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10-15-2018

## Faculty Senate Executive Committee Agenda, October 15, 2018

Utah State University

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## **FACULTY SENATE EXECUTIVE COMMITTEE**

October 15, 2018

3:30 – 5:00 p.m.

Old Main-Champ Hall

### **Agenda**

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- 3:30 Call to Order** ..... Rebecca Lawver  
Approval of Minutes - [September 17, 2018](#)
- 3:35 University Business** ..... Noelle Cockett, President | Frank Galey, Provost
- 3:50 Information**  
[EPC Monthly Report](#) – October 4, 2018 ..... Ed Reeve  
[ASR 2019-03](#) Sexual Discrimination and Harassment ..... Sierra Wise  
[ECR 2019-02](#) Mental Health Syllabus Resources ..... Kristin Hall
- 3:55 Reports**  
[Libraries Advisory Council](#) Annual Report ..... Bryce Fifield
- 4:10 Old Business**  
[Code 405.11.4](#) External Reviewers (first reading) ..... Britt Fagerheim
- 4:20 New Business**  
[IPCC Report](#) ..... Patrick Belmont
- 4:25 Adjourn**



## **FACULTY SENATE EXECUTIVE COMMITTEE MINUTES**

September 17, 2018

3:30 – 5:00 p.m.

Old Main-Champ Hall

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**Present:** Becki Lawver (President), Kimberly Lott (Past President), Patrick Belmont (President Elect), Provost Frank Galey (Ex-Officio), Michele Hillard (Exec. Sec.), Ben George, Zsolt Ugray, Jan Thornton, Robert Wagner, Timothy Taylor, David Brown, Matt Omasta, Rick Heflebower, Bryce Fifield, Erin Davis, President Noelle Cockett (Ex-Officio)

**Absent:** Marilyn Cuch, Jessica Lucero

**Guests:** Edward Reeve, Interim Vice Provost, Kristine Miller, Director

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**Call to Order** - Rebecca Lawver

Approval of [August 27, 2018 Minutes](#)

*Minutes approved as distributed.*

**University Business** - Noelle Cockett, President | Frank Galey, Provost

President Cockett notified the committee that candidates are being brought on campus for interviews for the position of Vice President for Marketing and Communications. The first candidate will arrive tonight and will be on campus Tuesday and Wednesday. Next candidate is coming on Wednesday. Another candidate comes next week and the final one will arrive October 3. There will be open forums scheduled for the faculty to attend, if they are interested. This position could be finalized within 3-4 weeks. Today is day 15 of classes and enrollment numbers will be coming out. We do not release those numbers until they have been submitted to the Utah System of Higher Education (USHE) and then USHE officially releases them. The official numbers are actually at the end of a term. The numbers are flat here in Logan and in the regional campuses. The Logan campus does continue to increase on full-time enrollment (FTE). There is also an increase in on-line broadcast classes. Enrollment numbers in Blanding are dropping but the Price campus numbers are increasing. USU would like to focus on FTE to help get students through graduation. Utah Valley University (UVU) continues with a significant increase in enrollment as does Dixie State. It might be a good idea to invite Robert Wagner and Michael Torrens to attend the FSEC and FS meetings to discuss enrollment trends and numbers. An enrollment report will be added to an upcoming FS agenda. Growth is dominating higher education conversations right now. Six of the eight public institutions in the state are now offering master degrees. Back in 2004 the University of Utah (UofU) and USU were the only institutions that could offer bachelor degrees. Now, 12 years later, the other institutions can offer both bachelor and master degrees. USU offers the full college experience and has been using scholarships for our main enrollment management tool. Enrollment management and recruitment is now under the office of Academic and Instructional Systems (AIS) and they will follow up with students to ask questions as to why they are or are not coming to USU. Recruiting and retaining students will be looked at and will work hand in hand for the students and the institution. USU tuition is just over \$7,000 and we consider this a tremendous return on investment. In state the cheapest tuition is \$4,000 and the U of U is at \$9,000. We are finding that students and their parents want to go to college and not have any debt. AIS will engage the colleges in more recruiting. The Theatre Arts department has a 100% job placement upon graduation and these kinds of stories need to be told. USU is looking at following students once they graduate and see where they end up. We need to toot our own horn and provide subtle messages regarding the programs and campus life at USU. Community colleges are now pressing to be able to provide 4-year programs/colleges in their towns. This trend forced the University

of Wyoming to move programs out to the community colleges. It is felt, however, that this is going to dilute the effort locally.

Provost Gale – The recent accreditation review assessed the various aspects of our curriculum. One item that we need to work on is the General Education program. The Math & English requirements are holding their own for QI/QL and CI, however, we need to do some work on the overall depth and breadth classes. Currently we are in the process of forming a task force to look at this issue. The task force will consist of a couple of Associate Deans, Faculty Members, Robert Wagner and Michael Torrens. We will try to do this as accurate and painless as possible for the faculty members. As we come up with ideas the Provost will communicate the outcome. Provost Gale will provide regular updates to the FSEC.

### **Information**

EPC Monthly Report – [September 6, 2018](#) - Ed Reeve

General Education – no report

Academic Standards – no action items

Curriculum Committee reviewed and approved 13 course requests and three R401 program requests.

Jon M. Huntsman School of Business updated prefixes to MSLE to reflect their new Marketing and Strategy department.

### **Reports**

[EPC Annual Report](#) - Ed Reeve

The EPC is made up of 3 committees, General Education, Academic Standards and EPC/Curriculum 776 requests were reviewed for the 2017-2018 academic year.

A Registered Student Policy was approved.

Final exam and no test day policy was updated and approved.

The student code revision was approved.

*Motion to move the Annual EPC Report to the Faculty Senate Agenda made by Matt Omasta. Seconded by Kimberly Lott. Moved to Faculty Senate agenda.*

[Honors Annual Report](#) - Kris Miller

The Honors Program is a place where people can meet and talk. Honors sends out weekly email list for events that are happening on campus to help keep their students informed and up to date. It is important to provide the students with a sense that the USU Honors Program is a great place to be. Socials are set up for faculty and students to mingle and socialize. These socials and other activities help students experience hands on learning. The faculty and student experiences help push the students out of their comfort zones and helps them stretch and grow. The Honors Program is also working and collaborating with the Office of Global Engagement. Last year the program served over 722 students. Approximately 75% of faculty are engaged with the honors students. Honors students and faculty are winning awards for their work and are showcasing USU.

