

- **Risks to unique and threatened systems.** There is new and stronger evidence of observed impacts of climate change on unique and vulnerable systems (such as polar and high mountain communities and ecosystems), with increasing levels of adverse impacts as temperatures increase further. An increasing risk of species extinction and coral reef damage is projected with higher confidence than in the TAR as warming proceeds. There is *medium confidence* that approximately 20-30% of plant and animal species assessed so far are *likely* to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C over 1980-1999 levels. Confidence has increased that a 1-2°C increase in global mean temperature above 1990 levels (about 1.5-2.5°C above pre-industrial) poses significant risks to many unique and threatened systems including many biodiversity hotspots. Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1-3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals. Increasing vulnerability of indigenous communities in the Arctic and small island communities to warming is projected.
- **Risks of extreme weather events.** Responses to some recent extreme events reveal higher levels of vulnerability than the TAR. There is now higher confidence in the projected increases in droughts, heatwaves, and floods as well as their adverse impacts.
- **Distribution of impacts and vulnerabilities.** There are sharp differences across regions and those in the weakest economic position are often the most vulnerable to climate change. There is increasing evidence of greater vulnerability of specific groups such as the poor and elderly in not only developing but also developed countries. Moreover, there is increased evidence that low-latitude and less-developed areas generally face greater risk, for example in dry areas and mega-deltas.
- **Aggregate impacts.** Compared to the TAR, initial net market-based benefits from climate change are projected to peak at a lower magnitude of warming, while damages would be higher for larger magnitudes of warming. The net costs of impacts of increased warming are projected to increase over time.
- **Risks of large-scale singularities.** There is *high confidence* that global warming over many centuries would lead to a sea level rise contribution from thermal expansion alone which is projected to be much larger than observed over the 20th century, with loss of coastal area and associated impacts. There is better understanding than in the TAR that the risk of additional contributions to sea level rise from both the Greenland and possibly Antarctic ice sheets may be larger than projected by ice sheet models and could occur on century time scales. This is because ice dynamical processes seen in recent observations but not fully included in ice sheet models assessed in AR4 could increase the rate of ice loss.

There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change. {5.3}

Adaptation is necessary in the short and longer term to address impacts resulting from the warming that would occur even for the lowest stabilisation scenarios assessed. There are barriers, limits and costs, but these are not fully understood. Unmitigated climate change would, in the long term, be *likely* to exceed the capacity of natural, managed and human systems to adapt. The time at which such limits could be reached will vary between sectors and regions. Early mitigation actions would avoid further locking in carbon intensive infrastructure and reduce climate change and associated adaptation needs. {5.2, 5.3}

Many impacts can be reduced, delayed or avoided by mitigation. Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts. {5.3, 5.4, 5.7}

In order to stabilise the concentration of GHGs in the atmosphere, emissions would need to peak and decline thereafter. The lower the stabilisation level, the more quickly this peak and decline would need to occur.²⁰ {5.4}

²⁰ For the lowest mitigation scenario category assessed, emissions would need to peak by 2015 and for the highest by 2090 (see Table SPM.3). Scenarios that use alternative emission pathways show substantial differences in the rate of global climate change.

Table SPM.6 and Figure SPM.11 summarise the required emission levels for different groups of stabilisation concentrations and the resulting equilibrium global warming and long-term sea level rise due to thermal expansion only.²¹ The timing and level of mitigation to reach a given temperature stabilisation level is earlier and more stringent if climate sensitivity is high than if it is low. {5.4, 5.7}

Sea level rise under warming is inevitable. Thermal expansion would continue for many centuries after GHG concentrations have stabilised (for any of the stabilisation levels assessed), causing an eventual sea level rise much larger than projected for the 21st century. The eventual contributions from Greenland ice sheet loss could be several metres, and larger than from thermal expansion, should warming in excess of 1.9-4.6°C above pre-industrial be sustained over many centuries. The long time scales of thermal expansion and ice sheet response to warming imply that stabilisation of GHG concentrations at or above present levels would not stabilise sea level for many centuries. {5.3, 5.4}

Table SPM.6. Characteristics of post-TAR stabilisation scenarios and resulting long-term equilibrium global average temperature and the sea level rise component from thermal expansion only. (Table 5.1^a)

