

**Scoping Meeting for the 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**

World Meteorological Organization, Geneva, Switzerland  
15-18 August 2016

**SCOPING MEETING BACKGROUND DOCUMENT**

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**1. Introduction**

This paper is provided as input for participants of the scoping meeting for the 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”, to be held from 15-18 August 2016 in Geneva, Switzerland. It presents the perspectives of the Scientific Steering Committee (SSC) of this scoping meeting.

Understanding the impacts of 1.5°C of warming, as well as the societal challenges faced along the transformative pathways to limit warming to 1.5°C requires a concerted level of multidisciplinary dialogue and interdisciplinary integration. The Special Report poses a challenge for IPCC, necessitating a full and balanced cross-Working Group perspective, including the expertise of the Task Force on National Greenhouse Gas Inventories and a stronger integration of the social sciences and the concerns of the practitioner community.

It is essential that those involved in the scoping – and eventually – writing of the Special Report meet this challenge, integrating knowledge from different social and natural scientific disciplines so as to give a coherent picture of the impacts of warming of 1.5°C above the pre-industrial levels and to assess the state of knowledge about the related greenhouse gas emission pathways, transformative challenges and opportunities.

This document presents the expected outcomes from the scoping meeting in Section 2; provides context to the invitation for the Special Report, including issues related to meeting the needs of the United Nations Framework Convention on Climate Change (UNFCCC) and other stakeholders in Section 3; frames the societal challenges in Section 4; sets out a suite of themes and scientific questions for consideration by participants in Section 5; raises some methodological challenges faced by the Special Report in Section 6; and concludes in Section 7.

The Chair of the IPCC established a Steering Committee to undertake the scoping of the special report (composition provided in Annex 1), with overarching support provided by the Technical Support Unit (TSU) for IPCC Working Group I (Annex 2).

## 2. Expected outcomes from the scoping meeting

During the scoping meeting, participants are invited to discuss all aspects of the scope, outline, and contents of the report. Recommendations are to be developed on the proposed structure of the Special Report, specifically:

- Title of the report, chapter structure, with an indicative length for each chapter;
- An annotated list of topics to be addressed by the authors of each chapter;
- Recommendations for the use and placement of communication tools such as Frequently Asked Questions (FAQs) and boxes (including case-studies);
- Recommendations for the form of the Summary for Policy Makers;
- A recommendation as to whether or not a Technical Summary should be included and;
- Possible recommendations for the scoping of other components of the AR6.

The meeting outcomes will be submitted as a report to the 44th Session of the IPCC for approval (to take place in October 2016). The proposed report structure is subject to modification by the Panel before final approval. The SSC will prepare the meeting report that will include the recommendations identified above and a description of preparations for the meeting and its conduct.

Upon approval by the IPCC, a call for authors will be issued around the areas of expertise defined by the chapter structure and content of the Special Report.

## 3. Context

### 3.1 The Paris Agreement and the UNFCCC invitation

The COP21 Paris Agreement<sup>1</sup> seeks to strengthen the global response to the threat of climate change, limiting the increase of global average temperature to "well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels", with the "aim to reach global peaking of greenhouse gas emissions as soon as possible" and "achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century". Nationally determined contributions will be evaluated on a 5-year cycle through a global stocktaking mechanism being established by the UNFCCC, supported by a facilitative dialogue in 2018, and a first formal review in 2023.

As part of the COP21 Paris agreement, the UNFCCC invited the IPCC to develop a Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways. The IPCC accepted the UNFCCC's invitation at its 43rd Session (11-13 April 2016, Nairobi, Kenya), noting the context of strengthening the global response to the threat of climate change, sustainable development and efforts to eradicate poverty.

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<sup>1</sup> [http://unfccc.int/paris\\_agreement/items/9485.php](http://unfccc.int/paris_agreement/items/9485.php)

This invitation builds partly on the 2013-2015 Structured Expert Dialogue (SED)<sup>2</sup> between experts and Parties to the UNFCCC. This dialogue concluded that a long-term global goal defined by a temperature limit serves its purpose well, but that the limitations of working only with a temperature limit could be taken into account, for example, by aiming to limit global warming to below 2°C. It also concluded that limiting global warming to below 2°C necessitates a radical transition through deep decarbonization starting now and going forward, not merely a fine tuning of current trends.