*Motion to move the Annual Honors Report to the Faculty Senate agenda made by Matt Omasta. Seconded by Patrick Belmont. Moved to Faculty Senate agenda.*

### **New Business**

Faculty Senate Meeting Time Change - Becki Lawver

Some faculty have expressed their concern in not being able to make it to the meetings on time due to teaching schedules. In order to make this change it would require a change to the faculty code. We need to obtain information regarding the pros and cons of moving the time. AIS can provide this data regarding classes and bell schedule. Ask the Faculty Senators about the time change. We would ultimately need to have a vote on this.

*Motion to hold straw poll to acquire senate interest in moving the time for senate meetings made by Patrick Belmont. Seconded by Matt Omasta. Timothy Taylor has agreed to pull together the numbers and information regarding classes and bell schedule.*

Nominating Committee Code – This request deals with finding individuals who can run for FS President-Elect each year. It is felt that there should be more input/participation than just the FS presidency looking for and soliciting nominations. If there is no committee set up to do this then the brunt of the responsibility falls back on the FS president. If we have a few more participants in this process we

might have more than one candidate which would call for a true election. Can a few individuals from the FSEC take on that responsibility? If the FSEC pulled together and formed an ad hoc committee three would not need to be a change in the faculty code. It could be as simple as adding a line into the code noting the FSEC will solicit candidates for the president elect position. It was recommended to bring the information earlier to the FS meetings, possibly begin in the February-March timeframe so that an election can be held at one of the April meetings.

**Code 403.3.2** Standards of Conduct-Professional Obligations - Kimberly Lott

Same add bullets #10 and #11.

*Motion to move code change 403.3.2 to the Faculty Senate agenda made by Bryce Field. Seconded by Patrick Belmont. Code moved to Faculty Senate agenda.*

**Code 407.1.1** Non-punitive Measures - Kimberly Lott

*Motion to move code change 407.1.1 to the Faculty Senate agenda made by Bryce Fifield. Seconded by Patrick Belmont. Code moved to Faculty Senate agenda.*

**Code 407.11.2** Inquiry into Allegations of Violation Policies 407.8 and/or 407.9 - Kimberly Lott

Leaving guidance in the code in 407.1.1 and add professional counseling.

*Motion to move code change 407.11.2 to the Faculty Senate agenda made by Bryce Fifield. Seconded by Patrick Belmont. Code moved to Faculty Senate agenda.*

**Code 407.11.3** Protection of Complainant and Others - Kimberly Lott

Should this be the provost and president making these decisions? Add the provost as well as the president.

*Motion to move code change 407.11.3 to the Faculty Senate agenda made by Bryce Fifield. Seconded Ben George. Code moved to Faculty Senate agenda.*

Matt Omasta is worried that there might be a conflict of interest problem. He felt that this issued needs to be addressed more. Spirit of motion is to open it up so that when it is returned from PRPC we will review and make sure that it is clear.

**Adjourn 5:05 pm**

## **Report from the Educational Policies Committee October 4, 2018**

The Educational Policies Committee (EPC) met on October 4, 2018. The agenda and minutes of the meeting are posted on the Educational Policies Committee web page ([www.usu.edu/epc](http://www.usu.edu/epc)).

During the October 4, 2018, meeting of the EPC, the following actions were taken:

### **1. General Education Subcommittee**

- No Action Items. Discussion presented on the Northwest Commission on Colleges and Universities (NWCCU) Accreditation Review and General Education

### **2.. Academic Standards Subcommittee**

- No Report.

### **3. Curriculum Subcommittee**

- Approval of 123-course requests.
- Approval of a request from the Department of History in the College of Humanities and Social Sciences to offer a **Masters in Ancient Languages and Cultures**.
- Approvals of the request from the Department of English in the College of Humanities and Social Sciences to change the name from American Studies to **Folklore and American Studies. Restructure Folklore and American Studies**.
- Approval of the request the Department of Languages, Philosophy and Communication Studies in the College of Humanities and Social Sciences to offer a **Baccalaureate degree in Chinese**.
- Table the request from the Department of Sociology, Social Work and Anthropology in the College of Humanities and Social Sciences to establish an **I-System Institute for Transdisciplinary Studies**.

**Committee:**  
**First Reading Date:**  
**Second Reading Date:**  
**Final Action Date:**  
**Final Action:**

**Proposed Revisions to the Faculty Code**

Description: As the student-elected governing body of Utah State University, we propose the following revisions to USU Legislation 400 (Faculty Code) to better define discrimination and harassment, allow for annual review of faculty conduct, as well as allow for administrative leave of faculty members.

1 **WHEREAS** Utah State University is a public university currently serving over 28,000 students and  
2 employing 800 faculty members

3 **WHEREAS** University administrators and faculty alike are bound to the constraints of USU Legislation  
4 Section 400 in matters of faculty conduct and promotion

5 **WHEREAS** The current USU Legislation Section 407.2 2.5 (Faculty Code-Sanctions) prevents faculty  
6 members from being twice subject to sanctions for the same instance of a violation of a standard of  
7 conduct.

8 **WHEREAS** USU policy 407.4.11 states “In the event that a faculty member is charged with a felony that  
9 affects an institutional interest, the president may temporarily suspend the faculty member with full pay  
10 without following the procedures above upon written notice to the faculty member. This suspension shall  
11 remain in effect until such time as the faculty member has resigned, been acquitted of the felony charges,  
12 or been sanctioned according to procedures above.”

13 **WHEREAS** USU Policy 407.8.5 D states: “In extraordinary circumstances, where the provost finds that  
14 it is reasonably certain that the alleged sexual harassment has occurred and serious and immediate harm  
15 will ensue if the faculty member continues to work, and after consulting the chair of the Academic  
16 Freedom and Tenure Committee, the provost may at any time during or after an inquiry or investigation  
17 into a sexual harassment complaint recommend to the president the suspension with pay of any faculty  
18 member or teaching assistant accused of sexual harassment.”

19 **WHEREAS** “Serious and immediate harm” is vague, far too open ended, difficult to define, and thus  
20 leaves the university liable and the student body at risk in the face of allegations of faculty misconduct.

