Summary for Policy Makers

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Introduction

This report responds to the UN Framework Convention on Climate Change's invitation to the IPCC in December 2015 "*... to prepare a Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways*". The IPCC accepted this invitation in April 2016, deciding to prepare this report in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

This Special Report assesses literature[1] relevant to all three IPCC Working Groups and uses the IPCC methodologies and calibrated language for communicating certainty in key findings[2].

The Summary for Policy Makers is structured into four sections: Section A, Understanding global warming of 1.5°C; Section B, Projected climatic changes, their potential impacts and associated risks at 1.5°C global warming; Section C, Emission pathways and system transitions consistent with 1.5°C global warming; and Section D, Strengthening the global response in the context of sustainable development and efforts to eradicate poverty.

Its narrative is supported by headline statements that taken together, provide an overview of the key findings. The underlying scientific basis for each paragraph can be traced to the chapter sections of the report as indicated by references provided.

Box SPM 1: Definitions central to SR1.5

Global mean surface temperature (GMST): Area-weighted global average of land surface air temperature and sea surface temperatures, unless otherwise specified, normally expressed relative to a specified reference period.

Global warming: An increase in GMST averaged over a 30-year period, relative to 1850-1900 unless otherwise specified. For periods shorter than 30 years, global warming refers to the estimated average temperature over the 30 years centred on that shorter period, accounting for the impact of any temperature fluctuations or trend within those 30 years.

Pre-industrial: The multi-century period prior to the onset of large-scale industrial activity. The reference period 1850-1900 is used to approximate pre-industrial GMST in this report.

1.5°C or 2°C warmer worlds: Projected worlds in which global warming has reached and, unless otherwise indicated, been limited to 1.5°C or 2°C above pre-industrial levels.

Net-zero CO_2 emissions: Conditions in which any remaining anthropogenic carbon dioxide (CO_2) emissions are balanced globally by anthropogenic CO_2 removals. Net-zero CO_2 emissions are also referred to as carbon neutrality.

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[1] FOOTNOTE: The assessment covers literature accepted for publication by May 15, 2018.

[2] FOOTNOTE: Each finding is grounded in an evaluation of underlying evidence and agreement. In many cases, a synthesis of evidence and agreement supports an assignment of confidence. The summary terms for evidence are: limited, medium or robust. For agreement, they are low, medium or high. A level of confidence is expressed using five qualifiers: very low, low, medium, high and very high, and typeset in italics, e.g., *medium confidence*. The following terms have been used to indicate the assessed likelihood of an outcome or a result: virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%. Additional terms (extremely likely 95–100%, more likely than not >50–100%, more unlikely than likely 0–<50%, extremely unlikely 0–5%) may also be used when appropriate. Assessed likelihood is typeset in italics, e.g., *very likely*. See for more details: Mastrandrea, M.D., C.B. Field, T.F. Stocker, O. Edenhofer, K.L. Ebi, D.J. Frame, H. Held, E. Kriegler, K.J. Mach, P.R. Matschoss, G.-K. Plattner, G.W. Yohe and F.W. Zwiers, 2010: Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties, Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland, 4 pp

Remaining carbon budget: Cumulative global CO_2 emissions from the start of 2018 to the time that CO_2 emissions reach net-zero that would result in a given level of global warming.

Overshoot: The temporary exceedance of a specified level of global warming, such as 1.5°C. Overshoot implies a peak followed by a decline in global warming, achieved through anthropogenic removal of CO_2 exceeding remaining CO_2 emissions globally.

1.5°C-consistent pathway: A pathway of emissions of greenhouse gases and other climate forcers that provides an approximately one-in-two to two-in-three chance, given current knowledge of the climate response, of global warming either remaining below 1.5°C or returning to 1.5°C by around 2100 following an overshoot.

Impacts: Effects of climate change, such as warming, sea level rise or changes in the frequency and intensity of heat waves, on human and natural systems. Impacts can have positive or negative outcomes for lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services, and infrastructure.

Risk: The potential for adverse consequences from a climate-related hazard for human and natural systems, resulting from the interactions between the hazard and the vulnerability and exposure of the affected system. Risk can also include the uncertain adverse outcomes of adaptation or mitigation responses.

Enabling conditions: Factors, including governance, policy, finance, behaviour, innovation and capacity, that can facilitate the global response to climate change and that underpin the feasibility of mitigation and adaptation options, acknowledging synergies and trade-offs among different options.

A. Understanding global warming of 1.5°C

A1. Human-induced global warming reached approximately 1±0.2°C (*likely* range) above pre-industrial levels in 2017 and is currently increasing at 0.2±0.1°C per decade (*high confidence*). {1.2, Figure SPM1}

A1.1. Observed global average surface temperature for the decade 2006-2015 was 0.87°C (±0.12°C)[3] warmer than 1850-1900 (*very high confidence*). Since 2000, the estimated level of human-induced warming has been equal to the level of observed warming with a *likely* range of ±20% (*high confidence*). {1.2.1, Table 1.1}

A1.2. Energy continues to accumulate in the climate system due to past and present greenhouse gas emissions and other anthropogenic climate forcers (*very high confidence*), causing continued warming at a rate of 0.2°C/decade with a *likely* range of ±0.1°C (*high confidence*). {1.2.1, 1.2.4}

A1.3. Warming greater than the global average is being experienced in many regions and seasons, with average warming greater over land than over the ocean (*high confidence*). {1.2.1, 1.2.2, Figure 1.1, Figure 1.3, 3.3.1, 3.3.2}

A2. Past emissions alone are *unlikely* to raise GMST to 1.5°C above pre-industrial levels, but do commit to further changes such as sea-level rise and associated impacts (*high confidence*). If emissions continue at their present rate, human-induced warming will exceed 1.5°C by around 2040 (*high confidence*). {1.2, 3.3, Figure SPM 1}

A2.1. If all anthropogenic emissions (including greenhouse gases, aerosols and their precursors) were reduced to zero immediately, it is *likely* that any further warming would be less than 0.5°C over the next two to three decades (*high confidence*), and *likely* less than 0.5°C on a century time scale (*medium confidence*), due to the compensating effects of different climate processes and climate forcers.{1.2.4, Figure 1.6}

A2.2. If emissions continue at their present rate over the coming decades, the present rate of human-induced warming of 0.2±0.1°C per decade will continue (*very high confidence*). {1.2.1, 1.2.4}

A2.3. Stabilising GMST requires net-zero CO_2 emissions and declining total radiative forcing[4] from other anthropogenic forcers (*high confidence*). The maximum level of warming is then determined by cumulative CO_2 emissions up to the time of net-zero (*high confidence*) and the level of non-CO_2 radiative forcing in the decades immediately prior to that time (*medium confidence*) (Figure SPM 2). {Cross-Chapter Box 2 in Chapter 1, 1.2.3, 1.2.4, 2.2.1, 2.2.2}

A3. Risks for natural and human systems are lower for global warming of 1.5°C than at 2°C depending on geographic location, levels of development and vulnerability, and on the choices of adaptation and mitigation options (*high confidence*) (Figure SPM2). {1.3, 3.3, 3.4, 5.6}

A3.1. Risks for natural and human systems are lower if global warming gradually stabilises at 1.5°C, compared to overshooting 1.5°C and returning later to this level later in the century {medium confidence). {3.4, Box 3.4, Cross-Chapter Box 8 in Chapter 3}

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[3] FOOTNOTE: This range spans several available peer-reviewed estimates of the observed global temperature change and also represents a *likely* range in warming to the decade 2006-2015, accounting for additional uncertainty due to possible short-term natural variability. {1.2.1, Table 1.1}

[4] FOOTNOTE: The change in the top-of-atmosphere balance between incoming and outgoing energy resulting from a human or natural perturbation to the climate system, allowing the atmosphere and land-surface to adjust but retaining sea-surface temperatures and sea-ice at their unperturbed state (called "Effective Radiative Forcing" in previous reports).