Along with the IPCC assessments and the SED, the science-policy dialogue and the global response to climate change has gained momentum in recent years. The post-2015 inter-governmental development agenda encompasses the adoption in 2015 of the Sendai Framework for Disaster Risk Reduction<sup>3</sup>, the 2030 Agenda for sustainable development<sup>4</sup>, including a climate action target, and the New Urban Agenda under preparation for adoption at the United Nation Habitat III<sup>5</sup> Summit in October 2016.

### 3.2 Reports scheduled for the IPCC 6<sup>th</sup> Assessment Cycle (AR6)

The scoping of this Special Report must carefully consider the other reports that will be prepared by the IPCC within the 6<sup>th</sup> Assessment Cycle to ensure that the suite of reports is coherent, complete and does not involve unnecessary overlap. A particular challenge will be to ensure that the Special Reports do not expand in scope to take on the characteristics of a scaled down Assessment Report and comprehensively cover topics best covered in the full Assessment Report. A key outcome of this scoping meeting will be to identify the critical topics that must be addressed specifically in this Special Report, considering that the 1.5°C report is a unique opportunity to integrate across disciplines and Working Groups.

The other reports scheduled during the AR6 cycle are:

- a Special Report on climate change and oceans and the cryosphere, scheduled for 2019;
- a Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems, where the scoping process may consider challenges and opportunities for both adaptation and mitigation. This special report is scheduled for 2019;
- a Methodology Report(s) on national greenhouse gas inventories, scheduled for 2019; and
- the full AR6 report (Synthesis Report and Working Group reports), scheduled for 2021-2022.

In addition, a Future Earth-PROVIA-IPCC co-sponsored workshop is being held in Stockholm on 29-31 August on "Integrating science across the IPCC on climate risk and sustainable solutions: Lessons learned from AR5 to support AR6", and an IPCC co-sponsored International Scientific Conference on Climate Change and Cities will take place during the AR6 cycle.

The scheduled approval of the final 1.5°C Special Report in a plenary IPCC session scheduled in **September 2018** gives a very tight schedule for the authors of this report and for new scientific publications to be assessed. Literature to be assessed will need to be submitted for publication by **October 2017** in order to be included in the Second Order Draft for review, and will need to be accepted by **April 2018** in order to be included in the Final Draft review.

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<sup>2</sup> [http://unfccc.int/science/workstreams/the\\_2013-2015\\_review/items/7521.php](http://unfccc.int/science/workstreams/the_2013-2015_review/items/7521.php)

<sup>3</sup> <http://www.unisdr.org/we/coordinate/sendai-framework>

<sup>4</sup> <https://sustainabledevelopment.un.org/post2015/transformingourworld>

<sup>5</sup> <https://www.habitat3.org/>

### 3.3 Building on key findings from the IPCC 5th Assessment Report (AR5)

Major conclusions of the AR5<sup>6</sup> were:

- Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.
- Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions, which, together with adaptation, can limit climate change risks.
- Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term, and contribute to climate-resilient pathways for sustainable development.
- Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales, and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives.

On the specific issue of warming below 2°C relative to pre-industrial levels, the AR5 concluded that:

- There are multiple mitigation pathways that are likely to limit warming to below 2°C relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades and near zero emissions of carbon dioxide and other long-lived greenhouse gases by the end of the century.
- Implementing such reductions poses substantial technological, economic, social, and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges, but on different timescales.

The AR5 report identified global emissions pathways associated with limiting warming to below 2°C relative to pre-industrial levels with different likelihood levels, and the substantial changes in technology, economic development, society and institutions that would be needed to follow these pathways. Pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels would require even earlier changes at higher rates and degrees of transformation. The assessment of new scientific publications since AR5 is expected to provide further insight into how these pathways may be realized and the wider consequences in terms of sustainable development and poverty eradication.

### 3.4 Meeting the needs of the IPCC stakeholders

Following the recommendations of the IPCC Expert Meeting on Communication<sup>7</sup>, the SSC has undertaken a **pre-scoping consultation with stakeholders**. A questionnaire was sent to Focal Points and IPCC Observer Organizations and was made available for a broader response on the Special Report website<sup>8</sup>. The full results of this consultation will be presented at the scoping meeting.

