Summary report on the third meeting of the structured expert dialogue Bonn, Germany, 6–8 June 2014

Note by the co-facilitators

16 October 2014

I. Introduction

A. Mandate

1. The Conference of the Parties (COP), at its eighteenth session, decided that the structured expert dialogue (SED) should consider on an ongoing basis, throughout the 2013–2015 review, the material from the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) as it becomes available, through regular scientific workshops and expert meetings, and with the participation of Parties and experts, particularly from the IPCC.[1] The contribution of Working Group II to the AR5[2] (AR5 WGII) and the contribution of the Working Group III to the AR5[3] (AR5 WGIII) were approved and accepted by the IPCC in March and April 2014, respectively.

2. At their thirty-ninth sessions, the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI) requested us, the co-facilitators of the SED, to organize its meetings in 2014 in conjunction with the fortieth and forty-first sessions of the subsidiary bodies.

3. In response to the above-mentioned mandate, we convened the third meeting of the SED (SED 3) during the fortieth sessions of the subsidiary bodies, to make a contribution to the assessment of the adequacy of the long-term global goal and the overall progress made towards achieving it, to the extent possible, on the basis of AR5 WGII and WGIII. Prior to SED 3, we provided Parties with an information note outlining our approach to the organization of the meeting.[4]

B. General objective and approach for the meeting

4. The goal of SED 3 was to make a contribution to the assessment of the adequacy of the long-term global goal and the overall progress made towards achieving it, to the extent possible, on the basis of AR5 WGII and WGIII.

5. Accordingly, we organized SED 3 in a similar manner to previous SED meetings as a fact-finding exchange of views between experts and Parties. IPCC experts presented findings from AR5 WGII and WGIII and highlighted their relevance to both themes of the 2013–2015 review (see para. 8 below). These presentations were followed by a moderated discussion guided by questions prepared by the co-facilitators[5] based on questions provided by Parties through their submissions,[6] questions from participants, and additional questions provided by some Parties before each part of the meeting.

[1] Decision 1/CP.18, paragraph 86(a).
[2] *Climate Change 2014: Impacts, Adaptation and Vulnerability*. Available at <http://www.ipcc.ch/report/ar5/wg2>.
[3] *Climate Change 2014: Mitigation of Climate Change*. Available at <http://www.ipcc.ch/report/ar5/wg3>.
[4] Available at <http://unfccc.int/7521.php>.
[5] For the list of questions, please see the SED 3 agenda, available at <http://unfccc.int/7521.php>.
[6] SBSTA 39 and SBI 39 agreed to continue consideration of the volumes of IPCC AR5 as they become available; other inputs as listed in decision 2/CP.17, paragraph 161; questions put forward by Parties to ensure a balanced consideration of these inputs; and the views of Parties on both themes of the 2013–2015 review, in accordance with decision 1/CP.18, paragraph 88, and requested Parties to submit their views on the future work of the SED, including the further use of different sources of information (FCCC/SBSTA/2013/5, paragraphs 134–135 and FCCC/SBI/2013/20, paragraphs 168–169). The submissions from Parties are available at <http://unfccc.int/science/workstreams/the_2013-2015_review/items/7590.php>.

II. Summary of the proceedings

6. SED 3 consisted of four parts and was held on 6–8 June 2014 at the Maritim Hotel in Bonn, Germany, during the fortieth sessions of the subsidiary bodies, and was open to all Parties and observers. Part 1 was held on Friday, 6 June (4–7 p.m.), part 2 was held on Saturday, 7 June (10 a.m.–1 p.m.) and parts 3 and 4 were held on Sunday, 8 June (10 a.m.–1 p.m. and 3–6 p.m., respectively).

7. The meeting was chaired and moderated by us, the co-facilitators. Christiana Figueres, Executive Secretary of the UNFCCC secretariat, opened the meeting, underlining that the purpose of the SED is to build a bridge between science and policy. While recognizing that science is always a few steps ahead of policy, she stressed that the AR5 highlights the urgent need for policy to "catch up", both in the short term to bend the emissions curve to stay on the path to limit global warming below 2 °C, and in the long term. She added that the 2015 agreement[7] should therefore provide the basis for reaching a level where the same amount of greenhouse gases (GHGs) are absorbed as are emitted.

8. The discussion at the meeting focused on the two themes of the review: the adequacy of the long-term global goal in the light of the ultimate objective of the Convention (theme 1), and overall progress made towards achieving the long-term global goal, including a consideration of the commitments under the Convention (theme 2).

9. With respect to AR5 WGII, the topics addressed included: the observed impacts and projected risks associated with various levels of warming, including warming to 2 °C or 1.5 °C; human interference with the climate system; the link between socioeconomic pathways and climate change risks; adaptation options, needs, opportunities and associated costs; climate-resilient pathways; and the link between adaptation, mitigation and sustainable development.

10. As regards AR5 WGIII, the topics addressed included: transformation pathways and limiting warming to 2 °C or 1.5 °C; sectoral and cross-sectoral mitigation pathways; trends in the stocks and flows of GHG emissions and their drivers; international cooperation on mitigation; policy, socioeconomic, equity and ethical aspects of climate change; and cross-cutting mitigation investment and finance issues.

11. In preparing the questions that guided the discussions in each part of SED 3, we took into consideration the above-mentioned questions submitted by Parties, our experience with the first and second meetings of the SED, as well as overarching issues such as: the requirements and limitations associated with the long-term goal to limit the increase in the global average temperature below a specific level, such as 2 °C or 1.5 °C above pre-industrial levels;[8] the costs and benefits of limiting warming to a given level; the level of unacceptable global warming; and the consequences of delaying action. The mandate of the 2013–2015 review requests the SED to address such issues; SED 3 enabled us to obtain the scientific information relevant to the quest for reliable answers to such questions.

12. **Part 1** of the meeting opened with a scene-setting presentation made by an IPCC expert on the overarching findings and new approaches of AR5 WGII that are relevant to both themes of the 2013–2015 review. The presentation was followed by a discussion guided by questions. Subsequently, presentations on theme 1 of the review focused on the past and current impacts of, as well as the projected risks posed by, climate change from global and regional perspectives with a view to assessing the adequacy of the long-term global goal using inputs from AR5 WGII, and outlined the climate risk management framework and the mapping of the so-called 'solution space'.[9]

13. **Part 2** started with presentations on impacts, adaptation and vulnerability issues relevant to theme 2 of the 2013–2015 review and explored: the link between socioeconomic pathways and the risks posed by climate change; adaptation options, needs, opportunities and associated costs; climate-resilient pathways and the relationship between adaptation, mitigation, and sustainable development in the context of assessing progress made towards achieving the long-term global goal. The presentations were followed by a substantive discussion guided by questions.

14. **Part 3** of the meeting opened with a scene-setting presentation by an IPCC expert on the overarching findings and new approaches of AR5 WGIII that are relevant to both themes of the 2013–2015 review. The presentation was followed by a discussion guided by questions. Subsequent presentations on theme 1 of the

[7] The COP, by decision 1/CP.17, launched a process to develop an agreement under the Convention applicable to all Parties, to be adopted at COP 21 in 2015 and to come into effect and be implemented from 2020.

[8] Decision 1/CP.16, paragraph 4.

[9] See figure SPM.8 in the summary for policymakers in AR5 WGII, available at <http://ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf>.

review focused on transformation pathways and limiting warming below 2 °C or 1.5 °C, including the likelihood of limiting global warming at those levels and the urgency of the action required to move towards such pathways; sectoral and cross-sectoral mitigation pathways; mitigation potentials, costs and technologies; investment patterns and international cooperation; regional development and cooperation; and national and subnational policies and institutions.

15. **Part 4** started with presentations on theme 2 of the 2013–2015 review, exploring progress made in: trends in stocks and flows of GHGs and their drivers; climate mitigation policy, value judgment, and ethical and equity concepts and considerations in the context of sustainable development; and cross-cutting investment and finance issues, with an assessment of the progress made towards achieving the long-term global goal. As in the previous three parts, the presentations were followed by a substantive discussion among experts and Parties guided by questions.

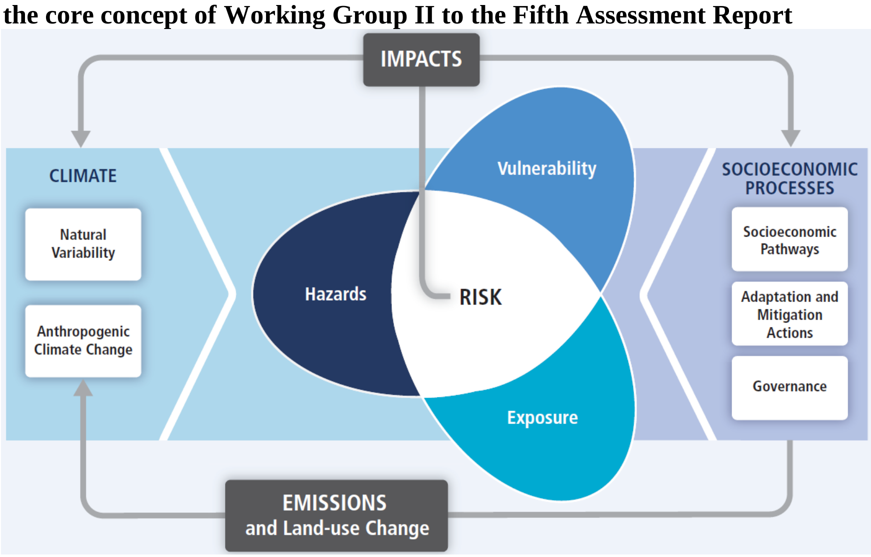
III. Summary of the discussion

A. Part 1: setting the scene for considering the contribution of Working Group II to the Fifth Assessment Report

1. Presentation by an expert

16. Part 1 of the meeting opened with a scene-setting presentation by Mr. Chris Field, Co-Chair of IPCC Working Group II (WGII), who outlined the overarching findings and new approaches of AR5 WGII that are relevant to both themes of the 2013–2015 review. He described the **concept of risk of climate-related impacts**, explaining that risk emerges from the overlap of climate-related hazards with vulnerability and exposure of human and natural systems (figure 1). The extent of climate change can therefore be controlled not only by through mitigation, but also by moderating and managing the risks of climate change (i.e. by any actions addressing vulnerability, exposure and/or hazards). Consequently, changes in both the climate system and socioeconomic processes, including adaptation and mitigation, are drivers of hazards, exposure and vulnerability.

Figure 1
Illustration of the core concept of Working Group II to the Fifth Assessment Report



Source: Summary for policymakers in the contribution of Working Group II (WGII) to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change, figure SPM.1. The figure illustrates the constituents of 'risk' – the fundamental concept used throughout AR5 by WGII.

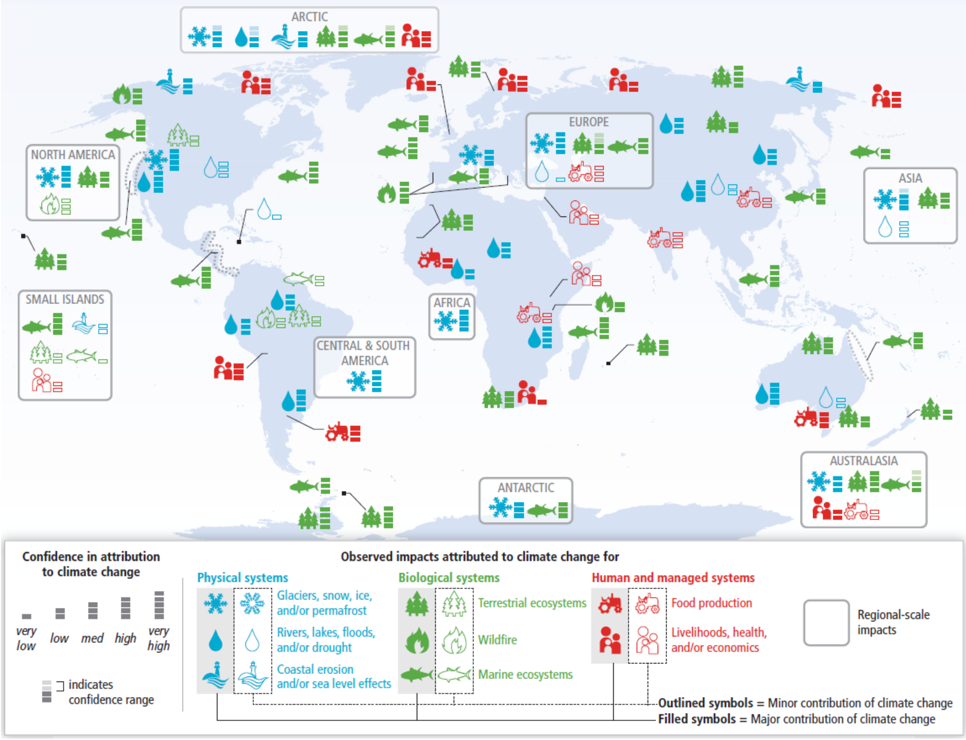
17. Mr. Field noted that the **observed impacts of climate change are consequential and wide-ranging**, spanning across all regions and sectors (figure 2) and that, compared to the IPCC Fourth Assessment Report (AR4), the confidence levels related to the impacts of climate change are higher in the AR5. He said that we should ask ourselves whether these impacts, individually or collectively, have already crossed the threshold as defined in Article 2 of the Convention, and presented some examples of these impacts, namely: the consistent

mass loss of glaciers, including that of the Himalayan glaciers; forest die backs; and wheat and maize yield decreases.[10]

18. He noted that **increasing magnitudes of warming increase severe, pervasive and irreversible impacts,** and that the decisions taken over the next two decades with regard to mitigation and adaptation will affect the risks of climate change throughout the twenty-first century. He presented two world maps prepared by IPCC Working Group I (WGI) showing projected temperature increases for the twenty-first century according to representative concentration pathway (RCP) scenarios RCP2.6 and RCP8.5, and noted that two eras can be distinguished (figure 4): a near-term era (the next few decades) where the temperature increase does not significantly depend on mitigation efforts and, therefore, adaptation provides the main options to control risks, while recognizing the essential role of mitigation investments in addressing climate change in the long term; and a long-term era, where there is a large difference between the projected global warming for RCP2.6 and RCP8.5. For RCP8.5, Mr. Field noted the significantly higher increase in projected temperature for land and oceans and, consequently, the associated risks compared with RCP2.6.

19. With respect to the **projected impacts** of future climate change and the importance of the rate of change, Mr. Field described a graph showing the maximum speed at which terrestrial species can move across landscapes depending on the rate of climate change, which illustrates that RCP6, the **impacts of climate change on many habitats are occurring faster than the estimated maximum speed at which most groups of organisms can move**. The impacts of climate change are therefore outrunning the speed at which ecosystems can be expected to possibly shift in order to adapt to these changes.

Figure 2
Widespread impacts in a changing world



Source: Summary for policymakers in the contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure SPM.2(A). The figure shows that various attributed impacts have been found in all sectors and regions, albeit with significant differences.

20. As regards transitioning from framing climate change in terms of temperature to **framing it in terms of risks**, he explained that one way to assess the adequacy of the long-term global goal could be to **examine the projected level of risk at 2 °C and question whether it should be decreased**. He explained that the assessment for each risk is based on an estimate of its current level, the level for the near term, and the level following a temperature rise of 2 °C and 4 °C at the end of the twenty-first century, as well as the prospects of reducing this risk based on the expert judgment of the WGII experts (figure 3). The benefits of investing in mitigation are shown by the difference in the level of risk for 2 °C and 4 °C. The grey area of each bar denoting the level of risk

[10] For details of observed regional impacts, see table SPM.A1 in the summary for policymakers in AR5 WGII, available at <http://ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf>.

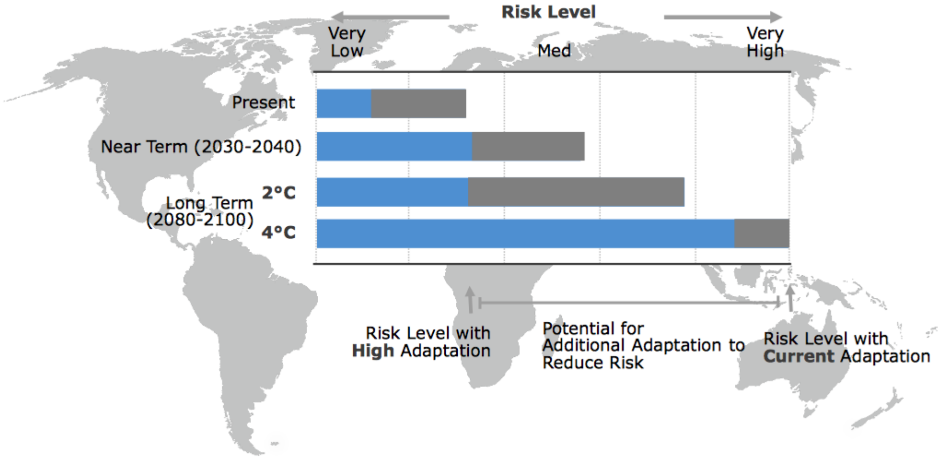
in figure 3 below illustrates the benefits of investing in adaptation. In the near term, the level of risk is often the same or similar for both RCP2.6 and RCP8.5.

21. Mr. Field stressed that there is a **limited prospect for risk to be reduced by adaptation action in a 4 °C warmer world**, but that there are still **significant opportunities for adaptation in a 2 °C warmer world**. However, under all of the assessed scenarios, some residual risk from adverse impacts remains. He presented examples of the assessment of key risks and prospects for adaptation in Australia and for the oceans.

22. Mr. Field explained that AR5 WGII identified **eight key climate-related risks** that span across all sectors and regions, which were identified based on expert judgment, and illustrated these risks for the main world regions. The risks can be **assessed according to the ethics, values and priorities of the various relevant stakeholders**. Furthermore, **five** integrative **reasons for concern** (RFCs) provide a framework for summarizing the key risks across sectors and regions, namely: unique and threatened systems; extreme weather events; the distribution of impacts; global aggregate impacts; and large singular events (figure 4). The first three categories are difficult to monetize. The forth category tends to be most consistent with monetization in comparison with mitigation, but does not include "all the things we care about". The last category, which also includes irreversible impacts resulting from systems crossing tipping points, such as major ice sheet loss and a sea level rise of several metres, is also difficult to evaluate comprehensively (e.g. assessing the impacts of all major coastal cities in the world disappearing).

23. In concluding, he underlined that addressing **climate change involves managing risk**. Therefore, in order to assess the adequacy of the long-term global goal, a key element is the assessment of **when the scale** (e.g. frequency and severity) **of impacts results in a transition from 'acceptable' to 'unacceptable' at the local level**.

Figure 3
Assessing risk



Source: Slide 13 of the presentation by Mr. Chris Field (Intergovernmental Panel on Climate Change), available at <http://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/0_field_sedpart1.pdf>. The figure explains the risk assessment approach adopted by Working Group II to the Fifth Assessment Report.

2. General discussion

24. The ensuing discussion was guided by the following questions:

(a) What does AR5 WGII tell us about the key risks, shifts in key risk patterns and potential benefits related to climate change?

(b) How can risks be reduced through adaptation and mitigation?

(c) How reliable are the projections of risks and how can they be used for decision-making at the global level?

(d) What are the options for managing risks through adaptation and sustainable development?

25. In response to a question on the **definition of 'moderate' and 'high' adaptation,** and if 'high' adaptation implies action that is not only plausible but also possible, the expert explained that the WGII authors took into account regional development pathways when assessing 'moderate' and 'high' adaptation, and that 'high' adaptation relates to the physical limits of adaptation and is generally indicative of potential for adaptation free of serious financial constraints (see para. 57). He added that even with 'high' adaptation, residual risks remain under all scenarios, which could trigger the decision to aim for a lower temperature limit than 2 °C.

26. One Party asked how to characterize **the point**, in terms of levels of warming, **at which there is no longer adaptation but loss**. The expert said that the **transition from adaptation to loss** depends on the scale, but that, in general, when proactive adaptation by communities to pursue sustainable development is eroded, adaptation is difficult. For example, a forced relocation is considered to be adaptation if development aspirations continue to be met. If there is still a residual risk with 'high' adaptation, this is considered to be loss and damage. In terms of WGII products, if there is still a residual risk with a 2 °C temperature rise with 'high' adaptation, then that equates to damage.

27. In response to a request for more information **on the consequences of a 1.5 °C temperature rise, as opposed to a 2 °C temperature rise,** the expert clarified that AR5 WGII contains very limited assessment of the impacts of a 1.5 °C warming because of the scarce literature available to assess the impacts resulting from this limit. The RFCs presented in figure 4 summarize some of the risks related to a 1.5 °C temperature rise. He added that **near-term risk, where warming is around 1.5 °C, could serve as an operational tool to provide an approximate indication of the impacts of a 1.5 °C long-term warming**.

28. Responding to a question on how to **cooperate internationally on adaptation**, taking into account the intrinsically local nature of adaptation, the expert underlined the importance of adaptation in the global strategy to address climate change, as well as the interplay between adaptation and mitigation action. He added that adaptation relies largely on decisions made at the local, regional and national levels.

29. One participant was of the view that AR5 WGII provides very important information, including on the observed impacts and future risks of climate change, as well as opportunities for effective action to reduce such risks. **A risk framework could help to improve the decision-making process on climate change** and, in the context of urgency of action, adaptation provides the main opportunity for developing countries to address climate risks in the short term. Adaptation is therefore the highest priority for developing countries and, in this context, international cooperation on adaptation plays an important role.

B. Part 1 – theme 1: the adequacy of the long-term global goal in the light of the ultimate objective of the Convention based on the contribution of Working Group II to the Fifth Assessment Report

1. Presentations by experts

30. Mr. Joern Birkmann (IPCC) made a presentation on **human interferences with the climate system** and RFCs. He explained that the **key climate-related risks and RFCs** can be used as **vehicles to understand "dangerous anthropogenic interferences with the climate system"** in view of the long-term global goal, assuming various upper limits of global warming and a range of levels of exposure and vulnerability. The key risks are potentially severe adverse consequences for humans and socio-ecological systems resulting from the interaction of hazards linked to climate change and the vulnerability of exposed societies and systems. The criteria for considering that a risk is 'key' is based on: the magnitude of the risk (not of the hazard); the probability that significant risks will materialize and their timing; the irreversibility and persistence of conditions that determine risks;[11] and the limited ability to reduce the magnitude and frequency or other characteristics of hazardous climate events and trends, and the vulnerability.

