Topic 5 – The long-term perspective: scientific and socio-economic aspects relevant to adaptation and mitigation, consistent with the objectives and provisions of the Convention, and in the context of sustainable development

(31 August 2007)

5.1 Risk management perspective

Decision-making about responding to climate change involves an iterative risk management process that includes both mitigation and adaptation, taking into account actual and avoided climate change impacts, co-benefits, sustainability, equity, and attitudes to risk. {WGII 20. 9, SPM; WGIII SPM}

Risk management techniques can explicitly accommodate sectoral, regional, and temporal diversity, but their application requires information about not only impacts resulting from the most likely climate scenarios, but also impacts arising from lower-probability but higher-consequence events and the consequences of proposed policies and measures. Risk is defined here as the product of likelihood and consequence. Climate change impacts depend on the characteristics of natural and human systems, their development pathways, and their specific locations. {SYR 3.3, Figure 3.5; WGII 20.2, 20.9, SPM; WGIII 3.5, 3.6, SPM}

Key Vulnerabilities and Article 2 of the UNFCCC

Article 2 of the UNFCCC states:

"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Determining what constitutes "dangerous anthropogenic interference" involves value judgements, and its interpretation varies across the globe and evolves with changes in scientific knowledge, social values, development status, political priorities and the potential to adapt. Science can facilitate informed decisions by offering explicit criteria for judging which vulnerabilities might be labeled "key" in this context. {SYR 3.3, WGII 19.ES}

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. Sharp differences across regions are evident from this assessment of key vulnerabilities. They show that those in the weakest economic and/or political position are frequently the most susceptible to climate-related damages, especially when they face multiple stresses. {WGII 19.ES, 20.ES, SPM}

5.2 Key vulnerabilities, impacts and risks – long term perspectives

The "reasons for concern" identified in the TAR are now stronger due to: (1) better understanding of the magnitude of impacts and risks associated with increases in global average temperature and GHG concentrations, including vulnerability to present-day climate variability, (2) more precise identification of especially vulnerable systems, sectors, groups and regions, and (3) growing evidence that the risk of very large impacts on multiple century time scales would continue to increase as long as GHG concentrations and temperature continue to increase. {WGII 4.4, 5.4, 19.ES, 19.3.7, TS.4.6; WGIII 3.5, SPM}

The TAR found that vulnerability is a function of exposure and sensitivity. Adaptation can influence sensitivity to climate change while mitigation can influence the rate and extent of climate change and hence exposure. Both conclusions are confirmed in this assessment. {WGII 20.2, 20.7.3}

No single metric can adequately describe the diversity of key vulnerabilities or support their ranking. A sample of relevant impacts is provided in Figure 3.5. The estimation of key vulnerabilities in any system, and damage implied, will depend on the rate and magnitude of climate change and development status, which also determines adaptive capacity.[19] Some key vulnerablities may be linked to thresholds that cause a system to shift from one state to another, while others have thresholds that are defined subjectively. {WGII 19.ES, 19.1}

The five "reasons for concern" that were identified in the TAR were intended to synthesise information on climate risks and key vulnerabilities and to "aid readers in making their own determination" about risk. These remain a viable framework to consider key vulnerabilities, and they have been updated in the AR4. {TAR WGII Chapter 19; WGII SPM}

Risks to unique and threatened systems. There is new and much stronger evidence of the adverse impacts of observed climate change to date on several unique and threatened systems, consistent with the expected effects of warming. Confidence has increased that a 1-2°C increase in global average temperature above 1980-1999 levels (about 1.5-2.5°C above pre-industrial) poses significant risks to many unique and threatened systems, including many biodiversity hotspots. For global average temperature increases above 1.5-2.5°C above 1980-1999 levels, predominantly negative effects on biodiversity are projected, with significant extinctions for warming over 4°C and widespread coral reefs mortality over 2.5-3.0°C. {SYR 3.3, 3.4, Figure 3.5, Table 3.2; WGII 4.4, 6.4, Figure TS.12, Figure TS.14, 19.3.7}

