Summary report on the SBSTA–IPCC special event: Unpacking the new scientific knowledge and key findings in the Working Group III contribution to the Sixth Assessment report: Mitigation of Climate Change

Bonn, Germany, 8 June 2022

Note by the Chairs of the SBSTA and the IPCC

20 October 2022

Contents

I. Introduction

A. Background

1. The Intergovernmental Panel on Climate Change (IPCC) finalized the Working Group III (WGIII) contribution to the Sixth Assessment Report (AR6) (referred to in this document as the WGIII report) at the 14th session of the WGIII and the 56th Session of the IPCC held from 21 March to 4 April 2022. The Working Group III contribution's Summary for Policymakers (SPM) was released on 4 April 2022.[1]

2. The report builds upon the 2014 WGIII contribution to the IPCC's Fifth Assessment Report (AR5) and the 2018–2019 IPCC Special Reports[2] of the AR6 cycle and incorporates subsequent new evidence from climate science.

3. The WGIII contribution benefited from 278 authors from 65 countries and 354 contributing authors with over 18,000 scientific publications assessed and over 59,000 expert and government review comments provided and addressed.

4. The WGIII contribution focuses on climate change mitigation, providing an updated assessment of global progress and pledges, including an examination of emissions sources. The report explores recent developments and current trends on greenhouse gas (GHG) emissions, modelled mitigation pathways, and mitigation options at the sectoral and system level in relation to long-term emissions goals, taking into account linkages with adaptation and sustainable development.

B. General objective and approach for the special event

5. The special event of the SBSTA and the IPCC on the WGII report was organized by Mr. Tosi Mpanu-Mpanu, the Chair of the Subsidiary Body for Scientific and Technological Advice (SBSTA), and Mr. Hoesung Lee, the Chair of the IPCC.

6. The event was organized to enhance a better understanding of the key findings of the WGIII report of the AR6 through a direct exchange of views between Parties and IPCC experts, by unpacking the new scientific knowledge and key findings.

7. In the lead up to the special event, the SBSTA and the IPCC Chairs issued an information note,[3] which provided background information on the WGIII report and proposed an approach for the special event, including the agenda and main topics of discussion.

8. The special event focused on the four themes of the SPM through presentations from the WGIII Co-Chairs and IPCC authors and discussions with participants. The themes were:

(a) Recent developments and current trends;

(b) System transformations to limit global warming;

(c) Linkages between mitigation, adaptation, and sustainable development;

(d) Strengthening the response.

9. The special event on the WGI contribution to AR6 took place in conjunction with the SBSTA 52–55 in Glasgow on 4 November 2021.[4] The special event on WGII component of AR6 was held in conjunction with SBSTA 56 in Bonn, on 6 June 2022.[5]

[1] See https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/.
[2] Global warming of 1.5: https://www.ipcc.ch/sr15/; Climate Change and Land: https://www.ipcc.ch/srccl/; and Ocean and Cryosphere in a Changing Climate: https://www.ipcc.ch/srocc/.
[3] See https://unfccc.int/sites/default/files/resource/AR6WG3Mitigation_InfoNote_SBSTA_IPCC_SB56.pdf.
[4] See https://unfccc.int/event/ar6wgi-special-event.
[5] See https://unfccc.int/event/ar6wgii-special-event.

II. Summary of the special event

10. The special event was held in conjunction with SBSTA 56 in Bonn, Germany, on 8 June 2022, from 11:00 to 14:00 in room New York of the World Conference Center.[6] The event was open to all attendees at the 56th session of the subsidiary bodies (SB 56) and webcasted.[7] The event was jointly chaired by the SBSTA and IPCC Chairs.

11. All information on the special event is available from the event webpage.

A. Opening

12. The SBSTA Chair welcomed all participants to the special event and thanked the IPCC Working Group III Co-Chairs, Mr. Jim Skea and Mr. Priyadarshi R. Shukla (who joined the event virtually), as well as all the IPCC authors present.

13. The SBSTA Chair emphasized that the WGIII assessment has shown that keeping global warming below 1.5°C and halving emissions by 2030 is still possible and expressed hope that the scientific information presented during the Special Event with this purpose informed the activities of SB56 participants.

14. The IPCC Chair highlighted that the WGIII report throws light on the fact that we have experienced the highest absolute decadal increase in GHG emissions in human history, and we are not on track to limit warming to 1.5°C. However, the assessment shows that we have the tools for achieving immediate and deep GHG emissions reductions across all sectors and regions, which would allow us to ensure a liveable future and achieve sustainable development.

15. An introductory video on the WGIII report was shown to introduce an overview of the main findings of each section of the report. The video included relevant information by topic, as well as interviews with the WGIII Co-Chairs, authors and IPCC officials.

B. Presentations by experts on unpacking the new scientific knowledge and key findings

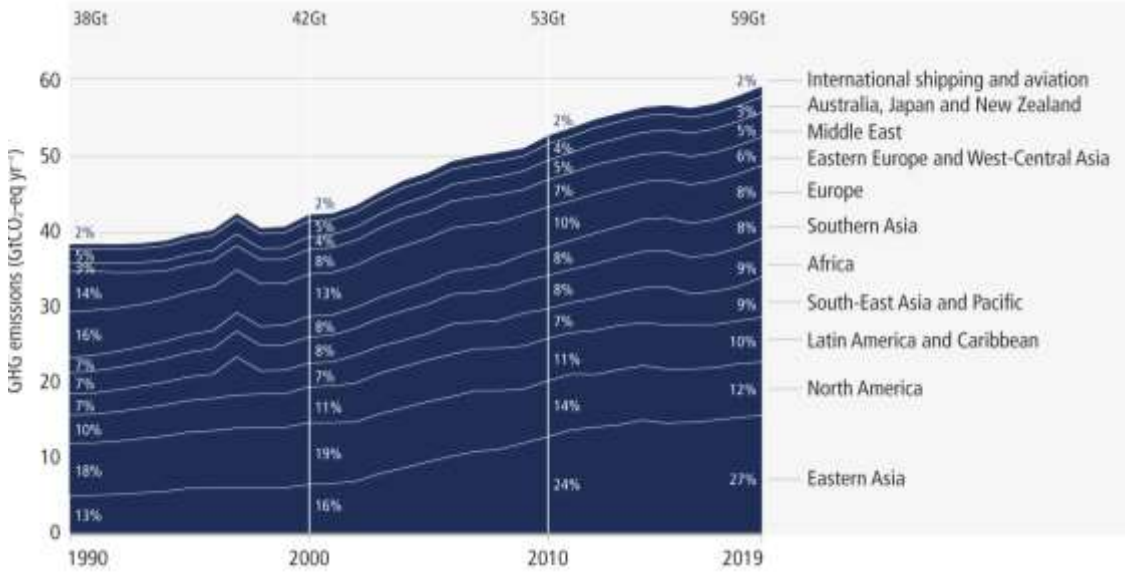
1. Recent developments and current trends

16. Mr. Jim Skea, WGIII co-chair began the presentations providing an outline of the WGIII report and how it fits with the WGI and WGII contributions, as well as the structure and main topics included in the summary for policymakers (SPM). He highlighted some of the main advances since AR5, which include a greater emphasis on the linkages between mitigation and development; new chapters on demand, services and social aspects of mitigation, and innovation, technology development and transfer; a more extensive treatment of carbon dioxide removal (CDR); and some changes in the literature in the characteristics of modelled global emissions pathways.

17. Ms. Shonali Pachauri continued the presentation by focusing on recent developments and current trends highlighted in the report. The global net anthropogenic GHG emissions have continued to rise during the period 2010–2019. In fact, this decade has seen the highest absolute increase in average emissions on record. Emissions are about 12% higher since 2010 and 54% higher than in 1990. Growth in anthropogenic emissions have persisted across all major GHGs since 1990, although at different rates, as well across all major sectors globally. (Figure 1).

[6] See https://unfccc.int/event/ar6wgiii-special-event.
[7] See https://unfccc.int/event/ipcc-sbsta-special-event-on-working-group-iii.