21 **WHEREAS** In the event that violations are filed against a faculty member, university policy should  
22 protect due process of accused faculty members, prevent double jeopardy sanctions, and protect the rights  
23 of students.

24 **WHEREAS** Not all violations of faculty conduct that may require administrative leave pending an  
25 investigation may be reasonably defined as a felony or causing “serious and immediate harm [to students  
26 or university personnel].”

27 **WHEREAS** Allegations of serious misconduct have been filed against multiple faculty members in the  
28 Caine College of the Arts Piano program and the university would have been able to take swifter action to  
29 protect accused faculty as well as students within the program had administrative leave been available  
30 through the faculty code.

31 **WHEREAS** Similar legislation already exists under USU Policy 311 (Corrective Action) stating, “When  
32 significant allegations are identified, a benefit-eligible, non-faculty employee may be put on leave with  
33 pay pending notice of and an opportunity to respond to the charges at a meeting. After an investigation  
34 has taken place and the employee has been given an opportunity to discuss the results, appropriate action  
35 will be taken by the University.” However, this policy does not currently extend to faculty members.

36 **BE IT THEREFORE ENACTED THAT** The faculty code be revised to allow for administrative leave  
37 with pay to be initiated when significant allegations of misconduct are identified allowing for the  
38 university to conduct a proper investigation of such charges.

39 **WHEREAS** USU Policy 400.5.12.1 (Annual review of faculty) currently reads: “This evaluation shall  
40 encompass a multi-year window of performance that covers a five-year span (to meet the  
41 requirements of post-tenure review for tenured faculty). Such reviews shall, at a minimum,  
42 incorporate an analysis of the fulfillment of the role statement. The basic standard for appraisal shall  
43 be whether the faculty member under review discharges conscientiously and with professional  
44 competence the duties appropriately associated with his or her position.”

45 **WHEREAS** The above policy currently only allows tenured faculty to be evaluated based on  
46 “professional competence” but not conduct.

47 **WHEREAS** Tenured faculty often work very closely with students and professional conduct should also  
48 be prioritized in addition to competence in their field.

49 **BE IT FURTHER ENACTED THAT** USU Policy 400.5.12.1 (Annual review of faculty) be revised to  
50 also include professional conduct as a criteria through which tenured faculty may be reviewed.

51 **WHEREAS** USU Policy 403.3.2 currently does not specify that faculty members will not engage in acts  
52 of discrimination, humiliation, intimidation, vindictiveness, and psychological abuse.

53 **WHEREAS** the Alan Sullivan investigation conducted in March of 2018 found the USU Piano Pedagogy  
54 Program guilty of acts of humiliation, intimidation, vindictiveness, and psychological abuse against  
55 current and former students.

56 **BE IT FURTHER ENACTED THAT** USU Policy 403.3.2 be amended to include language which  
57 specifies that no faculty member shall engage in acts of discrimination, humiliation, intimidation,  
58 vindictiveness, psychological abuse, or any other form of harassment against any USU student or USU  
59 personnel.

**Tags:** Faculty Code, Standards of Conduct, USU Piano Program, Discrimination and Harassment, Equal Opportunity, Annual Review of Tenured Faculty

**Sponsor:** Sierra Wise-USUSA Arts Senator

**Co-sponsor:** Jaren Hunsaker- USUSA Executive Vice President, Alexandra Smith-USUSA Executive Vice President, Samuel Jackson- USUSA Student Advocate VP, Joshua Johnson- USUSA Clubs and Diversity VP, Kristin Hall- USUSA Graduate Studies Senator, Erik Olson- USUSA Engineering Senator,

**Policy Paper** (This bolded section will be filled out by the Administrative Assistant)

**Committee:**

**In Attendance:**

**Absent:**

**Result:**

**History:**

This resolution was created in response to the ongoing sexual misconduct investigation and crisis intervention in the Caine College Piano Pedagogy Program. Both in the case of the former program coordinator, Gary Amano, as well as with the pending charges against Dennis Hirst, the need for easier access to administrative leave has become apparent. In the case of Gary Amano, he was placed a forced sabbatical to remove him from the department pending a formal investigation. In the case of Dennis Hirst, he was reassigned to duties that would remove him from the college pending an investigation. As student leaders, we believe that these accusations should not be taken lightly. Both due process as well as student rights should be upheld and protected. It is irresponsible to move forward from this experience without instating administrative leave.

Additionally, the major violations of conduct committed in the Piano Program have had lasting repercussions on the students who have been caught in the crossfire. Cindy Dewey (department head for music) was aware that Gary Amano was treating students unkindly (although she did not know of the extent) before the investigation was ever formally launched. However, with the wording as it currently stands within the code, she was unable to take any impactful corrective action against him. As the process currently stands, the only action available to help systemic issues of misconduct that have not escalated to being “imminently dangerous” or do not qualify as a felony charge is to remove the student having an issue with the tenured faculty and place them in another class. This system is unjust because it wrongfully punishes students and damages their academic process rather than allowing for the issue to be reformed by working with the faculty member.

After the press release in April of 2018 following the investigation into the piano department, a group of five independent students from the Caine College approached me, their academic senator, with concerns regarding the faculty code and internal policy concerning how issues of misconduct are handled through the university. While many of the points they brought up are important and valid to the argument as to why this change in legislation is necessary, the point most important is that these students do not feel safe at Utah State University. We understand that as Academic Senate and Executive Council, we do not hold legislative power over policy 400. For this reason, specifications regarding how these proposed changes should be worded and implemented have been left intentionally open-ended. However, this issue is academic in nature and thus has become a concern to the Academic Senate in that if students do not feel safe navigating their academic environment, they are unable to achieve the quality education they have paid for and deserve. As a student body, we respectfully petition the committees that hold legislative power over the faculty code to consider our recommendations and take swift action for reform and the implementation of these suggestions.

**Purpose:**

The purpose of this resolution is to make the necessary changes to USU policy 400 (the faculty code) in order to better protect the interests of Utah State University as well as the rights of students. These changes include: the implementation of administrative leave, the allowance of tenured faculty to be reviewed based on conduct, and better clarification of the definitions of discrimination and harassment.