A4. Sustainable development, poverty eradication and implications for ethics and equity will be will be key considerations in mitigation efforts to limit global warming to 1.5ºC and by efforts to adapt to 1.5ºC global warming {*high confidence*}. {1.1, 1.4, Cross-Chapter Box 4 in Chapter 1, 5.2. 5.3}

A4.1. The poor and vulnerable are disproportionately affected by many impacts of global warming as well as the challenges of remaining below global warming of 1.5°C; with associated mitigation options implying a combination of significant benefits and adverse effects, depending on the various mitigation options *(high confidence).* {1.1.1, 1.1.2, 1.4.3, 2.5.3, Cross-Chapter Boxes 4 in Chapter 1, 7 and 8 in Chapter 3 and 13 in Chapter 5}

A4.2. Effective adaptation requires the integration of scientific, technological and social conditions and capacities. Sustainable development, poverty eradication and reduction of inequalities are enabled by enhancing local capabilities *(high confidence*). {4.2.2, 4.4.1, 4.4.3, 4.5.3, 5.3.1}

A4.3. Climate resilient development pathways (CRDPs) are a framework to simultaneously achieve the goals of emission reduction, climate adaptation and climate resilience in the context of sustainable development, poverty eradication and reducing inequalities. {1.4.3, Cross Chapter Box 1, 5.1, 5.5.3}

A5. There is no simple answer to the question of whether it is feasible to limit warming to 1.5°C and to adapt to the consequences because feasibility has multiple dimensions that need to be considered simultaneously and systematically. {1.4, Cross-Chapter Box 3 in Chapter 1, 4.3, 4.4}

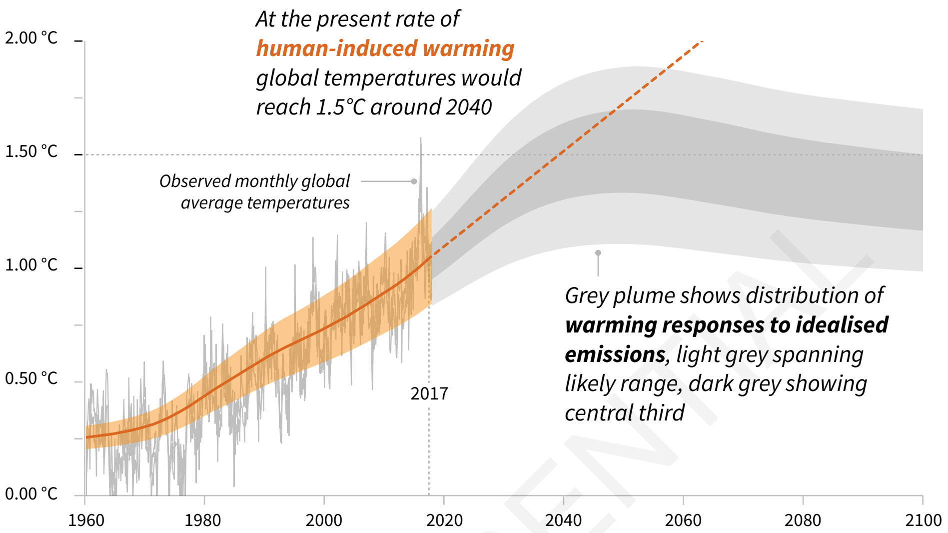
A5.1. In the context of sustainable development, feasibility depends on enabling conditions. These include institutional capacity, policy and finance, multi-level governance, technological innovation and transfer, and changes in human behaviour and lifestyles. Feasibility also reflects links, positive (synergies) and negative (trade-offs), between sustainable development, mitigation, and adaptation on multiple scales. {1.4, Cross-Chapter Box 3 in Chapter 1, 4.4, 5.6}

Cumulative emissions of CO_2 and future non-CO_2 radiative forcing determine the chance of limiting warming to 1.5°C

Observed global average temperatures, estimated human-induced warming to date, and one estimate of the range of temperature responses to an idealised 1.5°C-consistent emissions pathway in which CO_2 emissions decline in a straight line from 2020 to 2055, while non-CO_2 radiative forcing increases to 2030 and then declines.

Panels (a) to (e) explain how different aspects of future emissions affect the probability of temperatures exceeding 1.5°C.

Global warming relative to 1850-1900

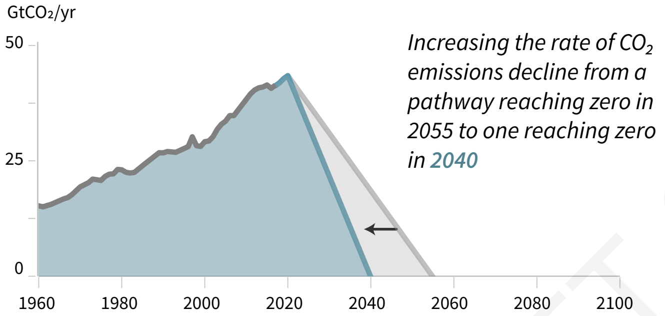


At the present rate of ***human-induced warming*** *global temperatures would reach 1.5°C around 2040*

Observed monthly global average temperatures

Grey plume shows distribution of ***warming responses to idealised emissions****, light grey spanning likely range, dark grey showing central third*

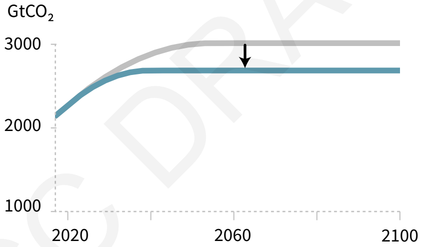
a) Idealised CO_2 emissions pathways



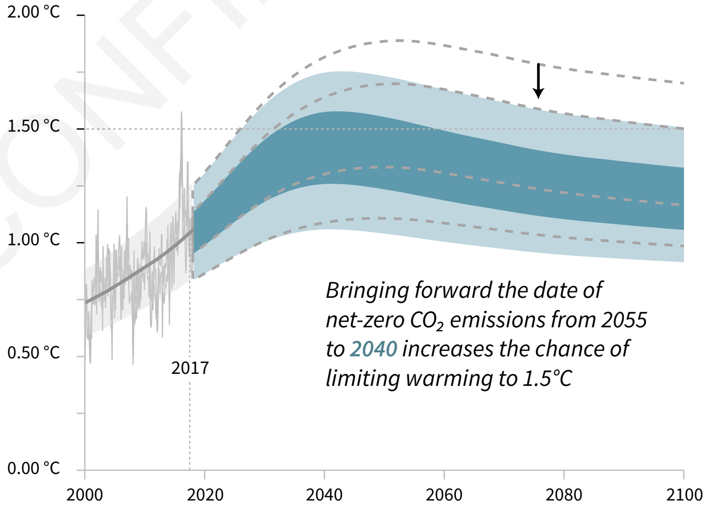
Increasing the rate of CO_2 emissions decline from a pathway reaching zero in 2055 to one reaching zero in 2040

b) Total cumulative CO_2 emissions

A faster rate of CO_2 emissions decline (panel a) means lower cumulative CO_2 emissions by the time emissions reach zero.

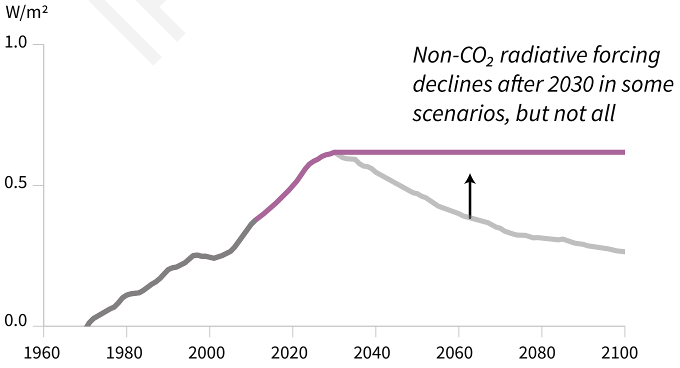


c) Warming response to lower future cumulative CO_2 emissions



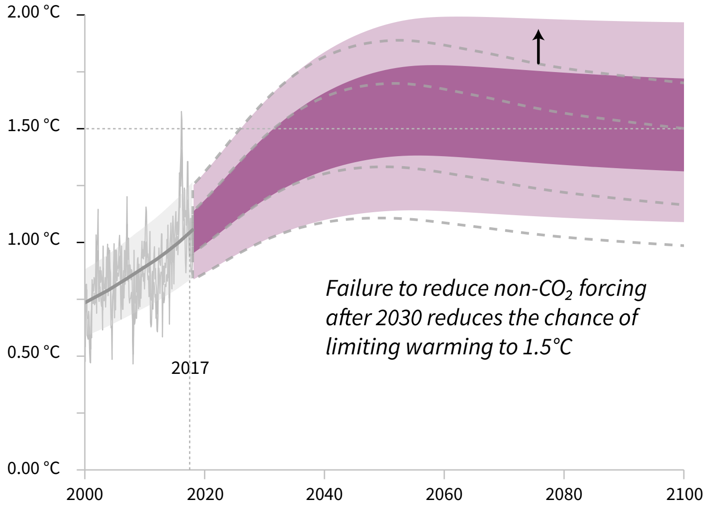
Bringing forward the date of net-zero CO_2 emissions from 2055 to 2040 increases the chance of limiting warming to 1.5°C

d) Scenarios for non-CO_2 radiative forcing



Non-CO_2 radiative forcing declines after 2030 in some scenarios, but not all

e) Warming response to higher future non-CO_2 radiative forcing



Failure to reduce non-CO_2 forcing after 2030 reduces the chance of limiting warming to 1.5°C