Figure 1: **Global net anthropogenic GHG emissions by region (1990–2019)**



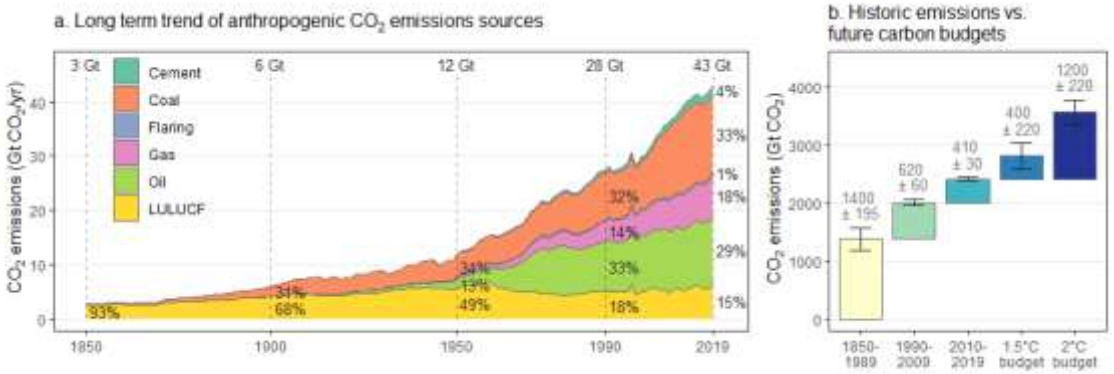
Source: Slide 8 of the presentation of the IPCC WGIII, 2022. SPM Figure 2, IPCC WGIII AR6: Global net anthropogenic GHG emissions by region (1990–2019), 2022.

18. While GHG emissions have continued to grow in absolute terms, there has been a decline in the rate of growth in recent years. Between 2000 and 2009, the rate of growth was about 2.1% per year, while between 2010 and 2019 there was a reduction to about 1.3% per year. Furthermore, regional contributions to global GHG emissions differ widely.

19. Ms. Pachauri shared the finding that CO_2 emissions from fossil fuel combustion and industrial processes (FFI) dropped temporarily in the first half of 2020 due to responses to the COVID-19 pandemic. In this regard, the annual average CO_2-FFI emissions reduction in 2020 relative to 2019 was about 5.8% [5.1–6.3%], or 2.2 [1.9–2.4] GtCO2. Impacts were differentiated by sector, with the largest drop in the land transport sector. However, more granular data shows that emissions had already rebounded by the end of the 2020.

20. Regarding the historical trends in CO_2 emissions since 1850, about 60% of the total cumulative CO_2 emissions from 1850 to 2019, occurred since 1970, about 43% since 1990, and about 17% since 2010. Carbon emissions of the last decade are about the same size as the remaining carbon budget for keeping global warming to 1.5°C with a 50% probability. (Figure 2).

Figure 2: **Historic anthropogenic CO_2 emission and cumulative CO_2 emissions (1850–2019) as well as remaining carbon budgets for likely limiting warming to 1.5°C and 2°C**

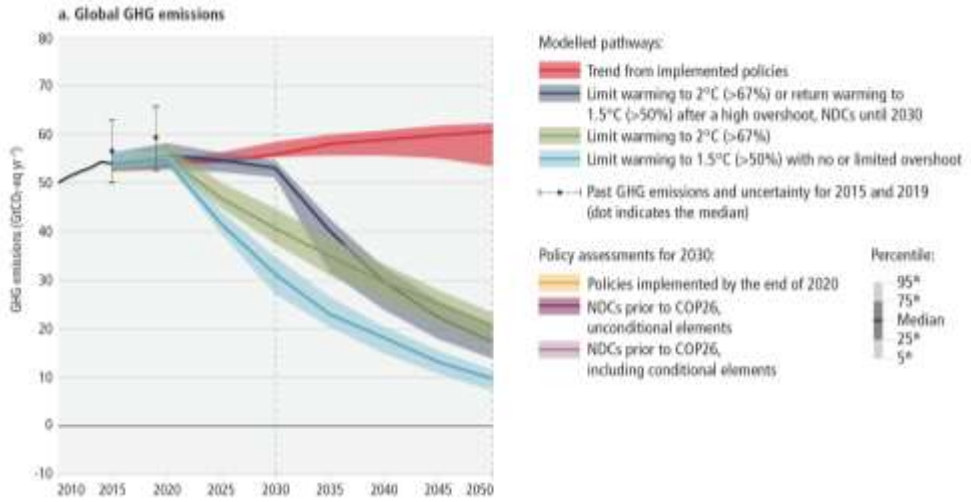


Source: Slide 10 of the presentation of the IPCC WGIII, 2022. Technical Summary Figure 3, IPCC WGII AR6: Historic anthropogenic CO2 emission and cumulative CO2 emissions (1850–2019) as well as remaining carbon budgets for likely limiting warming to 1.5°C and 2°C, 2022.

21. Another key finding by WGIII is that projected emissions from existing and planned fossil infrastructure are higher than those consistent with limiting warming to 1.5°C with no or limited overshoot. Aligning emissions with 1.5°C pathway would entail decommissioning and reduced utilization of existing infrastructure, shifts to low-carbon fuels, and cancellation of new coal power installations.

22. In relation to projected GHG emissions, the WGIII report indicates that if we consider NDCs submitted before COP26, it is likely that warming will exceed 1.5°C during the 21st century, and also make it harder after 2030 to limit warming to below 2°C. While the emissions gap is smaller than the one identified from the first round of NDCs in 2015/2016, achieving the long-term temperature goal of the Paris Agreement requires an unprecedented acceleration of mitigation efforts across all sectors, particularly during the 2030–2050 period. (Figure 3).

Figure 3: **Current NDCs are insufficient to keep 1.5°C well within reach**



Source: Slide 12 of the presentation of the IPCC WGIII, 2022. SPM Figure 4, IPCC WGIII AR6: Projected global GHG emissions from NDCs prior to COP26 would make it likely that warming will exceed 1.5°C and also make it harder after 2030 to limit warming below 2°C, 2022.

23. On the positive side, Ms. Pachauri noted that multiple low-carbon technologies have shown rapid progress since AR5 in performance and adoption, and unit costs of several technologies have fallen continuously in recent years. For example, there have been unit cost reductions of about 85% for photovoltaic solar energy (PV), 55% for onshore wind power, and 85% for batteries for passenger electric vehicles (EVs). This reduction has occurred much faster than had been anticipated. In some cases, costs for renewables have fallen below those of fossil fuels. Moreover, the political, economic, social and technical feasibility of these technologies has improved dramatically over the last few years.

24. Nevertheless, the combined market share of solar and wind generation technologies globally is still below 10%, and much lower that what is needed by 2050 to achieve the long-term temperature goal.

Summary of the Q&A session for theme 1: Recent developments and current trends

25. What does the WGIII report say on the emissions from Small Island Developing States (SIDS). What are the historical emissions of these countries? What are their current emission levels? What are their per capita emissions? And how does this compare to the global average?

> *IPCC experts*: SIDS have much lower per capita emissions (1.7 tCO2-eq) than the global average (6.9 tCO2-eq), excluding CO_2-LULUCF. If we look at historical cumulative CO_2-FFI emissions between 1850 and 2019, SIDS contributed only about half a percent (0.5%). These results are also highlighted in the SPM.

26. The WGIII report states that reducing GHG emissions across the full energy sector requires major transition, including a substantial reduction in overall fossil fuel use. Could you please elaborate on the need to: urgently phase out unabated fossil fuel investments, and fossil fuel subsidies; and the way to find inclusive pathways for a rapid and intense energy transition? Could you please elaborate on what are the pathways for such a rapid transition on fossil fuels, both on demand side management and infrastructure, to keep our world well below 1.5°C, avoid overshoot and tipping points on ice, sea-level rise, ecosystems and our society.

> *IPCC experts:* These points are addressed in the section on system transformations to limit global warming (see below paragraphs 34–54).

27. In some cases, the cost of renewables is lower than that of fossil fuels. However, in Africa, adoption of renewable energy technologies remains fairly low. What are the main factors behind the low adoption of low-emission technologies in Africa, and in developing countries in general, and how does this vary among regions? What can be done to scale-up these technologies in Africa?

