

To: Minister for the Environment (For Information)

Cc: Minister for Energy (For Information)

**HANDLING STRATEGY FOR THE RELEASE OF THE IPCC SPECIAL REPORT,  
GLOBAL WARMING OF 1.5°C**

Timing: 1 October 2018, the first day of the IPCC Plenary

**Recommendations:**

1. That you note the detailed handling strategy for the release of the Intergovernmental Panel on Climate Change (IPCC) Special Report *Global warming of 1.5°C*, on 8 October 2018, at **Attachment A**.

**Noted / Please discuss**

**Minister:**

Date:

**Comments:**

<b>Clearing Officer:</b> Sent 25/09/18	Brad Archer	First Assistant Secretary, International Climate Change and Energy Innovation Division	Ph: 6159 7592 Mob: s22
Contact Officer:	s22	Director (A/g), National Inventory Team	s22

**Key Points:**

1. The Intergovernmental Panel on Climate Change (IPCC) Special Report, *Global warming of 1.5°C*, is due to be finalised at the IPCC Plenary on 1-5 October 2018 and released on 8 October 2018.
  - a. The report was requested by the parties to the Paris Agreement.

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2. The release of the report is likely to draw media attention to the impacts of climate change and adequacy of the international response to reduce emissions, including in Australia. A detailed handling strategy is at **Attachment A**.
3. The report finds that limiting global warming to 1.5°C above pre-industrial levels would require rapid and far-reaching transitions in the coming one or two decades in energy, land, urban and industrial systems. Key messages are at **Attachment B**. The current draft of the IPCC's *Summary for Policy Makers* is at **Attachment C**.
4. The Department provided comments on early drafts of the report (MS18-000794 refers), a final draft report is expected to be released on 1 October 2018 for the Plenary.

5. The Australian delegation to the IPCC Plenary will support adoption of a final report that provides a balanced assessment of the scientific literature, is policy-neutral, is not policy prescriptive and within the scope agreed by governments in 2016.

## Sensitivities

*UNFCCC Conference of the Parties (COP 24)*

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8. There may be increased focus on actions to protect the Great Barrier Reef. The report:
  - a. identifies that the Great Barrier Reef has lost as much as 50 per cent of its shallow water coral cover in the last 3 years;

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- b. projects that further losses of coral both in Australia and worldwide may be substantial under even limited warming scenarios;
      - i. around 70-90 per cent of coral cover may be severely damaged under warming of 1.5°C and up to 99 per cent at 2°C warming (subject to some considerable uncertainty).

A key IPCC author is Professor Ove Hoegh-Guldberg, who is also a member of the Great Barrier Reef Foundation's International Scientific Advisory Committee and of the Government's Reef 2050 Plan Independent Expert Panel.

9. Other impacts of warming of 2°C compared to 1.5°C in Australia include increased frequency of some extreme weather events such as heatwaves, impacts on precipitation across Australia of varying intensities, increased coastal flooding, and impacts on human health, biodiversity and ecosystems.

## Consultation

10. Department of Foreign Affairs and Trade; International Climate Change and Energy Innovation Division; Climate Change Division; Reef Branch; External Communications.

**Attachments**

- A:** Handling Strategy – Release of the IPCC Special Report *Global warming of 1.5°C*
- B:** Key messages in the Special Report *Global warming of 1.5°C*
- C:** Summary for Policy Makers (SPM) of the Special Report *Global warming of 1.5°C*

## Media handling plan

### Background

The Intergovernmental Panel on Climate Change (IPCC) Special Report, *Global warming of 1.5°C* is due to be finalised at the IPCC Plenary on 1-5 October 2018 and released on 8 October 2018.

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The outcomes of the report are likely to draw media attention to the impacts of climate change and adequacy of the international response to reduce emissions, including in Australia. At the domestic level the report will likely draw media attention to the Australian Government's actions to protect the Great Barrier Reef, the adequacy of our 2030 target and domestic climate change and energy policy.

### Timing

The report will be released on 8 October following the IPCC Plenary on 1-5 October 2018.

### Stakeholders and contacts

- Australian delegation at the IPCC Plenary:

Name	Delegation	Email and phone
Rob Sturgiss	AS, National Inventory Systems and International Reporting Branch, ICCEI Division Head of Delegation, IPCC Delegation	<a href="mailto:Rob.Sturgiss@environment.gov.au">Rob.Sturgiss@environment.gov.au</a> 02 6159 7388 s22
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s22	UNFCCC negotiations advisor, IPCC Delegation Sustainability and Climate Change Branch, Department of Foreign Affairs and Trade	s22 s22

- Department of the Environment and Energy

Name	Delegation	Email and phone
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s22	A/g Assistant Secretary, National Inventory Systems and International Reporting Branch	s22
s22	Director A/g, National Inventory, ICCEI Division	s22
s22	Director, Mitigation and Climate Science, Climate Change Division	s22
s22	Director, Reef 2050 Heritage, Reef and Marine Division	s22
DoEE media team		<a href="mailto:media@environment.gov.au">media@environment.gov.au</a> 02 6275 9880
s22	Director, External Engagement and Media	s22
s22	External Engagement and Media team	s22

- Department of Foreign Affairs and Trade

Name	Delegation	Email and phone
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s22	Director, Mechanisms and Adaptation Section Sustainability and Climate Change Branch, Department of Foreign Affairs and Trade	s22
DFAT media team		<a href="mailto:media@dfat.gov.au">media@dfat.gov.au</a> 02 6261 1555

## Sensitivities

- UNFCCC Conference of the Parties (COP 24)

s33(a)iii

# s33(a)iii

There may be increased focus on actions to protect the Great Barrier Reef. The report:

- a. identifies that the Great Barrier Reef has lost as much as 50% of its shallow water coral cover in the last 3 years;

## s33(a)iii

- b. projects that further losses of coral cover both in Australia and worldwide may be substantial under even limited warming scenarios;
  - i. around 70-90% of coral cover may be severely damaged under warming of 1.5°C and up to 99% at 2°C warming (projections subject to some considerable uncertainty).

A key IPCC author is Professor Ove Hoegh-Guldberg, who is also a member of the Great Barrier Reef Foundation's International Scientific Advisory Committee and of the Government's Reef 2050 Plan Independent Expert Panel.

Impacts of warming of 2°C compared to 1.5°C in Australia include increased frequency of some extreme weather events such as heatwaves; impacts on precipitation across Australia of varying intensities, increased coastal flooding and impacts on human health, biodiversity and ecosystems.

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### Handling strategy

Talking points have been provided to the office as part of briefing MS18-000873, and also via the DoEE media team to the Minister's media advisers, as per usual protocol.

- **Department of the Environment and Energy**

DoEE will be the central point of contact for media enquiries regarding emissions reductions and targets, the Great Barrier Reef and the decoupling of energy and climate change policy.

**The DoEE's media team will:**

- work with the line area to prepare any additional key messages and talking points to those provided below, for use by all stakeholders as required

- draft a media release if required
  - be the central point of contact for media enquiries
  - direct relevant media enquiries to the Department of Foreign Affairs and Trade media team
  - where appropriate, coordinate responses to complex written media enquiries.
- **Department of Foreign Affairs and Trade**

DFAT is the point of contact for media enquiries regarding Australia's commitment to the Paris Agreement, Australian Aid, climate finance and relationships with Pacific countries.

**The Department of Foreign Affairs and Trade media team will:**

- handle enquiries about Australia's commitment to the Paris Agreement, Australian Aid and relationships with Pacific countries, climate finance (including the Green Climate Fund), compensation for loss and damage associated with climate impacts, which will be forwarded to DFAT's media team for response.
- where appropriate, liaise with the DoEE media team and line areas on other enquiries and agree on a handling strategy on a case by case basis.

### **Requests for interview/comment**

Requests for comment from the Minister/s will be referred to the respective Minister's media adviser.

### **Web content**

We will not be providing a link to the report on our website, it will be available on the IPCC website.

S47C

Key messages in the draft *Special Report on Global Warming of 1.5°C - SPM*

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s22

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**From:** s22  
**Sent:** Monday, 8 October 2018 9:31 AM  
**To:** s22  
**Subject:** Checking in | IPCC SPM [SEC=UNCLASSIFIED]

Just wanted to quickly check you have everything you need at this stage?

Regards  
s22

s22

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**From:** s22  
**Sent:** Monday, 8 October 2018 12:49 PM  
**To:** Kushla Munro; s22 ; s22  
**Subject:** FW: Special Report on Global warming of 1.5 - SPM and headline statements [SEC=UNCLASSIFIED]  
**Attachments:** sr15\_spm\_final.pdf; sr15\_headline\_statements.pdf

FYI

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**From:** s22  
**Sent:** Monday, 8 October 2018 12:48 PM  
**To:** Rob Sturgiss ; s22 ; s22 ; s22  
**Subject:** Special Report on Global warming of 1.5 - SPM and headline statements [SEC=UNCLASSIFIED]

Dear all,

The report has now been publicly released, see attached Summary for Policy Makers and headline statements.

The interim full report (5 chapters) is also available on the [IPCC website](#). The authors will be making changes to the underlying report to ensure consistency with the language used in the SPM, or to provide additional clarification as agreed at the meeting. The changes will not alter any substantive findings of the final draft of the underlying report that was distributed to governments on 29 August 2018.

Kind regards  
s22

s22  
National Inventory Team  
International Climate Change and Energy Innovation Division  
Department of the Environment and Energy  
s22

*The Department acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.*

# GLOBAL WARMING OF 1.5 °C

an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

## *Summary for Policymakers*

This Summary for Policymakers was formally approved at the First Joint Session of Working Groups I, II and III of the IPCC and accepted by the 48<sup>th</sup> Session of the IPCC, Incheon, Republic of Korea, 6 October 2018.

SUBJECT TO COPY EDIT

## Summary for Policymakers

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Affairs, and the National Institute for Space Research (INPE), Brazil; Met Office and the University of Exeter, The United Kingdom; Swedish Meteorological and Hydrological Institute (SMHI), Sweden; the Ministry of Environment Natural Resources Conservation and Tourism, the National Climate Change Committee in the Department of Meteorological Services and the Botswana Global Environmental Change Committee at the University of Botswana, Botswana; and the government of the Republic of Korea. The support provided by governments and institutions, as well as through contributions to the IPCC Trust Fund, is thankfully acknowledged as it enabled the participation of the author teams in the preparation of the report. The efficient operation of the Working Group I Technical Support Unit was made possible by the generous financial support provided by the government of France and administrative and information technology support from the University Paris Saclay (France), Institut Pierre Simon Laplace (IPSL) and the Laboratoire des Sciences du Climat et de l'Environnement (LSCE). We thank the Norwegian Environment Agency for supporting the preparation of the graphics for the Summary for Policymakers.

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Finally, our particular appreciation goes to the Working Group Technical Support Units whose tireless dedication, professionalism and enthusiasm led the production of this special report. This report could not have been prepared without the commitment of members of the Working Group I Technical Support Unit, all new to the IPCC, who rose to the unprecedented AR6 challenge, and were pivotal in all aspects of the preparation of the report: Yang Chen, Sarah Connors, Melissa Gomez, Elisabeth Lonnoy, Robin Matthews, Wilfran-Moufouma-Okia, Clotilde Péan, Roz Pidcock, Anna Pirani, Nicholas Reay, Tim Waterfield, and Xiao Zhou. Our warmest thanks go to the collegial and collaborative support provided by Marlies Craig, Andrew Okem, Jan Petzold, Melinda Tignor and Nora Weyer from the WGII Technical Support Unit and Bhushan Kankal, Suvadip Neogi, Joana Portugal Pereira from the WGIII Technical Support Unit. A special thanks goes to Kenny Coventry, Harmen Gudde, Irene Lorenzoni, and Steve Jenkins for their support with the figures in the Summary for Policymakers, as well as Nigel Hawtin for graphical support of the report. In addition, the following contributions are gratefully acknowledged: Tom Maycock (operational support and copy edit), Jatinder Padda (copy edit), Melissa Dawes (copy edit), Marilyn Anderson (index), Vincent Grégoire (layout) and Sarah le Rouzic (intern).

**Date of Summary for Policymakers: 6 October 2018**

## Introduction

This report responds to the invitation for IPCC ‘... to provide 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’ contained in the Decision of the 21st Conference of Parties of the United Nations Framework Convention on Climate Change to adopt the Paris Agreement.<sup>1</sup>

The IPCC accepted the invitation in April 2016, deciding to prepare this Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

This Summary for Policy Makers (SPM) presents the key findings of the Special Report, based on the assessment of the available scientific, technical and socio-economic literature<sup>2</sup> relevant to global warming of 1.5°C and for the comparison between global warming of 1.5°C and 2°C above pre-industrial levels. The level of confidence associated with each key finding is reported using the IPCC calibrated language.<sup>3</sup> The underlying scientific basis of each key finding is indicated by references provided to chapter elements. In the SPM, knowledge gaps are identified associated with the underlying chapters of the report.

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<sup>1</sup> Decision 1/CP.21, paragraph 21.

<sup>2</sup> The assessment covers literature accepted for publication by 15 May 2018.

<sup>3</sup> Each finding is grounded in an evaluation of underlying evidence and agreement. A level of confidence is expressed using five qualifiers: very low, low, medium, high and very high, and typeset in italics, for example, *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, for example, *very likely*. This is consistent with AR5.

## A. Understanding Global Warming of 1.5°C<sup>4</sup>

**A1. Human activities are estimated to have caused approximately 1.0°C of global warming<sup>5</sup> above pre-industrial levels, with a *likely* range of 0.8°C to 1.2°C. Global warming is *likely* to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (*high confidence*) {1.2, Figure SPM.1}**

**A1.1.** Reflecting the long-term warming trend since pre-industrial times, observed global mean surface temperature (GMST) for the decade 2006–2015 was 0.87°C (*likely* between 0.75°C and 0.99°C)<sup>6</sup> higher than the average over the 1850–1900 period (*very high confidence*). Estimated anthropogenic global warming matches the level of observed warming to within  $\pm 20\%$  (*likely* range). Estimated anthropogenic global warming is currently increasing at 0.2°C (*likely* between 0.1°C and 0.3°C) per decade due to past and ongoing emissions (*high confidence*). {1.2.1, Table 1.1, 1.2.4}

**A1.2.** Warming greater than the global annual average is being experienced in many land regions and seasons, including two to three times higher in the Arctic. Warming is generally higher 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}

**A1.3.** Trends in intensity and frequency of some climate and weather extremes have been detected over time spans during which about 0.5°C of global warming occurred (*medium confidence*). This assessment is based on several lines of evidence, including attribution studies for changes in extremes since 1950. {3.3.1, 3.3.2, 3.3.3}

**A.2. Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (*high confidence*), but these emissions alone are *unlikely* to cause global warming of 1.5°C (*medium confidence*) {1.2, 3.3, Figure 1.5, Figure SPM.1}**

**A2.1.** Anthropogenic emissions (including greenhouse gases, aerosols and their precursors) up to the present are *unlikely* to cause further warming of more than 0.5°C over the next two to three decades (*high confidence*) or on a century time scale (*medium confidence*). {1.2.4, Figure 1.5}

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<sup>4</sup> SPM BOX.1: Core Concepts

<sup>5</sup> Present level of global warming is defined as the average of a 30-year period centered on 2017 assuming the recent rate of warming continues.

<sup>6</sup> This range spans the four available peer-reviewed estimates of the observed GMST change and also accounts for additional uncertainty due to possible short-term natural variability. {1.2.1, Table 1.1}

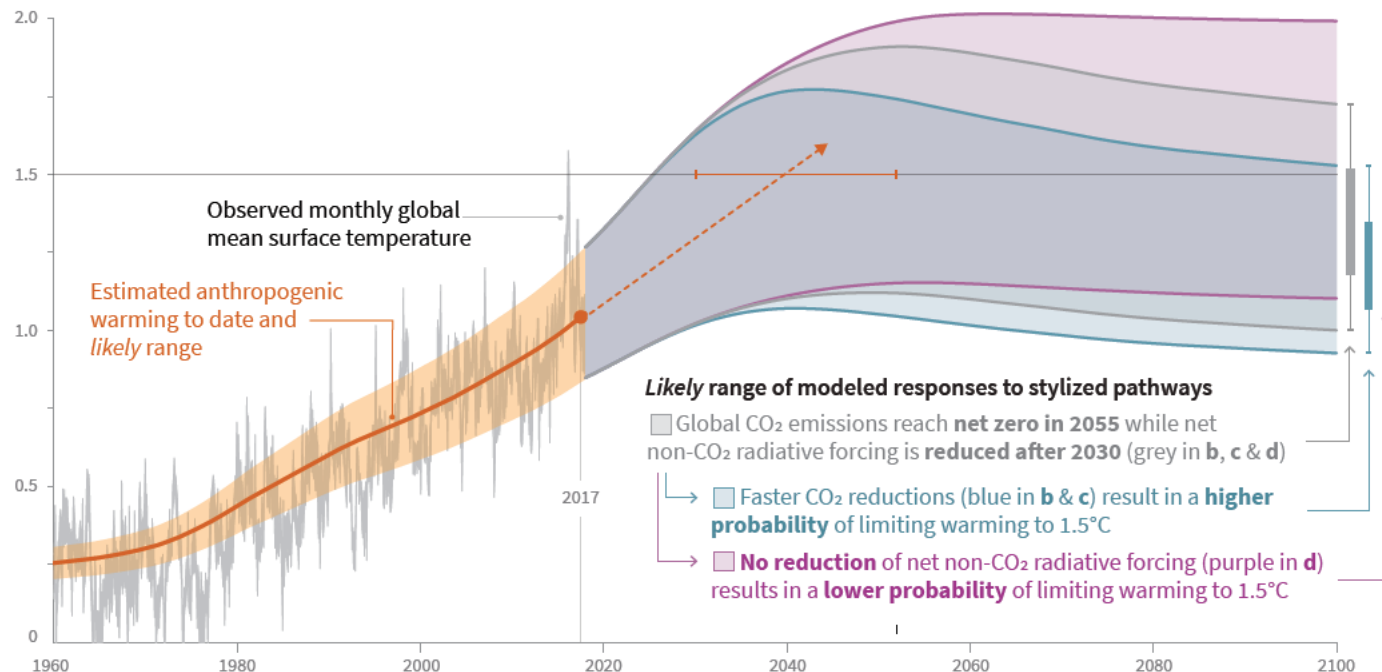
**A2.2.** Reaching and sustaining net-zero global anthropogenic CO<sub>2</sub> emissions and declining net non-CO<sub>2</sub> radiative forcing would halt anthropogenic global warming on multi-decadal timescales (*high confidence*). The maximum temperature reached is then determined by cumulative net global anthropogenic CO<sub>2</sub> emissions up to the time of net zero CO<sub>2</sub> emissions (*high confidence*) and the level of non-CO<sub>2</sub> radiative forcing in the decades prior to the time that maximum temperatures are reached (*medium confidence*). On longer timescales, sustained net negative global anthropogenic CO<sub>2</sub> emissions and/or further reductions in non-CO<sub>2</sub> radiative forcing may still be required to prevent further warming due to Earth system feedbacks and reverse ocean acidification (*medium confidence*) and will be required to minimise sea level rise (*high confidence*). {Cross-Chapter Box 2 in Chapter 1, 1.2.3, 1.2.4, Figure 1.4, 2.2.1, 2.2.2, 3.4.4.8, 3.4.5.1, 3.6.3.2}



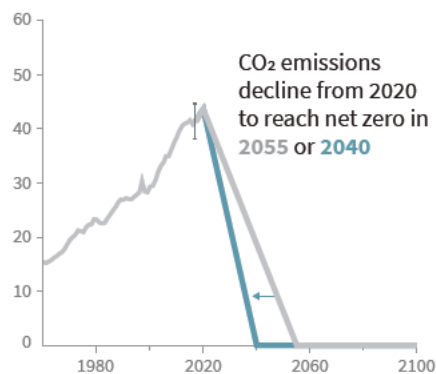
# Cumulative emissions of CO<sub>2</sub> and future non-CO<sub>2</sub> radiative forcing determine the probability of limiting warming to 1.5°C

## a) Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways

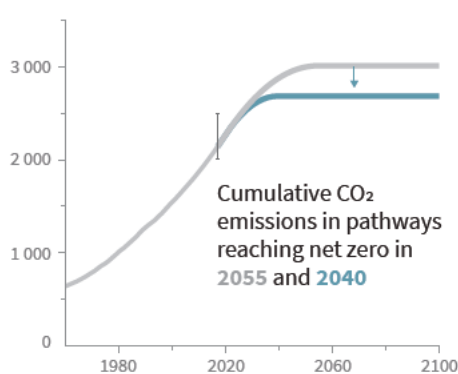
Global warming relative to 1850-1900 (°C)



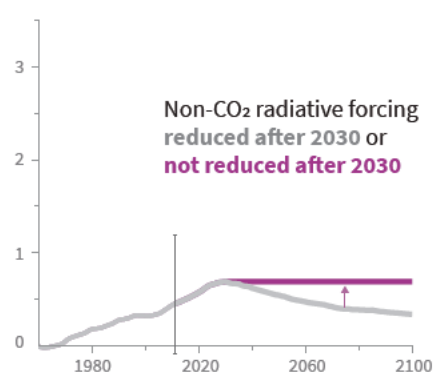
### b) Stylized net global CO<sub>2</sub> emission pathways Billion tonnes CO<sub>2</sub> per year (GtCO<sub>2</sub>/yr)



### c) Cumulative net CO<sub>2</sub> emissions Billion tonnes CO<sub>2</sub> (GtCO<sub>2</sub>)



### d) Non-CO<sub>2</sub> radiative forcing pathways Watts per square metre (W/m<sup>2</sup>)



Faster immediate CO<sub>2</sub> emission reductions limit cumulative CO<sub>2</sub> emissions shown in panel (c).

Maximum temperature rise is determined by cumulative net CO<sub>2</sub> emissions and net non-CO<sub>2</sub> radiative forcing due to methane, nitrous oxide, aerosols and other anthropogenic forcing agents.

**Figure SPM.1:** Panel a: Observed monthly global mean surface temperature (GMST) change grey line up to 2017, from the HadCRUT4, GISTEMP, Cowtan–Way, and NOAA datasets) and estimated anthropogenic global warming (solid orange line up to 2017, with orange shading indicating assessed *likely* range). Orange dashed arrow and horizontal orange error bar show respectively central estimate and *likely* range of the time at which 1.5°C is reached if the current rate of warming continues. The grey plume on the right of Panel a) shows the *likely* range of warming responses, computed with a simple climate model, to a stylized pathway (hypothetical future) in which net CO<sub>2</sub> emissions (grey line in panels b and c) decline in a straight line from 2020 to reach net zero in 2055 and net non-CO<sub>2</sub> radiative forcing (grey line in panel d) increases to 2030 and then declines. The blue plume in panel a) shows the response to faster CO<sub>2</sub> emissions reductions (blue line in panel b), reaching net zero in 2040, reducing cumulative CO<sub>2</sub> emissions (panel c). The purple plume shows the response to net CO<sub>2</sub> emissions declining to zero in 2055, with net non-CO<sub>2</sub> forcing remaining constant after 2030. The vertical error bars on right of panel a) show the *likely* ranges (thin lines) and central terciles (33rd – 66th percentiles, thick lines) of the estimated distribution of warming in 2100 under these three stylized pathways. Vertical dotted error bars in panels b, c and d show the *likely* range of historical annual and cumulative global net CO<sub>2</sub> emissions in 2017 (data from the Global Carbon Project) and of net non-CO<sub>2</sub> radiative forcing in 2011 from AR5, respectively. Vertical axes in panels c and d are scaled to represent approximately equal effects on GMST. {1.2.1, 1.2.3, 1.2.4, 2.3, Chapter 1 Figure 1.2 & Chapter 1 Supplementary Material, Cross-Chapter Box 2}

**A3. Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C (*high confidence*). These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options (*high confidence*) (Figure SPM.2). {1.3, 3.3, 3.4, 5.6}**

**A3.1.** Impacts on natural and human systems from global warming have already been observed (*high confidence*). Many land and ocean ecosystems and some of the services they provide have already changed due to global warming (*high confidence*). {1.4, 3.4, 3.5, Figure SPM.2}

**A3.2.** Future climate-related risks depend on the rate, peak and duration of warming. In the aggregate they are larger if global warming exceeds 1.5°C before returning to that level by 2100 than if global warming gradually stabilizes at 1.5°C, especially if the peak temperature is high (e.g., about 2°C) (*high confidence*). Some impacts may be long-lasting or irreversible, such as the loss of some ecosystems (*high confidence*). {3.2, 3.4.4, 3.6.3, Cross-Chapter Box 8}

**A3.3.** Adaptation and mitigation are already occurring (*high confidence*). Future climate-related risks would be reduced by the upscaling and acceleration of far-reaching, multi-level and cross-sectoral climate mitigation and by both incremental and transformational adaptation (*high confidence*). {1.2, 1.3, Table 3.5, 4.2.2, Cross-Chapter Box 9 in Chapter 4, Box 4.2, Box 4.3, Box 4.6, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.3.5, 4.4.1, 4.4.4, 4.4.5, 4.5.3}

## **B. Projected Climate Change, Potential Impacts and Associated Risks**

**B1. Climate models project robust<sup>7</sup> differences in regional climate characteristics between present-day and global warming of 1.5°C,<sup>8</sup> and between 1.5°C and 2°C.<sup>8</sup> These differences include increases in: mean temperature in most land and ocean regions (*high confidence*), hot extremes in most inhabited regions (*high confidence*), heavy precipitation in several regions (*medium confidence*), and the probability of drought and precipitation deficits in some regions (*medium confidence*). {3.3}**

**B1.1.** Evidence from attributed changes in some climate and weather extremes for a global warming of about 0.5°C supports the assessment that an additional 0.5°C of warming compared to present is associated with further detectable changes in these extremes (*medium confidence*). Several regional changes in climate are assessed to occur with global warming up to 1.5°C compared to pre-industrial levels, including warming of extreme temperatures in many regions (*high confidence*), increases in frequency, intensity, and/or amount of heavy precipitation in several regions (*high confidence*), and an increase in intensity or frequency of droughts in some regions (*medium confidence*). {3.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, Table 3.2}

**B1.2.** Temperature extremes on land are projected to warm more than GMST (*high confidence*): extreme hot days in mid-latitudes warm by up to about 3°C at global warming of 1.5°C and about

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<sup>7</sup> Robust is here used to mean that at least two thirds of climate models show the same sign of changes at the grid point scale, and that differences in large regions are statistically significant.

<sup>8</sup> Projected changes in impacts between different levels of global warming are determined with respect to changes in global mean surface air temperature.

