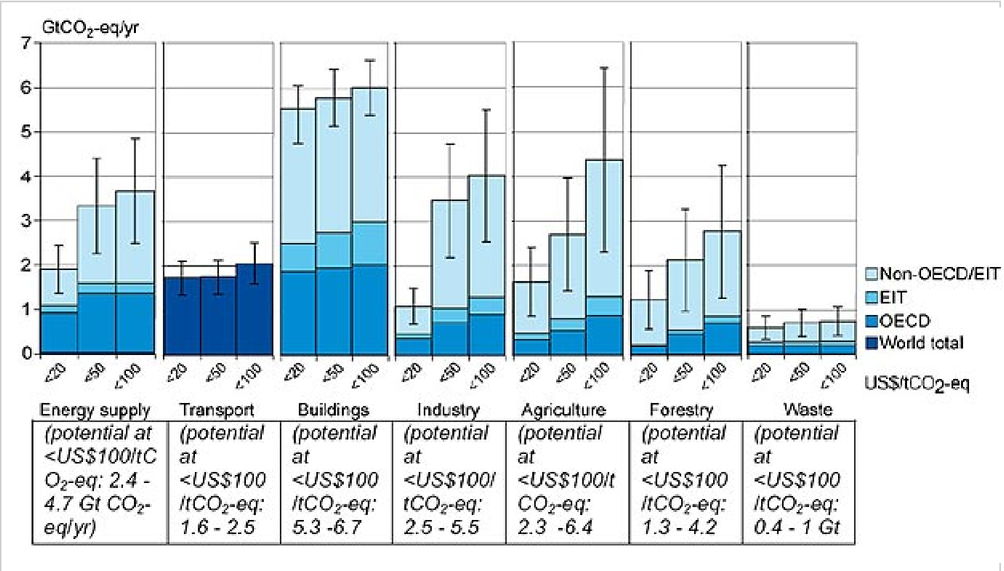
Figure SPM-6. (WGIII) Estimated economic mitigation potential in 2030 as a function of carbon price

Estimated sectoral economic potential for global mitigation for different regions as a function of carbon price in 2030 from bottom-up studies, compared to the respective baselines assumed in the sector assessments. A full explanation of the derivation of this figure is found in 11.3.

(GreenFacts note: The mitigation potential is expressed in Giga tonnes of CO_2 equivalent per year.

1 Giga tonne = 1 000 000 000 tonnes.

The economic mitigation potential for a “carbon price” of up to 20 USD, up to 50 USD and up to 100 USD was considered for each sector)

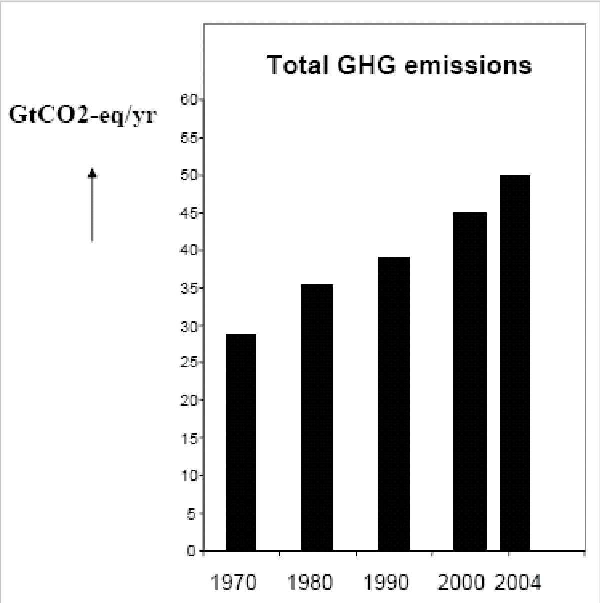


Source: IPCC Climate Change 2007: "Mitigation, Summary for Policymakers" [see http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm], p11

Annex 6:
Global greenhouse gas emissions 1970-2004

Expressed in Giga tonnes of CO_2 equivalent per year which includes different greenhouse gases scaled using global warming potentials.

(Note: 1 Giga tonne = 1 000 000 000 tonnes)



See detailed Figure SPM-1 (WGIII) [see Annex 7, p. 14]

Source: IPCC www.ipcc.ch/WG3_press_presentation.pdf [see http://www.ipcc.ch/WG3_press_presentation.pdf]

Annex 7:
Figure SPM-1. (WGIII) Emissions of different greenhouse gases 1970-2004

(GreenFacts note: Emissions are expressed in Giga tonnes of CO_2 equivalent per year which scales emissions using global warming potentials (GWPs).