IPCC experts: As highlighted in section B of the SPM, the adoption of low emission technologies lags in most developing countries, particularly in the least developed countries (LDCs), due to weaker enabling conditions, limited technology development and transfer, as well as finance. The regional differentiation on the trends in cost reductions, has been covered in examples in the WGIII report wherever possible. However, literature is not available for all regions equally. There is less information for LDCs and SIDs.

28. What are the levels of current finance flows for fossil fuels, as well as how do these compare to climate finance flows globally? In addition, what does the report assess to be the level of fossil fuel subsidies compared to renewable energy subsidies? What are the social and environmental effects of those subsidies?

IPCC experts: Flows for fossil fuel finance are assessed to be greater than climate finance flows. On subsidies, more information is elaborated in the chapter on the signalling effect for investment for the financial sector as a whole, and in particular, on the risk of stranded assets. More information on finance flows are addressed below (paragraphs 65–85).

29. What are the key enablers for a rapid energy transition? How important is this transition in reducing the increase in the rate of CO_2 emissions? What is the necessary rate of deployment of renewable energies in order to turn emissions downwards?

IPCC experts: The assessment shows a mix of policy instruments that have resulted in cost reductions and stimulated adoption, including research and development, funding for pilot projects, demand-pull instruments, and the deployment of subsidies in different regions. In comparison to modular or small-sized technologies, the empirical literature shows that larger-scale mitigation technologies have fewer opportunities for learning. Thus, there are lower cost reductions and slower adoption for these technologies.

30. What is the role of the LULUCF sector in limiting global warming in light of the current and future contribution from the sector? What is the current contribution to global emissions from the AFOLU sector? And what does this mean for relying on the AFOLU sector as a mitigation option to reduce emissions?

IPCC experts: The LULUCF sector is currently a significant source of emissions. Options to reduce those emissions are reducing the rate of deforestation, as well as protecting and restoring native ecosystems that have a potential to increase carbon storage.

However, as shown by many modelled mitigation pathways, carbon dioxide removal can be increased through afforestation and reforestation. Additionally, the LULUCF sector can be an important source of biomass for use in other areas, such as the substitution of emissions-intensive construction materials, or biofuel generation, which could displace the use of fossil fuels. If biofuels are combined with carbon capture and storage, this can result in the net removal of CO_2 from the atmosphere.

31. What is the emissions share, per capita emissions, and historical cumulative emissions of LDCs, as well as the LDCs' total historical contribution of CO_2, fossil fuel and industrial emissions?

IPCC experts: In 2019, LDCs are estimated to have emitted about 3.3% of global GHG emissions. The historical trends are included in the SPM.

32. In the past, reporting under the UNFCCC did not provide the full picture regarding emissions. Where did the IPCC get the complementary information on emissions? Which type of information and data was used, for example data from satellites or *in situ* observations? Can the enhanced transparency framework (ETF), enhance the information on global emissions in the future?

IPCC experts: The assessment uses the Emissions Database for Global Atmospheric Research (EDGAR) for most of the GHGs, as well as three bookkeeping models for the CO_2 LULUCF data. There was an effort to provide a complete assessment of all the data sources, and to use the data sources with the best consistency with other sources, as well as the widest coverage in terms of countries, gases and time periods. Furthermore, consistency with WGI and WGII approaches was taken into account.

33. How can we partner and maintain balance, equity and just transition for developing countries, in order for such countries to be able to maximize their fossil fuel reserves to advance their economies, especially with the current high oil prices? How can we partner to develop clear integrated roadmaps, nationally and multilaterally, to maximize opportunities, and facilitate the transition through technology deployment, financing of mitigation, and adaptation? Regarding the lowering costs of PV, onshore wind and EVs, what are the similar trends on cost reductions in fuel cell plants?

IPCC experts: IPCC assessments are policy relevant, but not policy prescriptive. The WGIII assessment makes very clear that in order to limit global warming to 1.5°C, not all of the fossil fuel reserves that we currently have can be exploited.

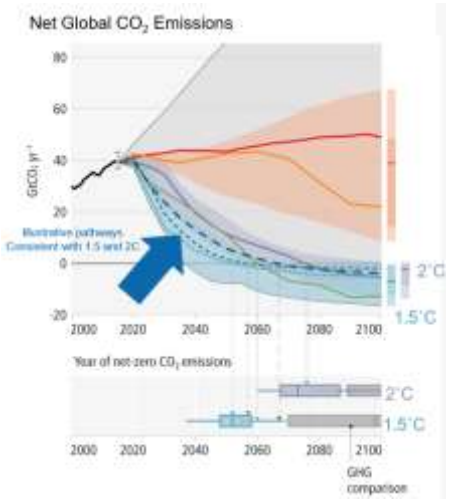
2. System transformations to limit global warming

34. Mr. Keywan Riahi highlighted that the AR6 was an unprecedented effort to collect, vet and assess more than 3,000 different scenarios, which are publicly available through an online scenario explorer. Global emissions pathways show alternative ways of limiting global warming to different levels, particularly consistent with 1.5°C and 2°C.

35. All scenarios show that net zero CO_2 emissions are required to halt climate change, and lower the warming level, and the earlier that net zero CO_2 emissions are achieved the better. For pathways that limit warming to 1.5°C with no or limited overshoot, this means net zero CO_2 emissions in the early 2050s and for pathways that limit warming to 2°C, it means net zero emissions must be reached in the 2070s.

36. Mr. Riahi explained that the analysis and assessment of the pathways show that, in order to achieve net zero CO_2 emissions, not every activity needs to be completely decarbonized. Instead, a net zero CO_2 emission system will provide a balance between emission sources and sinks. However, in order to achieve this, the priority is to deeply reduce emissions, and counterbalance or offset residual emissions with CDR. (Figure 4).

Figure 4: **Modelled mitigation pathways that limit warming to 1.5°C, and 2°C, involve deep, rapid and sustained emissions reductions**



Source: Slide 16 of the presentation of the IPCC WGIII, 2022. Based on SPM Figure 5, Illustrative Mitigation Pathways (IMPs) and net zero CO2 and GHG emissions strategies, panel a, 2022.

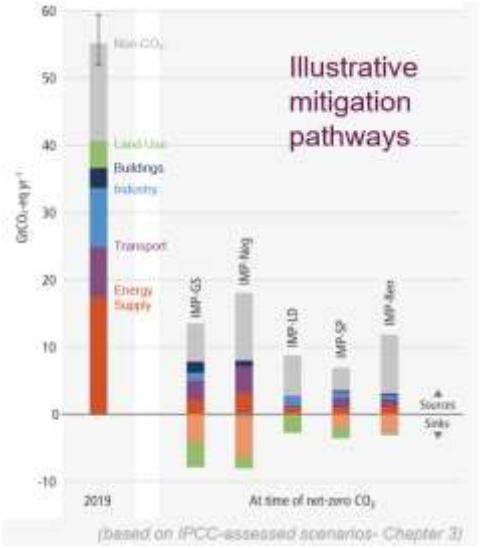
37. The WGIII report has identified five different illustrative mitigation pathways, which show a different portfolio of residual emissions, but also a portfolio of CDR measures (Figure 5). Most of the illustrative pathways do not include all the different CDR options that are available. Past analysis by the IPCC focused primarily on bioenergy with carbon capture and sequestration and measures in the forest sector to remove CO_2 from the atmosphere.

38. The WGIII report shows that in order to limit warming to 1.5°C or 2°C, deep and rapid emissions reductions are needed urgently across all sectors. This translates into GHG emissions reductions of around 27% [13–45%] for 2°C scenarios, and 43% [34–60%] for 1.5°C scenarios with no or limited overshoot.

39. Mr. Riahi highlighted that to limit warming to 1.5°C with no or limited overshoot, not all pathways assessed reach net zero GHG emissions. Those which reach net zero GHG emissions (or negative GHG emissions) manage to draw down temperature and lead to lower long-term temperature and impacts.

40. For the 1.5°C pathways with no or low overshoot that reach net zero GHGs, they have very similar emission reduction rates in the near term (2030/2040). Differences become more pronounced at about mid-century when the extent to which CDR is contributing to net negative GHG emissions varies greatly in the long term.