31. Mr. Birkmann explained that the WGII experts identified, in various chapters of AR5 WGII, over 80 regional and sectoral risks, including the hazards and key vulnerabilities that generated such risks, as being the most pressing based on the above-mentioned criteria. The risks were then condensed into **eight key risks** to avoid repetition. He provided some examples of the key risks, such as risks of death, injury or disrupted livelihoods in low-lying coastal zones (reflected in RFCs 1–5 in figure 4), risks of severe ill-health and disrupted livelihoods for large populations due to inland flooding in some regions (RFCs 2 and 3), and systemic risks due to extreme weather events leading to a breakdown of infrastructure networks and critical services (RFCs 2–4).

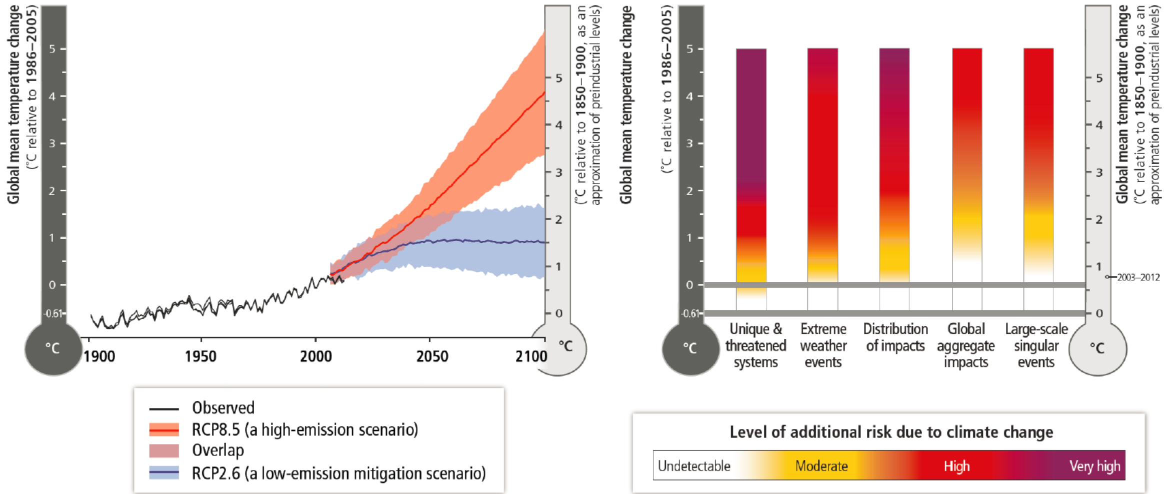
32. Underlining the **multidimensional nature of vulnerability**, Mr. Birkmann noted that addressing the different dimensions of vulnerability, such as its social, economic, environmental and institutional aspects, and accounting for the dynamics of exposure and vulnerability are as important as assessing the degree of warming and its implications for weather extremes. With regard to **the dynamics of exposure**, Mr. Birkmann noted that even if the climate remains unchanged, future risk could increase. For example, in China, more people will be exposed to climate hazards as a result of population increase.

[11] This refers to hazards as well as to societal changes.

33. Mr. Birkmann explained that the eight key climate-related risks were aggregated and translated into five RFCs, which represent the level of additional risk due to climate change (figure 4). He also compared the RFCs identified in the Third, Fourth and Fifth Assessment Reports to illustrate that the past trend and scenarios for future development trends indicate that **an increase in exposure to climatic hazards will be experienced in most regions**.

34. Mr. Christian Huggel (IPCC) addressed the **observed impacts and projected key sectoral risks**, as well as the **potential and opportunities for adaptation**, with a focus on ecosystems, food production and security, economic impacts and livelihoods (aspects related to Article 2 of the Convention). He explained that WGII considered chains of impacts,[12] noting that the observation and attribution of impacts to climate change and the projection of future risks becomes more difficult further down the chain, due to the influence of other convoluting factors.

Figure 4
A global perspective on climate-related risks



Source: Summary for policymakers in the contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, assessment box SPM.1 figure 1. The figure shows how the additional risks associated with the five reasons for concern are affected by a low-emission scenario (RCP2.6) compared with a high-emission scenario (RCP8.5).
Abbreviation: RCP = representative concentration pathway.

35. Mr. Huggel noted that **non-climatic factors are currently the dominant drivers of observed changes in terrestrial ecosystems**, with the exception of highly temperature-sensitive systems, such as the polar regions, high mountains and the tropics. It is worth noting that for these systems, the difference in **projected risks** between a warming of 1.5 °C and 2 °C is significant. Moreover, changes will continue to occur for many decades, even if global warming stops immediately. For example, glaciers worldwide are not in balance with the current climate (lagged response), and there can be significant differences between the level of local temperature increase and the global mean figure. Further, the delayed response in many ecosystems is key to identifying tipping points. Rising temperatures will lead to many changes, such as shifts in freshwater species, water-quality problems and an increase in the risk of forest fires.

36. On the issue of **food production and security**, Mr. Huggel noted that negative impacts of climate change on agricultural crops and marine fisheries have already been observed. Projected risks indicate an increase in negative impacts on crop yields with increasing warming, with all aspects of food security potentially being affected by climate change. **Economic losses** from extreme weather events have been increasing, mainly due to observed increases in exposure. Future losses will also be dominated by exposure (see figure 9), while vulnerability and losses due to climatic factors will also increase.

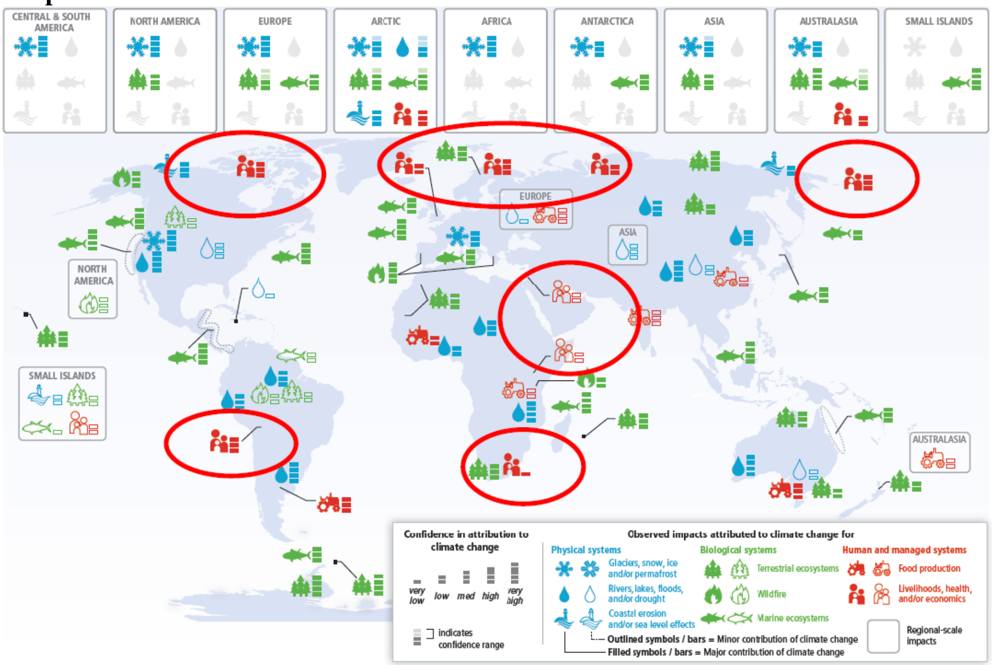
37. There is new, emerging and clearer evidence of climate change impacts on **livelihoods** (figure 5). The best evidence of these observed impacts comes from temperature-sensitive regions, such as the polar regions and high mountains. Climate change impacts are expected to slow down economic growth, jeopardize poverty reduction efforts and erode food security.

[12] For example, a temperature increase in Peru's mountainous areas will lead to glacier shrinkage, changes in water resources, and impacts on crops and cattle, as well as on livelihoods, in that area.

38. Generally speaking, the key question with regard to **projection of risk** is whether ecosystems will be able to render key services and functions under various emission pathways. **Climatic stressors will play an increasingly important role, which will then be largely determined by the emission pathway chosen**.

39. **Adaptation can effectively reduce risks if implemented in association with integrative strategies**; however, **it is restricted by a range of limits,** such as those related to space, high-emission pathways or constraints in adaptive capacity. The adaptive capacity of many ecosystems and species is insufficient for medium to high warming scenarios. In some systems, such as the cryosphere, the Arctic, high mountains or coral reefs, such limits have already been reached.

Figure 5
Observed impacts on livelihoods



Source: Slide 15 of the presentation by Mr. Christian Huggel (Intergovernmental Panel on Climate Change), available at <http://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/2_huggel_sedpart1.pdf>. The figure shows that various attributed impacts have been found in all sectors and regions, albeit with significant differences.

40. Ms. Penny Urquhart (IPCC) presented the observed and projected **regional impacts, risks and potential for adaptation**. Substantial adaptation deficits have been observed in some regions[13] and there is differential vulnerability to key regional risks (figure 6). Many key risks constitute particular challenges for the least developed countries and for vulnerable communities. Vulnerability is linked to multidimensional inequalities, often created by uneven development processes. She provided some examples of such differential vulnerabilities in relation to: **food insecurity and malnutrition** (high and very high risks in Africa, Asia, and Central and South Asia in relation to a global temperature increase of 4 °C); **flooding** (with the majority of the population affected in East, South-East and South Asia due to an increase in exposure and vulnerability); and **hot spells and heatwaves** (in Europe, Asia and Australia).

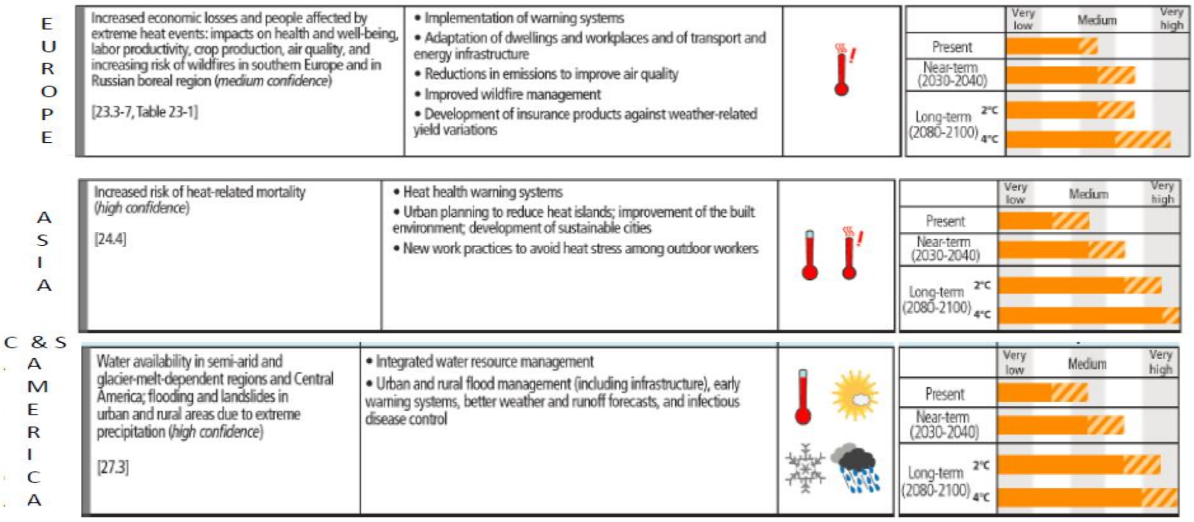
41. With regard to **regional adaptation trends**, Ms. Urquhart described the development of adaptation actions and policies in all regions, noting growing experience in Asia, Africa, Central and South America, small islands and the Arctic, through a combination of traditional and scientific knowledge and community-based adaptation. Common adaptation trends for these regions include ecosystem-based adaptation, growth of resilient crop varieties, expansion of agro-ecological approaches, and climate forecast and early warning systems. However, most adaptation in developing regions remains autonomous, reactive and unsupported, and not at scale. In Europe and North America there is greater involvement of adaptation governance systems, as well as more capacity, experience and resources at the municipal level.

42. Ms. Urquhart noted that **while some regional risks can be reduced through adaptation**, **others may be intractable**, such as threats to freshwater, terrestrial and marine ecosystems in the polar regions, threats to low-lying areas of small islands, and reduced biodiversity in and coastal protection from coral reefs in Australasia,

[13] For example, adaptation deficits have been observed for risks relating to food security in some parts of Africa, declining food production and quality in Central and South America, and food production in some regions of Australia.

small islands around the world and the east coast of Africa. While risks related to flooding can be reduced by adaptation from the category medium to very low in Europe in the case of a 2 °C temperature rise, flooding risks remain medium to high even with adaptation for the same amount of warming in Asia and in Central, South and North America, and would become more widespread with a 4 °C temperature rise.

Figure 6
Examples of regional risks under high adaptation with a 2 °C temperature increase



Source: Slide 12 of the presentation by Ms. Penny Urquhart (Intergovernmental Panel on Climate Change), available at <http://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/3_penny-sedpart1.pdf>. The figure shows how the risk assessment approach of figure 3 was applied in a regional context.

43. Significant **adaptation challenges are distributed unevenly across and within regions**, and some risks may be reduced in some regions but not others. For example, all nine assessed risks for Africa remain high or very high under current levels of adaptation under a 2 °C warming scenario. Adaptation policies and measures will be more effective if they address the underlying causes of poverty and inequality. However, many residual impacts will remain under a 2 °C warming scenario, even with 'high' adaptation, and these impacts will significantly increase under a 4 °C warming scenario for all regions.

44. Mr. Hans-Otto Pörtner (IPCC) made a presentation on **climate-related impacts on the world's oceans**. He outlined climate-related ocean issues, noting the key role of oceans in the climate cycle and the influence of human activities on ocean conditions. Temperature increase is currently the predominant driver of ongoing global changes, leading to shifts in biogeographical distributions of marine organisms. These changes are projected to continue in the future, leading to shifting stocks across fishing zones as organisms migrate to stay within their thermal tolerance range. For commercial species, an impoverishment at lower latitudes with a shift of stocks to higher latitudes is projected by the mid twenty-first century with a 2 °C warming (figure 7). These changes will result in risks to humans and infrastructure. Human adaptation options include the large-scale relocation of industrial fishing activities, but such options are limited for artisanal local fisheries and only exist in the near term, even for a 2 °C temperature increase.

45. As regards the degree of **ocean acidification**, projections depend on the emissions scenario and are associated with an uneven global pH distribution in the oceans and higher acidification in the polar regions. The human adaptation option of shifting to using more resilient species or protecting habitats with low natural carbon dioxide (CO_2) levels only exists in the near term and not in the long term, even for a 2 °C temperature increase, owing to the sensitivity of species, especially with a high level of acidity of the oceans.

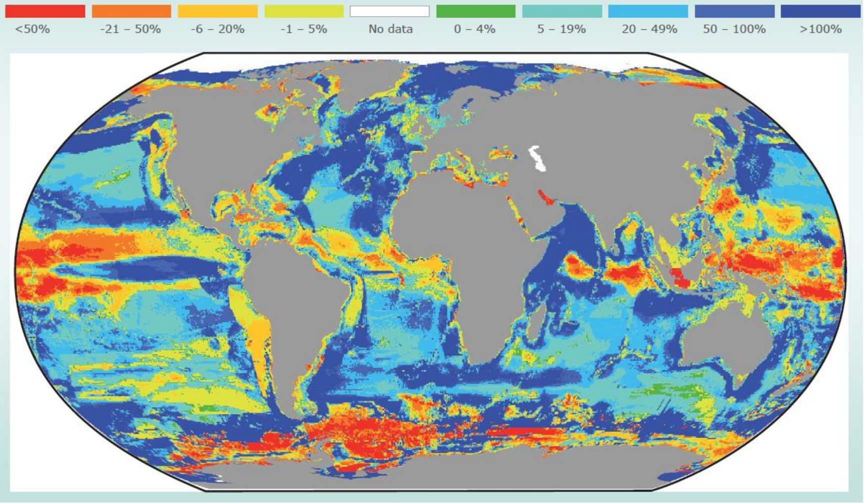
46. Mr. Pörtner noted that **oxygen levels in oceans are decreasing** and explained that the tolerance of organisms to low oxygen levels depends on their complexity, and larger body size organisms generally tend to be more vulnerable. Areas devoid of animal life are expanding. Underlining the **interaction of warming, acidification and hypoxia**, he stated that in animals, the strongest impacts are expected where these factors combine, indicating that assessments based on individual drivers are conservative.

47. On the issue of **sea level rise, beyond 2100** a rise of up to six or seven metres in 2500 is projected,[14] depending on the emissions scenario, with a high level of uncertainty. An examination of palaeo-analogues reveals that a sea level rise of this magnitude occurred in the Pliocene age, when atmospheric CO_2

[14] See the contribution of WG I to the AR5, table 13.8, available at <http://www.ipcc.ch/report/ar5/wg1>.

concentrations were 400 ppm, and in the last interglacial period, when temperatures were about 2 °C above pre-industrial levels.

Figure 7
Change in maximum catch potential (2051–2060 compared with 2001–-2010, *Special Report on Emissions* Scenarios, A1B, 2 °C warming)



Source: Summary for policymakers in the contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure SPM.6(A). The figure illustrates the significant projected change in a marine ecosystem service–based, fishery-related parameter for a global mean warming of only 2 °C.

48. Regarding the impacts of climate change on **vulnerable ecosystems**, Mr. Pörtner focused on warm-water coral reefs and the Arctic sea ice ecosystem. With respect to warm-water coral reefs, the impacts include the bleaching and die off of corals, and an increase in predators. **To protect at least 50 per cent of the coral reefs, the global mean temperature change would have to be limited to 1.1–1.4 °C** (without taking into account the effects of ocean acidification), especially given the lack of evidence to demonstrate that corals can evolve significantly on decadal timescales and under continually escalating thermal stress. As regards the Arctic sea ice ecosystem, summer sea ice is projected to be marginalized and to disappear by the mid twenty-first century under the highest warming scenarios.

49. In conclusion, Mr. Pörtner underlined that, with respect to ocean-related risks, **adaptation "buys time", but is very limited for some systems, such as the polar regions and coral reef systems**.

2. General discussion

50. The ensuing discussion was guided by the following questions:

(a) What impacts has the world observed, and what are the projected key risks and opportunities for the natural, human and managed systems at various levels of temperature increase?

(b) What is the regional variability of observed impacts and projected key risks and opportunities under various warming scenarios?

(c) Is there a difference in impacts, on both oceans and land, of a global warming of 1.5 °C and 2 °C relative to pre-industrial levels?

(d) What level of warming could be interpreted as dangerous and for what reasons, considering the associated scientific uncertainties?

(e) What uncertainties remain? What is their role in a risk management context? Are they calling for a global policy response?

(f) How do the above-mentioned findings relate to the adequacy of the long-term global goal in the context of policymaking in the UNFCCC process?

51. **Regarding the relationship between mitigation and adaptation**, a Party asked for clarification as to what extent these two actions depend on each other. An expert pointed to the existence of co-benefits and synergies between adaptation and mitigation actions. He said that the most attractive options for actions are those that have a mitigation and adaptation component and contribute to sustainable development. Another Party underlined the benefits of **setting mitigation and adaptation goals** and fully considering the risks of different pathways, which is important in the context of the 2013–2015 review. Responding to a question on the urgency of taking action on climate change and the long-term perspective, an expert noted the profound benefits of early

action, adding that mitigating to RCP2.6 depends heavily on rapid action, in a manner that society has never before experienced.

52. **With regard to the assessment of the 1.5 °C limit**, a Party asked if more literature would be made available in the near future. In response, an expert referred to recent literature on the possible irreversible loss of the West Antarctic ice sheet, noting that if these still tentative findings are to be further confirmed and strengthened, the level of risks for RFC 5, including such a large-scale singular event with its inevitable and significant sea level rise, would have to be reassessed and increased. Another Party added that there is now a case for reviewing the level of risk associated with the RFCs for sea level rise since there would already be a high risk under the 2 °C warming scenario based on this new information.

53. Regarding the **difference in impacts**, on both oceans and land, **of global warming of 1.5 °C and 2 °C** relative to pre-industrial levels, an expert reiterated that literature available to assess the 1.5 °C limit (see para. 27 above) is scarce. Another expert stressed that this may also be due to the fact that many scientists are unaware of the fact that a 1.5 °C warming is being discussed by policymakers. He added that the understanding of some physical systems, such as glaciers and permafrost, hinder the response to this question. For agricultural and human systems, the difference between a 1.5 °C and a 2 °C temperature rise is becoming increasingly difficult to assess. Yet another expert underlined the need to address this question in terms of the differences between vulnerability and exposure at these temperature level rises. To this end, for some regions the consequences of a 2 °C warming will be significantly different from those created by a 1.5 °C warming, in particular for low-lying coastal regions. An expert noted the need to consider large-scale changes and pointed to the benefits of the 1.5 °C warming scenario for vulnerable ecosystems such as coral reefs and the polar regions.

54. An expert stressed that current levels of warming are already causing impacts beyond the adaptive capacity of many people, and that there would be significant residual impacts even with a 1.5 °C warming (e.g. for sub-Saharan farmers), emphasizing that it would be preferable to move the limit downwards to 1.5 °C. Another expert noted that some technologies and policies required to effectively deal with a 1.5 °C temperature rise may negatively impact poverty reduction efforts. Yet another expert recalled that impacts are already occurring and that risk will increase with the degree of temperature rise. Therefore, even if studies that identify different risks at 1.5 °C and 2 °C are scarce, there is a high likelihood of meaningful differences between these temperature limits as regards the level of risk of extreme events or tipping points. He then raised the question whether the long-term global goal is a 'guardrail' or societally determined agreement on an acceptable limit. **He emphasized that the 'guardrail' concept is inadequate as impacts are already occurring and having significant effects**. Therefore, the long-term global goal should be the limit above which the impacts will become too widespread and unacceptable across the RFCs; setting this limit depends on the values and interests of Parties.