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<sup>6</sup> SPM of AR5 Synthesis Report - [https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5\\_SYR\\_FINAL\\_SPM.pdf](https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf)

<sup>7</sup> [http://www.ipcc.ch/meeting\\_documentation/meeting\\_documentation\\_ipcc\\_workshops\\_and\\_expert\\_meetings.shtml](http://www.ipcc.ch/meeting_documentation/meeting_documentation_ipcc_workshops_and_expert_meetings.shtml)

<sup>8</sup> <http://www.ipcc.ch/report/sr15/>

To be policy-relevant, the 1.5°C report must provide a rigorous assessment of answers to questions from stakeholders, and specifically the needs of the UNFCCC. To inform future UNFCCC work, there are **substantive challenges** that the 1.5°C report is expected to address:

- Given the UNFCCC's fundamental goal of avoiding dangerous interference in the climate system<sup>9</sup>, what are the adaptation needs and capabilities of natural and human systems to the adverse impacts of climate change of 1.5°C; how will the resilience of these systems be affected by climate change impacts and emission reduction efforts; and how likely is it that climate warming limited to 1.5°C allows society to avoid threats to food production?
- What are the implications for "loss and damage" if warming is limited to 1.5°C? How do the impacts of measures taken in response to climate change interact with the impacts of climate change itself?
- Noting the adoption of the Sustainable Development Goals (SDGs), what are the implications of both climate change impacts and emission reduction pathways associated with 1.5°C for sustainable development and eradication of poverty?
- Given the acknowledged gap between National Determined Contributions (NDCs) and the long term objectives of the Paris Agreement, what are the needs and prospects to limit warming to 1.5°C, and how can the IPCC inform the global stocktaking process?
- What are the benefits of avoided impacts given different levels of mitigation efforts?
- What are the needs for climate finance for significantly increased mitigation efforts and concurrent adaptation efforts to prepare for and manage the climate change impacts of 1.5°C?
- What types and level of capacity-building are needed – in both developing and developed nations – to meet the transformative challenges involved in limiting warming to 1.5°C?
- What negative emission technologies are available and practically feasible to help meet the "net-zero" emissions aim?
- What is the role of other options for influencing the climate system ("geo-engineering") in different impacts scenarios and emissions pathways; what are their implications; and what factors determine the feasibility of deploying such options?
- What are the needs, opportunities and barriers associated with technology development and transfer?
- How can we adequately consider and evaluate the roles of the diverse range of stakeholders (civil society, the private sector, financial institutions, cities and other subnational authorities) required by the Paris agreement "to scale up their efforts and support actions to reduce emissions and/or to build resilience and decrease vulnerability to the adverse effects of climate change"?

It is also necessary to bear in mind the ultimate objective of the UNFCCC, as indicated in Article 2 of the Convention, i.e., "to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner". The Convention also established in Articles 4.8 and 4.9 the request "to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change and/or the impact of the implementation of response measures". The needs of this specific set of stakeholders should be considered in the elaboration of the report.

#### **4. Societal transformation challenges and trans-disciplinary implications**

The impacts of 1.5°C of warming above pre-industrial levels and related greenhouse gas emissions pathways place before society and policy-makers the dual challenges of a) effectively preparing for and adapting to the impacts of such warming, and b) making emission reduction efforts at a level that would avoid such a level of warming. Both

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<sup>9</sup> [http://unfccc.int/files/essential\\_background/convention/application/pdf/english\\_paris\\_agreement.pdf](http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf)

would require substantial societal acceptance, support, compliance, and adjustments and thus constitute profound challenges: a wholesale transformation is required to avoid warming beyond 1.5°C of warming, and wholesale transformation will be required if the globe warms beyond 1.5°C.

"Business-as-usual" pathways in energy and land use, resource use, development and socio-economic policies will not achieve such ambitious climate and sustainability goals. The scoping of this report must carefully and systematically consider the interrelationships between climate change, mitigation and adaptation responses, and sustainability as decision-makers address these challenges in specific contexts, choosing the means and mechanisms available to them. While the scope of the challenge is generally understood in the scientific and a growing policy and practitioner community, much of the public is still unaware of the enormity of the challenges involved in responding to and mitigating climate change.