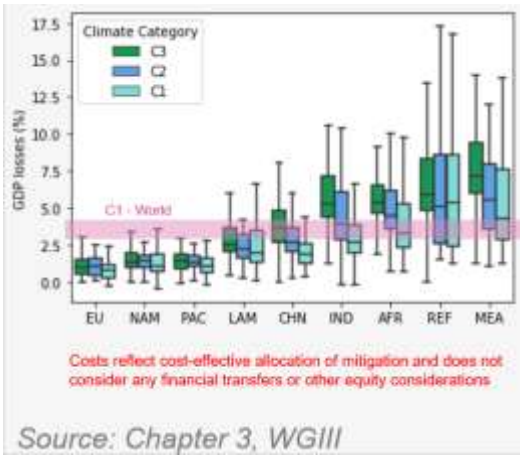
Figure 5: **Illustrative mitigation pathways**



Source: Slide 17 of the presentation of the IPCC WGIII, 2022. Based on SPM Figure 5, Illustrative Mitigation Pathways (IMPs) and net zero CO2 and GHG emissions strategies, panel b, 2022.

41. In terms of costs, the assessment shows that the macroeconomic costs of mitigation are small compared to global projected GDP growth in the same timeframe. For 1.5°C and 2°C scenarios, losses related to mitigation measures are a few percentage points in terms of GDP by 2050, while the global GDP more than doubles over the same timeframe in the different pathways. Furthermore, the economic benefits of avoided impacts are generally larger than the mitigation costs. Regionally, mitigation costs are quite different. Generally, costs are larger in regions which either rely heavily on fossil fuels today or rely on fossil fuel exports for generating revenues and incomes. (Figure 6).

Figure 6: **Regional costs of mitigation**



Source: Slide 20 of the presentation of the IPCC WGIII, 2022. Based on IPCC WGIII AR6 Report Figure 3.35, 2022 (still subject to edits).

42. Mr. Riahi emphasized that another new element of AR6 compared to the AR5 report is that the emission scenarios were evaluated in terms of challenges across different dimensions of feasibility. There are geophysical, economic, technological, socio-cultural and institutional reasons why pathways might have feasibility concerns. The evaluation showed that a major reason for concern is that a high portion of mitigation efforts are happening in regions where governance and institutional capacity is relatively low.

43. Mr. Smail Khennas continued the presentation on the topic of energy transitions. He explained that the assessment shows the need for substantial reductions of GHG emissions across the full energy sector, which means: a substantial reduction in overall fossil-fuel use; the deployment of low-emission energy sources; the switching to alternative energy carriers; and energy efficiency and conservation. This implies demand-side management.

44. Five key components were identified to achieve a net-zero CO_2 energy system: 1) substantial reduction in overall fossil fuel use and the use of carbon capture and storage (CCS) in the remaining fossil fuel system; 2) electricity systems that emit no net CO_2; 3) widespread electrification of the energy system including end uses; 4) energy carriers such as sustainable biofuels or low-emissions hydrogen in applications that are hard to electrify; and 5) greater physical, institutional, and operational integration across the energy system.

45. Mr. Khennas emphasized that electricity systems powered predominantly by renewables are increasingly viable. However, it will be challenging to supply the entire energy system with renewable energy. While a variety of systemic solutions to accommodate large shares of renewables have emerged, operational, technological, economic, regulatory, and social challenges remain. Therefore, a broad portfolio of options will ultimately be needed to accommodate large shares of renewables.

46. Limiting global warming to below 2ºC will leave a substantial amount of fossil fuels stranded, and this could also be extended to considerable fossil fuel infrastructure. Coal assets are projected to be at risk of being stranded before 2030, while oil and gas assets are projected to be more at risk toward mid-century. CCS could allow fossil fuels to be used longer, reducing stranded assets. In monetary terms, the discounted value of the stranded fossil fuels and fossil fuel infrastructure has been estimated to be around 1–4 trillion dollars from 2015 to 2050 to limit global warming to approximately 2ºC, and higher if global warming is limited to approximately 1.5ºC.

47. Mr. Khennas noted that the AR6 report has an added value of having assessed methane emissions from energy supply in 2019, finding they account for a substantial amount: 18% [13–23%] of GHG emissions from energy supply; 32% [22–42%] of global methane emissions; and 6% [2–4%] of global GHG emissions. On the positive side, about 50–80% of these emissions could be avoided with currently available technologies at less than USD50 tCO2-eq-1.

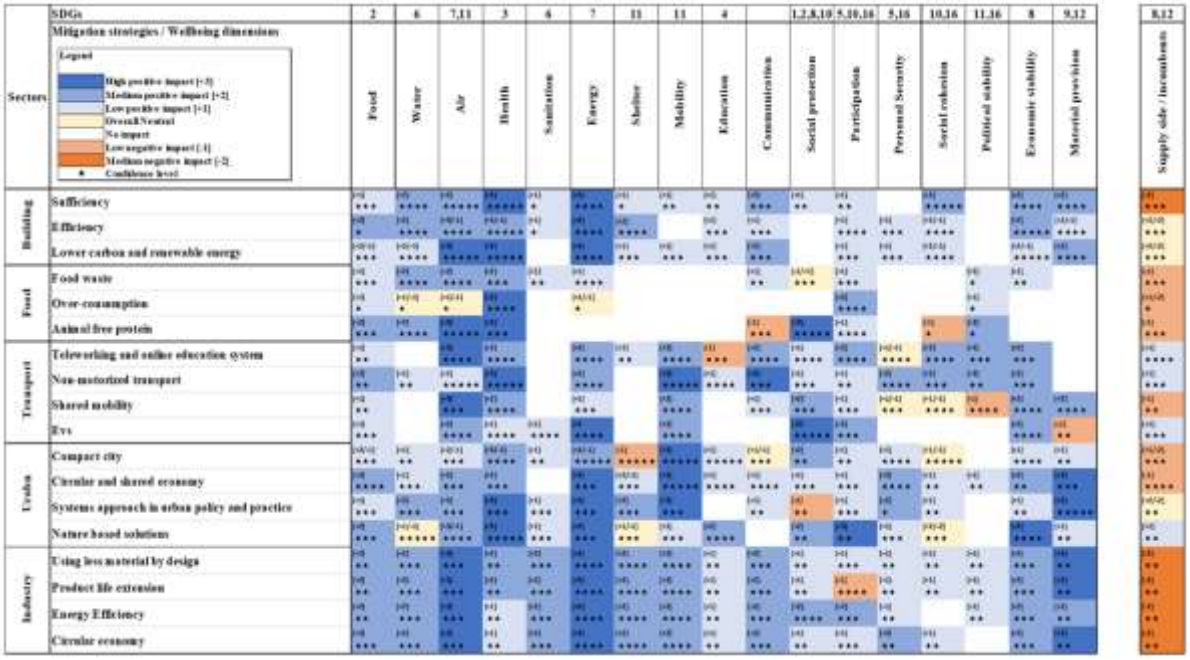
48. Ms. Joyashree Roy continued by highlighting that for the first time, the IPCC dedicated a chapter to demand, services and social aspects of mitigation, putting human wellbeing at the center of actions needed while mitigating climate change.

49. While assessing social science literature on what motivates people to take action, it was very clear that people want services to meet their needs and wellbeing. Technology adoption, accessing new infrastructure, and changes in behaviour, socio-cultural practices and lifestyle changes are necessary. The report found that global GHG emissions can be reduced in end-use sectors by 40 to 70% compared to a baseline scenario, and that this is still an untapped potential.

50. The WGIII report identified 60 actions which can be taken up at the level of individuals. The analysis looked into these options and their potential, presented in three broad categories: socio-cultural factors, infrastructure access and technology access. The relevance of each category varies according to the type of measure.

51. The assessment takes into account linkages between mitigation and the different dimensions of wellbeing, including food, water, air and health, and the Sustainable Development Goals (SDGs). While there are some trade-offs, in aggregate, most of the mitigation options have a positive wellbeing impact across all sectors. (Figure 7).

