**WG III Contribution to the IPCC AR6 report – Summary for Policy Makers**

**(Draft V1.1 \_29-06-2020)**

*[Note: This version of the SPM is in two parts:*

***Part 1 -*** *Pages 1-34 is a limited update based on SPM V1.0 revised to include some, but not all, suggestions that were made in track changes by authors up to 30th June 2020. These have been integrated into the SPM without further editing. Comments provided by the author team are captured in the Excel spreadsheet. ]*

***Part 2*** *- pages 35-49 provides a full list of high level SPM message suggestions provided by chapters 1, 5, 14, 15, 17]*

Section A - Introduction

***INTERNAL note on section scope:***

*Actions to mitigate climate change take place in the context of sustainable development and efforts to achieve the sustainable Development Goals (SDGs). Greenhouse gas emissions are closely tied to the development pathways followed by all countries, whatever their development status. The literature assessed in this report views the mitigation challenge through a number of lenses including sustainable development, equity, risk, costs and benefits, and socio-technical transitions.* *Delaying climate action will make achieving climate goals more difficult to reach or even beyond reach.*

This section has two purpose: a) to set out the principal framings for the report based largely on Chapter 1; and b) to set out some basic housekeeping e.g. literature cut-off, approach to confidence and role in the AR6 cycle. Given its nature, we have suggested not using the headline statement format but rather flowing text. It introduces the SPM by: noting the context for the report; what is new since AR5/SRs; key framings for the report including sustainable development; “urgency” (stated non-prescriptively), and brief summary of formal approaches to uncertainty and traceability (line of sight/confidence).

The Working Group III (WG III) contribution to the IPCC’s Sixth Assessment Report (AR6) assesses literature on the scientific, technological, environmental, economic and social aspects of mitigation of climate change. It builds upon the WG III contribution to the IPCC’s Fifth Assessment Report (AR5), and the three Special Reports in the sixth assessment cycle[[1]](#footnote-2). This report incorporates subsequent new findings and provides an updated assessment of the current state of knowledge[[2]](#footnote-3). The understanding of mitigation, including what the important enabling conditions are, has moved on considerably since AR5. This report reflects the multiplicity of approaches that can be used to obtain insights, including from models, top-down and bottom-up analysis, scenario frameworks, cost-benefits, treatment of uncertainty, risk assessment, data, and social science framings. Common framings on climate change mitigation used within the literature since AR5 include economic, ethical and transitional theories and perspectives. The literature increasingly combines these theories and perspectives to explore ways to accelerate action on climate mitigation. {1}

Frameworks describing technological, structural and behavioural changes in production and consumption and their carbon footprints are useful to analyse and address the implications of choices. Practical approaches to policy evaluation could usefully combine modeling at various scales with ethical and transitions analysis, through processes of aligning problem formulation, bridging of data and metrics, and iterative interactions between the different approaches.

A central framing of this report is an integrative perspective on climate change responses and sustainable development, in relation to the Agenda for Development 2030 and beyond. Since AR5, the literature on global and regional mitigation pathways has highlighted a strong dependence of attainability of stringent climate goals and the associated costs of mitigation on the underlying development pathway. The literature reflects how situating climate change mitigation in the context of sustainable development can facilitate and accelerate action whilst considering equity and efforts to eradicate poverty. {1}

The literature since AR5 has developed in the context of the Paris Agreement and climate action taken at the national level. It identifies response options available in the near-term that can address both climate change adaptation and mitigation. It also identifies co-benefits and risks linked to sustainable development. The literature shows that delaying climate mitigation and adaptation actions would limit future choices and reduce the prospect of following sustainable development pathways. {1}

This Summary for Policymakers (SPM) is structured in five parts, A: Introduction and framing, B: Where we are now and where we are headed, C: System transformations to limit global warming, D: Mitigation, adaptation and sustainable development, E: Strengthening the response. The basis for the SPM can be found in the chapter sections of the underlying report and in the Technical Summary (TS). References to these are given in square brackets.

Confidence in key findings is indicated using the IPCC calibrated language[[3]](#footnote-4).

SECTION B: Where are we now and where are we headed?

***INTERNAL note on scope of section:***

*Global emissions of greenhouse gases continue to rise although the rate of growth has fallen since 20xx. The main drivers are rising affluence, reflected in emissions embodied in international trade, and to a lesser extent population. Some decoupling of emissions and GDP has occurred but the extent varies from one region to another. Some future emissions are unavoidable because of past infrastructure investment and embedded practices. Current national commitments are in aggregate consistent with long-term pathways resulting in global warming of 2.x/3.y°C during the 21st century, but have brought projected emissions below business-as-usual levels. Since AR5, opportunities, actions and plans that can reduce emissions and enhance sinks have become evident across all sectors and systems but are not yet supported by sufficient or consistent policies to deliver on those targets in the context of sustainable development. Nonetheless, new policies and institutional arrangements have contributed to the take-up of mitigation actions at sub-national, national and regional to global scales.*

This sectiondoes what the title suggests.A quantitative re-cap of emissions and drivers, what national commitments could achieve and a quantification of lock-in comes first. The remainder is more qualitative, summarising what has changed since AR5 across four cross-cutting topics, each of which gets a Headline Statement: national and sub-national policies; international cooperation; finance; and technology. Before the cross-cutting topics, there is a single Headline Statement covering sectors, with separate sub-statements for each. Finance is included here as a sector as well as a cross-cutting topic.