Figure SPM 1: Top panel: Observed monthly global average surface temperature (grey line) and estimated human-induced warming to date (orange line and shading) reproduced from Chapter 1, Figure 1.2. Grey plume shows distribution of warming responses to an idealized 1.5°C-consistent pathway in which CO_2 emissions (grey line in sub-panels b and c) decline in a straight line from 2020 to 2055 while non-CO_2 radiative forcing increases to 2030 and then declines following an indicative 1.5°C-consistent pathway as assessed in Chapter 2 (grey line in panel d). Light grey shading in top panel shows an estimate of the *likely* range, while dark grey shows central third of the distribution. Sub-panels a) to e) explain how varying future cumulative CO_2 emissions (a-c) and non-CO_2 radiative forcing (d-e) affects the probability of warming exceeding 1.5°C. {1.2.1, 1.2.3, 1.2.4, 2.3}

B. Projected climatic changes, their potential impacts and associated risks at 1.5°C global warming

B1. There are substantial increases in extremes between the present-day and a global warming of 1.5°C, and between 1.5°C and 2°C, including hot extremes in all inhabited regions[5] (*high confidence*), heavy precipitation events in most regions (*high confidence*), and extreme droughts in some regions (*medium confidence*). {3.3, Cross-Chapter Box 8 in Chapter 3}

B1.1. Changes in temperature extremes and heavy precipitation indices are detectable in observations for the 1991-2010 period compared with 1960-1979, a time-span over which global warming of approximately 0.5°C occurred. {3.3.1, 3.3.2, 3.3.3}

B1.2. Temperature extremes on land are projected to warm more than the global average: extreme hot days in mid-latitudes by a factor of up to 2, i.e. ~3°C at 1.5°C global warming, and extreme cold nights in high-latitudes by a factor of up to 3, i.e. ~4.5°C at 1.5°C global warming (*high confidence*). The number of highly unusual hot days is projected to increase the most in the tropics (*high confidence*). {3.3.1, 3.3.2, Cross-Chapter Box 8 in Chapter 3}

B1.3. Limiting global warming to 1.5°C compared to 2°C reduces the likelihood of increases in heavy precipitation events in several northern hemisphere high latitude and high elevation regions (*medium confidence*). Less land would be affected by flood hazards (*medium confidence*) and the probability of extreme droughts would be less in some regions, including the Mediterranean and southern Africa (*medium confidence*). {3.3.3, 3.3.4, 3.3.5}

B2. On land, risks of climate-induced impacts on biodiversity and ecosystems, including species loss and extinction, are substantially less at 1.5°C global warming than at 2°C. Limiting global warming to 1.5°C has large benefits for terrestrial and wetland ecosystems and for the preservation of their services (*high confidence*). Temperature overshoot, if much higher than 1.5ºC (e.g. close to 2ºC), could have irreversible impacts on some species, ecosystems and their ecological functions and services to humans, even if global warming eventually stabilizes at 1.5ºC by 2100 (*high confidence*). (SPM Figure 2) {3.4, 3.5, Box 3.4, Box 4.2, Cross-Chapter Box 8 in Chapter 3}

B2.1. The number of species projected to lose over half of their climatically determined geographic range at 2ºC is reduced by a factor of two or more at 1.5°C, i.e. by 50% (plants, vertebrates) or 66% (insects) (*high confidence*). Impacts associated with other biodiversity-related risks such as forest fires, and the spread of invasive species, are also reduced substantially at 1.5°C compared to 2°C of global warming (*high confidence*). {3.4.3.2, 3.5.2}

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[5] FOOTNOTE: Region definition based on IPCC regions (AR5, SREX; see Fig. 3.2)

B2.2. The terrestrial area affected by ecosystem transformation (13%) at 2°C is approximately halved at 1.5°C global warming (*high confidence*). {3.3.4, 3.4.3.5, 3.4.6.1, 3.5.10, Box 4.2}

B2.3. High-latitude tundra and boreal forests are particularly at risk, with woody shrubs encroaching into the tundra (*high confidence*). Limiting global warming to 1.5°C could prevent the thawing of an estimated permafrost area of 2 million km^2 of permafrost area over centuries (*high confidence*) {3.3.2, 3.4.3, 3.5.5}

B3. Due to projected differences in ocean temperature, acidification and oxygen levels, limiting warming to 1.5°C compared to 2°C would substantially reduce risks to marine biodiversity, ecosystems and their ecological functions and services to humans in ocean and coastal areas, especially Arctic sea-ice ecosystems and warm water coral reefs. {3.3, 3.4, 3.5, Boxes 3.4, 3.5}

B3.1. With 2°C of global warming, it is *very likely* that there will be at least one sea ice-free Arctic summer per decade. This is reduced to one per century with 1.5°C global warming. Effects of an overshoot are reversible for Arctic sea-ice cover (*high confidence*). {3.3.8, 3.4.4.7}

B3.2. Ocean ecosystems are experiencing large-scale changes with critical thresholds being exceeded at 1.5°C and above (*high confidence*). Crossing these thresholds may have irreversible effects. The majority of warm water coral reefs, for example, are already experiencing the large scale loss of coral abundance (cover) today and would lose a further 70-90% of cover at 1.5°C global warming (*very high confidence*). {3.4.4, Box 3.4}

B3.3. The level of ocean acidification in a 1.5°C warmer world is expected to amplify the adverse effects of warming, impacting the survival, calcification, growth, development, and abundance of a broad range of taxonomic groups (i.e. from algae to fish) (*high confidence*). {3.3.10, 3.4.4}

B3.4. The risk of declining ocean productivity, distributional shifts (to higher latitudes), damage to ecosystems (e.g. coral reefs, wetlands), loss of fisheries productivity (at low latitudes), and changing ocean chemistry (e.g., acidification, hypoxia) are projected to be substantially lower at 1.5°C of global warming, as compared to 2°C (*high confidence*) {3.4.4, Box 3.4}

B4. By 2100, sea level rise would be around 0.1m lower with 1.5°C global warming compared to 2°C (*medium confidence*). Increased saltwater intrusions, flooding, and damage to infrastructure associated with increased sea level are especially harmful for vulnerable environments such as small islands, low-lying coasts, and deltas (*high confidence*) {3.3, 3.4, 3.6}

B4.1. Sea level rise will continue beyond 2100 (*high confidence).* Greenland and/or Antarctic ice sheet instabilities that could result in multi-metre rise in sea level on centennial to millennial time scales, maybe triggered even if global warming is limited to 1.5°C by 2100 (*medium confidence).* {3.3.9, 3.4.5, 3.5.2, 3.6.3, Box 3.3}

B4.2. A reduction to global sea level rise of 0.1m at global warming of 1.5°C compared to 2°C implies that approximately 10 million fewer people are expected to be exposed to related risks, based on a 2010 population estimate. The slower rate of rise for global warming of 1.5°C is expected to provide substantially greater opportunities for adaptation. {3.4.4, 3.4.5, 4.3.2}

B5. Impacts on health, livelihoods, food and water supply, human security, infrastructure, and the underlying potential for economic growth will increase with 1.5°C of warming compared to today, and even more with 2°C warming compared to 1.5°C. (SPM Figure 2) {3.4, 3.5, Box 3.2, Box 3.3, Box 3.5, Box 3.6, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 5.2}

B5.1. Disadvantaged and vulnerable populations and nations will be disproportionately affected by the impacts of global warming of 1.5°C and beyond (*high confidence*). This is particularly the case for Indigenous peoples and systems in the Arctic, populations dependent on agriculture- and coastal livelihoods, and small-island developing states, many of which face limits to adaptation already (*medium confidence*). {3.4.10, 3.4.11, Box 3.5, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 11 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 5.2.1, 5.2.2, 5.2.3, 5.6.3}

B5.2. While any future increase in global warming will affect human health (*high confidence*), risks will be lower at 1.5°C than at 2°C for heat-related morbidity and mortality (*very high confidence*). Risks are with increasing warming are particularly high in urban areas due to the urban heat island effect (*high* confidence). Risks are projected to increase for some vector-borne diseases, such as malaria and dengue fever (*high confidence*). {3.4.7}

B5.3. Limiting global warming to 1.5°C compared to 2°C would result in a lower global reduction in crop yields and nutritional quality (*high confidence*) and lower risks to crop production in Sub-Saharan Africa (particularly West Africa, southern Africa), South-East Asia, and Central and South America. Risks of food shortages in the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon are significantly lower with 1.5°C of warming, compared to 2°C. {3.4.6, 3.5.4, 3.5.5, Box 3.1, Cross-Chapter Box 6 in Chapter 3, 4.3.2, 4.3.5, 4.5.3, Box 4.2, Box 4.3, Cross-Chapter Box 9 in Chapter 4}