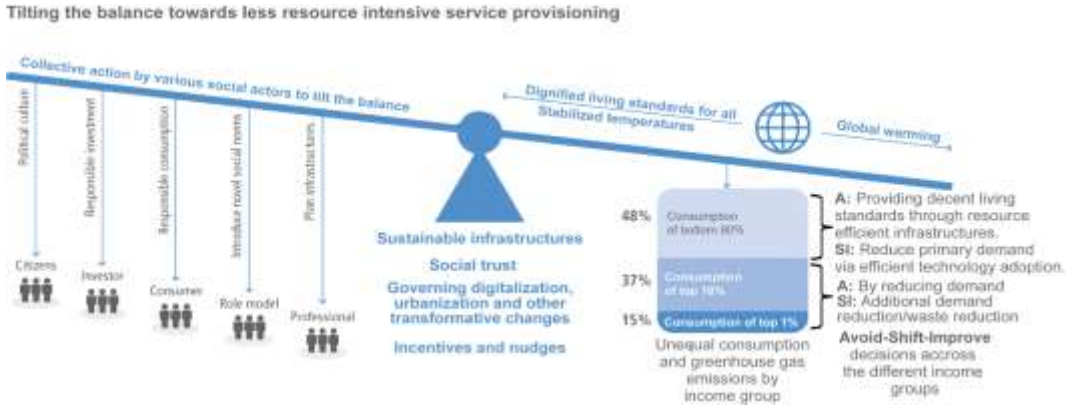
Figure 7: **Demand side mitigation response options are consistent with improving basic wellbeing for all**



Source: Slide 33 of the presentation of the IPCC WGIII, 2022. Based on IPCC WGIII AR6 Report Figure 5.6, 2022 (still subject to edits).

52. Other findings include that there is an inequality in the distribution of consumption and GHG emissions by income group that needs to be addressed. The consumption of the top 1% of the global population contributes 15% of global emissions, while the bottom 90% contributes to only 48% of global emissions. (Figure 8).

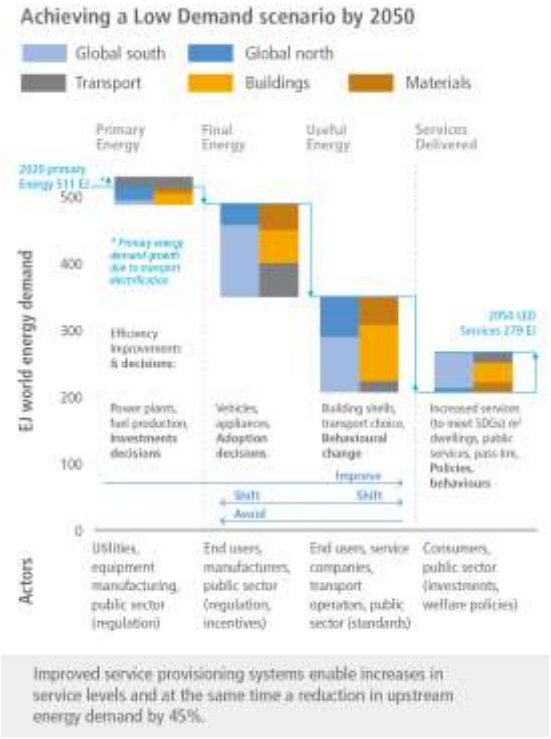
Figure 8: **People matter**



Source: Slide 34 of the presentation of the IPCC WGIII, 2022. IPCC WGIII AR6 Report Figure 5.14, 2022 (still subject to edits).

53. Ms. Roy also highlighted that demand-side mitigation encompasses changes in infrastructure use, end-use technology adoption, and socio-cultural behavioural changes. More efficient end-use energy conversion can improve services while reducing the need for upstream energy by 45% by 2050 compared to 2020 values. However, the assessment showed regional differences in potential because the lowest quartile of the population globally still requires additional housing, nutrition, energy and resources for human wellbeing. So there will be some increases in emissions due to this rise in consumption, but the increase is much lower than the upstream reduction potential. (Figure 9).

Figure 9: **Achieving a low-demand scenario**



Source: Slide 35 of the presentation of the IPCC WGIII, 2022. IPCC WGIII AR6 Report Figure 5.10, 2022 (still subject to edits).

54. In sum, there are multiple options which can allow us to avoid 5–30% of global annual GHG emissions from end-use sectors by 2050 compared to the 2050 emissions projection of two scenarios consistent with policies announced by national governments until 2020. These include changes in the built environment, new and repurposed infrastructures and service provision through compact cities, co-location of jobs and housing, etc. However, the WGIII report shows that there needs to be a combination of systemic changes, market instruments and behavioural changes.

3. Linkages between mitigation, adaptation, and sustainable development

55. Mr. Michael Grubb opened this section by providing an overview of the relation between mitigation and sustainable development with reference to four dimensions: aggregate economic efficiency, including the benefits of avoided impacts; ethics and equity, including culture and capacity; technology, innovation and transition processes; and socio-political frameworks, including institutions and governance.

56. Regarding the question of trade-offs between mitigation and GDP, the WGIII report shows that costs associated with mitigation are fairly small compared with projected economic growth. Impact on annual global GDP growth rate would be only 0.04–0.09 percentage points lower. Moreover, the global cost of limiting warming to 2°C over the 21st century is lower than the global economic benefits of reducing warming considering the damages resulting from climate change.

57. However, Mr. Grubb stressed that national circumstances can differ very significantly, which is reflected in Figure 10 below. It shows that there is a general relation between per capita GHG emissions and scores of the Human Development Index (HDI), but also wide variations between countries with very similar development levels. Meeting human needs and aspirations for sustainable development means that all regions would need to move towards the lower right space of this diagram.

Figure 10: **Countries start from very different situations**

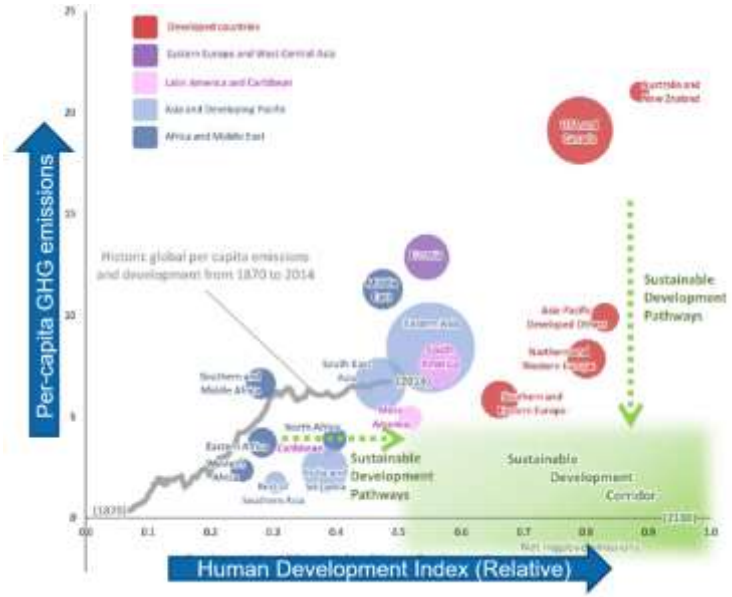
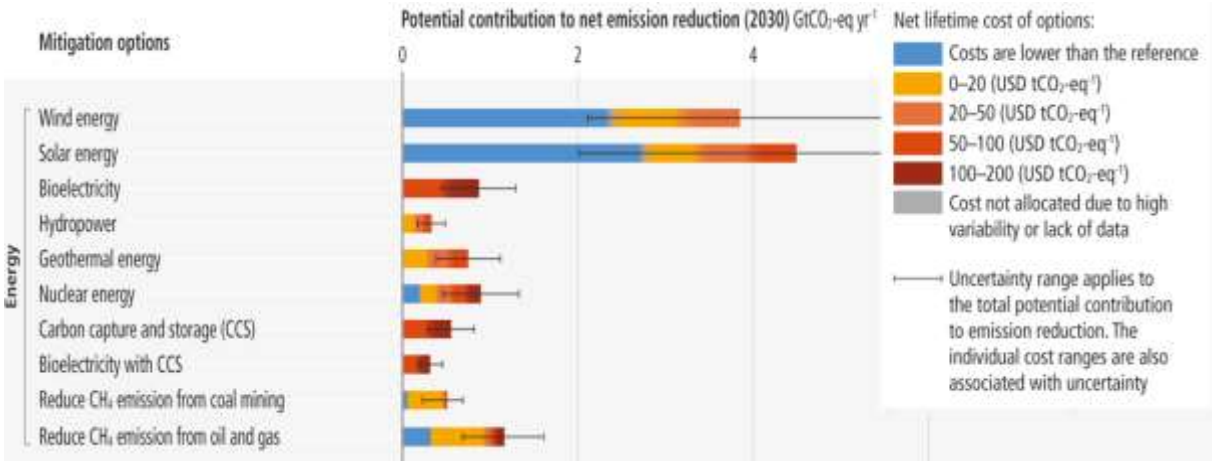


Figure TS.1: Sustainable development pathways towards fulfilling the Sustainable Development Goals

Source: Slide 40 of the presentation of the IPCC WGIII, 2022. Based on Technical Summary Figure 1, IPCC WGII AR6: Sustainable development pathways towards fulfilling the Sustainable Development Goals, 2022.