4°C at 2°C, and extreme cold nights in high latitudes warm by up to about 4.5°C at 1.5°C and about 6°C at 2°C (*high confidence*). The number of hot days is projected to increase in most land regions, with highest increases in the tropics (*high confidence*). {3.3.1, 3.3.2, Cross-Chapter Box 8 in Chapter 3}

**B1.3.** Risks from droughts and precipitation deficits are projected to be higher at 2°C compared to 1.5°C global warming in some regions (*medium confidence*). Risks from heavy precipitation events are projected to be higher at 2°C compared to 1.5°C global warming in several northern hemisphere high-latitude and/or high-elevation regions, eastern Asia and eastern North America (*medium confidence*). Heavy precipitation associated with tropical cyclones is projected to be higher at 2°C compared to 1.5°C global warming (*medium confidence*). There is generally *low confidence* in projected changes in heavy precipitation at 2°C compared to 1.5°C in other regions. Heavy precipitation when aggregated at global scale is projected to be higher at 2.0°C than at 1.5°C of global warming (*medium confidence*). As a consequence of heavy precipitation, the fraction of the global land area affected by flood hazards is projected to be larger at 2°C compared to 1.5°C of global warming (*medium confidence*). {3.3.1, 3.3.3, 3.3.4, 3.3.5, 3.3.6}

**B2.** By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C (*medium confidence*). Sea level will continue to rise well beyond 2100 (*high confidence*), and the magnitude and rate of this rise depends on future emission pathways. A slower rate of sea level rise enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas (*medium confidence*). {3.3, 3.4, 3.6 }

**B2.1.** Model-based projections of global mean sea level rise (relative to 1986-2005) suggest an indicative range of 0.26 to 0.77 m by 2100 for 1.5°C global warming, 0.1 m (0.04-0.16 m) less than for a global warming of 2°C (*medium confidence*). A reduction of 0.1 m in global sea level rise implies that up to 10 million fewer people would be exposed to related risks, based on population in the year 2010 and assuming no adaptation (*medium confidence*). {3.4.4, 3.4.5, 4.3.2}

**B2.2.** Sea level rise will continue beyond 2100 even if global warming is limited to 1.5°C in the 21st century (*high confidence*). Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet could result in multi-metre rise in sea level over hundreds to thousands of years. These instabilities could be triggered around 1.5°C to 2°C of global warming (*medium confidence*). {3.3.9, 3.4.5, 3.5.2, 3.6.3, Box 3.3, Figure SPM.2}

**B2.3.** Increasing warming amplifies the exposure of small islands, low-lying coastal areas and deltas to the risks associated with sea level rise for many human and ecological systems, including increased saltwater intrusion, flooding and damage to infrastructure (*high confidence*). Risks associated with sea level rise are higher at 2°C compared to 1.5°C. The slower rate of sea level rise at global warming of 1.5°C reduces these risks enabling greater opportunities for adaptation including managing and restoring natural coastal ecosystems, and infrastructure reinforcement (*medium confidence*). {3.4.5, Figure SPM.2, Box 3.5}

**B3.** On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C. Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater, and coastal ecosystems and to retain more of their services to humans (*high confidence*). (Figure SPM.2) {3.4, 3.5, Box 3.4, Box 4.2, Cross-Chapter Box 8 in Chapter 3}

**B3.1.** Of 105,000 species studied,<sup>9</sup> 6% of insects, 8% of plants and 4% of vertebrates are projected to lose over half of their climatically determined geographic range for global warming of 1.5°C, compared with 18% of insects, 16% of plants and 8% of vertebrates for global warming of 2°C (*medium confidence*). Impacts associated with other biodiversity-related risks such as forest fires, and the spread of invasive species, are lower at 1.5°C compared to 2°C of global warming (*high confidence*). {3.4.3, 3.5.2}

**B3.2.** Approximately 4% (interquartile range 2–7%) of the global terrestrial land area is projected to undergo a transformation of ecosystems from one type to another at 1°C of global warming, compared with 13% (interquartile range 8–20%) at 2°C (*medium confidence*). This indicates that the area at risk is projected to be approximately 50% lower at 1.5°C compared to 2°C (*medium confidence*). {3.4.3.1, 3.4.3.5}

**B3.3.** High-latitude tundra and boreal forests are particularly at risk of climate change-induced degradation and loss, with woody shrubs already encroaching into the tundra (*high confidence*) and will proceed with further warming. Limiting global warming to 1.5°C rather than 2°C is projected to prevent the thawing over centuries of a permafrost area in the range of 1.5 to 2.5 million km<sup>2</sup> (*medium confidence*). {3.3.2, 3.4.3, 3.5.5}

**B4. Limiting global warming to 1.5°C compared to 2°C is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (*high confidence*). Consequently, limiting global warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm water coral reef ecosystems (*high confidence*). {3.3, 3.4, 3.5, Boxes 3.4, 3.5}**

**B4.1.** There is *high confidence* that the probability of a sea-ice-free Arctic Ocean during summer is substantially lower at global warming of 1.5°C when compared to 2°C. With 1.5°C of global warming, one sea ice-free Arctic summer is projected per century. This likelihood is increased to at least one per decade with 2°C global warming. Effects of a temperature overshoot are reversible for Arctic sea ice cover on decadal time scales (*high confidence*). {3.3.8, 3.4.4.7}

**B4.2.** Global warming of 1.5°C is projected to shift the ranges of many marine species, to higher latitudes as well as increase the amount of damage to many ecosystems. It is also expected to drive the loss of coastal resources, and reduce the productivity of fisheries and aquaculture (especially at low latitudes). The risks of climate-induced impacts are projected to be higher at 2°C than those at global warming of 1.5°C (*high confidence*). Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C (*high confidence*) with larger losses (>99%) at 2°C (*very high confidence*). The risk of irreversible loss of many marine and coastal ecosystems increases with global warming, especially at 2°C or more (*high confidence*). {3.4.4, Box 3.4}

**B4.3.** The level of ocean acidification due to increasing CO<sub>2</sub> concentrations associated with global warming of 1.5°C is projected to amplify the adverse effects of warming, and even further at 2°C,

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<sup>9</sup> Consistent with earlier studies, illustrative numbers were adopted from one recent meta-study.

impacting the growth, development, calcification, survival, and thus abundance of a broad range of species, e.g., from algae to fish (*high confidence*). {3.3.10, 3.4.4}

**B4.4.** Impacts of climate change in the ocean are increasing risks to fisheries and aquaculture via impacts on the physiology, survivorship, habitat, reproduction, disease incidence, and risk of invasive species (*medium confidence*) but are projected to be less at 1.5°C of global warming than at 2°C. One global fishery model, for example, projected a decrease in global annual catch for marine fisheries of about 1.5 million tonnes for 1.5°C of global warming compared to a loss of more than 3 million tonnes for 2°C of global warming (*medium confidence*). {3.4.4, Box 3.4}

**B5. Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C. (Figure SPM.2) {3.4, 3.5, 5.2, 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.** Populations at disproportionately higher risk of adverse consequences of global warming of 1.5°C and beyond include disadvantaged and vulnerable populations, some indigenous peoples, and local communities dependent on agricultural or coastal livelihoods (*high confidence*). Regions at disproportionately higher risk include Arctic ecosystems, dryland regions, small-island developing states, and least developed countries (*high confidence*). Poverty and disadvantages are expected to increase in some populations as global warming increases; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050 (*medium confidence*). {3.4.10, 3.4.11, Box 3.5, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 4.2.2.2, 5.2.1, 5.2.2, 5.2.3, 5.6.3}

**B5.2.** Any increase in global warming is projected to affect human health, with primarily negative consequences (*high confidence*). Lower risks are projected at 1.5°C than at 2°C for heat-related morbidity and mortality (*very high confidence*) and for ozone-related mortality if emissions needed for ozone formation remain high (*high confidence*). Urban heat islands often amplify the impacts of heatwaves in cities (*high confidence*). Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographic range (*high confidence*). {3.4.7, 3.4.8, 3.5.5.8}

**B5.3.** Limiting warming to 1.5°C, compared with 2°C, is projected to result in smaller net reductions in yields of maize, rice, wheat, and potentially other cereal crops, particularly in sub-Saharan Africa, Southeast Asia, and Central and South America; and in the CO<sub>2</sub> dependent, nutritional quality of rice and wheat (*high confidence*). Reductions in projected food availability are larger at 2°C than at 1.5°C of global warming in the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon (*medium confidence*). Livestock are projected to be adversely affected with rising temperatures, depending on the extent of changes in feed quality, spread of diseases, and water resource availability (*high confidence*). {3.4.6, 3.5.4, 3.5.5, Box 3.1, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4}

**B5.4.** Depending on future socioeconomic conditions, limiting global warming to 1.5°C, compared to 2°C, may reduce the proportion of the world population exposed to a climate-change induced increase in water stress by up to 50%, although there is considerable variability between regions (*medium confidence*). Many small island developing states would experience lower water 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, Cross-Chapter Box 9 in Chapter 4}

**B5.5.** Risks to global aggregated economic growth due to climate change impacts are projected to be lower at 1.5°C than at 2°C by the end of this century<sup>10</sup> (*medium confidence*). This excludes the costs of mitigation, adaptation investments and the benefits of adaptation. Countries in the tropics and Southern Hemisphere subtropics are projected to experience the largest impacts on economic growth due to climate change should global warming increase from 1.5°C to 2 °C (*medium confidence*). {3.5.2, 3.5.3}

**B5.6.** Exposure to multiple and compound climate-related risks increases between 1.5°C and 2°C of global warming, with greater proportions of people both so exposed and susceptible to poverty in Africa and Asia (*high confidence*). For global warming from 1.5°C to 2°C, risks across energy, food, and water sectors could overlap spatially and temporally, creating new and exacerbating current hazards, exposures, and vulnerabilities that could affect increasing numbers of people and regions (*medium confidence*). {Box 3.5, 3.3.1, 3.4.5.3, 3.4.5.6, 3.4.11, 3.5.4.9}

**B5.7.** There are multiple lines of evidence that since the AR5 the assessed levels of risk increased for four of the five Reasons for Concern (RFCs) for global warming to 2°C (*high confidence*). The risk transitions by degrees of global warming are now: from high to very high between 1.5°C and 2°C for RFC1 (Unique and threatened systems) (*high confidence*); from moderate to high risk between 1.0°C and 1.5°C for RFC2 (Extreme weather events) (*medium confidence*); from moderate to high risk between 1.5°C and 2°C for RFC3 (Distribution of impacts) (*high confidence*); from moderate to high risk between 1.5°C and 2.5°C for RFC4 (Global aggregate impacts) (*medium confidence*); and from moderate to high risk between 1°C and 2.5°C for RFC5 (Large-scale singular events) (*medium confidence*). (Figure SPM.2) {3.4.13; 3.5, 3.5.2}

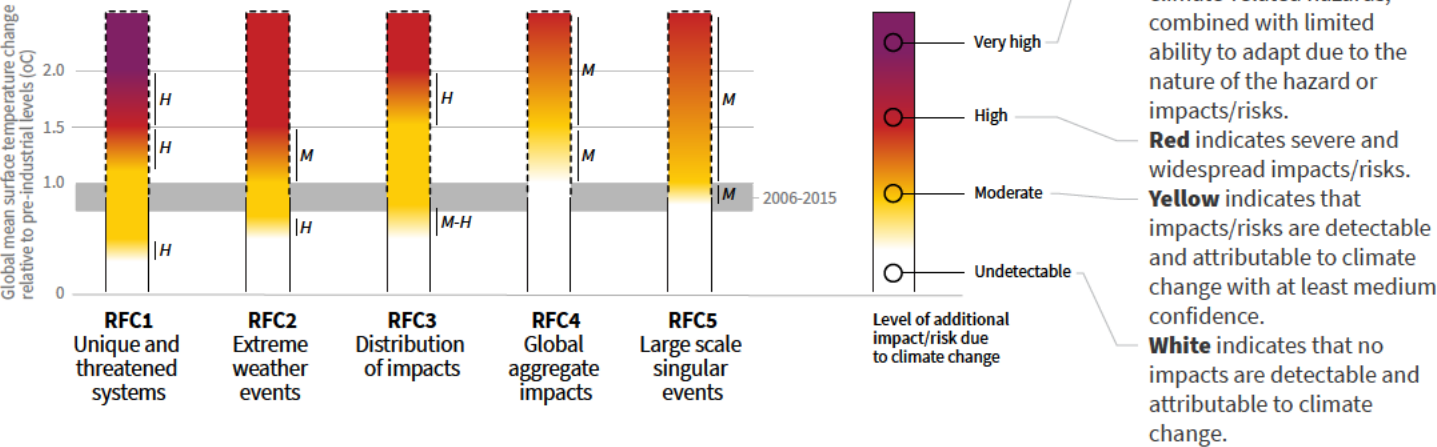
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<sup>10</sup> Here, impacts on economic growth refer to changes in GDP. Many impacts, such as loss of human lives, cultural heritage, and ecosystem services, are difficult to value and monetize.

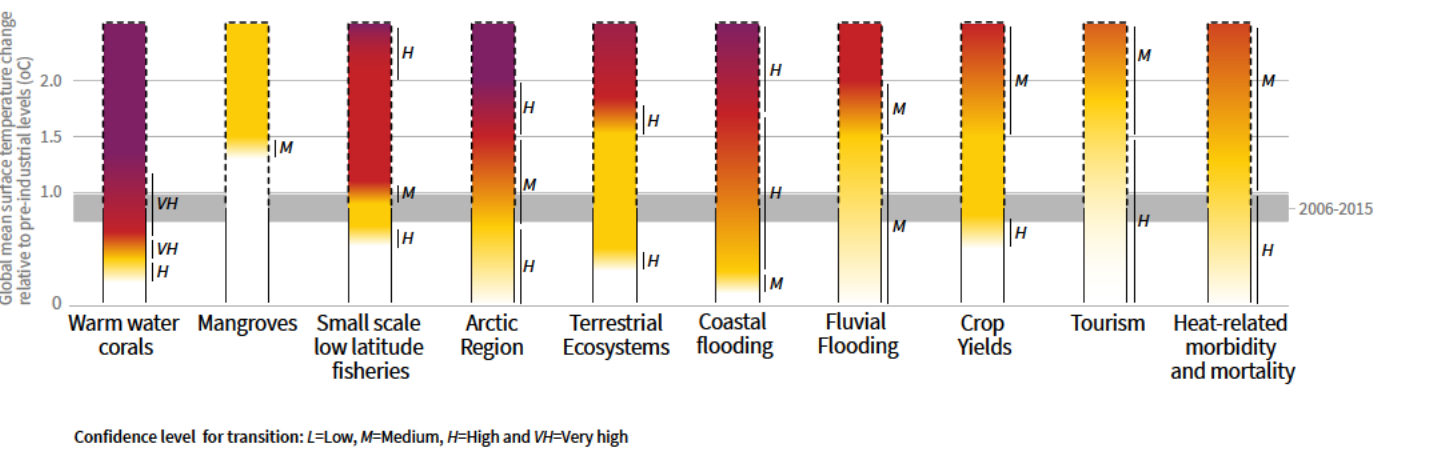
# How the level of global warming affects impacts and/or risks associated with the Reasons for Concern (RFCs) and selected natural, managed and human systems

Five Reasons For Concern (RFCs) illustrate the impacts and risks of different levels of global warming for people, economies and ecosystems across sectors and regions.

Impacts and risks associated with the Reasons for Concern (RFCs)



Impacts and risks for selected natural, managed and human systems



Confidence level for transition: L=Low, M=Medium, H=High and VH=Very high



**Figure SPM.2:** Five integrative reasons for concern (RFCs) provide a framework for summarizing key impacts and risks across sectors and regions, and were introduced in the IPCC Third Assessment Report. RFCs illustrate the implications of global warming for people, economies, and ecosystems. Impacts and/or risks for each RFC are based on assessment of the new literature that has appeared. As in the AR5, this literature was used to make expert judgments to assess the levels of global warming at which levels of impact and/or risk are undetectable, moderate, high or very high. The selection of impacts and risks to natural, managed and human systems in the lower panel is illustrative and is not intended to be fully comprehensive. **RFC1 Unique and threatened systems:** ecological and human systems that have restricted geographic ranges constrained by climate related conditions and have high endemism or other distinctive properties. Examples include coral reefs, the Arctic and its indigenous people, mountain glaciers, and biodiversity hotspots. **RFC2 Extreme weather events:** risks/impacts to human health, livelihoods, assets, and ecosystems from extreme weather events such as heat waves, heavy rain, drought and associated wildfires, and coastal flooding. **RFC3 Distribution of impacts:** risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability. **RFC4 Global aggregate impacts:** global monetary damage, global scale degradation and loss of ecosystems and biodiversity. **RFC5 Large-scale singular events:** are relatively large, abrupt and sometimes irreversible changes in systems that are caused by global warming. Examples include disintegration of the Greenland and Antarctic ice sheets. {3.4, 3.5, 3.5.2.1, 3.5.2.2, 3.5.2.3, 3.5.2.4, 3.5.2.5, 5.4.1 5.5.3, 5.6.1, Box 3.4}

**B6. Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C (*high confidence*). There are a wide range of adaptation options that can reduce the risks of climate change (*high confidence*). There are limits to adaptation and adaptive capacity for some human and natural systems at global warming of 1.5°C, with associated losses (*medium confidence*). The number and availability of adaptation options vary by sector (*medium confidence*). {Table 3.5, 4.3, 4.5, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5}**

**B6.1.** A wide range of adaptation options are available to reduce the risks to natural and managed ecosystems (e.g., ecosystem-based adaptation, ecosystem restoration and avoided degradation and deforestation, biodiversity management, sustainable aquaculture, and local knowledge and indigenous knowledge), the risks of sea level rise (e.g., coastal defence and hardening), and the risks to health, livelihoods, food, water, and economic growth, especially in rural landscapes (e.g., efficient irrigation, social safety nets, disaster risk management, risk spreading and sharing, community-based adaptation) and urban areas (e.g., green infrastructure, sustainable land use and planning, and sustainable water management) (*medium confidence*). {4.3.1, 4.3.2, 4.3.3, 4.3.5, 4.5.3, 4.5.4, 5.3.2, Box 4.2, Box 4.3, Box 4.6, Cross-Chapter Box 9 in Chapter 4}.

**B6.2.** Adaptation is expected to be more challenging for ecosystems, food and health systems at 2°C of global warming than for 1.5°C (*medium confidence*). Some vulnerable regions, including small islands and Least Developed Countries, are projected to experience high multiple interrelated climate risks even at global warming of 1.5°C (*high confidence*). {3.3.1, 3.4.5, Box 3.5, Table 3.5, Cross-Chapter Box 9 in Chapter 4, 5.6, Cross-Chapter Box 12 in Chapter 5, Box 5.3}

**B6.3.** Limits to adaptive capacity exist at 1.5°C of global warming, become more pronounced at higher levels of warming and vary by sector, with site-specific implications for vulnerable regions, ecosystems, and human health (*medium confidence*) {Cross-Chapter Box 12 in Chapter 5, Box 3.5, Table 3.5}

## **C. Emission Pathways and System Transitions Consistent with 1.5°C Global Warming**

**C1. In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO<sub>2</sub> emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C<sup>11</sup> CO<sub>2</sub> emissions are projected to decline by about 20% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2075 (2065–2080 interquartile range). Non-CO<sub>2</sub> emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C. (*high confidence*) (Figure SPM.3a) {2.1, 2.3, Table 2.4}**

**C1.1.** CO<sub>2</sub> emissions reductions that limit global warming to 1.5°C with no or limited overshoot can involve different portfolios of mitigation measures, striking different balances between lowering energy and resource intensity, rate of decarbonization, and the reliance on carbon dioxide removal. Different portfolios face different implementation challenges, and potential synergies and trade-offs with sustainable development. (*high confidence*). (Figure SPM.3b) {2.3.2, 2.3.4, 2.4, 2.5.3}

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<sup>11</sup> References to pathways limiting global warming to 2°C are based on a 66% probability of staying below 2°C.

**C1.2.** Modelled pathways that limit global warming to 1.5°C with no or limited overshoot involve deep reductions in emissions of methane and black carbon (35% or more of both by 2050 relative to 2010). These pathways also reduce most of the cooling aerosols, which partially offsets mitigation effects for two to three decades. Non-CO<sub>2</sub> emissions<sup>12</sup> can be reduced as a result of broad mitigation measures in the energy sector. In addition, targeted non-CO<sub>2</sub> mitigation measures can reduce nitrous oxide and methane from agriculture, methane from the waste sector, some sources of black carbon, and hydrofluorocarbons. High bioenergy demand can increase emissions of nitrous oxide in some 1.5°C pathways, highlighting the importance of appropriate management approaches. Improved air quality resulting from projected reductions in many non-CO<sub>2</sub> emissions provide direct and immediate population health benefits in all 1.5°C model pathways. (*high confidence*) (Figure SPM.3a) {2.2.1, 2.3.3, 2.4.4, 2.5.3, 4.3.6, 5.4.2}

**C1.3.** Limiting global warming requires limiting the total cumulative global anthropogenic emissions of CO<sub>2</sub> since the preindustrial period, i.e. staying within a total carbon budget (*high confidence*).<sup>13</sup> By the end of 2017, anthropogenic CO<sub>2</sub> emissions since the preindustrial period are estimated to have reduced the total carbon budget for 1.5°C by approximately 2200 ± 320 GtCO<sub>2</sub> (*medium confidence*). The associated remaining budget is being depleted by current emissions of 42 ± 3 GtCO<sub>2</sub> per year (*high confidence*). The choice of the measure of global temperature affects the estimated remaining carbon budget. Using global mean surface air temperature, as in AR5, gives an estimate of the remaining carbon budget of 580 GtCO<sub>2</sub> for a 50% probability of limiting warming to 1.5°C, and 420 GtCO<sub>2</sub> for a 66% probability (*medium confidence*).<sup>14</sup> Alternatively, using GMST gives estimates of 770 and 570 GtCO<sub>2</sub>, for 50% and 66% probabilities,<sup>15</sup> respectively (*medium confidence*). Uncertainties in the size of these estimated remaining carbon budgets are substantial and depend on several factors. Uncertainties in the climate response to CO<sub>2</sub> and non-CO<sub>2</sub> emissions contribute ±400 GtCO<sub>2</sub> and the level of historic warming contributes ±250 GtCO<sub>2</sub> (*medium confidence*). Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 GtCO<sub>2</sub> over the course of this century and more thereafter (*medium confidence*). In addition, the level of non-CO<sub>2</sub> mitigation in the future could alter the remaining carbon budget by 250 GtCO<sub>2</sub> in either direction (*medium confidence*). {1.2.4, 2.2.2, 2.6.1, Table 2.2, Chapter 2 Supplementary Material}

**C1.4.** Solar radiation modification (SRM) measures are not included in any of the available assessed pathways. Although some SRM measures may be theoretically effective in reducing an overshoot, they face large uncertainties and knowledge gaps as well as substantial risks,

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<sup>12</sup> Non-CO<sub>2</sub> emissions included in this report are all anthropogenic emissions other than CO<sub>2</sub> that result in radiative forcing. These include short-lived climate forcers, such as methane, some fluorinated gases, ozone precursors, aerosols or aerosol precursors, such as black carbon and sulphur dioxide, respectively, as well as long-lived greenhouse gases, such as nitrous oxide or some fluorinated gases. The radiative forcing associated with non-CO<sub>2</sub> emissions and changes in surface albedo is referred to as non-CO<sub>2</sub> radiative forcing. {x.y}

<sup>13</sup> There is a clear scientific basis for a total carbon budget consistent with limiting global warming to 1.5°C. However, neither this total carbon budget nor the fraction of this budget taken up by past emissions were assessed in this report.

<sup>14</sup> Irrespective of the measure of global temperature used, updated understanding and further advances in methods have led to an increase in the estimated remaining carbon budget of about 300 GtCO<sub>2</sub> compared to AR5. (*medium confidence*) {x.y}

<sup>15</sup> These estimates use observed GMST to 2006–2015 and estimate future temperature changes using near surface air temperatures.

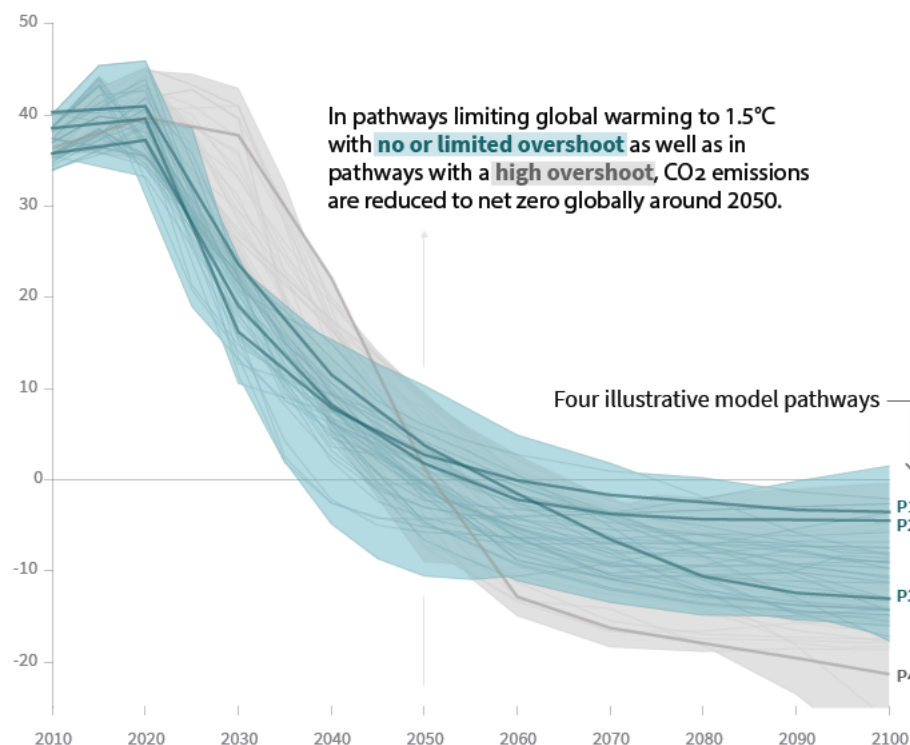
institutional and social constraints to deployment related to governance, ethics, and impacts on sustainable development. They also do not mitigate ocean acidification. (*medium confidence*). {4.3.8, Cross-Chapter Box 10 in Chapter 4}

## Global emissions pathway characteristics

General characteristics of the evolution of anthropogenic net emissions of CO<sub>2</sub>, and total emissions of methane, black carbon, and nitrous oxide in model pathways that limit global warming to 1.5°C with no or limited overshoot. Net emissions are defined as anthropogenic emissions reduced by anthropogenic removals. Reductions in net emissions can be achieved through different portfolios of mitigation measures illustrated in Figure SPM3B.

### Global total net CO<sub>2</sub> emissions

Billion tonnes of CO<sub>2</sub>/yr



#### Timing of net zero CO<sub>2</sub>

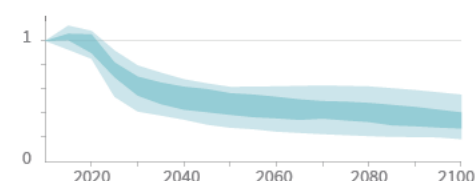
Line widths depict the 5-95th percentile and the 25-75th percentile of scenarios



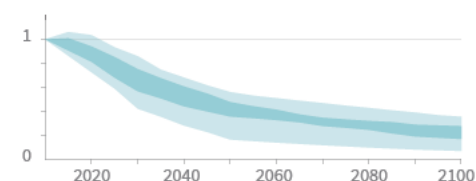
### Non-CO<sub>2</sub> emissions relative to 2010

Emissions of non-CO<sub>2</sub> forcers are also reduced or limited in pathways limiting global warming to 1.5°C with **no or limited overshoot**, but they do not reach zero globally.

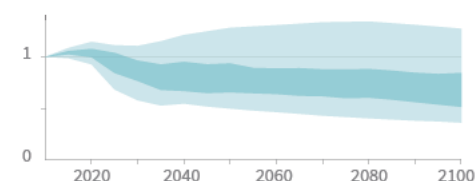
#### Methane emissions



#### Black carbon emissions



#### Nitrous oxide emissions



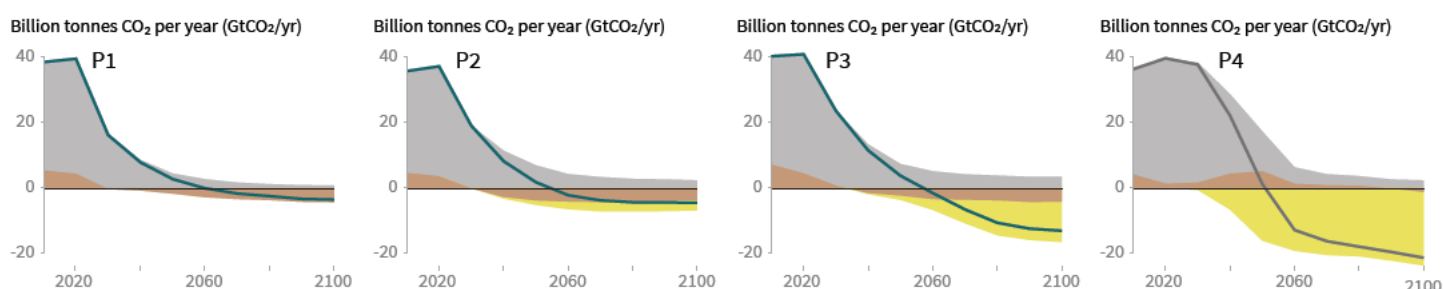
**Figure SPM.3a:** Global emissions pathway characteristics. The main panel shows global net anthropogenic CO<sub>2</sub> emissions in pathways limiting global warming to 1.5°C with no or limited (less than 0.1°C) overshoot and pathways with higher overshoot. The shaded area shows the full range for pathways analysed in this report. The panels on the right show non-CO<sub>2</sub> emissions ranges for three compounds with large historical forcing and a substantial portion of emissions coming from sources distinct from those central to CO<sub>2</sub> mitigation. Shaded areas in these panels show the 5–95% (light shading) and interquartile (dark shading) ranges of pathways limiting global warming to 1.5°C with no or limited overshoot. Box and whiskers at the bottom of the figure show the timing of pathways reaching global net zero CO<sub>2</sub> emission levels, and a comparison with pathways limiting global warming to 2°C with at least 66% probability. Four illustrative model pathways are highlighted in the main panel and are labelled P1, P2, P3 and P4, corresponding to the LED, S1, S2, and S5 pathways assessed in Chapter 2. Descriptions and characteristics of these pathways are available in Figure SPM3b. {2.1, 2.2, 2.3, Figure 2.5, Figure 2.10, Figure 2.11}

## Characteristics of four illustrative model pathways

Different mitigation strategies can achieve the net emissions reductions that would be required to follow a pathway that limit global warming to 1.5°C with no or limited overshoot. All pathways use Carbon Dioxide Removal (CDR), but the amount varies across pathways, 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. This has implications for the emissions and several other pathway characteristics.