B5.4. Limiting global warming to 1.5°C compared to 2°C would approximately halve the proportion of the world population expected to suffer water scarcity, although there is considerable variability between regions (*medium confidence*). Many small island developing states would experience substantially less freshwater stress as a result of projected changes in aridity when global warming is limited to 1.5°C, as compared to 2°C (*medium confidence*). {3.3.5, 3.4.2, 3.4.8, 3.5.5, Box 3.2, Box 3.5, 4.3.2, 4.3.3, 4.4.1, 4.4.2, 4.4.5, 4.5.3, Cross-Chapter Box 9 in Chapter 4}

B5.5. Impacts of 1.5ºC global warming on global economic growth are larger than those of the present-day, with the largest impacts expected in the tropics and the Southern Hemisphere subtropics (*low confidence*). Economic growth is projected to be lower at 2°C than at 1.5°C of global warming for many developed and developing countries (*medium* confidence*)*. {3.5.2, 3.5.3}

B5.6. There are multiple lines of evidence that since AR5 that the levels of risk has increased for four of the five Reasons for Concern (RFCs) for global warming levels of up to 2ºC (*high confidence*), see Figure SPM2. Constraining warming to 1.5ºC reduces the risk of reaching a 'very high' level in RFC1 (Unique and threatened systems) (*high confidence*), and reduces the risk of reaching a 'high' level in RFC3 (Distribution of impacts) (*high confidence*) and RFC4 (Global Aggregate Impacts) (*medium confidence*). It would also reduce risks associated with RFC2 (Extreme weather events) and RFC5 (Large scale singular events) (*high confidence*) (SPM Figure 2) {3.4.13; 3.5, 3.5.2}

B6. Limits to adaptation and associated losses exist at every level of global warming (*medium confidence*) with site-specific implications for vulnerable regions and populations. Further adaptation is required within the assessed sectors of energy, land and ecosystems, urban, industrial, and transport systems, and within cross-cutting sectors such as disaster risk management, health and education; adaptation needs will be lower at global of 1.5ºC, compared to 2ºC.

B6.1. Adaptation opportunities will be reduced and the risks of unavoidable damages increased (*medium confidence*) in vulnerable regions, including small islands, that are projected to experience higher multiple inter-related climate risks at 1.5°C global warming compared to today, with risks increasing further with warming of 2ºC (*high confidence*). {3.3.1, 3.4.5, Box 3.5, 4.4.1, 4.4.3, 4.4.5, 5.6, Cross-Chapter Box 12 in Chapter 5, Box 5.3}

B6.2. Infrastructure investments and innovative mechanisms to target finance towards adaptation, including transformational approaches, at various scales may alleviate the impacts of climate change at 1.5°C. {4.4.5, 4.5.3}

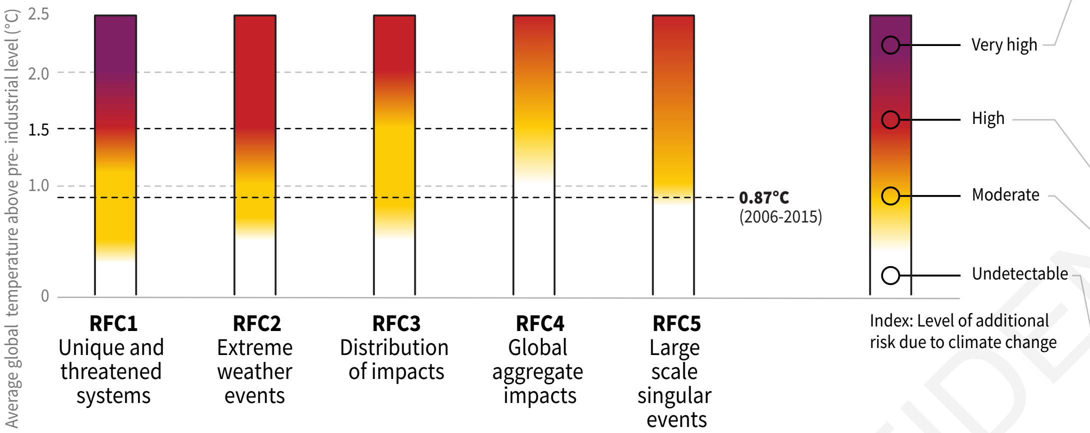
B6.3. In energy and industrial systems, options considered feasible for adaptation at global warming of 1.5°C are water management and cooling strategies and resilience of existing infrastructure *(medium confidence)*. Adaptation options for land and ecosystems at global warming of 1.5°C include conservation agriculture, efficient irrigation, efficient livestock, agroforestry, community-based adaptation, ecosystem restoration and avoided deforestation, biodiversity management and coastal defence and hardening (*high confidence)*. Urban adaptation options at global warming of 1.5°C include green infrastructure, resilient water and urban ecosystem services, urban and peri-urban agriculture, and adapting buildings and land use through regulation and planning (*high confidence*). {4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.5.3}

B6.4. Several overarching adaptation options that are closely linked to sustainable development can be implemented across rural landscapes, such as investing in health, social safety nets, and insurance for risk management, or disaster risk management and education-based adaptation options. These are being implemented today and can also be scaled up for 1.5°C of global warming {1.4.3, 4.3.5, 4.5.3}

How the level of global warming affects risk associated with the Reasons for Concern (RFCs) and specific natural, managed and human systems

Five Reasons For Concern (RFCs) illustrate the implications of different levels of warming and of adaptation limits for people, economies and ecosystems across sectors and regions. The figure is updated since AR5 and the focus is on levels of global warming between 0°C and 2°C. {3.5}

Risk associated with the Reasons for Concern (RFCs)



Purple indicates very high risk of severe impacts and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impact.

Red indicates severe and widespread impacts.

Yellow indicates that associated impacts are both detectable and attributable to climate change with at least medium confidence.

White indicates that no associated impacts are detectable and attributable to climate change.

Assessment of risks at 2°C or higher are beyond the scope of the present assessment

Risks for specific natural, managed and human systems

The key elements are presented here as a function of the risk level assessed between 1.5 and 2°C.

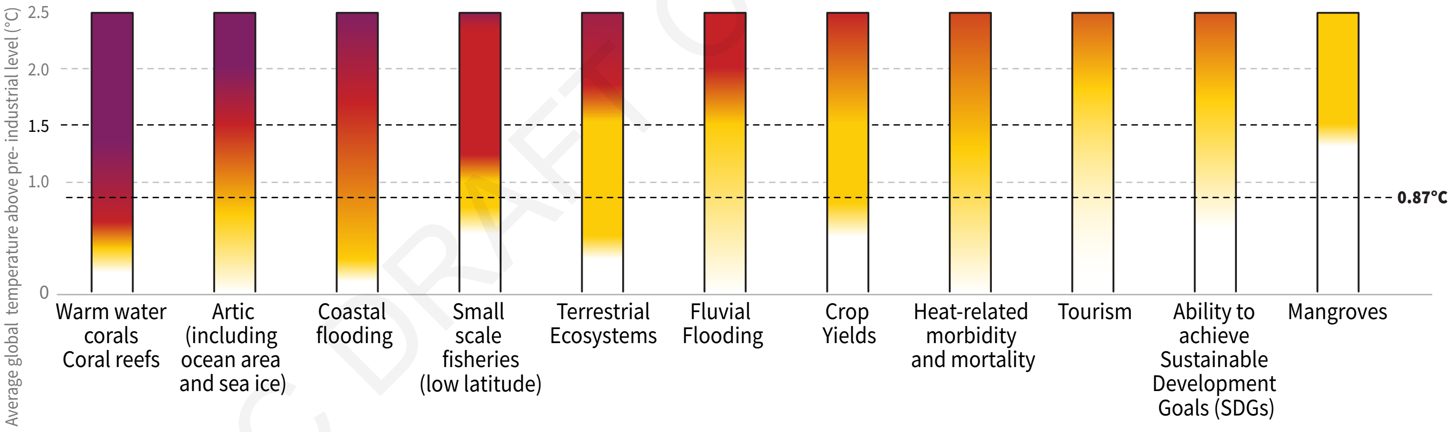


Figure SPM 2: The dependence of risk on the extent of global warming for five Reasons for Concern (RFCs) together with a range of key elements of the Earth system, on the level of global warming. The colour shading indicates the additional risk due to climate change when a temperature level is reached and then sustained or exceeded. Comparison of the increase in risk across RFCs, or across elements, indicates the relative sensitivity to increases in global mean temperature above pre-industrial levels. The RFC component is updated from AR5 with a focus on levels of global warming between 0°C and 2°C global warming. Assessment of risks at higher than 2°C is beyond the scope of the present assessment. The levels of risk illustrated here reflect the expert judgment of the report authors. The selection of risks to key elements of the Earth system in the lower panel is illustrative and is not intended to be fully comprehensive. {3.4.13; 3.5, 3.5.2.1, 3.5.2.2, 3.5.2.3, 3.5.2.4, 3.5.2.5}