**Pros:**

This resolution will better protect the interests of the university, faculty members, and students. Additionally, it will streamline the process of conducting university investigations, protect due process, and clarify the definitions of discrimination and harassment.

Cons:

This may be difficult to implement. Could place stress on college administration as they try to fill positions if a faculty member is placed on leave. Could be perceived as a threat to tenure.

**ECR 2019-02**

**Committee: Executive Council**  
**First Reading Date: September 25, 2018**  
**Second Reading Date: October 2, 2018**  
**Final Action Date: October 2, 2018**  
**Final Action: Passed**

**Mental Health Syllabus Resources**

- 1   **WHEREAS** the purpose of USUSA is to improve student life on the campus of Utah State University,
- 2   **WHEREAS** mental health awareness has been a focal point of the Government Relations Council, the  
3   Student Advocate Vice President, and USUSA as a whole,
- 4   **WHEREAS** the Government Relations Council, Student Advocate Vice President, and USUSA as a  
5   whole lobbied for the passage of HCR 016 in 2017,
- 6   **WHEREAS** HCR 016 declared mental health as a crisis across the higher education institutions of the  
7   state of Utah,
- 8   **WHEREAS** HCR 016 was passed with an overwhelming majority in both chambers of the Utah State  
9   Legislature, and signed into law by the governor,
- 10   **WHEREAS** a new \$3.50 student fee for increased CAPS funding was voted on and enacted via student  
11   referendum in 2017,
- 12   **WHEREAS** more students now have access to counseling as a result of this new fee,
- 13   **WHEREAS** a significant portion of students at Utah State University remain unaware of the counseling  
14   services available to them,
- 15   **WHEREAS** every student at Utah State University receives a syllabus for their respective classes, and is  
16   therefore expected to read through their syllabi,
- 17   **BE IT THEREFORE ENACTED THAT** Counseling and Psychological Services information be  
18   required for every instructor to include on their course syllabus. This information includes, but is not  
19   limited to office location, office phone number, and hours of operation.
- 20   **WHEREAS** there are students who may seek immediate assistance with a mental health issue,
- 21   **WHEREAS** the CAPS office is only open during business hours (M-F) every week,
- 22   **BE IT FURTHER ENACTED THAT** the Suicide Prevention Hotline and USU Campus Police  
23   information also be included in syllabi as well.
- 24   **WHEREAS** students may be eligible to take an “incomplete” demarcation in their classes due to  
25   “extenuating circumstances,”

26 **WHEREAS** mental health crises and sexual assault incidents are not listed in syllabi as reasons to take a  
27 class as “incomplete.”

28 **BE IT FURTHER ENACTED THAT** the language regarding incomplete classes in syllabi be changed  
29 to state the following:

30 Withdrawal Policy and “I” Grade Policy:

31 Students are required to complete all courses for which they are registered by the end of the  
32 semester. In some cases, a student may be unable to complete all of the coursework because  
33 of extenuating circumstances, but not due to poor performance or to retain financial aid. The  
34 term 'extenuating' circumstances includes: Incapacitating illness which prevents a student from  
35 attending classes for a minimum period of two weeks, A death in the immediate  
36 family, Financial responsibilities requiring a student to alter a work schedule to secure  
37 employment, Change in work schedule as required by an employer, or other emergencies  
38 deemed appropriate by the instructor (including, but not limited to, a serious mental health crisis  
39 or sexual assault incident). <http://www.usu.edu/policies/pdf/Incomplete-Grade.pdf>  
40

41 **Tags:** mental health, HCR 016, syllabi, sexual assault

42 **Sponsor:** Sam Jackson, Student Advocate Vice President

43 **Co-sponsor:** Jaren Hunsaker, President

**Policy Paper** (This bolded section will be filled out by the Administrative Assistant)

**Committee:** Executive Council

**In Attendance:** Linda Zimmerman, President Jaren Hunsaker, VP Allie Smith, VP Samuel Jackson, VP Bannon Greer, VP Meghan Tatom, VP Joshua Johnson, VP Jenna Stoker, VP Daria Griffith, Senator Kristin Hall, Director Braxton Moon, Assistant Brooke Jorgensen, Senator Erik Olson

**Result:** Passed

History:

This resolution is being written to further USUSA's goal to reduce the stigma surrounding mental health issues, as well as increase awareness for resources available to students. This resolution falls directly in line with other action USUSA has taken in past years – including the sponsorship of HCR 016 and the 2017 CAPS student fee referendum.

Purpose:

To increase awareness/access of student resources in regards to mental health on campus. We are aiming to make the action of seeking help for mental health issues more mainstream in student life.

Pros:

- More information available to students
- Can reduce stigma of mental health issues

Cons:

- Students may not read their syllabus
- Instructors may be hesitant to be forced to include more information in the syllabus
- Could create longer wait times for counseling

# University Libraries Advisory Council

## Report to the Utah State University Faculty Senate October 2018

### Charge

The University Libraries Advisory Council advises the Vice-Provost for University Libraries and Instructional Support in (1) meeting the learning, instruction, and research needs of students, faculty and staff; (2) formulating library policies in relation to circulation, services, and the collection development of resources for instruction and research; and (3) interpreting the needs and policies of the libraries to the University. The Council membership consists of nine faculty members, one from each College and Extension with one undergraduate and graduate student appointed by the Provost. Faculty members serve three-year terms and are renewable once. The Vice-Provost for University Libraries and Instructional Support serves as an ex-officio, non-voting member. The chair is elected from the Council membership on an annual basis.

(<https://www.usu.edu/policies/105/>, accessed September 20, 2018).

### Council Members (2017-2018)

Council members who served during the 2017-2018 academic year included: David Wall, Caine College of the Arts, Chair; Charles Miller, College of Engineering; Susanne Janecke, College of Science; Bryce Fifield, Emma Eccles Jones College of Education and Human Services; Travis Dowdle, USUSU Science Senator; Anuj Khasgiwala, Graduate Student Senator; Steven Hanks, Huntsman School of Business; Amanda, College of Agriculture and Extension; Christine Cooper-Rompato, College of Humanities and Social Sciences; Peter Adler, College of Natural Resources; Dean Brad Cole, Ex-officio, Libraries and Instructional Support.