Risks of extreme weather events. Recent extreme climate events have exposed a higher vulnerability in both developing and developed countries than was assessed in the TAR. As summarised in Table 3.2, changes in extreme events (such as drought, heat-waves and tropical cyclones) are projected in many regions and would have mostly adverse impacts, including increased water stress and wild fire frequency, adverse effects on food production, adverse health effects, increased flood risk and extreme high sea level, and damage to infrastructure. {SYR 3.2, 3.3, Table 3.2; WGI 10.3, Table SPM.2; WGII 1.3, 5.4, 7.1, 7.5, 8.2, 12.6, 19.3, Table 19.1, Table SPM.1}

---

[19] WGII identifies seven criteria from the literature that are often used to identify key vulnerabilities; they are listed in topic 3.3.1. {WGII 19.2}

Distribution of impacts and vulnerabilities. Substantial improvements have occurred in the prediction of regional patterns of climate change (see topic 3.2) and in the projections of regional impacts, enabling better identification of particularly vulnerable systems, sectors and regions (see topic 3.3). For example, observed adverse impacts of climate change on Arctic indigenous communities and natural ecosystems are projected to increase with warming. New studies confirm that Africa is one of the most vulnerable continents because of the range of projected impacts, multiple stresses and low adaptive capacity. Substantial risks due to sea level rise are projected particularly for Asian megadeltas and for small-island communities. {SYR 3.2, 3.3, 5.4; WGI 11.2-11.7, SPM; WGII 3.4.3, 5.3, 5.4, 9.ES, Table 10.9, 10.6, 16.3, 19.3, Table 19.1, TS.5.4, Tables TS.3 and TS.4}

Net aggregate impacts. There is some evidence that initial market benefits from climate change will peak at a lower magnitude and sooner than was assessed in the TAR. Aggregate impacts have also been quantified in other metrics (see topic 3.3): for example, climate change over the next century could adversely affect hundreds of millions of people through increased likelihood of coastal flooding, reductions in water supplies, increased likelihood of malnutrition and increased exposure to health impacts. {SYR 3.3, Figure 3.5; WGII 19.3.7, 20.7.3, TS.5.3}

Risks of large scale singularities: abrupt or irreversible changes.[20] As discussed in topic 3.4, during the current century, a large-scale abrupt change in the MOC is *very unlikely*. Ice sheet models project a gradual widespread loss of ice from the Greenland ice sheet if warming were to be sustained for millennia. There is, nonetheless, a risk that larger sea level contributions from both the Greenland and Antarctic ice sheets could occur on century time scales, because ice dynamical processes not included in current ice sheet models, but seen in recent observations, could increase the rate of ice loss. Complete deglaciation of the Greenland ice sheet would raise sea level by 7 m over millennia and could be irreversible. {SYR 3.4; WGI 10.3, Box 10.1; WGII 4.ES, 4.4, Box 4.3, 19.3.7, SPM}

5.3 Adaptation and mitigation

There is *high confidence* that neither adaptation nor mitigation alone can avoid significant climate change impacts. Adaptation is necessary both in the short term and in the longer term, even for the lowest stabilisation scenarios assessed, but there are significant barriers, limits and costs. However, adaptation and mitigation can complement each other and together can significantly reduce the risks of climate change. {WGII 4.ES, TS 5.1, 18.4, 18.6, 20.7, SPM; WGIII 1.2, 2.5, 3.5, 3.6}

Adaptation will be ineffective in some cases (such as for biodiversity and natural ecosystems e.g. loss of Arctic sea ice and polar bear ecosystem viability, disappearance of mountain glaciers that play vital roles in water storage and supply, or adaptation to sea level rise of several metres[21]) and less feasible or very costly in many cases for the projected climate change beyond the next several decades (such as deltaic regions and estuaries). The adaptive capacity

---

[20] Singularities are defined in the AR4 as the property of something which may behave irregularly, abruptly, non-linearly or in a discontinuous manner in response to smoothly changing driving forces, which is broadly consistent with the TAR. For further discussion refer to TAR WGII 19.6.