C. Emission pathways and system transitions consistent with 1.5°C global warming

C1. All 1.5°C-consistent pathways imply rapid reductions in net global anthropogenic CO_2 emissions to reach net-zero around mid-century, together with rapid reductions in other anthropogenic emissions, particularly methane. Greater emissions reductions by 2030 lead to a higher chance of limiting global warming to 1.5°C without, or with only limited overshoot (zero to 0.2°C). (*high confidence*) (Figures SPM1 and SPM3) {1.3, 1.2, 2.2, 2.4, 2.3, 2.5}

C1.1. 1.5°C-consistent pathways differ in the portfolio of measures deployed to achieve emissions reductions. This results in different implications regarding synergies and trade-offs with sustainable development, poverty eradication and reducing inequalities. Solar radiation modification (SRM) measures are not included in any of the available assessed pathways. Though some may be theoretically effective in reducing an overshoot, SRM measures face large uncertainties and knowledge gaps as well as substantial institutional and social constraints to deployment related to governance, ethics, and impacts on sustainable development (*medium confidence*). (Figures SPM3 and SPM4) {2.2, 2.4, 2.5, 4.3, 4.3.8, 4.5, Cross-Chapter Box 10 in Chapter 4, 5.4.2, 5.5.2}

C1.2. The remaining carbon budget for a one-in-two chance of limiting global warming to 1.5°C is about 750 $GtCO_2$, and about 550 $GtCO_2$ for a two-in-three chance *(medium confidence)*. These remaining budgets are larger than those estimated in AR5[6]. Estimates of remaining budgets for 1.5°C vary by more than 50% due to assessed uncertainties in the climate response to emissions, and by ±250 $GtCO_2$ due to assessed uncertainties in global warming until the decade 2006-2015. If calculated out to 2100, budgets could be reduced by up to 100 $GtCO_2$ by permafrost thawing and potential methane release from wetlands (*medium confidence*). {2.2.2, 2.6.1, Table 2.2, Technical Annex Chapter 2}

C1.3. Different amounts of non-CO_2 mitigation result in variations in the remaining carbon budget consistent with 1.5°C of ±250 $GtCO_2$ (*medium confidence*). In the next two to three decades, removal of SO_2 would add to future warming, but reductions in methane emissions would partially compensate (*high confidence*). However, emissions of N_2O increase in some pathways with high bioenergy demand. (Figures SPM1 and SPM3) {2.2.2, 2.3.1, 2.4.2, 2.5.3}

C1.4. Pathways that aim for no or limited (zero to 0.2°C) overshoot of 1.5°C have substantial emission reductions by 2030, keeping global GHG emissions[7] in 2030 to 25-30 $GtCO_2eq/yr$ (interquartile range), a 40-50% reduction from 2010. Uncertainties in the climate response imply the possibility of lower or higher warming levels being reached by these pathways. (SPM Figure 1) {2.2.1, 2.3.3}

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[6] FOOTNOTE: New literature consistently shows larger remaining 1.5°C and 2°C carbon budgets compared to those reported in AR5. This literature does not challenge the AR5 relationship between cumulative emissions and global-mean temperature but expresses the remaining carbon budget relative to a recent period that reflects the observational record, rather than relative to the preindustrial period.

[7] FOOTNOTE: For consistency with other IPCC assessments, greenhouse gas emissions have been aggregated to CO_2-equivalent emissions with 100-year GWP values of the IPCC Second Assessment Report.

C2. 1.5°C-consistent pathways can have different levels of carbon dioxide removal (CDR). Some limit global warming to 1.5°C without relying on bioenergy with carbon capture and storage (BECCS). Behaviour change, demand-side measures and emission reductions in the short term can limit the dependence on CDR (*high confidence*). {2.3, 2.5, 4.3}

C2.1. Different CDR methods exist, with widely differing maturity, potentials, costs and side-effects. Examples include afforestation and reforestation, BECCS, direct air carbon capture and storage and soil carbon sequestration. The feasibility of CDR measures relates to their impacts on sustainable development, and depends on scale, implications for land, water and energy use (*high confidence*). Feasibility of CDR could be enhanced by a portfolio of options deployed at smaller scales, rather than a single option at a large scale (*high confidence*). (Figure SPM3) {2.3, 2.5.3, 2.6, 3.6.2, 4.3.7, 4.5.2, 5.4.1, 5.4.2; Cross-Chapter Boxes 7 and 8 in Chapter 3, Table 4.11, Table 5.3, Figure 5.3}.

C2.2. The faster reduction in emissions associated with 1.5°C-consistent pathways compared to holding warming below 2°C-consistent pathways is predominantly achieved by measures that result in less CO_2 being emitted, and only to a smaller degree through additional CDR. Pathways that overshoot 1.5°C need to rely on CO_2 removal exceeding remaining CO_2 emissions to return global warming to below 1.5°C by 2100 (*high confidence*). Geophysical understanding is limited about the effectiveness of CDR to reduce temperatures after they peak. (Figure SPM3) {2.2, 2.3, 2.6, 4.3.7, 4.5.2, Table 4.11}

C2.3. There is variation in the amount and types of CDR used in 1.5°C-consistent pathways, suggesting flexibility in addressing implementation challenges (*medium confidence*). In 1.5°C-consistent pathways, BECCS deployment ranges from 0–9 $GtCO_2$/yr in 2050, and 0–16 $GtCO_2$/yr in 2100, while agriculture, forestry and land-use (AFOLU) related CDR measures remove 0–11 $GtCO_2$/yr in 2050 and 1–5 $GtCO_2$/yr in 2100. Some pathways avoid BECCS deployment through low energy demand and greater reliance on AFOLU-related CDR measures. Bioenergy can still be substantial without BECCS due to its cross-sectoral potential for replacing fossil fuels (*high confidence*) (Figure SPM3) {2.3.3, 2.3.4, 2.4.2, 3.6.2, 5.4.1, Cross-Chapter Box 7 in Chapter 3, 4.4.3, 4.3.7, Table 2.4}

C2.4. Some AFOLU measures have potential other benefits, for example, improved biodiversity and soil quality, when combined with policies to conserve and restore land carbon stocks and protect natural ecosystems (*medium confidence*). (Figure SPM 4) {2.3.3, 2.3.4, 2.4.2, 3.6.2, 5.4.1, Cross-Chapter Box 7 in Chapter 3, 4.3.2, 4.3.7, 4.5.2, Table 2.4}

C3. Limiting global warming to 1.5°C would require rapid and far-reaching systems transitions occurring during the coming one to two decades, in energy, land, urban, and industrial systems. {2.3, 2.4, 2.5, 4.2, 4.3, 4.5, 5.4}

C3.1. Pathways that are consistent with limiting global warming to 1.5°C are qualitatively similar to those for 2°C, but their system changes are more rapid and pronounced over the next decades (*high confidence*). These rates of change were observed in the past within specific sectors, technologies and spatial contexts, but there is no documented historic precedent for the scale found in 1.5°C-consistent pathways. {2.3.3, 2.3.4, 2.4, 2.5, 4.2.1, 4.2.2, 4.5}

C3.2. In energy systems, 1.5°C-consistent pathways include a substantial reduction in energy demand, a decline in the carbon intensity of electricity to zero by mid-century, and an increase in electrification of energy use (*high confidence*). By 2030, the median level of primary renewable energy (including bioenergy, hydro, wind and solar) in 1.5°C-consistent pathways increases by 60% compared to 2020, while primary energy from coal decreases by two-thirds. By 2050, renewables are expected to supply 49–67% of primary energy, while coal would be expected to supply 1–7%. The political, economic, social and technical feasibility of solar energy, wind energy and electricity storage technologies increased over the past few years (*high confidence*), signalling that such a system transition in electricity generation may be underway. {2.4.2, 4.2.1, 4.3.1, 4.5.2, Cross-Chapter Box 6 in Chapter 3}

C3.3. Transitions in global and regional land use are required to limit warming to 1.5°C. Such transitions require integrative policies to sustainably manage competing demands on land for human settlements, food, livestock feed, fibre, bioenergy, carbon storage, biodiversity and ecosystem services. This may include sustainable intensification of land use practices, enhanced agricultural productivity and diet changes. Such options are often limited by institutional, environmental and socio-cultural feasibility, though experiences show that these constraints can be overcome (*high confidence*). {1.4.2, 2.3.4, 2.4.4, 4.3.2, 4.4.5, 4.4.3, 5.4.2, 5.4.1, Cross-Chapter Boxes 3 in Chapter 1 and 7 in Chapter 3}