### 2017-2018 Activities

The Library Advisory Council met twice during the 2017-2018 academic year. Key topics addressed included the following:

The expansion of student digital exhibits to involve more faculty and students. The purpose of the digital exhibits initiative is to encourage faculty to think differently about research assignments and outputs and to encourage students to interact directly with primary resources. Student digital exhibits are available at <http://exhibits.usu.edu/exhibits>.

The challenges of meeting the increasing costs of journal costs with existing fee and funding structures. Last year, there was an inflationary increase of \$275,000 and is expected to exceed \$300,000 next year. Council members provided input on several cost-reducing strategies. Council members also solicited input from their colleges and academic departments on the impact of cancelling selected journal packages.

Council members participated in and provided input into the Library's strategic planning process. The involvement of Library employees, faculty, researchers, students, and other stakeholders is identifying a number of possible strategic areas and initiatives. Library staff participated in departmental retreats this fall and conducted a faculty survey. From these sources, Library staff, with input from the Council are selecting five or six critical issues to address over the coming year.

Council members provided input into a number of Library services, programs, and resources including The Human Library, availability of a remote book drop, support for student research, inservice resources for new and existing faculty, and development/fundraising efforts. An ongoing issue is the difficulty of informing students, faculty, and other campus constituents about the availability of Library services and resources. Council members have provided suggestions about possible communication strategies and in turn are encouraged to communicate with their own academic units about these issues.

Original Code:

405.7.211.47.2 Additional Events During the Year in which a Tenure Decision is to be Made

(1) External peer reviews.

Prior to September 15, the department head or supervisor will make a solicitation of letters from at least four peers of rank equivalent to or higher than that sought by the candidate. If fewer than four letters arrive, additional letters will be solicited only to attain the minimum of four letters.

The reviewers must be external to the university and must be held with respect in academe. The candidate will be asked to submit the names of potential reviewers and to state the nature of his or her acquaintance with each of them. The number of names should be at least equal to the number of letters to be solicited. At least one-half of the reviewers must be selected from the candidate's list. The candidate may also submit names of potential reviewers that he or she does not want contacted, although this list is not binding on the department head or supervisor.

The department head or supervisor and the tenure advisory committee shall mutually agree to the peer reviewers from whom letters will be solicited. A summary of the pertinent information in his or her file initially prepared by the candidate and a cover letter initially drafted by the department head or supervisor with final drafts mutually agreed upon by the candidate, the tenure advisory committee, and the department head or supervisor shall be sent to each reviewer by the department head or supervisor. Each external reviewer should be asked to state, the nature of his or her acquaintance with the candidate and to evaluate the performance, record, accomplishments, recognition and standing of the candidate in the major area of emphasis of his or her role statement. If the candidate, department head, and tenure advisory committee all agree, external reviewers may be asked to evaluate the secondary area of emphasis in the role statement as well. Copies of these letters will become supplementary material to the candidate's file (see Code 405.6.3).

Under exceptional circumstances, a waiver of the external review process may be granted by the president when such a process is operationally not feasible for a particular set of academic titles and ranks.

Proposed Code Change:

405.117.427.2 Additional Events During the Year in which a Tenure Decision is to be Made

(1) External peer reviews.

Prior to September 15, the department head or supervisor will make a solicitation of letters from at least four peers of rank equivalent to or higher than that sought by the candidate. If fewer than four letters arrive, additional letters will be solicited only to attain the minimum of four letters.

The candidate will be asked to submit the names of potential reviewers and to state the nature of his or her acquaintance with each of them. The reviewers must be external to the university and must be held in high regard by the academic community. The reviewers must be external to the university and must be held with respect in academe in high regard by the academic community. These persons should be familiar with the candidate's field of study and may know the candidate, but those with potential

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Commented [BF1]: Committee thought the current wording is awkward

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~~conflicts of interest should not be asked to serve as a reviewer, but the reviewer must be far enough removed from the candidate as to avoid a conflict of interest. A candidate may be asked to submit additional names if it is decided that the nature of the candidate's acquaintance with the potential reviewers might prevent them from making an objective evaluation.~~ The number of names should be at least equal to the number of letters to be solicited. At least one-half of the reviewers must be selected from the candidate's list. The candidate may also submit names of potential reviewers that he or she does not want contacted, although this list is not binding on the department head or supervisor.

The department head or supervisor and the tenure advisory committee shall mutually agree to the peer reviewers from whom letters will be solicited ~~to ensure an objective appraisal of the candidate's file.~~ A summary of the pertinent information in his or her file initially prepared by the candidate and a cover letter initially drafted by the department head or supervisor with final drafts mutually agreed upon by the candidate, the tenure advisory committee, and the department head or supervisor shall be sent to each reviewer by the department head or supervisor. ~~Each external reviewer should be asked to state (i) the nature of his or her acquaintance with the candidate; and (ii) if any potential conflicts of interest exist.~~ External reviewers will be asked to evaluate the performance, record, accomplishments, recognition and standing of the candidate in the major area of emphasis of his or her role statement. ~~Each external reviewer should be asked to state the nature of his or her acquaintance with the candidate and to evaluate the performance, record, accomplishments, recognition and standing of the candidate in the major area of emphasis of his or her role statement.~~ If the candidate, department head, and tenure advisory committee all agree, external reviewers may be asked to evaluate the secondary area of emphasis in the role statement as well. Copies of these letters will become supplementary material to the candidate's file (see Code 405.6.3).

Under exceptional circumstances, a waiver of the external review process may be granted by the president when such a process is operationally not feasible for a particular set of academic titles and ranks.

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# 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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**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.