55. **On the issue of regional differences**, a Party underlined the importance of a 1.5 °C temperature rise limit for some regions, as well as the disproportionate distribution of impacts and differences in the amount of literature for some regions. He asked about the risks of conflicts at the local and regional levels, especially when water resources are become scarcer. An expert said that it is often the case that the least amount of research is conducted and literature is available for the most vulnerable regions, stressing the need for more research. He added that this need is most acute in relation to projecting impacts and characterizing risk, particularly for high degrees of warming. He also noted a growing volume of literature on human security and indicated that the issue of conflicts would be discussed in part 2 of the meeting. Another expert added that the IPCC experts made great efforts to include traditional and indigenous knowledge in their assessment, and that there have been significant improvements in the assessment of risks related to high mountain ecosystems, in particular the Andes and the Himalayas.

56. In response to a question relating to the **regional and global food security risk at different levels of warming**, taking into account the large differences in risks between the local and regional levels even under the 1.5 °C and 2 °C warming scenarios, an expert stated that for any level of warming, regional differences are going to be large, thereby underlining the importance of using a risk-based framework. Another expert pointed to the chapter of AR5 WGII on Africa, where the levels of risk for some countries such as South Africa and Zimbabwe are higher than at the global level with, for example, a reduction in maize yields of up to 30 per cent by 2050.

57. One Party asked about the **disconnect between the prospects for 'high' adaptation at the global level and realities at the regional level**, in particular for regions where some impacts are projected to be irreversible, such as the polar regions and small island developing States. An expert clarified that the reality on the ground was built into the assessment, since the experts based their assessment of 'high' adaptation on the most probable development pathways for each region using pertinent regional information, as currently available. Another Party mentioned the difference between the levels of risk at the global and local levels for the same temperature scenario, and the fact that the local temperature increase can be higher than the global mean level. Another

expert replied by underlining the importance of the regional assessments, adding that regional risk could not be deducted from global scenarios.

58. Responding to a question on what can constitute a **limit to 'high' adaptation**, an expert noted that constraints to 'high' adaptation are sensitive to the particular issue and reflect the fact that adaptation is difficult to assess, particularly for long-term time frames (2040 and 2100). Another expert added that, in addition to biophysical and economic limits, which persist as long as adaptation is not seen as a cost-effective investment, limits to adaptation can be perceptional or cultural.

59. In response to a question related to timescales associated with **planetary equilibrium**, an expert noted the discrepancy between the fact that ocean warming reduces the impact of climate change, and that this may delay both attainment of the equilibrium and our response to climate change, thereby increasing the difficulty of addressing this challenge. According to the warming scenarios, the equilibrium in terms of temperature and sea level would only be reached after several centuries.

60. As regards the role of **non-climate stressors**, in particular those related to sea level rise, a Party asked if it were possible to look beyond exposure and vulnerability to identify the types of development or urbanization decisions that will drive down the climate signal. An expert pointed to lessons learned from past extreme events that could guide urbanization and development decisions, including the opportunities and limits associated with steering the urbanization process. He stressed that a better strategy is to think in terms of urbanization scenarios and define a larger protected area rather than simply defining a threshold for protected and unprotected areas. The AR5 shows that rural–urban migration is a "moving target" that should be considered within the context of land-use planning and the development of risk reduction strategies. Another expert noted that the risk framework allows for a better understanding of the role of non-climatic stressors.

61. In response to a follow-up question regarding **losses due to the placement of economic assets or human settlements and their attribution to climate change**, an expert pointed to the subtle but important difference in the definition of attribution between WGI and WGII given the nature of the systems studied. The chapter on attribution in AR5 WGII emphasizes the need to recognize that the baselines, in particular for human systems, are constantly changing. Therefore, the literature that would enable a distinction to be drawn between anthropogenic and natural climate change in the sphere of WGII does not currently exist and future work is required, including research on methodologies. Highlighting the increasing cascading effects of impacts, another expert stated that, although there can be a clear climate signal, attribution in the strict sense is often unclear. For example, in the case of Hurricane Sandy, the major impacts came from secondary effects on infrastructure and their attribution to climate change is unclear. He noted the political interest in subdividing these components and highlighted the need to recognize the complexities involved in attribution and to consider this matter within the context of a risk management framework.

62. With respect to **progress made in determining metrics for adaptation**, an expert explained that the WGII experts moved away from using a single metric to assess adaptation needs and options, based on the recognition that the best adaptation options address multiple dimensions of vulnerability and contribute to other mitigation and sustainable development goals. It is therefore very difficult to apply an additionality criterion to evaluate the effects of adaptation investments. Adaptation options that affect the trajectory of societal development are very difficult to evaluate with a simple metric, precisely because of the simultaneous difference occurring across a multitude of aspects.

63. Responding to a follow-up question on the global and regional **consequences associated with a 50 per cent loss of coral reefs**, an expert noted that the location of the reefs would determine the magnitude of the loss, which would depend not only on many local factors influencing the fate of the coral reefs, but also on the value of the reefs in relation to the various ecosystem services they render. The total value of coral reefs, probably the most vulnerable and valuable ecosystem, is estimated at more than USD 600 billion; a 50 per cent loss would therefore be significant. He stressed that the loss of coral reefs has already begun and that the prospects for adaptation are very low. The adaptive capacity of coral reefs may only play a limited role at the present rate of temperature change and ocean acidification (limited evidence). Another expert added that there is some evidence indicating that coral reefs in the West Indian Ocean may be more resilient than those in the East Indian Ocean.

64. Responding to questions raised by two Parties **on the qualification of risk**, including on how some risks have been deemed as high and how local risks have been used to determine regional risks, an expert explained that AR5 WGII includes hundreds of diagrams depicting risks and that the challenge is to understand the meaning of these diagrams in relation to the long-term global goal and Article 2 of the Convention. He added that WGII used expert judgment on the level of risk and the possibility for adaptation based on a series of explicit criteria, in accordance with the IPCC's mandate. Another expert explained that the experts involved in compiling chapter 19 of the WGII report used information on risks from other chapters of the report to identify key risks, which were then condensed into eight key risks (see para. 31 above). Local high risks are included in

the tables of the underlying report as the experts assessed not only global but also local studies and local risks (e.g. in urban areas), and identified generalizable aspects.

65. One Party asked if there are areas of change with respect to different levels of stabilization where a **rapid change in risk levels** may take place from a regional, sectoral, systemic or integrated point of view, in order to help policymakers focus on such areas. An expert explained that the WGII report not only identifies the risk levels, but also the changes in risk levels. For example, in chapter 19 of the report, hot spots have been considered (e.g. areas where risk is very high or where risk levels could change significantly). Low-lying coastal areas in Asia pose a particular challenge, in part because of their expected increase in exposure. Sub-Saharan Africa also poses a challenge, as a result of increased vulnerability and overlapping climate hazards. Focusing on these changes should make mitigation and adaptation policies more effective (e.g. policies aimed at reducing exposure or vulnerability). Another expert underlined the non-linear aspect of organisms' responses to climate stressors, noting that determining thresholds may not be a useful exercise and that it would be preferable to determine instead the degree of change that is tolerable. Yet another expert noted that it is important to study the ways in which risks interact. In terms of RFCs, these interactions are better understood for global aggregated impacts, but other RFCs should be further examined. In response to a follow-up question from Mr. Fischlin, co-facilitator, regarding the effect of mutual drivers exacerbating risks and impacts, an expert explained that climate change impacts are complicating existing risks and that societal stress is generated by multiple interacting impacts. A deeper understanding of these interactions will allow the IPCC to better estimate climate risks.

66. A Party questioned the **comparability of studies and risks** and asked **how different risks could be weighted** (e.g. comparing risks to coral reefs with risks to subsistence farming in Africa). An expert noted the change in terminology from "vulnerability" in AR4 to "risk" in AR5. While recognizing that "vulnerability" is a more ecological concept whereas "risk" is derived from a disaster risk management perspective, he stated that the risk concept is robust and enables better comparability. However, risks for farmers could be caused by, for example, extreme events and droughts, while for coral reefs the risks could be caused by ocean acidification. Another expert commented on the challenges involved in comparing studies that use different methodologies, noting in particular the inconsistent use of estimates of adaptation costs, not all of which factor in the existing adaptation deficits, and indicated that AR5 WGII highlights these constraints.

C. Part 2 – theme 2: overall progress made towards achieving the long-term global goal, including a consideration of the commitments under the Convention based on the contribution of Working Group II to the Fifth Assessment Report

1. Presentations by experts

67. Mr. Lennart Olsson (IPCC) made a presentation on the **links between socioeconomic pathways and climate change risks**, with a focus on poverty and livelihoods. Stressing the multidimensional aspects of poverty, he said that income poverty is complemented by other dimensions, such as health, education, access to basic services and standard of living, noting that there are more people living in multidimensional poverty than there are people qualified as "poor" according to the traditional economic approach to poverty. He explained that climate change may damage six types of assets that are crucial to maintaining livelihoods, namely: natural (e.g. vegetation, soil, water, climate); human (e.g. skills); physical (e.g. land); social (e.g. mobilization capacity); financial (e.g. savings); and cultural (e.g. identity, sense of place, knowledge).

68. Mr. Olsson highlighted **three key risks** from climate change for people living in poverty and their livelihoods, namely the risks of: **deteriorating food security**; **deteriorating access to water**; and **increasing heatwaves** (figure 8). As regards the risk of deteriorating food security, he underlined that the current risk is low, but that there is little adaptation potential due to low government support or the exclusion of small-scale farmers. In the near term (2030–2040), the adaptation potential is significant but requires adaptation capacity to be strengthened. With regard to the risk of deteriorating water access, he indicated that some areas are already subject to high risks but that adaptation opportunities exist. Rainwater harvesting technologies are inexpensive but not sufficiently deployed due to social and economic constraints. Regarding the risk of increasing heatwaves, which is currently low, adaptation potential exists. However, this potential is very limited for people living in poverty in both the near term and the long term. He added that the potential for adaptation to heatwaves for those carrying out physical outdoor work is very limited, and presented a figure illustrating the integration of key climate hazards, farm work and possible diseases to determine periods of hardship, coping and recovery for each month of the year.[15]

[15] See AR5 WGII, figure 13.4.

69. As regards **extreme events**, risks from hurricanes and floods are projected to increase, and in some areas migration may be an adaptation option (figure 9). There is no large difference in the number of people exposed to **flood risk** in the various RCP scenarios until 2050. However, if GHG emissions continue to increase in line with RCP8.5 or RCP6.0, the risks will become very high in the second half of the twenty-first century, and some will be beyond the limits of adaptation for the poor. Under the lower GHG emission scenarios, the flood risk remains manageable in the second half of the twenty-first century.

70. Mr. Olsson concluded that **various forms of inequality will make people more vulnerable to climate change**; **high risks already exist for the poor, both at present and in the short term**; **warming above 2 °C will imply very high risks after 2050** and in some cases may reach adaptation limits (e.g. coastal flooding and heatwaves); and **current mitigation policies may negatively impact poor people**, thereby stressing the need for policies that take into account the circumstances of those living in poverty.

Figure 8
Key risks from climate change for poor people and their livelihoods and the potential for risk reduction through adaptation

Key risk	Adaptation issues and prospects	Climatic drivers	Supporting ch. sections	Timeframe	Potential for reducing risk through adaptation
Shifts from transient to chronic poverty due to persistent economic and political marginalization of poor people combined with deteriorating food security (*high confidence*)	Adaptation options are limited due to exclusion from markets and low government support. Policies for adaptation are unsuccessful because of failure to address persistent inequalities.		13.2.1.3, 13.2.2.4	Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high
Declining work productivity, morbidity (e.g. dehydration, heat stroke, and heat exhaustion) and mortality from exposure to heat waves. Particularly at risk are agricultural and construction workers as well as children, homeless people, the elderly, and women who have to walk long hours to collect water (*high confidence*)	Adaptation options are limited for people who are dependent on agriculture and too poor to afford agricultural machinery. Adaptation options are limited in the construction sector where many poor people work under insecure arrangements. Adaptation might be impossible in certain areas in a +4C world.		13.2.1.1, 13.2.1.5, 13.2.2.4, Box 13-1	Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high
Reduced access to water for rural and urban poor people due to water scarcity and increasing competition for water (*high confidence*)	Adaptation through reducing water use is not an option for the large number of people already lacking adequate access to safe water. Access to water is subject to various forms of discrimination, for instance due to gender and location. Poor and marginalized water users are unable to compete with water extraction by industries, large-scale agriculture, and other powerful users.		13.2.1.1, 13.2.1.3, 13.2.1.5, Box 13-1	Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high

Source: The contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, table 13.2. The figure illustrates the key risks from climate change for poor people.

71. Ms. Purnamita Dasgupta made a presentation on **rural areas and human settlements**. She highlighted that almost 50 per cent of the world's population and 70 per cent of the developing world's poor live in rural areas. Poverty rates in rural areas are high but are falling sharply, except in sub-Saharan Africa. Multiple non-climate stressors of vulnerability affect rural areas. Owing to their low adaptive capacity, geographical location, and high dependence on natural resource based livelihoods and agriculture, climate-related impacts on rural communities in developing countries are projected to be more significant than in developed countries. Evidence of such impacts already exists, including with regard to water access, food security and agricultural production. Rural areas in developing countries are also subject to secondary impacts and trade-offs between mitigation and adaptation policy affecting rural livelihoods, such as that on biofuels and on reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) (see the discussion on biofuels in paras. 83, 108 and 115 below).

72. Ms. Dasgupta drew a distinction between **two types of adaptation** interventions: one that relates to **access** to credit, land, water, technology, markets, knowledge and information; and the other that relates to **perceptions** regarding the need for change in terms of relative neglect, lack of voice or lack of information.

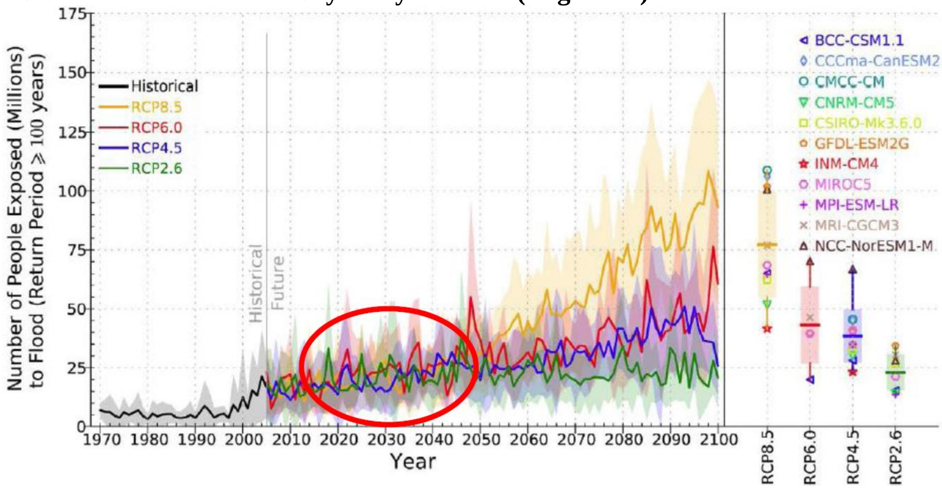
73. She then discussed the different scales at which the **interaction of hazards, vulnerabilities and adaptation takes place in rural and urban areas**, focusing on the risk of drought and water shortage in rural areas, and of inland and coastal flooding in urban areas. While noting that climate change impacts rural and urban areas in different ways, she drew attention to **rural–urban interactions**, in particular how climate change stressors can exacerbate rural–urban conflicts related to the management of natural resources. Sectoral interactions also exist; for example, irrigation increases climate resilience for food and fibre production, but reduces water availability for other uses, such as energy production.

74. Ms. Dasgupta underlined that the **differential impacts of climate change** across people, countries and time **lead to situations of trade-offs and synergies**, creating challenges for a comparison of values. In this context, economic valuation of impacts and adaptation costs are key inputs for decision-making. However,

costing challenges exist when evaluating non-market goods and services that cannot be monetized, especially where communities and economies are directly dependent on ecosystem services. It is possible to follow a multi-metric approach that uses a mix of quantifiable and non-quantifiable costs, and monetary and non-monetary metrics (e.g. declining calorie consumption per capita). However, considerable challenges remain in relation to distributional impacts and uncertainty.

75. Ms. Dasgupta concluded that a variety of interventions are effective for **adaptation in human settlements**, including incentives, regulation and instruments, and underlined the role of the public sector in removing institutional barriers, providing basic public health and amenities and protecting biodiversity.

Figure 9
Global exposure to the twentieth century 100-year flood (or greater)



Source: The contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure 3.6. The figure shows the number of people exposed to floods under historical and future scenarios of climate change.
Note: The abbreviations on the right-hand side of the figure identify the models used.
Abbreviations: RCP = representative concentration pathway;

76. Ms. Balgis Osman-Elasha made a presentation on **adaptation options, needs, opportunities and associated costs**. She noted that the framing of adaptation has moved from a focus on biophysical vulnerability to the wider social and economic drivers of vulnerability and people's ability to respond. The **definition of adaptation** in AR5 is slightly different from that used in AR4, as it distinguishes more explicitly between human and natural systems. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities, while in natural systems, human intervention may at best facilitate adjustment to expected climate change and its effects. The theory and the evidence indicate that, in general, adaptation cannot overcome all climate change effects.

77. Regarding **adaptation needs**, Ms. Osman-Elasha explained that they arise when the anticipated risks or experienced impacts of climate change require action to ensure the safety of populations and the security of assets, including ecosystems and their services. The concept of 'needs' has evolved from national adaptation programmes of action (NAPAs), where needs were identified as priority adaptation activities, and the focus has shifted from biophysical vulnerability to a focus on the wider social and economic drivers of vulnerability and people's ability to respond. The AR5 introduces an iterative risk management framework for adaptation, which includes a long-term practice of assessing and reassessing the effectiveness of past decisions within a continuous learning process (figure 10).

78. She grouped **adaptation options**, which refer to the strategies and measures available to address needs, into three categories: structure/physical; social; and institutional. The AR5 emphasizes the role of institutional options for identifying, developing and pursuing climate-resilient pathways, as well as technological innovation and integration of adaptation development planning. Many of the technological and engineering options are still the most commonly used strategies, but there is growing recognition of the value of ecosystem-based adaptation. The options for addressing needs in ocean systems are still poorly developed. AR5 WGII outlines the opportunities, constraints and limits to adaptation in different sectors and regions.[16]

79. On the issue of **costing adaptation**, she underlined that global adaptation cost estimates are greater than current adaptation funding and investments, particularly in developing countries, thereby suggesting a funding gap and a growing adaptation deficit. The World Bank estimates that the global need for adaptation funds is in

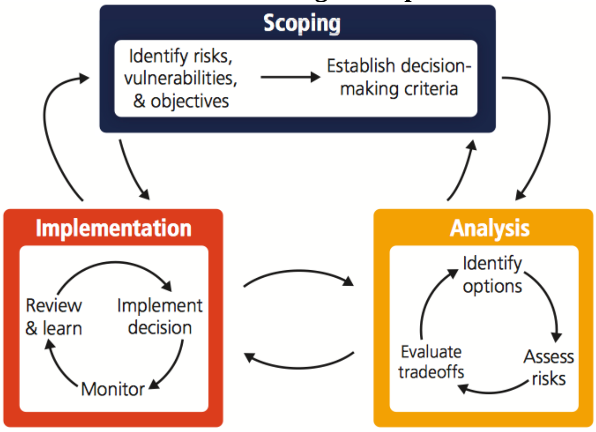
[16] See the AR5 WGII, table 16.3.

the range of USD 70–100 billion per annum, with actual expenditures estimated at USD 244 million in 2011 and at USD 395 million in 2012. She noted that a variety of approaches were used to calculate the estimates, generating considerable uncertainty regarding the full range.

80. In concluding, Ms. Osman-Elasha stressed that: adaptation assessments have demonstrably led to a general awareness among decision makers and stakeholders of climate risks and adaptation needs and options, but that this has often not translated into adaptation action; adaptation generally needs to be seen within the framework of the overall development pathway of the country, particularly for developing countries; opportunities exist to enable adaptation planning and implementation for actors across all sectors and geographic regions; and successful adaptation requires not only identifying adaptation options and assessing their costs and benefits, but also exploiting available mechanisms to expand the adaptive capacity of human and natural systems.

Figure 10

Climate-change adaptation - as an iterative risk management process with multiple feedbacks



Source: Summary for p*olicymakers* in the contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure SPM.3. The figure shows adaptation understood as part of an iterative risk management process.

81. Ms. Asuncion Lera St. Clair made a presentation on **climate-resilient pathways** and the relationship between adaptation, mitigation and sustainable development. Regarding the informational basis used by AR5 WGII, she pointed to a large increase in the literature on climate change and especially on adaptation, enabling a clearer view of the risks posed by climate change. She also noted an enhanced knowledge of the interactions among adaptation, mitigation and sustainable development. Such a holistic, integrated perspective grounded in an extensive, multidimensional set of research results provides the informational basis for analysing risks and options for solutions; identifying links among adaptation, mitigation and sustainable development; and making decisions and choices.