C3.4. Emissions from industry in 1.5°C-consistent pathways are about 70-90% lower in 2050 compared to 2010. Energy-intensive industry can achieve these reductions through combinations of novel technologies and practices, including low-emission electrification, hydrogen, bio-based feedstocks, product substitution, and in several cases CCS (*high confidence*). Although technically proven, the deployment at scale of these options is limited by economic feasibility and institutional constraints. Energy efficiency can have a positive effect (synergy) on a large number of SDGs and is a more economically feasible enabler of industrial system transitions, though by itself provides insufficient emission reductions in industry (Figure SPM4) (*high confidence)*. {4.2.1, 4.3.4, 4.5.2, 5.4.1}

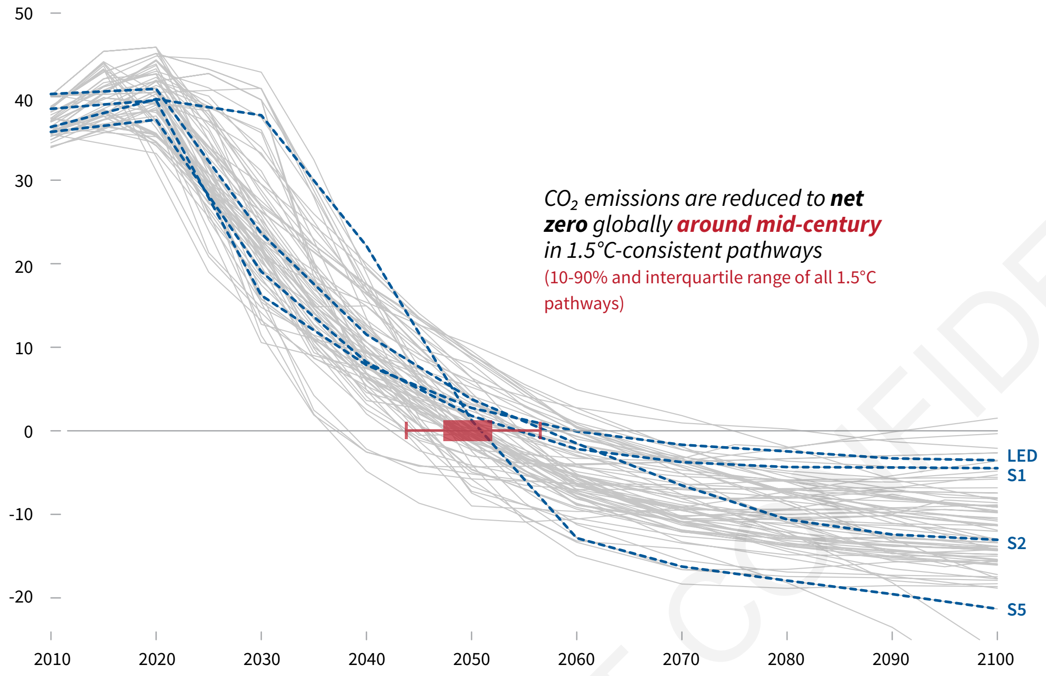
C3.5. Transport and buildings, and their associated infrastructure, achieve deep emission reductions by 2050 in 1.5°C-consistent pathways. Technical measures (such as efficient appliances, insulation and electrification) and lifestyle choices that lower energy demand or favour cycling and walking can achieve such deep emissions reductions while enhancing multiple SDGs. While technological performance can be improved for all these options, socio-cultural, market, and economic barriers may inhibit rapid and far-reaching change (*high confidence*) (Figure SPM4). {2.3.4, 2.4.3, 4.3.3, 4.4.3, 4.5.2, 4.4.5, 5.4.1, Table 5.3}

Emissions in four 1.5°C-consistent pathways and their temperature implications

Limiting warming to 1.5°C during the 21st century is achieved by **reducing CO_2 emissions to net zero** in combination with **marked reductions in non-CO_2 emissions.** The overall level of **carbon dioxide removal (CDR) varies** across pathways depending on mitigation choices, as do the relative contributions of Bioenergy with Carbon Capture and Storage (BECCS) and removals in the Agriculture Forestry and Other Land Use (AFOLU) sector. The shape of the emissions trajectory over time has implications for peak warming and temperature overshoot.

Global CO_2 emissions in 1.5°C-consistent pathways (four archetype pathways are highlighted)

Global total CO_2 emissions [$GtCO_2$ yr-¹]



*CO_2 emissions are reduced to **net zero** globally **around mid-century** in 1.5°C-consistent pathways*

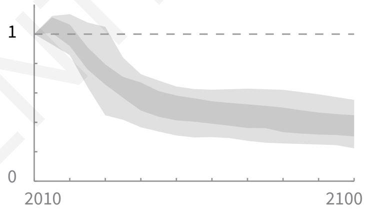
(10-90% and interquartile range of all 1.5°C pathways)

Non-CO_2 emissions relative to 2010

Emissions of non-CO_2 forcers are also reduced in 1.5°C-consistent pathways but they do not reach zero levels

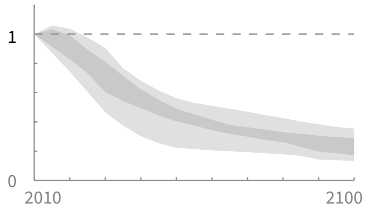
Methane

CH_4 emissions [relative to 2010]

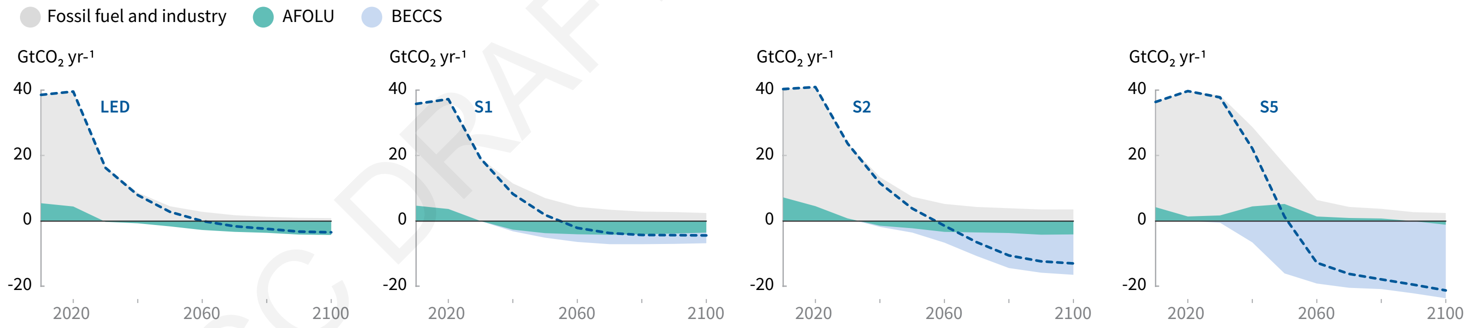


Black Carbon

BC emissions [relative to 2010]



Breakdown of contributions to global CO_2 emissions in four archetype pathways [$GtCO_2$ yr-¹]



Pathway LED

A scenario in which social, business, and technological innovations lead to dramatic reductions in the energy needed to provide useful services, resulting in lower energy demand to 2050 while living standards rise, particularly in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil CCS nor BECCS are used.

Pathway S1

A scenario with a broad focus on sustainability and a shift towards energy intensity improvements, human development, economic convergence and international cooperation, sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

Pathway S2

A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by demand reductions.

Pathway S5

A resource and energy-intensive scenario in which rapid economic growth and globalization lead to widespread adoption of greenhouse-gas intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

Temperature implications of emissions trajectories

1.5°C-consistent pathways that reduce CO_2 emissions markedly by 2030 have a higher chance of limiting peak warming to 1.5°C, and thus have comparatively lower overshoots of the 1.5°C limit. Smaller net negative CO_2 emissions in second half of the century imply a slower temperature decline after peak warming.