To produce an assessment relevant to these transformative societal challenges, scoping meeting participants and, eventually, report authors are asked to scope and conduct an integrative yet rigorous and focussed assessment. Useful questions to bring focus to the societal challenges involved may include the following:

- Is there only one way or are there multiple ways to think of or envisage transformation or development?
- What types of knowledge are needed – from within science and beyond – to document a plurality of models of social transformation? How can we include and integrate the contributions of climate and Earth system modelling, natural and economic sciences with those from the humanities and social sciences in a rigorous assessment of the impacts of 1.5°C and associated emission pathways?
- What do we know from the various sciences about physical, ecological and social inflection points that could either undermine or accelerate the transformative changes needed to avoid climate change beyond 1.5°C, environmental degradation, and societal destabilization?
- What can we learn from the practitioner community about the opportunities and challenges to transformation on the ground?

Maybe more than in previous IPCC assessments, scientific understanding will be challenged, as this report is tasked to assess the state of knowledge about complex systems and projected system changes that go beyond empirical evidence and historical experience. Thus, scoping meeting participants and report authors are expected to constantly challenge themselves and the published literature on underlying assumptions about natural and social system changes, feasibility and rates of transformations.

## **5. Framing the scientific challenges**

In addition to the societal transformation issues, the 1.5°C report entails a number of scientific challenges. They are grouped here by broad themes, within which a number of scientific questions are posed. The purpose of the themes and the questions is to prompt discussion at the scoping meeting. It is not to suggest that the Special Report will address all of these questions, that there is a relevant literature amenable to assessment by the IPCC, or that the themes might define the structure of the Special Report. Comprehensive coverage of all the questions is unlikely to be possible and it will be up to the meeting to determine which might best be covered in the Special Report rather than the full AR6 assessment.

## *Changes in the climate system and response to perturbations of the Earth's energy balance*

Projecting changes in the climate system, including regional changes associated with global long-term temperature change of 1.5°C or higher, since the pre-industrial period, depends on complex and computationally demanding global climate models, including Earth System Models. The timescales of climate system dynamical responses and the timescales of upscaling global mitigation efforts will complicate the ability to project climate changes. More specifically, questions to be considered include:

- How has global mean surface temperature changed since pre-industrial levels, in relationship with other key characteristics of the climate system?
- How are anthropogenic climate change and climate variability currently expressed at both global and regional scales?
- What will be the interplay between natural variability and long-term climate response to human influence, including extreme events, abrupt change, and slow-onset events<sup>10</sup>, for different amplitudes of global warming?
- If warming is limited to 1.5°C, what are the projected changes in regional temperature, water cycle, characteristics of extreme events, state of the cryosphere, ocean heat content, ocean chemistry and sea level at global/regional scales?
- How has understanding of climate sensitivity and its impact on climate response and pathways changed since AR5?
- How sensitive are climate projections for the near term (i.e., 2035) to various pathways?
- What is our understanding of the impacts of other climate drivers in addition to CO<sub>2</sub>, especially the role of short-lived gases, aerosols and land use?
- What are the projected changes in global biogeochemical cycles, including ocean acidification, marine and terrestrial primary productivity (and bioenergy potentials), what are the characteristics of Earth system feedbacks in pathways with decreasing or negative CO<sub>2</sub> emissions?
- What is the available carbon budget to stay below 1.5°C in light of a) larger cumulative emissions, b) the current state of the climate system, and c) new scientific findings since the AR5? How does this compare to the carbon budget for other temperature limits, given the uncertainties in climate sensitivity and the carbon cycle?

## *Mitigation pathways*

There are multiple mitigation and emission reduction pathways consistent with a 1.5°C global mean temperature increase (and other global temperature goals); each is associated with different levels of likelihood. A charge to the 1.5°C report is to distinguish these from pathways consistent with larger temperature increases. Potential questions include the following:

- What are the possible pathways and how do they dynamically evolve (in the short and long term)? When do peak emissions need to occur? How do different pathways balance anthropogenic sources and sinks? How do sources and sinks vary at global, regional, national and sub-national scales?
- What are the implications of a 1.5°C target vs. a 2°C target vs. current climate policies (NDCs) for the pathways, types of mitigation measures and the rates of their deployment? What are the implications of any of these pathways for sustainable development, poverty eradication and food security?