[21] While it is technically possible to adapt to several metres of sea level rise, the resources required are so unevenly distributed that in reality this risk is outside the scope of adaptation. {WGII 17.4.2, 19.4.1}

of natural ecosystems is limited and there is *high confidence* that the ability of many ecosystems to adapt naturally is *likely* to be exceeded this century. In addition, multiple barriers and constraints to effective adaptation exist in human systems (see topic 4.2). {SYR 4.2; WGII 17.4.2, 19.2, 19.4.1}

Reliance on adaptation alone could eventually lead to a magnitude of climate change to which effective adaptation is not possible, or will only be available at very high social, environmental and economic costs. {WGII 18.1}

Efforts to mitigate GHG emissions to reduce the rate and magnitude of climate change need to account for inertia in the climate and socio-economic systems. {SYR 3.2; WGI 10.3, 10.4, 10.7, SPM; WGIII 2.3.4}

After GHG concentrations are stabilised, the rate at which the global average temperature increases is expected to slow within a few decades, assuming the absence of substantial carbon cycle and methane feedbacks. Small increases in global average temperature could still be expected for several centuries. Sea level rise from thermal expansion would continue for many centuries at a rate that eventually decreases from that reached before stabilisation due to ongoing heat uptake by oceans. The eventual contribution from Greenland ice sheet loss, should global temperature increases in excess of 1.9-4.6^{o}C above pre-industrial be sustained over many centuries, could be much larger than from thermal expansion. {SYR 3.2, WGI 10.3, 10.4, 10.7, SPM}

The extent to which risks of major impacts on vulnerable systems can be reduced, avoided or delayed in the long term depends on the scale of mitigation effort and investments over the next two to three decades. Even though benefits of mitigation measures in terms of avoided climate change would take several decades to materialise, mitigation actions begun in the short term would avoid locking in both long-lived carbon intensive infrastructure and development pathways, reduce the rate of climate change and reduce the adaptation needs associated with higher levels of warming. {WGII 18.4, 20.6, 20.7, SPM; WGIII 2.3.4, 3.4, 3.5, 3.6, SPM}

5.4 Emission trajectories for stabilisation

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 (Figure 5.1). {WGIII 3.3, 3.5, SPM}

Advances in modelling since the TAR permit the assessment of multi-gas mitigation strategies for exploring the attainability and costs for achieving stabilisation of GHG concentrations. These scenarios explore a wider range of future scenarios, including lower levels of stabilisation, than reported in the TAR. {WGIII 3.3, 3.5, SPM}

Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels (Table 5.1 and Figure 5.1). {WGIII 3.5, SPM}

Table 5.1 summarises the required emission levels for different groups of stabilisation concentrations and the associated equilibrium global average temperature increase, using the ‘best estimate’ of climate sensitivity (see Figure 5.1 for the *likely* range of uncertainty).

Stabilisation at lower concentration and related equilibrium temperature levels advances the date when emissions need to peak, and requires greater emissions reductions by 2050.[22] Climate sensitivity is a key uncertainty for risk management and, in particular, for mitigation scenarios that aim to meet specific temperature levels. If climate sensitivity is high, then the timing and level of mitigation is earlier and more stringent than if it is low. {WGIII 3.3, 3.4, 3.5, 3.6, SPM}

Table 5.1. Characteristics of post-TAR stabilisation scenarios. {WGI 10.7; WGIII Table TS.2, Table 3.10, Table SPM.5}

Category	CO_2 concentration (a)	CO_2-equivalent concentration (a)	Peaking year for CO_2 emissions (b)	Change in global CO_2 emissions in 2050 (% of 2000 emissions) (b)	Global average temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity (c), (d)	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only (e)	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:

a) Atmospheric CO_2 concentrations have increased by about 100 ppm since pre-industrial times, reaching 379 ppm in 2005. The best estimate of total CO_2-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 CO_2-eq. {WGI 2.3.1, Table 2.12}

b) Ranges correspond to the 15th to 85th percentile of the post-TAR scenario distribution. CO_2 emissions are shown so multi-gas scenarios can be compared with CO_2-only scenarios.

c) The best estimate of climate sensitivity is 3°C. {WGI SPM}

d) Global average temperature at equilibrium is different from expected global average temperature at the time of stabilisation 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.

e) Equilibrium sea level rise is for the contribution from 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 ice sheets, glaciers and ice caps. Long-term thermal expansion is projected to result in 0.2 to 0.6 m per degree of global average warming above present temperatures.