### Breakdown of contributions to global net CO<sub>2</sub> emissions in four illustrative model pathways

● Fossil fuel and industry ● AFOLU ● BECCS



**P1:** A scenario in which social, business, and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

**P2:** A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

**P3:** 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 reductions in demand.

**P4:** A resource and energy-intensive scenario in which 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.

Global indicators	P1	P2	P3	P4	Interquartile range
<b>Pathway classification</b>	No or low overshoot	No or low overshoot	No or low overshoot	High overshoot	No or low overshoot
<b>CO<sub>2</sub> emission change in 2030 (% rel to 2010)</b>	-58	-47	-41	4	(-59,-40)
↳ in 2050 (% rel to 2010)	-93	-95	-91	-97	(-104,-91)
<b>Kyoto-GHG emissions* in 2030 (% rel to 2010)</b>	-50	-49	-35	-2	(-55,-38)
↳ in 2050 (% rel to 2010)	-82	-89	-78	-80	(-93,-81)
<b>Final energy demand** in 2030 (% rel to 2010)</b>	-15	-5	17	39	(-12, 7)
↳ in 2050 (% rel to 2010)	-32	2	21	44	(-11, 22)
<b>Renewable share in electricity in 2030 (%)</b>	60	58	48	25	(47, 65)
↳ in 2050 (%)	77	81	63	70	(69, 87)
<b>Primary energy from coal in 2030 (% rel to 2010)</b>	-78	-61	-75	-59	(-78, -59)
↳ in 2050 (% rel to 2010)	-97	-77	-73	-97	(-95, -74)
<b>from oil in 2030 (% rel to 2010)</b>	-37	-13	-3	86	(-34,3)
↳ in 2050 (% rel to 2010)	-87	-50	-81	-32	(-78,-31)
<b>from gas in 2030 (% rel to 2010)</b>	-25	-20	33	37	(-26,21)
↳ in 2050 (% rel to 2010)	-74	-53	21	-48	(-56,6)
<b>from nuclear in 2030 (% rel to 2010)</b>	59	83	98	106	(44,102)
↳ in 2050 (% rel to 2010)	150	98	501	468	(91,190)
<b>from biomass in 2030 (% rel to 2010)</b>	-11	0	36	-1	(29,80)
↳ in 2050 (% rel to 2010)	-16	49	121	418	(123,261)
<b>from non-biomass renewables in 2030 (% rel to 2010)</b>	430	470	315	110	(243,438)
↳ in 2050 (% rel to 2010)	832	1327	878	1137	(575,1300)
<b>Cumulative CCS until 2100 (GtCO<sub>2</sub>)</b>	0	348	687	1218	(550, 1017)
↳ of which BECCS (GtCO <sub>2</sub> )	0	151	414	1191	(364, 662)
<b>Land area of bioenergy crops in 2050 (million hectare)</b>	22	93	283	724	(151, 320)
<b>Agricultural CH<sub>4</sub> emissions in 2030 (% rel to 2010)</b>	-24	-48	1	14	(-30,-11)
↳ in 2050 (% rel to 2010)	-33	-69	-23	2	(-46,-23)
<b>Agricultural N<sub>2</sub>O emissions in 2030 (% rel to 2010)</b>	5	-26	15	3	(-21,4)
↳ in 2050 (% rel to 2010)	6	-26	0	39	(-26,1)

NOTE: Indicators have been selected to show global trends identified by the Chapter 2 assessment. National and sectoral characteristics can differ substantially from the global trends shown above.

\* Kyoto-gas emissions are based on SAR GWP-100

\*\* Changes in energy demand are associated with improvements in energy efficiency and behaviour change

**Figure SPM.3b:** Characteristics of four illustrative model pathways in relation to global warming of 1.5°C introduced in Figure SPM3a. These pathways were selected to show a range of potential mitigation approaches and vary widely in their projected energy and land use, as well as their assumptions about future socioeconomic developments, including economic and population growth, equity and sustainability. A breakdown of the global net anthropogenic CO<sub>2</sub> emissions into the contributions in terms of CO<sub>2</sub> emissions from fossil fuel and industry, agriculture, forestry and other land use (AFOLU), and bioenergy with carbon capture and storage (BECCS) is shown. AFOLU estimates reported here are not necessarily comparable with countries' estimates. Further characteristics for each of these pathways are listed below each pathway. These pathways illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements. For comparison, the right-most column shows the interquartile ranges across pathways with no or limited overshoot of 1.5°C. Pathways P1, P2, P3 and P4, correspond to the LED, S1, S2, and S5 pathways assessed in Chapter 2. (Figure SPM.3a) {2.2.1, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.4.1, 2.4.2, 2.4.4, 2.5.3, Figure 2.5, Figure 2.6, Figure 2.9, Figure 2.10, Figure 2.11, Figure 2.14, Figure 2.15, Figure 2.16, Figure 2.17, Figure 2.24, Figure 2.25, Table 2.4, Table 2.6, Table 2.7, Table 2.9, Table 4.1}

**C2. Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (*high confidence*). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (*medium confidence*). {2.3, 2.4, 2.5, 4.2, 4.3, 4.4, 4.5}**

**C2.1.** Pathways that limit global warming to 1.5°C with no or limited overshoot show system changes that are more rapid and pronounced over the next two decades than in 2°C pathways (*high confidence*). The rates of system changes associated with limiting global warming to 1.5°C with no or limited overshoot have occurred in the past within specific sectors, technologies and spatial contexts, but there is no documented historic precedent for their scale (*medium confidence*). {2.3.3, 2.3.4, 2.4, 2.5, 4.2.1, 4.2.2, Cross-Chapter Box 11 in Chapter 4}

**C2.2.** In energy systems, modelled global pathways (considered in the literature) limiting global warming to 1.5°C with no or limited overshoot (for more details see Figure SPM.3b), generally meet energy service demand with lower energy use, including through enhanced energy efficiency, and show faster electrification of energy end use compared to 2°C (*high confidence*). In 1.5°C pathways with no or limited overshoot, low-emission energy sources are projected to have a higher share, compared with 2°C pathways, particularly before 2050 (*high confidence*). In 1.5°C pathways with no or limited overshoot, renewables are projected to supply 70–85% (interquartile range) of electricity in 2050 (*high confidence*). In electricity generation, shares of nuclear and fossil fuels with carbon dioxide capture and storage (CCS) are modelled to increase in most 1.5°C pathways with no or limited overshoot. In modelled 1.5°C pathways with limited or no overshoot, the use of CCS would allow the electricity generation share of gas to be approximately 8% (3–11% interquartile range) of global electricity in 2050, while the use of coal shows a steep reduction in all pathways and would be reduced to close to 0% (0–2%) of electricity (*high confidence*). While acknowledging the challenges, and differences between the options and national circumstances, political, economic, social and technical feasibility of solar energy, wind energy and electricity storage technologies have substantially improved over the past few years (*high confidence*). These improvements signal a potential system transition in electricity generation (Figure SPM.3b) {2.4.1, 2.4.2, Figure 2.1, Table 2.6, Table 2.7, Cross-Chapter Box 6 in Chapter 3, 4.2.1, 4.3.1, 4.3.3, 4.5.2}

**C2.3.** CO<sub>2</sub> emissions from industry in pathways limiting global warming to 1.5°C with no or limited overshoot are projected to be about 75–90% (interquartile range) lower in 2050 relative to 2010, as compared to 50–80% for global warming of 2°C (*medium confidence*). Such reductions can be achieved through combinations of new and existing technologies and practices, including electrification, hydrogen, sustainable bio-based feedstocks, product substitution, and carbon capture, utilization and storage (CCUS). These options are technically proven at various scales but their large-scale deployment may be limited by economic, financial, human capacity and institutional constraints in specific contexts, and specific characteristics of large-scale industrial installations. In industry, emissions reductions by energy and process efficiency by themselves are insufficient for limiting warming to 1.5°C with no or limited overshoot (*high confidence*). {2.4.3, 4.2.1, Table 4.1, Table 4.3, 4.3.3, 4.3.4, 4.5.2}

**C2.4.** The urban and infrastructure system transition consistent with limiting global warming to 1.5°C with no or limited overshoot would imply, for example, changes in land and urban planning practices, as well as deeper emissions reductions in transport and buildings compared to pathways that limit global warming below 2°C (see 2.4.3; 4.3.3; 4.2.1) (*medium confidence*). Technical



measures and practices enabling deep emissions reductions include various energy efficiency options. In pathways limiting global warming to 1.5°C with no or limited overshoot, the electricity share of energy demand in buildings would be about 55–75% in 2050 compared to 50–70% in 2050 for 2°C global warming (*medium confidence*). In the transport sector, the share of low-emission final energy would rise from less than 5% in 2020 to about 35–65% in 2050 compared to 25–45% for 2°C global warming (*medium confidence*). Economic, institutional and socio-cultural barriers may inhibit these urban and infrastructure system transitions, depending on national, regional and local circumstances, capabilities and the availability of capital (*high confidence*). {2.3.4, 2.4.3, 4.2.1, Table 4.1, 4.3.3, 4.5.2}.

**C2.5.** Transitions in global and regional land use are found in all pathways limiting global warming to 1.5°C with no or limited overshoot, but their scale depends on the pursued mitigation portfolio. Model pathways that limit global warming to 1.5°C with no or limited overshoot project the conversion of 0.5–8 million km<sup>2</sup> of pasture and 0–5 million km<sup>2</sup> of non-pasture agricultural land for food and feed crops into 1–7 million km<sup>2</sup> for energy crops and a 1 million km<sup>2</sup> reduction to 10 million km<sup>2</sup> increase in forests by 2050 relative to 2010 (*medium confidence*).<sup>16</sup> Land use transitions of similar magnitude can be observed in modelled 2°C pathways (*medium confidence*). Such large transitions pose profound challenges for sustainable management of the various demands on land for human settlements, food, livestock feed, fibre, bioenergy, carbon storage, biodiversity and other ecosystem services (*high confidence*). Mitigation options limiting the demand for land include sustainable intensification of land use practices, ecosystem restoration and changes towards less resource-intensive diets (*high confidence*). The implementation of land-based mitigation options would require overcoming socio-economic, institutional, technological, financing and environmental barriers that differ across regions (*high confidence*). {2.4.4, Figure 2.24, 4.3.2, 4.5.2, Cross-Chapter Box 7 in Chapter 3}

**C2.6** Total annual average energy-related mitigation investment for the period 2015 to 2050 in pathways limiting warming to 1.5°C is estimated to be around 900 billion USD<sub>2015</sub> (range of 180 billion to 1800 billion USD<sub>2015</sub> across six models<sup>17</sup>). This corresponds to total annual average energy supply investments of 1600 to 3800 billion USD<sub>2015</sub> and total annual average energy demand investments of 700 to 1000 billion USD<sub>2015</sub> for the period 2015 to 2050, and an increase in total energy-related investments of about 12% (range of 3% to 23%) in 1.5°C pathways relative to 2°C pathways. Average annual investment in low-carbon energy technologies and energy efficiency are upscaled by roughly a factor of five (range of factor of 4 to 5) by 2050 compared to 2015 (*medium confidence*). {2.5.2, Box 4.8, Figure 2.27}

**C2.7.** Modelled pathways limiting global warming to 1.5°C with no or limited overshoot project a wide range of global average discounted marginal abatement costs over the 21st century. They are roughly 3–4 times higher than in pathways limiting global warming to below 2°C (*high confidence*). The economic literature distinguishes marginal abatement costs from total mitigation costs in the economy. The literature on total mitigation costs of 1.5°C mitigation pathways is limited and was not assessed in this report. Knowledge gaps remain in the integrated assessment of the economy wide costs and benefits of mitigation in line with pathways limiting warming to 1.5°C. {2.5.2; 2.6; Figure 2.26}

<sup>16</sup> The projected land use changes presented are not deployed to their upper limits simultaneously in a single pathway.

<sup>17</sup> Including two pathways limiting warming to 1.5°C with no or limited overshoot and four pathways with high overshoot.

**C3. All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO<sub>2</sub> over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (*high confidence*). CDR deployment of several hundreds of GtCO<sub>2</sub> is subject to multiple feasibility and sustainability constraints (*high confidence*). Significant near-term emissions reductions and measures to lower energy and land demand can limit CDR deployment to a few hundred GtCO<sub>2</sub> without reliance on bioenergy with carbon capture and storage (BECCS) (*high confidence*). {2.3, 2.4, 3.6.2, 4.3, 5.4}**

**C3.1.** Existing and potential CDR measures include afforestation and reforestation, land restoration and soil carbon sequestration, BECCS, direct air carbon capture and storage (DACCS), enhanced weathering and ocean alkalization. These differ widely in terms of maturity, potentials, costs, risks, co-benefits and trade-offs (*high confidence*). To date, only a few published pathways include CDR measures other than afforestation and BECCS. {2.3.4, 3.6.2, 4.3.2, 4.3.7}

**C3.2.** In pathways limiting global warming to 1.5°C with limited or no overshoot, BECCS deployment is projected to range from 0–1, 0–8, and 0–16 GtCO<sub>2</sub> yr<sup>-1</sup> in 2030, 2050, and 2100, respectively, while agriculture, forestry and land-use (AFOLU) related CDR measures are projected to remove 0–5, 1–11, and 1–5 GtCO<sub>2</sub> yr<sup>-1</sup> in these years (*medium confidence*). The upper end of these deployment ranges by mid-century exceeds the BECCS potential of up to 5 GtCO<sub>2</sub> yr<sup>-1</sup> and afforestation potential of up to 3.6 GtCO<sub>2</sub> yr<sup>-1</sup> assessed based on recent literature (*medium confidence*). Some pathways avoid BECCS deployment completely through demand-side measures and greater reliance on AFOLU-related CDR measures (*medium confidence*). The use of bioenergy can be as high or even higher when BECCS is excluded compared to when it is included due to its potential for replacing fossil fuels across sectors (*high confidence*). (Figure SPM.3b) {2.3.3, 2.3.4, 2.4.2, 3.6.2, 4.3.1, 4.2.3, 4.3.2, 4.3.7, 4.4.3, Table 2.4}

**C3.3.** Pathways that overshoot 1.5°C of global warming rely on CDR exceeding residual CO<sub>2</sub> emissions later in the century to return to below 1.5°C by 2100, with larger overshoots requiring greater amounts of CDR (Figure SPM.3b). (*high confidence*). Limitations on the speed, scale, and societal acceptability of CDR deployment hence determine the ability to return global warming to below 1.5°C following an overshoot. Carbon cycle and climate system understanding is still limited about the effectiveness of net negative emissions to reduce temperatures after they peak (*high confidence*). {2.2, 2.3.4, 2.3.5, 2.6, 4.3.7, 4.5.2, Table 4.11}

**C3.4.** Most current and potential CDR measures could have significant impacts on land, energy, water, or nutrients if deployed at large scale (*high confidence*). Afforestation and bioenergy may compete with other land uses and may have significant impacts on agricultural and food systems, biodiversity and other ecosystem functions and services (*high confidence*). Effective governance is needed to limit such trade-offs and ensure permanence of carbon removal in terrestrial, geological and ocean reservoirs (*high confidence*). Feasibility and sustainability of CDR use could be enhanced by a portfolio of options deployed at substantial, but lesser scales, rather than a single option at very large scale (*high confidence*). (Figure SPM.3b). {2.3.4, 2.4.4, 2.5.3, 2.6, 3.6.2, 4.3.2, 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}

**C3.5.** Some AFOLU-related CDR measures such as restoration of natural ecosystems and soil carbon sequestration could provide co-benefits such as improved biodiversity, soil quality, and local

food security. If deployed at large scale, they would require governance systems enabling sustainable land management to conserve and protect land carbon stocks and other ecosystem functions and services (*medium confidence*). (Figure SPM.4) {2.3.3, 2.3.4, 2.4.2, 2.4.4, 3.6.2, 5.4.1, Cross-Chapter Boxes 3 in Chapter 1 and 7 in Chapter 3, 4.3.2, 4.3.7, 4.4.1, 4.5.2, Table 2.4}

## **D. Strengthening the Global Response in the Context of Sustainable Development and Efforts to Eradicate Poverty**

**D1. Estimates of the global emissions outcome of current nationally stated mitigation ambitions as submitted under the Paris Agreement would lead to global greenhouse gas emissions<sup>18</sup> in 2030 of 52–58 GtCO<sub>2</sub>eq yr<sup>-1</sup> (*medium confidence*). Pathways reflecting these ambitions would not limit global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030 (*high confidence*). Avoiding overshoot and reliance on future large-scale deployment of carbon dioxide removal (CDR) can only be achieved if global CO<sub>2</sub> emissions start to decline well before 2030 (*high confidence*). {1.2, 2.3, 3.3, 3.4, 4.2, 4.4, Cross-Chapter Box 11 in Chapter 4}**

**D1.1.** Pathways that limit global warming to 1.5°C with no or limited overshoot show clear emission reductions by 2030 (*high confidence*). All but one show a decline in global greenhouse gas emissions to below 35 GtCO<sub>2</sub>eq yr<sup>-1</sup> in 2030, and half of available pathways fall within the 25–30 GtCO<sub>2</sub>eq yr<sup>-1</sup> range (interquartile range), a 40–50% reduction from 2010 levels (*high confidence*). Pathways reflecting current nationally stated mitigation ambition until 2030 are broadly consistent with cost-effective pathways that result in a global warming of about 3°C by 2100, with warming continuing afterwards (*medium confidence*). {2.3.3, 2.3.5, Cross-Chapter Box 11 in Chapter 4, 5.5.3.2}

**D1.2.** Overshoot trajectories result in higher impacts and associated challenges compared to pathways that limit global warming to 1.5°C with no or limited overshoot (*high confidence*). Reversing warming after an overshoot of 0.2°C or larger during this century would require upscaling and deployment of CDR at rates and volumes that might not be achievable given considerable implementation challenges (*medium confidence*). {1.3.3, 2.3.4, 2.3.5, 2.5.1, 3.3, 4.3.7, Cross-Chapter Box 8 in Chapter 3, Cross-Chapter Box 11 in Chapter 4}

**D1.3.** The lower the emissions in 2030, the lower the challenge in limiting global warming to 1.5°C after 2030 with no or limited overshoot (*high confidence*). The challenges from delayed actions to reduce greenhouse gas emissions include the risk of cost escalation, lock-in in carbon-emitting infrastructure, stranded assets, and reduced flexibility in future response options in the medium to long-term (*high confidence*). These may increase uneven distributional impacts between countries at different stages of development (*medium confidence*). {2.3.5, 4.4.5, 5.4.2}

**D2. The avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C, if mitigation and adaptation synergies are maximized while trade-offs are minimized (*high confidence*). {1.1, 1.4, 2.5, 3.3, 3.4, 5.2, Table 5.1}**

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<sup>18</sup> GHG emissions have been aggregated with 100-year GWP values as introduced in the IPCC Second Assessment Report

**D2.1.** Climate change impacts and responses are closely linked to sustainable development which balances social well-being, economic prosperity and environmental protection. The United Nations Sustainable Development Goals (SDGs), adopted in 2015, provide an established framework for assessing the links between global warming of 1.5°C or 2°C and development goals that include poverty eradication, reducing inequalities, and climate action (*high confidence*) {Cross-Chapter Box 4 in Chapter 1, 1.4, 5.1}

**D2.2.** The consideration of ethics and equity can help address the uneven distribution of adverse impacts associated with 1.5°C and higher levels of global warming, as well as those from mitigation and adaptation, particularly for poor and disadvantaged populations, in all societies (*high confidence*). {1.1.1, 1.1.2, 1.4.3, 2.5.3, 3.4.10, 5.1, 5.2, 5.3, 5.4, Cross-Chapter Box 4 in Chapter 1, Cross-Chapter Boxes 6 and 8 in Chapter 3, and Cross-Chapter Box 12 in Chapter 5}

**D2.3.** Mitigation and adaptation consistent with limiting global warming to 1.5°C are underpinned by enabling conditions, assessed in SR1.5 across the geophysical, environmental-ecological, technological, economic, socio-cultural and institutional dimensions of feasibility. Strengthened multi-level governance, institutional capacity, policy instruments, technological innovation and transfer and mobilization of finance, and changes in human behaviour and lifestyles are enabling conditions that enhance the feasibility of mitigation and adaptation options for 1.5°C consistent systems transitions. (*high confidence*) {1.4, Cross-Chapter Box 3 in Chapter 1, 4.4, 4.5, 5.6}

**D3. Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible (*high confidence*). {1.4, 4.3, 4.5}**

**D3.1.** Adaptation options that reduce the vulnerability of human and natural systems have many synergies with sustainable development, if well managed, such as ensuring food and water security, reducing disaster risks, improving health conditions, maintaining ecosystem services and reducing poverty and inequality (*high confidence*). Increasing investment in physical and social infrastructure is a key enabling condition to enhance the resilience and the adaptive capacities of societies. These benefits can occur in most regions with adaptation to 1.5°C of global warming (*high confidence*). {1.4.3, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.5, 4.4.1, 4.4.3, 4.5.3, 5.3.1, 5.3.2}

**D3.2.** Adaptation to 1.5°C global warming can also result in trade-offs or maladaptations with adverse impacts for sustainable development. For example, if poorly designed or implemented, adaptation projects in a range of sectors can increase greenhouse gas emissions and water use, increase gender and social inequality, undermine health conditions, and encroach on natural ecosystems (*high confidence*). These trade-offs can be reduced by adaptations that include attention to poverty and sustainable development (*high confidence*). {4.3.2, 4.3.3, 4.5.4, 5.3.2; Cross-Chapter Boxes 6 and 7 in Chapter 3}

**D3.3.** A mix of adaptation and mitigation options to limit global warming to 1.5°C, implemented in a participatory and integrated manner, can enable rapid, systemic transitions in urban and rural areas (*high confidence*). These are most effective when aligned with economic and sustainable development, and when local and regional governments and decision makers are supported by national governments (*medium confidence*) {4.3.2, 4.3.3, 4.4.1, 4.4.2}

**D3.4.** Adaptation options that also mitigate emissions can provide synergies and cost savings in most sectors and system transitions, such as when land management reduces emissions and disaster

risk, or when low carbon buildings are also designed for efficient cooling. Trade-offs between mitigation and adaptation, when limiting global warming to 1.5°C, such as when bioenergy crops, reforestation or afforestation encroach on land needed for agricultural adaptation, can undermine food security, livelihoods, ecosystem functions and services and other aspects of sustainable development. (*high confidence*) {3.4.3, 4.3.2, 4.3.4, 4.4.1, 4.5.2, 4.5.3, 4.5.4}

**D4. Mitigation options consistent with 1.5°C pathways are associated with multiple synergies and trade-offs across the Sustainable Development Goals (SDGs). While the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition. (*high confidence*) (Figure SPM.4) {2.5, 4.5, 5.4}**

**D4.1.** 1.5°C pathways have robust synergies particularly for the SDGs 3 (health), 7 (clean energy), 11 (cities and communities), 12 (responsible consumption and production), and 14 (oceans) (*very high confidence*). Some 1.5°C pathways show potential trade-offs with mitigation for SDGs 1 (poverty), 2 (hunger), 6 (water), and 7 (energy access), if not carefully managed (*high confidence*) (Figure SPM.4). {5.4.2; Figure 5.4, Cross-Chapter Boxes 7 and 8 in Chapter 3}

**D4.2.** 1.5°C pathways that include low energy demand (e.g., see P1 in Figure SPM.3a and SPM.3b), low material consumption, and low GHG-intensive food consumption have the most pronounced synergies and the lowest number of trade-offs with respect to sustainable development and the SDGs (*high confidence*). Such pathways would reduce dependence on CDR. In modelled pathways sustainable development, eradicating poverty and reducing inequality can support limiting warming to 1.5°C. (*high confidence*) (Figure SPM.3b, Figure SPM.4) {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.** 1.5°C and 2°C modelled pathways often rely on the deployment of large-scale land-related measures like afforestation and bioenergy supply, which, if poorly managed, can compete with food production and hence raise food security concerns (*high confidence*). The impacts of carbon dioxide removal (CDR) options on SDGs depend on the type of options and the scale of deployment (*high confidence*). If poorly implemented, CDR options such as BECCS and AFOLU options would lead to trade-offs. Context-relevant design and implementation requires considering people's needs, biodiversity, and other sustainable development dimensions (*very high confidence*). {Figure SPM.4, 5.4.1.3, Cross-Chapter Box 7 in Chapter 3}

**D4.4.** Mitigation consistent with 1.5°C pathways creates risks for sustainable development in regions with high dependency on fossil fuels for revenue and employment generation (*high confidence*). Policies that promote diversification of the economy and the energy sector can address the associated challenges (*high confidence*). {5.4.1.2, Box 5.2}

**D4.5.** Redistributive policies across sectors and populations 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 pathways. (*high confidence*) {2.4.3, 5.4.2, Figure 5.5}

# Indicative linkages between mitigation options and sustainable development using SDGs (The linkages do not show costs and benefits)

Mitigation options deployed in each sector can be associated with potential positive effects (synergies) or negative effects (trade-offs) with the Sustainable Development Goals (SDGs). The degree to which this potential is realized will depend on the selected portfolio of mitigation options, mitigation policy design, and local circumstances and context. Particularly in the energy-demand sector, the potential for synergies is larger than for trade-offs. The bars group individually assessed options by level of confidence and take into account the relative strength of the assessed mitigation-SDG connections.

Length shows strength of connection

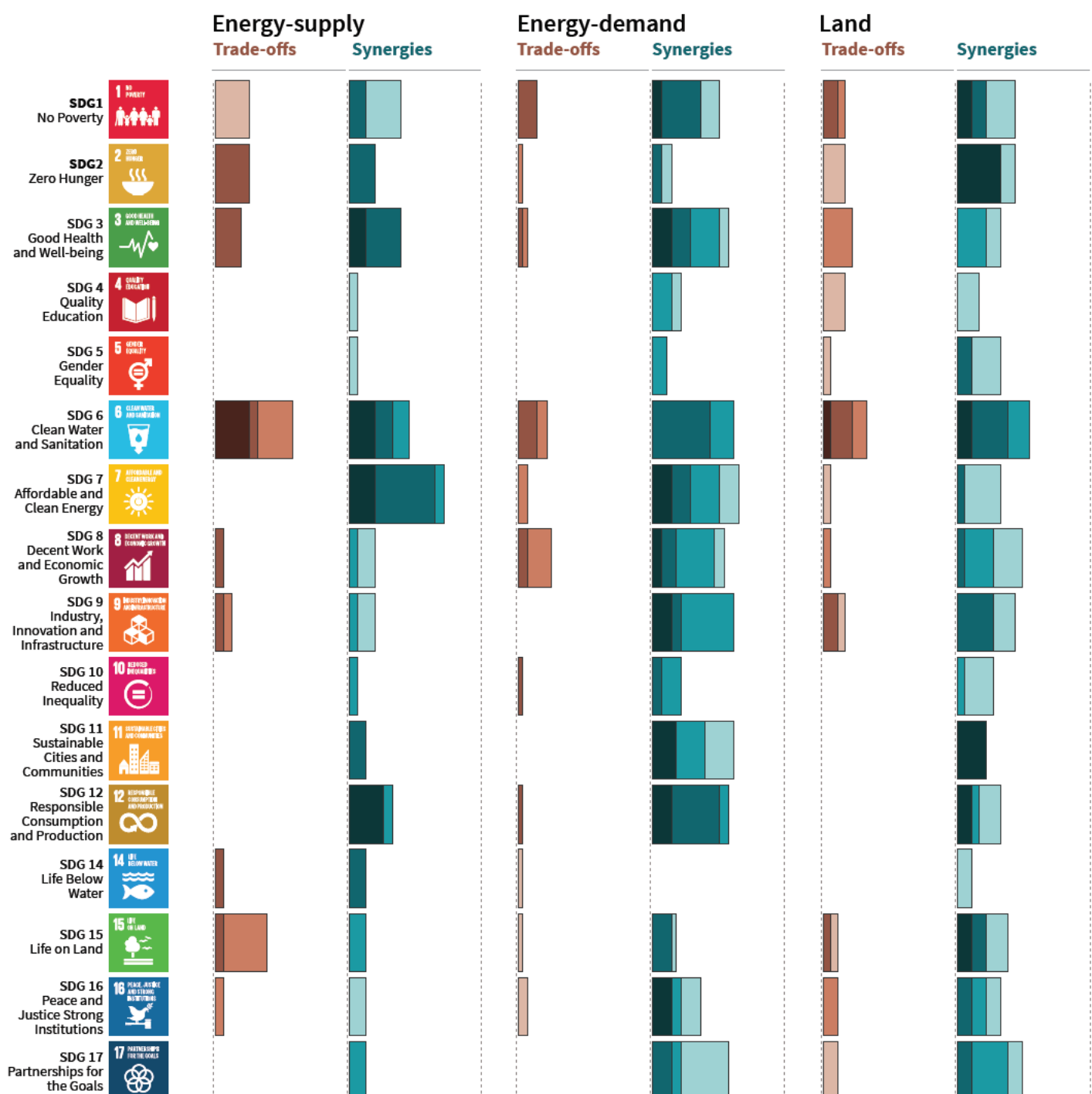


The overall size of the coloured bars depict the relative for synergies and trade-offs between the sectoral mitigation options and the SDGs.

Shades show level of confidence



The shades depict the level of confidence of the assessed potential for Trade-offs/Synergies.



**Figure SPM.4:** Potential synergies and trade-offs between the sectoral portfolio of climate change mitigation options and the Sustainable Development Goals (SDGs). The SDGs serve as an analytical framework for the assessment of the different sustainable development dimensions, which extend beyond the time frame of the 2030 SDG targets. The assessment is based on literature on mitigation options that are considered relevant for 1.5°C. The assessed strength of the SDG interactions is based on the qualitative and quantitative assessment of individual mitigation options listed in Table 5.2. For each mitigation option, the strength of the SDG-connection as well as the associated confidence of the underlying literature (shades of green and red) was assessed. The strength of positive connections (synergies) and negative connections (trade-offs) across all individual options within a sector (see Table 5.2) are aggregated into sectoral potentials for the whole mitigation portfolio. The (white) areas outside the bars, which indicate no interactions, have *low confidence* due to the uncertainty and limited number of studies exploring indirect effects. The strength of the connection considers only the effect of mitigation and does not include benefits of avoided impacts. SDG 13 (climate action) is not listed because mitigation is being considered in terms of interactions with SDGs and not vice versa. The bars denote the strength of the connection, and do not consider the strength of the impact on the SDGs. The energy demand sector comprises behavioural responses, fuel switching and efficiency options in the transport, industry and building sector as well as carbon capture options in the industry sector. Options assessed in the energy supply sector comprise biomass and non-biomass renewables, nuclear, CCS with bio-energy, and CCS with fossil fuels. Options in the land sector comprise agricultural and forest options, sustainable diets & reduced food waste, soil sequestration, livestock & manure management, reduced deforestation, afforestation & reforestation, responsible sourcing. In addition to this figure, options in the ocean sector are discussed in the underlying report. {5.4, Table 5.2, Figure 5.2}

**Statement for knowledge gap:**

Information about the net impacts of mitigation on sustainable development in 1.5°C pathways is available only for a limited number of SDGs and mitigation options. Only a limited number of studies have assessed the benefits of avoided climate change impacts of 1.5°C pathways for the SDGs, and the co-effects of adaptation for mitigation and the SDGs. The assessment of the indicative mitigation potentials in Figure SPM.4 is a step further from AR5 towards a more comprehensive and integrated assessment in the future.