58. Regarding technology, progress has alleviated trade-offs for some countries in key sectors. For example, in the energy sector, lower costs of clean energy technologies have the potential to reduce huge amounts of emissions, strengthening synergies and reducing trade-offs. However, this varies regionally. (Figure 11).

Figure 11: **Overview of mitigation options and their estimated ranges of costs and potentials in 2030**



Source: Slide 41 of the presentation of the IPCC WGIII, 2022. Based on SPM Figure 7, Overview of mitigation options and their estimated ranges of costs and potentials in 2030, 2022.

59. Mr. Grubb highlighted that even with cost effective technologies, major transitions to low emission economies will involve big changes that will disrupt existing patterns and bring significant distributional impacts within and among countries. Just transitions along with robust governance will therefore be key.

60. Ms. Minal Pathak continued the presentation noting that the assessment clearly indicates that early and equitable mitigation action, as well as adaptation action, are critical to sustainable development. However, there are particular challenges for developing countries and vulnerable populations, including indigenous peoples and groups that have limited institutional, technology and financial capacity.

61. There are synergies and trade-offs between mitigation actions and SDGs, which depend on the development context, including existing inequalities. Relevant factors include the means of implementation, international cooperation, as well as the sequencing and timing of mitigation actions, among others. Moreover, trade-offs need to be identified in advance and policies need to be coordinated across sectors.

62. Ms. Pathak pointed out that while developing countries experience high vulnerability and may have low-adaptive capacity, there is evidence of synergies between mitigation and adaptation in human settlements, land management, and in relation to ecosystems.

63. Regarding impacts on employment, the WGIII report also shows that new jobs could be created, taking into account that transition pathways will vary across countries and contexts. While it may be challenging, there are opportunities to enhance skills and integrated policy packages exist that can improve equity and other forms of justice. Just transition actions are taking place in many countries.

64. Importantly, enabling conditions can accelerate mitigation and minimize trade-offs. The range of enabling conditions includes capacity building, finance, governance, technology transfer, investments, and development and social equity considerations with meaningful participation of indigenous peoples and vulnerable populations. Finally, choices taken by policymakers, citizens, private sector and other stakeholders can influence societies' development pathways.

4. Strengthening the response

65. Ms. Heleen de Coninck noted that current development pathways in most countries around the world do not yet enable the acceleration of mitigation action. The key challenge is how to enable both the system transformations and mitigation options and implement them faster in order to limit warming to 1.5°C or 2°C, and shift development pathways.

66. The WGIII report identified a number of enabling conditions that can be mutually reinforcing and create positive feedbacks, leading to accelerated mitigation. The presentation focused on some of these enablers in turn.

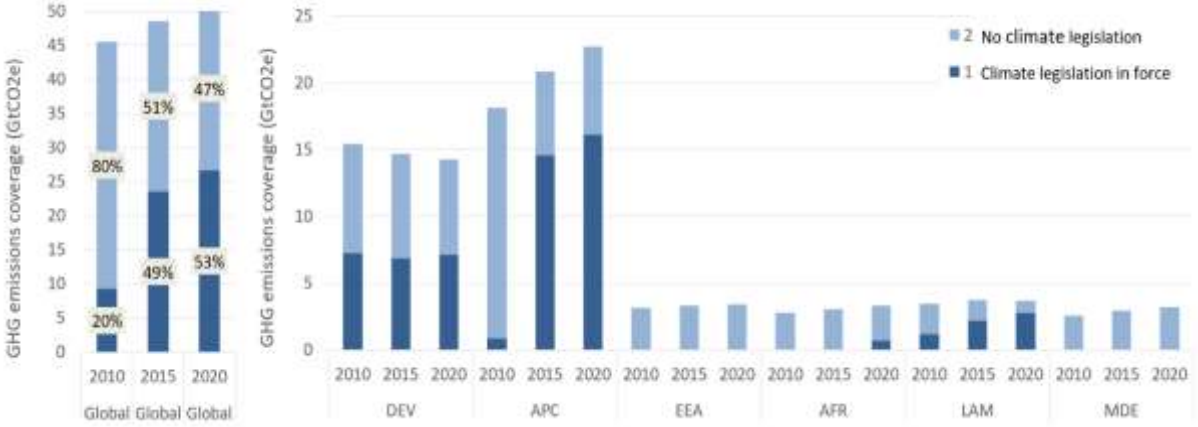
67. Behaviour can contribute directly to emission reductions on a substantial scale. But it also relates to adoption and acceptance of technologies and policies, linking it with other enabling conditions.

68. On technology and innovation, the fast drop in the unit costs of various modular technologies and their accelerated implementation is a positive development, which allows for further cost reductions. These developments can be traced back to policies and investments, in particular by public entities, over the past decades, including advances in research and development and scientific training.

69. Institutional barriers are still faced for many mitigation options and need to be overcome. Institutional barriers, such as regulatory or legal barriers, are especially relevant in least developed and developing countries, where not only the adoption of low emission technologies is slower, but the associated benefits are also generally lower. In this light, international cooperation on finance, technology and capacity building can help address some of these risks and remains important for the sustainability and equity of technological innovation.

70. Mr. Navroz Dubash continued the presentation by focusing on the assessment of governance and policies. While climate governance provides frameworks for action, laws and policies provide a direction, set targets, mainstream action, create specialised organisations and enable mobilisation of finance. The approach varies among countries, but there has been a general increase in climate laws, which now cover more than 50% of global emissions (Figure 12).

Figure 12: **National climate change mitigation legislation**



Source: Slide 53 of the presentation of the IPCC WGIII, 2022. Based on Technical Summary Figure 24, IPCC WGII AR6: Prevalence of Legislation and Emissions Targets across Regions, 2022 (still subject to edits).

71. A complementary element of climate governance is effective national institutions, which help coordinate different areas of action through horizontal linkages across ministries and vertical linkages across different parts of government, as well as between government and non-state actors. Additional elements of governance are political agreement and civic engagement.

72. The WGIII report shows that policies are growing both in number and scope, and that they work more effectively when designed in complementary ways. Regarding regulatory instruments, the assessment found that they are effective at sectoral level and when designed with flexibility mechanisms that can reduce costs.

73. Economic instruments, such as taxes and cap and trade policies, have incentivized low-cost reductions. Removing fossil fuel subsidies would reduce emissions, improve revenue and macroeconomic performance and yield co-benefits, but may result in distributional impacts which require attention.