**B.1 Global greenhouse gas (GHG) emissions have continued to rise in [all/most sectors] since AR5 although the rate of growth has fallen since 20xx, especially in […]. *(xxx confidence*) {2}**

**[CH LEAD: 2]**

B.1.1 Global GHG emissions were likely 58 (±5.8) GtCO2eq in 2018, the highest in human history. Global emissions have flattened since 201x, but have grown by [xx]% since 1990 and [yy]% since 2000. Cumulative emissions from the pre-industrial period to 2018 are [zzzz] *(xxx confidence).* {2}

B.1.2 In 2018, CO2 emissions from fossil fuel and industry (FFI) were 38 (± 3.0) Gt, CO2 from AFOLU 5.5 (± 2.8) Gt, CH4 11 (± 2.2) Gt CO2eq, N2O 2.5 (± 1.5) GtCO2eq and F-gases 1.6 (± 0.32) GtCO2eq. While CO2 emissions from FFI have grown by 66% (since xxxx), emission growth was only 24% and 28% for CH4 and N2O *(xxx confidence)*. {2}

B.1.3 Despite having lower per capita emissions, developing countries accounted for [xx%] of global CO2 emissions growth after 2008, mostly driven by increased consumption and investment *(robust evidence, high agreement).* {2}

B.1.4 Consumption-based CO2 emissions in developed economies are considerably higher than in developing economies (*high confidence*). Consumption-based CO2 emissions in developed economies reached a peak of [17 Gt] in 2007 with a subsequent 10% decline by 2015. Yet, with [46%] of global emissions, this group was still the largest contributor from a consumption perspective, compared to [41%] from developing economies, and less than 1% from least developed ones. This is due to net CO2 emission transfer from developing to developed countries via global trade chains (*robust evidence, high agreement*). {2}

B.1.5 Production based GHG emissions have peaked in several countries, but in no country does the current annual average rate of decline [over a sufficiently long recent period] match the sustained decline rates over the next 2-3 decades in global emission scenarios that limit warming to well below 2°C *(xxx confidence)*. {2}

B.1.6 [*A statement based on sectoral emissions - important to pull out land-based to compensate for energy bias in these statements.]*

B.1.7 A decomposition analysis of recent emission trends shows that materials and energy consumption due to growing affluence has been the strongest driver of CO2 emissions growth from fossil fuel combustion, followed by population (*robust evidence, high agreement*). Emissions are decoupled from economic growth through technological change that has enabled improved energy efficiency and a switch to lower carbon energy sources *(xxx confidence)*.{2}.

B.1.x Emissions from industry have increased faster than emissions in any other sector since 2000, driven by increased basic materials extraction and processing. Global energy intensity is decreasing but global materials intensity is increasing with in-use stock growing faster than GDP since 2000 (*xxx confidence)*. {11} Since AR5 the literature on mitigation potentials for emissions intensive industry has increased, exploring options such as material efficiency improvement, direct and indirect electrification (e.g., with hydrogen) and carbon capture and use (CCU), in addition to established options such as energy efficiency (high confidence). (Earlier B5.4)

**B.2 Current national commitments have brought projected aggregate global emissions below the levels associated with the implementation of current policies. Current commitments for 2030 are not in aggregate consistent with long-term pathways that will limit global warming to less than 2°C during the 21st century *(xxx confidence)*. {4}**

**[CH LEAD: 4]**

B.2.1 Current policies lead to median global GHG emissions of 60 GtCO2eq with a full range of 57–65 by 2030 and unconditional and conditional NDCs to 56 (54–62) and 52 (49–56) GtCO2-eq, respectively (*medium evidence, high agreement*). {4}

B.2.2 Current GHG emission trends at the global level and the mitigation investments expected by 2030 are not compatible with the long-term temperature goal in the Paris Agreement even when a broad range of potential rapid reductions in emissions after 2030 is considered *(xxx confidence).* {1, 3}.

B.2.3 The comparison of unconditional NDCs and cost-effective long-term mitigation pathways gives rise to a 2030 emissions gap of 28–34 GtCO2eq yr-1 for limiting warming to 1.5°C, and 11–16 GtCO2eq yr-1 for limiting warming to 2°C. Meanwhile, the comparison of conditional NDCs and cost-effective long-term mitigation pathways gives rise to a 2030 emissions gap of 23–29 GtCO2eq for limiting warming to 1.5°C, and 6–10 GtCO2eq for limiting warming to 2°C. *(xxx confidence)* {4}

B.2.4 In mitigation pathways that close the emissions gap consistent with limiting warming to 1.5°C (2°C), renewable energy supply is scaled up by a factor of yy–yy (yy–yy) by 2030 compared to today while efficiency measures and behavioral change reduce energy demand across all sectors by xx–xx% (xx–xxx%). In scenarios that limit average global temperature change to below 1.5°C, the investment needs into mitigation actions are about [USD xx billion] by 2030, and increase further to [USD xx trillion] by 2050. (*xxx confidence)* {3, 6}

**B.3 Current and planned infrastructure and investments, institutional inertia and social norms is leading to future committed CO2 emissions that may be costly or difficult to abate due to the need for early retirement, lower than expected utilization and devaluation of assets *(high confidence* {2}**