**D5. Limiting the risks from global warming of 1.5°C in the context of sustainable development and poverty eradication implies system transitions that can be enabled by an increase of adaptation and mitigation investments, policy instruments, the acceleration of technological innovation and behaviour changes (*high confidence*). {2.3, 2.4, 2.5, 3.2, 4.2, 4.4, 4.5, 5.2, 5.5, 5.6}**

**D5.1.** Directing finance towards investment in infrastructure for mitigation and adaptation could provide additional resources. This could involve the mobilization of private funds by institutional investors, asset managers and development or investment banks, as well as the provision of public funds. Government policies that lower the risk of low-emission and adaptation investments can facilitate the mobilization of private funds and enhance the effectiveness of other public policies. Studies indicate a number of challenges including access to finance and mobilisation of funds (*high confidence*) {2.5.2, 4.4.5}

**D5.2.** Adaptation finance consistent with global warming of 1.5°C is difficult to quantify and compare with 2°C. Knowledge gaps include insufficient data to calculate specific climate resilience-enhancing investments, from the provision of currently underinvested basic infrastructure. Estimates of the costs of adaptation might be lower at global warming of 1.5°C than for 2°C. Adaptation needs have typically been supported by public sector sources such as national and subnational government budgets, and in developing countries together with support from development assistance, multilateral development banks, and UNFCCC channels (*medium confidence*). More recently there is a growing understanding of the scale and increase in NGO and private funding in some regions (*medium confidence*). Barriers include the scale of adaptation financing, limited capacity and access to adaptation finance (*medium confidence*). {4.4.5, 4.6}

**D5.3.** Global model pathways limiting global warming to 1.5°C are projected to involve the annual average investment needs in the energy system of around 2.4 trillion USD<sub>2010</sub> between 2016 and 2035 representing about 2.5% of the world GDP (*medium confidence*). {2.5.2, 4.4.5, Box 4.8}

**D5.4.** Policy tools can help mobilise incremental resources, including through shifting global investments and savings and through market and non-market based instruments as well as accompanying measures to secure the equity of the transition, acknowledging the challenges related with implementation including those of energy costs, depreciation of assets and impacts on international competition, and utilizing the opportunities to maximize co-benefits (*high confidence*) {1.3.3, 2.3.4, 2.3.5, 2.5.1, 2.5.2, Cross-Chapter Box 8 in Chapter 3 and 11 in Chapter 4, 4.4.5, 5.5.2}

**D5.5.** The systems transitions consistent with adapting to and limiting global warming to 1.5°C include the widespread adoption of new and possibly disruptive technologies and practices and enhanced climate-driven innovation. These imply enhanced technological innovation capabilities, including in industry and finance. Both national innovation policies and international cooperation can contribute to the development, commercialization and widespread adoption of mitigation and adaptation technologies. Innovation policies may be more effective when they combine public support for research and development with policy mixes that provide incentives for technology diffusion. (*high confidence*) {4.4.4, 4.4.5}.

**D5.6.** Education, information, and community approaches, including those that are informed by Indigenous knowledge and local knowledge, can accelerate the wide scale behaviour changes consistent with adapting to and limiting global warming to 1.5°C. These approaches are more



effective when combined with other policies and tailored to the motivations, capabilities, and resources of specific actors and contexts (*high confidence*). Public acceptability can enable or inhibit the implementation of policies and measures to limit global warming to 1.5°C and to adapt to the consequences. Public acceptability depends on the individual's evaluation of expected policy consequences, the perceived fairness of the distribution of these consequences, and perceived fairness of decision procedures (*high confidence*). {1.1, 1.5, 4.3.5, 4.4.1, 4.4.3, Box 4.3, 5.5.3, 5.6.5}

**D6. Sustainable development supports, and often enables, the fundamental societal and systems transitions and transformations that help limit global warming to 1.5°C. Such changes facilitate the pursuit of climate-resilient development pathways that achieve ambitious mitigation and adaptation in conjunction with poverty eradication and efforts to reduce inequalities (*high confidence*). {Box 1.1, 1.4.3, Figure 5.1, 5.5.3, Box 5.3}**

**D6.1.** Social justice and equity are core aspects of climate-resilient development pathways that aim to limit global warming to 1.5°C as they address challenges and inevitable trade-offs, widen opportunities, and ensure that options, visions, and values are deliberated, between and within countries and communities, without making the poor and disadvantaged worse off (*high confidence*). {5.5.2, 5.5.3, Box 5.3, Figure 5.1, Figure 5.6, Cross-Chapter Boxes 12 and 13 in Chapter 5}

**D6.2.** The potential for climate-resilient development pathways differs between and within regions and nations, due to different development contexts and systemic vulnerabilities (*very high confidence*). Efforts along such pathways to date have been limited (*medium confidence*) and enhanced efforts would involve strengthened and timely action from all countries and non-state actors (*high confidence*). {5.5.1, 5.5.3, Figure 5.1}

**D6.3.** Pathways that are consistent with sustainable development show fewer mitigation and adaptation challenges and are associated with lower mitigation costs. The large majority of modelling studies could not construct pathways characterized by lack of international cooperation, inequality and poverty that were able to limit global warming to 1.5°C. (*high confidence*) {2.3.1, 2.5.3, 5.5.2}

**D7. Strengthening the capacities for climate action of national and sub-national authorities, civil society, the private sector, indigenous peoples and local communities can support the implementation of ambitious actions implied by limiting global warming to 1.5°C (*high confidence*). International cooperation can provide an enabling environment for this to be achieved in all countries and for all people, in the context of sustainable development. International cooperation is a critical enabler for developing countries and vulnerable regions (*high confidence*). {1.4, 2.3, 2.5, 4.2, 4.4, 4.5, 5.3, 5.4, 5.5, 5.6, 5, Box 4.1, Box 4.2, Box 4.7, Box 5.3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 13 in Chapter 5}**

**D7.1.** Partnerships involving non-state public and private actors, institutional investors, the banking system, civil society and scientific institutions would facilitate actions and responses consistent with limiting global warming to 1.5°C (*very high confidence*). {1.4, 4.4.1, 4.2.2, 4.4.3, 4.4.5, 4.5.3, 5.4.1, 5.6.2, Box 5.3}.

**D7.2.** Cooperation on strengthened accountable multilevel governance that includes non-state actors such as industry, civil society and scientific institutions, coordinated sectoral and cross-sectoral

policies at various governance levels, gender-sensitive policies, finance including innovative financing and cooperation on technology development and transfer can ensure participation, transparency, capacity building, and learning among different players (*high confidence*). {2.5.2, 4.2.2, 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.5.3, Cross-Chapter Box 9 in Chapter 4, 5.3.1, 4.4.5, 5.5.3, Cross-Chapter Box 13 in Chapter 5, 5.6.1, 5.6.3}

**D7.3.** International cooperation is a critical enabler for developing countries and vulnerable regions to strengthen their action for the implementation of 1.5°C-consistent climate responses, including through enhancing access to finance and technology and enhancing domestic capacities, taking into account national and local circumstances and needs (*high confidence*). {2.3.1, 4.4.1, 4.4.2, 4.4.4, 4.4.5, 5.4.1 5.5.3, 5.6.1, Box 4.1, Box 4.2, Box 4.7}.

**D7.4.** Collective efforts at all levels, in ways that reflect different circumstances and capabilities, in the pursuit of limiting global warming to 1.5°C, taking into account equity as well as effectiveness, can facilitate strengthening the global response to climate change, achieving sustainable development and eradicating poverty (*high confidence*). {1.4.2, 2.3.1, 2.5.2, 4.2.2, 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5, 4.5.3, 5.3.1, 5.4.1, 5.5.3, 5.6.1, 5.6.2, 5.6.3}

**Box SPM 1: Core Concepts Central to this Special Report**

**Global mean surface temperature (GMST):** Estimated global average of near-surface air temperatures over land and sea-ice, and sea surface temperatures over ice-free ocean regions, with changes normally expressed as departures from a value over a specified reference period. When estimating changes in GMST, near-surface air temperature over both land and oceans are also used.<sup>19</sup> {1.2.1.1}

**Pre-industrial:** The multi-century period prior to the onset of large-scale industrial activity around 1750. The reference period 1850–1900 is used to approximate pre-industrial GMST. {1.2.1.2}

**Global warming:** The estimated increase in GMST averaged over a 30-year period, or the 30-year period centered on a particular year or decade, expressed relative to pre-industrial levels unless otherwise specified. For 30-year periods that span past and future years, the current multi-decadal warming trend is assumed to continue. {1.2.1}

**Net zero CO<sub>2</sub> emissions:** Net-zero carbon dioxide (CO<sub>2</sub>) emissions are achieved when anthropogenic CO<sub>2</sub> emissions are balanced globally by anthropogenic CO<sub>2</sub> removals over a specified period.

**Carbon dioxide removal (CDR):** Anthropogenic activities removing CO<sub>2</sub> from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but excludes natural CO<sub>2</sub> uptake not directly caused by human activities.

**Total carbon budget:** Estimated cumulative net global anthropogenic CO<sub>2</sub> emissions from the preindustrial period to the time that anthropogenic CO<sub>2</sub> emissions reach net zero that would result, at some probability, in limiting global warming to a given level, accounting for the impact of other anthropogenic emissions. {2.2.2}

**Remaining carbon budget:** Estimated cumulative net global anthropogenic CO<sub>2</sub> emissions from a given start date to the time that anthropogenic CO<sub>2</sub> emissions reach net zero that would result, at some probability, in limiting global warming to a given level, accounting for the impact of other anthropogenic emissions. {2.2.2}

**Temperature overshoot:** The temporary exceedance of a specified level of global warming.

**Emission pathways:** In this Summary for Policymakers, the modelled trajectories of global anthropogenic emissions over the 21st century are termed emission pathways. Emission pathways are classified by their temperature trajectory over the 21st century: pathways giving at least 50% probability based on current knowledge of limiting global warming to below 1.5°C are classified as ‘no overshoot’; those limiting warming to below 1.6°C and returning to 1.5°C by 2100 are classified as ‘1.5°C limited-overshoot’; while those exceeding 1.6°C but still returning to 1.5°C by 2100 are classified as ‘higher-overshoot’.

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<sup>19</sup> Past IPCC reports, reflecting the literature, have used a variety of approximately equivalent metrics of GMST change.

**Impacts:** Effects of climate change on human and natural systems. Impacts can have beneficial or adverse outcomes for livelihoods, health and well-being, ecosystems and species, services, infrastructure, and economic, social and cultural assets.

**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 integrates the likelihood of exposure to a hazard and the magnitude of its impact. Risk also can describe the potential for adverse consequences of adaptation or mitigation responses to climate change.

**Climate-resilient development pathways (CRDPs):** Trajectories that strengthen sustainable development at multiple scales and efforts to eradicate poverty through equitable societal and systems transitions and transformations while reducing the threat of climate change through ambitious mitigation, adaptation, and climate resilience.

Global Warming of 1.5 °C an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

## Headline Statements

### A. Understanding Global Warming of 1.5°C<sup>4</sup>

A1. Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate (*high confidence*).

A2. Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (*high confidence*), but these emissions alone are unlikely to cause global warming of 1.5°C (*medium confidence*).

A3. Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C (*high confidence*). These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options (*high confidence*).

### B. Projected Climate Change, Potential Impacts and Associated Risks

B1. Climate models project robust<sup>7</sup> differences in regional climate characteristics between present-day and global warming of 1.5°C, and between 1.5°C and 2°C. These differences include increases in: mean temperature in most land and ocean regions (*high confidence*), hot extremes in most inhabited regions (*high confidence*), heavy precipitation in several regions (*medium confidence*), and the probability of drought and precipitation deficits in some regions (*medium confidence*).

B2. By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C (*medium confidence*). Sea level will continue to rise well beyond 2100 (*high confidence*), and the magnitude and rate of this rise depends on future emission pathways. A slower rate of sea level rise enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas (*medium confidence*).

B3. On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C. Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater, and coastal ecosystems and to retain more of their services to humans (*high confidence*).

B4. Limiting global warming to 1.5°C compared to 2°C is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (*high confidence*). Consequently, limiting global

warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm water coral reef ecosystems (*high confidence*).

B5. Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C.

B6. Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C (*high confidence*). There are a wide range of adaptation options that can reduce the risks of climate change (*high confidence*). There are limits to adaptation and adaptive capacity for some human and natural systems at global warming of 1.5°C, with associated losses (*medium confidence*). The number and availability of adaptation options vary by sector (*medium confidence*).

### **C. Emission Pathways and System Transitions Consistent with 1.5°C Global Warming**

C1. In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO<sub>2</sub> emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C, CO<sub>2</sub> emissions are projected to decline by about 20% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2075 (2065–2080 interquartile range). Non-CO<sub>2</sub> emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C (*high confidence*).

C2. Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (*high confidence*). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (*medium confidence*).

C3. All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO<sub>2</sub> over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (*high confidence*). CDR deployment of several hundreds of GtCO<sub>2</sub> is subject to multiple feasibility and sustainability constraints (*high confidence*). Significant near-term emissions reductions and measures to lower energy and land demand can limit CDR deployment to a few hundred GtCO<sub>2</sub> without reliance on bioenergy with carbon capture and storage (BECCS) (*high confidence*).

### **D. Strengthening the Global Response in the Context of Sustainable Development and Efforts to Eradicate Poverty**

D1. Estimates of the global emissions outcome of current nationally stated mitigation ambitions as submitted under the Paris Agreement would lead to global greenhouse gas emissions in 2030 of 52–58 GtCO<sub>2</sub>eq yr<sup>-1</sup> (*medium confidence*). Pathways

reflecting these ambitions would not limit global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030 (*high confidence*). Avoiding overshoot and reliance on future largescale deployment of carbon dioxide removal (CDR) can only be achieved if global CO<sub>2</sub> emissions start to decline well before 2030 (*high confidence*).

D2. The avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C, if mitigation and adaptation synergies are maximized while trade-offs are minimized (*high confidence*).

D3. Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible (*high confidence*).

D4. Mitigation options consistent with 1.5°C pathways are associated with multiple synergies and trade-offs across the Sustainable Development Goals (SDGs). While the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition (*high confidence*).

D5. Limiting the risks from global warming of 1.5°C in the context of sustainable development and poverty eradication implies system transitions that can be enabled by an increase of adaptation and mitigation investments, policy instruments, the acceleration of technological innovation and behaviour changes (*high confidence*).

D6. Sustainable development supports, and often enables, the fundamental societal and systems transitions and transformations that help limit global warming to 1.5°C. Such changes facilitate the pursuit of climate-resilient development pathways that achieve ambitious mitigation and adaptation in conjunction with poverty eradication and efforts to reduce inequalities (*high confidence*).

D7. Strengthening the capacities for climate action of national and sub-national authorities, civil society, the private sector, indigenous peoples and local communities can support the implementation of ambitious actions implied by limiting global warming to 1.5°C (*high confidence*). International cooperation can provide an enabling environment for this to be achieved in all countries and for all people, in the context of sustainable development. International cooperation is a critical enabler for developing countries and vulnerable regions (*high confidence*).

s22

**From:** s22  
**Sent:** Sunday, 7 October 2018 2:49 PM  
**To:** Rob Sturgiss  
**Cc:** Kushla Munro; s22; Brad Archer; s22; s22  
**Subject:** Re: EMBARGOED: IPCC Special Report Global Warming of 1.5 degrees [DLM=For-Official-Use-Only]

Thanks Rob.

Sent from my iPhone

On 7 Oct 2018, at 12:28 pm, Rob Sturgiss <[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)> wrote:

s22 Kushla

attached is the final SPM of the IPCC Special Report.

It is under EMBARGO until Monday 12 noon.

s22 – please note, journalists will get access to the document today so that the stories will start at noon tomorrow.

s22

Of course, previous drafts of the report have been extensively leaked, so another one wouldn't be out of the question.

Rob

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**From:** s22  
**Sent:** Saturday, 6 October 2018 7:01 PM  
**To:** Rob Sturgiss <[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)>; s22  
s22  
**Cc:** s22  
s22  
**Subject:** Approved IPCC Special Report Global Warming of 1.5 degrees [DLM=For-Official-Use-Only]

Rob and s22

The Summary for Policy Makers of the Special Report on Global Warming of 1.5 degrees is attached.

s22

The report will be made public on Monday 10am here.

Regards



s22

# s22

s22

National Inventory Team

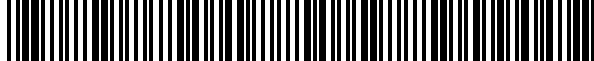
International Climate Change and Energy Innovation Division

Department of the Environment and Energy

s22

*The Department acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.*

<Approved Summary for Policymakers IPCC Special Report 1.5 degrees.pdf>



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**FORTY-EIGHTH SESSION OF THE IPCC**  
**Incheon, Republic of Korea, 1 – 5 October 2018**

IPCC-XLVIII/Doc. 5  
(6.X.2018)  
Agenda Item: 5  
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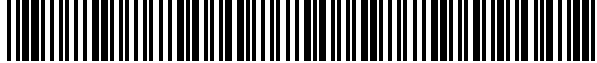
**ACCEPTANCE OF THE ACTIONS TAKEN AT THE FIRST JOINT SESSION OF WORKING  
GROUPS I, II AND III**

**IPCC Special Report on Global Warming of 1.5°C**

*An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.*

**Approved Summary for Policymakers**

(Submitted by the Co-Chairs of Working Groups, I, II and III)



## Summary for Policymakers

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**Date of Summary for Policymakers: 6 October 2018**



## Introduction

This report responds to the invitation for IPCC ‘... to provide 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’ contained in the Decision of the 21st Conference of Parties of the United Nations Framework Convention on Climate Change to adopt the Paris Agreement.<sup>1</sup>

The IPCC accepted the invitation in April 2016, deciding to prepare this Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

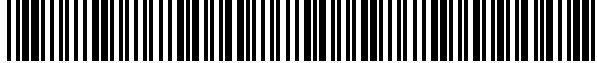
This Summary for Policy Makers (SPM) presents the key findings of the Special Report, based on the assessment of the available scientific, technical and socio-economic literature<sup>2</sup> relevant to global warming of 1.5°C and for the comparison between global warming of 1.5°C and 2°C above pre-industrial levels. The level of confidence associated with each key finding is reported using the IPCC calibrated language.<sup>3</sup> The underlying scientific basis of each key finding is indicated by references provided to chapter elements. In the SPM, knowledge gaps are identified associated with the underlying chapters of the report.

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<sup>1</sup> Decision 1/CP.21, paragraph 21.

<sup>2</sup> The assessment covers literature accepted for publication by 15 May 2018.

<sup>3</sup> Each finding is grounded in an evaluation of underlying evidence and agreement. A level of confidence is expressed using five qualifiers: very low, low, medium, high and very high, and typeset in italics, for example, *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, for example, *very likely*. This is consistent with AR5.



## A. Understanding Global Warming of 1.5°C<sup>4</sup>

**A1. Human activities are estimated to have caused approximately 1.0°C of global warming<sup>5</sup> above pre-industrial levels, with a *likely* range of 0.8°C to 1.2°C. Global warming is *likely* to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (*high confidence*) {1.2, Figure SPM.1}**

**A1.1.** Reflecting the long-term warming trend since pre-industrial times, observed global mean surface temperature (GMST) for the decade 2006–2015 was 0.87°C (*likely* between 0.75°C and 0.99°C)<sup>6</sup> higher than the average over the 1850–1900 period (*very high confidence*). Estimated anthropogenic global warming matches the level of observed warming to within  $\pm 20\%$  (*likely* range). Estimated anthropogenic global warming is currently increasing at 0.2°C (*likely* between 0.1°C and 0.3°C) per decade due to past and ongoing emissions (*high confidence*). {1.2.1, Table 1.1, 1.2.4}

**A1.2.** Warming greater than the global annual average is being experienced in many land regions and seasons, including two to three times higher in the Arctic. Warming is generally higher 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}

**A1.3.** Trends in intensity and frequency of some climate and weather extremes have been detected over time spans during which about 0.5°C of global warming occurred (*medium confidence*). This assessment is based on several lines of evidence, including attribution studies for changes in extremes since 1950. {3.3.1, 3.3.2, 3.3.3}

**A.2. Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (*high confidence*), but these emissions alone are *unlikely* to cause global warming of 1.5°C (*medium confidence*) {1.2, 3.3, Figure 1.5, Figure SPM.1}**

**A2.1.** Anthropogenic emissions (including greenhouse gases, aerosols and their precursors) up to the present are *unlikely* to cause further warming of more than 0.5°C over the next two to three decades (*high confidence*) or on a century time scale (*medium confidence*). {1.2.4, Figure 1.5}

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<sup>4</sup> SPM BOX.1: Core Concepts

<sup>5</sup> Present level of global warming is defined as the average of a 30-year period centered on 2017 assuming the recent rate of warming continues.

<sup>6</sup> This range spans the four available peer-reviewed estimates of the observed GMST change and also accounts for additional uncertainty due to possible short-term natural variability. {1.2.1, Table 1.1}

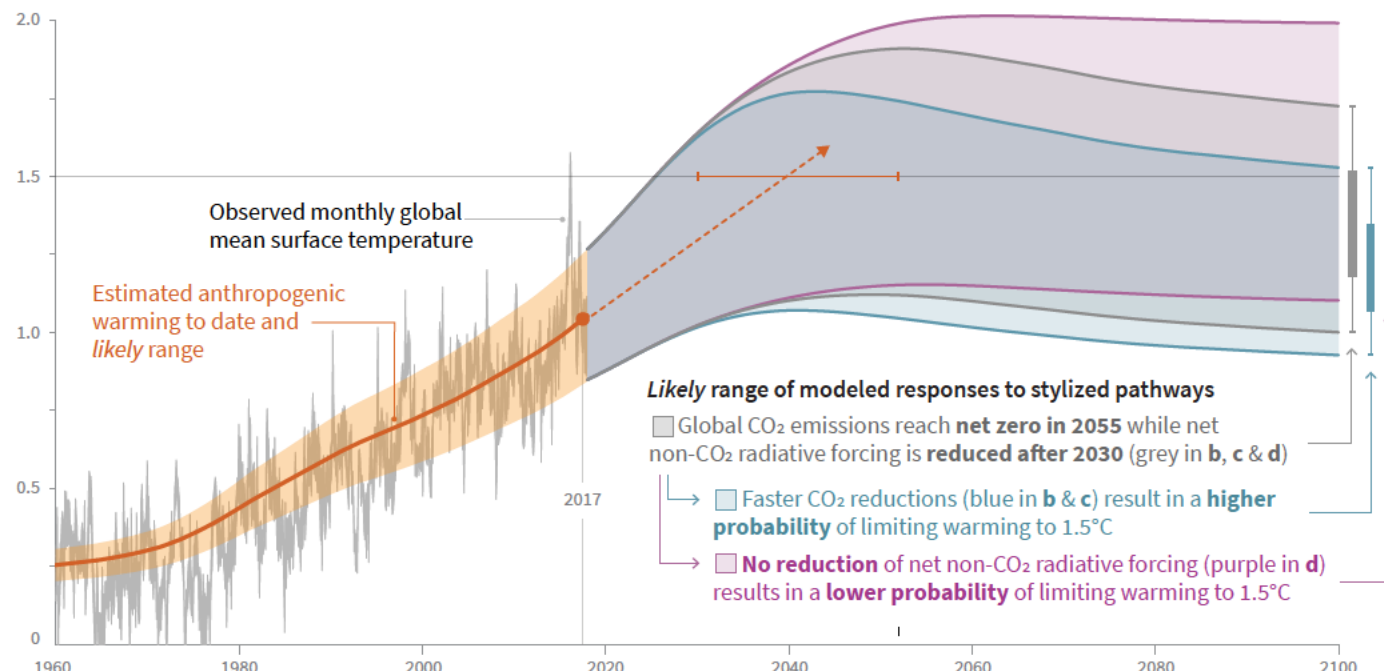


**A2.2.** Reaching and sustaining net-zero global anthropogenic CO<sub>2</sub> emissions and declining net non-CO<sub>2</sub> radiative forcing would halt anthropogenic global warming on multi-decadal timescales (*high confidence*). The maximum temperature reached is then determined by cumulative net global anthropogenic CO<sub>2</sub> emissions up to the time of net zero CO<sub>2</sub> emissions (*high confidence*) and the level of non-CO<sub>2</sub> radiative forcing in the decades prior to the time that maximum temperatures are reached (*medium confidence*). On longer timescales, sustained net negative global anthropogenic CO<sub>2</sub> emissions and/or further reductions in non-CO<sub>2</sub> radiative forcing may still be required to prevent further warming due to Earth system feedbacks and reverse ocean acidification (*medium confidence*) and will be required to minimise sea level rise (*high confidence*). {Cross-Chapter Box 2 in Chapter 1, 1.2.3, 1.2.4, Figure 1.4, 2.2.1, 2.2.2, 3.4.4.8, 3.4.5.1, 3.6.3.2}

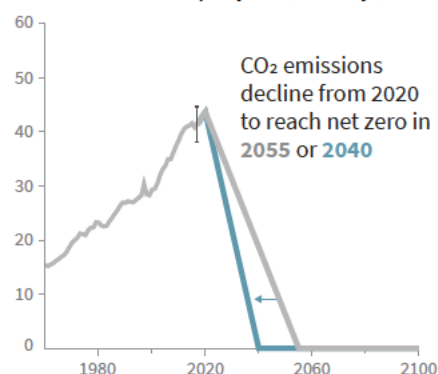
# Cumulative emissions of CO<sub>2</sub> and future non-CO<sub>2</sub> radiative forcing determine the probability of limiting warming to 1.5°C

## a) Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways

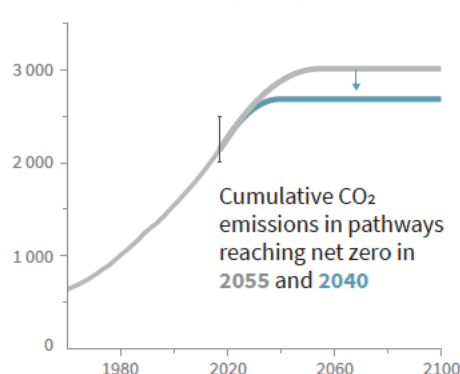
Global warming relative to 1850-1900 (°C)



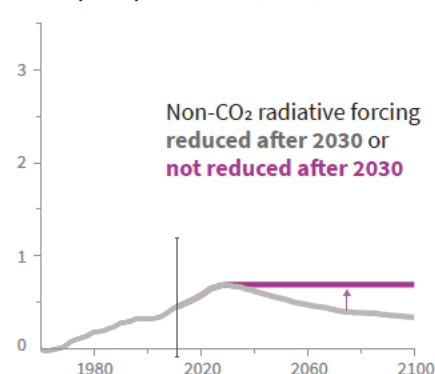
### b) Stylized net global CO<sub>2</sub> emission pathways Billion tonnes CO<sub>2</sub> per year (GtCO<sub>2</sub>/yr)



### c) Cumulative net CO<sub>2</sub> emissions Billion tonnes CO<sub>2</sub> (GtCO<sub>2</sub>)



### d) Non-CO<sub>2</sub> radiative forcing pathways Watts per square metre (W/m<sup>2</sup>)



Faster immediate CO<sub>2</sub> emission reductions limit cumulative CO<sub>2</sub> emissions shown in panel (c).

Maximum temperature rise is determined by cumulative net CO<sub>2</sub> emissions and net non-CO<sub>2</sub> radiative forcing due to methane, nitrous oxide, aerosols and other anthropogenic forcing agents.