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<sup>10</sup> **Slow onset events, as included in Decision 1/CP.16**, include: desertification, glacial retreat and related impacts, land and forest degradation, loss of biodiversity, ocean acidification, increasing temperatures, salinization, sea level rise

- What are the implications of different pathways for the likelihood of overshoot and the probabilities of reaching/returning to 1.5 °C and other targets?
- What are the regional and global land-use scenarios consistent with 1.5°C and what are their consequences for other sustainability goals?
- What implications do high-level mitigation pathways hold for progress in reducing energy intensity, decarbonizing energy supply, CO<sub>2</sub> removal from the atmosphere and research, development and demonstration of less mature mitigation technologies and options?
- What are the implications of the deployment of various negative emission technologies and geo-engineering options for emission pathways? What are the wider implications of geoengineering for reversible and irreversible impacts on climate/carbon cycle feedbacks, as well as natural and managed systems?

### *Impacts on ecosystems and human systems*

Impacts on terrestrial, freshwater and marine ecosystems and human systems will emerge under both 1.5°C and higher levels of warming with differences between regions and climate scenarios in time of emergence, intensity, rates, thresholds, and trajectories. The complexities of these systems will challenge the assessment to differentiate among levels of warming, however, evidence from observed impacts and the functional understanding of ecosystems and human systems allow a range of questions to be considered such as:

- How do projected climate impacts for a given warming level vary depending on the underlying emissions pathway? What are the avoided impacts with a 1.5°C stabilization target versus a 2°C stabilization target and beyond?
- What are the impacts of 1.5°C warming (with and without adaptation) on terrestrial, freshwater and marine natural and managed systems including on their productivity, structure and functioning?
- What are the impacts of 1.5°C warming on human systems, including agriculture/crop production, food security, land use change, water access, disease/health, cities, and cultural heritage?
- What are the impacts of 1.5°C warming on fisheries and aquaculture, and ocean-dependent industries (shipping, resource extraction, tourism)?
- What are the impacts of 1.5°C warming on livelihoods and poverty, well-being (including indigenous groups) and regional security?
- When natural or social systems are pushed outside their observed ranges, what is known about their possible (linear or non-linear) behaviour and what are the consequences of these shifts for system characteristics and functioning? What is known about their resilience?
- To what extent is historical experience informative or limiting to the understanding of future impacts trajectories?

### *Risks and Adaptation*

The observed patterns and limits of adaptation *in situ* to the impacts of global warming by ecosystems, human communities, or even entire nations (e.g., small island states) suggest that adaptation is already a challenging issue for many. In many instances, effective, context-sensitive societal adaptations require transformations that need to be implemented rapidly. Countries vary greatly in their ability to deal with these challenges. Some questions to consider include:



- What are the requirements, options, and opportunities of adaptation across systems and sectors? What adaptation options are available to meet the challenges associated with the impacts of 1.5°C warming? What conditions will enable these adaptation options to be effectively implemented?
- What is the potential to effectively utilise ecosystem-based adaptation in marine, freshwater and terrestrial systems, particularly for poor and vulnerable communities?
- Can we identify gradual and significant differences in magnitude, probability, severity of impacts and associated risks from warming up to 1.5°C compared to 2°C and above, also considering natural variability? How would such differences inform adaptation pathways?
- Can we assess the progress, constraints and limits to adaptation for natural, managed and human systems with different degrees of climate change? What are the implications for adaptation if the 1.5°C goal is not attained?
- What critical lessons can be learned for the adaptation challenges associated with the impacts of 1.5°C from the adaptation responses to date, attempted or implemented at different levels, to the impacts of climate change that are already being experienced?
- What are the costs and feasibilities of adaptation pathways across temporal scales and emission trajectories including ambitious mitigation?
- What are the impacts and vulnerabilities arising from ambitious mitigation attaining 1.5°C and what are the consequences for adaptation needs and effectiveness? Are there negative feedbacks in terms of adaptive capacity of natural, managed and human systems?
- What are the co-benefits, tradeoffs and negative feedbacks between emission trajectories and the various adaptation options at various scales, and in different regions?
- When or under what circumstances will adaptation limits be approached, reached, or exceeded by ecosystems, different nations, communities, and economic/industrial sectors if warming is or is not limited to 1.5°C?