**[CH LEAD: 2]**

B.3.1 Assuming continued historical retirement rates and capacity utilization, estimates of future CO2 emission commitments from current energy infrastructures vary between 660 and 720 GtCO2. In addition, Accounting for energy infrastructure proposals future CO2 commitments of 850 [range] GtCO2 fill up the remaining carbon budget for keeping warming well below 2°C and exceed the remaining carbon budget for 1.5°C *(xxx confidence)*. *{Ch?}*

B.3.2 Limiting warming to well 2°C or 1.5°C will necessitate the early retirement of fossil energy infrastructure, particularly infrastructure linked to coal *(xxx confidence*). Limiting near-term investments in fossil infrastructure can help to minimize stranded assets.{.{2.8.2, 6}

B.3.3 Factors limiting ambitious transformation include structural barriers, inertia, and both ‘hard’ lock-in (like infrastructure and assets) and ‘soft’ lock-in (political economy, regulatory inertia and vested interests). The interaction between power, politics and economy is central in explaining why broad commitment does not always translate to urgent action in states and beyond. {1} *(xxx confidence)*

B.3.4 *[Institutions and behavioral norms: Current trends show the potential of demand-side solutions, but also that this potential is underutilized {5}].*

**B.4 Since AR5, many countries have developed cross-sectoral and integrated climate policy frameworks, including policies focused on goals which have climate mitigation as a co-benefit, and corresponding institutional arrangements. Gaps remain both at the level of coverage and ambition of climate commitments and their effective enabling factors for implementation, such as sufficient policies, their stringency and suitable institutions (*xxx confidence).*** **{13}**

B.4.1 [*Qualitative and* *Quantitative statement about the spread of climate legislation, national strategies, carbon pricing etc {13}]*

B.4.2 Climate mitigation is increasingly being undertaken by a diverse set of actors going well beyond national governments, including cities, states/provinces, businesses, and citizens themselves (*xxx confidence)*. {6}

B.4.3 Sub-national actors have a various set of climate mitigation policy tools in hand ranging from economic and regulatory instruments to information programs and government provision of goods, services, and infrastructure; however, due to the limitations of jurisdictional authority the success of mitigation actions depends on complementary climate mitigation and energy policies from senior level of government and coordination between different levels of governments.

B.4.4 Many national and subnational actors are not equipped with the capacities needed to mobilize financial and human resources, build coalitions, facilitate coordination, develop relationships across old and new organizations, and create new competences at both the individual and institutional level (*xxx confidence)*. {13}

B.4.5 While dominating presently in direct and indirect emissions, industry has not so far been as affected or targeted by climate policy as other sectors due to international competition. Specific safeguards (e.g. free allocation of emission permits, reduced carbon tax rates) have been implemented to avoid the risk of carbon leakage (*high confidence)*. Reducing emissions from emissions intensive industries has not been a focus for both national and international institutions {11} *[More on other sectors is needed]*

B.4.6 *[Placeholder statement on carbon disclosure. A statement about the distinct absence of climate policies in some sectors (existing mitigation potential has remained untapped; e.g. AFOLU)]*

B.4.7 Demand-side policy success stories have been demonstrated in multiple service categories and in many countries *(xxx confidence).* {5} *[Elaborate on success stories]*

**B.5 In all sectors, there have been developments since AR5 which have limited GHG emissions below previously projected levels, or which have the potential to limit future emission reductions, reflecting the relevance of [technology, policies, behavior, …]** *(****xxx confidence).***

**[CH LEAD: 12]**

B.5.1 Electricity generation from non-fossil sources, has increased by 23% from 2013, although bioenergy remains to 2017. Wind and solar power have shown particularly high growth rates, but from low absolute levels. contribute the largest share. However, total share of renewable energy in total energy provision has remained very constant at 17%. . The growth in non-fossil electricity generation is well below what would be needed to meet the Paris goals. From 2013 to 2017, generation from low-carbon electricity has increased by 23%. The vast majority of the growth has been solar PV and wind power, which have grown by 217% and 74%. Growth in hydropower (7%), nuclear power (6%), and CCUS has been limited. (*xxx confidence)*. {6}

B.5.2 Climate change, increasing population, urbanization, welfare, and aspirations for wellbeing for all, will continue to drive a higher energy demand in buildings, especially for cooling and digitalization *(xxx confidence)*. {9}

B.5.3 Since AR5, technological change in the transport sector has begun to show a widening gap between transport modes. Mitigation of land-based transport increasingly focuses on electrification of vehicles, although biofuels remain important in some regions and especially for heavy duty trucks. Electrification of land-based transport can be associated with up-front GHG emissions but offers strong mitigative capacity if supported by electricity generation with low GHG emissions. Shipping and aviation rely to a larger degree on efficiency improvements and fuel shift from fossil fuels to biofuels and, on the longer term, hydrogen and other electrofuels. , X*(xxx confidence)* {10}

B5.4 moved to B1

B.5.5 [*Statement on* *Finance sector: what has happened to climate finance. e.g., Financial Stability Board]*

B5.6 Placeholder: diet choices and novel food products and systems. Significant development since AR5

B.5.7 [B5.6] Deforestation, a main driver of AFOLU emissions, has slowed in most tropical forest regions since the early 2000s (high confidence). A key driver of this reduction in several countries is policy innovation (medium confidence), although recent reversals of past gains illustrate the difficulty of sustaining a reduction in deforestation through policies without broader attention to policies or measures that also influence the underlying drivers of deforestation (medium confidence). Agriculture emissions have grown further, although per produced product have come down in [*intensive agriculture? Add types, regions? ]*

