Twelfth Meeting of the SBSTA Research Dialogue - Science for global net-zero: Updates on science and enhancing understanding to accelerate mitigation and adaptation

Note by the Chair of the SBSTA

4 November 2020

I. Introduction

1. The Paris Agreement provides the framework for action on climate change. As Parties submit updated or revised nationally determined contributions (NDCs) in 2020, Parties are considering how to move to a global net-zero greenhouse gas (GHG) emissions society (Article 4.1) whilst enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change (Article 7.1) in the context of the long-term temperature goal (Article 2). This action must be based on the best available science.

2. The work of the research and systematic observation agenda lies at the heart of the role of SBSTA as the interface between the Convention and the Paris Agreement and the scientific community. As part of the research and systematic observation agenda, the annual SBSTA research dialogue provides the opportunity for Parties to foster their understanding of the latest scientific developments and to allow for fruitful exchange between Parties and leading experts to inform climate decision making and action.

3. Six submissions[1] have been received by the secretariat from Parties providing possible themes and topics for the twelfth meeting of the research dialogue.

4. Building on the themes of previous research dialogues and in response to the submissions of Parties, the twelfth meeting of the research dialogue (2020) will explore the scientific research and understanding of moving towards net zero global anthropogenic carbon dioxide emissions (hereafter referred to as global net-zero) and building resilience to the unavoidable impacts and risks of climate change in this context. The meeting is undertaken in recognition of the strong basis provided by the three IPCC special reports made available in 2018-19.[2] The dialogue will provide scientific updates including on exploring current, near-term and future impacts and risks, mitigation in regards to both carbon dioxide reduction and removal, and adaptation. Furthermore, it will discuss aspects of enhancing understanding of different aspects of research and scientific information to accelerate action on mitigation and adaptation.

5. The COVID-19 pandemic is a world changing event with far ranging impacts on the science community. In June 2020, the SBSTA Chair held an information event on science and COVID-19.[3] The event discussed, among other impacts on science, new opportunities emerging for recovering sustainably from the COVID-19 crisis and this topic remains an important aspect of ongoing research work as well as decision making on climate change. The twelfth meeting of the research dialogue will include, as relevant, updates on understanding, and options for, sustainable recovery from COVID-19 in regard to global net zero.

[1] Submissions were received from the Belize on behalf of Alliance of Small Island States (AOSIS), Bhutan on behalf of the Least Developed Countries Group, Croatia and the European Commission on behalf of the European Union and its Member States, Fiji, Gabon on behalf of the African Group of Negotiators and Japan. See: https://www4.unfccc.int/sites/submissionsstaging/Pages/Home.aspx.

[2] Special Report on the Impacts of Global Warming of 1.5 °C, https://www.ipcc.ch/sr15;
Special Report on the Ocean and Cryosphere in a Changing Climate, https://www.ipcc.ch/srocc/; and
Special Report on Climate Change and Land, https://www.ipcc.ch/srccl/.

[3] Full event listing here: https://unfccc.int/event/sbsta-chair-information-event-with-the-scientific-community

6. In 2018, at the tenth meeting of the research dialogue, amongst other discussion, the importance of strengthening communication at the science/policy interface was highlighted. In 2019, at the eleventh meeting of the research dialogue (2019), the focus was on exploring the transformation needed for rapid emission reduction and building resilience through adaptation. This year's research dialogue meeting builds on these discussions to continue to provide the interface between the science, innovation communities and Parties to the UNFCCC so as to better understand what is needed to remain resilient to climate change and achieve global net-zero.

II. Themes and guiding questions

7. Based on the submissions from Parties, and in consideration of the mandates and the wider context of ongoing work under the UNFCCC, the SBSTA Chair identified two themes for the dialogue:

Theme 1. **Updates on advancements in research and modelling**.

Theme 2. **Factors for enhancing understanding to accelerate adaptation and mitigation.**

8. Suggested guiding questions include:

a) With regards to the topic presented, what is the latest scientific research and information available, and its implications for policy makers, to accelerate the sustainable way forwards post-COVID 19 towards resilience and a global net-zero society?

b) What are some of the research disciplines and/or research capacity building options that must be considered and better understood with regards to understanding how to accelerate action on climate change and sustainable development?

c) What are the opportunities, gaps and needs in research knowledge, access to research, capacity building for research, as well as in support to unlock understanding?

III. Format and indicative programme

9. The 12th meeting of the research dialogue will take place virtually over two days on **24-25 November** 2020. Theme 1 will be addressed on day 1 and theme 2 addressed on day 2. The programme consists of a number of events during the two days.