### *Mitigation options and their wider impacts*

Pathways associated with 1.5°C will require the greater uptake, at a faster rate, of a range of mitigation options already addressed in the literature. They may also entail the deployment of options, including negative emission technologies, that have received less attention and where there are knowledge gaps. In addition, the large-scale deployment of some options may have implications for poverty eradication, food security and sustainable development of the type associated with climate change itself. The 1.5°C report is charged to distinguish these from pathways consistent with larger temperature increases. Potential questions to explore through the integration of top-down models and bottom-up sector studies, including mitigation potential by sector and emission component, include the following:

- What are the possible pathways and how do they dynamically evolve (in the short and long term) and when do peak emissions occur? How do different pathways balance anthropogenic carbon sources and sinks? What are the implications of any of these pathways for natural systems, sustainable development, poverty eradication and food security?
- What are the options, costs, feasibility, and consequences of different mitigation technologies and measures, including emerging opportunities such as blue carbon, that would be required to limit warming to well below 2°C? What are the milestones and timetables for research, development, demonstration and deployment of these options compared to current plans and activities? What are the consequences of locking-in to high-carbon infrastructure and technologies?
- What is the role of biofuels? What are the key food vs. fuel issues associated with different pathways to 1.5°C? What economic and social tensions due to the competition for land (food-energy -water-

sequestration) might arise? What are the side-effects (albedo, surface energy fluxes, non-CO<sub>2</sub> emissions, socioeconomic consequences) of large-scale bioenergy?

- What negative emission technologies and other geo-engineering techniques might be available and on what timescales? What is the magnitude of their potential and their possible costs and also that of the management of impacts (responses)? What are the implications of large-scale deployment in terms of poverty eradication, food security and sustainable development and social acceptability? What are the governance, ethical and equity aspects of negative emission technologies and other geoengineering options?
- What are high-level indicators (energy/GDP, zero-carbon energy, carbon removals etc.) that would allow nations to track progress along their mitigation pathways? What would constitute useful and effective “carbon accounting”?
- What are the tools available for initiating and sustaining rapid social change at different levels of social organization (e.g. State, communities, households, industrial sectors, businesses, and civic networks)? How effective are economic interventions, regulatory tools, legal or educational approaches, and other tools, and in which contexts, under which circumstances? What are the most effective leverage points? What are the limitations to people's knowledge of climate change, sustainability, mitigation and adaptation, as well as their willingness and ability to act? What challenges persist that prevent the scaling up or broader application of these approaches and what opportunities exist to expand these approaches?
- Regarding measurement, reporting and verification (MRV) of human influences on the climate system toward a 1.5°C goal, what is the role of greenhouse gas emission inventories in the MRV process? What is the role of indirect greenhouse gas emissions and associated MRV needs? What is the role of MRV of other human influences in the climate system (SO<sub>2</sub>, aerosols, black carbon, albedo, etc.) and associated information needs?

### *The interaction of climate risks, adaptation and mitigation*

In anticipation of emerging and potential impacts, adaptive responses will have to be implemented at the same time that strong mitigation efforts must be undertaken, adding to the burden on nations, industries, human communities, and households. Including geoengineering in this portfolio would further increase the complexity of governance challenges of mitigation, planning for impacts, and MRV.

The 1.5°C report is thus expected to maintain a holistic, integrative perspective of mitigation and adaptation, including the consideration of broader sustainability and resilience challenges, while identifying critical leverage points for synergistic, transformative and positive change. Some questions to consider include:

- Can the risks of climate change be reduced by synergies and linkages between adaptation and mitigation, taking into account climate-dependent capacities for adaptation and mitigation, the pre-existing state of human and socio-economic development in the context of the sustainable development goals?
- Can thresholds leading to significant and irreversible impacts on natural and human systems be identified in relationship to different emissions pathways? How would potential overshoots affect the likelihood of crossing such thresholds?
- What are optimal balances of adaptation and mitigation actions and associated impacts, considering the possibility that high levels of mitigation may undermine adaptive capacity (and vice versa)?
- Considering adaptation and mitigation from a risk perspective in the context of reversible vs. irreversible risks, where and over what timeframes can adaptation and mitigation reduce risks to socially acceptable levels?