| Category | CO ₂ concentration at stabilization (2005 = 379 ppm) ^(b) | CO ₂ -equivalent concentration at stabilization including GHGs and aerosols (2005 = 375 ppm) ^(b) | Peaking year for CO ₂ emissions ^(a,c) | Change in global CO ₂ emissions in 2050 (% of 2000 emissions) ^(a,c) | Global average temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity ^(d,e) | Global average sea level rise above pre-industrial at equilibrium from thermal expansion only ^(f) | Number of assessed scenarios |
|----------|--|--|---|---|---|--|------------------------------|
| | ppm | ppm | Year | Percent | °C | metres | |
| I | 350 – 400 | 445 – 490 | 2000 – 2015 | -85 to -50 | 2.0 – 2.4 | 0.4 – 1.4 | 6 |
| II | 400 – 440 | 490 – 535 | 2000 – 2020 | -60 to -30 | 2.4 – 2.8 | 0.5 – 1.7 | 18 |
| III | 440 – 485 | 535 – 590 | 2010 – 2030 | -30 to +5 | 2.8 – 3.2 | 0.6 – 1.9 | 21 |
| IV | 485 – 570 | 590 – 710 | 2020 – 2060 | +10 to +60 | 3.2 – 4.0 | 0.6 – 2.4 | 118 |
| V | 570 – 660 | 710 – 855 | 2050 – 2080 | +25 to +85 | 4.0 – 4.9 | 0.8 – 2.9 | 9 |
| VI | 660 – 790 | 855 – 1130 | 2060 – 2090 | +90 to +140 | 4.9 – 6.1 | 1.0 – 3.7 | 5 |

Notes:

- The emission reductions to meet a particular stabilization level reported in the mitigation studies assessed here might be underestimated due to missing carbon cycle feedbacks (see also Topic 2).
- Atmospheric CO₂ concentrations were 379 ppm in 2005. The best estimate of total CO₂-eq concentration in 2005 for all long-lived GHGs is about 455 ppm, while the corresponding value including the net effect of all anthropogenic forcing agents is 375 ppm CO₂-eq.
- Ranges correspond to the 15th to 85th percentile of the post-TAR scenario distribution. CO₂ emissions are shown so multi-gas scenarios can be compared with CO₂-only scenarios (see Figure SPM.3).
- The best estimate of climate sensitivity is 3°C.
- Note that global average temperature at equilibrium is different from expected global average temperature at the time of stabilization of GHG concentrations due to the inertia of the climate system. For the majority of scenarios assessed, stabilisation of GHG concentrations occurs between 2100 and 2150 (see also Footnote 9).
- Equilibrium sea level rise is for the contribution from ocean thermal expansion only and does not reach equilibrium for at least many centuries. These values have been estimated using relatively simple climate models (one low resolution AOGCM and several EMICs based on the best estimate of 3°C climate sensitivity) and do not include contributions from melting ice sheets, glaciers and ice caps. Long-term thermal expansion is projected to result in 0.2 to 0.6 m per degree Celsius of global average warming above pre-industrial. (AOGCM refers to Atmosphere Ocean General Circulation Models and EMICs to Earth System Models of Intermediate Complexity.)

²¹ Estimates for the evolution of temperature over the course of this century are not available in the AR4 for the stabilisation scenarios. For most stabilisation levels global average temperature is approaching the equilibrium level over a few centuries. For the much lower stabilisation scenarios (category I and II, Figure SPM.11), the equilibrium temperature may be reached earlier.

CO₂ emissions and equilibrium temperature increases for a range of stabilisation levels