A. Dialogue Sessions

10. Oral presentations by experts and Q&A on both days will take place as follows:

Theme 1. 24 November 12.00-14.00 (CET)

Theme 2. 25 November 12.00-14.00 (CET)

B. Posters

11. Posters will be available via an online exhibition page THROUGHOUT the Climate Change Dialogues., and via the research dialogue event page thereafter.

12. Participants registered for the dialogue will also be able to participate in live audio-visual Q&A sessions with poster presenters at the following times:

Theme 1. 24 November 09:00-10.00 (CET) and/or 17:00-18:00 (CET)

Theme 2. 25 November 09:00-10.00 (CET) and/or 17:00-18:00 (CET)

C. Special Event

13. Launch of the World Adaptation Science Programme (WASP) Science and Adaptation Policy Briefs

24 November 16:00-17:00 (CET)

14. WASP will launch three new Science for Adaptation Policy Briefs (SAPBs) on i) Adaptation Decision Support Tools and Platforms, ii) Transboundary Climate Risks and Adaptation, and iii) Adapting to High-End Climate Risks and Adaptation. The authors will present the major findings and provide policy-related guidance. This will be followed by a stakeholder engagement in order to receive feedback.

D. Indicative Programme

15. The indicative programme of the event follows below. A detailed agenda will be made available on the event webpage.

Day 1 *24 Nov 2020*	**Theme 1:** **Updates on advancements in research and modelling**	
09:00-10:00 ***All times shown in CET***	**Poster Q&A theme 1** Between registered participants and poster contributors	*PLEASE NOTE: Posters available throughout the Climate Change Dialogues* *Contributors: TBC*
12:00-14:00	**Dialogue Part 1**	*Chair:* SBSTA Chair *Contributors from:* CBD, IAMC, IOC, WASP, WCRP, academic institutions, Parties
16:00-17:00	**Special event** **WASP Science and Adaptation Policy Briefs**	*WASP*
17:00-18:00	**Poster Q&A theme 1** between registered participants and poster contributors (Repeated)	*Contributors: TBC*

Day 2 *25 Nov 2020*	**Theme 2:** **Factors for enhancing understanding to accelerate adaptation and mitigation**	
09:00-10:00	**Poster Q&A theme 2** Between registered participants and poster contributors	*PLEASE NOTE: Posters available throughout the Climate Change Dialogues* *Contributors: TBC*
12:00-14:00 (CET)	**Dialogue Part 2**	*Chair:* SBSTA Chair *Contributors from:* APN, International Science Council, IRENA, academic institutions, Parties
17:00-18:00	**Poster Q&A theme 2 between registered participants and poster contributors** **(Repeated)**	*Contributors TBC*

IV. Next steps

16. Additional information on the dialogue including a detailed programme will be posted online at https://unfccc.int/node/210302.

17. The SBSTA Chair will prepare an informal summary report of the twelfth meeting of the research dialogue that will be made available early in 2021.

V. Background information

E. Relevant activities under the UNFCCC

18. This section provides information on some of the relevant engagement between the scientific community and the workstreams of the Convention.

19. The **Technology Executive Committee** (TEC) organised the Virtual Regional Technical Expert Meetings on Mitigation (TEM-M) 2020 on "Climate smart cooling solutions for sustainable buildings" where regional experts discussed the challenge of maintaining and creating sustainably cool interior spaces as the planet continues to warm. The outcomes of the meetings will be published in a technical paper and summary for policy makers in 2020.

20. The TEC held a session in October at the 4th Global Sustainable Technology and Innovation Community Conference to discuss "Innovative Approaches for Climate Adaptation Technologies". At the UNFCCC climate dialogues in November, the TEC will hold a session on innovative approaches to technologies and solutions for climate smart agriculture, and will discuss a compilation of 'good practices and lessons on international collaborative research, development and demonstration initiatives of climate technology' at TEC21. The compilation paper will be published before the end of 2020.

21. The **Paris Committee on Capacity-building** (PCCB) together with committed partners, co-designed the Capacity-building Knowledge to Action Days in 2019 and 2020. Sessions held during the 2019 Latin America and Caribbean and the Asia-Pacific Climate Weeks explored the very real and pressing challenge of translating research findings and existing knowledge into useful inputs for decision-makers and civil society. They also took a critical look at the problems surrounding the hierarchy of knowledge (e.g. climate impact models often seen as more relevant than findings from a community-based adaptation project). Several approaches to capacity-building were conceived as entry points to address the challenge.