**B.6 The role of international cooperation has changed, but not diminished, since AR5. There has been a shift from multi-lateral standard setting and enforcement to enabling and strengthening national action and regional cooperation (*high agreement, robust evidence*).**

**[CH LEAD: 14]**

B.6.1 The 2015 Paris Agreement aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by: (a) holding the global average temperature increase to well below 2°C above pre-industrial levels and by pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels (long-term temperature goal); (b) increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production (adaptation goal); and (c) making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development (finance goal). The Paris Agreement contains binding obligations for states to submit Nationally Determined Contributions (NDCs) towards this end. Achievement of the goals of the Paris Agreement depends upon effective international cooperation regarding means of implementation and support, namely sufficient finance flows, technology development and transfer, and capacity-building for developing country parties, particularly the least developed countries and those most vulnerable to the adverse effects of climate change (high agreement, robust evidence). 

B.6.2 Emissions from international aviation and shipping, which represent a growing share of global emissions, are governed by international cooperative arrangements, rather than by national mitigation policies due to the international location of these emission releases. The Kyoto Protocol required developed country parties to pursue emissions reductions from aviation and marine bunker fuels by working through the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO). Since the conclusion of the Paris Agreement, IMO and ICAO have introduced new measures to control emissions from international shipping and aviation but these are limited in their ambition and face implementation difficulties. The absence of a provision in the Paris Agreement regarding the exclusive competence of IMO and ICAO for governance of international transportation emissions expands the scope for greater cooperative efforts on aviation and shipping emissions under the Paris Agreement, as well as within the IMO and ICAO.

B.6.3 *[Other sectoral agreements; technology cooperation/transfer agreements Bilateral/plurilateral cooperation agreements] Lack of cooperation in heavy industry could be mentioned here.*

**B.7 Climate financing needs have increased compared to AR5 levels driven by shorter period remaining until 2050/2030, relatively low mitigation investment activity in the past several years and rising levels of adaptation costs and linked to climate-related extreme events. Average annual mitigation investments required come in between [xx–yy] trillion USD for 2020–2030 with annual adaptation action expected to add between [xx–yy] trillion USD *(xxx confidence)*. *{15}***

**[CH LEAD: 15]**

B.7.1 Climate-related pledges, commitments and risk management by investors and finance providers, both public and private, do not necessarily result in climate mitigation and adaptation action/results on the ground *(xxx confidence)*. {15} *[Elaborate with more empirical inputs]*

B.7.2 Macroeconomic headwinds including unstable and slowing global GDP growth, larger prospective fiscal costs of climate shocks, rising financial and insurance sector stresses and losses, politically increasingly infeasible carbon taxes, short term economic gains of deforestation versus unpaid long term biodiversity gains and near-term economic slowdown some of which may be exacerbated by the effects of Covid-19 *(xxx confidence)*. {15} have hampered mitigation efforts xxxx*[Elaborate with implication on mitigation]*

B7.x Most country-level mitigation modelling studies report negative impacts of mitigation on GDP in 2030 and 2050, relative to the reference (*robust evidence, high agreement*) [4.3.3.2]. Impacts on unemployment are mixed [4.3.3.3]. Distributional implications of mitigation are context- and policy-specific [4.3.3.4]. Adverse impacts of mitigation on GDP, unemployment and distribution can be mitigated, in part, through policy design [4.3.3 ].”

B.7.3 Private sector climate finance has outpaced public climate finance in recent years with the total still remaining far below required levels. Lack of adequate public climate finance, including international public finance, risks a slow redirection of private finance and the transformations in sectors with limited private sector activity *(xxx confidence)*. {15}

B.7.4 The climate finance gap is widening with the gap having increased roughly by xxx% from an estimate of xxx to xxx in the last [5] years [*or since the last AR5 assessment*]. *(xxx confidence)* {15} *[More on sectors and regions]*

B.7.5 Climate related financial risk arising from physical impact of climate change and a disorderly transition to a low carbon economy due to delayed action is considerably underestimated by financial institutions and markets. This results in investments inconsistent with both adaptation and mitigation objectives. It can also lead to missing the time window for the transition and failing to achieve the climate goals of PA. (*xxx confidence)*. *{15}*

B.7.6 Two-thirds of the expected low-carbon investments required to meet [2°C] are in developing countries, while the bulk (80%) of financial assets (and current emissions), are located in developed country markets. The delay in redirecting cross-borders climate finance flows can exacerbate the carbon lock-in of emerging countries *(xxx confidence)*. {15} *[Focus on near term investments needs]*

**B.8 Many individual technologies have shown rapid progress since AR5 in terms of cost, performance and adoption (*robust evidence, high agreement*). Cross-cutting technological change, notably digitalization, has far-reaching implications on mitigation opportunities and potential across all sectors, not all of which are supportive of more stringent targets. There remains a substantial gap between the current patterns and rates of technological change and what is needed to achieve climate and sustainable development goals.** **{2}**

**[CH LEAD: 16]**

B.8.1 Advances in technologies, including transformative changes in some regions and sectors, has opened up new and large-scale opportunities for deep decarbonization, and for alternative development pathways, which could deliver multiple social and developmental goals *(xxx confidence)*. {1} [*Examples of successes (digitalization, batteries)]*