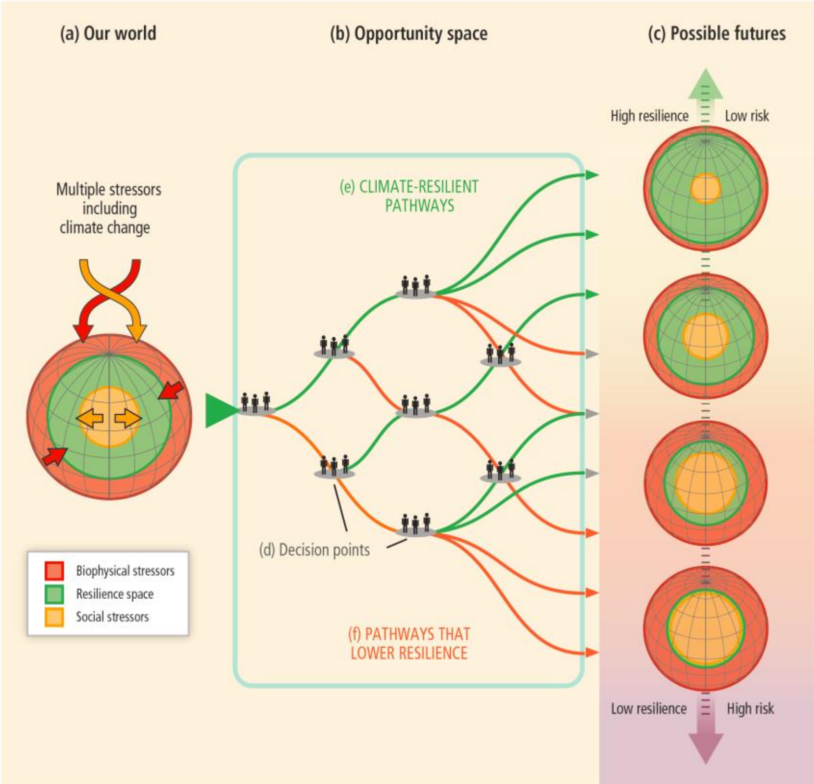
82. Underlining that adaptation as an isolated set of actions may have limited consequences because of the multiple interactions between human and natural systems, Ms. Lera St. Clair stressed that: **adaptation and mitigation are interdependent**; they can both reduce climate risks but do so according to different time scales; adaptation addresses current and committed climate change; mitigation reduces future climate risks; and **adaptation and mitigation choices in the near term will affect the risks of climate change throughout the twenty-first century**.

83. On the issue of **risks and trade-offs between adaptation and mitigation**, she stated that the integration of mitigation and adaptation responses can generate mutual benefits and co-benefits with sustainable development, but may also lead to negative consequences if choices are not carefully analysed, pointing to the example of land use for biofuels or food, or REDD+ programmes that lead to livelihood losses (see para. 115 below). She added that while climate change poses a moderate threat to current sustainable development in general, there are cases of residual damage and limits to adaptation. **In the future, climate change will pose a severe threat to sustainable development**.

84. She described **climate-resilient pathways** as development trajectories that combine mitigation and adaptation to realize the goal of sustainable development and help to avoid “dangerous interference with the climate system”. Climate-resilient pathways include actions to ensure that effective risk management and adaptation can be implemented and sustained while avoiding negative consequences from trade-offs. While recognizing that effective adaptation strategies that are linked with development and have mitigation co-benefits can help to reduce vulnerability, she underscored the need for more research on the benefits, synergies, trade-offs and limitations of major mitigation and adaptation options, along with their implications for sustainable and equitable development.

85. Ms. Lera St. Clair highlighted that **the prospects for climate-resilient pathways are fundamentally related to progress on climate change mitigation**, while stressing that both mitigation and adaptation are essential for climate risk management at all levels. Delayed action reduces the number of options for the future because high emission pathways will reduce future options for climate-resilient pathways as adaptation limits are reached. To promote sustainable development within the context of climate change, climate-resilient pathways may involve significant transformations in political, economic and sociotechnical systems. These transformations, which have ethical and equity dimensions, may be reactive, forced or induced, as well as deliberatively created through social and political processes.

Figure 11
Opportunity space and climate-resilient pathways



Source: Summary for policymakers in the contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure SPM.9. The figure demonstrates that climate-resilient pathways offer some flexibility, yet depend on past decisions, which can significantly reduce or enhance future potentials.

86. In concluding, she noted that the expanded scientific focus of AR5 WGII, combined with increased practice and experience with adaptation, as well as with synergies with mitigation and development, creates opportunities for evaluating policy options and their risks in the search for climate-resilient development pathways. The opportunities show that there is still time in which to avoid the catastrophic effect of climate change, and that various decision points and pathways that lead to a more resilient world exist (figure 11).

2. General discussion

87. The discussion was guided by the following guiding questions:

(a) What does AR5 WGII tell us about the overall progress on adaptation made thus far and the projected progress in view of the long-term global goal?

(b) Are the existing adaptation activities adequate and effective, particularly in terms of the support provided to developing countries?

(c) What are the adaptation costs associated with various mitigation pathways as defined by their degree of global mean warming?

(d) What are the adaptation options, needs, opportunities and costs associated with the projected risks?

(e) What are the differences in terms of adaptation options, needs, opportunities and costs between various groups of people as determined by their livelihoods, poverty and development level?

(f) What types of adaptation are the most promising to cope with the various climate change risks?

(g) What is the relationship between the key climate risks and various levels of global temperature rise in the long term, including the possible impacts beyond 2100? How can this be factored into policymaking under the Convention?

88. As regards the **adaptation funding gap** in developing countries, a Party mentioned that the costs of adaptation could be higher in those countries due to, inter alia, the economic situation, the large population and socioeconomic aspects. The experts answered that many of the studies on adaptation costs, including a study by the World Bank,[17] focus on developing countries, and that the findings on adaptation costs were not included in the AR5 WGII summary for policymakers because of the wide range of figures.

89. Responding to a question on whether the estimates of **adaptation costs** were calculated in the light of developing countries' needs or the funding available, and in response to a comment on the discrepancy between the actual costs of adaptation and the costs estimated by some models, an expert answered that adaptation costs are typically estimated based on needs rather than on available or spent funds. Another expert added that the aggregated costs of adaptation, estimated using a top-down approach and not by sector, are uncertain and the estimates differ, not least because of the discrepancy between needs and actual expenditures (with expenditures being in the order of one per cent of the needs), mentioning the specific estimates calculated in a World Bank study (see para. 79 above). Another expert explained that the costs of adaptation and of climate change need to be clearly distinguished. The former is calculated using evidence from foreign domestic aid, such as NAPAs and non-governmental studies. The latter is related to loss and damage, which is difficult to capture with economic models, in particular because models use damage functions that are incapable of capturing the reality, poorly represent extreme events, and use only a percentage of gross domestic product (GDP), meaning that model-based estimates are most likely to provide only a lower indication of actual adaptation costs. The experts further commented that some adaptation costs, such as loss of place or culture are difficult to monetize; that costs differ significantly between studies owing to the assumptions used and as a result of the limitations arising from uncertain or incomplete damage functions; that externality costs or ancillary costs are not included in the cost estimate; and that there is a need for additional information, including on the costs of adaptation by sector, and actual data rather than estimated data.

90. One Party commented that **costs will depend on the definition of "adaptation"**, noting the difficulty in distinguishing between adaptation and general development flows, and asked if the differences between the cost estimates of various studies may be due to the different definitions used for "adaptation". An expert responded that the World Bank launched a study to track adaptation versus development financing,[18] and that if the methodology proposed in the study is used, more reliable adaptation costs could be generated. Another expert added that further difficulties exist when costing adaptation, since mitigation and adaptation are also linked through the fact that mitigation helps to reduce the costs of adaptation.

91. One Party noted that **adaptation costs are not limited to developing countries**, stressing that in his country over 150 climate-related events had been recorded since 1980, with concomitant adaptation costs exceeding USD 1 billion (total adaptation costs exceeding USD 1 trillion). He requested clarification regarding the **uncertainties and limitations associated with top-down estimates of global adaptation costs**. An expert responded that opportunities for capitalizing on adaptation needs vary by country in both developed and developing regions, and that he could not explain why so many assessments focus on developing countries. He added that the cost uncertainties are due to the use of different models and impacts, as the models do not cover all sectors, especially human livelihoods and ecosystem protection. AR5 WGII therefore provided limited evidence, indicating a medium confidence level in relation to these costs.

92. Regarding **methodologies to quantify the adaptation benefit** of various options, an expert explained that the majority of the approaches in the literature examined benchmarks of desired adaptive capacity and measured the level of deviation from the benchmarks for specific sectors, interventions (e.g. sea level rise) and global goals, although no standardized methodologies exist to quantify these benefits. The same observation applies to costing adaptation, which typically focuses on what can be quantified, rather than on the ancillary or externality costs which tend to be excluded (see para. 89 above). Another expert commented that multiple overlapping methodologies, each focusing on one particular aspect only, have the benefit of providing overviews, but that no single methodology exists to cover all aspects as some adaptation benefits are not quantifiable. This is comparable to the fact that no methodology exists to quantify the overall benefits of development.

[17] World Bank. *Economics of Adaptation to Climate Change*. *Synthesis report*. Available at <http://documents.worldbank.org/curated/en/2010/01/16436675/economics-adaptation-climate-change-synthesis-report>.

[18] World Bank. *Monitoring Climate Finance and ODA*. Available at <http://siteresources.worldbank.org/ENVIRONMENT/Resources/DevCC3_Monitoring.pdf>.

93. Responding to a question on **what is included in the portfolio of adaptation activities**, an expert indicated that AR5 WGII calls for adaptation to be addressed within the local context and that, in many cases, adaptation opportunities could arise in actions that may be different from traditional concepts of adaptation.

94. One Party requested clarification regarding the global amount of **investment in adaptation, the bodies investing** in adaptation and the attractive options for investment. Another Party asked why **investment in adaptation is seen as unattractive** in comparison with mitigation, as these investments could build reliance, for example in infrastructure, and should be seen as an opportunity, not as a cost. In response, an expert said that WGII concluded that there are attractive, synergistic opportunities for adaptation investment, especially in the context of the co-benefits with mitigation and sustainable development. He added that the world is moving into an era in which such investment opportunities can be created to address adaptation, mitigation and sustainable development needs. Another expert referred to the opportunities for adaptation identified in table 16.3 of AR5 WGII.

95. A Party commented on the **lack of communication between the Financial Mechanism under the Convention** (e.g. the Green Climate Fund) **and scientists** (e.g. the IPCC). He asked **how governments can carry out options identified in the UNFCCC process**, and how the IPCC could advise urban areas, communities and governments that are engaging in a non-climate-resilient development pathway. An expert underlined that, in order to move towards proactive adaptation, progress needs to be achieved as regards: the perception by policymakers and stakeholders that there is a risk; assessment of that risk; recognition that the risk needs to be acted upon and that the investment needed to respond thereto is justified; and capitalization on the opportunities for adaptation.

96. On the issue of the **difference between risk levels at 1.5 °C and 2 °C limits**, an expert answered that relatively few studies have explicitly considered the 1.5 °C limit, and that most of the adaptation literature does not generally identify a specific risk level for a specific temperature. In response to a follow-up question suggesting that more emphasis should be given to the 1.5 °C limit in the assessment process, an expert reiterated that all available literature on this temperature limit was considered in AR5 WGII. He added that risk-framing enables the analysis of a wide range of motivations for setting a target at various levels.

97. Some Parties commented that immediate emission reductions are required to reach low-stabilization pathways, illustrating that mitigation is the key to **avoiding dangerous anthropogenic interferences**; others pointed out the need for discussion regarding safe levels of impacts to achieve the objective of the Convention. An expert commented that if mitigation action is delayed, the opportunities to stay below the 2 °C limit will disappear. She added that the IPCC may not determine the ‘safe’ or ‘dangerous’ level, as this value judgment will be made by governments based on their perspectives of what is ‘safe’, for whom, for what, and according to which time frame. Another expert said that recognition of the associated safety issues was required, which depends on the scale, frequency and severity of the impact, since the widespread consequences of climate change have already been witnessed. For example, from the perspective of a species, human individual or village that is currently facing those impacts, it has already reached an unsafe level. This shows the need to recognize that there is no ‘guardrail’ below which there are no impacts and that a more nuanced view should instead be fostered.

98. Regarding **pathways linking mitigation and adaptation**, a Party noted that mitigation can reduce adaptation needs, although the issue of quantification of adaptation benefits remains. Another Party said that prospects for climate-resilient pathways are fundamentally related to progress on mitigation, adding that poverty often prevents transition towards climate-resilient pathways. An expert noted that although mitigation is of benefit to adaptation, it cannot be quantified. Therefore, in implementing actions to address climate change, a holistic perspective should be used, together with an iterative risk management process and learning by doing, seeking ‘no regrets’ options, synergies and co-benefits, with a focus on those who are most vulnerable.

99. A Party commented that, according to figure 3, the **levels of additional risks for unique and threatened systems and due to extreme weather events are already moderate at 1 °C**. Noting that, for example, early warning systems and multipurpose-resistant houses could minimize loss of life, he asked for guidance to set policy priorities aimed at improving the resilience of the most affected people (e.g. minimizing the loss of life versus livelihoods versus ecosystem services). An expert responded that AR5 WGII identifies risks, and that policy priorities should be set by policymakers. Another expert replied that the establishment of early warning systems is a productive method only when used in an appropriate manner by combining knowledge and action, but will be ineffective if these two elements are not combined in a fair and just way.

100. Several questions arose regarding the definition of "**climate resilience"** and "**climate-resilient pathways"**,[19] the difference between **"resilient" and "sustainable" development**, the extent to which a level of resilience can be seen as a target, and the likelihood of attaining sustainable development with the existing adaptation opportunities. As regards the ability to attain sustainable development, an expert said that this depends on the decisions to be made by policymakers. Regarding the difference between "resilient" and "sustainable" development, an expert explained that sustainable development includes "development" and has historically featured a strong economic component, while "resilience" is more independent from development – it can be related to development, but in a more flexible way. One Party commented that, before aiming for sustainable development, resilience must be built. Another expert underlined that the term "resilience" implies multiple synergies among approaches identified in the 'solution space' (figure 1) and has moved from natural sciences to social sciences. One expert emphasized that the scientific community is divided on this term, since its use varies from specific meanings in some disciplines, such as in ecology, to very vague interpretations in others. Further, in social sciences, "resilience" often focuses on the normative outcome of being resilient, thereby running the risk of masking the important process of actually reaching that desirable outcome.

101. Several questions were related to **international cooperation** on the transfer of technologies for adaptation to developing countries and adaptation in general. Experts stressed that while technology transfer is needed for some modern agricultural work, many low-cost, simple, efficient adaptation technologies are available, such as water-harvesting technology or clean cook stoves in rural households. Such technologies are not being fully deployed due to social, political and economic constraints, rather than due to technology transfer issues (see para. 106 below). Further, the role of social, political and organizational aspects should no longer be underestimated and should be appropriately addressed. In response to a follow-up question regarding how national adaptation planning could address some of these challenges, for instance in remote rural areas, an expert clarified that social and political aspects should be included in the national planning process in order to obtain a broader perspective of the risks, options and opportunities.

102. One Party asked for clarification regarding the **areas and issues that Parties should focus on in the context of international cooperation for adaptation** and the provision of means of implementation. An expert replied that this question relates more to the political, rather than the scientific, arena. Another expert underlined the importance of considering cooperation while bearing in mind the linkages among adaptation, mitigation and sustainable development. She further noted several overlapping approaches for managing the risks of climate change, including by reducing vulnerability and exposure, adaptation (incremental and transformational) and transformation approaches (see table SPM.1). International cooperation is involved in many of these approaches (see para. 28 above).

103. Responding to a question on the **risks related to rural–urban interaction and the urbanization process** taking place in developing countries, an expert answered that this process will exacerbate risks such as a high mortality rate, injuries or loss of infrastructure, mainly due to the high population density resulting from urbanization and gaps in infrastructure. The disruption of an integrated service provision would affect larger areas and populations.

104. As regards the differences between **climate-smart and climate-resilient agriculture**, an expert commented that, in the past, the focus was on sustainable smart agriculture and the creation of optimal conditions for crops, for example in terms of soil moisture, but that in a changing climate optimal conditions can no longer be created. Thus, the main challenge for climate-smart agriculture is to become more resilient by using crops that can perform under suboptimal conditions, such as heat stress and drought. One Party asked about means of raising awareness of existing climate-smart agricultural technologies in rural settlements. An expert answered that adaptation planning should not be limited to technologies and infrastructure, but should also encompass social, political and institutional aspects if risks and opportunities are to be fully understood (see para. 101 above).

105. Regarding adaptation options to deal with **sea level rise**, including migration, one expert noted that the scale of what is currently perceived as adaptation may change in the long term following a sea level rise of many metres. Another expert responded that, today, one in eight people is mobile. People make mobility choices (ranging from voluntary mobility to forced relocation), taking into account food security, employment opportunities, livelihood security, and physical (natural) or conflict safety. One concern identified in AR5 WGII is that people are moving due to food security and climate-sensitive livelihoods. While most movements are currently internal, as the impacts of climate change unfold these could lead to undesirable displacement or

[19] Climate-resilient pathways are sustainable-development trajectories that combine adaptation and mitigation to reduce climate change and its impacts. They include iterative processes to ensure that effective risk management can be implemented and sustained (*Summary for Policymakers* in the contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, page 28, section C.2).

relocation. Concerns are greater in areas with geographical constraints such as small islands. She underlined that, currently, four times as many people are displaced by extreme weather events and earthquakes than by conflicts.

106. On the issue of **key barriers to adaptation on the ground**, **and elements required to conduct better adaptation assessments and adaptation planning**, an expert noted that there is a lack of awareness and of communication among various ministries and a misunderstanding of risks, with some pointing to technology aspects and others drawing attention to social, political and institutional issues. At the same time, farmers, other local stakeholders and indigenous people often have a different understanding of risks at the local level. Another expert pointed to the considerable challenges involved in taking into account the wide range of factors determining risk in a system. As multiple stressors are involved, all of which may interact, they are likely to create circumstances that are very difficult to predict, regardless of the level of ambition of the research conducted. **Decision-making under uncertainty is therefore the primary mode of action for the foreseeable future**. Yet another expert underlined that while some constraints to adaptation need to be overcome both in developed and in developing countries, it should be recognized that in developing regions climate change is not the only pressing need. In the developed world, there is a greater focus on mainstreaming adaptation in national planning and awareness-raising, but fewer actions are focused on implementation. Another expert underlined that while engineering and technological adaptation options are the most commonly used, the importance of other types of adaptation, such as ecosystem-based behavioural changes or diversification of livelihoods, needs to be recognized.

107. In response to a question on examples of policies and measures that have successfully addressed **non-climatic stressors** and how inadequate planning can lead to maladaptation, an expert answered that climate is indirectly, rather than directly, linked to a number of risks, such as food insecurity or water competition, but that these interactions are difficult to assess. She illustrated how, in a multiple causal chain, climate change could exacerbate food production issues and lead to price shocks, and how adaptation measures could vary from food imports to food aid. Another expert noted that additional climate stressors may lead to the disappearance of landraces in agriculture, and thus reduce the number of adaptation options, as well as to increased vulnerability of deltas around cities. He added that there are many such confounding factors and alluded to the examples of water competition being problematic only for those consumers without a water tap or for poor people who are pushed into areas with higher exposure to climatic impacts. He emphasized that all such phenomena could nevertheless be clearly connected to climate change.

108. Some Parties asked about the **positive and negative impacts of mitigation policies at the local level and the scope of the assessment of biofuels**. An expert clarified that literature in four areas was assessed to identify the implications for livelihoods of implementing mitigation policies (e.g. the clean development mechanism (CDM), REDD+, the voluntary carbon market, and the biofuels policy and its impact on other countries in terms of indirect land-use change). He distinguished between two types of literature assessed: one that focuses on the effectiveness of GHG emission reductions; and the other that focuses on the effect of these reductions on the poor, pointing to the threats posed by REDD+ to indigenous peoples and people who rely on protected forest areas. He further noted that voluntary carbon markets do not take into account local benefits, except for Gold Standard projects; extensive literature exists on the positive and negative effects of biofuel development from a poverty alleviation point of view; and that each of the four above-mentioned policies has proved to be a strong mechanism for global mitigation, but that few mechanisms have created benefits at the local level or in terms of poverty alleviation (see paras. 71 and 83 above and 115 below).

D. Part 3: setting the scene for the consideration of the contribution of Working Group III to the Fifth Assessment Report

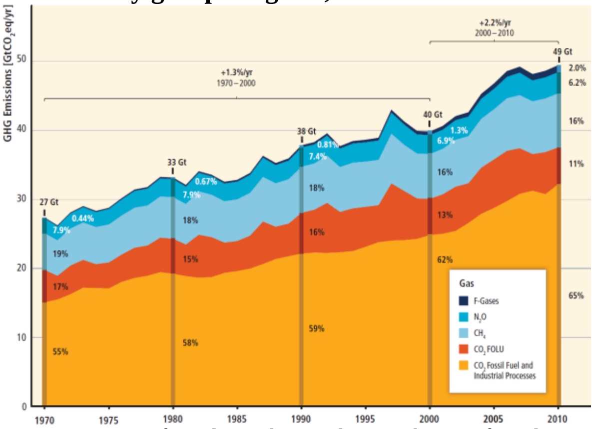
1. Presentation by an expert

109. Part 3 of the meeting opened with a scene-setting presentation by Mr. Ottmar Edenhofer, Co-Chair of IPCC Working Group III (WGIII), on the overarching findings and new approaches of AR5 WGIII relevant to the two themes of the 2013–2015 review. He explained that WGIII explored the full ‘solution space’ in order to inform decision makers on the various possible emission pathways, their underlying costs, risks and opportunities.

110. On the issue of **trends in stocks and flows of GHG emissions**, Mr. Edenhofer stressed that GHG emissions growth has accelerated despite mitigation efforts and the global economic crisis, and that emissions growth between 2000 and 2010 was greater than in any of the previous three decades (figure 12). Regarding the historical perspectives of anthropogenic GHG emissions, he noted that about half of the cumulative anthropogenic CO_2 emissions between 1750 and 2010 occurred in the last 40 years (figure 13). He underlined that, for the first time, the IPCC presented the underlying uncertainties in the estimated historical emissions in more detail.

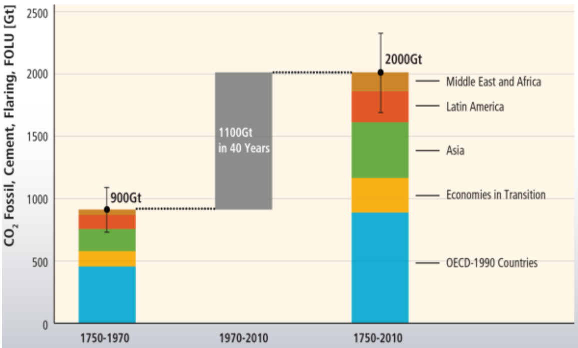
111. With respect to **regional patterns of GHG emissions**, Mr. Edenhofer explained that these patterns are shifting along with structural changes in the world economy. Upper middle-income countries are replicating the emissions trajectories of upper-income countries, and the industrial and energy sectors play the most important part in the increase in emissions. The land-use sector is not as significant in high- and middle-income countries as in low-income countries, where it is the main emission source (figure 14).[20] Income is the most important driver of GHG emissions at the global level, followed by population growth. Emission growth driven by these two factors has overtaken emission reductions from improvements in energy efficiency. The long-lasting trend in gradual decarbonization has been reversed during the last decade, mainly owing to an increased use of coal in the power sector (figure 15).