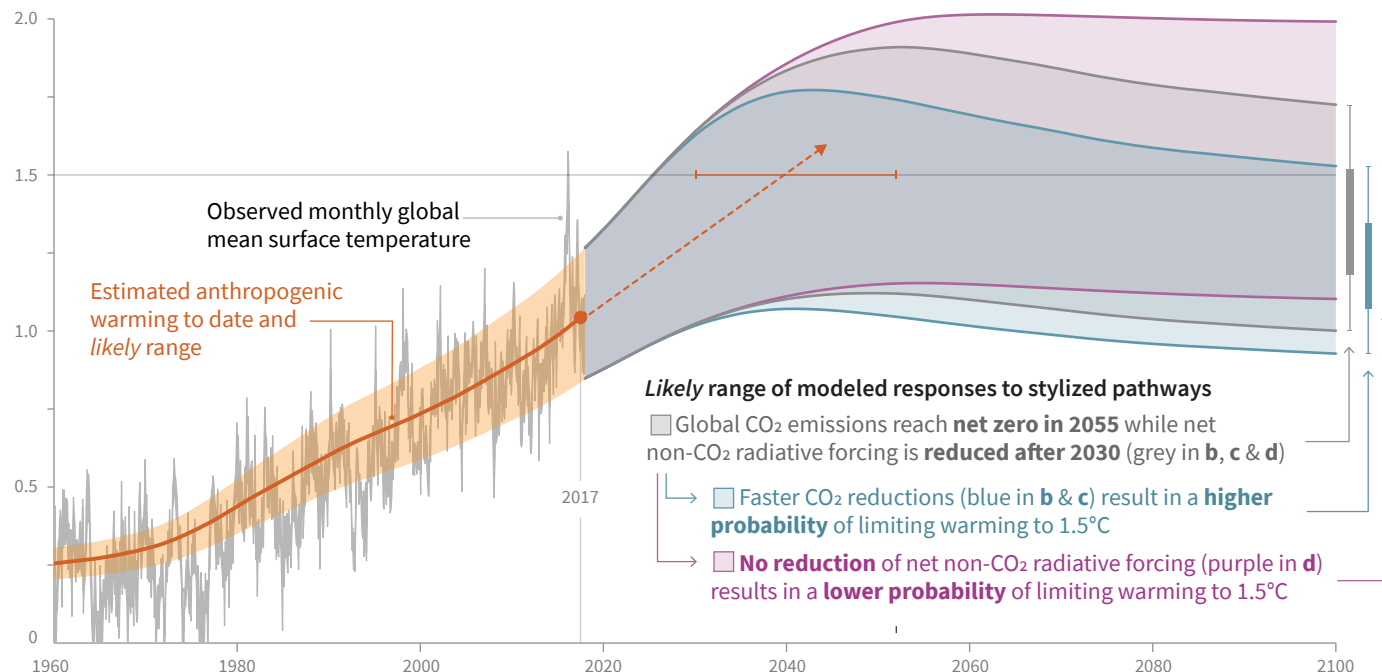
<sup>6</sup> This range spans the four available peer-reviewed estimates of the observed GMST change and also accounts for additional uncertainty due to possible short-term natural variability. {1.2.1, Table 1.1}

**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

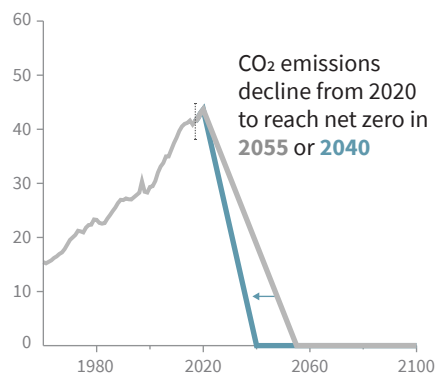
## a) Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways

Global warming relative to 1850-1900 (°C)



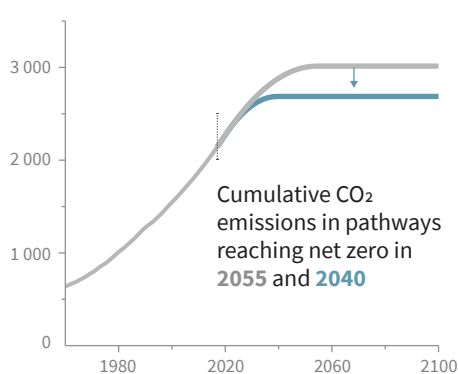
### b) Stylized net global CO<sub>2</sub> emission pathways

Billion tonnes CO<sub>2</sub> per year (GtCO<sub>2</sub>/yr)



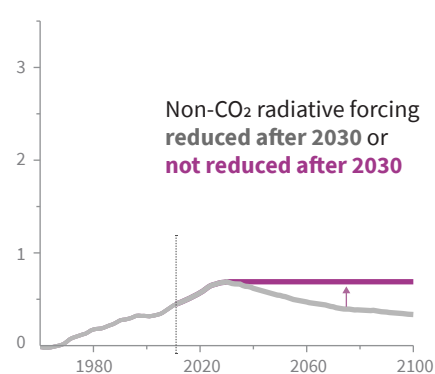
### c) Cumulative net CO<sub>2</sub> emissions

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}

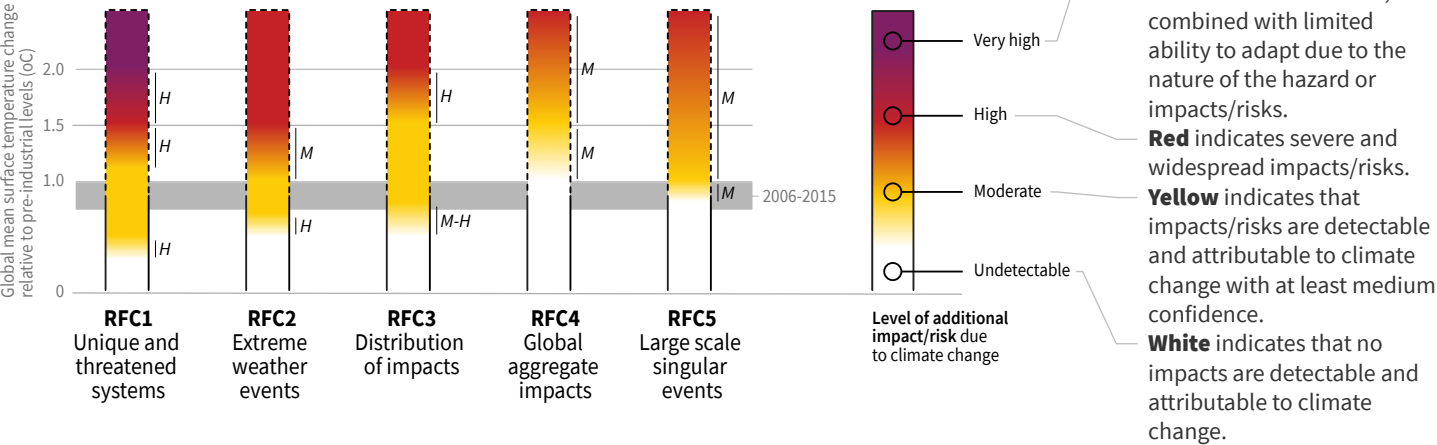
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<sup>10</sup> Here, impacts on economic growth refer to changes in GDP. Many impacts, such as loss of human lives, cultural heritage, and ecosystem services, are difficult to value and monetize.