B.8.2 *[Gap between the current patterns of technological change and what is needed to achieve climate and sustainable development goals. Example: slow progress (CCS); uneven rate of penetration in different regions; energy access] {16, sectoral chapters}*

B.8.3 To strengthen innovation processes, governments can adopt holistic perspectives. *[Elaborate on international collaboration on technology]* {16}

**B.? Greenhouse gas (GHG) emissions differ significantly between nations and among rich and poor people within nations, mirroring global income inequalities. Eradicating poverty and reducing inequality, key development priorities in many countries, can be achieved with negligible implications for GHG emissions growth, while increasing the ability of poor countries and communities to adapt to the adverse impacts of climate change, and enhancing their capacity to participate in climate decisions and governance […]. *(xxx confidence*) {2}**

B.?.1Inequality in greenhouse gas (GHG) emissions between countries decreased over the last decades in parallel with steady economic and GHG emissions growth *(robust evidence, high agreement)*. Aggregate emissions increased slower than income in most high-income countries and at the same rate or faster in middle and low-income countries *(low evidence, medium agreement).*

B.?.2 Within countries, inequalities have increased for both income and GHG emission. The top 10% emitters (the global richest 10% on a per capita basis) contribute about 36-45% of global GHG emissions*(robust evidence, high agreement)*. The top global 10% emitters live on all continents, with two thirds in high-income regions and one third in emerging economies *(robust evidence, strong agreement)*

B.?.3 Eradicating extreme poverty and providing universal access to modern energy services to poor populations across the globe has negligible implications for emissions growth (*robust evidence, medium agreement*). Greater inequality can lead to a deterioration in environmental quality and may be associated with higher GHG emissions under certain contexts (*limited evidence, medium agreement*).

B.?.4 The carbon footprint of providing a Decent Standard of Living to all is far less than the current world average energy (carbon footprint). Higher income consumers have large carbon footprints and emissions associated with affluent lifestyles. Carbon-intensive consumption patterns and affluent lifestyles of wealthy consumers are emulated by middle and low-income segments of the population that can increase future emissions growth (*medium evidence, medium agreement*).

B.?.5 Growing within country inequality in greenhouse gas (GHG) emissions creates redistributions and social cohesion dilemmas and affects the willingness of rich and poor to accept mitigation and other policies to protect the environment *(medium evidence, medium agreement)*.

Section C: System transformations to limit global warming

***INTERNAL note on scope of section:***

*Revised estimates of warming associated with a given emissions scenario since AR5 mean that only a handful of published mitigation pathways are now compatible with limiting global warming to 1.5°C, even allowing for overshoot. As a result, remaining carbon budgets to 1.5°C (and higher levels of warming) are smaller than previously estimated in AR5 and the Special Report on Global Warming of 1.5°C. This means even more rapid and pervasive system changes are required over the next few decades. A central projection based on current national commitments suggests that global warming of 1.5°C will be exceeded by 203x. Opportunities to reduce emissions and enhance sinks are numerous and include inter alia net zero energy systems, energy efficiency, electrification of energy demand, afforestation, agricultural intensification, sustainable cities and carbon dioxide removal. Delays to action could place limiting global warming to 1.5°C, or even 2°C, increasingly beyond reach.*

This section has two main components: a) to assess global emissions pathways in the context of different warming levels including those indicated in the Paris Agreement long-term temperature goal; and b) to identify transitions at the system and sectoral level that would limit warming (it would also be possible to split this into two sections).

The first three bullets address emission/mitigation pathways, illustrative pathways, carbon budgets/net zero drawing largely on Chapter 3. This depends on the development of thinking about illustrative pathways, engagement with WG I on carbon budgets and the availability of new scenarios. The second part is essentially a deep dive into response options – from a techno-economic perspective – at the sectoral level. A specific Headline Statement on the demand side is suggested. The precise scope of each system/sectoral Headline Statement would depend on the availability of material (e.g. combining transport and settlements).

**C.1** **Mitigation pathways describe warming levels that range from less than 1.5°C peak warming over the 21st century to greater than 4.5**°**C warming by 2100, depending on the strength and timing of the mitigation policies applied. Weaker near-term action makes achieving the Paris Agreement temperature goal impossible as it would entail assumptions about accelerated technology and policy development and deployment not found in the assessed literature and inconsistent with current evidence and projections (*xxx confidence*). {3}**

**[CH LEAD: 3]**

C.1.1 In the absence of new climate policies (meaning non-implementation of NDCs and even including a failure to implement current policies), annual GHG emissions may increase from [XX] to 65–95 GtCO2eq yr-1 by 2050, resulting in a global average temperature change of 3.5 to 4.5°C by 2100 (*xxx confidence*); leading to large additional land use emissions (relate to WG I & II). {3}

C.1.2 Most pathways achieving mitigation levels below 3.0°C by 2100 peak GHG emissions at some point before the end of the 21st century. Pathways describing the most ambitious level of mitigation, and most stringent policies consistent with the temperature goal of the PA typically lead to a GHG emissions peak before 2030. Few pathways in the literature are compatible with <1.5°C without some level of temporary temperature overshoot during the course of the 21st century (*xxx confidence*). {3}