**Figure SPM.1:** Panel a: Observed monthly global mean surface temperature (GMST) change grey line up to 2017, from the HadCRUT4, GISTEMP, Cowtan–Way, and NOAA datasets) and estimated anthropogenic global warming (solid orange line up to 2017, with orange shading indicating assessed *likely* range). Orange dashed arrow and horizontal orange error bar show respectively central estimate and *likely* range of the time at which 1.5°C is reached if the current rate of warming continues. The grey plume on the right of Panel a) shows the *likely* range of warming responses, computed with a simple climate model, to a stylized pathway (hypothetical future) in which net CO<sub>2</sub> emissions (grey line in panels b and c) decline in a straight line from 2020 to reach net zero in 2055 and net non-CO<sub>2</sub> radiative forcing (grey line in panel d) increases to 2030 and then declines. The blue plume in panel a) shows the response to faster CO<sub>2</sub> emissions reductions (blue line in panel b), reaching net zero in 2040, reducing cumulative CO<sub>2</sub> emissions (panel c). The purple plume shows the response to net CO<sub>2</sub> emissions declining to zero in 2055, with net non-CO<sub>2</sub> forcing remaining constant after 2030. The vertical error bars on right of panel a) show the *likely* ranges (thin lines) and central terciles (33rd – 66th percentiles, thick lines) of the estimated distribution of warming in 2100 under these three stylized pathways. Vertical dotted error bars in panels b, c and d show the *likely* range of historical annual and cumulative global net CO<sub>2</sub> emissions in 2017 (data from the Global Carbon Project) and of net non-CO<sub>2</sub> radiative forcing in 2011 from AR5, respectively. Vertical axes in panels c and d are scaled to represent approximately equal effects on GMST. {1.2.1, 1.2.3, 1.2.4, 2.3, Chapter 1 Figure 1.2 & Chapter 1 Supplementary Material, Cross-Chapter Box 2}



**A3. Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C (*high confidence*). These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options (*high confidence*) (Figure SPM.2). {1.3, 3.3, 3.4, 5.6}**

**A3.1.** Impacts on natural and human systems from global warming have already been observed (*high confidence*). Many land and ocean ecosystems and some of the services they provide have already changed due to global warming (*high confidence*). {1.4, 3.4, 3.5, Figure SPM.2}

**A3.2.** Future climate-related risks depend on the rate, peak and duration of warming. In the aggregate they are larger if global warming exceeds 1.5°C before returning to that level by 2100 than if global warming gradually stabilizes at 1.5°C, especially if the peak temperature is high (e.g., about 2°C) (*high confidence*). Some impacts may be long-lasting or irreversible, such as the loss of some ecosystems (*high confidence*). {3.2, 3.4.4, 3.6.3, Cross-Chapter Box 8}

**A3.3.** Adaptation and mitigation are already occurring (*high confidence*). Future climate-related risks would be reduced by the upscaling and acceleration of far-reaching, multi-level and cross-sectoral climate mitigation and by both incremental and transformational adaptation (*high confidence*). {1.2, 1.3, Table 3.5, 4.2.2, Cross-Chapter Box 9 in Chapter 4, Box 4.2, Box 4.3, Box 4.6, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.3.5, 4.4.1, 4.4.4, 4.4.5, 4.5.3}

## **B. Projected Climate Change, Potential Impacts and Associated Risks**

**B1. Climate models project robust<sup>7</sup> differences in regional climate characteristics between present-day and global warming of 1.5°C,<sup>8</sup> and between 1.5°C and 2°C.<sup>8</sup> These differences include increases in: mean temperature in most land and ocean regions (*high confidence*), hot extremes in most inhabited regions (*high confidence*), heavy precipitation in several regions (*medium confidence*), and the probability of drought and precipitation deficits in some regions (*medium confidence*). {3.3}**

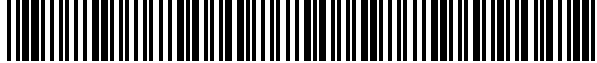
**B1.1.** Evidence from attributed changes in some climate and weather extremes for a global warming of about 0.5°C supports the assessment that an additional 0.5°C of warming compared to present is associated with further detectable changes in these extremes (*medium confidence*). Several regional changes in climate are assessed to occur with global warming up to 1.5°C compared to pre-industrial levels, including warming of extreme temperatures in many regions (*high confidence*), increases in frequency, intensity, and/or amount of heavy precipitation in several regions (*high confidence*), and an increase in intensity or frequency of droughts in some regions (*medium confidence*). {3.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, Table 3.2}

**B1.2.** Temperature extremes on land are projected to warm more than GMST (*high confidence*): extreme hot days in mid-latitudes warm by up to about 3°C at global warming of 1.5°C and about

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<sup>7</sup> Robust is here used to mean that at least two thirds of climate models show the same sign of changes at the grid point scale, and that differences in large regions are statistically significant.

<sup>8</sup> Projected changes in impacts between different levels of global warming are determined with respect to changes in global surface air temperature.



4°C at 2°C, and extreme cold nights in high latitudes warm by up to about 4.5°C at 1.5°C and about 6°C at 2°C (*high confidence*). The number of hot days is projected to increase in most land regions, with highest increases in the tropics (*high confidence*). {3.3.1, 3.3.2, Cross-Chapter Box 8 in Chapter 3}

**B1.3.** Risks from droughts and precipitation deficits are projected to be higher at 2°C compared to 1.5°C global warming in some regions (*medium confidence*). Risks from heavy precipitation events are projected to be higher at 2°C compared to 1.5°C global warming in several northern hemisphere high-latitude and/or high-elevation regions, eastern Asia and eastern North America (*medium confidence*). Heavy precipitation associated with tropical cyclones is projected to be higher at 2°C compared to 1.5°C global warming (*medium confidence*). There is generally *low confidence* in projected changes in heavy precipitation at 2°C compared to 1.5°C in other regions. Heavy precipitation when aggregated at global scale is projected to be higher at 2.0°C than at 1.5°C of global warming (*medium confidence*). As a consequence of heavy precipitation, the fraction of the global land area affected by flood hazards is projected to be larger at 2°C compared to 1.5°C of global warming (*medium confidence*). {3.3.1, 3.3.3, 3.3.4, 3.3.5, 3.3.6}

**B2.** By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C (*medium confidence*). Sea level will continue to rise well beyond 2100 (*high confidence*), and the magnitude and rate of this rise depends on future emission pathways. A slower rate of sea level rise enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas (*medium confidence*). {3.3, 3.4, 3.6 }

**B2.1.** Model-based projections of global mean sea level rise (relative to 1986-2005) suggest an indicative range of 0.26 to 0.77 m by 2100 for 1.5°C global warming, 0.1 m (0.04-0.16 m) less than for a global warming of 2°C (*medium confidence*). A reduction of 0.1 m in global sea level rise implies that up to 10 million fewer people would be exposed to related risks, based on population in the year 2010 and assuming no adaptation (*medium confidence*). {3.4.4, 3.4.5, 4.3.2}

**B2.2.** Sea level rise will continue beyond 2100 even if global warming is limited to 1.5°C in the 21st century (*high confidence*). Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet could result in multi-metre rise in sea level over hundreds to thousands of years. These instabilities could be triggered around 1.5°C to 2°C of global warming (*medium confidence*). {3.3.9, 3.4.5, 3.5.2, 3.6.3, Box 3.3, Figure SPM.2}

**B2.3.** Increasing warming amplifies the exposure of small islands, low-lying coastal areas and deltas to the risks associated with sea level rise for many human and ecological systems, including increased saltwater intrusion, flooding and damage to infrastructure (*high confidence*). Risks associated with sea level rise are higher at 2°C compared to 1.5°C. The slower rate of sea level rise at global warming of 1.5°C reduces these risks enabling greater opportunities for adaptation including managing and restoring natural coastal ecosystems, and infrastructure reinforcement (*medium confidence*). {3.4.5, Figure SPM.2, Box 3.5}

**B3.** On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C. Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater, and coastal ecosystems and to retain more of their services to humans (*high confidence*). (Figure SPM.2) {3.4, 3.5, Box 3.4, Box 4.2, Cross-Chapter Box 8 in Chapter 3}



**B3.1.** Of 105,000 species studied,<sup>9</sup> 6% of insects, 8% of plants and 4% of vertebrates are projected to lose over half of their climatically determined geographic range for global warming of 1.5°C, compared with 18% of insects, 16% of plants and 8% of vertebrates for global warming of 2°C (*medium confidence*). Impacts associated with other biodiversity-related risks such as forest fires, and the spread of invasive species, are lower at 1.5°C compared to 2°C of global warming (*high confidence*). {3.4.3, 3.5.2}

**B3.2.** Approximately 4% (interquartile range 2–7%) of the global terrestrial land area is projected to undergo a transformation of ecosystems from one type to another at 1°C of global warming, compared with 13% (interquartile range 8–20%) at 2°C (*medium confidence*). This indicates that the area at risk is projected to be approximately 50% lower at 1.5°C compared to 2°C (*medium confidence*). {3.4.3.1, 3.4.3.5}

**B3.3.** High-latitude tundra and boreal forests are particularly at risk of climate change-induced degradation and loss, with woody shrubs already encroaching into the tundra (*high confidence*) and will proceed with further warming. Limiting global warming to 1.5°C rather than 2°C is projected to prevent the thawing over centuries of a permafrost area in the range of 1.5 to 2.5 million km<sup>2</sup> (*medium confidence*). {3.3.2, 3.4.3, 3.5.5}

**B4. Limiting global warming to 1.5°C compared to 2°C is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (*high confidence*). Consequently, limiting global warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm water coral reef ecosystems (*high confidence*). {3.3, 3.4, 3.5, Boxes 3.4, 3.5}**

**B4.1.** There is *high confidence* that the probability of a sea-ice-free Arctic Ocean during summer is substantially lower at global warming of 1.5°C when compared to 2°C. With 1.5°C of global warming, one sea ice-free Arctic summer is projected per century. This likelihood is increased to at least one per decade with 2°C global warming. Effects of a temperature overshoot are reversible for Arctic sea ice cover on decadal time scales (*high confidence*). {3.3.8, 3.4.4.7}

**B4.2.** Global warming of 1.5°C is projected to shift the ranges of many marine species, to higher latitudes as well as increase the amount of damage to many ecosystems. It is also expected to drive the loss of coastal resources, and reduce the productivity of fisheries and aquaculture (especially at low latitudes). The risks of climate-induced impacts are projected to be higher at 2°C than those at global warming of 1.5°C (*high confidence*). Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C (*high confidence*) with larger losses (>99%) at 2°C (*very high confidence*). The risk of irreversible loss of many marine and coastal ecosystems increases with global warming, especially at 2°C or more (*high confidence*). {3.4.4, Box 3.4}

**B4.3.** The level of ocean acidification due to increasing CO<sub>2</sub> concentrations associated with global warming of 1.5°C is projected to amplify the adverse effects of warming, and even further at 2°C,

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<sup>9</sup> Consistent with earlier studies, illustrative numbers were adopted from one recent meta-study.



impacting the growth, development, calcification, survival, and thus abundance of a broad range of species, e.g., from algae to fish (*high confidence*). {3.3.10, 3.4.4}

**B4.4.** Impacts of climate change in the ocean are increasing risks to fisheries and aquaculture via impacts on the physiology, survivorship, habitat, reproduction, disease incidence, and risk of invasive species (*medium confidence*) but are projected to be less at 1.5°C of global warming than at 2°C. One global fishery model, for example, projected a decrease in global annual catch for marine fisheries of about 1.5 million tonnes for 1.5°C of global warming compared to a loss of more than 3 million tonnes for 2°C of global warming (*medium confidence*). {3.4.4, Box 3.4}

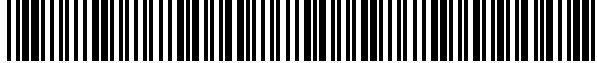
**B5. Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C. (Figure SPM.2) {3.4, 3.5, 5.2, Box 3.2, Box 3.3, Box 3.5, Box 3.6, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 5.2}**

**B5.1.** Populations at disproportionately higher risk of adverse consequences of global warming of 1.5°C and beyond include disadvantaged and vulnerable populations, some indigenous peoples, and local communities dependent on agricultural or coastal livelihoods (*high confidence*). Regions at disproportionately higher risk include Arctic ecosystems, dryland regions, small-island developing states, and least developed countries (*high confidence*). Poverty and disadvantages are expected to increase in some populations as global warming increases; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050 (*medium confidence*). {3.4.10, 3.4.11, Box 3.5, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 4.2.2.2, 5.2.1, 5.2.2, 5.2.3, 5.6.3}

**B5.2.** Any increase in global warming is projected to affect human health, with primarily negative consequences (*high confidence*). Lower risks are projected at 1.5°C than at 2°C for heat-related morbidity and mortality (*very high confidence*) and for ozone-related mortality if emissions needed for ozone formation remain high (*high confidence*). Urban heat islands often amplify the impacts of heatwaves in cities (*high confidence*). Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographic range (*high confidence*). {3.4.7, 3.4.8, 3.5.5.8}

**B5.3.** Limiting warming to 1.5°C, compared with 2°C, is projected to result in smaller net reductions in yields of maize, rice, wheat, and potentially other cereal crops, particularly in sub-Saharan Africa, Southeast Asia, and Central and South America; and in the CO<sub>2</sub> dependent, nutritional quality of rice and wheat (*high confidence*). Reductions in projected food availability are larger at 2°C than at 1.5°C of global warming in the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon (*medium confidence*). Livestock are projected to be adversely affected with rising temperatures, depending on the extent of changes in feed quality, spread of diseases, and water resource availability (*high confidence*). {3.4.6, 3.5.4, 3.5.5, Box 3.1, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4}

**B5.4.** Depending on future socioeconomic conditions, limiting global warming to 1.5°C, compared to 2°C, may reduce the proportion of the world population exposed to a climate-change induced increase in water stress by up to 50%, although there is considerable variability between regions (*medium confidence*). Many small island developing states would experience lower water 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, Cross-Chapter Box 9 in Chapter 4}

**B5.5.** Risks to global aggregated economic growth due to climate change impacts are projected to be lower at 1.5°C than at 2°C by the end of this century<sup>10</sup> (*medium confidence*). This excludes the costs of mitigation, adaptation investments and the benefits of adaptation. Countries in the tropics and Southern Hemisphere subtropics are projected to experience the largest impacts on economic growth due to climate change should global warming increase from 1.5°C to 2 °C (*medium confidence*). {3.5.2, 3.5.3}

**B5.6.** Exposure to multiple and compound climate-related risks increases between 1.5°C and 2°C of global warming, with greater proportions of people both so exposed and susceptible to poverty in Africa and Asia (*high confidence*). For global warming from 1.5°C to 2°C, risks across energy, food, and water sectors could overlap spatially and temporally, creating new and exacerbating current hazards, exposures, and vulnerabilities that could affect increasing numbers of people and regions (*medium confidence*). {Box 3.5, 3.3.1, 3.4.5.3, 3.4.5.6, 3.4.11, 3.5.4.9}

**B5.7.** There are multiple lines of evidence that since the AR5 the assessed levels of risk increased for four of the five Reasons for Concern (RFCs) for global warming to 2°C (*high confidence*). The risk transitions by degrees of global warming are now: from high to very high between 1.5°C and 2°C for RFC1 (Unique and threatened systems) (*high confidence*); from moderate to high risk between 1.0°C and 1.5°C for RFC2 (Extreme weather events) (*medium confidence*); from moderate to high risk between 1.5°C and 2°C for RFC3 (Distribution of impacts) (*high confidence*); from moderate to high risk between 1.5°C and 2.5°C for RFC4 (Global aggregate impacts) (*medium confidence*); and from moderate to high risk between 1°C and 2.5°C for RFC5 (Large-scale singular events) (*medium confidence*). (Figure SPM.2) {3.4.13; 3.5, 3.5.2}

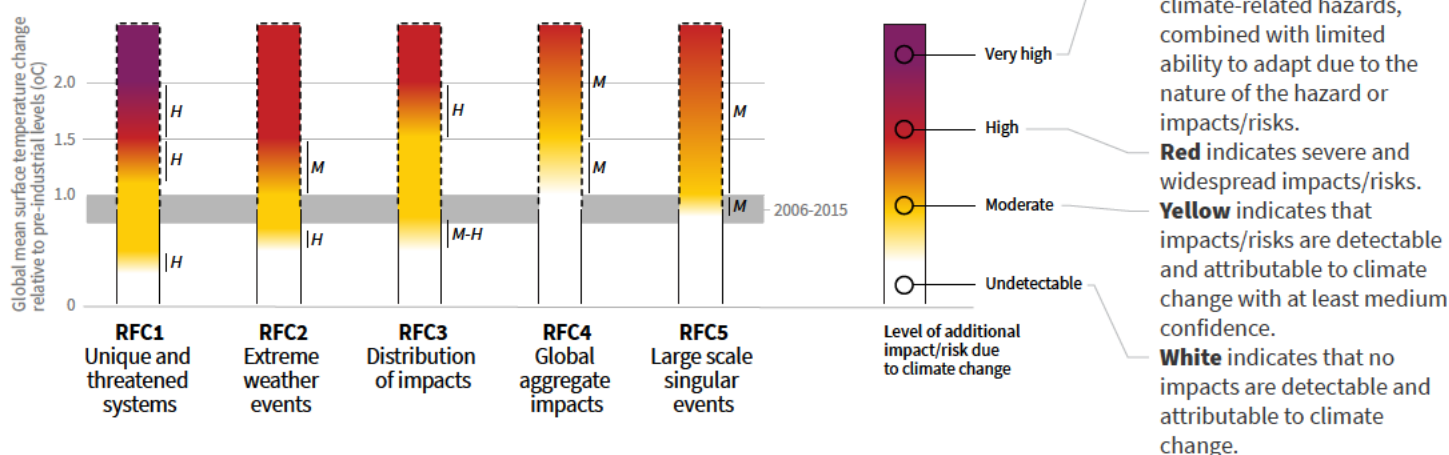
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<sup>10</sup> Here, impacts on economic growth refer to changes in GDP. Many impacts, such as loss of human lives, cultural heritage, and ecosystem services, are difficult to value and monetize.

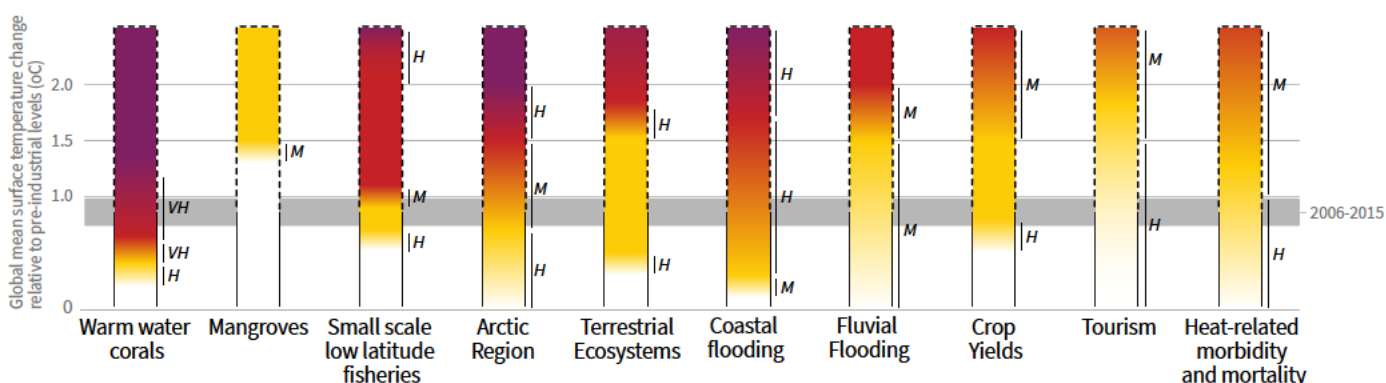
# How the level of global warming affects impacts and/or risks associated with the Reasons for Concern (RFCs) and selected natural, managed and human systems

Five Reasons For Concern (RFCs) illustrate the impacts and risks of different levels of global warming for people, economies and ecosystems across sectors and regions.

## Impacts and risks associated with the Reasons for Concern (RFCs)



## Impacts and risks for selected natural, managed and human systems



Confidence level for transition: L=Low, M=Medium, H=High and VH=Very high



**Figure SPM.2:** Five integrative reasons for concern (RFCs) provide a framework for summarizing key impacts and risks across sectors and regions, and were introduced in the IPCC Third Assessment Report. RFCs illustrate the implications of global warming for people, economies, and ecosystems. Impacts and/or risks for each RFC are based on assessment of the new literature that has appeared. As in the AR5, this literature was used to make expert judgments to assess the levels of global warming at which levels of impact and/or risk are undetectable, moderate, high or very high. The selection of impacts and risks to natural, managed and human systems in the lower panel is illustrative and is not intended to be fully comprehensive. **RFC1 Unique and threatened systems:** ecological and human systems that have restricted geographic ranges constrained by climate related conditions and have high endemism or other distinctive properties. Examples include coral reefs, the Arctic and its indigenous people, mountain glaciers, and biodiversity hotspots. **RFC2 Extreme weather events:** risks/impacts to human health, livelihoods, assets, and ecosystems from extreme weather events such as heat waves, heavy rain, drought and associated wildfires, and coastal flooding. **RFC3 Distribution of impacts:** risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability. **RFC4 Global aggregate impacts:** global monetary damage, global scale degradation and loss of ecosystems and biodiversity. **RFC5 Large-scale singular events:** are relatively large, abrupt and sometimes irreversible changes in systems that are caused by global warming. Examples include disintegration of the Greenland and Antarctic ice sheets. {3.4, 3.5, 3.5.2.1, 3.5.2.2, 3.5.2.3, 3.5.2.4, 3.5.2.5, 5.4.1 5.5.3, 5.6.1, Box 3.4}





**B6. Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C (*high confidence*). There are a wide range of adaptation options that can reduce the risks of climate change (*high confidence*). There are limits to adaptation and adaptive capacity for some human and natural systems at global warming of 1.5°C, with associated losses (*medium confidence*). The number and availability of adaptation options vary by sector (*medium confidence*). {Table 3.5, 4.3, 4.5, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5}**

**B6.1.** A wide range of adaptation options are available to reduce the risks to natural and managed ecosystems (e.g., ecosystem-based adaptation, ecosystem restoration and avoided degradation and deforestation, biodiversity management, sustainable aquaculture, and local knowledge and indigenous knowledge), the risks of sea level rise (e.g., coastal defence and hardening), and the risks to health, livelihoods, food, water, and economic growth, especially in rural landscapes (e.g., efficient irrigation, social safety nets, disaster risk management, risk spreading and sharing, community-based adaptation) and urban areas (e.g., green infrastructure, sustainable land use and planning, and sustainable water management) (*medium confidence*). {4.3.1, 4.3.2, 4.3.3, 4.3.5, 4.5.3, 4.5.4, 5.3.2, Box 4.2, Box 4.3, Box 4.6, Cross-Chapter Box 9 in Chapter 4}.

**B6.2.** Adaptation is expected to be more challenging for ecosystems, food and health systems at 2°C of global warming than for 1.5°C (*medium confidence*). Some vulnerable regions, including small islands and Least Developed Countries, are projected to experience high multiple interrelated climate risks even at global warming of 1.5°C (*high confidence*). {3.3.1, 3.4.5, Box 3.5, Table 3.5, Cross-Chapter Box 9 in Chapter 4, 5.6, Cross-Chapter Box 12 in Chapter 5, Box 5.3}

**B6.3.** Limits to adaptive capacity exist at 1.5°C of global warming, become more pronounced at higher levels of warming and vary by sector, with site-specific implications for vulnerable regions, ecosystems, and human health (*medium confidence*) {Cross-Chapter Box 12 in Chapter 5, Box 3.5, Table 3.5}

## **C. Emission Pathways and System Transitions Consistent with 1.5°C Global Warming**

**C1. In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO<sub>2</sub> emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C<sup>11</sup> CO<sub>2</sub> emissions are projected to decline by about 20% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2075 (2065–2080 interquartile range). Non-CO<sub>2</sub> emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C. (*high confidence*) (Figure SPM.3a) {2.1, 2.3, Table 2.4}**

**C1.1.** CO<sub>2</sub> emissions reductions that limit global warming to 1.5°C with no or limited overshoot can involve different portfolios of mitigation measures, striking different balances between lowering energy and resource intensity, rate of decarbonization, and the reliance on carbon dioxide removal. Different portfolios face different implementation challenges, and potential synergies and trade-offs with sustainable development. (*high confidence*). (Figure SPM.3b) {2.3.2, 2.3.4, 2.4, 2.5.3}

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<sup>11</sup> References to pathways limiting global warming to 2°C are based on a 66% probability of staying below 2°C.



**C1.2.** Modelled pathways that limit global warming to 1.5°C with no or limited overshoot involve deep reductions in emissions of methane and black carbon (35% or more of both by 2050 relative to 2010). These pathways also reduce most of the cooling aerosols, which partially offsets mitigation effects for two to three decades. Non-CO<sub>2</sub> emissions<sup>12</sup> can be reduced as a result of broad mitigation measures in the energy sector. In addition, targeted non-CO<sub>2</sub> mitigation measures can reduce nitrous oxide and methane from agriculture, methane from the waste sector, some sources of black carbon, and hydrofluorocarbons. High bioenergy demand can increase emissions of nitrous oxide in some 1.5°C pathways, highlighting the importance of appropriate management approaches. Improved air quality resulting from projected reductions in many non-CO<sub>2</sub> emissions provide direct and immediate population health benefits in all 1.5°C model pathways. (*high confidence*) (Figure SPM.3a) {2.2.1, 2.3.3, 2.4.4, 2.5.3, 4.3.6, 5.4.2}

**C1.3.** Limiting global warming requires limiting the total cumulative global anthropogenic emissions of CO<sub>2</sub> since the preindustrial period, i.e. staying within a total carbon budget (*high confidence*).<sup>13</sup> By the end of 2017, anthropogenic CO<sub>2</sub> emissions since the preindustrial period are estimated to have reduced the total carbon budget for 1.5°C by approximately 2200 ± 320 GtCO<sub>2</sub> (*medium confidence*). The associated remaining budget is being depleted by current emissions of 42 ± 3 GtCO<sub>2</sub> per year (*high confidence*). The choice of the measure of global temperature affects the estimated remaining carbon budget. Using global mean surface air temperature, as in AR5, gives an estimate of the remaining carbon budget of 580 GtCO<sub>2</sub> for a 50% probability of limiting warming to 1.5°C, and 420 GtCO<sub>2</sub> for a 66% probability (*medium confidence*).<sup>14</sup> Alternatively, using GMST gives estimates of 770 and 570 GtCO<sub>2</sub>, for 50% and 66% probabilities,<sup>15</sup> respectively (*medium confidence*). Uncertainties in the size of these estimated remaining carbon budgets are substantial and depend on several factors. Uncertainties in the climate response to CO<sub>2</sub> and non-CO<sub>2</sub> emissions contribute ±400 GtCO<sub>2</sub> and the level of historic warming contributes ±250 GtCO<sub>2</sub> (*medium confidence*). Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 GtCO<sub>2</sub> over the course of this century and more thereafter (*medium confidence*). In addition, the level of non-CO<sub>2</sub> mitigation in the future could alter the remaining carbon budget by 250 GtCO<sub>2</sub> in either direction (*medium confidence*). {1.2.4, 2.2.2, 2.6.1, Table 2.2, Chapter 2 Supplementary Material}

**C1.4.** Solar radiation modification (SRM) measures are not included in any of the available assessed pathways. Although some SRM measures may be theoretically effective in reducing an overshoot, they face large uncertainties and knowledge gaps as well as substantial risks,

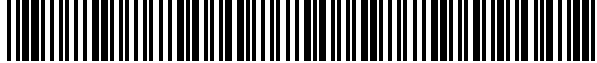
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<sup>12</sup> Non-CO<sub>2</sub> emissions included in this report are all anthropogenic emissions other than CO<sub>2</sub> that result in radiative forcing. These include short-lived climate forcers, such as methane, some fluorinated gases, ozone precursors, aerosols or aerosol precursors, such as black carbon and sulphur dioxide, respectively, as well as long-lived greenhouse gases, such as nitrous oxide or some fluorinated gases. The radiative forcing associated with non-CO<sub>2</sub> emissions and changes in surface albedo is referred to as non-CO<sub>2</sub> radiative forcing. {x.y}

<sup>13</sup> There is a clear scientific basis for a total carbon budget consistent with limiting global warming to 1.5°C. However, neither this total carbon budget nor the fraction of this budget taken up by past emissions were assessed in this report.

<sup>14</sup> Irrespective of the measure of global temperature used, updated understanding and further advances in methods have led to an increase in the estimated remaining carbon budget of about 300 GtCO<sub>2</sub> compared to AR5. (*medium confidence*) {x.y}

<sup>15</sup> These estimates use observed GMST to 2006–2015 and estimate future temperature changes using near surface air temperatures.



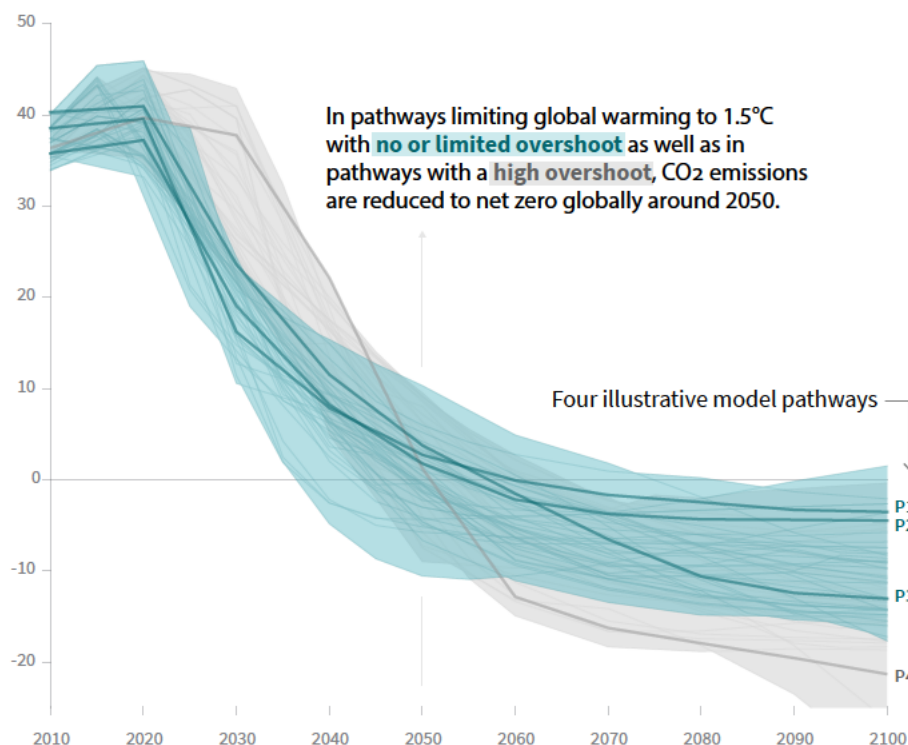
institutional and social constraints to deployment related to governance, ethics, and impacts on sustainable development. They also do not mitigate ocean acidification. (*medium confidence*). {4.3.8, Cross-Chapter Box 10 in Chapter 4}

## Global emissions pathway characteristics

General characteristics of the evolution of anthropogenic net emissions of CO<sub>2</sub>, and total emissions of methane, black carbon, and nitrous oxide in model pathways that limit global warming to 1.5°C with no or limited overshoot. Net emissions are defined as anthropogenic emissions reduced by anthropogenic removals. Reductions in net emissions can be achieved through different portfolios of mitigation measures illustrated in Figure SPM3B.