Thermal expansion of the ocean will cause, for any of the assessed GHG concentration levels, a continuing sea level rise that is much larger than that projected for the 21st century (Table 5.1). If GHG and aerosol concentrations had been stabilised at year 2000 levels, thermal expansion alone would be expected to lead to further sea level rise of 0.3-0.8 m. These long-term

---

[22] Estimates for transient 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 with overshoot of GHG concentrations above the stabilisation level (category I and II, Figure 5.1), the equilibrium temperature may be reached earlier.

consequences could have major implications for world coastlines, and they do not include contributions from ice sheets, glaciers, or ice caps. The long time scale response of thermal expansion and ice sheets implies that mitigation strategies that seek to stabilise GHG concentrations (or radiative forcing) at or above present levels do not stabilise sea level for more than a millennium. {WG1 10.7}

Gobal CO_2 emission pathways and equilibrium temperatures for a range of stabilisation scenarios

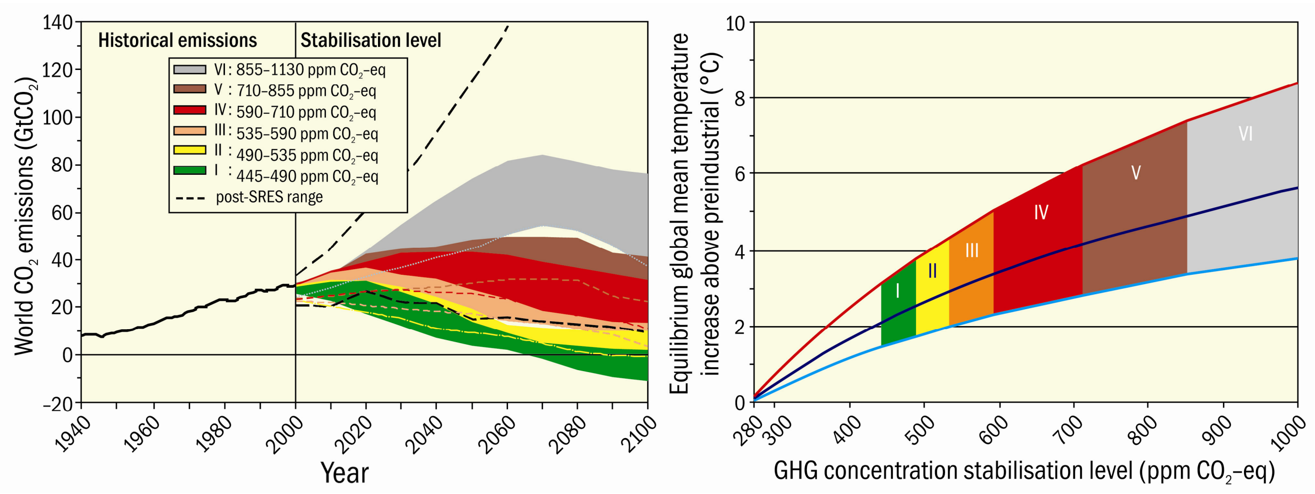


Figure 5.1. Global CO_2 emissions for 1940 to 2000 and emissions ranges for groups of stabilisation scenarios from 2000 to 2100 (left-hand panel); and the corresponding relationship between the stabilisation target and the likely equilibrium global average temperature increase above pre-industrial (right-hand 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 post-SRES baseline scenarios. Emissions ranges of the stabilisation scenarios correspond to the 10th-90th percentile of the full scenario distribution. {Figures SPM.7 and SPM.8}

Feedbacks between the carbon cycle and climate change affect the required mitigation and adaptation response to climate change. Climate-carbon cycle coupling is expected to increase the fraction of anthropogenic emissions that remains in the atmosphere as the climate system warms (see topic 2.3 and 3.2.1), but mitigation studies have not yet incorporated the full range of these feedbacks. As a consequence, the emission reductions to meet a particular stabilisation level reported in the mitigation studies assessed in Table 5.1 might be underestimated. Based on current understanding of climate-carbon cycle feedbacks, model studies suggest that stabilising CO_2 concentrations at, for example, 450 ppm[23], could require that cumulative emissions over the 21st century be reduced from approximately 2460 [2310 to 2600] $GtCO_2$ to approximately 1800 [1370 to 2200] $GtCO_2$. {SYR 2.3, 3.2.1; WGI 7.3, 10.4, SPM}