1 Giga tonne = 1 000 000 000 tonnes)

100 year GWPs from IPCC 1996 (SAR) were used to convert emissions to CO_2-eq. (cf. UNFCCC reporting guidelines). CO_2, CH4, N2O, HFCs, PFCs and SF6 from all sources are included.

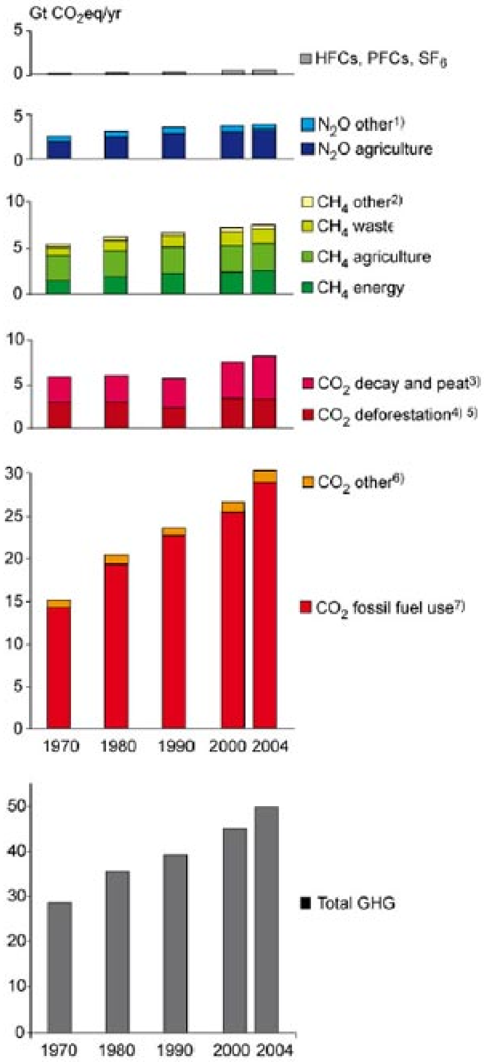


Figure SPM 1: Global Warming Potential (GWP) weighted global greenhouse gas emissions

Source: IPCC Climate Change 2007: IPCC Climate Change 2007: "Mitigation, Summary for Policymakers" (2007) [see http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm], p4

Annex 8:
Likelihood

In this Summary for Policymakers, the following terms have been used to indicate the assessed likelihood, using expert judgement, of an outcome or a result:

Terms	Probability of occurrence
Virtually certain	> 99%
Extremely likely	> 95%
Very likely	> 90%
Likely	> 66%
More likely than not	> 50%
Unlikely	< 33%
Very unlikely	< 10%
Extremely unlikely	< 5%

Source & © IPCC Climate Change 2007:
The Physical Science Basis, Summary for Policymakers (2007) [see http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm], p4

Annex 9:

Table SPM-1. (WGI) Observed rate of sea level rise and estimated contributions from different sources.

Source of sea level rise	Rate of sea level rise (mm per year)	
	1961 – 2003	1993 – 2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland ice sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic ice sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	**1.1 ± 0.5**	**2.8 ± 0.7**
Observed total sea level rise	1.8 ± 0.5[a]	3.1 ± 0.7[a]
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0

Table note:
[a] Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.

Source: IPCC Climate Change 2007: The Physical Science Basis, Summary for Policymakers (2007) [see http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm], p7

Annex 10:

Table SPM-2. (WGIII) Global economic mitigation potential in 2030 estimated from top-down studies.

Carbon price	Economic potential	Reduction relative to SRES A1 B (68 $GtCO_2$-eq/yr)	Reduction relative to SRES B2 (49 $GtCO_2$-eq/yr)
(US$/t$CO_2$-eq)	($GtCO_2$-eq/yr)	(%)	(%)
20	9-18	13-27	18-37
50	14-23	21-34	29-47
100	17-26	25-38	35-53

(GreenFacts note: The mitigation potential is expressed in Giga tonnes of CO_2 equivalent per year.
1 Giga tonne = 1 000 000 000 tonnes)

Source: IPCC Climate Change 2007: "Mitigation, Summary for Policymakers" [see http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm], p9

Partners for this publication

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