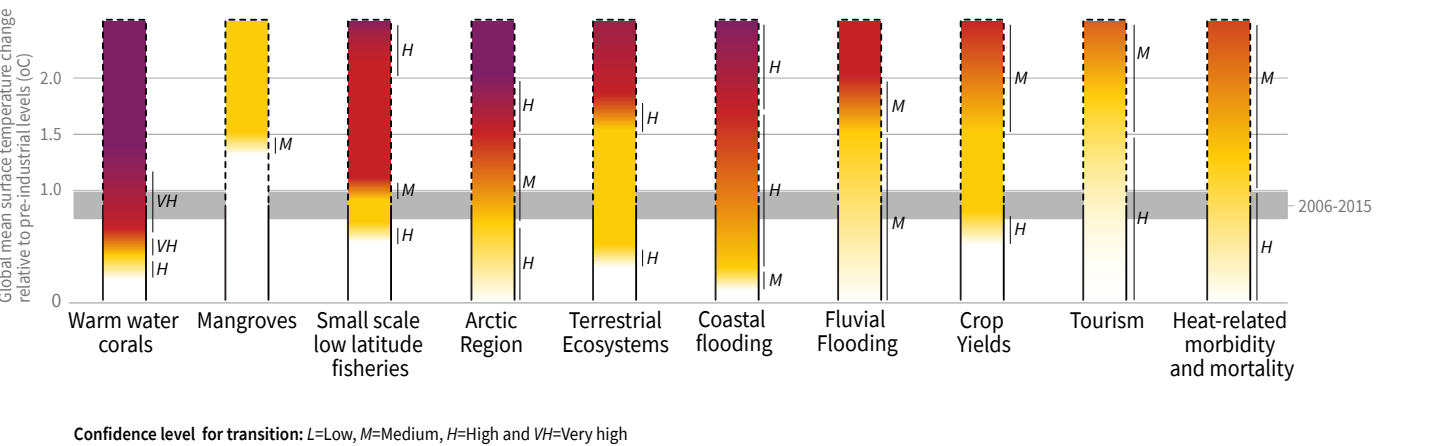
# How the level of global warming affects impacts and/or risks associated with the Reasons for Concern (RFCs) and selected natural, managed and human systems

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.

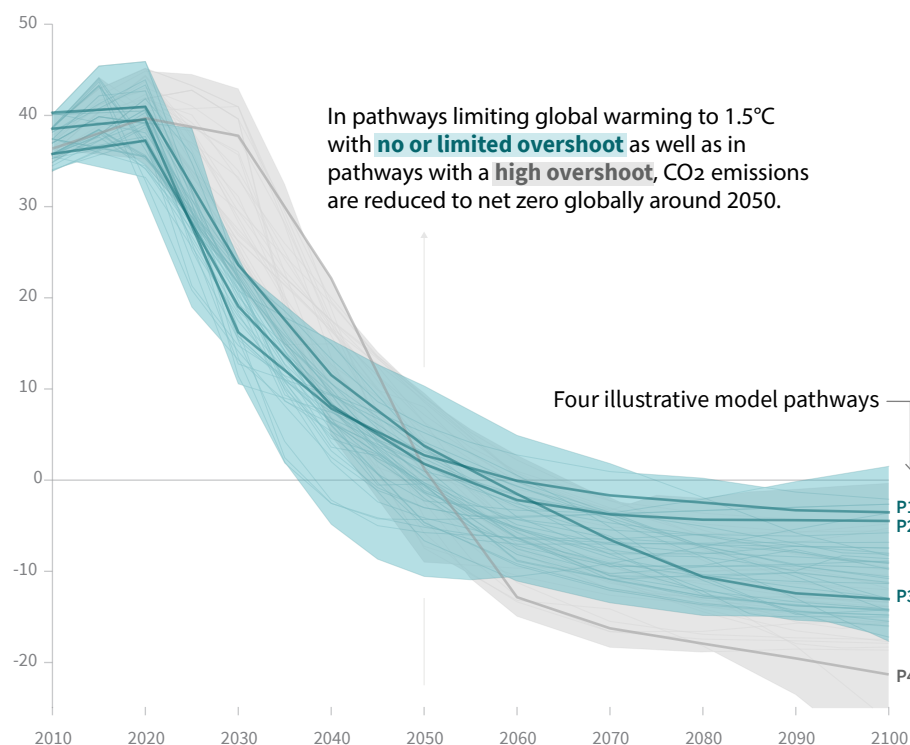
institutional and social constraints to deployment related to governance, ethics, and impacts on sustainable development. They also do not mitigate ocean acidification. (*medium confidence*). {4.3.8, Cross-Chapter Box 10 in Chapter 4}

## 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

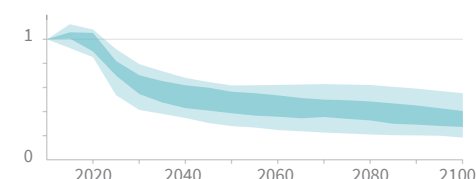
Billion tonnes of CO<sub>2</sub>/yr



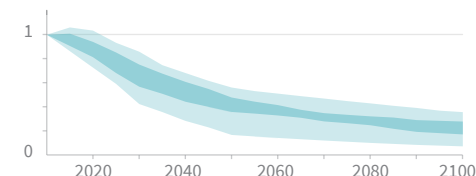
### Non-CO<sub>2</sub> emissions relative to 2010

Emissions of non-CO<sub>2</sub> forcings 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.