---

[23] Based on the range of multigas scenarios reviewed such a CO_2 concentration scenario would involve substantial emissions of other GHGs raising the overall radiative forcing to about 550 ppm CO_2-eq. To stabilise at 1000 ppm CO_2 (which with other GHGs emissions in multigas scenarios would correspond to about 1800 ppm CO_2-eq.) this feedback could require that cumulative emissions be reduced from a model average of approximately 5190 [4910 to 5460] $GtCO_2$ to approximately 4030 [3590 to 4580] $GtCO_2$. {WGI 7.3, 10.4, SPM}

5.5 Technology flows and development

There is *high agreement* and *much evidence* that the range of stabilisation levels assessed can be achieved by deployment of a portfolio of technologies that are currently available and those that are expected to be commercialised in coming decades. This assumes that appropriate and effective incentives are in place for development, acquisition, deployment and diffusion of technologies and for addressing related barriers. {WGIII SPM}

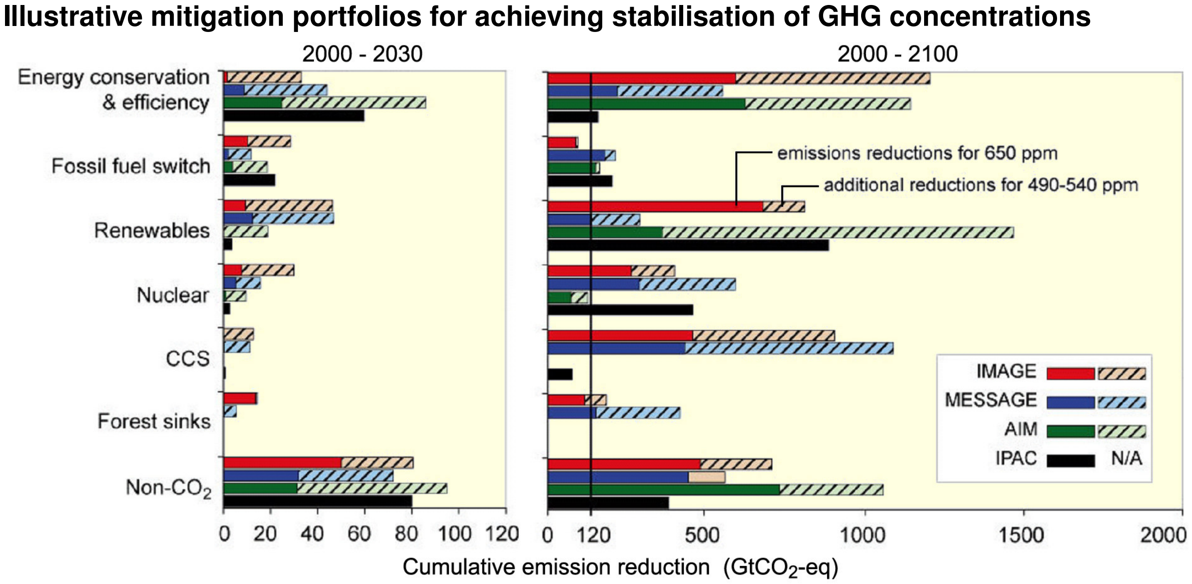
The lower the stabilisation levels, especially those of 550 ppm CO_2-eq or lower, the greater the need for more investment in new technologies during the next few decades. {WGIII SPM}

World-wide deployment of low-GHG emission technologies as well as technology improvements through public and private RD&D would be required for achieving stabilisation targets as well as cost reduction.[24] Figure 5.2 gives illustrative examples of the contribution of the portfolio of mitigation options. The contribution of different technologies varies over time and region and depends on the baseline development path, available technologies and relative costs, and the analysed stabilisation levels. Stabilisation at low levels (490-540 ppm CO_2-eq) requires early investments and substantially more rapid commercialisation of advanced low-emissions technologies over the next decades (2000-2030) and higher contributions across abatement options in the long term (2000-2100). This requires that barriers to development, acquisition, deployment and diffusion of technologies are effectively addressed with appropriate incentives. {WGIII 2.7, 3.3, 3.4, 3.6, 4.3, 4.4, 4.6, SPM}

There are large uncertainties concerning the future contribution of different technologies. However, all assessed stabilisation scenarios concur that 60-80% of the reductions over the course of the century would come from energy supply and use and industrial processes. Including non-CO_2 and CO_2 land-use and forestry mitigation options provides greater flexibility and cost-effectiveness. Energy efficiency plays a key role across many scenarios for most regions and timescales. For lower stabilisation levels, scenarios put more emphasis on the use of low carbon energy sources, such as renewable energy and nuclear power, and the use of CO_2 capture and storage (CCS). In these scenarios improvements of carbon intensity of energy supply and the whole economy needs to be much faster than in the past (Figure 5.2). {WGIII 3.3, 3.4, TS.3, SPM}