22. At COP 25, the PCCB hosted a global Capacity-building Knowledge to Action Day to reflect on the outcomes of the first two regional events, hold multi-stakeholder consultations on the planned workshop for the Africa region, and promote further exchanges on topics such as indigenous knowledge, collaborative online platforms, the role of the private sector in climate-related knowledge generation, and the various models of the contribution of research to climate action.

23. The Capacity-building Knowledge to Action Day for Africa was held virtually on the 24th of September 2020 to move forward the evolving learning on the relationship between capacity-building, knowledge, research, and action. The PCCB is producing a joint report on the findings of these regional workshops.

24. The first meeting of the **Structured Expert Dialogue** (SED) of the second periodic review will be held 26-27 November.[4] The SED will focus on information available from sources including the IPCC Special Reports on Global warming of 1.5°C, Climate Change and Land and Ocean and the Cryosphere in Changing Climate, information from Parties and from other relevant reports from UN agencies and other international organizations. It will make a contribution to enhancing Parties' understanding of the long-term global goal (LTGG) and scenarios towards achieving it, progress made in relation to addressing

[4] https://unfccc.int/event/first-meeting-of-the-structured-expert-dialogue.

information and knowledge gaps, and challenges and opportunities; and assessing the overall aggregated effect of the steps taken by Parties in order to achieve the LTGG.

25. The **Technical Expert Meetings on Adaptation** (TEM-A) held in July and August focussed on education and training, public participation, and youth to enhance adaptation action[5]. As part of the 2020 **Technical Examination Process on adaptation** (TEP-A), several volunteer expert organizations developed a series of policy briefs relevant to this theme[6]. A technical paper and summary for policymakers will be published in 2021.

F. Brief update of information and activities by UN and other relevant programmes and organizations

26. This section provides an update on some of the background information and research activities relevant for the twelfth meeting of the research dialogue. It is a non-exhaustive list of activities by relevant organizations provided in alphabetical order.

27. Through its core programmes of regional research and capacity building, the **Asia Pacific Network** (APN) is enhancing the capacity of researchers in Asia to conduct research in global environmental change and sustainability for science-based policy and decision-making. On the types of projects undertaken by APN, a recent knowledge synthesis for the period 2013-2018, indicates that 115 APN-supported projects in the Asian region centred on community-based adaptation and mitigation in areas including biodiversity and ecosystems, climate-induced extreme events, water-food-energy nexus, sustainable waste management, and climate education[7] from which knowledge products of different levels of policy relevance were produced. Further outputs by way of a compiled special issue of 15 projects published in Elsevier's Environmental Research journal on climate impacts, vulnerability and adaptation are shown, the results of which are expected to add value to the scientific literature[8].

28. APN carried out three community-based case studies addressing: scientific and human resource capacity in Bhutan and India on effective agricultural waste management through local-scale smart solutions[9]; simple assessment tools to empower communities in Cambodia to build resilience[10]; and institutional resilience as a cornerstone to effective climate-adaptive action in the Philippines[11]. These case studies show strategic approaches and best practices to advance action on climate change.

29. In essence, APN's approaches are advancing science and human capacity in Asia that will help shape local and regional responses to climate change and sustainable development, in order to tackle adverse impacts on natural and human systems. As APN enters its 5th strategic phase (2020-2024) responses to the Covid-19 pandemic will be addressed by calling for proposals related to "Covid-19 Era: Pursuit of transformation to more resilient societies" that will aim to promote approaches to decarbonized society, define more sustainable

[5] See here for more details: http://tep-a.org/technical-expert-meetings-on-adaptation/technical-expert-meeting-on-adaptation-2020/

[6] Available here: http://tep-a.org/policy-briefs/

[7] Uchiyama, C., Stevenson, L. A., & Tandoko, E. (2020). Climate change research in Asia: A knowledge synthesis of Asia-Pacific Network for Global Change Research (2013–2018). Environmental Research, 188, 109635. doi:10.1016/j.envres.2020.109635

[8] Shrestha, S., Stevenson, L. A., Shaw, R., & Pulhin, J. (2020). Special Issue on Climate Change Impacts, Vulnerability and Adaptation: Asian Perspective. Environmental Research, 109826. doi:10.1016/j.envres.2020.109826

[9] Dey, D., Gyeltshen, T., Aich, A., Naskar, M., & Roy, A. (2020). Climate adaptive crop-residue management for soil-function improvement; recommendations from field interventions at two agro-ecological zones in South Asia. Environmental Research, 183, 109164. doi:10.1016/j.envres.2020.109164

[10] Jacobson, C. (2020). Community climate resilience in Cambodia. Environmental Research, 186, 109512. doi:10.1016/j.envres.2020.109512

[11] Grefalda, L. B., Pulhin, J. M., Tapia, M. A., Anacio, D. B., Luna, C. C., Sabino, L. L., . . . Inoue, M. (2020). Building institutional resilience in the context of climate change in Aurora, Philippines. Environmental Research, 186, 109584. doi:10.1016/j.envres.2020.109584

pathways for society to live in harmony with nature, and address impacts on local livelihoods and human security.