- Considering adaptation and mitigation from a cost and human benefit perspective, how can different policy instruments (e.g., climate finance, technology development and transfer) be deployed to minimize costs and damages and maximize benefits?
- What challenges may emerge from 1.5°C of warming on urban climates and associated challenges in urbanisation (patterns and processes), infrastructure development, urban adaptation and mitigation strategies (including co-benefits and conflicts)?
- How do perceptions and acceptability of and social attitudes toward the risks of climate change and response options vary across nations? What are the psychological, sociological, economic and cultural underpinnings of human responses to these risks and management efforts?

### *Adaptation and mitigation in relation to sustainable development, poverty eradication and food security*

Avoiding the impacts of global warming of 1.5°C above pre-industrial levels and efforts to advance sustainable development, including the eradication of poverty are inter-related global concerns. As the unfolding impacts of global warming induce persistent stresses beyond people's coping capacity or produce repeated catastrophic disruptions, uncertainty, greater vulnerability for the poorest, and social tensions grow and may undermine the prospects of sustainability, human dignity and well-being. The scoping meeting must carefully consider the interactions between impact of climate change, societal responses to climate change, and the prospects and efforts needed to achieve the sustainable development goals through questions such as:

- What are the impacts of low emission pathways and negative/zero emission technologies on sustainable development, poverty, food security, energy access, biodiversity, air quality, energy access and energy security, including the different impacts of 1.5°C versus 2°C warming?
- Which impacts, globally and regionally, can undermine the fulfilment of sustainable development goals and/or exacerbate the vulnerability of societies?
- Can the ultimate objective of UNFCCC (Article 2) and Article 2 of the Paris Agreement act as mechanisms to stimulate early action that can avoid negative emissions in the long-term and safeguard against climate extremes? How much breathing space is gained that will simultaneously help avoid degradation of terrestrial, freshwater, and ocean ecosystems, agriculture production and food security and enable equitable economic development?
- Is it possible to think about sustainable development as a plurality of models of development for different nations, regions and cities? What alternative models of development exist that are sustainable for different communities, including their ecosystems, by shaping ways of living that are perceived as viable, acceptable and culturally appropriate? What is known about the co-existence of such different development models?
- What are the distributional and ethical implications of mitigation efforts required to limit warming to 1.5°C? What are the distributional and ethical implications of not limiting warming to 1.5°C?
- What are the avoided costs in terms of reduced impacts associated with mitigation options?
- How can issues of justice and equity be addressed through different models of sustainable development? How can the impacts of global warming (and related mitigation and adaptation responses) also be an opportunity to address poverty, migration and other sustainability challenges in specific contexts?
- What is the best balance of technological solutions, market mechanisms, and other socio-cultural interventions? Which criteria should be used to assess their feasibility, appropriateness, effectiveness, and acceptability? For example, what is the capacity of a community to manage the technology now and in the future? What are potential side effects? Where unacceptable trade-offs are confronted, what creative solutions could make a difficult path of change more acceptable?

### *Socio-technical transitions*

The challenges of large-scale transitions associated with low emission pathways and net zero emissions must be viewed from a systems perspective. It must take into account how different mitigation measures might be integrated and what the role of various policies, institutions and infrastructural developments at different levels is in facilitating such transitions. Potential questions to explore include:

- What is the role of governments (at various levels), international cooperation, the private sector and civil society in the socio-technical transition to a low-carbon society?
- What are the drivers of development trends that would significantly influence transition costs and economic conditions for this transition (finance, compensatory transfers, fiscal reforms, public infrastructure etc)?
- What are the socio-economic implications of the rate of decarbonisation for different countries and sectors? What are the sustainability and resilience co-benefits (e.g. health) and adverse effects of negative and zero emission technologies?
- What is the relevance and use of the Shared Socioeconomic Pathways in assessing the potential of socio-technical transitions?
- What is the use and effectiveness of the 1.5°C global temperature limit target to anchor economic measures and financial incentives and support the implementation and reinforcement of Nationally Determined Contributions?
- What is the role of climate finance and technology development and transfer in socio-technical transitions? What non-technical, non-financial measures and interventions can be mobilized to assist in a transition to a zero-carbon society?