Figure 12
Total annual anthropogenic greenhouse gas emissions by groups of gases, 1970–2010



Source: Summary for policymakers in the contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure SPM.1. The figure illustrates that emission growth has accelerated in the last decade.
Abbreviation: FOLU = forestry and other land use.

Figure 13
Cumulative anthropogenic CO_2 emissions between 1750 and 2010



Source: Simplified version of figure TS.2 from the technical summary in the contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (see slide 7 of the presentation by Mr. Ottmar Edenhofer (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_edenhofer_sbsta_sed_wg3_overview.pdf>. The figure illustrates the historical cumulative anthropogenic CO_2 emissions per region and group of countries between 1970 and 2010.

112. Regarding the **action required to limit warming to 2 °C**, Mr. Edenhofer underscored the substantial technological, economic and institutional requirements, in particular in the energy sector and potentially in land use. Without additional mitigation, the global mean surface temperature is projected to increase by 3.7–4.8 °C over the course of the twenty-first century (based on median transient climate response estimate; the range (90% percentile) is 2.5°C to 7.8°C when adding climate uncertainty). The stabilization of anthropogenic concentrations at low levels requires a move away from the baseline, regardless of the global mitigation goal. Even a 3 °C limit requires a substantial reduction in GHG emissions and a fundamental transformation of the energy system. A 2 °C limit requires a larger emissions reduction in the short to medium term, and negative emissions in the second half of the twenty-first century. Both require substantial scaling-up of low-carbon energy. Important aspects of risks of mitigation are therefore associated with the scaling-up of low-carbon technologies (approximately 300 per cent above current levels by 2050 for a 2 °C limit).

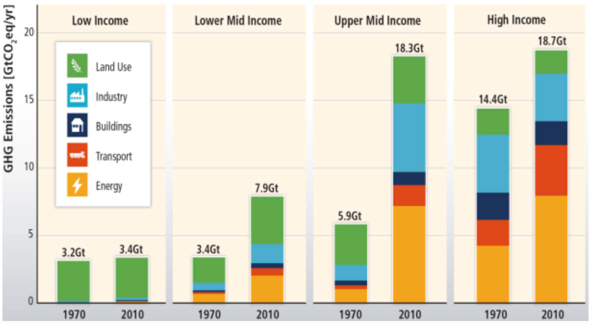
113. **Delaying mitigation** increases the difficulty and narrows the options for limiting warming to 2 °C. Immediate mitigation action, which is consistent with a cost-effective emissions pathway to achieve the 2 °C target, would imply a reduction in emissions of about 3 per cent annually between 2030 and 2050, an unprecedented emission reduction rate in economic history. On the other hand, delaying action would imply even larger emission reductions in the future (about 6 per cent per year between 2030 and 2050), at higher costs and with higher risks (figure 17). Mr. Edenhofer added that the current Cancun pledges are insufficient to achieve the long-term global goal.

114. With regard to **the 1.5 °C target**, scientific evidence remains limited because of the limited number of studies on this limit for global warming and the absence of multi-model comparison studies that analyze the relevant pathways more systematically. Available scenarios in these existing studies are characterized by a

[20] The *structure* and dynamic of emissions data for the upper middle-income group indicates limited leapfrogging (see para. 183 above).

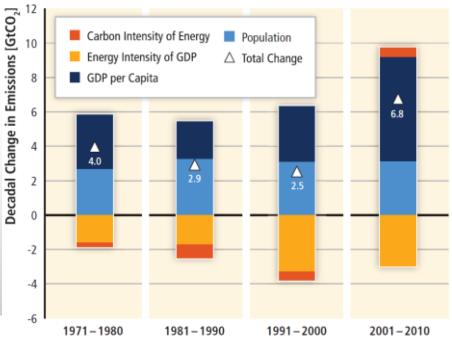
temperature overshoot and large-scale application of CO_2 removal technologies; immediate mitigation action; a rapid scaling-up of the full set of technologies; and development along a low-energy demand pathway.

Figure 14
Greenhouse gas emissions by country group and economic sector



Source: Slide 8 of the presentation by Mr. Ottmar Edenhofer (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_edenhofer_sbsta_sed_wg3_overview.pdf>.

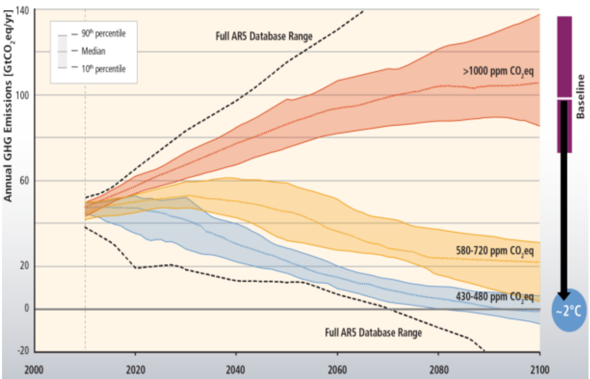
Figure 15
Decomposition of the change in total global CO_2 emissions from fossil-fuel combustion



Source: Summary for policymakers in the contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure SPM.3.
Abbreviation: GDP = gross domestic product.

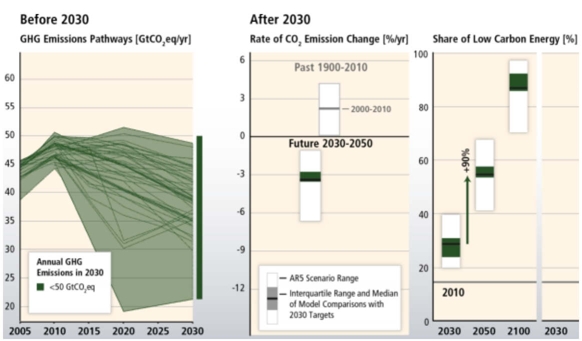
115. Regarding **mitigation costs**, Mr. Edenhofer noted that available estimates vary widely, but do not significantly affect global GDP growth. He explained that the uncertainties surrounding the global cost estimates are due to the wide range of mitigation costs, which are partially due to the differences in projected low-carbon technology uptake in the various models. While underlining that global costs rise with the level of ambition of the mitigation goal, he pointed out that mitigation action would delay, but not sacrifice, economic growth. Mitigation consistent with the 2° C limit involves annualized reduction in consumption growth of 0.04 to 0.14 (median: 0.06) percentage points over the century relative to annualized consumption growth from the baseline that is between 1.6 and 3 per cent per year. He added that the availability of technologies seriously affects mitigation costs. Without carbon dioxide capture and storage (CCS) and with limited availability of bioenergy, the mitigation costs would increase markedly in the medium term. Specifically, if CCS is unavailable, the costs of staying below the 2 °C limit (with a larger than 50 per cent chance) will increase by approximately 140 per cent relative to default technology assumptions, and if bioenergy is limited, the costs will increase by approximately 70 per cent. The combination of bioenergy and CCS (BECCS) in the models is also important for negative emissions to be achieved in the second half of the twenty-first century (figure 18) (see paras. 71, 83 and 108 above). Projections in many models could not stay below 2 °C by 2100 if additional mitigation is considerably delayed or if the availability of key technologies, such as bioenergy, CCS, and their combination (BECCS), is limited.

Figure 16
Greenhouse gas emission pathways, 2000–2100: scenarios from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change



Source: Slide 16 of the presentation by Mr. Ottmar Edenhofer (Intergovernmental Panel on Climate Change (IPCC)), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_edenhofer_sbsta_sed_wg3_overview.pdf>. The figure shows some emission pathway scenarios as used in the IPCC Fifth Assessment Report.

Figure 17
The implications of greenhouse gas emission levels in 2030 for the rate of CO_2 emission reductions and scaling-up of low-carbon energy (mitigation scenarios reaching about 450 to 500 ppm by 2100)



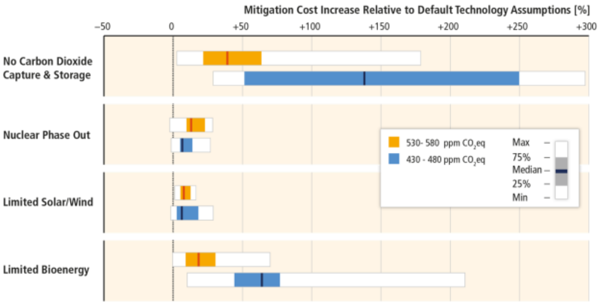
Source: Slide 20 of the presentation by Mr. Ottmar Edenhofer (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_edenhofer_sbsta_sed_wg3_overview.pdf>. The figure summarizes the near- and mid-term mitigation needed to limit greenhouse gas concentrations to between 450 and

500 ppm CO_2 eq by 2100.

116. On the issue of **options to reduce GHG emissions**, he emphasized that mitigation scenarios indicate the necessity to fully decarbonize energy, but that there is flexibility in that process. The scale of energy demand reductions is important as it will determine the level of flexibility in decarbonizing energy supply and the associated ability to hedge against supply-side risks, avoid infrastructure lock-in, and determine the co-benefits of mitigation. Regarding **mitigation co-benefits**, he pointed to positive side effects of mitigation, in particular for human health, but also for other societal goals. For example, low stabilization scenarios carry substantial health benefits through reductions of emissions of black carbon. At the same time he explained the difficulty of translating such co-benefits into net welfare gains (figure 19).

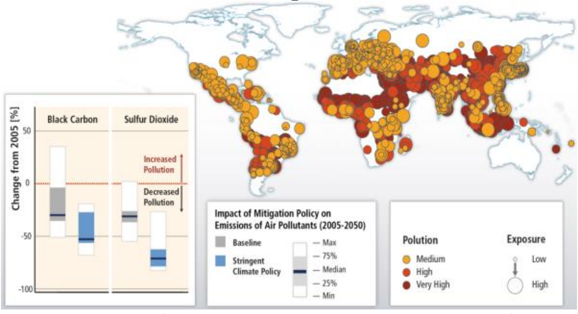
117. With regard to **policies that have attracted the greatest interest,** Mr. Edenhofer underlined that all scenarios considered in AR5 WGIII identified the pricing of CO_2 as a necessary condition to achieving the long-term global goal, in conjunction with other policies. Substantial reductions in GHG emissions would require large changes in annual investment flows and in investment policies, which would lead to an adjustment of global investment in the energy sector (figure 36). Such policies would require a credible CO_2 price signal. While recognizing the increase in available literature since AR4 on policies designed to integrate multiple objectives, increase co-benefits and reduce adverse side effects (e.g. government provision of public goods and services, regulatory approaches, economic instruments and information programmes), he called for future research and ex-post evaluation of such policies that are already in place; and the provision of information to stakeholders on the appropriate way of combining the available policy instruments, so that they effectively complement each other.

Figure 18
Availability of technologies and mitigation costs



Source: Slide 27 of the presentation by Mr. Ottmar Edenhofer (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_edenhofer_sbsta_sed_wg3_overview.pdf>. The figure shows the dependence of mitigation costs on some mitigation technologies.

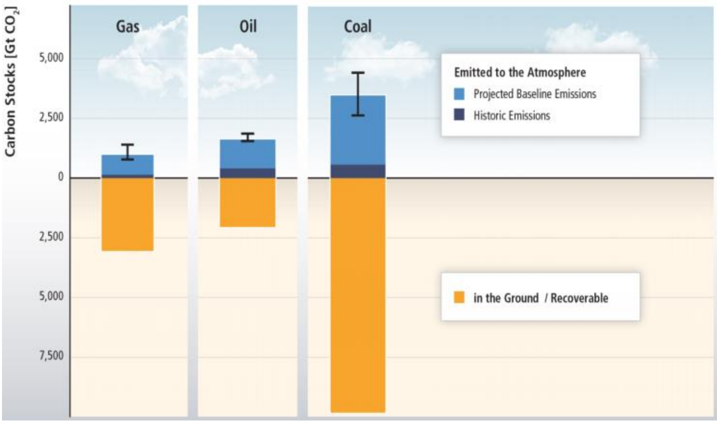
Figure 19
Health co-benefits of mitigation



Source: Slide 32 of the presentation by Mr. Ottmar Edenhofer (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_edenhofer_sbsta_sed_wg3_overview.pdf>. The figure illustrates some of the co-benefits of mitigation.

118. In concluding, Mr. Edenhofer stressed that **there is far more carbon in the ground than can be emitted, given the limited disposal space in the atmosphere**, which is why low-stabilization pathways are so demanding in terms of technological and institutional requirements (figure 20).

Figure 20
Levels of carbon in the ground and emitted for different types of fossil fuels



Source: Slide 41 of the presentation by Mr. Ottmar Edenhofer (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_edenhofer_sbsta_sed_wg3_overview.pdf>. The figure shows the amount of carbon that is estimated to be in the ground and the amount that has already been emitted to the atmosphere.

2. General discussion

119. The ensuing discussion was guided by the following questions:

(a) What does AR5 WGIII tell us about the mitigation action required to limit global warming to 2 °C or 1.5 °C, the relationship between mitigation and other climate change responses such as adaptation, and valuations, including expert value judgment?

(b) How reliable are the projections of emission pathways and how can they be used for decision-making at the global level?

(c) What are the options to reduce emissions through mitigation and low-carbon development?

120. A Party asked **how much CCS and bioenergy deployment could be performed at scale**, and if such an uptake is realistic in the long term. The expert explained that the WGIII findings on how much CCS, BECCS and bioenergy would be needed are based on the requirement in ambitious scenarios to have negative emissions in the second half of the twenty-first century to achieve low stabilization targets. He pointed to an appendix to the agriculture, forestry and other land use (AFOLU) chapter on bioenergy that highlights the diversity of opinions on this question and outlines the underlying risks of generating large amounts of bioenergy for food security and prices, as well as for biodiversity. He stressed the need for policymakers to consider the risks and benefits of using these technologies. The expert added that CCS and bioenergy are low-cost options for reducing emissions, but to reduce the associated risks, such options should be accompanied by an integrative institutional framework that would take into account the competition for land, notably a comprehensive carbon-pricing mechanism that covers all sectors, including land use.

121. Responding to a question raised by a Party regarding the **window of opportunity in relation to a 1.5 °C and 2 °C temperature rise**, the expert said that in AR5 WGIII this window is driven by the speed of the scaling-up of low-carbon technologies and the level of risk of such scaling-up, rather than by atmospheric physics, which is only the boundary condition. Scenarios consistent with a temperature rise of 1.5 °C combine all of the most ambitious features we know from the literature on the 2 °C limit. He added that mitigation action over the next decade will determine the required mitigation action after 2030 and its cost. The risk related to the scaling-up of low-carbon technologies becomes higher when mitigation is delayed. In response to a question on the additional risks that would be created by an overshoot in emissions and temperature, the expert said that overshoot is a typical feature of low stabilization scenarios, all of which therefore have risks.

122. Regarding the **global carbon budget**, a Party referred to figure 19 and asked how much CO_2 can still be emitted to achieve the long-term global goal. The expert indicated that the global carbon budget specified in AR5 WGIII is broadly consistent with that of AR5 WGI, but that a broader range of mitigation pathways have been considered in the former. He added that the limiting factor in the twenty-first century is not the availability of fossil fuels (figure 20), but rather the limited disposal space in the atmosphere, which is why climate change should be understood as a global common problem.

123. With respect to the **impact of mitigation on economic growth**, one Party asked how the reduction in consumption was calculated by the IPCC, in particular if the opportunities created by shifts in investments and the reduced spending on energy because of increased efficiency have been taken into account. The expert underlined that although climate mitigation can indeed be seen as an opportunity cost since it will reduce future consumption to some extent, it will also provide opportunities for new investments. He further explained that, for example, carbon pricing reduces return on investment in some sectors, and that, although the reallocation of budget creates opportunities in other sectors (figure 36), this reallocation comes at a cost. He added that two types of models exist: one that assumes the full utilization of all resources in the long term (i.e. without any idle resources and, consequently, with positive opportunity costs); and another where there are idle resources leading to smaller opportunity costs.

124. As regards the **total annual GHG emissions**, a Party asked if removals by sinks were included in the figures. The expert explained that land-use change, deforestation and afforestation were taken into account by the models, adding that in scenarios where CCS is not available, AFOLU becomes more important and more afforestation is needed.[21] Low stabilization pathways therefore depend not only on changes in energy supply, but also on changes in the AFOLU sector (figure 25).

125. Regarding the **use by the SED of information not included in the AR5 WGIII summary for policymakers** (SPM), several Parties opposed such use, in particular in relation to information on the categorization of countries based on income levels, and reminded participants that several countries also opposed

[21] See the summary for policymakers in AR5 WGIII, figure SPM.7, available at <http://report.mitigation2014.org/spm/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf>.

the inclusion of this information in AR5 WGIII. They noted that the categorization of countries is not in line with the provisions of the Convention, and asked if such information is available in AR5 WGIII for Parties included in Annex I to the Convention and Parties not included in Annex I to the Convention. Other Parties welcomed the use of this information by the SED. The expert replied that deleted information from the SPM is available in the technical summary and underlying report, adding that the IPCC presents historical and factual data, such as cumulative, production-based and consumption-based emissions, from different perspectives, including according to income categories, so that policymakers can explore the issue from different perspectives.

126. On the issue of **metrics**, one Party commented that the global temperature potential (GTP) metric is better suited to carrying out an assessment of certain aspects of climate change only and asked about the importance of using GTP to guide mitigation policies, taking into account the fact that Parties have agreed on a temperature-related long-term global goal. The expert responded that global warming potential (GWP), GTP, and global damage potential were discussed by WGIII, and that GWP is "relatively robust", taking into consideration the fact that costs and mitigation strategies do not differ greatly if other metrics are used and the required data are available.

127. Regarding **fossil-fuel subsidies**, a Party asked about the emission reductions that would be achieved by their removal. The expert said the WGIII did not assess the impact of removing such subsidies, but stressed that it would require distinguishing between subsidy removal scenarios both with or without a carbon price.

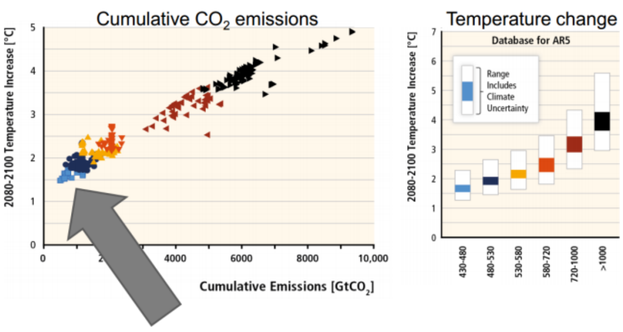
E. Part 3 – theme 1: the adequacy of the long-term global goal in the light of the ultimate objective of the Convention based on the contribution of Working Group III to the Fifth Assessment Report

1. Presentations by experts

128. Mr. Volker Krey (IPCC) made a presentation on **transformation pathways and limiting warming to specific levels, notably a global mean warming of 2 °C or 1.5 °C relative to pre-industrial levels**. He explained that the WGIII experts collected approximately 1,200 scenarios from existing literature in an "AR5 scenario database" to assess transformation pathways, and their costs and mitigation implications. The scenarios were then categorized based on their CO_2 eq concentration in order to link them with the various RCPs assessed by WGI. Around 150–200 pathways corresponding to a concentration of 400 ppm CO_2 eq by 2100 are consistent with RCP2.6. While noting the wide range of scenarios, he said that their common element is the stringent emissions reduction required to limit warming below 2 °C.

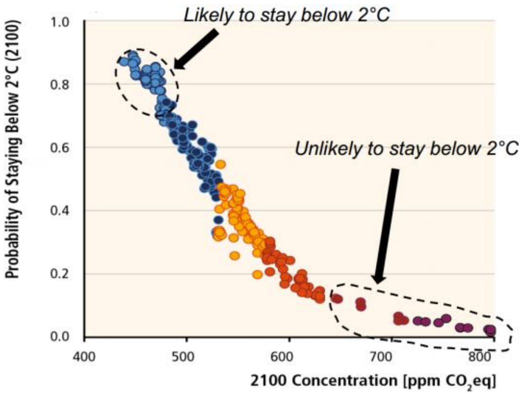
129. Noting that, to achieve low levels of temperature change, cumulative CO_2 emissions must be limited, he indicated that the **emissions budget for staying below the 2 °C limit** is about 600–1,200 Gt CO_2 for the period 2011–2100, and historical emissions for the period 1870–2011 are about 1,850 Gt CO_2 (figure 21). Figure 21 also illustrates the range of temperature increase by the end of the twenty-first century for the six ranges of CO_2 eq concentrations used to categorize the scenarios in AR5 WGIII.

Figure 21
Relationship between cumulative CO_2 emissions and global temperature change



Source: Slide 5 of the presentation by Mr. Volker Krey (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/2_krey_vuuren_sed3.pdf>. The figure illustrates how global warming is related to cumulative CO_2 emissions.

Figure 22
Probabilistic interpretation of the 2 °C warming scenarios



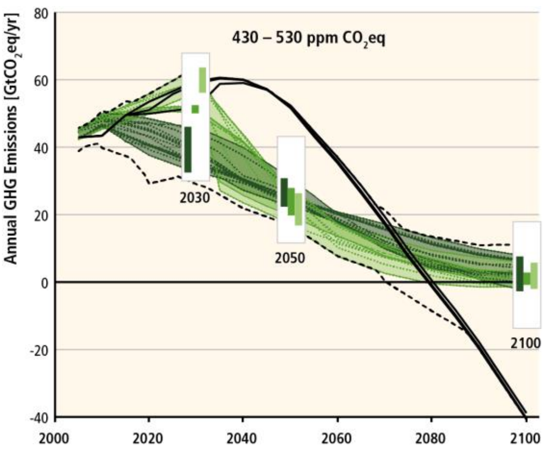
Source: Slide 6 of the presentation by Mr. Volker Krey (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/2_krey_vuuren_sed3.pdf>. The figure shows the probability of staying below a 2°C limit as determined by atmospheric CO_2 eq concentrations.