30. The **Convention on Biological Diversity** (CBD) released, in September 2020, its Fifth Global Biodiversity Outlook (GBO-5), which summarises the latest data on the status and trends of global biodiversity.[12] GBO-5 synthesizes comprehensive evidence of the growing biodiversity crisis and the urgent need for action in the face of climate change, with the understanding that climate change threatens to undermine all efforts to conserve and sustainably manage biodiversity and that nature itself offers some of the most effective solutions to avert the worst impacts of the warming planet. It examines causes of biodiversity and ecosystem change, the implications for people, and policy options based on programs worldwide that demonstrate successful approaches. The report also examines the essential links between biodiversity and other global agendas, including the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change.

31. **Integrated Assessment Modelling Community** (IAMC) is carrying out research on COVID-19 implications, net-zero scenarios and bridging the emissions reduction gap. Analysis based on two macro-economic models capturing the structural change caused by the COVID-19 pandemic and reflecting demand and supply shocks with short- and long-term legacies show the impacts on GDP, jobs and income. When viewed through the lens of past pandemics, the researchers estimate that an additional 50-60 million people will live in poverty in 2021 as a result of the COVID-19 pandemic. Furthermore, looking at developing countries, there will be drastic, albeit temporary, increases in inequality, although this rising inequality has the potential to become persistent in some areas. The preliminary results of an expert survey will be discussed, regarding expectations on the impact of the COVID-19 pandemic on energy and climate policy.

32. The latest generation of scenarios exploring mitigation pathways for limiting temperature change to below specific thresholds have adopted a new scenario design[13] and focus on the remaining carbon budget in the near term until the time when net-zero CO_2 emissions are reached. The scenarios do not allow for any net negative emissions, as they are designed to keep temperatures below certain thresholds without overshoots. Several significant insights emerge from the new scenarios. First, limiting temperature to below 2°C, or any other level, requires more rapid and pervasive emission reductions in the near-term such as a pronounced acceleration of the near-term deployment of low-carbon energy portfolios. Second, economic analysis of peak-budgets finds near-term GDP losses of the peak-budget scenarios to be higher than the full-century budget scenarios. However, the upfront investment for accelerating fundamental structural changes also creates significant long-term benefits. Across all scenarios and models, the peak-budget scenarios lead to long-term net economic gains and higher long-term GDP levels compared to scenarios with large-scale negative emissions and overshoot. Thus, there are largescale benefits of rapid transformations towards zero emissions, even without accounting for additional benefits of mitigation due to avoided impacts.

33. Research also shows similar cost benefits of early action when looking at policy adoption. Policies that have proven to be successful in one country can be considered to close the emissions gap between NDCs and the global Paris goals in other countries as well, even though it is important to acknowledge differences in local circumstances. Therefore, the researchers defined nationally relevant measures in a two-way interaction with country experts. Based on the analysis of scenarios by multiple global IAMs, the research shows that a global roll-out of these good practice policies until 2030 and bridging to a 2°C pathway thereafter (the Bridge scenario) is projected to lead to a scale-up of renewable energy, to account for up to 50% of electricity supply by 2050, as well as the electrification of energy services, efficiency improvements in energy demand sectors, and enhanced afforestation and reforestation. These changes in energy and land-use systems are well-defined in the short-term, somewhat less radical than some of the immediate action scenarios, but still allow

[12] https://www.cbd.int/gbo5.

[13] See Rogelj, J., Huppmann, D., Krey, V. *et al.* A new scenario logic for the Paris Agreement long-term temperature goal. *Nature* **573,** 357–363 (2019). https://doi.org/10.1038/s41586-019-1541-4.

reaching the long-term Paris goals. As such, this bridge scenario closes the emissions gap between current NDCs and a cost-optimal 2°C scenario almost fully by 2030, particularly through exploiting the mitigation potential in the energy sector and in Asia. In terms of policy costs expressed as GDP relative to the current policies scenario, the analysis of the bridge scenario suggests that early but non-cost-optimal action is clearly preferable over climate policy delay.