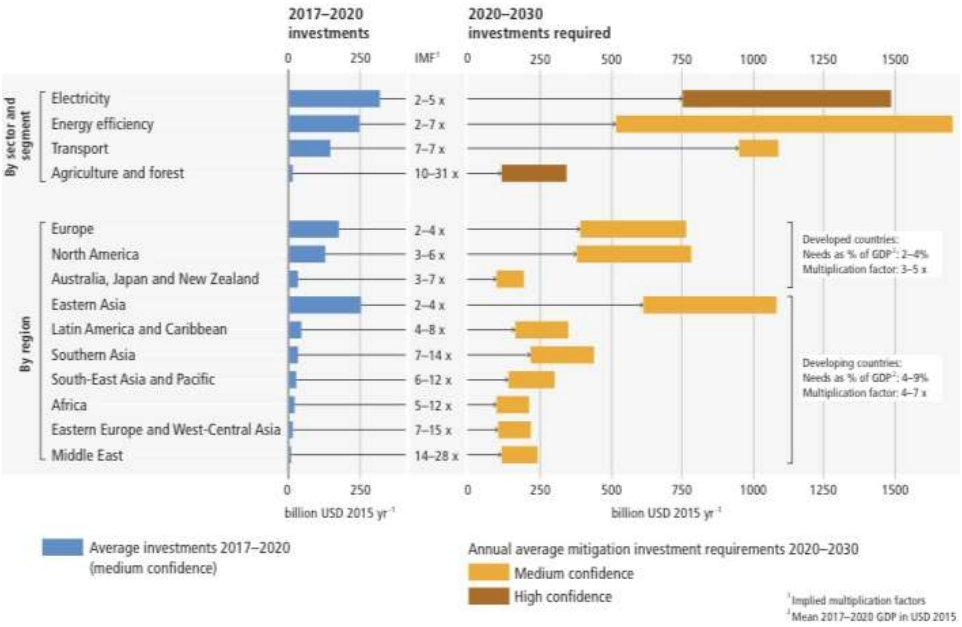
74. Policy packages are better able than individual policies to realise synergies and avoid trade-offs, as well as to support a low-emission development future. It is important to look beyond individual policies to sectoral, behavioural, financial or macroeconomic policies that can help shift development pathways towards sustainability by broadening the range of mitigation options.

75. Regarding international cooperation as an enabler, the WGIII report found that international processes such as the UNFCCC and the Paris Agreement are enhancing collaboration, national ambition and policy development. Transnational partnerships and sectoral agreements are also helping to reduce emissions. Two areas with potential for enhanced international cooperation are trade agreements and international aviation and shipping.

76. Ms. Silvie Kreibiehl focused on the assessment of finance flows in the WGIII report. She pointed out that while we have seen a strong momentum in recent commitments, the actual progress on the alignment of financial flows with the long-term global goals has been slow. Yearly tracked, financial flows for climate change grew by about 60% between 2013–14 and 2019–20, but growth has slowed down since 2017. Mitigation represents approximately 90 to 95% of flows compared to adaptation.

77. The relatively slow implementation of commitments by countries and stakeholders to scale up climate finance will result in significant carbon lock and stranded assets, as well as additional economic costs. Regarding the finance gap, financial flows are a factor of three to six below the average levels needed between 2020–2030 to limit warming to below 1.5°C or 2°C. (Figure 13).

Figure 13: **Breakdown of average investment flows and needs until 2030 to limit warming to below 1.5°C or 2°C**



Source: Slide 57 of the presentation of the IPCC WGIII, 2022. Based on the IPCC WGIII AR6 Report Figure 15.4, 2022.

78. Total mitigation investments have to substantially increase across all sectors and regions to limit warming to below 1.5°C or 2°C, but investment requirements can be absorbed by capital markets. Furthermore, the financial gap is only one indicator. A more comprehensive analysis is needed to understand the challenges of scaling up investments in the different regions and sectors. In some cases, for example the energy sector, there is a need to redirect investments rather than the need for new allocations.

79. Decarbonizing the economy requires global action to address fundamental economic inequalities. In developing countries, the costs and risks of financing mitigation often represent a significant challenge for stakeholders at all levels, which is exacerbated by the countries' general economic vulnerability and indebtedness.

80. The finance gap is much bigger in developing countries (multiplication factor of 4–7) than in developed countries (multiplication factor of 3–5), although differences among developing countries are quite significant. Financing and investment requirements for adaptation, reduction of losses and damages and climate responsive social protection will further widen the gap between developed and developing countries.

81. While there is sufficient capital to close the investment gaps given the size of the global financial system, there are barriers to redirect capital to climate action. Inadequate risk assessment is a key barrier to the deployment of commercial finance. Physical risks are systematically underestimated. Therefore, stronger capacities and knowledge for appropriate assessment in the private sector need to be built.

82. Clear policy choices and signals from governments and the international community can support an appropriate risk assessment and scaling up mitigation finance flows, including a stronger alignment of public finance and policy, as well as higher levels of public finance for climate in order to reduce uncertainty for commercial investors.

83. If we want to move on to a 1.5°C or 2°C pathway, it will be crucial to translate investment needs into concrete investment opportunities. There are positive advances, such as business models that have proven to facilitate scalable and replicable investment opportunities, or investor demand driving the development of new labelled instruments like green bonds.

84. Accelerated financial support from developed to developing countries is another critical enabler. The WGIII report highlights the need for scaled-up public grants for mitigation and adaptation for vulnerable regions, and stresses the importance of increased levels of public finance and publicly mobilized private flows from developed to developing countries in the context of the 100 billion per annum goal. Public guarantees to reduce risks and attract private sector investments are crucial. Multilateral and national climate funds and development banks would also need to lower financing costs for underserved groups.

85. Finally, economic instruments which consider economic and social equity, and distributional impacts, can support the alignment of financial flows with gender-responsive programs, as well as with better access to finance for local communities, indigenous people and small landowners.

Summary of the Q&A session for theme 2: System transformations to limit global warming, theme 3: Linkages between mitigation, adaptation, and sustainable development, and theme 4: Strengthening the response

86. Addressing the regional differentiation and distributional costs of mitigation remains a major gap. Global level metrics such as global cost and global GDP do not represent impact and cost encountered by specific economies. Lowering global GDP for a few percentages could mean significant cuts for specific economies, jeopardizing efforts for sustainable development. There needs to be a comprehensive and transparent discussion on the economics of all mitigation options and the cost of transition. Technology, and specifically abatement technologies, have been recognized in the WGIII report as unavoidable to achieve net zero. How can research and global efforts reveal how best to incorporate such technologies as CCS and circularity options?

> *IPCC experts*: There are two regional cost dimensions that are provided in the WGIII report: investment opportunities and needs in different regions of the world and the regional costs in terms of macroeconomic GDP losses. The report does not address who should cover those costs and investments because that is an equity question related to the political dimension. Further information is provided in chapters 3 and 12.

87. Could the authors provide further detail on the most feasible mitigation options assessed in the report, including in terms of their individual potentials to close the 2030 emission gap and costs? We understand that the assessment of options and costs might not apply in the same way for all regions of the world. Could authors share findings of this situation for the most vulnerable countries? How do potentials and costs of these different options available to regions relate to the global numbers provided in the SPM?

> *IPCC experts*: Figure SPM.7 shows the potential of different mitigation options for 2030 divided up by cost. The biggest contributions for reducing emissions by 2030 are in the energy sector (wind and solar energy, some of it available at very low cost) and land-use sector (carbon sequestration in agriculture, reduced conversion of forests and other ecosystems, and ecosystem restoration). There is potential across various other sectors, including buildings and transport, but some of these measures will take a longer time to be implemented.

88. Could the authors provide information on what the report assesses on the mitigation options with the highest trade-offs and synergies with sustainable development, in particular for the energy sector? Could authors further elaborate on the trade-offs of bioenergy and CCS with sustainable development as assessed in the report?

IPCC experts: The report is very clear about the trade-offs of bioenergy in terms of competition for land for food production, and possible negative implications for biodiversity, and this is very strongly related to the scale of bioenergy use. Pathways differ a lot depending on to which extent sustainability concerns have been taken into account.

89. We understand that the majority of the sustainable development assessment is based on the SSP2 scenario, Could the authors provide insights on the implications of this assessment and whether findings would be different, for example, for SSP1 scenario?

IPCC experts: Many scenarios rely on SSP2, which is the middle-of-the-road socio-economic development pathway. However, there is also a limited number of pathways that have looked into the implications of the transformation in a sustainable development environment. In the SSP1 illustrative pathway there are major synergies with sustainable development policies and a lower reliance on CDR.

90. We heard much about options on mitigation, but what are the policy instruments that would help us to raise mitigation action? Could the authors expand on what are the most relevant mitigation co-benefits, for adaptation and SDGs?

IPCC experts: The WGIII report looks at multiple policy instruments, including instruments focused on mitigation as the central challenge, instruments in the regulatory space, a range of sectoral instruments and policy approaches that look at shifting development pathways. The literature has moved now to also encompass how these instruments might be combined in different ways to address context-specific circumstances. The policy conversation is therefore focused on how packages of policies can be tailored, given different contexts and objectives.