C.1.3 Mitigation pathways consistent with limiting temperature change to “well below 2°C” are typically associated with net GHG emissions of 30–50 GtCO2eq yr-1 by 2030 and 5–25 GtCO2eq yr-1 by 2050. ; including additional land based sinks of xx GtCO2eq yr-1. This corresponds to global GHG emissions reductions of 0–40% by 2030, and 55–90% by 2050 (relative to 2018 emissions levels). Pathways that aim at limiting temperature to below 1.5°C require a further acceleration of the pace of the transformation, with GHG emissions reductions of about 50–70% by 2030 and 70–100% in 2050 (relative to 2018) and an additional land based sink of xx GtCO2eq yr-1. (*xxx confidence*). {3}

C.1.4 For CO2 emissions, a warming limit of 1.5°C (at >50% probability of staying below) with no or low (< 0.1°C) temporary overshoot of the limit implies net emissions below 30 GtCO2 in 2030 including additional land based sinks. A warming limit of 2°C (at 50% probability) implies net emissions below 30 GtCO2 in 2030. (At 66% probability of staying below the 2°C limit, this implies net emissions below 40 GtCO2 in 2030.) (*xxx confidence*). {3}

**BOX SPM XXX.***[Suggested Box on Net Zero & Carbon Budgets (max half page)]* [*CH LEAD: 3]*

**C.2** **The timing of carbon neutrality is the main determinant for the timing of the temperature peak over the 21st century. The height of the temperature peak is primarily determined by the quantity of carbon emitted before neutrality is achieved. Remaining carbon budgets (toward a given level of peak warming) therefore influence the pace of required emissions reductions. {3}**

**[CH LEAD: 3]**

C.2.1 Data from modeled emissions pathways show that there is a clear relationship between the temperature target, the year that emissions reach net zero globally, and the global carbon budget (*xxx confidence*). {3}

C.2.2 A temperature target of below 3.0°C (category C6) corresponds approximately to reaching net-zero emissions by the end of the century and a roughly 3,000 GtCO2 carbon budget (*xxx confidence*). {3}

C.2.3 A below 2.0°C (category C4) or well below 2.0°C (category C3) target meanwhile corresponds to a larger range of years for carbon neutrality (around 2050–2080) and carbon budgets (from 2016 to 2100) of around 1100 and 800 GtCO2, respectively (*xxx confidence*). {3}

C.2.4 A <1.5C target with either high or low overshoot requires carbon neutrality before 2050 and carbon budgets (from 2016 to 2100) of around 200 GtCO2 (*xxx confidence*). {3}

C.2.5 In the well below 2.0°C and <1.5°C pathways, carbon budgets up until the year carbon neutrality is reached are considerably higher than the budgets to 2100, owing to carbon dioxide removal (CDR) technologies being deployed (*xxx confidence*). {3}

C.2.6 For total GHGs, similar trends can be found, though the net-zero emissions year is typically around 20 years later (*xxx confidence*). {3}

**C.3 Pathways describing rapid and extensive mitigation in the near term entail rapid decarbonization of the electric sector, increased service-demand efficiencies within the end-use sectors (transport, buildings, industry), and much greater deployment of low-carbon electricity and fuels (hydrogen, biofuels). Many of these pathways also entail negative emissions from CDR including A/R and technical solutions (BECCS and DACS). *(xxx confidence)* {3}**

**[CH LEAD: 3]**

C.3.1 The illustrative pathways (IPs) describe archetypical routes toward different temperature goals relying on alternative sets of mitigation options; the IPs thus highlight trade-offs between different mitigation and policy choices (*xxx confidence*). {3} *[Add key insights from IPs along the dimensions that differentiate them: temperature targets, timing, mitigation options employed, SDG linkages]*

C.3.2 Accelerated mitigation pathways describe rapid and extensive mitigation in the near term, moving from current trends onto a 1.5°C or well below 2°C pathway over the next decade and then fall below NDC-consistent emission levels in 2030 by around 10 GtCO2eq. *(xxx confidence)* {X}

C.3.3 A world that relies far less on fossil carbon will depend much more on renewable resources, including resources from land. The availability of sustainable land resources is contingent on investments in and proper management of the AFOLU sector (*xxx confidence*). {7}

C.3.4 In most pathways the AFOLU and energy supply sectors reach net zero CO2 emissions earlier than the demand sectors, such as transport, industry and buildings. Emissions from the latter sectors often remain positive in scenarios and are thus compensated by negative CO2 emissions in the AFOLU and energy supply sectors in the middle and later parts of the century (*xxx confidence*). {3}

C.3.5 While the growing number of accelerated mitigation pathways in the literature aid understanding of the various technological solutions to keeping global warming within check, less attention has been paid to demand-side options on the behavioral side, and to systems-analytical studies that bring all supply- and demand-side solution together in an internally consistent way. Moreover, the current literature focuses less attention on non-CO2 GHGs (*robust evidence, medium agreement*). {4}

C.3.6 *[Non-CO2 mitigation does not alter the need to reduce CO2 to net-zero but can vary the time by which net-zero CO2 has to be reached by ±X years {3}]*

C.3.7 *[Early mitigation of short-lived non-CO2 gases has little effect on peak temperature but can reduce the rate of warming over the next two decades and, depending on implementation, can yield strong co-benefits {3}]*