130. Mr. Krey underlined that a major advancement since AR4 is the probabilistic interpretation of the scenario literature, which shows the relationship between the atmospheric concentration of CO_2 eq in 2100 and the probability of staying under the 2 °C limit (figure 22). Scenarios in the lowest concentration category (430–480 ppm) have at least 66 per cent probability of staying below a 2 °C warming. For a concentration of 600 ppm CO_2 eq, which corresponds to the range of scenarios for RCP4.5, the likelihood of staying under the 2 °C limit is below 20 per cent. Therefore, to better cover the ranges of possible concentrations, two additional categories of scenarios were considered in AR5 WGIII in between RCP2.6 and RCP4.5, corresponding to concentrations ranging between 480–530 ppm (dark blue in the figure) and 530–580 ppm (yellow in the figure).

131. Regarding the **relationship between global GHG emissions and the likelihood of different temperature limits**, he showed how atmospheric concentration levels are linked to emission budgets and reductions (in 2050 and 2100), and the expert assessment of the likelihood of temperature change (see table SPM.1). Scenarios where atmospheric concentration levels of about 450 ppm CO_2 eq are reached by 2100, consistent with a likely probability of keeping temperature change below 2 °C, are characterized by emission reductions of 40–70 per cent below 2010 levels by 2050 and by reductions of 80–120 per cent by the end of the twenty-first century. He stressed the interdependence between emission levels in 2050 and 2100 for scenarios in a given category due to the cumulative budget constraint – a high-end emissions level in 2050 would require a low-end emissions level in 2100 and the use of CO_2 reduction technologies such as BECCS.

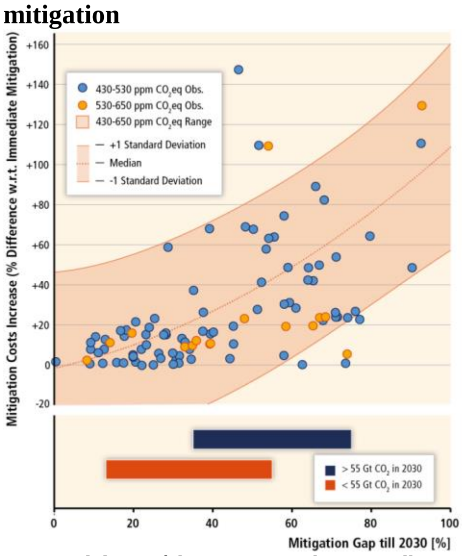
132. As regards **concentration overshoot**, Mr. Krey underlined that temporary overshooting is an integral part of all pathways that lead to a 2 °C warming (430–480 ppm category), and that this overshoot is more pronounced for the 1.5 °C limit (in fact, 1.5 °C compatible pathways typically involve temperature overshoot). He added that overshooting was explicitly considered in the 480–530 ppm and 530–580 ppm scenarios. In addition, he noted that only a few scenarios, based on two models, have examined pathways with a likelihood of staying below a 1.5 °C warming (less than 430 ppm CO_2 eq in 2100), and were not included in the quantitative analysis of the scenario literature in the report as they would have distorted the overall picture by introducing some model bias.[22] For limiting warming below 3 °C instead of 2 °C, the cumulative CO_2 budgets is two to three times higher, but emission levels in 2100 of around zero will still be required for such scenarios.

Figure 23
Possible trajectories to stay below a 2 °C limit



Source: Slide 8 of the presentation by Mr. Volker Krey (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/2_krey_vuuren_sed3.pdf>. The figure illustrates that there are several emission pathways to stay under a 2 °C limit, but with varying subsequent requirements for CO_2 removal technologies (e.g. a combination of bioenergy and carbon dioxide capture and storage).

Figure 24
Increased mitigation costs resulting from delayed mitigation



Source: Slide 15 of the presentation by Mr. Volker Krey (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/2_krey_vuuren_sed3.pdf>. The figure shows that late mitigation action increases the mitigation costs and deviates from an optimal, cost-effective pathway.

133. Regarding the **role of CO_2 removal technologies**, different trajectories are possible to reach the same target, but scenarios where early mitigation action is not taken rely heavily on negative emissions in the second half of the twenty-first century through the use of bioenergy and CCS (figure 23). The Cancun pledges are not

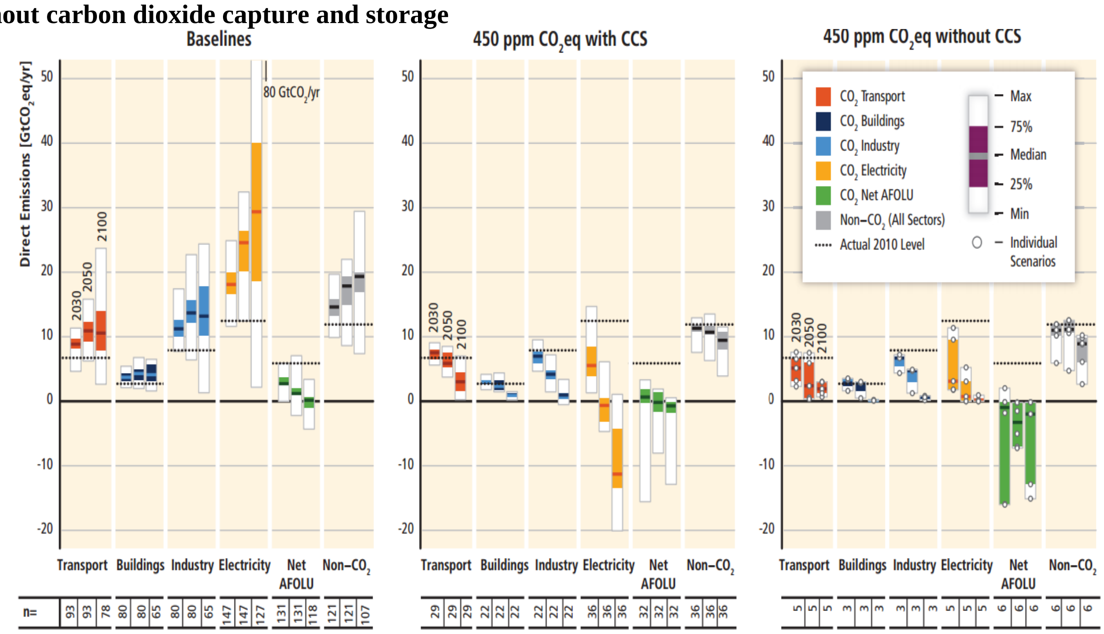
[22] See the summary for policymakers in AR5 WGIII, table SPM.1, available at <http://report.mitigation2014.org/spm/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf>.

consistent with the goal of staying under the 2 °C limit in a cost-effective manner. He stressed that mitigation costs increase if mitigation action is delayed (figure 24) or if the availability of low-carbon technologies is limited (figure 26), noting that many models were unable to produce 2 °C pathways if CCS and bioenergy technologies were not available. He added that, while mitigation costs vary widely, they are relatively modest compared to overall economic growth (see also table SPM.2). Figure 24 illustrates the increase in mitigation costs if mitigation action is delayed as a function of the mitigation gap until 2030.

134. On the issue of **sectoral emissions**, he pointed to a projected increase in emissions in all sectors according to the baseline scenarios, except for the AFOLU sector. Mitigation action in one sector depends on such action in another sector, as well as the availability of CCS and bioenergy. For example, 450 ppm CO_2 eq scenarios without CCS rely on large-scale afforestation. Some scenarios with CCS rely on negative emissions in the electricity sector that allows other sectors, such as transport, to modestly increase emissions by 2030 compared with current levels and to reduce their emissions at a slower pace thereafter (figure 25).

Figure 25

Direct sectoral CO_2 and non-CO_2 greenhouse gas emissions in baseline and mitigation scenarios with and without carbon dioxide capture and storage



Source: Summary for policymakers in the contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure SPM.7. The figure illustrates the effects of the availability of carbon dioxide capture and storage on greenhouse gas emissions in various sectors.
Abbreviation: AFOLU = agriculture forestry and other land use.

135. Ms. Joyashree Roy (IPCC) made a presentation on **sectoral and cross-sectoral mitigation**. She highlighted that **GHG emissions continue to rise in the energy supply and energy end-use sectors**, implying the need for widespread mitigation actions in order to achieve low stabilization scenarios. Almost 80 per cent of the GHG emissions growth between 2000 and 2010 comes from the energy supply and industrial sectors (figure 27). She indicated that the IPCC identified a range of low-carbon power-generating technologies that are currently commercially available or at the pre-commercial stage and estimated the specific direct and lifecycle emissions for such technologies, as well as the levelized cost of electricity, underlining that some are already cost-competitive in comparison with conventional fossil-fuel technologies.[23]

136. Regarding **energy supply mitigation options**, she noted that in the majority of low-stabilization scenarios, the share of **low-carbon electricity supply** (comprising renewable energy, nuclear energy and CCS) increases from the current level of approximately 30 per cent to over 80 per cent by 2050, and fossil-fuel power generation without CCS is almost entirely phased out by 2100. She added that in mitigation scenarios in which CO_2 eq concentration levels of 450 ppm are reached by 2100, **natural gas power generation without CCS** acts as a bridging technology, peaking before, and reaching below, current levels by 2050, and declining further in the second half of the twenty-first century. Although the energy sector was the largest GHG emitter in 2010, the importance of the industry and buildings sectors rises as indirect emissions are accounted for (figure 27).

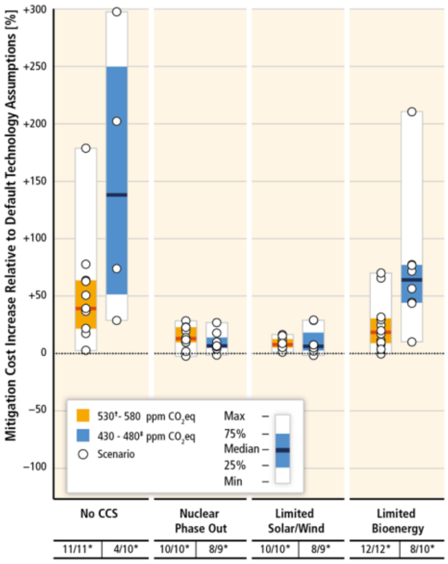
[23] See also the technical summary in AR5 WGIII, figure TS.19, available at <http://www.ipcc.ch/report/ar5/wg3>.

137. With respect to the **industrial sector,** Ms. Roy emphasized that global production of minerals and manufactured products is growing steadily and driving GHG emissions. She outlined five main options for mitigating end-use sector-specific emissions: energy efficiency; emissions efficiency (e.g. switching to a non-fossil fuel electricity supply or cement production with CCS); material efficiency in manufacturing (e.g. using old steel structures without melting) or product design (e.g. lightweight car design); product-service efficiency (e.g. car-sharing or increased building occupancy); and service-demand reduction (e.g. switching from private to public transport).

138. Using the example of the steel sector, she highlighted that significant **mitigation potentials exist in various costs ranges**, including cost-effective measures. She added that attractive mitigation potentials exist in all areas and described these potentials for various sectors (figure 28).[24] In the waste sector, emissions have doubled since 1970 and mitigation measures could follow the waste hierarchy, starting with preventative measures and ending with disposal for which the cost ranges were provided.

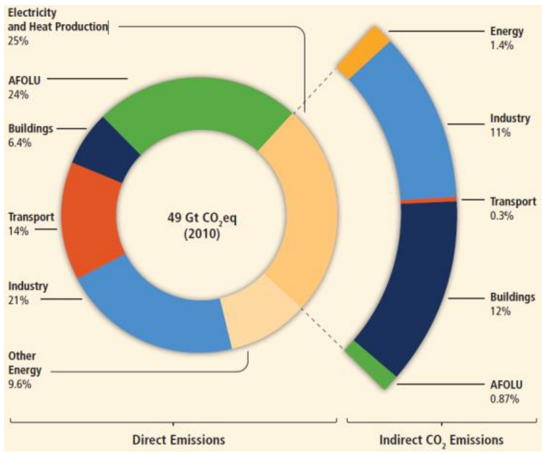
139. In the **buildings sector**, advances in technologies and lifestyle change can significantly reduce GHG emissions by the mid twenty-first century. Efficiency improvements in the range of 25–30 per cent are available at lower costs than marginal energy supply costs. Retrofitting, with a 50–90 per cent emissions reduction potential for existing buildings, offers significant mitigation potential, and low-energy building codes could avoid lock-in. Lifestyle change and better architecture can further reduce GHG emissions in the near term to the mid twenty-first century.

Figure 26
Increased mitigation costs resulting from the limited availability of technologies



Source: Slide 15 of the presentation by Mr. Volker Krey (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/2_krey_vuuren_sed3.pdf>. The figure shows the increase in mitigation costs if low-carbon technologies are not freely available.

Figure 27
Total anthropogenic greenhouse gas emissions by economic sector in 2010



Source: Summary for policymakers in the contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, figure SPM.2. The figure shows the current contributions to emissions by sector.
Abbreviation: AFOLU = agriculture forestry and other land use.

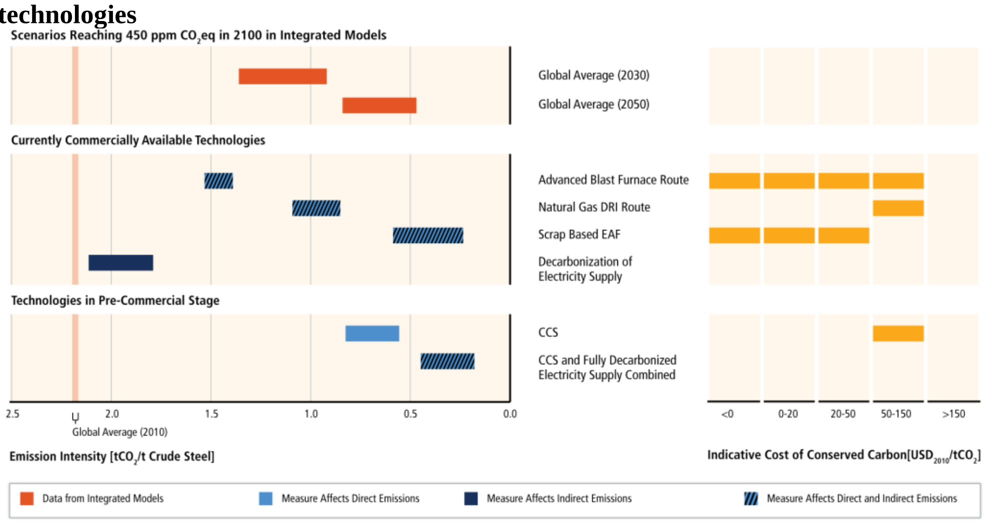
140. In the **transport sector**, she noted that emissions will grow until 2100 according to the ‘business as usual’ scenario, with a faster rate for passenger transport than freight transport. She detailed the possible mitigation options with various costs for passenger and freight transport[25], noting that some of these technologies currently have higher levelized costs than the conserved carbon, indicating that policies are needed for their deployment. Regarding **human settlements**, infrastructure and spatial planning, she stressed that urban areas account for more than half of global primary energy use and energy-related CO_2 emissions, and that the largest opportunities for future urban GHG emissions reduction might be found in rapidly urbanizing countries where urban form and infrastructure are not locked-in. However, she warned that governance, as well as technical, financial and institutional capacities, is often limited in such countries. In addition, significant differences exist in per capita GHG emissions between cities within a single country.

[24] See also the technical summary in AR5 WGIII, figure TS.27, available at <http://www.ipcc.ch/report/ar5/wg3>.
[25] See also the technical summary in AR5 WGIII, figures TS.21 and TS.22, available at <http://www.ipcc.ch/report/ar5/wg3>.

141. Regarding **AFOLU**, Ms. Roy said that this unique sector accounts for 24 per cent of total anthropogenic GHG emissions and is the only sector in which net emissions fell in the last decade. She specified that while agricultural non-CO_2 GHG emissions increased, net CO_2 emissions fell, mainly due to decreasing deforestation and increased afforestation rates (figure 29).[26] She outlined the possible economic mitigation options in the AFOLU sector, including in forestry, such as the restoration of cultivated organic soils and grazing land management, stressing the need to consider both demand- and supply-side measures.[27]

142. Ms. Roy underlined that most **systemic approaches to mitigation across the economy are expected to be environmentally and cost-effective**. Efforts in one sector determine mitigation efforts in others, thereby highlighting the importance of negative emission options in some sectors in ambitious mitigation scenarios (see para. 133 above). Reducing energy demand through efficiency enhancements and behavioural changes are key mitigation strategies.

Figure 28
Indicative CO_2 emission intensities and the levelized cost of conserved carbon for various steel production practices/technologies



Source: Slide 13 of the presentation by Mr. Joyashree Roy (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/3_roy_sed3_final.pdf>. The figure illustrates the mitigation potentials in a specific sector.
Abbreviations: CCS = carbon capture and storage; EAF = electric arc furnace.

143. In concluding, she stated that the wide application of available best-practice low-GHG technologies could lead to substantial emission reductions, and that financial and institutional barriers may be overcome by packages of complementary policies that take regional specificities into account.

144. Mr. Axel Michaelowa (IPCC) addressed the **performance of climate policies and climate finance at the international, regional and national levels**. He stressed that climate change mitigation is a global public good and thus requires international cooperation. Regarding the performance of national climate policy, he noted that from 2007 to 2012, the share of global emissions in countries with such policies rose from 45 to 67 per cent and, thus far, these policies have not significantly influenced the emissions trend. Consequently, there is a need to learn from successful examples at all policy levels to address the mitigation challenge.

145. Regarding the performance of **international climate policy**, while stressing that the UNFCCC regime is the only platform with broad legitimacy, he noted increased cooperation outside the UNFCCC, which, with the exception of the Montreal Protocol, has not led to significant emissions reductions. Although the Kyoto Protocol commitments have been reached, benefiting from changes in countries with economies in transition and the use of market-based mechanisms which mobilized low-cost mitigation, the additionality of these measures is debatable and the Kyoto Protocol has been viewed as less successful than envisaged. As regards the Cancun pledges, he stated that they are more consistent with a 3 °C temperature increase than with a 2 °C temperature increase by 2100, underlining that their impact could differ substantially depending on their interpretation (figure 30).

146. With respect to the performance of **policies at the subnational level**, Mr. Michaelowa noted the lack of evidence on the contribution to mitigation of agreements between non-State actors, highlighting the difficulties of differentiating between subnational and national efforts. With regard to the private sector, he noted that

[26] See also AR5 WGIII, figure 11.2(A), available at <http://www.ipcc.ch/report/ar5/wg3>.
[27] See also the technical summary in AR5 WGIII, figure TS.31, available at <http://www.ipcc.ch/report/ar5/wg3/>.

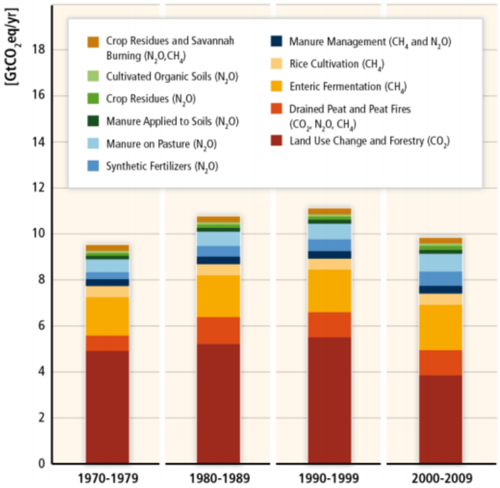
private–public partnerships work in the presence of a strong signal from government regulators; private-sector initiatives in isolation are not successful in driving down emissions; and emission reductions are driven by public policies.

147. **Regional cooperation**, which is a new chapter in the AR5, has had only a limited positive impact on mitigation, even in areas of regional integration such as the European Union, due to unexpected economic shocks; uncertainty about the long-term emission reduction targets; and interaction with other policy instruments. Binding regulation-based approaches in areas of deep integration have had some impact on mitigation, but despite a plethora of agreements on technology, their impact on mitigation has been negligible to date.

148. Regarding **national policies**, he noted that the issue of co-benefits, such as energy security and local air quality, has gained increased attention, but remains to be assessed, in particular at the desegregated level. He outlined the assessment of the performance of various instruments, stressing that emission taxes are found to be more effective than voluntary mitigation. Sectoral policies are easier to implement than economy-wide policies. Some direct regulation, especially efficiency standards for buildings, cars and household appliances, is cost-effective. Emissions trading systems introduced to date suffer from caps that are too lenient and have thus experienced price decreases. Emission taxes have been effective and can be applied in conjunction with other instruments, while the efficiency of technology policies is unclear.

Figure 29

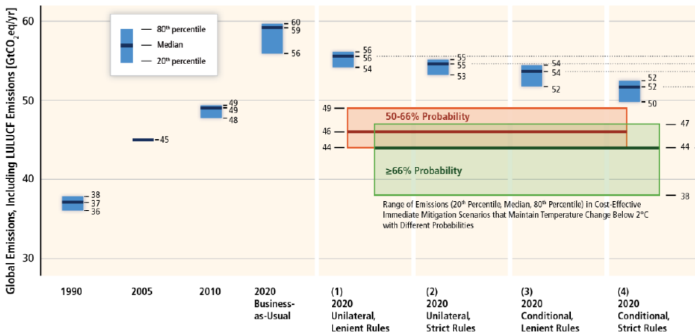
Agriculture, forestry and other land use emissions over the last four decades, 1970–2010



Source: Slide 22 of the presentation by Ms. Joyashree Roy (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/3_roy_sed3_final.pdf>. The figure depicts the level of emissions over the last four decades for the agriculture, forestry and land use sector, in which emissions have decreased.

Figure 30

The Cancun pledges and the emissions pathway



Source: Slide 4 of the presentation by Mr. Axel Michaelowa (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/4_michaelowa_sed3.pdf>. The figure shows that the estimated effectiveness of Cancun pledges depends to a large extent on how they are interpreted.