### Global total net CO<sub>2</sub> emissions

Billion tonnes of CO<sub>2</sub>/yr



#### Timing of net zero CO<sub>2</sub>

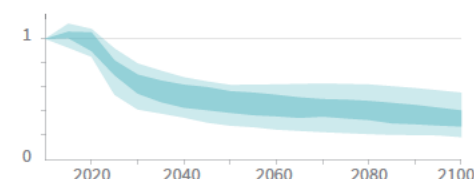
Line widths depict the 5-95th percentile and the 25-75th percentile of scenarios



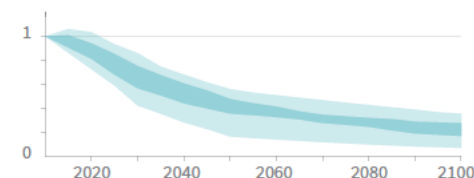
### Non-CO<sub>2</sub> emissions relative to 2010

Emissions of non-CO<sub>2</sub> forcers are also reduced or limited in pathways limiting global warming to 1.5°C with **no or limited overshoot**, but they do not reach zero globally.

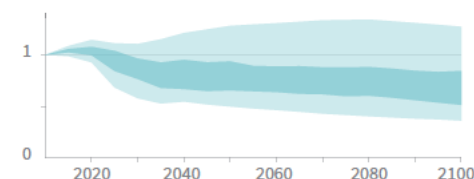
#### Methane emissions



#### Black carbon emissions



#### Nitrous oxide emissions



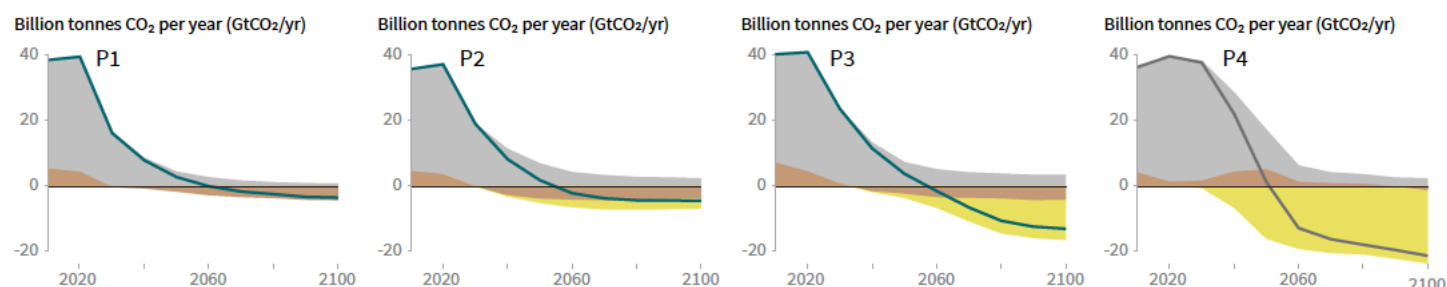
**Figure SPM.3a:** Global emissions pathway characteristics. The main panel shows global net anthropogenic CO<sub>2</sub> emissions in pathways limiting global warming to 1.5°C with no or limited (less than 0.1°C) overshoot and pathways with higher overshoot. The shaded area shows the full range for pathways analysed in this report. The panels on the right show non-CO<sub>2</sub> emissions ranges for three compounds with large historical forcing and a substantial portion of emissions coming from sources distinct from those central to CO<sub>2</sub> mitigation. Shaded areas in these panels show the 5–95% (light shading) and interquartile (dark shading) ranges of pathways limiting global warming to 1.5°C with no or limited overshoot. Box and whiskers at the bottom of the figure show the timing of pathways reaching global net zero CO<sub>2</sub> emission levels, and a comparison with pathways limiting global warming to 2°C with at least 66% probability. Four illustrative model pathways are highlighted in the main panel and are labelled P1, P2, P3 and P4, corresponding to the LED, S1, S2, and S5 pathways assessed in Chapter 2. Descriptions and characteristics of these pathways are available in Figure SPM3b. {2.1, 2.2, 2.3, Figure 2.5, Figure 2.10, Figure 2.11}

## Characteristics of four illustrative model pathways

Different mitigation strategies can achieve the net emissions reductions that would be required to follow a pathway that limit global warming to 1.5°C with no or limited overshoot. All pathways use Carbon Dioxide Removal (CDR), but the amount varies across pathways, 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. This has implications for the emissions and several other pathway characteristics.

### Breakdown of contributions to global net CO<sub>2</sub> emissions in four illustrative model pathways

● Fossil fuel and industry ● AFOLU ● BECCS



**P1:** A scenario in which social, business, and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

**P2:** A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

**P3:** 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 reductions in demand.

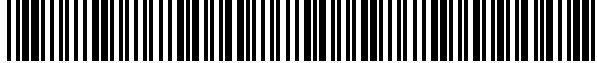
**P4:** A resource and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

Global indicators	P1	P2	P3	P4	Interquartile range
<b>Pathway classification</b>	No or low overshoot	No or low overshoot	No or low overshoot	High overshoot	No or low overshoot
CO <sub>2</sub> emission change in 2030 (% rel to 2010)	-58	-47	-41	4	(-59,-40)
↳ in 2050 (% rel to 2010)	-93	-95	-91	-97	(-104,-91)
Kyoto-GHG emissions* in 2030 (% rel to 2010)	-50	-49	-35	-2	(-55,-38)
↳ in 2050 (% rel to 2010)	-82	-89	-78	-80	(-93,-81)
Final energy demand** in 2030 (% rel to 2010)	-15	-5	17	39	(-12, 7)
↳ in 2050 (% rel to 2010)	-32	2	21	44	(-11, 22)
Renewable share in electricity in 2030 (%)	60	58	48	25	(47, 65)
↳ in 2050 (%)	77	81	63	70	(69, 87)
Primary energy from coal in 2030 (% rel to 2010)	-78	-61	-75	-59	(-78, -59)
↳ in 2050 (% rel to 2010)	-97	-77	-73	-97	(-95, -74)
from oil in 2030 (% rel to 2010)	-37	-13	-3	86	(-34,3)
↳ in 2050 (% rel to 2010)	-87	-50	-81	-32	(-78,-31)
from gas in 2030 (% rel to 2010)	-25	-20	33	37	(-26,21)
↳ in 2050 (% rel to 2010)	-74	-53	21	-48	(-56,6)
from nuclear in 2030 (% rel to 2010)	59	83	98	106	(44,102)
↳ in 2050 (% rel to 2010)	150	98	501	468	(91,190)
from biomass in 2030 (% rel to 2010)	-11	0	36	-1	(29,80)
↳ in 2050 (% rel to 2010)	-16	49	121	418	(123,261)
from non-biomass renewables in 2030 (% rel to 2010)	430	470	315	110	(243,438)
↳ in 2050 (% rel to 2010)	832	1327	878	1137	(575,1300)
Cumulative CCS until 2100 (GtCO <sub>2</sub> )	0	348	687	1218	(550, 1017)
↳ of which BECCS (GtCO <sub>2</sub> )	0	151	414	1191	(364, 662)
Land area of bioenergy crops in 2050 (million hectare)	22	93	283	724	(151, 320)
Agricultural CH <sub>4</sub> emissions in 2030 (% rel to 2010)	-24	-48	1	14	(-30,-11)
in 2050 (% rel to 2010)	-33	-69	-23	2	(-46,-23)
Agricultural N <sub>2</sub> O emissions in 2030 (% rel to 2010)	5	-26	15	3	(-21,4)
in 2050 (% rel to 2010)	6	-26	0	39	(-26,1)

NOTE: Indicators have been selected to show global trends identified by the Chapter 2 assessment. National and sectoral characteristics can differ substantially from the global trends shown above.

\* Kyoto-gas emissions are based on SAR GWP-100

\*\* Changes in energy demand are associated with improvements in energy efficiency and behaviour change



**Figure SPM.3b:** Characteristics of four illustrative model pathways in relation to global warming of 1.5°C introduced in Figure SPM3a. These pathways were selected to show a range of potential mitigation approaches and vary widely in their projected energy and land use, as well as their assumptions about future socioeconomic developments, including economic and population growth, equity and sustainability. A breakdown of the global net anthropogenic CO<sub>2</sub> emissions into the contributions in terms of CO<sub>2</sub> emissions from fossil fuel and industry, agriculture, forestry and other land use (AFOLU), and bioenergy with carbon capture and storage (BECCS) is shown. AFOLU estimates reported here are not necessarily comparable with countries' estimates. Further characteristics for each of these pathways are listed below each pathway. These pathways illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements. For comparison, the right-most column shows the interquartile ranges across pathways with no or limited overshoot of 1.5°C. Pathways P1, P2, P3 and P4, correspond to the LED, S1, S2, and S5 pathways assessed in Chapter 2. (Figure SPM.3a) {2.2.1, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.4.1, 2.4.2, 2.4.4, 2.5.3, Figure 2.5, Figure 2.6, Figure 2.9, Figure 2.10, Figure 2.11, Figure 2.14, Figure 2.15, Figure 2.16, Figure 2.17, Figure 2.24, Figure 2.25, Table 2.4, Table 2.6, Table 2.7, Table 2.9, Table 4.1}



**C2. Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (*high confidence*). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (*medium confidence*). {2.3, 2.4, 2.5, 4.2, 4.3, 4.4, 4.5}**

**C2.1.** Pathways that limit global warming to 1.5°C with no or limited overshoot show system changes that are more rapid and pronounced over the next two decades than in 2°C pathways (*high confidence*). The rates of system changes associated with limiting global warming to 1.5°C with no or limited overshoot have occurred in the past within specific sectors, technologies and spatial contexts, but there is no documented historic precedent for their scale (*medium confidence*). {2.3.3, 2.3.4, 2.4, 2.5, 4.2.1, 4.2.2, Cross-Chapter Box 11 in Chapter 4}

**C2.2.** In energy systems, modelled global pathways (considered in the literature) limiting global warming to 1.5°C with no or limited overshoot (for more details see Figure SPM.3b), generally meet energy service demand with lower energy use, including through enhanced energy efficiency, and show faster electrification of energy end use compared to 2°C (*high confidence*). In 1.5°C pathways with no or limited overshoot, low-emission energy sources are projected to have a higher share, compared with 2°C pathways, particularly before 2050 (*high confidence*). In 1.5°C pathways with no or limited overshoot, renewables are projected to supply 70–85% (interquartile range) of electricity in 2050 (*high confidence*). In electricity generation, shares of nuclear and fossil fuels with carbon dioxide capture and storage (CCS) are modelled to increase in most 1.5°C pathways with no or limited overshoot. In modelled 1.5°C pathways with limited or no overshoot, the use of CCS would allow the electricity generation share of gas to be approximately 8% (3–11% interquartile range) of global electricity in 2050, while the use of coal shows a steep reduction in all pathways and would be reduced to close to 0% (0–2%) of electricity (*high confidence*). While acknowledging the challenges, and differences between the options and national circumstances, political, economic, social and technical feasibility of solar energy, wind energy and electricity storage technologies have substantially improved over the past few years (*high confidence*). These improvements signal a potential system transition in electricity generation (Figure SPM.3b) {2.4.1, 2.4.2, Figure 2.1, Table 2.6, Table 2.7, Cross-Chapter Box 6 in Chapter 3, 4.2.1, 4.3.1, 4.3.3, 4.5.2}

**C2.3.** CO<sub>2</sub> emissions from industry in pathways limiting global warming to 1.5°C with no or limited overshoot are projected to be about 75–90% (interquartile range) lower in 2050 relative to 2010, as compared to 50–80% for global warming of 2°C (*medium confidence*). Such reductions can be achieved through combinations of new and existing technologies and practices, including electrification, hydrogen, sustainable bio-based feedstocks, product substitution, and carbon capture, utilization and storage (CCUS). These options are technically proven at various scales but their large-scale deployment may be limited by economic, financial, human capacity and institutional constraints in specific contexts, and specific characteristics of large-scale industrial installations. In industry, emissions reductions by energy and process efficiency by themselves are insufficient for limiting warming to 1.5°C with no or limited overshoot (*high confidence*). {2.4.3, 4.2.1, Table 4.1, Table 4.3, 4.3.3, 4.3.4, 4.5.2}

**C2.4.** The urban and infrastructure system transition consistent with limiting global warming to 1.5°C with no or limited overshoot would imply, for example, changes in land and urban planning practices, as well as deeper emissions reductions in transport and buildings compared to pathways that limit global warming below 2°C (see 2.4.3; 4.3.3; 4.2.1) (*medium confidence*). Technical



measures and practices enabling deep emissions reductions include various energy efficiency options. In pathways limiting global warming to 1.5°C with no or limited overshoot, the electricity share of energy demand in buildings would be about 55–75% in 2050 compared to 50–70% in 2050 for 2°C global warming (*medium confidence*). In the transport sector, the share of low-emission final energy would rise from less than 5% in 2020 to about 35–65% in 2050 compared to 25–45% for 2°C global warming (*medium confidence*). Economic, institutional and socio-cultural barriers may inhibit these urban and infrastructure system transitions, depending on national, regional and local circumstances, capabilities and the availability of capital (*high confidence*). {2.3.4, 2.4.3, 4.2.1, Table 4.1, 4.3.3, 4.5.2}.

**C2.5.** Transitions in global and regional land use are found in all pathways limiting global warming to 1.5°C with no or limited overshoot, but their scale depends on the pursued mitigation portfolio. Model pathways that limit global warming to 1.5°C with no or limited overshoot project the conversion of 0.5–8 million km<sup>2</sup> of pasture and 0–5 million km<sup>2</sup> of non-pasture agricultural land for food and feed crops into 1–7 million km<sup>2</sup> for energy crops and a 1 million km<sup>2</sup> reduction to 10 million km<sup>2</sup> increase in forests by 2050 relative to 2010 (*medium confidence*).<sup>16</sup> Land use transitions of similar magnitude can be observed in modelled 2°C pathways (*medium confidence*). Such large transitions pose profound challenges for sustainable management of the various demands on land for human settlements, food, livestock feed, fibre, bioenergy, carbon storage, biodiversity and other ecosystem services (*high confidence*). Mitigation options limiting the demand for land include sustainable intensification of land use practices, ecosystem restoration and changes towards less resource-intensive diets (*high confidence*). The implementation of land-based mitigation options would require overcoming socio-economic, institutional, technological, financing and environmental barriers that differ across regions (*high confidence*). {2.4.4, Figure 2.24, 4.3.2, 4.5.2, Cross-Chapter Box 7 in Chapter 3}

**C2.6** Total annual average energy-related mitigation investment for the period 2015 to 2050 in pathways limiting warming to 1.5°C is estimated to be around 900 billion USD<sub>2015</sub> (range of 180 billion to 1800 billion USD<sub>2015</sub> across six models<sup>17</sup>). This corresponds to total annual average energy supply investments of 1600 to 3800 billion USD<sub>2015</sub> and total annual average energy demand investments of 700 to 1000 billion USD<sub>2015</sub> for the period 2015 to 2050, and an increase in total energy-related investments of about 12% (range of 3% to 23%) in 1.5°C pathways relative to 2°C pathways. Average annual investment in low-carbon energy technologies and energy efficiency are upscaled by roughly a factor of five (range of factor of 4 to 5) by 2050 compared to 2015 (*medium confidence*). {2.5.2, Box 4.8, Figure 2.27}

**C2.7.** Modelled pathways limiting global warming to 1.5°C with no or limited overshoot project a wide range of global average discounted marginal abatement costs over the 21st century. They are roughly 3–4 times higher than in pathways limiting global warming to below 2°C (*high confidence*). The economic literature distinguishes marginal abatement costs from total mitigation costs in the economy. The literature on total mitigation costs of 1.5°C mitigation pathways is limited and was not assessed in this report. Knowledge gaps remain in the integrated assessment of the economy wide costs and benefits of mitigation in line with pathways limiting warming to 1.5°C. {2.5.2; 2.6; Figure 2.26}

<sup>16</sup> The projected land use changes presented are not deployed to their upper limits simultaneously in a single pathway.

<sup>17</sup> Including two pathways limiting warming to 1.5°C with no or limited overshoot and four pathways with high overshoot.





**C3. All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO<sub>2</sub> over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (*high confidence*). CDR deployment of several hundreds of GtCO<sub>2</sub> is subject to multiple feasibility and sustainability constraints (*high confidence*). Significant near-term emissions reductions and measures to lower energy and land demand can limit CDR deployment to a few hundred GtCO<sub>2</sub> without reliance on bioenergy with carbon capture and storage (BECCS) (*high confidence*). {2.3, 2.4, 3.6.2, 4.3, 5.4}**

**C3.1.** Existing and potential CDR measures include afforestation and reforestation, land restoration and soil carbon sequestration, BECCS, direct air carbon capture and storage (DACCS), enhanced weathering and ocean alkalization. These differ widely in terms of maturity, potentials, costs, risks, co-benefits and trade-offs (*high confidence*). To date, only a few published pathways include CDR measures other than afforestation and BECCS. {2.3.4, 3.6.2, 4.3.2, 4.3.7}

**C3.2.** In pathways limiting global warming to 1.5°C with limited or no overshoot, BECCS deployment is projected to range from 0–1, 0–8, and 0–16 GtCO<sub>2</sub> yr<sup>-1</sup> in 2030, 2050, and 2100, respectively, while agriculture, forestry and land-use (AFOLU) related CDR measures are projected to remove 0–5, 1–11, and 1–5 GtCO<sub>2</sub> yr<sup>-1</sup> in these years (*medium confidence*). The upper end of these deployment ranges by mid-century exceeds the BECCS potential of up to 5 GtCO<sub>2</sub> yr<sup>-1</sup> and afforestation potential of up to 3.6 GtCO<sub>2</sub> yr<sup>-1</sup> assessed based on recent literature (*medium confidence*). Some pathways avoid BECCS deployment completely through demand-side measures and greater reliance on AFOLU-related CDR measures (*medium confidence*). The use of bioenergy can be as high or even higher when BECCS is excluded compared to when it is included due to its potential for replacing fossil fuels across sectors (*high confidence*). (Figure SPM.3) {2.3.3, 2.3.4, 2.4.2, 3.6.2, 4.3.1, 4.2.3, 4.3.2, 4.3.7, 4.4.3, Table 2.4}

**C3.3.** Pathways that overshoot 1.5°C of global warming rely on CDR exceeding residual CO<sub>2</sub> emissions later in the century to return to below 1.5°C by 2100, with larger overshoots requiring greater amounts of CDR (Figure SPM.3). (*high confidence*). Limitations on the speed, scale, and societal acceptability of CDR deployment hence determine the ability to return global warming to below 1.5°C following an overshoot. Carbon cycle and climate system understanding is still limited about the effectiveness of net negative emissions to reduce temperatures after they peak (*high confidence*). {2.2, 2.3.4, 2.3.5, 2.6, 4.3.7, 4.5.2, Table 4.11}

**C3.4.** Most current and potential CDR measures could have significant impacts on land, energy, water, or nutrients if deployed at large scale (*high confidence*). Afforestation and bioenergy may compete with other land uses and may have significant impacts on agricultural and food systems, biodiversity and other ecosystem functions and services (*high confidence*). Effective governance is needed to limit such trade-offs and ensure permanence of carbon removal in terrestrial, geological and ocean reservoirs (*high confidence*). Feasibility and sustainability of CDR use could be enhanced by a portfolio of options deployed at substantial, but lesser scales, rather than a single option at very large scale (*high confidence*). (Figure SPM.3). {2.3.4, 2.4.4, 2.5.3, 2.6, 3.6.2, 4.3.2, 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}

**C3.5.** Some AFOLU-related CDR measures such as restoration of natural ecosystems and soil carbon sequestration could provide co-benefits such as improved biodiversity, soil quality, and local



food security. If deployed at large scale, they would require governance systems enabling sustainable land management to conserve and protect land carbon stocks and other ecosystem functions and services (*medium confidence*). (Figure SPM.4) {2.3.3, 2.3.4, 2.4.2, 2.4.4, 3.6.2, 5.4.1, Cross-Chapter Boxes 3 in Chapter 1 and 7 in Chapter 3, 4.3.2, 4.3.7, 4.4.1, 4.5.2, Table 2.4}

## **D. Strengthening the Global Response in the Context of Sustainable Development and Efforts to Eradicate Poverty**

**D1. Estimates of the global emissions outcome of current nationally stated mitigation ambitions as submitted under the Paris Agreement would lead to global greenhouse gas emissions<sup>18</sup> in 2030 of 52–58 GtCO<sub>2</sub>eq yr<sup>-1</sup> (*medium confidence*). Pathways reflecting these ambitions would not limit global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030 (*high confidence*). Avoiding overshoot and reliance on future large-scale deployment of carbon dioxide removal (CDR) can only be achieved if global CO<sub>2</sub> emissions start to decline well before 2030 (*high confidence*). {1.2, 2.3, 3.3, 3.4, 4.2, 4.4, Cross-Chapter Box 11 in Chapter 4}**

**D1.1.** Pathways that limit global warming to 1.5°C with no or limited overshoot show clear emission reductions by 2030 (*high confidence*). All but one show a decline in global greenhouse gas emissions to below 35 GtCO<sub>2</sub>eq yr<sup>-1</sup> in 2030, and half of available pathways fall within the 25–30 GtCO<sub>2</sub>eq yr<sup>-1</sup> range (interquartile range), a 40–50% reduction from 2010 levels (*high confidence*). Pathways reflecting current nationally stated mitigation ambition until 2030 are broadly consistent with cost-effective pathways that result in a global warming of about 3°C by 2100, with warming continuing afterwards (*medium confidence*). {2.3.3, 2.3.5, Cross-Chapter Box 11 in Chapter 4, 5.5.3.2}

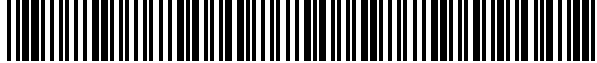
**D1.2.** Overshoot trajectories result in higher impacts and associated challenges compared to pathways that limit global warming to 1.5°C with no or limited overshoot (*high confidence*). Reversing warming after an overshoot of 0.2°C or larger during this century would require upscaling and deployment of CDR at rates and volumes that might not be achievable given considerable implementation challenges (*medium confidence*). {1.3.3, 2.3.4, 2.3.5, 2.5.1, 3.3, 4.3.7, Cross-Chapter Box 8 in Chapter 3, Cross-Chapter Box 11 in Chapter 4}

**D1.3.** The lower the emissions in 2030, the lower the challenge in limiting global warming to 1.5°C after 2030 with no or limited overshoot (*high confidence*). The challenges from delayed actions to reduce greenhouse gas emissions include the risk of cost escalation, lock-in in carbon-emitting infrastructure, stranded assets, and reduced flexibility in future response options in the medium to long-term (*high confidence*). These may increase uneven distributional impacts between countries at different stages of development (*medium confidence*). {2.3.5, 4.4.5, 5.4.2}

**D2. The avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C, if mitigation and adaptation synergies are maximized while trade-offs are minimized (*high confidence*). {1.1, 1.4, 2.5, 3.3, 3.4, 5.2, Table 5.1}**

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<sup>18</sup> GHG emissions have been aggregated with 100-year GWP values as introduced in the IPCC Second Assessment Report



**D2.1.** Climate change impacts and responses are closely linked to sustainable development which balances social well-being, economic prosperity and environmental protection. The United Nations Sustainable Development Goals (SDGs), adopted in 2015, provide an established framework for assessing the links between global warming of 1.5°C or 2°C and development goals that include poverty eradication, reducing inequalities, and climate action (*high confidence*) {Cross-Chapter Box 4 in Chapter 1, 1.4, 5.1}

**D2.2.** The consideration of ethics and equity can help address the uneven distribution of adverse impacts associated with 1.5°C and higher levels of global warming, as well as those from mitigation and adaptation, particularly for poor and disadvantaged populations, in all societies (*high confidence*). {1.1.1, 1.1.2, 1.4.3, 2.5.3, 3.4.10, 5.1, 5.2, 5.3, 5.4, Cross-Chapter Box 4 in Chapter 1, Cross-Chapter Boxes 6 and 8 in Chapter 3, and Cross-Chapter Box 12 in Chapter 5}

**D2.3.** Mitigation and adaptation consistent with limiting global warming to 1.5°C are underpinned by enabling conditions, assessed in SR1.5 across the geophysical, environmental-ecological, technological, economic, socio-cultural and institutional dimensions of feasibility. Strengthened multi-level governance, institutional capacity, policy instruments, technological innovation and transfer and mobilization of finance, and changes in human behaviour and lifestyles are enabling conditions that enhance the feasibility of mitigation and adaptation options for 1.5°C consistent systems transitions. (*high confidence*) {1.4, Cross-Chapter Box 3 in Chapter 1, 4.4, 4.5, 5.6}

**D3. Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible (*high confidence*). {1.4, 4.3, 4.5}**

**D3.1.** Adaptation options that reduce the vulnerability of human and natural systems have many synergies with sustainable development, if well managed, such as ensuring food and water security, reducing disaster risks, improving health conditions, maintaining ecosystem services and reducing poverty and inequality (*high confidence*). Increasing investment in physical and social infrastructure is a key enabling condition to enhance the resilience and the adaptive capacities of societies. These benefits can occur in most regions with adaptation to 1.5°C of global warming (*high confidence*). {1.4.3, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.5, 4.4.1, 4.4.3, 4.5.3, 5.3.1, 5.3.2}

**D3.2.** Adaptation to 1.5°C global warming can also result in trade-offs or maladaptations with adverse impacts for sustainable development. For example, if poorly designed or implemented, adaptation projects in a range of sectors can increase greenhouse gas emissions and water use, increase gender and social inequality, undermine health conditions, and encroach on natural ecosystems (*high confidence*). These trade-offs can be reduced by adaptations that include attention to poverty and sustainable development (*high confidence*). {4.3.2, 4.3.3, 4.5.4, 5.3.2; Cross-Chapter Boxes 6 and 7 in Chapter 3}

**D3.3.** A mix of adaptation and mitigation options to limit global warming to 1.5°C, implemented in a participatory and integrated manner, can enable rapid, systemic transitions in urban and rural areas (*high confidence*). These are most effective when aligned with economic and sustainable development, and when local and regional governments and decision makers are supported by national governments (*medium confidence*) {4.3.2, 4.3.3, 4.4.1, 4.4.2}

**D3.4.** Adaptation options that also mitigate emissions can provide synergies and cost savings in most sectors and system transitions, such as when land management reduces emissions and disaster



risk, or when low carbon buildings are also designed for efficient cooling. Trade-offs between mitigation and adaptation, when limiting global warming to 1.5°C, such as when bioenergy crops, reforestation or afforestation encroach on land needed for agricultural adaptation, can undermine food security, livelihoods, ecosystem functions and services and other aspects of sustainable development. (*high confidence*) {3.4.3, 4.3.2, 4.3.4, 4.4.1, 4.5.2, 4.5.3, 4.5.4}

**D4. Mitigation options consistent with 1.5°C pathways are associated with multiple synergies and trade-offs across the Sustainable Development Goals (SDGs). While the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition. (*high confidence*) (Figure SPM.4) {2.5, 4.5, 5.4}**

**D4.1.** 1.5°C pathways have robust synergies particularly for the SDGs 3 (health), 7 (clean energy), 11 (cities and communities), 12 (responsible consumption and production), and 14 (oceans) (*very high confidence*). Some 1.5°C pathways show potential trade-offs with mitigation for SDGs 1 (poverty), 2 (hunger), 6 (water), and 7 (energy access), if not carefully managed (*high confidence*) (Figure SPM.4). {5.4.2; Figure 5.4, Cross-Chapter Boxes 7 and 8 in Chapter 3}

**D4.2.** 1.5°C pathways that include low energy demand (e.g., see P1 in Figure SPM.3a and SPM.3b), low material consumption, and low GHG-intensive food consumption have the most pronounced synergies and the lowest number of trade-offs with respect to sustainable development and the SDGs (*high confidence*). Such pathways would reduce dependence on CDR. In modelled pathways sustainable development, eradicating poverty and reducing inequality can support limiting warming to 1.5°C. (*high confidence*) (Figure SPM.3, Figure SPM.4) {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.** 1.5°C and 2°C modelled pathways often rely on the deployment of large-scale land-related measures like afforestation and bioenergy supply, which, if poorly managed, can compete with food production and hence raise food security concerns (*high confidence*). The impacts of carbon dioxide removal (CDR) options on SDGs depend on the type of options and the scale of deployment (*high confidence*). If poorly implemented, CDR options such as BECCS and AFOLU options would lead to trade-offs. Context-relevant design and implementation requires considering people's needs, biodiversity, and other sustainable development dimensions (*very high confidence*). {Figure SPM.4, 5.4.1.3, Cross-Chapter Box 7 in Chapter 3}

**D4.4.** Mitigation consistent with 1.5°C pathways creates risks for sustainable development in regions with high dependency on fossil fuels for revenue and employment generation (*high confidence*). Policies that promote diversification of the economy and the energy sector can address the associated challenges (*high confidence*). {5.4.1.2, Box 5.2}

**D4.5.** Redistributive policies across sectors and populations 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 pathways. (*high confidence*) {2.4.3, 5.4.2, Figure 5.5}

# Indicative linkages between mitigation options and sustainable development using SDGs (The linkages do not show costs and benefits)

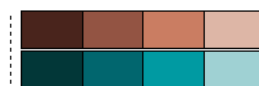
Mitigation options deployed in each sector can be associated with potential positive effects (synergies) or negative effects (trade-offs) with the Sustainable Development Goals (SDGs). The degree to which this potential is realized will depend on the selected portfolio of mitigation options, mitigation policy design, and local circumstances and context. Particularly in the energy-demand sector, the potential for synergies is larger than for trade-offs. The bars group individually assessed options by level of confidence and take into account the relative strength of the assessed mitigation-SDG connections.