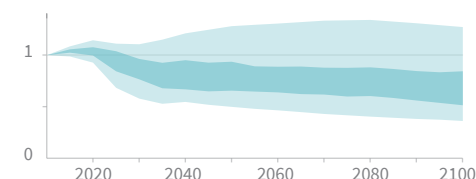
#### Methane emissions



#### Black carbon emissions

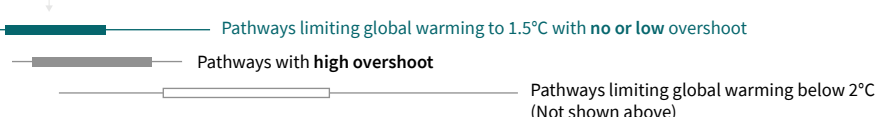


#### Nitrous oxide emissions



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

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



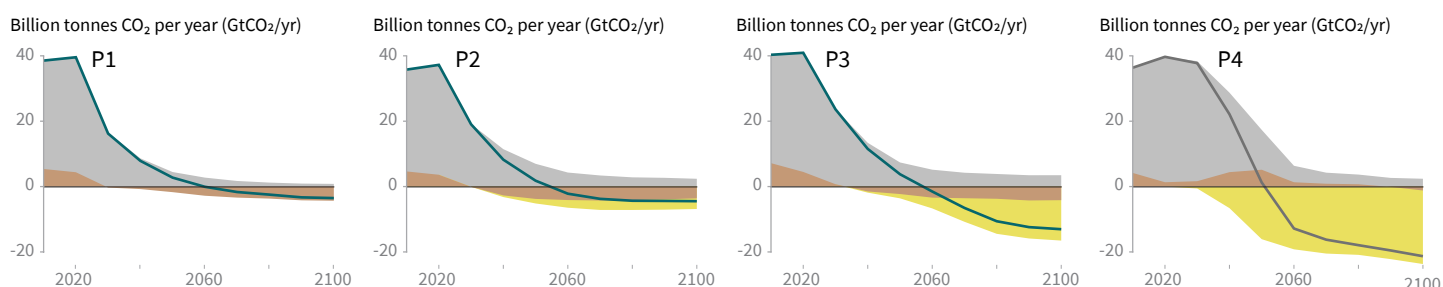
**Figure SPM3a:** Global emissions pathway characteristics. The main panel shows global net anthropogenic CO<sub>2</sub> emissions in pathways limiting global warming to 1.5°C with no or limited (less than 0.1°C) overshoot and pathways with higher overshoot. The shaded area shows the full range for pathways 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.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

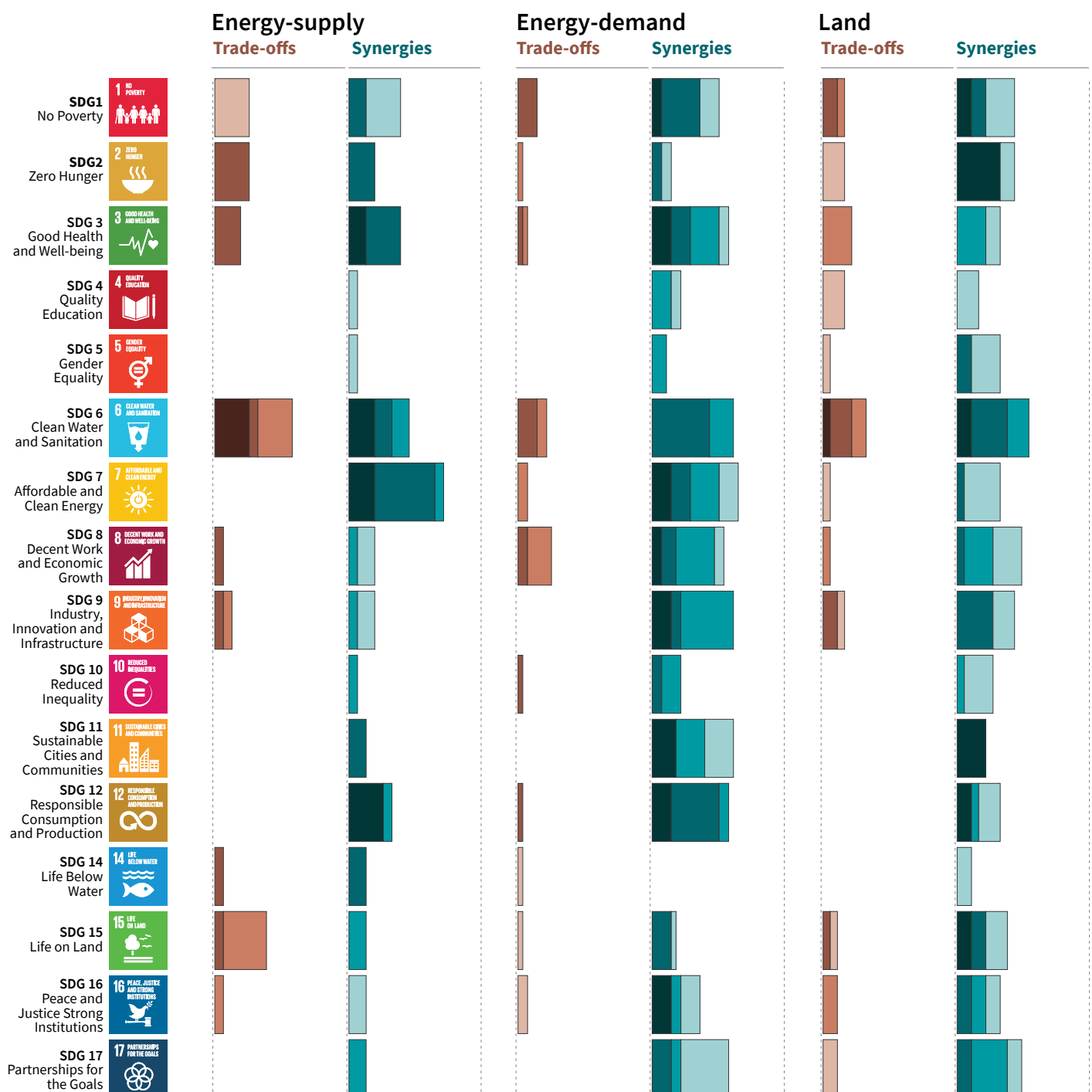


The overall size of the coloured bars depict the relative for synergies and trade-offs between the sectoral mitigation options and the SDGs.

## 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.