149. As to the performance of **climate finance**, he indicated that total public and private **climate finance investments** are estimated at USD 343–385 billion per annum, with an almost even distribution among developed and developing countries, with 95 per cent of the investments directed at mitigation. Public climate finance is estimated at USD 35–49 billion per annum, but robust information on levels of private-sector flows from developed to developing countries is very scarce. In addition, dedicated financial instruments to decrease the risks of low-carbon technologies (e.g. credit enhancement and insurance, guarantees or finance in local currency) have rarely been applied in the context of mitigation, and performance assessment is therefore limited.

2. General discussion

150. The ensuing discussion was guided by the following questions:

(a) What will the increase in temperature be by the end of the twenty-first century without additional mitigation compared with the 'business as usual' scenario, and how do the AR5 WGIII findings on this matter compare with the findings of WGI?

(b) What mitigation pathways will limit global warming below 2 °C or 1.5 °C? What changes in emissions are required to stay below a 2 °C or 1.5 °C increase in global mean temperature relative to pre-industrial levels?

(c) What is the cost associated with the mitigation pathways for various levels of global mean warming and what will be the consequences of limited access to technologies or of delaying mitigation?

(d) What are the sector-specific emission trends, mitigation potentials, technologies and investment patterns? How do mitigation efforts in one sector influence mitigation efforts in others?

(e) Based on technology development trends, what are the low-cost abatement opportunities that can be pursued in the near term? What are the higher cost opportunities that are not yet commercially viable but could hold significant abatement potential over the longer term?

(f) What policies have attracted the greatest attention? How can we maximize climate policy co-benefits and reduce adverse side effects?

(g) What is the role of international climate change cooperation? What role can subnational actors play (e.g. the private sector, cities and sub-national authorities) in reaching the long-term global goal and creating enabling environments?

151. One Party asked whether, for the **1.5 °C limit,** the assumption was maintaining this temperature increase **for the entire twenty-first century or by the end of the century**. An expert explained that the probabilities specified in AR5 WGIII correspond to staying below a given temperature limit throughout the century. He added that there is no scenario in the data set where the global mean temperature is likely to remain below 1.5 °C throughout the century and only a few scenarios where the global mean temperature is more likely than not to remain below this limit in 2100. Another Party noted that for the 430–480 ppm category of scenarios with overshoot of less than 0.4 W/m^2 the projected temperature increase by 2100 is between 1.5 °C and 1.7 °C and, hence, the low part of these emission scenarios has a 50 per cent probability of limiting global warming below 1.5 °C.[28] The Party then asked about the required technologies and their scaling-up, the technology portfolio and the costs related to achieving these scenarios for the category with CO_2 concentration levels below 430 ppm, and how they compare with scenarios in the 430–480 ppm category that are more consistent with the 2 °C limit. The expert stated that the required technologies are the same as for the 2 °C pathway, the only difference being that they need to be deployed faster and that energy demand needs to be reduced earlier, implying a higher cost than the 2 °C scenarios. However, he added that due to the limited model studies available, the cost results lack robustness and are uncertain. Another expert added that mitigation costs for 1.5 °C scenarios increase substantially not only in the long term, but in particular also in the short term.

152. Another Party asked experts to **comment on how mitigation fundamentally reduces the risk of warming and climate impacts, as well as on the cost of avoided impacts**. An expert said that the mitigation costs presented in AR5 WGIII for various temperature increases are not based on a comprehensive cost–benefit analysis, which was not carried out by WGIII and would require value judgments on uncertain avoided impacts, including impacts of a “catastrophic” nature (i.e. very large impacts with a low probability). The Party further asked how to reconcile the fact that a delay in mitigation action would increase mitigation costs, and the fact that a 1.5 °C pathway would be more expensive than a 2 °C pathway. The expert drew a distinction between mitigation costs and the notion of net benefits. The 1.5 °C limit has a higher mitigation cost than a 2 °C limit, a difference which needs to be compared with avoided damages, which is the realm of WGII. He added that the costs information provided has no implications on whether or not it is worthwhile to pursue the 1.5 °C limit (see paras. 155 and 157 below).

153. In a follow-up comment on the fact that the rapid increase in mitigation costs of reaching the 1.5 °C limit may not be matched by the reduced impacts, the Party pointed out that four out of the five RFCs show that the impacts of climate change increase in a non-linear fashion between 1.5 °C and 2 °C, especially for unique and threatened systems (e.g. the massive loss of coral reefs), large-scale singular events (e.g. the disintegration of ice sheets in Greenland and Antarctica in this warming range), or impacts on local agriculture. The Party asked about the comparison between the increased costs of mitigation, the reduced costs of adaptation and the avoided non-monetary impacts between these two limits.

154. A Party commented on the usefulness of the graphic presented in figure 22 and asked if this could be generated for a 1.5 °C limit of global warming. An expert stated that a publicly available IPCC database can be used to generate such graphics for 1.5 °C, 3 °C and 4 °C limits of global warming.

[28] See AR5 WGIII, table 6.3, available at <http://www.ipcc.ch/report/ar5/wg3>.

155. Responding to a question regarding **the current atmospheric concentration of CO_2 eq**, an expert indicated that in 2011 the concentration was about 430 ppm CO_2 eq, noting that current concentration levels are within the lower range of the 430–480 ppm category and that it has already become evident that achieving such concentration levels in 2100 without temporary concentration overshoot will therefore be very difficult.

156. In response to a question on the **role of non-CO_2 GHGs** in achieving low-emission scenarios and possible policy implications (figure 23), an expert explained that the WGIII experts did not have the data to break down the emissions by gas at the sectoral level. He added that non-CO_2 GHGs such as methane (CH_4), nitrous oxide (N_2O) and some fluorinated gases, are dominated by agricultural sources since incentives exist in the energy sector to address CH_4 leakages. Furthermore, a switch to a less meat-rich diet and a reduction in red meat consumption would yield further CH_4 emission reductions. However, not all models are responsive to such a change in consumption patterns and many uncertainties exist in the AFOLU sector in relation to demand-side measures. Another expert added that this matter was addressed in the industrial sector. On a follow-up question related to the role of **short-lived climate pollutants** and on policies to reduce them, an expert underlined that in many cases they are co-emitted with GHGs. While recognizing that the reduction of those short-lived forcers that have warming effects is beneficial, he warned that such policies focusing on short-lived gases should not be seen as a substitute for reducing other GHGs, in particular long-lived CO_2.

157. Regarding **assumptions related to bioenergy and CCS** uptake in terms of achieving negative emissions in the second half of the twenty-first century, an expert clarified that some coordinated studies with harmonized assumptions have been carried out and are reflected in the cost estimates presented (table SPM.2). However, he emphasized that, in general, the assumptions vary greatly depending on the studies and models used to make the assessment.

158. Noting that the **costs of emissions reduction in 2050** were presented in table SPM.1 for a wide range of reductions (e.g. a 41–72 per cent emissions reduction in 2050 for scenarios likely to stay under a 2 °C limit), a Party asked if details of mitigation costs could be provided, such as costs for specific levels of emissions reduction in 2050 and marginal costs. An expert underscored that the levels of emissions reduction in 2100 are dramatically different across categories; mitigation action in 2050 is key, where emission reduction levels are different between categories; and chapter 6 of AR5 WGIII contains additional information on marginal mitigation costs. **For 1.5 °C warming scenarios, the required mitigation action in 2030 is very different from the action required for 2 °C warming scenarios**. He underlined that the cost-effectiveness of mitigation action is shown by all models and relates to the monetization of co-benefits. Another expert pointed to the difficulty of monetizing the social costs of carbon, in particular taking into account impacts, using discount rates and considering low-probability high-impact events, which explains why WGIII confined its assessment to mitigation costs (see paras. 151 and 152 above). With regard to co-benefits, he added that it would be incorrect to directly combine the mitigation costs assessed by AR5 WGIII with the co-benefits reported in other sources of information because an evaluation of co-benefits would require an evaluation of the difference between the current level of regulation and an optimal level of regulation, for example for sulphur dioxide or black carbon. A third expert stressed the low reliability of estimated damage costs included in integrated assessment models,[29] noting that they should only be used with caution. In addition to the challenges of monetizing social costs or the choice of a discount rate, he pointed to an institutional issue, namely the gap between WGII, which studies impacts with a small number of economists, and WGIII, which has more economists but less information on impacts and on the calculation of damages.

159. A Party asked about the **differences in mitigation costs among regions and countries**. An expert said that these differences relate to burden-sharing and that in integrated systems, emission reductions to achieve a global target occur where it is cheaper to do so, without necessarily implying that the reductions are paid for by the country where they occur. Reductions could occur under an effort-sharing scheme, with carbon allowances and trade flows, as in the example presented in figure 6.30 of AR5 WGIII.

160. Regarding the **Cancun pledges**, a Party asked whether the uncertainty related to the projections beyond 2020 or to the translation of the pledges in a quantifiable emissions reduction. An expert explained that the main driver of differentials is the fact that the pledges are frequently not clearly formulated, pointing to the upper and lower values of the pledges that depend on policy decisions. Another Party asked for the experts' views on what could be done to bridge the gap between the Cancun pledges and what is required to maintain a temperature increase below 2 °C.

161. As to the **effectiveness of the Kyoto Protocol**, one Party disagreed with the expert presentation and noted that the Kyoto Protocol is the only existing rule-based instrument. He added that CDM projects have resulted in real climate change mitigation benefits, based on the robust certified emission reduction system that has

[29] See AR5 WGIII, chapter 3, available at <http://www.ipcc.ch/report/ar5/wg3>.

mobilized over USD 215 billion of investments in developing countries as of June 2012, with USD 5–13 billion of direct benefits to developing countries, and which has resulted in over 1.5 billion tonnes of avoided CO_2.[30] Noting that it often takes time for policies to bear fruit, another Party asked about the expected results of policies in the years to come. The expert indicated that there is agreement regarding the good performance of carbon taxes over the past 20 years and the mixed experience with emissions trading over the past 10 years. Regarding market-based mechanisms, including the CDM, he recognized that a large number of projects have been generated, but clarified that what is debated by experts is whether the mechanisms always fulfil the environmental integrity target. He added that the market-based mechanisms under the Kyoto Protocol are fast in learning the experience and that the effectiveness of policies is likely to increase in the long term.

162. In response to a question on the **relationship between carbon taxes and technology policies** and on national and regional action to enhance the **effectiveness of technology policies**, an expert answered that the introduction of pricing provides incentives for technology development, pointing to some successful examples of carbon taxing and emissions trading. He added that the determination of the effectiveness of various policies aimed at the selection of a particular technology was still unclear. The Party further asked about the coverage of emissions by national climate policies. The expert said that large countries in Asia and Latin America adopted national climate polices with increased emissions coverage between 2007 and 2011, but the type and effect of these polices had not yet been assessed.

163. Regarding the **reduction of emissions in the forestry and other land use** sectors, a Party commented that although it strives to reduce its deforestation rates, these efforts “mean nothing” unless they are accompanied by emission reductions from fossil fuels and cement production, which were in the order of 10 GtC per year in 2010 compared with 1 GtC per year for land use,[31] as well as by the development of CCS technologies.

164. In relation to hydropower, one Party asked for clarification regarding the high emissions from electricity supply sources and the related uncertainties for hydropower emissions. Another Party asked whether the uncertainties relate to hydropower itself or to the difference between the hydropower station, such as its location, and how it is developed. An expert answered that uncertainties stem from the availability of water; competition with forest conservation; and uncertainties of policies on decentralized hydropower stations. Another expert added that location drives a range of uncertainties; for example, in tropical areas when a dam is constructed, strong CH_4 emission peaks occur in the first 10 years following the associated decomposition of biomass.

165. Several Parties asked for clarification of **public and private climate finance flows**, noting that the figures presented showed that about 10 per cent of total climate finance comes from public sources. An expert explained the debate is still continuing as to whether or not climate finance is more than just the incremental finance that drives high-carbon investments to low-carbon investments. The figure of USD 350 billion relates to the entire amount of investment, of which only a small proportion may be driven by climate change related flows, which may explain why the actual amount of public finance is much lower than the entire amount of investment. He added that the low evidence level of this finding is related to the lack of definition of what constitutes climate finance, calling for guidance at the political level on this matter. Another Party asked about the definition of public climate finance, and whether the USD 35–49 billion figure for public finance relates to total public finance or only the finance flowing to developing countries. The expert clarified that the public climate finance figures are from the fast-start period (public finance flows to developing countries).

166. One Party asked about the **timeline for achieving tariff parity in the power generation sector**, in particular among fossil fuels with CCS, renewables and nuclear energy, which would allow a seamless transition from one energy source to another. An expert pointed to the difficulties of responding to a question relating to grid parity and levelized cost of electricity, underlining that levelized cost of electricity is not a very useful indicator for identifying the optimum timing for different technologies and combining intermittent (e.g. renewables) and base-load technologies. Grid parity would require consideration of the different possible pathways to decarbonize the power sector; for example, with more renewables or with more CCS and nuclear energy. The full range of scenarios must therefore be studied, as well as the system costs of electricity, rather than the technology level.

167. Responding to a question on whether **literature published after the IPCC’s cut-off date** could alter the findings of AR5 WGIII, an expert said that the additional literature would require a new assessment, noting that on the subject of bioenergy alone, roughly 5,000 peer-reviewed publications have been released over the past

[30] See *Benefits of the Clean Development Mechanism 2012,* annex B, available at <http://cdm.unfccc.int/about/dev_ben/ABC_2012.pdf>.

[31] See figure TS.4 in the technical summary in the contribution of WGI to the AR5, available at <http://www.ipcc.ch/report/ar5/wg1>.

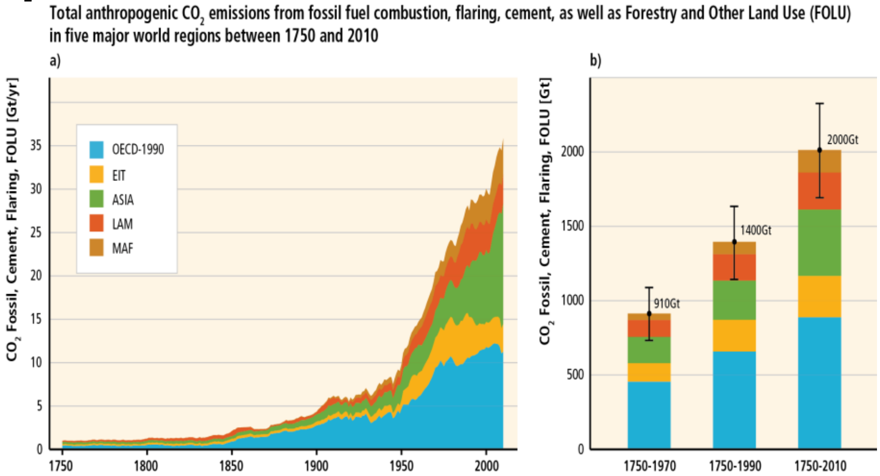
three years. He added that, to the best of his knowledge, there are no new findings that would fundamentally change the AR5.

F. Part 4 – theme 2: overall progress made towards achieving the long-term global goal, including a consideration of the commitments under the Convention based on the contribution of Working Group III to the Fifth Assessment Report

1. Presentations by experts

168. Mr. Gabriel Blanco (IPCC) made a presentation on trends in stocks and flows of GHGs and their drivers, explaining that the years 1970–2010 were used as a reference period, being the smallest common denominator for all gases. He added that for CO_2 emissions, some data are available until 2012, and long-term historic data are available for the period 1750–2010. Short-lived climate forcers were not included in the historic assessments due to their limited residence in the atmosphere.

Figure 31
Cumulative CO_2 emissions since 1750



Source: Slide 4 of the presentation by Mr. Gabriel Blanco (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_wgiii_ar5_blanco_final.pdf>.The figure shows CO_2 emission levels for the 1750–2010 reference period.
Abbreviations: OECD-1990 = countries members of the Organisation for Economic Co-operation and Development in 1990; EIT = economies in transition; LAM = Latin America and the Caribbean; MAF = Africa and the Middle East.

169. WGIII analysed GHG stocks and flows from multiple perspectives: cumulative CO_2 emissions; GHG emissions per region, gas, sector, capita and GDP; production-based GHG emissions; and consumption-based GHG emissions. **Cumulative CO_2 emissions have more than doubled over the last 40 years compared to pre-industrial levels**, and annual anthropogenic GHG emissions have increased by 2.2 per cent per year over the past decade, despite reduction efforts, with CO_2 remaining the main contributing gas to these emissions (65 per cent from fossil fuels and industrial processes). Energy-related emissions increased by 36 per cent in the last decade, followed by industry (a 45 per cent increase) and transport (an 18 per cent increase). The fact that the five databases used by WGIII contain very similar data illustrates the robustness of the data sets when harmonized to cover the same sources (figure 31).

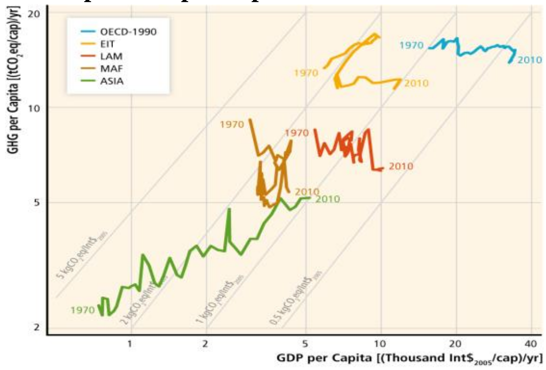
170. The comparison of **GHGs per capita and GDP per capita** shows a marked upward trend for Asia (GHG per capita grew with the increase in GDP per capita), while the trend is linear for member countries of the Organisation for Economic Co-operation and Development (OECD) (figure 32). OECD countries have larger **consumption-related emissions than production-related emissions**, while the reverse is true for the Asia region (figure 33). This is because a growing share of CO_2 emissions from fossil-fuel combustion and industrial processes in low- and middle-income countries has been released in the production of goods and services exported to high-income countries.

171. As regards **drivers of emissions**, Mr. Blanco drew a distinction between **immediate and underlying drivers**. The effect of **immediate drivers** of GHG emissions can be quantified, while the effects of underlying ones are more difficult to assess. Immediate drivers, or factors in the decomposition of total GHG emissions, include GDP per capita, which is the main driver of emissions, and population growth (figure 15). In the last decade, energy intensity has changed from reducing emissions to positively contributing to them, owing to a return to coal use in some countries since 2000 (figure 14). AFOLU is the only sector where the correlation

between emissions and GDP growth is loose. **Underlying drivers, which are subject to policies and measures,** include fossil-fuel endowment and availability, consumption patterns, structural and technological changes, and behavioural choices.

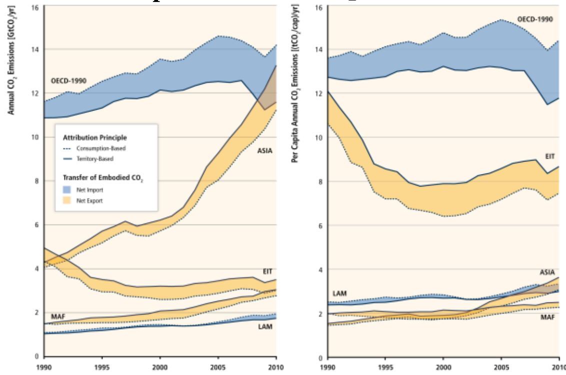
172. Mr. Blanco underlined that both **economic and population growth have outpaced emission reductions from technological improvements in energy intensity**. Without additional efforts to reduce GHG emissions beyond those currently in place, emissions growth is expected to persist, driven by growth in global population and economic activities. Baseline scenarios result in global mean surface temperature increases in 2100 of between 3.7 °C and 4.8 °C (median values) compared to pre-industrial levels. He concluded by underscoring the need to examine the drivers of emissions when designing climate change strategies, and "looking at the past when planning for the future".

Figure 32
Greenhouse gas emissions per capita versus gross domestic product per capita



Source: Slide 9 of the presentation by Mr. Gabriel Blanco (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_wgiii_ar5_blanco_final.pdf>. The figure illustrates some of the relationships between greenhouse gas emissions per capita as a function of gross domestic product.
Abbreviations: OECD-1990 = countries members of the Organisation for Economic Co-operation and Development in 1990; EIT = economies in transition; LAM = Latin America and the Caribbean; MAF = Africa and the Middle East.

Figure 33
Production-related CO_2 emissions (territorial) versus consumption-related CO_2 emissions



Source: Slide 11 of the presentation by Mr. Gabriel Blanco (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/1_wgiii_ar5_blanco_final.pdf>. The figure illustrates the differences in production-related (territorial) and consumption-related CO_2 emissions.

173. Mr. Sivan Kartha (IPCC) addressed the guiding question of SED 3, "How can current and future efforts to implement commitments under the Convention increase mitigation ambition and keep us on track for keeping global warming below 2° C/1.5 °C", and focused on the equity and ethical concepts relevant to international cooperation toward the long-term global goal (see para. 181(f) below). He presented three lines of argument relating to equity and equitable effort-sharing in relation to achieving the long-term global goal. The first is the **legal argument**, according to which Parties have accepted legal commitments to act against climate change in an equitable manner, with specific reference to equity in the Convention (Article 3, paragraph 1). The second is the **moral argument**, according to which it is morally proper to allocate burdens associated with the common global climate challenge according to ethical principles, which is a translation to the international level of the principles that are already generally respected at national level. The third is the **effectiveness argument**, that equitable effort-sharing will be necessary if the climate challenge is to be effectively met. This argument is based on the recognition that climate change is a global common problem. That is, effective mitigation will not be achieved if individual agents advance their own interests independently. Mr. Kartha said that this third argument is the strongest in the context of a global effort to cooperate on climate change.

174. Expanding on the **effectiveness argument and international cooperation**, he pointed out that no single country can protect its own climate by reducing its own emissions, and thereby no country can solve its climate change problem by itself. He underlined that countries thus undertake mitigation activities and cooperate in other ways, for example through financial and technological support, not only to directly protect their own climate, but also for the sake of inducing reciprocal effort in other countries. A country is more likely to be successful in seeking cooperation with other countries if perceived as doing its fair share of the effort. In short, a cooperative agreement based on effort-sharing that is seen to be equitable, and based on ethical principles may lead to more effective cooperation.