Length shows strength of connection

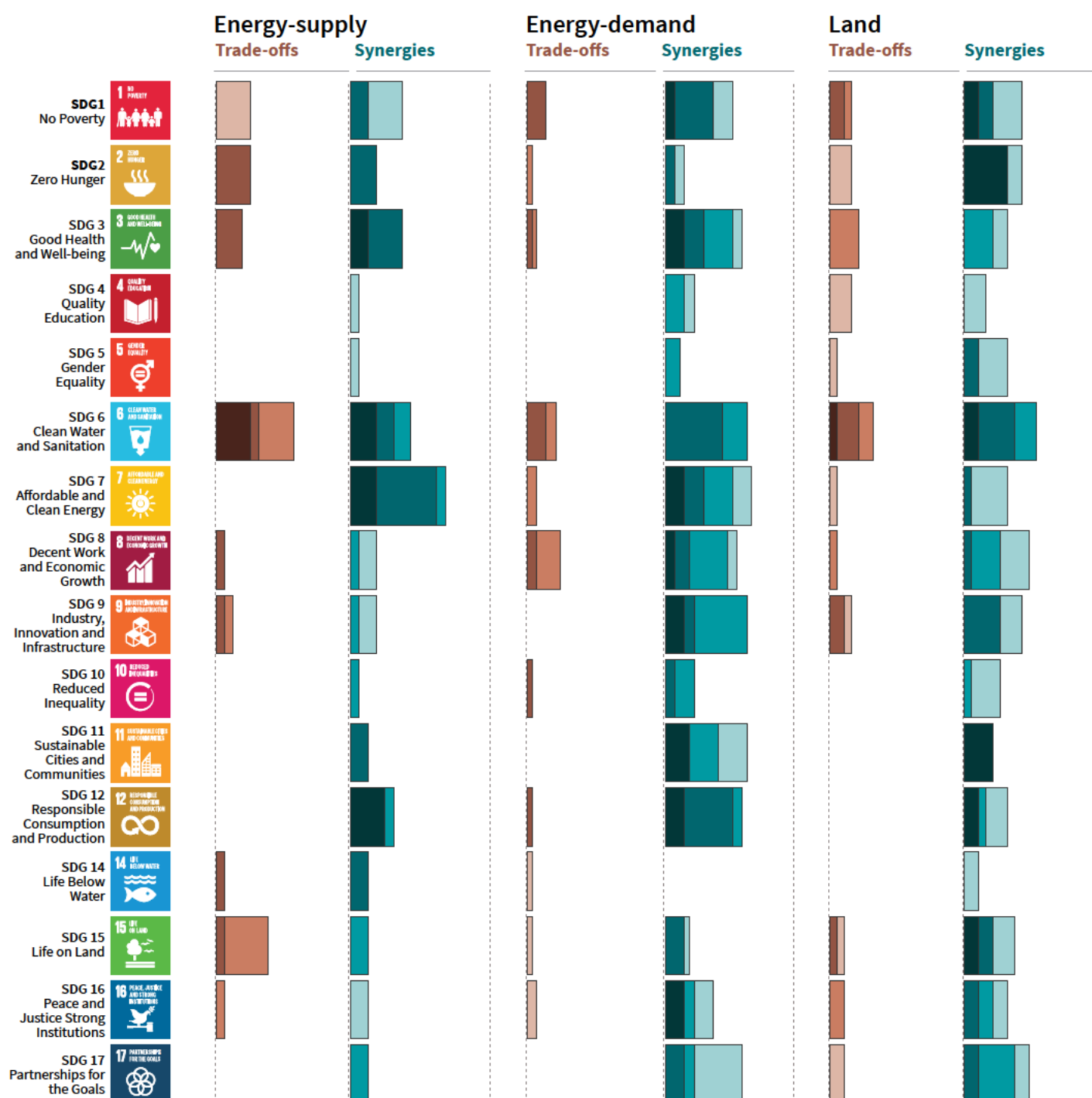


The overall size of the coloured bars depict the relative for synergies and trade-offs between the sectoral mitigation options and the SDGs.

Shades show level of confidence



The shades depict the level of confidence of the assessed potential for Trade-offs/Synergies.



**Figure SPM.4:** Potential synergies and trade-offs between the sectoral portfolio of climate change mitigation options and the Sustainable Development Goals (SDGs). The SDGs serve as an analytical framework for the assessment of the different sustainable development dimensions, which extend beyond the time frame of the 2030 SDG targets. The assessment is based on literature on mitigation options that are considered relevant for 1.5°C. The assessed strength of the SDG interactions is based on the qualitative and quantitative assessment of individual mitigation options listed in Table 5.2. For each mitigation option, the strength of the SDG-connection as well as the associated confidence of the underlying literature (shades of green and red) was assessed. The strength of positive connections (synergies) and negative connections (trade-offs) across all individual options within a sector (see Table 5.2) are aggregated into sectoral potentials for the whole mitigation portfolio. The (white) areas outside the bars, which indicate no interactions, have *low confidence* due to the uncertainty and limited number of studies exploring indirect effects. The strength of the connection considers only the effect of mitigation and does not include benefits of avoided impacts. SDG 13 (climate action) is not listed because mitigation is being considered in terms of interactions with SDGs and not vice versa. The bars denote the strength of the connection, and do not consider the strength of the impact on the SDGs. The energy demand sector comprises behavioural responses, fuel switching and efficiency options in the transport, industry and building sector as well as carbon capture options in the industry sector. Options assessed in the energy supply sector comprise biomass and non-biomass renewables, nuclear, CCS with bio-energy, and CCS with fossil fuels. Options in the land sector comprise agricultural and forest options, sustainable diets & reduced food waste, soil sequestration, livestock & manure management, reduced deforestation, afforestation & reforestation, responsible sourcing. In addition to this figure, options in the ocean sector are discussed in the underlying report. {5.4, Table 5.2, Figure 5.2}

**Statement for knowledge gap:**

Information about the net impacts of mitigation on sustainable development in 1.5°C pathways is available only for a limited number of SDGs and mitigation options. Only a limited number of studies have assessed the benefits of avoided climate change impacts of 1.5°C pathways for the SDGs, and the co-effects of adaptation for mitigation and the SDGs. The assessment of the indicative mitigation potentials in Figure SPM.4 is a step further from AR5 towards a more comprehensive and integrated assessment in the future.



**D5. Limiting the risks from global warming of 1.5°C in the context of sustainable development and poverty eradication implies system transitions that can be enabled by an increase of adaptation and mitigation investments, policy instruments, the acceleration of technological innovation and behaviour changes (*high confidence*). {2.3, 2.4, 2.5, 3.2, 4.2, 4.4, 4.5, 5.2, 5.5, 5.6}**

**D5.1.** Directing finance towards investment in infrastructure for mitigation and adaptation could provide additional resources. This could involve the mobilization of private funds by institutional investors, asset managers and development or investment banks, as well as the provision of public funds. Government policies that lower the risk of low-emission and adaptation investments can facilitate the mobilization of private funds and enhance the effectiveness of other public policies. Studies indicate a number of challenges including access to finance and mobilisation of funds (*high confidence*) {2.5.2, 4.4.5}

**D5.2.** Adaptation finance consistent with global warming of 1.5°C is difficult to quantify and compare with 2°C. Knowledge gaps include insufficient data to calculate specific climate resilience-enhancing investments, from the provision of currently underinvested basic infrastructure. Estimates of the costs of adaptation might be lower at global warming of 1.5°C than for 2°C. Adaptation needs have typically been supported by public sector sources such as national and subnational government budgets, and in developing countries together with support from development assistance, multilateral development banks, and UNFCCC channels (*medium confidence*). More recently there is a growing understanding of the scale and increase in NGO and private funding in some regions (*medium confidence*). Barriers include the scale of adaptation financing, limited capacity and access to adaptation finance (*medium confidence*). {4.4.5, 4.6}

**D5.3.** Global model pathways limiting global warming to 1.5°C are projected to involve the annual average investment needs in the energy system of around 2.4 trillion USD<sub>2010</sub> between 2016 and 2035 representing about 2.5% of the world GDP (*medium confidence*). {2.5.2, 4.4.5, Box 4.8}

**D5.4.** Policy tools can help mobilise incremental resources, including through shifting global investments and savings and through market and non-market based instruments as well as accompanying measures to secure the equity of the transition, acknowledging the challenges related with implementation including those of energy costs, depreciation of assets and impacts on international competition, and utilizing the opportunities to maximize co-benefits (*high confidence*) {1.3.3, 2.3.4, 2.3.5, 2.5.1, 2.5.2, Cross-Chapter Box 8 in Chapter 3 and 11 in Chapter 4, 4.4.5, 5.5.2}

**D5.5.** The systems transitions consistent with adapting to and limiting global warming to 1.5°C include the widespread adoption of new and possibly disruptive technologies and practices and enhanced climate-driven innovation. These imply enhanced technological innovation capabilities, including in industry and finance. Both national innovation policies and international cooperation can contribute to the development, commercialization and widespread adoption of mitigation and adaptation technologies. Innovation policies may be more effective when they combine public support for research and development with policy mixes that provide incentives for technology diffusion. (*high confidence*) {4.4.4, 4.4.5}.

**D5.6.** Education, information, and community approaches, including those that are informed by Indigenous knowledge and local knowledge, can accelerate the wide scale behaviour changes consistent with adapting to and limiting global warming to 1.5°C. These approaches are more



effective when combined with other policies and tailored to the motivations, capabilities, and resources of specific actors and contexts (*high confidence*). Public acceptability can enable or inhibit the implementation of policies and measures to limit global warming to 1.5°C and to adapt to the consequences. Public acceptability depends on the individual's evaluation of expected policy consequences, the perceived fairness of the distribution of these consequences, and perceived fairness of decision procedures (*high confidence*). {1.1, 1.5, 4.3.5, 4.4.1, 4.4.3, Box 4.3, 5.5.3, 5.6.5}

**D6. Sustainable development supports, and often enables, the fundamental societal and systems transitions and transformations that help limit global warming to 1.5°C. Such changes facilitate the pursuit of climate-resilient development pathways that achieve ambitious mitigation and adaptation in conjunction with poverty eradication and efforts to reduce inequalities (*high confidence*). {Box 1.1, 1.4.3, Figure 5.1, 5.5.3, Box 5.3}**

**D6.1.** Social justice and equity are core aspects of climate-resilient development pathways that aim to limit global warming to 1.5°C as they address challenges and inevitable trade-offs, widen opportunities, and ensure that options, visions, and values are deliberated, between and within countries and communities, without making the poor and disadvantaged worse off (*high confidence*). {5.5.2, 5.5.3, Box 5.3, Figure 5.1, Figure 5.6, Cross-Chapter Boxes 12 and 13 in Chapter 5}

**D6.2.** The potential for climate-resilient development pathways differs between and within regions and nations, due to different development contexts and systemic vulnerabilities (*very high confidence*). Efforts along such pathways to date have been limited (*medium confidence*) and enhanced efforts would involve strengthened and timely action from all countries and non-state actors (*high confidence*). {5.5.1, 5.5.3, Figure 5.1}

**D6.3.** Pathways that are consistent with sustainable development show fewer mitigation and adaptation challenges and are associated with lower mitigation costs. The large majority of modelling studies could not construct pathways characterized by lack of international cooperation, inequality and poverty that were able to limit global warming to 1.5°C. (*high confidence*) {2.3.1, 2.5.3, 5.5.2}

**D7. Strengthening the capacities for climate action of national and sub-national authorities, civil society, the private sector, indigenous peoples and local communities can support the implementation of ambitious actions implied by limiting global warming to 1.5°C (*high confidence*). International cooperation can provide an enabling environment for this to be achieved in all countries and for all people, in the context of sustainable development. International cooperation is a critical enabler for developing countries and vulnerable regions (*high confidence*). {1.4, 2.3, 2.5, 4.2, 4.4, 4.5, 5.3, 5.4, 5.5, 5.6, 5, Box 4.1, Box 4.2, Box 4.7, Box 5.3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 13 in Chapter 5}**

**D7.1.** Partnerships involving non-state public and private actors, institutional investors, the banking system, civil society and scientific institutions would facilitate actions and responses consistent with limiting global warming to 1.5°C (*very high confidence*). {1.4, 4.4.1, 4.2.2, 4.4.3, 4.4.5, 4.5.3, 5.4.1, 5.6.2, Box 5.3}.

**D7.2.** Cooperation on strengthened accountable multilevel governance that includes non-state actors such as industry, civil society and scientific institutions, coordinated sectoral and cross-sectoral





policies at various governance levels, gender-sensitive policies, finance including innovative financing and cooperation on technology development and transfer can ensure participation, transparency, capacity building, and learning among different players (*high confidence*). {2.5.2, 4.2.2, 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.5.3, Cross-Chapter Box 9 in Chapter 4, 5.3.1, 4.4.5, 5.5.3, Cross-Chapter Box 13 in Chapter 5, 5.6.1, 5.6.3}

**D7.3.** International cooperation is a critical enabler for developing countries and vulnerable regions to strengthen their action for the implementation of 1.5°C-consistent climate responses, including through enhancing access to finance and technology and enhancing domestic capacities, taking into account national and local circumstances and needs (*high confidence*). {2.3.1, 4.4.1, 4.4.2, 4.4.4, 4.4.5, 5.4.1 5.5.3, 5.6.1, Box 4.1, Box 4.2, Box 4.7}.

**D7.4.** Collective efforts at all levels, in ways that reflect different circumstances and capabilities, in the pursuit of limiting global warming to 1.5°C, taking into account equity as well as effectiveness, can facilitate strengthening the global response to climate change, achieving sustainable development and eradicating poverty (*high confidence*). {1.4.2, 2.3.1, 2.5.2, 4.2.2, 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5, 4.5.3, 5.3.1, 5.4.1, 5.5.3, 5.6.1, 5.6.2, 5.6.3}

**Box SPM 1: Core Concepts Central to this Special Report**

**Global mean surface temperature (GMST):** Estimated global average of near-surface air temperatures over land and sea-ice, and sea surface temperatures over ice-free ocean regions, with changes normally expressed as departures from a value over a specified reference period. When estimating changes in GMST, near-surface air temperature over both land and oceans are also used.<sup>19</sup> {1.2.1.1}

**Pre-industrial:** The multi-century period prior to the onset of large-scale industrial activity around 1750. The reference period 1850–1900 is used to approximate pre-industrial GMST. {1.2.1.2}

**Global warming:** The estimated increase in GMST averaged over a 30-year period, or the 30-year period centered on a particular year or decade, expressed relative to pre-industrial levels unless otherwise specified. For 30-year periods that span past and future years, the current multi-decadal warming trend is assumed to continue. {1.2.1}

**Net zero CO<sub>2</sub> emissions:** Net-zero carbon dioxide (CO<sub>2</sub>) emissions are achieved when anthropogenic CO<sub>2</sub> emissions are balanced globally by anthropogenic CO<sub>2</sub> removals over a specified period.

**Carbon dioxide removal (CDR):** Anthropogenic activities removing CO<sub>2</sub> from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but excludes natural CO<sub>2</sub> uptake not directly caused by human activities.

**Total carbon budget:** Estimated cumulative net global anthropogenic CO<sub>2</sub> emissions from the preindustrial period to the time that anthropogenic CO<sub>2</sub> emissions reach net zero that would result, at some probability, in limiting global warming to a given level, accounting for the impact of other anthropogenic emissions. {2.2.2}

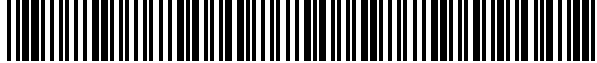
**Remaining carbon budget:** Estimated cumulative net global anthropogenic CO<sub>2</sub> emissions from a given start date to the time that anthropogenic CO<sub>2</sub> emissions reach net zero that would result, at some probability, in limiting global warming to a given level, accounting for the impact of other anthropogenic emissions. {2.2.2}

**Temperature overshoot:** The temporary exceedance of a specified level of global warming.

**Emission pathways:** In this Summary for Policymakers, the modelled trajectories of global anthropogenic emissions over the 21st century are termed emission pathways. Emission pathways are classified by their temperature trajectory over the 21st century: pathways giving at least 50% probability based on current knowledge of limiting global warming to below 1.5°C are classified as ‘no overshoot’; those limiting warming to below 1.6°C and returning to 1.5°C by 2100 are classified as ‘1.5°C limited-overshoot’; while those exceeding 1.6°C but still returning to 1.5°C by 2100 are classified as ‘higher-overshoot’.

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<sup>19</sup> Past IPCC reports, reflecting the literature, have used a variety of approximately equivalent metrics of GMST change.



**Impacts:** Effects of climate change on human and natural systems. Impacts can have beneficial or adverse outcomes for livelihoods, health and well-being, ecosystems and species, services, infrastructure, and economic, social and cultural assets.

**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 integrates the likelihood of exposure to a hazard and the magnitude of its impact. Risk also can describe the potential for adverse consequences of adaptation or mitigation responses to climate change.

**Climate-resilient development pathways (CRDPs):** Trajectories that strengthen sustainable development at multiple scales and efforts to eradicate poverty through equitable societal and systems transitions and transformations while reducing the threat of climate change through ambitious mitigation, adaptation, and climate resilience.

s22

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**From:** s22  
**Sent:** Tuesday, 2 October 2018 11:16 AM  
**To:** s22; Rob Sturgiss  
**Cc:** s22; s22; Lesley Dowling; s22; s22  
**Subject:** RE: New phone numbers: IPCC media handling strategy MS18-000873 Attach A [SEC=UNCLASSIFIED]

Thanks s22

s22

**Adviser | Office of the Hon Melissa Price MP**

**Minister for the Environment**

**a:** Parliament House, Canberra, ACT 2600

s22

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**From:** s22  
**Sent:** Tuesday, 2 October 2018 11:16 AM  
**To:** s22; Rob Sturgiss  
**Cc:** s22; s22; Lesley Dowling; s22; s22  
**Subject:** RE: New phone numbers: IPCC media handling strategy MS18-000873 Attach A [SEC=UNCLASSIFIED]

Hi s22,

Yes, drafts of the report have been leaked before.

- In June 2018, the draft report was leaked to Reuters and was the subject of two media articles
  - On 14 June Alister Doyle (Reuters)
  - On 15 June Lisa Cox (The Guardian)
- The articles disclosed the outcomes of the report, drawing attention to the key scientific findings on the difference between 1.5 and 2 degrees warming in both natural and human systems and adequacy of the international response.
- The review of the draft report is an ongoing and confidential process.

Kind Regards

s22

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**From:** s22  
**Sent:** Tuesday, 2 October 2018 10:44 AM  
**To:** Rob Sturgiss <[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)>  
**Cc:** s22  
s22; Lesley Dowling <[lesley.dowling@environment.gov.au](mailto:lesley.dowling@environment.gov.au)>; s22  
s22  
s22  
**Subject:** RE: New phone numbers: IPCC media handling strategy MS18-000873 Attach A [SEC=UNCLASSIFIED]

Hi Rob,

Re the media reporting below, do you have any further talking points or handling advice for the Minister?

Have draft of the IPCC reports been leaked before?

Any feedback today from you or the team here would be much appreciated.

Cheers,

s22

***Less meat, coal key to a cooler planet***

**The Australian, General News, 02/10/18, Graham Lloyd, page 1**

An accelerated withdrawal from coal and a change in the global diet away from meat are needed to limit global temperature rises to 1.5C, leaked copies of a major new climate report say. Scientists and diplomats are meeting in South Korea this week to finalise the report that distills the findings of more than 6000 scientific papers. The 400-page report, scheduled to be released on Sunday, has been described by scientists involved as the most "politically charged" document in the history of the Intergovernmental Panel on Climate Change. The draft talks of "climate mayhem" and "a swift and complete transformation not just of the global economy, but of society, too". This is despite claims by reviewer Bob Ward from London's Grantham Institute that scientists had "pulled their punches" to make policy recommendations seem more palatable to countries such as the US, Saudi Arabia and Australia. This week, the political representatives of countries that have signed the Paris Agreement are going through the 22-page draft summary line by line to reach an agreed text for policymakers. Opening the talks yesterday, IPCC chairman Hoesung Lee said the meeting would "produce a strong, robust and clear summary for policymakers while upholding the scientific integrity of the IPCC". Leaked copies of the draft document have opened a window on the negotiations. Continued on Page 4 Less meat, coal key to cool planet Continued from Page 1 The bottom line, according to a report by AFP in Paris, is that at current levels of greenhouse gas emissions, there is "high confidence" the 1.5C threshold will be passed around 2040. The draft report says carbon dioxide emissions should peak not later than 2020 and the global economy must become "carbon-neutral" by 2050.

Read Item: <http://www.mediaportal.com/0tt1219861912>

Also displayed on the Australian website.

s22

**Adviser | Office of the Hon Melissa Price MP  
Minister for the Environment**

**a:** Parliament House, Canberra, ACT 2600

s22

---

**From:** Rob Sturgiss

**Sent:** Sunday, 30 September 2018 9:55 PM

**To:** s22

**Cc:** s22

s22 Lesley Dowling <[lesley.dowling@environment.gov.au](mailto:lesley.dowling@environment.gov.au)>

**Subject:** RE: New phone numbers: IPCC media handling strategy MS18-000873 Attach A [SEC=UNCLASSIFIED]

Ok ta

s22

# s22

From: s22

Sent: Friday, 28 September 2018 8:50 AM

To: 'Julia.Feeny@dfat.gov.au' <Julia.Feeny@dfat.gov.au>; s22

s22 'helen.wilson@pmc.gov.au' <helen.wilson@pmc.gov.au>;

s22 Kristin Tilley

<Kristin.Tilley@environment.gov.au>; Jo Evans <Jo.Evans@environment.gov.au>; Chris Johnston

<Chris.Johnston@environment.gov.au>; s22

s22 Dowling, Lesley

Cc: s22

s22

s22 Rob Sturgiss <Rob.Sturgiss@environment.gov.au>

**Subject:** New phone numbers: IPCC media handling strategy MS18-000873 Attach A

[SEC=UNCLASSIFIED]

Dear all

For information, there has been an update to the contact phone numbers contained in the Media Handling Plan for the release of the IPCC Special Report, *Global warming of 1.5°C* on 8 October 2018 (MS18-000873, Attachment A):

Rob Sturgiss: s22

s22

Kind regards

s22

s22

National Inventory Team

International Climate Change and Energy Innovation Division

Department of the Environment and Energy

s22

*The Department acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.*

s22

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**From:** s22  
**Sent:** Friday, 28 September 2018 9:26 AM  
**To:** s22  
**Cc:** s22  
**Subject:** RE: New phone numbers: IPCC media handling strategy MS18-000873 Attach A [SEC=UNCLASSIFIED]

Hi s22

Yes, we sent it to Helen Wilson and s22 yesterday, on Jo Evans' request.

Feel free to get in touch if you have any questions.

Kind regards  
s22

---

**From:** s22  
**Sent:** Friday, 28 September 2018 9:25 AM  
**To:** s22  
**Cc:** s22  
**Subject:** RE: New phone numbers: IPCC media handling strategy MS18-000873 Attach A [SEC=UNCLASSIFIED]

Thanks s22

Has the IPCC brief also been provided to PM&C?

Cheers,

s22

s22  
**Adviser | Office of the Hon Melissa Price MP**  
**Minister for the Environment**  
[a: Parliament House, Canberra, ACT 2600](#)

s22

s22

# s22



s22

---

**From:** s22  
**Sent:** Monday, 8 October 2018 1:25 PM  
**To:** s22  
**Cc:** Jo Evans; Kushla Munro; Rob Sturgiss; s22 Kristin Tilley; s22  
**Subject:** s22  
Special Report on Global warming of 1.5 - SPM and headline statements |  
s47C [DLM=For-Official-Use-Only]  
**Attachments:** s47C docx; sr15\_headline\_statements.pdf; sr15\_spm\_final.pdf

Hi s22,

s47C

For reference, *Summary for Policy Makers* and headline statements are also attached.

Kind Regards  
s22

s22

---

**From:** s22  
**Sent:** Wednesday, 26 September 2018 10:46 AM  
**To:** s22  
**Cc:** Media; s22  
**Subject:** Handling brief - IPCC Special Report on 1.5oC. [SEC=UNCLASSIFIED]  
**Attachments:** Minister - Handling strategy SR 1.5oC MS18-000873.docx; Minister - Handling strategy SR 1.5oC MS18-000873 Attach A.docx; Minister - Handling strategy SR 1.5oC MS18-000873 Attach B.docx; Minister - Handling strategy SR 1.5oC MS18-000873 Attach C.pdf

Hi s22,

The Intergovernmental Panel on Climate Change (IPCC) Special Report, *Global warming of 1.5°C*, is due to be finalised at the IPCC Plenary on 1-5 October 2018 with a planned release on 8 October 2018.

The release of the report is likely to draw media attention to the impacts of climate change and adequacy of the international response to reduce emissions, including in Australia.

The attached briefing has been sent to the office today, and we've prepared a media handling strategy and key messages as part of the briefing.

I'm not sure if this has been sent to you within the office already, but thought I'd provide you with a copy for your files in anticipation of the planned release on the 8<sup>th</sup>.

Let me know if you need anything further.

Thanks

s22

s22

External Engagement | Communications, Innovation and Partnerships Branch  
Department of the Environment and Energy  
Ph: s22



s22

**From:** Media  
**Sent:** Monday, 8 October 2018 2:47 PM  
**To:** s22  
**Subject:** FW: IPCC report is now out [SEC=UNCLASSIFIED]

FYI

**Media Team**

Communications and Engagement Branch  
Department of the Environment and Energy  
GPO Box 787, CANBERRA ACT 2601  
T: 02 6275 9880



---

**From:** s22  
**Sent:** Monday, 8 October 2018 12:14 PM  
**To:** Media ; s22  
**Subject:** FW: IPCC report is now out [SEC=UNCLASSIFIED]

<http://www.ipcc.ch/>

FYI.

s22  
**Media Adviser | Office of the Hon Melissa Price MP**  
**Minister for the Environment**  
a: Parliament House, Canberra, ACT 2600  
s22

---

**From:** s22  
**Sent:** Monday, 8 October 2018 12:13 PM  
**To:** s22  
s22  
**Subject:** IPCC report is now out [SEC=UNCLASSIFIED]

**Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C  
approved by governments**

Incheon, Republic of Korea, October 8 – Limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society, the IPCC said in a new assessment. With clear benefits to people and natural ecosystems, limiting global warming to 1.5°C compared to 2°C could go hand in hand with ensuring a more sustainable and equitable society, the Intergovernmental Panel on Climate Change (IPCC) said on Monday.

The Special Report on Global Warming of 1.5°C was approved by the IPCC on Saturday in Incheon, Republic of Korea. It will be a key scientific input into the Katowice Climate Change Conference in Poland in December, when governments review the Paris Agreement to tackle climate change.

"With more than 6,000 scientific references cited and the dedicated contribution of thousands of expert and government reviewers worldwide, this important report testifies to the breadth and policy relevance of the IPCC," said Hoesung Lee, Chair of the IPCC.

Ninety-one authors and review editors from 40 countries prepared the IPCC report in response to an invitation from the United Nations Framework Convention on Climate Change (UNFCCC) when it adopted the Paris Agreement in 2015.

The report's full name is *Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.*

"One of the key messages that comes out very strongly from this report is that we are already seeing the consequences of 1°C of global warming through more extreme weather, rising sea levels and diminishing Arctic sea ice, among other changes," said Panmao Zhai, Co-Chair of IPCC Working Group I.

s22

**Media Adviser | Office of the Hon Melissa Price MP**  
**Minister for the Environment**

**a:** Parliament House, Canberra, ACT 2600

s22

s22

---

**From:** Media  
**Sent:** Monday, 8 October 2018 1:40 PM  
**To:** s22  
**Cc:** Media; s22  
**Subject:** FW: Minister's media release [SEC=UNCLASSIFIED]

Hi s22,

Did you want to link to the report in the release?

Thanks,  
s22

**Media Team**

Communications and Engagement Branch  
Department of the Environment and Energy  
GPO Box 787, CANBERRA ACT 2601  
s22



---

**From:** s22  
**Sent:** Monday, 8 October 2018 1:35 PM  
**To:** Media  
**Cc:** s22  
**Subject:** RE: Minister's media release [SEC=UNCLASSIFIED]

Hi

Media release is now up. Please check. Should it have a link in it? It reads like there should be a report somewhere to link to?

<http://www.environment.gov.au/minister/price/media-releases/mr20181008.html>

Kind regards,  
s22

---

**From:** Media  
**Sent:** Monday, 8 October 2018 1:08 PM  
**To:** Web Helpdesk <[Web.Helpdesk@environment.gov.au](mailto:Web.Helpdesk@environment.gov.au)>  
**Cc:** Media <[Media@environment.gov.au](mailto:Media@environment.gov.au)>; s22  
s22  
s22  
**Subject:** Minister's media release [SEC=UNCLASSIFIED]

Hi there

Can we please get this put up on the Minister's website?