---

[24] By comparison, government funding in real absolute terms for most energy research programmes has been flat or declining for nearly two decades (even after the UNFCCC came into force) and is now about half of the 1980 level. {WGIII 2.7, 3.4, 4.5, 11.5, 13.2}



Illustrative mitigation portfolios for achieving stabilisation of GHG concentrations

Figure 5.2. Cumulative emissions reductions for alternative mitigation measures for 2000-2030 (left-hand panel) and for 2000-2100 (right-hand panel). The figure shows illustrative scenarios from four models (AIM, IMAGE, IPAC and MESSAGE) aiming at the stabilisation at low (490-540 ppm CO_2-eq) and intermediate levels (650 ppm CO_2-eq) respectively. Dark bars denote reductions for a target of 650 ppm CO_2-eq and light bars the additional reductions to achieve 490-540 ppm CO_2-eq. Note that some models do not consider mitigation through forest sink enhancement (AIM and IPAC) or CO_2 capture and storage (CCS) (AIM) and that the share of low-carbon energy options in total energy supply is also determined by inclusion of these options in the baseline. CCS includes CO_2 capture and storage from biomass. Forest sinks include reducing emissions from deforestation. The figure shows emissions reductions from baseline scenarios with cumulative emissions between 6000 to 7000 $GtCO_2$-eq (2000-2100). {WGIII Figure SPM.9}

5.6 Costs of mitigation and long-term stabilisation targets

The macro-economic cost of mitigation generally rises as the stringency of the stabilisation target is increased, and it is relatively higher when derived from baseline scenarios characterised by high emission levels. {WGIII SPM}

There is *high agreement* and *medium evidence* that in 2050 global average macro-economic costs for multi-gas mitigation towards stabilisation between 710 and 445 ppm CO_2-eq are between a 1% gain to a 5.5% decrease of global GDP (Table 5.2). Estimated GDP losses by 2030 are on average lower and show a smaller spread compared to 2050 (Table 5.2). For specific countries and sectors, costs vary considerably from the global average.[25] {WGIII 3.3, 13.3, SPM}

---

[25] Studies on mitigation portfolios and macro-economic costs assessed in this report are based on top-down modelling. Most models use a global least cost approach to mitigation portfolios and with universal emissions trading, assuming transparent markets, no transaction cost, and thus perfect implementation of mitigation measures throughout the 21st century. Costs are given for a specific point in time. Global modelled costs will increase if some regions, sectors (e.g. land-use), options or gases are excluded. Global modelled costs will decrease with lower baselines, use of revenues from carbon taxes and auctioned permits, and if induced technological learning is included. These models do not consider climate benefits and generally also co-benefits of mitigation measures, or equity issues. In models that consider induced technological change projected costs for a given stabilisation level are reduced; the reductions are greater at lower stabilisation level. {WGIII SPM}

Table 5.2. 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. {WGIII 3.3, 13.3, Tables SPM.4 and SPM.6}

Stabilisation levels (ppm CO_2-eq)	Median GDP reduction [(a)] (%)		Range of GDP reduction [(b)] (%)		Reduction of average annual GDP growth rates (percentage points) [(b), (c)]	
	2030	2050	2030	2050	2030	2050
590 – 710	0.2	0.5	-0.6 to 1.2	-1 to 2	< 0.06	< 0.05
535 – 590	0.6	1.3	0.2 to 2.5	slightly negative to 4	< 0.1	< 0.1
445 – 535 [(d)]	Not available		< 3	< 5.5	< 0.12	< 0.12

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 market exchange rates.
b) The 10th and 90th percentile range of the analysed data are given.
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.