34. The **Intergovernmental Oceanographic Commission** (IOC) of UNESCO launched the United Nations Decade of Ocean Science for Sustainable Development that supports a new cooperative framework to ensure that global ocean science provides greater benefits for ocean ecosystems and wider society. The implementation plan has been submitted to the 75th session of UNGA in accordance with Resolution 74/19.[14]

35. The Integrated Ocean Carbon Research (IOC-R) program of IOC UNESCO is formed in response to the UN Decade of Ocean Science for Sustainable Development (2021-2030). The IOC-R will address the questions i) Will the ocean uptake of anthropogenic carbon dioxide (CO2) continue as primarily an abiotic process? ii) What is the (changing) role of biology in the ocean carbon cycle? iii) What are the exchanges of carbon between the land-ocean-ice continuum and how are they evolving over time? and iv) How are humans altering the ocean carbon cycle and resulting feedbacks?

36. The GESAMP Working Group 41 on 'Ocean Interventions for Climate Change Mitigation' (formerly the WG on Marine Geoengineering) is jointly sponsored by IOC UNESCO, WMO and IMO. In 2019 it published a 'High level review of a wide range of proposed marine geoengineering techniques'.[15] A key finding is that for each and every technique, information on the approaches available in the permanent public record, and/or as peer-reviewed documents, is inadequate to permit a robust scientific assessment. The current activities of GESAMP WG 41 aim to enable a thorough scientific and societal assessment of potential ocean interventions for climate change mitigation so that their potential contribution to net zero and green recovery can be reliably evaluated.

37. A critical element of any new assessments and research must be the inclusion of focussed attention on governance, both in terms of decision making and regulation, but also social licence. GESAMP cooperate on the governance of ocean carbon dioxide removal with the Carnegie Climate Governance Initiative (C2G).

38. The **Intergovernmental Panel on Climate Change** (IPCC) has published three Special Reports during its sixth assessment cycle:

a). The Intergovernmental Panel on Climate Change (IPCC) **Special Report on Global Warming of 1.5°C** (SR15)[16] was published in 2018. The report presented four illustrative model pathways compatible with limiting global warming to 1.5°C, based on different socioeconomic and technological development assumptions, showing the uses of three different types of sources and sinks: emissions from fossil fuel and industry; sources or sinks from AFOLU; and sinks associated with BECCS. As presented at the SBSTA-IPCC special event on the report in 2018,[17] the net CO_2 emissions reached net zero at approximately mid-century for all pathways, but each involved different portfolios of mitigation measures, including different balances between lowering energy and resource intensity, rates of decarbonisation and reliance on CO2 removals.

b). The **IPCC Special Report on the Ocean and Cryosphere in a Changing Climate** (SROCC)[18] was published in 2019. The report describes how the ocean and cryosphere have and are expected to change with ongoing global warming, the resulting risks these changes bring to ecosystems and people, as well as mitigation, adaptation and governance options for reducing future risks. The report finds that changes in the ocean and

[14] A/RES/74/19, https://undocs.org/en/A/RES/74/19.
[15] http://www.gesamp.org/publications/high-level-review-of-a-wide-range-of-proposed-marine-geoengineering-techniques.
[16] See https://www.ipcc.ch/sr15/.
[17] See https://www.unfccc.int/node/184281.
[18] See https://www.ipcc.ch/report/srocc/.

cryosphere are pervasive and observed from high mountains, to the polar regions, to coasts, and into the deep ocean. It also finds that changes and risks in these environments will be larger under high greenhouse gas emission scenarios compared with low emission scenarios that account for high mitigation efforts.

c). The **IPCC Special Report on Climate Change and Land** (SRCCL)[19] was also published in 2019. The report addresses greenhouse gas (GHG) fluxes in land-based ecosystems, land use and sustainable land management in relation to climate change adaptation and mitigation, desertification, land degradation and food security. The report finds that warming over land has occurred at a faster rate than the global mean and that this has had observable impacts on the land system. It further finds that rapid reductions in anthropogenic greenhouse gas emissions that restrict warming to "well-below" 2°C would greatly reduce the negative impacts of climate change on land ecosystems, and that in the absence of rapid emissions reductions, reliance on large-scale, land-based, climate change mitigation is projected to increase, which would aggravate existing pressures on land.