Peak warming **at or below** 1.5°C
Reduced overshoot
Limited temperature decline after peak (<0.01°C/decade)

Peak warming **more than 0.2°C higher**
Marked overshoot
Pronounced temperature decline after peak (>0.1°C/decade)

Figure SPM 3: Emissions in 1.5°C-consistent pathways and their temperature implications. Global CO_2 emissions in 1.5°C-consistent pathways and a breakdown of the contributions in terms of emissions from fossil fuel and industry, agriculture, forestry and other land use (AFOLU), and Bioenergy with Carbon Capture and Storage (BECCS) for four illustrative archetype pathways[8] that illustrate a range of potential mitigation approaches. Temperature implications are illustrated at the bottom. Non-CO_2 emissions ranges in the inset show the 10-90% (light grey) and interquartile (dark grey) ranges. {2.2, 2.3, Figure 2.5, Figure 2.10, Figure 2.11}

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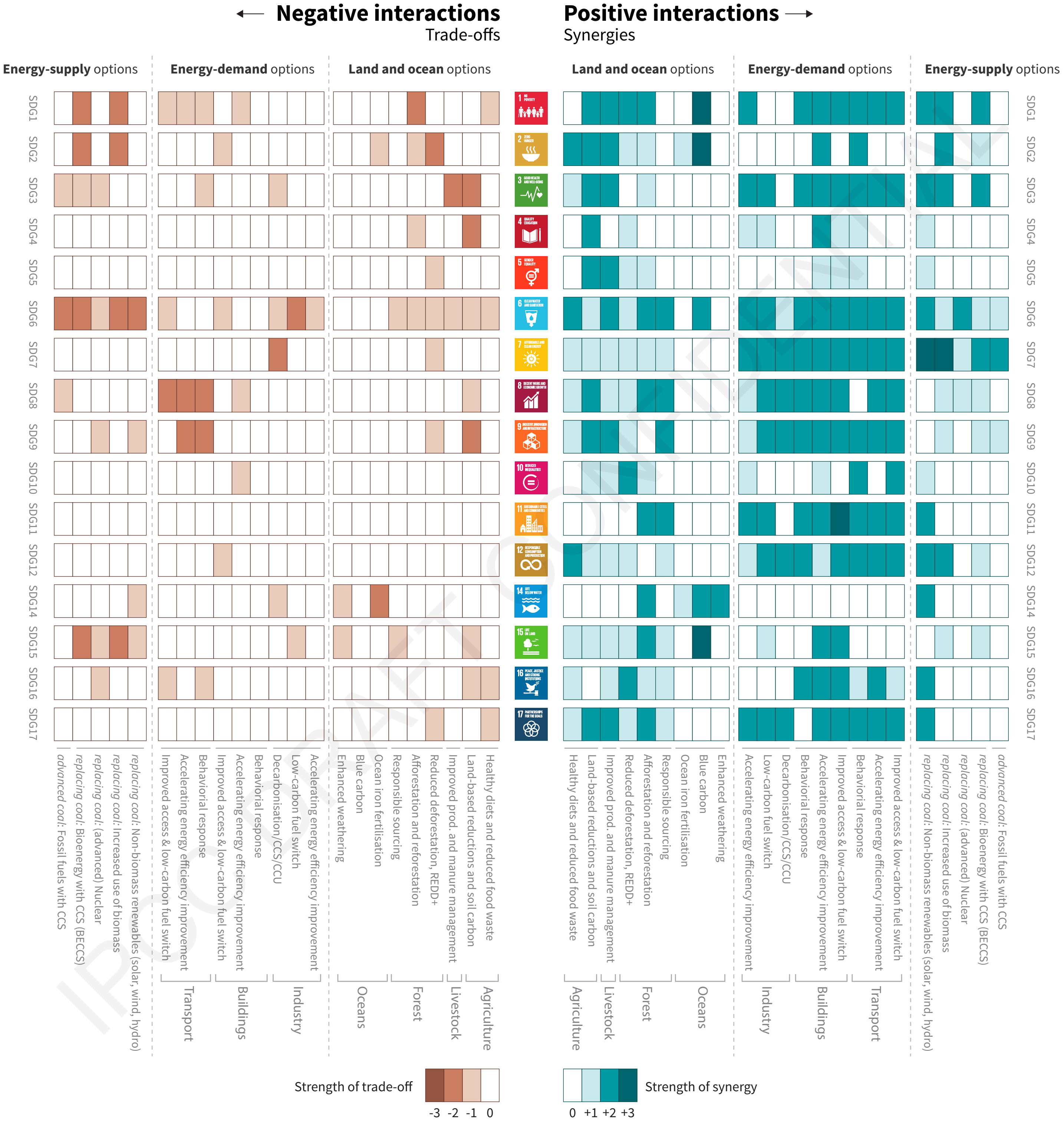
[8] FOOTNOTE : Four archetypes of 1.5°C-consistent pathways are shown, which illustrate different approaches to reduce GHG emissions. The S5 pathway pursues GHG intensive lifestyles and focusses on technological means to reduce GHG emissions through CDR. The S1 and LED pathways pursue sustainable development and lifestyles with strong energy efficiency improvements and low energy demand, with the LED pathway avoiding the use of carbon capture and storage altogether. The S2 pathways is a middle-of-the-road scenario which continues historical patterns of societal and technological development with a mix of supply and demand-side measures.

Synergies and trade-offs between climate change mitigation and the SDGs

Specific climate change mitigation options can result in different synergies and trade-offs with UN Sustainable Development Goals (SDGs). Pathways can use different strategies and portfolios of mitigation options, for example, focusing more on reducing energy demand or favouring specific supply-side options. The overall synergies and trade-offs in the 1.5°C pathways will depend on the selected technology portfolio, the design of the mitigation policy, and the local circumstances and context.



Alignment of 1.5°C pathways with SDG synergies and trade-offs

Different 1.5°C emission pathways reflect choices about preferred mitigation options and strategies, which can either support the simultaneous achievement of other SDGs or make their achievement relatively harder.

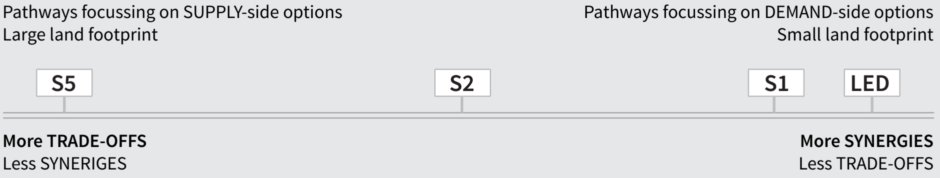


Figure SPM 4: Potential positive effects (synergies) and risk of negative effects (trade-offs) between climate change mitigation measures and the UN Sustainable Development Goals (SDGs). Potential interactions are indicated for each assessed combination of a mitigation measure and a SDG. SDG 13 (climate action) is not listed as it is implicitly represented in the various mitigation measures. The alignment of 1.5°C-consistent pathways with SDG synergies and trade-offs is based on the relative deployment of specific mitigation measures in each pathway. Pathway archetypes LED, S1, S2, and S5 are introduced in Figure SPM3. {2.5.3, Figure 2.28, 5.4, Table 5.3, Figure 5.3}

D. Strengthening the global response in the context of sustainable development and efforts to eradicate poverty

D1. Fulfilling the current pledges under the Paris Agreement (known as Nationally-Determined Contributions or NDCs) will still result in global warming of more than 1.5°C, with associated risks and adaptation challenges. Emissions reductions and action in addition to current NDCs lead to lower overshoot and lower transitional challenges after 2030 and can contribute to the achievement of the UN Sustainable Development Goals (SDGs) (*high confidence*) {1.2, 2.3, 3.3, 3.4, 4.2, 4.4, Cross-Chapter Box 11 in Chapter 4}

D1.1. Implementation of the conditional and unconditional NDCs is projected to result in global GHG emissions in 2030 of 50-54 $GtCO_2eq/yr$ and 52-58 $GtCO_2eq/yr$, respectively (*high confidence*). {Cross-Chapter Box 11 in Chapter 4}

D1.2. Collectively meeting the current conditional or unconditional NDCs would imply pursuing an overshoot trajectory to return global warming to 1.5°C. This would result in higher impacts and adaptation challenges, higher transitional challenges to reduce GHG emissions after 2030 and a higher reliance on CDR compared to pathways that are consistent with limited or no overshoot and which have deeper GHG emissions reductions until 2030 (*high confidence*) {1.3.3, 2.3.4, 2.3.5, 2.5.1, Cross-Chapter Box 8 in Chapter 3 and 11 in Chapter 4}

D2. Limiting global warming to 1.5°C in the context of sustainable development and poverty eradication requires a portfolio of mitigation and adaptation actions that work across sectors and scales. These actions would face key barriers and are enabled by change, such as finance, technology and behaviour (*high confidence*). {2.3, 2.4, 2.5, 3.2, 4.2, 4.4, 4.5, 5.2, 5.5, 5.6}

D2.1. Abatement costs resulting in 1.5°C-consistent pathway modelling are 3-4 times higher, on average, compared to holding warming to 2°C (*high confidence*). {2.5.1, 2.5.2, 4.4.5, 5.5.2}