On the mitigation options that deliver adaptation benefits, a few sectors are highlighted in the SPM and technical summary: urban green and blue infrastructure, efficient and low-energy building solutions, and restoration of mangroves and coastal wetlands.

91. How much bioenergy is included in the 1.5°C scenarios in terms of volume or energy? Can you quantify the additional forest area needed in these scenarios for carbon storage and sinks? In different scenarios, what are the important trade-offs between the need for forest and bioenergy in this regard?

IPCC experts: There are two main options, on the one hand increasing the forest area, or on the other hand, using land for bioenergy either for the energy system, or bioenergy with carbon capture and storage (BECCS) for negative emissions. The scale across the scenarios is roughly a doubling of bioenergy compared to today. The land requirements of that are between 50 to hundreds of millions of hectares (200 million hectares in average), although this is not a statistical sample. Land requirements are much lower in scenarios that shift pathways towards sustainable development, than in those which rely more on supply-side and technical solutions.

In terms of forest, the expansion in the scenarios is similar: roughly around 300 million hectares as a middle value. More detailed numbers can be found in chapters 3 and 7, and the SPM.

92. How are equity and regional differentiation included in the projections and scenarios? International cooperation, the need for financial and technology transfer from developed to developing countries, as well as developing country vulnerabilities and adaptation costs should be better considered.

IPCC experts: It was clarified that scenarios include equity, some in a very explicit way. There is an equity box in in chapter 3, which illustrates, for example, scenarios with a much more equal distribution in terms of per capita emissions. Increasing effort needs to be made to include governance, institutional capacity and equity dimension in the scenarios. On regional assumptions, users can access the data and information in the scenarios and look at the regional emissions and results.

It was also noted that IPCC does not produce the scenarios, but only assesses existing ones. At the same time, the IPCC has decided to hold a scenarios workshop before the end of its sixth cycle to take stock of the contribution of scenarios to the AR6 products, strengths and weaknesses of the approaches adopted, as well as to identify gaps, taking account the needs and expectations of governments and other users. This workshop will be a mechanism for comments to be more systematically included. Governments will be invited to nominate participants for the workshop.

93. The report assesses the current targeted mitigation finance flows. How do these compare to required investment flows in order to still limit warming to 1.5°C? What is known in terms of existing finance flows from

developed to developing countries? What information does the report contain in terms of access to finance for vulnerable regions and SIDS? In particular, what are the most relevant barriers for these countries to access climate finance and how can these be overcome, as assessed in this report?

IPCC experts: For the WGIII report, the IPCC decided to focus more on a holistic analysis of investment requirements across sectors rather than a very energy-focused analysis, which was the case for AR5. However, the figures for the investment requirements for energy from the models for 1.5°C and 2°C are assessed. This is different for the other sectors, for which findings are aggregated from various studies and those studies cannot always be categorized into the same system.

The WGIII report highlights the implication of climate change on the economic vulnerability on country ratings, and consequently, also on fiscal space. It also notes issues around the various funding sources and international cooperation not having standardized procedures, which makes it difficult for smaller countries with a limited institutional capacity to tap those funding sources.

94. Would it be possible to assess how to take advantage on the cost reduction of renewables to increase finance flows, reducing the current finance gap? How can we find synergies between the reduction of costs and the need of increasing finance in some sectors?

IPCC experts: Lower costs for renewable energy have helped commercial investors tap renewables markets. The business cases do not depend solely on the actual economic costs, but also on the regulatory access and the support which is granted. A higher economic viability means lower political risks to investors. Which has facilitated investors to finance renewable energy. Regulatory interventions are still needed to enhance investments and access to those markets.

95. The WGIII report mentions that pathways consistent with limiting global warming to 1.5°C are characterized by global GHG emission reductions of around 43% below 2019 levels by 2030. The earlier *Global Warming of 1.5°C Special Report* (SR1.5) indicates a 45% reduction of CO_2 below 2010 levels. Have the authors performed any comparison between these two figures? How much more ambitious do we have to be today compared to what we thought at the time of the 1.5°C report, specifically with a 2030 horizon? Any advice on how we should interpret the change of CO_2 to GHG emissions in those figures?

IPCC experts: In terms of comparing those two different scenario sets, the most rapid, attainable emissions reduction across the different models has not changed since SR1.5. But, since the historical emissions have increased by now, a higher emissions level is reached by 2030 with the emissions reduction rate indicated in SR1.5. Therefore, looking at the whole ensemble of scenarios in category one, the lowest and most stringent scenarios, generally the likelihood of staying below 1.5°C has declined. We are starting from a higher point in the base year.

96. What are the possible safeguards that can be put in place to protect and promote development, the rights to development of the African continent and in terms of the energy-intensive systems? What is the financial and technological support that can be provided to ensure that African countries can develop into low emissions pathways? What are the current finance flows to Africa, and how does it compare to the levels needed to achieve low-emissions resilient development?

IPCC experts: For Africa, the ratio between the investment requirements in the 1.5°C to 2°C range is 5–12 times. The report shows that, in particular for Africa, climate mitigation finance flows have come down over the past year, which is an alarming trend.

97. CDR is a feasible and effective option only if rapid reductions of GHG emissions are achieved. Could the authors specify the side-effects of CDR measures if implemented at a large scale?

IPCC experts: CDR covers a very wide range of methods, which differ in their technological maturity, timescale for storage, and potential for adverse side-effects, risks, and benefits. Some measures tend to have mostly co-benefits, such as soil carbon storage through protection and restoration of native ecosystems. Other methods have known trade-offs, such as direct air carbon capture and storage, which requires energy. Managing CDR measures is a question of system design. For the use of biomass for bioenergy, risks or benefits highly depend on implementation. A higher scale is not in itself a predictor of a negative outcome, but it makes it harder to manage. In sum, if well-managed, CDR can produce co-benefits, if managed poorly, it can present adverse side-effects.

98. What policy measures are effective to achieve individual behavioural change rapidly? What are good practices or model examples to trigger economic and social transformation to decarbonisation at either the local, national or regional level?

IPCC experts: Chapter 5, section 6, describes policies used in many different countries to help to avoid emissions, and related enablers. For example, integrated city planning to avoid travel growth or food waste reduction. A number of examples of success stories are presented, including with links to wellbeing.

C. Summary of the general discussion and interventions from Parties

99. A total of 26 Party interventions were made to pose questions and/or provide comments. Participants expressed their gratitude to the IPCC, particularly the WGIII experts, for their work on climate change mitigation. Participants also welcomed the report and thanked the SBSTA and IPCC for organizing the special event.

100. Parties raised issues such as, for example, equity and just transitions, options to limit global warming to 1.5°C, finance flows, historical emissions, rights to development and synergies with low-emission resilient pathways, investments in the renewable energy sector, particular circumstances of developing countries, including SIDS and African countries, risks and benefits of CDR and CCS, land use, carbon budgets, transition from fossil fuels, mitigation costs, enablers and good practices. Parties also requested clarifications from the authors on the scenarios and pathways, as well as figures on investment needs and costs, emission reductions needed to limit global warming to 1.5°C, finance flows for the energy sector, among others.

101. The various authors present in the room and connected virtually provided answers to the different questions and comments with information from the report.

102. A Party noted that figure 15.4 was not included in the SPM because the use of the term “developed and developing countries” was contested between members of the IPCC.

D. Closing remarks

103. In his closing remarks, the IPCC Chair, Mr. Hoesung Lee thanked Parties for the rich and stimulating discussion. He expressed the hope that the new knowledge and findings of this report would inform discussions during SB 56 and for COP 27 with a view to increase climate action. He thanked the UNFCCC and IPCC secretariats for organizing the event, the WGIII co-chairs, Bureau members, authors and Technical Support Unit staff for the preparation, and Parties for their interest and support.

104. The SBSTA Chair, Mr. Tosi Mpanu-Mpanu, closed the event by joining in his gratitude with the IPCC Chair and expressing his gratitude to the WGIII co-chairs and the IPCC experts present, as well as the over 270 authors that made it possible to benefit from the best knowledge that the scientific community around the world has made available on mitigation to climate change.