### *Integrative framework for implementation pathways*

In AR5, climate change impacts and responses were viewed through a risk-based framing. In AR6, the intention is to move toward a solutions-focused, problem-solving framing and analysis. Such a focus would imply questions such as the following:

- Can we identify global-scale opportunities for interventions that have clear implementation pathways? For example, given the current rate of urbanisation, what can be achieved with infrastructure development? What are other opportunities to avoid carbon-lock-in?
- How can local governments, large businesses, and civil society be mobilised to take a more active role in achieving emission cuts and sustainability goals?
- Can we identify global-scale opportunities that – if effectively realised – could significantly accelerate the transformation to low-carbon futures? Are there opportunities that at the same time meet the requirements of the 2030 Development Agenda, i.e., help improve well-being and ensure that no one is left behind?
- Can we determine how much time different countries, regions, and sectors have to achieve certain levels of transformations in their emissions pathways so as to achieve the 1.5 °C target while also achieving sustainability goals?
- Can we also assess transformative pathways from a social perspective, including the associated challenges and opportunities of realising them?

## 6. Methodological challenges

In addition to the specific scientific questions that this report might address, an integrated assessment of the impacts of 1.5 °C and associated emission pathways also poses methodological challenges, here described in three main categories.

### 6.1 Baselines, targets, alternative pathways

A number of these methodological challenges stem from differences in defining baselines, selecting different temperature or alternative climate indicators, and the alternative ways of reaching them. Relevant questions include, but are not limited to:

- Given the singular focus of the special report on 1.5°C, how can the benefits of achieving this target best be assessed and communicated? What is the best baseline comparison (e.g., impacts above current conditions or avoided impacts associated with a business-as-usual scenario or a 2°C scenario), given that the assessment of impacts and risks depends on the rates of change?
- What are the limitations of using global mean surface temperature change as a single indicator of the state of the climate system? What are other complementary suitable indicators of change to characterize the climate response to human influence, and for which purpose is their (additional or alternative) use most appropriate (e.g. rate of change, sea level rise, sea ice, ocean heat content, ocean acidification)? What are the best indicators, considering that impacts on natural and human systems depend on pathways and rates of change?
- What is the best way to characterize the pre-industrial reference level and warming above a pre-industrial level, compared to how this was done in the AR5?
- How can non well-mixed greenhouse gas drivers and other drivers linked with human activities (aerosols, land use) be best accounted for?
- How can pathways associated with 1.5°C and those associated with other (higher) levels of warming be confidently distinguished in terms of the evolution of the climate system and climate impacts?

### 6.2 Uncertainties

Integrated assessment models offer the prospect of a synthetic and conceptual view of complex, interactive factors or drivers of change. Earth system models increasingly resolve complex dynamical and biogeochemical feedbacks of the climate system. Uncertainty cascades suggest that the level of cumulative uncertainty may produce a wide range of impact projections, making results of such studies of the impacts of 1.5°C of warming above pre-industrial levels difficult to distinguish from equivalent impact studies of 2°C of warming.

- Can the confidence level with which warming will remain below 1.5°C above pre-industrial levels be quantified? And if likelihood cannot be quantified, can the confidence in integrated scientific findings be assessed, given the diversity of analytical approaches underlying the existing knowledge base?
- How do we best characterize and communicate uncertainties in scenarios and pathways in climate response to different emission pathways (climate sensitivity, carbon cycle, radiative forcing of short- and long-lived greenhouse gases and aerosols, impacts of land use change, etc.), model structures and assumptions, socio-economic assumptions (SSPs), and parametric uncertainty?

### 6.3 Integrating different types of knowledge

Scientific knowledge is the basis of IPCC assessments. However, some questions may require a broader reach of inquiries and bodies of knowledge. For example, this is relevant when considering adaptive transformation pathways in resource-limited contexts where high technology mitigation options may be unrealistic. Integrating different knowledge systems may also enhance the perception of legitimacy and the broader relevance of the report. It would also offer opportunities for wider engagement in the assessment process. Some cultural translation and mediation may be needed. Relevant questions may include:

- How can robust knowledge be developed and assessed by scientific experts? How can assessment participants effectively draw on diverse sets of underlying information from communities who have very different (e.g., traditional, practical, scientific) knowledge systems and who speak and publish in various languages (i.e. not in English)?
- What is known about generating new cultural visions and pathways adapted to specific contexts of where people live (e.g., North/South; urban/rural; coastal/inland etc.)? How do perspectives, and thus engagement, differ by gender, age, socioeconomic status, and cultural background? How can these be better integrated in IPCC assessments?

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