D2.2. Limiting global warming to 1.5°C requires enhanced action by countries and non-state actors in the next decade. Stringent near-term policies to support the transitions required to limit warming to 1.5°C are more effective when integrated policy packages are used, involving innovative non-price and price instruments. {1.3.3, 2.3.4, 2.3.5, 2.5.1, Cross-Chapter Box 8 in Chapter 3 and 11 in Chapter 4}

D2.3. Global investments in energy, transportation, buildings, and water and sanitisation infrastructure are higher in most 1.5°C-consistent pathways compared to today, with an additional 1.7% to 2.5% of annual economy-wide investment required from the present to 2035. Such changes can be enabled by a portfolio of policies and measures, including pricing instruments, fiscal policies, technology policies, performance standards and reforming of energy subsidies. In the next two decades, investments in low-carbon energy technologies and energy efficiency is expected to roughly double in 1.5ºC-consistent pathways, while fossil-fuel extraction decreases by about a quarter *(medium confidence).* {2.5.2, 4.4.5, Box 4.8}

D2.4. Effective innovation policies combine support for research and development and incentives for market uptake, as well as on the degree of cooperation between governments and the private sector. Both national and international innovation policies can contribute to the commercialisation and widespread adoption of new technologies {4.4.4}

D2.5. Public acceptability can enable or inhibit the implementation of policy to limit global warming to 1.5°C and to adapt to the consequences, and depends on the evaluation and distribution of expected policy consequences and perceived fairness of decision procedures. {4.4.3}

D2.6. Education, information and feedback, and community approaches that rely on Indigenous and local knowledge, when combined with the policies mentioned in D2.3 and tailored to motivations and circumstances of specific actors and contexts, can accelerate the wide scale behaviour changes assumed in 1.5°C-consistent pathways to adapt to and limit global warming to 1.5°C (*high confidence*). {1.1, 1.5, 4.3.5, 4.4.1, 4.4.3, Box 4.3, 5.5.3, 5.6.5}

D3. Adaptation can reduce vulnerability to global warming of 1.5ºC and is mostly beneficial for sustainable development and poverty reduction. There can also be negative consequences (trade-offs) with some of the UN SDGs if actions are not context-specific and managed carefully *(high confidence)*. {1.4, 4.5, 5.3}

D3.1. Both incremental and transformational adaptation are needed to reduce vulnerability with 1.5ºC global warming involving deep and long-term societal changes that influence sustainable development, poverty reduction and foster equity *(high confidence*). {1.4.3, 4.2.2, 4.4.1, 4.4.3, 4.5.3, 5.3.1}

D3.2. Adaptation options to reduce vulnerability at 1.5ºC global warming, have significant synergies with SDGs for agriculture, health, urban sectors, and ecosystems *(high confidence).* Investments in health and social security can be cost effective measures for adaptation with potential for scaling up (*medium confidence*). {4.3.3, 4.5.3, 4.5.4, 5.3.2}

D3.3. Agricultural adaptation and securing provision of food security with 1.5ºC global warming can result in trade–offs with seven SDGs, including health and wellbeing, gender equality, climate action, water, resilient infrastructure, marine and terrestrial ecosystem *(high confidence).* {4.3.3, 4.5.4, 5.3.2; Cross-Chapter Boxes 6, 7 and 8 in Chapter 3}

D4. Mitigation consistent with 1.5°C global warming pathways is associated with multiple synergies and trade-offs across a range of UN SDGs, depending on the pace and magnitude of changes and the management of the transition *(high confidence*). (SPM Figure 4) {2.5, 4.5, 5.4}

D4.1. Pathways consistent with 1.5°C global warming indicate robust synergies particularly for the SDGs 3 (health), 7 (sub goal of clean energy), 11 (cities and communities), 12 (responsible consumption and production), and 14 (oceans) (*very high confidence*). For SDGs 1 (poverty), 2 (hunger), 6 (water), and 7 (sub-goal of energy access), stringent mitigation actions compatible with 1.5°C can have trade-offs or negative side-effects if not carefully managed (*high confidence*) (Figures SPM2 and SPM4). {4.3.1, 4.5.2, 5.4.2; Figure 5.4, Cross-Chapter Boxes 7 and 8 in Chapter 3}

D4.2. 1.5°C-consistent pathways that achieve low carbon energy and material consumption, and low GHG-intensive food consumption have most pronounced synergies and the lowest number of trade-offs with respect to sustainable development and the SDGs (*high confidence*) and can be achieved with high economic growth *(high confidence)* (Figure SPM4). {2.4.3, 2.5.1, 2.5.3, Figure 2.4, Figure 2.28, 5.4.1, 5.4.2, Figure 5.4}

D4.3. Mitigation measures of 1.5°C-consistent pathways can create risks for development, for example as a result of the economic losses from the projected decline in the use of coal, oil and gas (*high confidence*). Policies that promote diversification of the economy and the energy sector can facilitate this transition (*high confidence*). {5.4.1, Box 5.2}

D4.4. Redistributive policies that shield the poor and vulnerable can resolve trade-offs for a range of SDGs particularly hunger, poverty and energy access. Investment needs for such complementary policies are only a small fraction of the overall mitigation investments in 1.5°C-consistent pathways (*high confidence*). {2.4.3, 4.2.1, Box 4.8, 5.4.2, Figure 5.5}

D5. Pursuing climate-resilient development pathways can limit warming to 1.5°C while adapting to its consequences and simultaneously achieving sustainable development *(high confidence)*. {Box 1.1, 1.4, 2.5, 4.4, Box 4.6, 5.5.3, Box 5.3}

D5.1. Sustainable development can enable societal and systems transformations that can help limit warming to 1.5°C (*high confidence*). Pathways that are consistent with sustainable development are associated with reduced mitigation and adaptation challenges, and limit warming to 1.5°C at comparatively lower mitigation costs as compared to development pathways that have high inequality and poverty (*high confidence*). {2.5.3, 5.5.2}.

D5.2. The integration between adaptation, mitigation, and sustainable development requires a systemic approach to reconciling trade-offs and exploiting synergies across sectors and spatial scales (*very high confidence*). The potential for climate-resilient development pathways differs between and within regions and nations, due to different development contexts and starting points (*very high confidence*). {4.4.1, 4.4.3, 4.5.4, 5.5.1, 5.5.3, Figure 5.1}

D5.3. 1.5°C-consistent development pathways that encompass joint, iterative planning and transformative visions and consider power asymmetries and unequal opportunities for development at multiple levels show potential for sustainable futures and benefit for all affected populations (*high confidence*). {5.5.3, Figure 5.6, 5.6.4, Box 5.3, Cross-Chapter Box 13 in Chapter 5}

D6. Policy implementation to successfully limit warming to 1.5ºC and to adapt to global warming of 1.5ºC implies international cooperation and strengthening institutional capacity of national and sub-national authorities from civil society, the private sector, cities, local communities and Indigenous peoples (*high confidence*). {4.4, 4.2}

D6.1 Transformational adaptation implies deep and long-term societal changes linked to ipoverty reduction and promoting equity with benefits for sustainable development goals. These changes can be enabled by multi-level governance, coordinated sectoral and cross-sectoral policies, collaborative stakeholder partnerships and innovative financing mechanisms that provide greater access to financing and technology. *(high confidence*). {4.2.2, 4.4.1, 4.4.3, 4.5.3, Cross-Chapter Box 9 in Chapter 4, 5.3.1}

D6.2. Implementing 1.5ºC-consistent climate responses in developing countries and for poor and vulnerable people requires international resources supporting access to finance, technology and capacity building (*high confidence*). Financial, institutional and innovation capabilities currently fall short of implementing far-reaching measures at scale in all countries *(high confidence)*. Enhanced capacities of local public and private sectors support the deployment of context-specific climate responses and hence support systems' transitions to limiting warming to 1.5°C (*high confidence*). {2.5.2, 4.2.2, 4.4.1, 4.4.2, 4.4.4, 4.4.5}

D6.3. International funding and technology transfer can support fast and profound local transformation when they consider the context-specific needs of recipients (*high confidence*). Strengthened global-to-local structures enable inclusive access to finance and technology and ensure participation, transparency, capacity building, and learning among different players (*high confidence*) {4.4.1, 4.4.4, 5.5.3, Cross-Chapter Box 13 in Chapter 5, 5.6.1, 5.6.3}

D6.4. International agreements that are sensitive to equity and the SDGs enable transformation consistent with a 1.5°C warmer world. The governance of global partnerships involving non-state actors including public and private sectors, civil society and scientific institutions supporting sustainable development and poverty eradication would facilitate actions and responses consistent with constraining global warming to 1.5ºC (*very high confidence*). {1.4, 4.4, 4.4.1, 4.2.2, 4.4.3, 4.5.3, 5.3.1, 5.6.2, Box 5.3}