Thanks

s22

**Media Team**

Communications and Engagement Branch  
Department of the Environment and Energy

s22

GPO Box 787, CANBERRA ACT 2601



---

**From:** s22

**Sent:** Monday, 8 October 2018 12:53 PM

**To:** apo <[apo@accessap.com.au](mailto:apo@accessap.com.au)>

**Cc:** Media <[Media@environment.gov.au](mailto:Media@environment.gov.au)>

**Subject:** Could I get the following statement put up on CCH Alerts please? [SEC=UNCLASSIFIED]

Thanks team...

Media team – can you put up on our website also?

Thanks s22

s22

**Media Adviser | Office of the Hon Melissa Price MP**  
**Minister for the Environment**

**a:** Parliament House, Canberra, ACT 2600

s22

s22

**From:** s22  
**Sent:** Sunday, 7 October 2018 1:41 PM  
**To:** Media  
**Subject:** Fwd: FOR INFORMATION: IPCC Special Report - Key outcomes [SEC=UNCLASSIFIED]  
**Attachments:** 1.5C report\_s22.docx

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----- Forwarded message -----

From: s22  
Date: Sun, Oct 7, 2018 at 1:22 PM +1100  
Subject: FOR INFORMATION: IPCC Special Report - Key outcomes [SEC=UNCLASSIFIED]  
To: "'Price, Melissa (MP)'" <[Melissa.Price.MP@aph.gov.au](mailto:Melissa.Price.MP@aph.gov.au)>  
Cc: s22  
s22  
s22

s333(a)iii

s33(b)

The report will be released at a press conference to be held by the IPCC Chair Hoesung Lee on Monday at 10am Korea time (12 noon Sydney time).

Cheers,

s22

**Adviser | Office of the Hon Melissa Price MP  
Minister for the Environment**

[a:](#) Parliament House, Canberra, ACT 2600

s22

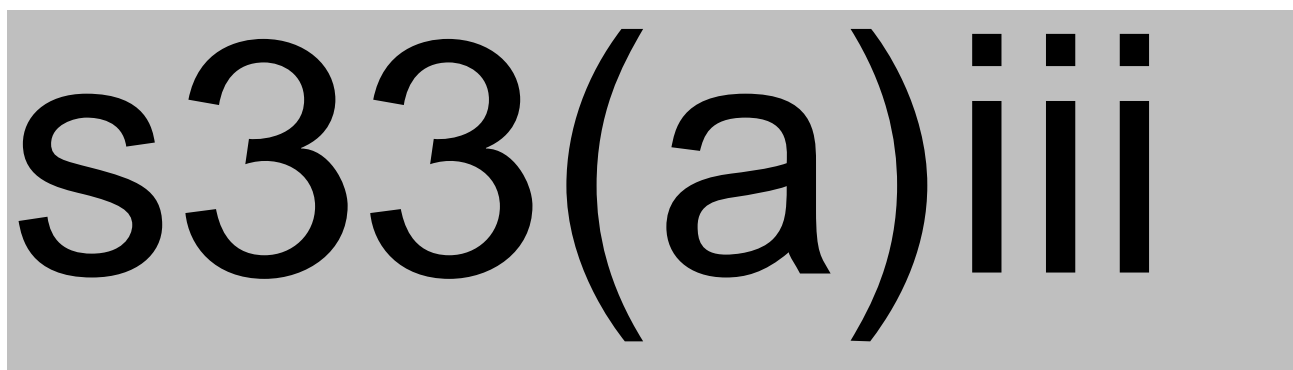


## IPCC Special Report on Global Warming of 1.5C warming

This IPCC Special Report summarises and interprets the available scientific literature on 1.5C warming, at the invitation of parties to the Paris Agreement.

The Paris Agreement sets a temperature target of 2 degrees above pre-industrial levels, which is used as a benchmark in this report.

The headline statement of the Report is that, at current rates of increase, global warming will reach 1.5C above pre-industrial levels sometime between 2030 to 2052.



### Mitigation pathways

The Report characterises the required action to stabilise global average temperature as requiring the stabilisation of net CO<sub>2</sub> emissions at zero. This outcome follows logically from an estimated relationship between global average temperature and cumulative CO<sub>2</sub> emissions. Non CO<sub>2</sub> emissions are treated separately.

The results are robust, although significant uncertainties exist.

*Survey of the available literature on the modelling results – what difference does a target of 1.5C make?*

Adopting 1.5C as a global target brings forward the timing of the point when global net CO<sub>2</sub> emissions become zero by around 25 years: - under 1.5C, global net CO<sub>2</sub> emissions are reduced to zero in 2050 whereas under 2C the timing is 2075.

The marginal abatement cost of mitigation rises quickly in adopting lower temperature targets – the median implicit carbon price in the literature is around US\$400/tCO<sub>2</sub> in 2050 under the 1.5C scenario whereas the carbon price is US\$150/tCO<sub>2</sub> in the 2C scenario in 2050.

This transformation task under 1.5C is modelled to require new investment of around \$1600 billion in annual energy supply investment which, together with other investments, amounts to an increase of 12% on current levels and which is equivalent to 2.5% of annual economic wide investment.

# S33(a)iii

## **Benefits of limiting warming to 1.5C**

Future climate-related risks are larger if global warming exceeds 1.5°C before returning to that level by 2100 than if global warming gradually stabilizes at 1.5°C, especially if the peak temperature is high. Some risks may be long-lasting or irreversible, such as the loss of ecosystems.

Temperature extremes on land are projected to warm more than global mean surface temperature. Extreme hot days in mid-latitudes warm by up to about 3°C at global warming of 1.5°C and about 4°C at 2°C and extreme cold nights in high latitudes warm by up to about 4.5°C at 1.5°C and about 6°C at 2°C.

Risks from droughts and precipitation deficits are projected to be higher at 2°C compared to 1.5°C global warming in some regions. Heavy precipitation associated with tropical cyclones is

projected to be higher and land area affected by floods is projected to be larger at 2°C compared to 1.5°C.

By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C. A reduction of 0.1 m in global sea level rise implies that up to 10 million fewer people would be exposed to related risks, based on population in the year 2010 and assuming no adaptation.

Sea level rise will continue beyond 2100 even if global warming is limited to 1.5°C in the 21st century. Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet could result in multi-metre rise in sea level over hundreds to thousands of years. These instabilities could be triggered around 1.5°C to 2°C of global warming.

Increasing warming amplifies the exposure of small islands, low-lying coastal areas and deltas to the risks associated with sea level rise for many human and ecological systems, including increased saltwater intrusion, flooding and damage to infrastructure. The slower rate of sea level rise at global warming of 1.5°C reduces these risks enabling greater opportunities for adaptation including managing and restoring natural coastal ecosystems, and infrastructure reinforcement.

Limiting global warming to 1.5°C compared to 2°C has important benefits for terrestrial, freshwater, and coastal ecosystems and for the preservation of their services to humans.

- Of 105,000 species studied, 6% of insects, 8% of plants and 4% of vertebrates are projected to lose over half of their climatically determined geographic range for global warming of 1.5°C, compared with 18% of insects, 16% of plants and 8% of vertebrates for global warming of 2°C.
- Impacts associated with other biodiversity related risks such as forest fires, and the spread of invasive species, are lower at 1.5°C compared to 2°C of global warming.
- Approximately 4% of the global terrestrial land area is projected to undergo a transformation of ecosystems from one type to another at 1°C of global warming, compared with 13% at 2°C. This indicates that the area at risk is projected to be approximately 50% lower at 1.5°C compared to 2°C.
- Global warming of 1.5°C is projected to shift the ranges of many marine species to higher latitudes and increase the amount of damage to many ecosystems. It is also expected to drive the loss of coastal resources, and reduce the productivity of fisheries and aquaculture (especially at low latitudes).

- The risks of climate-induced impacts are projected to be higher at 2°C than those at global warming of 1.5°C. Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C with larger losses (>99%) at 2°C.
- Climate-related risks to health, livelihoods, food and water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C.
- Populations at disproportionately higher risk of adverse consequences of global warming of 1.5°C and beyond include disadvantaged populations, indigenous peoples, and populations dependent on agriculture or coastal livelihoods.
- Any increase in global warming is expected to affect human health, with primarily negative consequences.
  - Urban heat island effects generally amplify the impacts of heatwaves in cities.
  - Risks from some vector-borne diseases, such as malaria and dengue fever are projected to increase with the level of future warming, including potential shifts in their geographic range.
- Limiting warming to 1.5°C, compared with 2°C, is projected to result in smaller net reductions in yields of maize, rice, wheat, and potentially other cereal crops, particularly in sub-Saharan Africa, Southeast Asia, and Central and South America. Benefits from limiting warming to 1.5C are complex to estimate and largely flow from:

s22

**From:** s22  
**Sent:** Sunday, 7 October 2018 10:02 PM  
**To:** Media; s22 s22  
**Cc:** Adam Carlon; Rachel Bacon; s22  
**Subject:** Fwd: IPCC Report (climate change impacts) Summary and Talking Points [SEC=UNCLASSIFIED]  
**Attachments:** Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018.docx; IPCC Special Report Summary and TPs.docx; ATT00001.htm; attachment 2.pdf; ATT00002.htm

Fyi and final statement attached also. We won't issue until 12 noon tomorrow unless we get hassled. s22

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----- Forwarded message -----

**From:** s22  
**Date:** Sun, Oct 7, 2018 at 9:58 PM +1100  
**Subject:** Fwd: IPCC Report (climate change impacts) Summary and Talking Points [SEC=UNCLASSIFIED]  
**To:** s22  
**Cc:** s22

Hi s22

FYI – Please find attached a summary and talking points on the Intergovernmental Panel on Climate Change (IPCC) report on limiting global warming to 1.5°C.

The report (also attached) is due to be released at noon tomorrow. An embargoed copy has been provided to the media.

s33(a)iii

s33(a)iii

s333(a)iii

s333(b)

The report will be released at a press conference to be held by the IPCC Chair Hoesung Lee [on Monday at 10am](#) Korea time (12 noon Sydney time).

Cheers,

s22

s22

**Adviser | Office of the Hon Melissa Price MP  
Minister for the Environment**

**a:** Parliament House, Canberra, ACT 2600

s22



**THE HON MELISSA PRICE MP**  
**Minister for the Environment**

**STATEMENT**

8 October 2018

**INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE  
RELEASES REPORT**

The Australian Government will consider the Intergovernmental Panel on Climate Change's report as part of our ongoing review of our country's contribution to global action on climate change.

The Morrison Government is committed to the Paris Agreement and takes its international obligations seriously.

While Australia contributes only around one per cent of global emissions, we will deliver on our commitment to reduce emissions by 26 to 28 per cent of 2005 levels by 2030.

Australia's emissions intensity is at its lowest level for 28 years.

The report was requested by parties to the Paris Agreement, including Australia, to provide the IPCC's assessment of the latest available science on impacts of a 1.5° C global warming scenario (on pre-industrial levels) compared with a 2°C scenario.

The 600 page report covers all aspects of climate change policy, including the science, impacts and mitigation and we will consider its detail carefully.

We're particularly concerned about the implications for coral reefs, with the report finding climate change will impact reefs across the world, including Australia.

More than ever this report shows the necessity of the Morrison Government's \$400 plus million investment in the Great Barrier Reef's management.

Our investment will specifically address key areas for action identified by the Reef 2050 Plan.

I want to reassure Australians that, in the International Year of the Reef, the Morrison Government prioritises action over words. International efforts to reduce global climate change, combined with action at national and local levels to build the resilience of the Reef by reducing impacts, is the best insurance for protecting the Reef.

IPCC Reports are designed to inform policy makers, but without being policy prescriptive. The Australian Delegation at the meeting in Korea consisted of officials from the Department of Foreign Affairs and Trade and the Department of the Environment and Energy.

## IPCC Special Report on Global Warming of 1.5°C

### Summary

The Report was requested by parties to the Paris Agreement to provide the latest science on impacts of a 1.5°C warming scenario (on pre-industrial levels) compared with a 2°C scenario. The Report also provides options for strengthening the global response to climate change.

The Report is currently being finalised at an IPCC meeting in Korea (1-5 Oct) ahead of release on 8 Oct. A draft has been leaked and findings reported in the media (The Australian, 2/10/18).

IPCC reports are confidential until released but have been leaked before.

- In June 2018, the draft report was leaked to Reuters and was the subject of two media articles
  - On 14 June Alister Doyle (Reuters)
  - On 15 June Lisa Cox (The Guardian)
- The articles disclosed the outcomes of the report, drawing attention to the key scientific findings on the difference between 1.5 and 2 degrees warming in both natural and human systems and adequacy of the international response.
- The review of the draft report is an ongoing and confidential process.

s333(a)iii

s333(a)iii



s33(a)iii

s33(a)iii

## **Background**

### What is the Intergovernmental Panel on Climate Change (IPCC)?

The IPCC is the leading international body for assessment of climate change science. It is the source of science to the United Nations Framework Convention on Climate Change (UNFCCC).

The IPCC develops regular Assessment Reports and Special Reports. It reviews and assesses the most recent science. Technology and socio-economic information worldwide to provide policy-makers with a scientific basis for decision-making. It does not conduct research or monitoring and is not a decision-making body.

### Australia's participation in development of the Report

Australia supports the work of the IPCC, including for this Report. Australia participated in the IPCC session that adopted the report and in reviews of the draft report.

Australia supported adoption of the summary for policy-makers that is accurate and balanced and not prescriptive.

Australian research and literature has been taken into account in the Report with over 100 Australian journal articles cited.

Four Australian scientists contributed to the Report:

- Professor Ove Hoegh-Guldberg (University of Queensland)
- Dr Jatin Kala (Murdoch University)
- Professor Petra Tschakert (University of Western Australia) and
- Professor Peter Newman (Curtin University).

s22

**From:** s22  
**Sent:** Tuesday, 2 October 2018 12:55 PM  
**To:** Media; s22  
**Subject:** Fwd: IPCC Report (climate change impacts) Summary and Talking Points [SEC=UNCLASSIFIED]  
**Attachments:** IPCC Special Report Summary and TPs.docx  
**Categories:** For information

Fyi.

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From: s22  
 Date: Tue, Oct 2, 2018 at 11:39 AM +1000  
 Subject: IPCC Report (climate change impacts) Summary and Talking Points [SEC=UNCLASSIFIED]  
 To: "'melissa.price.mp@aph.gov.au'" <[melissa.price.mp@aph.gov.au](mailto:melissa.price.mp@aph.gov.au)>  
 Cc: s22  
 s22

Good morning Minister,

FYI – Please find attached a summary and talking points on the Intergovernmental Panel on Climate Change (IPCC) report on limiting global warming to 1.5°C.

The report is due to be finalised by the IPCC this week ahead of its public release on 8 October. A copy of the draft report has been leaked and reported on in The Australian today (article below). Leaks of these reports are not unusual and often used to raise the profile of the reports and the extent of climate impacts.

I will also share this summary and talking points with the PMO and Minister Payne's office.

The Department has provided a brief (MS18-000873) on the report with more detailed findings and talking points if you need.

Cheers,

s22

Media clip – The Australian

***Less meat, coal key to a cooler planet*****The Australian, General News, 02/10/18, Graham Lloyd, page 1**

An accelerated withdrawal from coal and a change in the global diet away from meat are needed to limit global temperature rises to 1.5C, leaked copies of a major new climate report say. Scientists and diplomats are meeting in South Korea this week to finalise the report that distils the findings of more than 6000 scientific papers. The 400-page report, scheduled to be released on Sunday, has been described by scientists involved as the most "politically charged" document in the history of the Intergovernmental Panel on Climate Change. The draft talks of "climate mayhem" and "a swift and complete transformation not just of the global economy, but of society, too". This is despite claims by reviewer Bob Ward from London's Grantham Institute that scientists had "pulled their punches" to make policy recommendations seem more palatable to countries such as the US, Saudi Arabia and Australia. This week, the political representatives of countries that have signed the Paris Agreement are going through the 22-page draft summary line by line to reach an agreed text for policymakers. Opening the talks yesterday, IPCC chairman Hoesung Lee said the meeting would "produce a strong, robust and clear summary for policymakers while upholding the scientific integrity of the IPCC". Leaked copies of the draft document have opened a window on the negotiations. Continued on Page 4 Less meat, coal key to cool planet Continued from Page 1 The bottom line, according to a report by AFP in Paris, is that at current levels of greenhouse gas emissions, there is "high confidence"

the 1.5C threshold will be passed around 2040. The draft report says carbon dioxide emissions should peak not later than 2020 and the global economy must become "carbon-neutral" by 2050.

Read Item: <http://www.mediaportal.com/Ott1219861912>

*Also displayed on the Australian website.*

s22

**Adviser | Office of the Hon Melissa Price MP**

**Minister for the Environment**

**a:** Parliament House, Canberra, ACT 2600

s22

Fri 15 Jun 2018 13.39 AEST

## The Guardian

<https://www.theguardian.com/environment/2018/jun/15/leaked-un-draft-report-warns-of-urgent-need-to-cut-global-warming>

[Lisa Cox](#)

### LEAKED UN DRAFT REPORT WARNS OF URGENT NEED TO CUT GLOBAL WARMING

IPCC says 'rapid and far-reaching' measures required to combat climate change

The world is on track to exceed 1.5C of warming unless countries rapidly implement "far-reaching" actions to reduce carbon emissions, according to a draft UN report [leaked to Reuters](#).

The final draft report from the UN's intergovernmental panel on climate change (IPCC) was due for publication in October. It is the guiding scientific document for what countries must do to combat climate change.

Human-induced warming would exceed 1.5C by about 2040 if emissions continued at their present rate, the report found, but countries could keep warming below that level if they made "rapid and far-reaching" changes.

Under the 2015 [Paris climate agreement](#), almost 200 countries signed up to limit global temperature rises to well below 2C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5C.

Climate scientist and Climate Analytics director Bill Hare said the draft report showed with greater clarity how much faster countries needed to move towards decarbonisation under various temperature situations and that the impacts of climate change greatly increased between 1.5C and 2C of warming.

Necessary actions include making the transition to renewable energy, powering the transport sector with zero carbon electricity, improving agricultural management and stopping deforestation.

"This IPCC report shows anyone drawing from published papers that there are big differences between 1.5 and 2 degrees warming in both natural and human systems," Hare said. "Two degrees warming and the tropical reefs have basically no chance – 1.5 degrees, they have a small to modest chance of survival.

"There's a range of commentary that comes out of the report that provides a stronger narrative for us to act than ever before."

He said it showed that if emissions continued on their present pathway, there was no chance of limiting global temperature rises even to 3C.

Economic modelling in the draft report showed that the dangers for economic growth, particularly in developing countries, were significantly greater at 2C than 1.5C.

The [Greenpeace](#) International executive director, Jennifer Morgan, said the moment of truth had come for leaders and the feasibility of achieving the Paris goals was a political choice.

“This choice must be driven by a moral obligation that binds us together. Through international cooperation, real ambition and working with communities, our leaders still have the time to do what they must,” she said.

“That means saying no to fossil fuels and standing up for forest and ocean protection with decisions that prove they understand the urgency. It means cutting down on meat and dairy consumption, and changing the way we produce our food.”

JUNE 14, 2018 / 9:44 PM / 3 DAYS AGO

REUTERS

<https://www.reuters.com/article/us-climatechange-report-exclusive/exclusive-global-warming-set-to-exceed-1-5c-slow-growth-u-n-draft-idUSKBN1JA1HD>

## Exclusive: Global warming set to exceed 1.5°C, slow growth - U.N. draft

Alister Doyle Environment Correspondent

OSLO (Reuters) - Global warming is on course to exceed the most stringent goal set in the Paris agreement by around 2040, threatening economic growth, according to a draft report that is the U.N.'s starkest warning yet of the risks of climate change.

FILE PHOTO: Water from the melting glacier runs down through a hole in the Aletsch Glacier on the Jungfrau Glacier, Switzerland, August 28, 2015. REUTERS/Denis Balibouse/File Photo

Governments can still cap temperatures below the strict 1.5 degrees Celsius (2.7° Fahrenheit) ceiling agreed in 2015 only with “rapid and far-reaching” transitions in the world economy, according to the U.N.'s Intergovernmental Panel on Climate Change (IPCC).

The final government draft, obtained by Reuters and dated June 4, is due for publication in October in South Korea after revisions and approval by governments.

It will be the main scientific guide for combating climate change.

“If emissions continue at their present rate, human-induced warming will exceed 1.5°C by around 2040,” according to the report, which broadly reaffirms findings in an earlier draft in January but is more robust, after 25,000 comments from experts and a wider pool of scientific literature.

The Paris climate agreement, adopted by almost 200 nations in 2015, set a goal of limiting warming to “well below” a rise of 2°C above pre-industrial times while “pursuing efforts” for the tougher 1.5° goal.

The deal has been weakened after U.S. President Donald Trump decided last year to pull out and promote U.S. fossil fuels. (nL1N1IZ1BA)

Temperatures are already up about 1°C (1.8°F) and are rising at a rate of about 0.2°C a decade, according to the draft, requested by world leaders as part of the Paris Agreement.

“Economic growth is projected to be lower at 2°C warming than at 1.5° for many developed and developing countries,” it said, drained by impacts such as floods or droughts that can undermine crop growth or an increase in human deaths from heatwaves.

In a plus-1.5°C world, for instance, sea level rise would be 10 centimeters (3.94 inches) less than with 2°C, exposing about 10 million fewer people in coastal areas to risks such as floods, storm surges or salt spray damaging crops.

It says current government pledges in the Paris Agreement are too weak to limit warming to 1.5°C.

### ***‘A BIT PUNCHIER’***

IPCC spokesman Jonathan Lynn said it did not comment on the contents of draft reports while work was still ongoing.

A man holds an umbrella as he walks next to his buffalo on the banks of the river Ganga on a hot summer day in Allahabad, India May 24, 2016. REUTERS/Jitendra Prakash

“It’s all a bit punchier,” said one official with access to the report who said it seemed slightly less pessimistic about prospects of limiting a rise in global temperatures that will affect the poorest nations hardest.

The report outlines one new scenario to stay below 1.5°C, for instance, in which technological innovations and changes in lifestyles could mean sharply lower energy demand by 2050 even with rising economic growth.

And there is no sign that the draft has been watered down by Trump’s doubts that climate change is driven by man-made greenhouse gases.

The draft says renewable energies, such as wind, solar and hydro power, would have to surge by 60 percent from 2020 levels by 2050 to stay below 1.5°C “while primary energy from coal decreases by two-thirds”.

By 2050, that meant renewables would supply between 49 and 67 percent of primary energy.

The report says governments may have to find ways to extract vast amounts of carbon from the air, for instance by planting vast forests, to turn down the global thermostat if warming overshoots the 1.5°C target.

It omits radical geo-engineering fixes such as spraying chemicals high into the atmosphere to dim sunlight, saying such measures “face large uncertainties and knowledge gaps.”

Reporting By Alister Doyle; editing by John Stonestreet





s22

---

**From:** s22  
**Sent:** Tuesday, 9 October 2018 9:33 PM  
**To:** Media  
**Subject:** Fwd: TPs [DLM=For-Official-Use-Only]

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**From:** s22  
**Date:** Tue, Oct 9, 2018 at 9:27 PM +1100  
**Subject:** Fwd: TPs [DLM=For-Official-Use-Only]  
**To:** s22  
**Cc:** s22

Hi s22 - see below but if you need more let us know.

s47C

s22

---

**From:** s22  
**Sent:** Friday, 5 October 2018 5:31 PM  
**To:** Rob Sturgiss; s22  
**Cc:** Media; s22 ; s22 ; s22 ; s22  
Kushla Munro; s22 ; Lesley Dowling  
**Subject:** RE: Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018 [SEC=UNCLASSIFIED]  
**Attachments:** Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018.docx

Hi Rob – for your feedback again – revised statement.

Thanks all!

s22

**Media Adviser | Office of the Hon Melissa Price MP**  
**Minister for the Environment**

**a:** Parliament House, Canberra, ACT 2600

**t:** s22 | **m:** s22 | **e:** s22

---

**From:** Rob Sturgiss  
**Sent:** Friday, 5 October 2018 4:27 PM  
**To:** s22 ; s22  
**Cc:** Media ; s22 ; s22 ; s22 ; s22 ; s22 ; Kushla Munro ; s22  
Lesley Dowling  
**Subject:** RE: Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018 [SEC=UNCLASSIFIED]

s22 Apologies for the confusion!

12 noon Sydney time it is for the Report Launch.

Rob.

---

**From:** s22  
**Sent:** Friday, 5 October 2018 4:19 PM  
**To:** s22 ; Rob Sturgiss  
<[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)>  
**Cc:** Media <[Media@environment.gov.au](mailto:Media@environment.gov.au)>; s22 ; s22  
s22 ; s22  
s22 ; Kushla Munro <[Kushla.Munro@environment.gov.au](mailto:Kushla.Munro@environment.gov.au)>; s22  
s22 ; Lesley Dowling <[lesley.dowling@environment.gov.au](mailto:lesley.dowling@environment.gov.au)>  
**Subject:** RE: Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018 [SEC=UNCLASSIFIED]

A comment on the time, it will be midday in Canberra (change to daylight savings this weekend).

---

**From:** s22  
**Sent:** Friday, 5 October 2018 4:16 PM

To: Rob Sturgiss <[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)>

Cc: Media <[Media@environment.gov.au](mailto:Media@environment.gov.au)>; s22

s22

s22 s22

s22; Kushla Munro <[Kushla.Munro@environment.gov.au](mailto:Kushla.Munro@environment.gov.au)>; s22

s22 s22 Lesley

Dowling <[lesley.dowling@environment.gov.au](mailto:lesley.dowling@environment.gov.au)>

**Subject:** RE: Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018

[SEC=UNCLASSIFIED]

Thanks for the advice Rob... am combining comments and will recirculate to you all.

Ta s22

s22

**Media Adviser | Office of the Hon Melissa Price MP**

**Minister for the Environment**

a: Parliament House, Canberra, ACT 2600

s22

---

**From:** Rob Sturgiss

**Sent:** Friday, 5 October 2018 4:10 PM

**To:** s22

**Cc:** Media <[Media@environment.gov.au](mailto:Media@environment.gov.au)>; s22

s22

s22 s22;

s22; Kushla Munro <[Kushla.Munro@environment.gov.au](mailto:Kushla.Munro@environment.gov.au)>; s22

s22 s22 Lesley

Dowling <[lesley.dowling@environment.gov.au](mailto:lesley.dowling@environment.gov.au)>

**Subject:** RE: Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018

[SEC=UNCLASSIFIED]

s22

The Report will be released at 10am Monday (Korean time) – 11am your time.

The press conference will be available on the internet.

The press will receive embargoed copies prior to the conference some time on Sunday.

I have made some suggested comments on the press release in an earlier email.

Thanks

Rob

---

**From:** s22

**Sent:** Friday, 5 October 2018 3:44 PM

**To:** Rob Sturgiss <[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)>

**Cc:** Media <[Media@environment.gov.au](mailto:Media@environment.gov.au)>; s22

s22

s22 s22

s22 Kushla Munro <[Kushla.Munro@environment.gov.au](mailto:Kushla.Munro@environment.gov.au)>; s22

s22

**Subject:** Re: Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018

[SEC=UNCLASSIFIED]

Nope not yet we wanted to check in first before going to DFAT and Minister yet to clear also. Will revise including s22 comments and send back.

Tks s22

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On Fri, Oct 5, 2018 at 2:38 PM +1000, "Rob Sturgiss" <[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)> wrote:

s22

Has DFAT been consulted on this?

Cheers

Rob

---

**From:** s22

**Sent:** Friday, 5 October 2018 2:06 PM

**To:** Rob Sturgiss <[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)>

**Cc:** Media <[Media@environment.gov.au](mailto:Media@environment.gov.au)>; s22; s22

s22; s22

s22; Kushla Munro <[Kushla.Munro@environment.gov.au](mailto:Kushla.Munro@environment.gov.au)>; s22

s22

**Subject:** Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018  
[SEC=UNCLASSIFIED]

Hi Rob,

Suggested statement to go out from Minister once report agreed – could you fact check for us and advise if/when report agreed?

Thanks s22

s22

Media Manager  
Communications and Engagement Branch  
Department of the Environment and Energy  
GPO Box 787, CANBERRA ACT 2601

s22

s22



The Department acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.

s22

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**From:** s22  
**Sent:** Saturday, 6 October 2018 8:49 AM  
**To:** Media; s22; Lesley Dowling; s22  
s22 Rob Sturgiss  
**Subject:** Re: Minister Price - Intergovernmental Panel on Climate Change Report statement 8102018 [SEC=UNCLASSIFIED]

Thanks all. Have reviewed and accepted changes. Cheers s22

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On Fri, Oct 5, 2018 at 7:02 PM +1000, "Rob Sturgiss" <[Rob.Sturgiss@environment.gov.au](mailto:Rob.Sturgiss@environment.gov.au)> wrote:

s22

Have a few minor tweaks.

Rob

s22

---

**From:** Rob Sturgiss  
**Sent:** Saturday, 6 October 2018 5:36 PM  
**To:** s22  
**Cc:** Kushla Munro <Kushla.Munro@environment.gov.au>  
**Subject:** FW: IPCC Special Report 1.5C adopted [SEC=UNCLASSIFIED]

s22

FYI.

Just letting you know that the IPCC Special Report has been approved, after an all-night and most-of-the-next-day experience at the end.

s33(a)iii

s33(b)

The report will be released at a press conference to be held by the IPCC Chair Hoesung Lee on Monday at 10am Korea time (12 noon Sydney time).

Rob