39. Work is advancing on the **IPCC Sixth Assessment Report** (AR6), although there is some delay due to the COVID-19 pandemic. The IPCC AR6 Synthesis Report is now due in 2022. It will be based on the content of the three Working Groups Assessment Reports: WG1 – The Physical Science Basis, WG2 – Impacts, Adaptation and Vulnerability, WG3 – Mitigation of Climate change, as well as the preceding three Special Reports.

40. The **International Renewable Energy Agency** (IRENA) recently published Post-COVID recovery: An agenda for resilience, development and equality, which provides practical advice on key investment and policy decisions for the crucial post-COVID recovery.

41. The report describes, among other topics, how policy measures and investments for stimulus and recovery can drive a wider structural shift, fostering national and regional energy transition strategies as a decisive step in building resilient economies and societies; how the energy sector must be viewed as an integral part of the broader economy to fully understand the impact of the transition, and ensure it is timely and just; and how decentralized systems can help to adapt other sectors, most notably water.

42. The **International Science Council** co-sponsors a number of science initiatives and research programmes that mobilise knowledge of diverse scientific disciplines across the world to help accelerate scientific and societal cooperation and progress in climate science. These include: the World Climate Research Programme, Future Earth, Scientific Committees on Antarctic[20] and Ocean Research[21], and Integrated Research on Disaster Risk. Through the ISC - IIASA- Consultative Science Platform: Pathways to a post-COVID World[22], the ISC works to ensure effective use of interdisciplinary scientific evidence in shaping global resilient recovery strategies. The ISC also recognizes the need for transdisciplinary research and the contribution from the social sciences and humanities in advancing the societal transformations towards a more sustainable and low-carbon future. In this context, it supports transdisciplinary research projects on climate issues as part of the Transformations to Sustainability[23] and LIRA 2030 Africa[24] programmes.

43. The **World Adaptation Science Programme** (WASP) organised a webinar series in September, during which 'action research' was discussed as a means of strengthening knowledge to action linkages. The webinar explored the concept of "action-orientated, user-centric" research through specific examples and case studies. It highlighted the importance of this research for accelerating and scaling adaptation action, and suggested ways through which it may be supported and made more widespread. The webinar presented the Adaptation Research Alliance, a new initiative that is being developed with the importance of this type of research in mind.

[19] See https://www.ipcc.ch/report/srccl/.
[20] See https://www.scar.org/
[21] See https://scor-int.org/
[22] See https://covid19.iiasa.ac.at/isc/
[23] See https://www.norface.net/program/transformations-to-sustainability/
[24] See https://council.science/what-we-do/funding-programmes/lira2030/

44. The WASP will co-organise the 2020 Adaptation Futures conference, which is postponed to 2021.[25] The conference will facilitate dialogues towards action-oriented solutions from a diverse range of stakeholders that includes academia, practitioners, scientists and policy makers from across the world.

45. The **World Climate Research Programme**[26] (WCRP) is prioritizing its science and implementing its Strategic Plan 2019-2028[27] by pursuing a series of Lighthouse Activities, along with other core research activities, to deliver and achieve critical outcomes over the next decade. These activities include

i. Earth System Change: To design, and take major steps toward delivery of, an integrated capability for quantitative observation, explanation, early warning and prediction of Earth System Change on global and regional scales, with a focus on multi-annual to decadal timescales.

ii. My Climate Risk: To develop a new framework for assessing and explaining regional climate risk to deliver climate information that is meaningful at the local scale.

iii. Safe Landing Climates: To explore the routes to climate-safe landing 'spaces' for human and natural systems, on multi-decadal to centennial timescales; connecting climate, Earth system and socio-economic sciences. Explore present-to-future "pathways" for achievement of key SDGs.

46. The WCRP also highlights developments in modelling. For the current generation of earth system models participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6), the range of equilibrium climate sensitivity (ECS, a hypothetical value of global warming at equilibrium for a doubling of CO2) is 1.8°C to 5.6°C, the largest of any generation of models dating to the 1990s. Meanwhile, the range of transient climate response (TCR, the surface temperature warming around the time of CO2 doubling in a 1% per year CO2 increase simulation) for the CMIP6 models of 1.7°C (1.3°C to 3.0°C) is only slightly larger than for the CMIP3 and CMIP5 models. Cloud feedbacks and cloud-aerosol interactions are the most likely contributors to the high values and increased range of ECS in CMIP6.

[25] See http://adaptationfutures2020.in.
[26] See www.wcrp-climate.org
[27] See https://www.wcrp-climate.org/wcrp-sp-overview