**C.4 [Mitigation Costs and Potentials] Mitigation costs and potentials consistent with pathways limiting global temperature increase to below 2C are significantly different when looked at from a top-down than when looked at from a bottom-up context due to large synergies and trade-offs involved. GHG mitigation potentials from IAM are on the order of xx% (higher/lower) than those from sectoral assessments and associated costs from IAM are on the order of yy% (higher/lower) than those assessed from sectoral studies. {This is very much a placeholder}**

**[CH LEAD: 12]**

C.4.1 […] e.g. Comparative statement on potential and costs per technology providing ranges {placeholder}

C.4.2 […] Role and significance of land-based mitigation options in comparison to emerging technologies potentials such for electrification and hydrogen {placeholder}

**C.5. Demand-side mitigation measures increase the likelihood of equitable service provision and offer the potential to decouple GHG emissions and GDP growth. Policies encouraging demand-side measures complement supply-side interventions by limiting the need for new energy supplies, the reliance on negative emissions technologies and associated demand for land. (*xxx confidence)* {5}**

**[CH LEAD: 5]**

C.5.1 Demand-side measures cut across all sectors and can bring multiple benefits [*such as…*]. Demand-side policy approaches are critical components of supply side transformations as they reduce the need for supply-side infrastructure (and associated costs), accelerate structural change, and reduce reliance on large-scale negative emissions technologies (*xxx confidence*). {5}

C.5.2 Recent scenarios suggest it may be possible to increase the equitable provision of services significantly while at the same time reducing absolute energy, materials, and resource use (of up to 40% below current levels globally by 2050, or about two thirds compared to current trend scenarios by 2050) (*xxx confidence*). {5}

C.5.3 Demand-side, service-oriented solutions can deliver additional climate change mitigation, while saving costs (*high confidence*). Low-cost behaviour changes such heating and cooling set-point adjustments, shorter showers, reduced appliance use, shifts to public transit, more diverse diets less reliant on ruminant products, and improved recycling can deliver an additional 3GtCO2-eq savings in 2050, beyond the savings achieved in traditional technology-centric mitigation 1.5°C scenarios (*xxx confidence*). {5}

*C*.5.xStudies show that a shift to diets with higher share of plant protein could lead to substantial reduction of GHG emissions and nutrient losses, while at the same timeproviding health benefits and reducing mortality from diet-related non-communicable diseases (robust evidence, high agreement). Diets low in meat and dairy are already prevalent in many countries and cultures and are increasing in others, though from currently low levels. GHG emissions from vegetarian or vegan diets have been estimated so save up to 50% of GHG emissions as compared to current Western diets. {12.4}

C.5.4 Transformative demand-side change may be supported by combinations of behavioural, socio-cultural, corporate, institutional, technological, and policy drivers. Emerging megatrends, for example digitalisation, the sharing and the circular economies, can also support transformative change *(xxx confidence*). {5}

**C.6** **Energy systems needs to alter their course over coming decades to limit warming to ‘well below 2**°**C’ and <1.5**°**C. The necessary transformation will include substantial reductions in fossil fuels in the energy system, major investments in low-carbon energy forms, fuel switching to low-carbon carriers in end uses, and energy efficiency and conservation efforts to reduce the needs for energy supply investments. The urgency of this transformation has only increased since AR5. Fossil fuel ‘lock-in’ is a major risk arising from delayed mitigation action beyond the 2020–2030 timeframe. (*xxx confidence*)**

**[CH LEAD: 6]**

C.6.1 Energy systems need to become carbon-neutral around 2045-2060 to limit temperature change to 1.5°C; they need to become carbon-neutral around 2060-2075 to limit temperature change to 2.0°C. Reaching zero CO2 by 2050 requires emissions decrease by about 3.3%/year for the next 30 year; emissions grew at over 2%/year on average from 2000 till 2018. (xxx *confidence*) {6}

C.6.2 Robust characteristics of carbon-neutral energy systems include: (1) electricity systems that produce zero CO2 or that remove CO2 from the atmosphere; (2) widespread electrification of end uses; (3) substantially lower use of fossil fuels than today, (4) targeted use of alternative fuels (e.g., hydrogen, bioenergy, ammonia) in harder to decarbonize sectors; (5) more efficient use of energy than today; and (6) greater integration across components of the energy system. (xxx *confidence*) {6}

C.6.3. Since AR5, there have been rapid improvements and deployment of key energy system technologies, including batteries, wind and solar power, and digitalization across the energy systems. Deployment of these mitigation options, however, significantly lags what would be needed to limit warming to 2.0C or 1.5C. (xxx *confidence*) {6}

C.6.4 Electricity generation from low-carbon sources needs to grow by more than 80% (xx%) over the next 30 years to limit warming to 2C (1.5C). Investments in low-carbon electricity generation, could be around USD 700 billion per year by 2030, as comparison to overall electricity generation investment today of USD 350 billion. New management approaches will be needed to manage high-renewable electricity systems (xxx *confidence*) {6}

C.6.5 New investments in fossil infrastructure are at risk of being “stranded” in order to limit warming to 2C or 1.5C. Near-term investments in coal generation without CCUS are particularly vulnerable. Natural gas without CCUS must be largely eliminated in carbon-neutral energy systems. Investments in refining may be stranded with a move to electric transportation infrastructure. Limiting warming to 2.0C or 1.5C will lead to substantial reduction to the value of fossil resources in the ground. *(xxx confidence)* {6}

C.6.6. Societal and institutional changes are fundamental to energy system transformation. The large-scale technological transformations needed to reduce energy system emissions to zero will not occur without important changes across technologies and infrastructure, institutions, firms, and individuals.