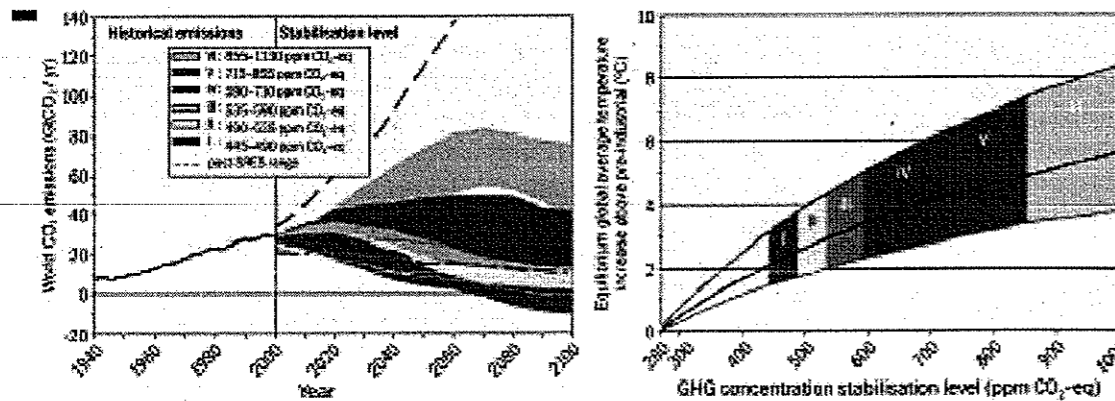


Figure SPM.11. Global CO₂ emissions for 1940 to 2000 and emissions ranges for categories of stabilisation scenarios from 2000 to 2100 (left-hand panel); and the corresponding relationship between the stabilisation target and the likely equilibrium global average temperature increase above pre-industrial (right-hand panel). Approaching equilibrium can take several centuries, especially for scenarios with higher levels of stabilisation. Coloured shadings show stabilisation scenarios grouped according to different targets (stabilisation category I to VI). Right-hand panel shows ranges of global average temperature change above pre-industrial, using (i) "best estimate" climate sensitivity of 3°C (black line in middle of shaded area), (ii) upper bound of likely range of climate sensitivity of 4.5°C (red line at top of shaded area) (iii) lower bound of likely range of climate sensitivity of 2°C (blue line at bottom of shaded area). Black dashed lines in the left panel give the emissions range of recent baseline scenarios published since the SRES (2000). Emissions ranges of the stabilisation scenarios comprise CO₂-only and multigas scenarios and correspond to the 10th-90th percentile of the full scenario distribution. Note: CO₂ emissions in most models do not include emissions from decay of above ground biomass that remains after logging and deforestation, and from peat fires and drained peat soils. {Figure 5.1}

There is high agreement and much evidence that all stabilisation levels assessed can be achieved by deployment of a portfolio of technologies that are either currently available or expected to be commercialised in coming decades, assuming appropriate and effective incentives are in place for their development, acquisition, deployment and diffusion and addressing related barriers. {5.5}

All assessed stabilisation scenarios indicate that 60-80% of the reductions would come from energy supply and use, and industrial processes, with energy efficiency playing a key role in many scenarios. Including non-CO₂ and CO₂ land-use and forestry mitigation options provides greater flexibility and cost-effectiveness. Low stabilisation levels require early investments and substantially more rapid diffusion and commercialisation of advanced low-emissions technologies.

Without substantial investment flows and effective technology transfer, it may be difficult to achieve emission reduction at a significant scale. Mobilizing financing of incremental costs of low-carbon technologies is important. {5.5}

The macro-economic costs of mitigation generally rise with the stringency of the stabilisation target (Table SPM.7). For specific countries and sectors, costs vary considerably from the global average.²² {5.6}

In 2050, global average macro-economic costs for mitigation towards stabilisation between 710 and 445ppm CO₂-eq are between a 1% gain and 5.5% decrease of global GDP (Table SPM.7). This corresponds to slowing average annual global GDP growth by less than 0.12 percentage points. {5.6}

²² See footnote 17 for more detail on cost estimates and model assumptions.

Table SPM.7. Estimated global macro-economic costs in 2030 and 2050. Costs are relative to the baseline for least-cost trajectories towards different long-term stabilisation levels. {Table 5.2}

| Stabilisation levels (ppm CO ₂ -eq) | Median GDP reduction ^(a) (%) | | Range of GDP reduction ^(b) (%) | | Reduction of average annual GDP growth rates (percentage points) ^(c) | |
|--|---|------|---|------------------------|---|--------|
| | 2030 | 2050 | 2030 | 2050 | 2030 | 2050 |
| 445 – 535 ^(d) | Not available | | < 3 | < 5.5 | < 0.12 | < 0.12 |
| 535 – 590 | 0.6 | 1.3 | 0.2 to 2.5 | slightly negative to 4 | < 0.1 | < 0.1 |
| 590 – 710 | 0.2 | 0.5 | -0.6 to 1.2 | -1 to 2 | < 0.06 | < 0.05 |

Notes: Values given in this table correspond to the full literature across all baselines and mitigation scenarios that provide GDP numbers.

- a) Global GDP based on market exchange rates.
- b) The 10th and 90th percentile range of the analysed data are given where applicable. Negative values indicate GDP gain. The first row (445-535 ppm CO₂-eq) gives the upper bound estimate of the literature only.
- c) The calculation of the reduction of the annual growth rate is based on the average reduction during the assessed period that would result in the indicated GDP decrease by 2030 and 2050 respectively.
- d) The number of studies is relatively small and they generally use low baselines. High emissions baselines generally lead to higher costs.
- e) The values correspond to the highest estimate for GDP reduction shown in column three.

Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity, and attitudes to risk. {5.1}

Impacts of climate change are very likely to impose net annual costs which will increase over time as global temperatures increase. Peer-reviewed estimates of the social cost of carbon in 2005 average US\$12 per tonne of CO₂, but the range from 100 estimates is large (-\$3 to \$95/tCO₂). This is due in large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates. Aggregate estimates of costs mask significant differences in impacts across sectors, regions and populations and very likely underestimate damage costs because they cannot include many non-quantifiable impacts. {5.7}

Limited and early analytical results from integrated analyses of the costs and benefits of mitigation indicate that they are broadly comparable in magnitude, but do not as yet permit an unambiguous determination of an emissions pathway or stabilisation level where benefits exceed costs. {5.7}

Climate sensitivity is a key uncertainty for mitigation scenarios for specific temperature levels.

Choices about the scale and timing of GHG mitigation involve balancing the economic costs of more rapid emission reductions now against the corresponding medium-term and long-term climate risks of delay. {5.4}

²³ Net economic costs of damages from climate change aggregated across the globe and discounted to the specified year.