5.7 Costs, benefits and avoided climate impacts at global and regional levels

Impacts of climate change will vary regionally but, aggregated and discounted to the present, they are very likely to impose net annual costs which will increase over time as global temperatures increase. {WGII SPM}

For increases in global average temperature of less than 1-3°C above 1980-1999 levels, some impacts are projected to produce market benefits in some places and some sectors, and produce costs in other places and other sectors. Global mean losses could be 1-5% of GDP for 4°C of warming. {WGII 9.ES, 10.6, 15.ES, SPM}

Peer-reviewed estimates of the social cost of carbon (net economic costs of damages from climate change across the globe discounted to the present) for 2005 have an average value of US$12 per tonne of CO_2, but the range around this mean is large (-$3 to $95/t$CO_2$ in a survey of 100 estimates). They indicate that the net damages of climate change are likely to be significant and to increase over time. {WGII 20.6, SPM}

It is *very likely* that globally-aggregated figures underestimate the damage costs because they do not include many non-monetised impacts. It is *virtually certain* that aggregate estimates of costs mask significant differences in impacts across sectors, regions, countries, and populations. In some locations and amongst some groups of people with high exposure, high sensitivity, and/or low adaptive capacity, net costs will be significantly larger than the global aggregate. {WGII 7.4, 20.ES, 20.6, 20.ES, SPM}

Many impacts can be avoided, reduced or delayed by mitigation. {WGII SPM}

Although the small number of impact assessments that evaluate stabilisation scenarios do not take full account of uncertainties in projected climate under stabilisation, they nevertheless provide indications of damages avoided or vulnerabilities and risks reduced for different amounts of emissions reduction. The rate and magnitude of future human induced climate change and its associated impacts are determined by human choices defining alternative socio-economic futures and mitigation actions that influence emission pathways. Figure 3.2 demonstrates that alternative SRES emission pathways could lead to substantial differences in climate change throughout the 21st century. Some of the impacts at the high temperature end of Figure 3.5 could be avoided by socio-economic development pathways that limit emissions and associated climate change towards the lower end of the ranges illustrated in Figure 3.5. {SYR 3.2, 3.3; WGIII 3.5, 3.6, SPM}

Stabilisation alternatives, with associated temperature ranges and sea level rise estimates, illustrated in Table 5.1 and Figure 3.5, show how choices between different stabilisation targets could reduce the risk of specific impacts. Figure 3.5 illustrates that limiting global average warming to below about 3°C relative to 1980-1999 average temperatures could, for example, reduce the likelihood of affecting a significant (>40%) number of ecosystems and reduce the risk of extinctions, and reduce the likelihood that cereal productivity in some regions would tend to fall. Limiting warming to below about 1.5°C relative to 1980-1999 average temperatures could reduce significantly the number of people directly affected by coastal flooding, further reduce the risk of extinctions and damage to coral reefs, and reduce the risk of damage to infrastructure and loss of agricultural production in small island states. However, some impacts appear already unavoidable even if warming were limited to 1.5°C relative to 1980-1999 average temperatures (see topic 3.3). {SYR 3.3, Figure 3.5; WGII 4.4, 5.4, Table 20.6}

Limited and early analytical results from integrated analyses of the costs and benefits of mitigation indicate that these 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. {WGIII SPM}

Comparing the costs of mitigation with avoided damages would require the reconciliation of welfare impacts on people living in different places and at different points in time into a global aggregate measure of well-being. {WGII 18.ES}

5.8 Broader environmental and sustainability issues

Unabated climate change, with *very high confidence*, threatens sustainable development and would impede achievement of the mid-century Millennium Development Goals. {WGII 20.6, 20.7, SPM}

Climate change will interact at all scales with other trends in global environmental and natural resource concerns, including water, soil and air pollution, health hazards, disaster risk, and deforestation. Their combined impacts may be compounded in the future in the absence of integrated mitigation and adaptation measures. {WGII 20.3, 20.7, 20.8, SPM}

Making development more sustainable can enhance mitigative and adaptive capacities, reduce emissions, and reduce vulnerability, but there may be barriers to implementation. {WGII 20.8; WGIII 12.2, SPM}

Both adaptive and mitigative capacities can be enhanced through sustainable development. Sustainable development can, thereby, reduce vulnerability to climate change by reducing sensitivities (through adaptation) and/or exposure (through reduced emissions). At present, however, few plans for promoting sustainability have explicitly included either adapting to climate change impacts, or promoting adaptive capacity. Similarly, changing development paths can make a major contribution to mitigation but may require resources to overcome multiple barriers. {WGII 20.3, 20.5, SPM; WGIII 2.1, 2.5, 12.1, SPM}