175. **Linking the arguments presented above with the costs of achieving the long-term global goal**, Mr. Kartha stressed that more than 100 scenarios assessed by the IPCC provide pathways for keeping global warming below the 2 °C limit (figure 16), at an estimated cost of a 1.0 to 3.7 per cent reduction in consumption relative to the baseline for 2030, or a growth reduction of 0.06 per cent per year, equivalent to around USD 1–3

trillion per year in 2030 (figure 34). He emphasized that these costs of roughly 1 to 4 per cent need to be calibrated against a baseline growth of 300 to 900 per cent over the same period.[32] He noted that these scenarios imply stringent emission reductions starting in 2020, with global and regional emissions peaking in the next 10–15 years, which will require broad low-GHG transformation in all regions.

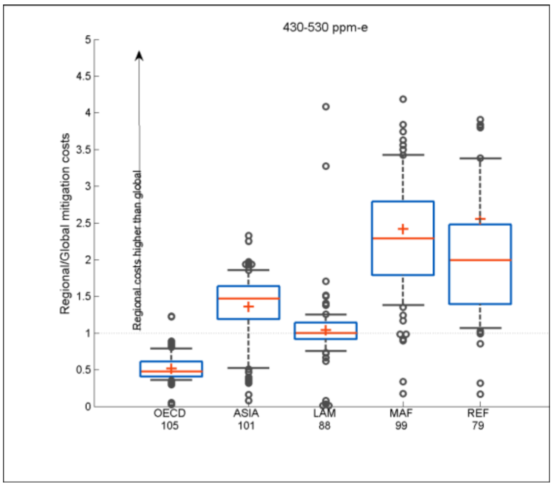
176. The **regional breakdown of mitigation expenditure**, based on mitigation potential (i.e. where each region undertakes mitigation up to a common equal marginal abatement cost), is as follows: the lowest expenditure is for OECD countries; it is twice that amount for Latin America; three times that amount for Asia; and four to five times that amount for Africa and the Middle East and countries with economies in transition (figure 35).[33] These figures reflect a distribution of costs that is the reverse of what might be expected if the mitigation burden was instead shared according to equity, which is at the core of the effort-sharing problem. Effort-sharing schemes have the potential to yield more equitable cost distribution across countries based on ethical principles rather than on mitigation potential. Effort-sharing approaches differentiate the mitigation costs borne in a region according to who pays for those costs, and thereby could provide a basis for compensatory payments across regions that can make climate coalitions effective and stable. There is a small set of widely invoked and rarely disputed ethical principles – founded on responsibility, capacity and equality – that forms the basis of discussions of frameworks for effort-sharing.

Figure 34
Estimated mitigation costs of a likely 2 °C limit and other emission pathways

	Consumption losses in cost-effective implementation scenarios			
	[% reduction in consumption relative to baseline]			[percentage point reduction in annualized consumption growth rate]
2100 Concentration (ppm CO_2eq)	2030	2050	2100	2010-2100
450 (430–480)	1.7 (1.0–3.7) [N: 14]	3.4 (2.1–6.2)	4.8 (2.9–11.4)	0.06 (0.04–0.14)
500 (480–530)	1.7 (0.6–2.1) [N: 32]	2.7 (1.5–4.2)	4.7 (2.4–10.6)	0.06 (0.03–0.13)
550 (530–580)	0.6 (0.2–1.3) [N: 46]	1.7 (1.2–3.3)	3.8 (1.2–7.3)	0.04 (0.01–0.09)
580–650	0.3 (0–0.9) [N: 16]	1.3 (0.5–2.0)	2.3 (1.2–4.4)	0.03 (0.01–0.05)

Source: Slide 9 of the presentation by Mr. Sivan Kartha (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/2-wgiii_ar5_kartha.pdf>. The figure shows the costs of mitigation.

Figure 35
Global distribution of mitigation expenditures, as a percentage of gross domestic product



Source: Slide 13 of the presentation by Mr. Sivan Kartha (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/2-wgiii_ar5_kartha.pdf>.
Abbreviations: OECD-1990 = countries members of the Organisation for Economic Co-operation and Development in 1990; LAM = Latin America and the Caribbean; MAF = Africa and the Middle East; REF = reference across scenarios.

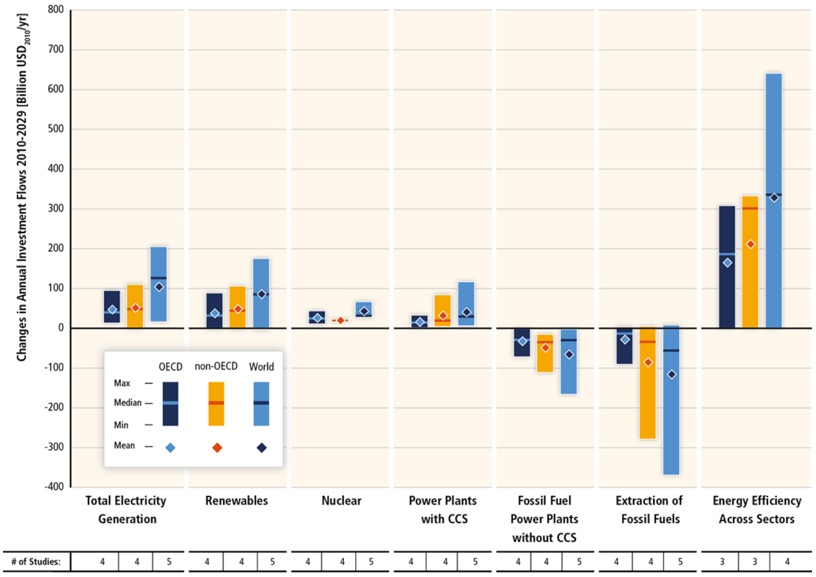
177. As to the broader **implications of mitigation measures for sustainable development** (see para. 181(g) below), Mr. Kartha explained that for each sector, WGIII looked at the interaction of climate policies with other societal objectives, although some uncertainties remain in identifying co-benefits or adverse side effects[34] and only a partial answer can be provided to this question. He noted that there are broad interactions between mitigation and all three pillars of sustainable development (i.e. the social, environmental and economic pillars), which results from the fact that the low-carbon transition being invoked is an encompassing transition of entire economic systems. Although co-benefits or adverse side effects can be substantial, they are often difficult to quantify (e.g., in monetary terms), and have not yet been thoroughly analysed. There is no "silver bullet" for enhancing co-benefits and reducing adverse side effects as they depend on local circumstances, as well as on implementation practice, pace and scale. However, practices that improve policies generally, such as good governance, transparency, stakeholder participation, cross-sectoral analysis and design, etc., are expected to help

[32] This overall reduction amounts to 0.1 per cent in the most optimistic assumption to 1.2 per cent in the most pessimistic assumption combination.
[33] See AR5 WGIII, figure 6.27, available at <http://www.ipcc.ch/report/ar5/wg3>.
[34] See AR5 WGIII, table TS.3, available at <http://www.ipcc.ch/report/ar5/wg3>.

enhance co-benefits and reduce side effects. Nonetheless, these co-benefits are significant both in welfare and political terms, and managing the interactions between mitigation action and other societal goals implies mainstreaming mitigation into the broader context of sustainable development.

178. Mr. Luis Gómez-Echeverri (IPCC) made a presentation on **cross-cutting investment and finance issues** with a view to assessing the progress made towards achieving the long-term global goal. He underlined that this is the first time that an IPCC assessment report has included a chapter dedicated to climate finance and investments. He noted that there is **no** widely accepted **definition** of what constitutes **climate finance and climate investments;** scientific literature on investment and finance to address climate change is still very limited, and knowledge gaps are substantial. He presented an overview of climate finance, from possible sources of capital, managers of capital and financial instruments to adaptation and mitigation projects, and indicated that climate finance is estimated at USD 343–385 billion per year, with 95 per cent being allocated to mitigation action. Regarding the share of public versus private climate finance, flows to developing countries from public climate finance amount to USD 35–49 billion per year, and flows from private climate finance amount to USD 10–72 billion per year.

Figure 36
Limiting greenhouse gas concentrations to 430–530 ppm by 2100 requires large changes in annual investment: 2010–2029



Source: Slide 7 of the presentation by Mr. Gómez-Echeverri (Intergovernmental Panel on Climate Change), available at <https://unfccc.int/files/science/workstreams/the_2013-2015_review/application/pdf/3_gomez_sed3.pdf>. The figure shows the required investment change by sector for a possibility of limiting global warming to 2 °C.
Abbreviations: CCS = carbon capture and storage; OECD = countries members of the Organisation for Economic Co-operation and Development.

179. Mr. Gómez-Echeverri underlined that: resources to address climate change need to be scaled up considerably over the next few decades, both in developed and developing countries; public revenues can be raised by collecting carbon taxes and auctioning carbon allowances; and emission scenarios that limit temperature increase from pre-industrial levels to below 2 °C require considerably different investment patterns during the period 2010–2029, including a fall in investments in fossil-fuel plants without CCS of USD 30 billion, an increase by USD 147 billion in investment in low-emission generation technologies, and an increase by USD 336 billion in energy-efficiency investments in the buildings, transport and industry sectors (figure 36).

180. He emphasized that **increasing access to modern energy services** to meet basic cooking and lighting needs could yield substantial improvements in human welfare at relatively low cost and with only minor effects on global GHG emission levels (USD 72–95 billion per year until 2030 to achieve nearly universal access).

181. Essential elements to scale up climate finance include: the existence of enabling environments that would allow private-sector investments to be scaled up; the de-risking of climate investment; appropriate governance and institutions at all levels; and synergies and trade-offs between mitigation and adaptation financing.

2. General discussion

182. The ensuing discussion was guided by the following questions:

(a) What are the global trends in historical, current and future GHG emissions and ambient GHG concentrations, including mitigation pathways for meeting the long-term global goal? What is the degree of probability?

(b) What are the key drivers of trends and projections of global GHG emissions and subsequent radiative forcing by sector, region and gas?

(c) Which policies and measures that appear to be reducing emissions, or that show emission reduction potential, could be strengthened, or emulated?

(d) How can long-term policy effects, such as investments in technological innovation, be evaluated? How could this possibly be factored into policymaking under the Convention?

(e) What are the assumptions for policies in the 'business as usual' scenario and what is their aggregate mitigation potential and uncertainty? Is there any gap between the actual mitigation and that needed to reach the long-term global goal and, if so, how could it be bridged? How could the implementation of these efforts be further assessed?

(f) How can current and future efforts to implement commitments under the Convention increase mitigation ambition and keep us on track to limiting global warming below 2 °C or 1.5 °C?

(g) What are the social and economic impacts of the implementation of mitigation measures on developing countries within mitigation pathways for various levels of global mean warming? What is the relationship between mitigation and impacts in terms of key risks, notably for the most vulnerable people and systems as assessed by AR5 WGII?

183. With regard to the **costs of mitigation in Africa**, the assumptions used and the question whether adaptation and disaster risk reduction were considered, an expert clarified that Africa would have the highest mitigation costs because costs have been calculated as a percentage of GDP and its GDP is low; estimates take into account not only present emission levels, but also their projected growth; and the region for which results are presented includes Africa and the Middle East. The cost figures presented are for mitigation only. In response to a follow-up question by a Party on the impacts of technological leapfrogging on the costs of mitigation in different regions, the expert stated that the acceleration of leapfrogging through, for example, a technology mechanism, would indeed reduce mitigation costs, but since historically this has only happened in few cases, there is an assumption of minimal leapfrogging built into the assessment based on models calibrated with historical data. Another expert added that middle- to high-income countries tend to replicate the historical development of high-income countries. Hence, current evidence shows that leapfrogging is limited (figure 14). Leapfrogging could be accelerated in the future, but only if there is a reliable carbon-pricing signal. In response to a question related to the identification of 'low-hanging fruits' in terms of global mitigation actions, an expert confirmed that there are indeed some indications of 'negative mitigation costs' for the building sector. He added that there are many options to decarbonize the power sector; transport will be the most challenging sector to decarbonize (few options); and carbon pricing allows finding for the detection of a way across all sectors of the economy to identify 'low-hanging fruits', taking into account the timing of mitigation action that is otherwise difficult to address. In response to a comment by a representative of civil society who pointed to some cost-effective options for the transport sector, the expert stated that achieving the low-emission scenarios in the second half of the twenty-first century requires negative emissions and therefore also depends on options to decarbonize the transport sector, irrespective of whether or not cheap electric vehicles are available.

184. Regarding **climate finance**, a Party expressed its surprise at the high **percentage of climate flows directed towards mitigation** (95 per cent) and asked if this could be related to a problem with the definition of "adaptation finance". An expert explained that the figure is in part due to the definition of adaptation finance, which is often difficult to distinguish from development or disaster risk management flows. He added that private-sector finance, which constitutes the largest part of climate finance, is definitely mostly channelled to mitigation. Responding to another question about the assumptions used in the projections of required climate finance, the expert explained that the assessment indicates that a major transformation is required to achieve the scaling-up of investment. He emphasized that elements of the enabling environment to achieve this transformation, in particular when targeted at the private sector, include greater certainty in policies, policies to lower the costs of capital, and the de-risking of investments, including a consistent carbon pricing.

185. A Party suggested **assessing progress towards the long-term global goal by breaking it down to a partial temperature limit for each decade** (e.g. 0.1 °C), based on best available science and updating it based on reduction of uncertainties and action on mitigation. An expert pointed to various difficulties of doing so, namely that: in addition to a limit in the change in global mean temperature as a long-term global goal at the end

of the twenty-first century, it should be associated with a ‘speed limit’ at which temperature changes, which can only be assessed when the effect on impacts is also considered; the 2 °C and 1.5 °C targets can only be achieved with concentration and/or temperature overshoots; and any assessment of such an approach should therefore also be carried out in coordination with WGII. He added that the IPCC currently has no mandate to make the assessment suggested, as it would require a closer collaboration or even a merging of WGII and WGIII, but that such tasks could be part of the IPCC’s future work.

186. Responding to a question on the **impact of fossil-fuel subsidy removal on emission reductions**, including on the refocusing of public expenditures, an expert explained that WGIII had not been able to carry out this quantification because of the absence of the required large-scale modelling comparison exercise. In response to a follow-up comment from a Party, he added that although no quantitative assessment has been carried out, chapter 16 of AR5 WGIII could only provide qualitative descriptions of the benefits of the removal of these subsidies. For example, reducing fossil-fuel subsidies would lower emissions and release public funds for other purposes. The expert also underlined the importance of the context in which such a removal is carried out, in particular the need for it to be accompanied by a pricing of carbon.

187. One Party noted that in the next 15 years, it will be necessary to transition from a 2.2 per cent per year increase in global emissions to an unprecedented reduction of 3 per cent per year, while the underlining drivers of emissions are increasing. The Party asked **where the focus of policymakers should lie in order to achieve the radical transformation called for in AR5 WGIII to achieve the long-term global goal**, and if such a transformation is feasible. An expert replied that all scenarios illustrate that the carbon price is a necessary condition, which should be complemented by additional policy instruments aimed, for example, at curbing carbon leakage effects and integrating all sectors, including land use. He added that significant additional research is required to design such policymaking packages. He commented that the price of carbon needs to be increased over time and that all sectors should be subject to this pricing, warning against the risk of carbon leakage if some sectors are exempt from the pricing. Responding to a follow-up question, he stressed the importance of having comprehensive carbon pricing that is not merely based on the fossil-fuel sector. To be successful, such a carbon-pricing scheme requires not only the inclusion of the land-use sector but may also call for a fundamental change in that sector. Another expert emphasized the feasibility as well as the significance of consumption patterns and behavioural changes, and underscored the importance of the Paris agreement.

188. An expert highlighted that AR5 WGIII indicates that **the required transformation is technologically feasible;** the **costs are manageable**, especially in the light of the stakes at hand; and various **policy portfolios could be deployed**. The key question is the political feasibility of the transformation, since WGIII calls for a fundamental transition that implies a “serious political challenge” with winners and losers. He added that the difficulties involved with such a near-term transition have not been assessed. Another expert pointed to the strong role of institutions in order to assess the feasibility of the required transition, calling for the capacity-building of decision makers in developing countries to enable them to make the right decisions. Responding to a follow-up question from a Party on the definition of these enabling environments, another expert noted the need to look at success stories, not least from a country-specific perspective.

189. Commenting on the **importance of pricing carbon**, a Party pointed to the uncertainties of technological developments, noting that a major technological breakthrough could generate significant mitigation benefits at low cost and that most of the scenarios analysed do not decouple economic growth and emissions growth. An expert explained that such a technological development cannot be anticipated, but that AR5 WGIII indicates that the lowest emission scenarios can be achieved through the scaling-up of existing technologies. Any technological breakthrough would additionally improve the situation. He added that without a carbon price, technological advances will not solve the climate challenge because of the risk of a very high rebound effect. Regarding decoupling economic growth and emissions growth, an expert said both high- and low-growth pathways are possible, with the latter making it easier to achieve such decoupling. Another expert stressed that the assessment of policies shows that those that have had a consistent carbon price over a long period have been effective, whereas those that did not include such a pricing were not necessarily effective. In response to a follow-up question regarding the long-term benefits of mitigation polices, he mentioned the example of the successful use of carbon taxing in Scandinavian countries for 20 years, emphasizing that there is a sufficient body of evidence on mitigation policies that will deliver results if applied consistently. Another Party pointed to its experience with such carbon taxes and its associated quota system, underlining that to achieve a technological change, the carbon pricing should be supplemented by other policy instruments. He drew attention to chapter 6 of AR5 WGIII on transformation pathways, which can help to **determine how high the price of carbon should be set to achieve the 2 °C goal**.

190. In response to a question on the **uncertainties in the estimates of different gases**, an expert explained that uncertainties exist in all databases used in the assessment, for all gases and sectors (in the full report). However, he noted that despite the uncertainties, the upward emissions trend is clear. On a follow-up question regarding the **uncertainties related to the assumptions for ‘business as usual’ scenarios**, an expert explained

that a large-scale modelling comparison exercise was carried out for **'business as usual'** scenarios and the uncertainties related to the assumptions were reduced. However, there are significant differences in the assumptions used for technologies, learning curves and externalities for mitigation scenarios within each model. With the establishment of the modelling community, these assumptions could be better estimated and uncertainties further reduced in the future.

191. In response to a question related to the **definition of and assumptions behind 'business as usual' scenarios**, in particular inasmuch as these relate to RCP scenarios also used by WGI, an expert explained that **WGIII 'business as usual' scenarios are typically consistent with RCP8.5, but cover a much broader range of possible future scenarios**. He added that the 'business as usual' scenarios include known polices, such as the Cancun pledges.

192. Commenting on the data on **consumption- and production-based emissions**, a Party asked for suggestions as to how to achieve substantial emission reductions in the context of globalization. Another Party noted that while the production-based emissions of OECD countries have decreased, their consumption-based emissions increased, emphasizing the need for a global perspective to effectively mitigate climate change. An expert stated that an analysis of this matter was carried out based on the available literature rather than by using data from databases. He said that there is no clear answer, underlining the need to look at all sources of emissions and their drivers, including consumption patterns and behavioural changes. Another expert added that production- and consumption-based accounting should not be used to identify responsibilities nor misused to imply particular emission reduction measures, stressing that in studies assuming an ideal world, the method used to account for emissions is irrelevant.

G. Reflections on the third meeting of the structured expert dialogue

193. SED 3 was well attended, bringing together many government delegates and experts from all regions, as well as civil society representatives. During each of the four parts of the meeting, the time dedicated to discussions was substantial and balanced between the two themes of the 2013–2015 review. Parties actively engaged in a rich exchange of views with experts that enabled an in-depth discussion of the findings of AR5 WGII and AR5 WGIII as they pertain to the 2013–2015 review. SED 3 saw Parties and IPCC experts engage in a remarkably constructive, productive and rich manner in all discussions. Consequently, the dialogue was deepened, with many follow-up questions and comments. We believe the productive and informative discussions at SED 3 supported Parties in internalizing the key findings contained in AR5 WGII and AR5 WGIII, which are relevant to both themes of the 2013–2015 review, thus completing the consideration of the contributions of all three working groups to the AR5.

194. At SED 2, a number of issues were identified as requiring further consideration at SED 3, namely: risk management, including the relationship between risk and overshooting of the long-term global goal, the geographical distribution of risks given regional differences in impacts and in economic or other costs of adaptation for various levels of warming; and the underlying assumptions, feasibility and cost of impacts, mitigation and adaptation in terms of RCPs and other scenarios considered by the IPCC, as well as the temporal aspects of emission pathways while considering aspects such as short-lived GHGs and commitments in carbon infrastructure. At SED 3, these issues were fully addressed by the IPCC experts in their presentations and during the discussions with Parties.

195. Nonetheless, the discussions at SED 3 underlined a number of issues where additional information and discussions would be required at future meetings of the SED, including: the evaluation of the costs of adaptation; the assessment of the value of the co-benefits of climate change mitigation; and the assessment of the 1.5 °C temperature limit. However, the IPCC repeatedly emphasized that their hands are tied, pointing out that scientific insights on the 1.5 °C limit are limited since results of the needed research are not yet available or not of the same robust nature as those on the 2 °C long-term global goal.

196. At SED 3, IPCC experts stated repeatedly that assessing the adequacy of the upper limit of global warming in the light of Article 2 of the Convention involves both risk assessments and value judgments. In the AR5 the IPCC assessed risks across contexts and through time, providing an analytical framework that can be a foundation for a collective agreement on how much global warming is acceptable. While recognizing that the work of the SED is still ongoing, it is already a successful vehicle for informing and supporting policy formulation, taking into account the various values and recognizing that what constitutes an intolerable risk may differ across sectors, regions and countries.

197. One of the clear messages that emerged from SED 2 and SED 3 is that limiting global warming to below 2 °C calls for adopting a long-term approach to climate change, which in turn calls for science-based management of the global pathway towards a low-carbon and climate-resilient future. To that end, the SED has been able to contribute considerably to an increased understanding of the relationship between near- and long-

term actions on mitigation and adaptation. Furthermore, the periodic review of the long-term global goal can play a positive and essential role in any process established for assessing the progress made towards achieving the long-term global goal, thereby strengthening the science–policy interface.

198. We, the co-facilitators, believe that the approach taken at SED 3 worked well and we congratulate Parties and experts for a successful meeting, while encouraging all stakeholders to maintain this positive and collaborative spirit at future meetings of the SED.