**C.7 Agriculture, Forestry and Other Land Use (AFOLU) is the only sector for which it is currently feasible to enhance removals at scales that are significant in the context of 1.5 and 2-degree targets. Several mitigation options with a large emission [xxx–xxx GtC] reduction potential and medium scale land based sinks and provision of renewable resources are cost effective, but can be associated with co-benefits as well as adverse side effects (*xxx confidence*) and implementation can be challenging (*xxx confidence*). As for other mitigation options, requirements for large and rapid mitigation entails sustainability challenges (*xxx confidence*). But many factors influence the outcome of AFOLU measures and there is no straightforward correlation between implementation scale and impacts.**

**[CH LEAD: 7]**

C.7.0. A world that relies far less on fossil carbon will depend much more on renewable resources from the land which is only possible when large investments are made in the AFOLU sector. the AFOLU sector need to play an important role and contribute to mitigation through (i) substitution of fossil fuels and other GHG-intensive products; and (ii) carbon sequestration and storage in soils, vegetation and biobased products. There will be a large need for biogenic carbon (materials, chemicals, fuels, etc) if we phase out fossil carbon. There is also the need to reduce emission associated with, e.g., cement, metals, petroleum-based plastics and chemicals. Although AFOLU is sometimes perceived as an easy green washing opportunity, there is no free ride in this sector. {7}.

C.7.1 Avoided deforestation and peat/mangrove conversion is assessed to represent the largest mitigation potential in the AFOLU sector, with 3.7 GtCO2 yr-1. Afforestation/reforestation is the second largest with 3.0 GtCO2 yr-1. Agriculture and agricultural soils can achieve 1.7 GtCO2 yr-1. Better forest management, peat restoration and harvested wood products can achieve 1.5 GtCO2 yr-1; totaling 9.9 GtCO2 yr-1. Partly overlapping with the re-/afforestation, harvested wood products, and soil sinks results, bioenergy can substitute in the energy sector between 2.8–7 GtCO2 yr-1, providing some 130 EJ/y [*give range*] (*xxx confidence*). {7} *[This bullet could potentially be replaced with table]*

C.7.x Policy and project efforts have achieved mitigation of 0.7 Gt CO2 yr-1 in the last 12 years (medium confidence), however, to achieve warming of less than 1.5°C, global effort has to be increased 5-fold within the next decade, and more than 10-fold by 2050. Given the large total investment necessary to achieve this level of mitigation (>$500 billion yr-1), current institutional and policy constraints within and across countries, and critical, but unresolved, tradeoffs with other important ecosystem services, this level of abatement is unlikely to emerge (high confidence).

C.7.2 All options that involve land conversion increase the demand for land, with increasingly strong side effects as scale increases. Many of the forestry options, including avoided deforestation and reforestation, will have positive effects on many SDGs, although they may hinder food security if deployed at very large scale (high confidence). At very high ( >xx) deployment, BECCS leads to adverse side effects for adaptation, biodiversity, desertification, local communities, land degradation and food security (*medium confidence).* {7} At very large scale reforestation also has adverse effects on biophysics and at high latitude: albedo.

C.7.3 Around XX Gt CO2 yr-1 can be achieved through mitigation options that do not increase competition with other land uses (*medium confidence*). It is also possible to reduce agricultural land requirementsSustainable intensification , reduced food wastes and diet change can mitigate net emissions while also making land available for other uses In this way, a xxx share of the 7.2 million km2 required globally for agriculture can be allocated and applied to improved agriculture with less emissions, forest and other ecosystem restoration, climate-smart forestry, a wider range of nature based solutions and plantations providing biomass for bioenergy other biobased products while enhancing land sinks *(medium confidence*). {7}. Given the large demand for renewables in the future, an active management, maintaining carbon stocks on the land while continuously producing food, feed and renewable wood is a highly preferable approach as well as a necessity. This can go hand in hand with maintaining intact landscapes as well as restoring landscapes.

C.7.4 Land-based mitigation options have wider implications for other social and environmental goals and may thus have limitations to deploy these options. The implementation of mitigation options in the AFOLU is particularly challenging because of its decentralized nature and the distinct value systems associated with land tenure and management (millions of landowners under different cultural, economic, and political circumstances and unequal conditions for long-term planning). (*xxx confidence)* {7}

C.7.x Improved quantification of land-based mitigation activities in recent years has provided higher resolution about where which land-based activities can be implemented, what positive and negative interactions mitigation activities may have with other ecosystem services, and their potential costs. These data products and new technologies will allow a wider array of actors, including governments, NGOs individuals, and private businesses to take more meaningful actions in the future if financing is available (medium confidence).

**C.8 The scale and pace of urbanization around the world, and especially the construction of new cities, risks carbon lock-in but also carries the potential to build low-carbon cities by designs that are conducive to both low-carbon lifestyles and technologies. There are large emissions reduction potentials associated with existing urban settlements and scope for avoided emissions from new demands in yet to be built urban settlements. {8}**

**[CH LEAD: 8 & 9]**

C.8.1 Urban planning that creates compact, walkable neighbourhoods connected by transit, with associated price instruments can reduce urban energy use and GHG emissions by 25% in 2050, compared to the business as usual (BAU) pathways (*xxx confidence*). {5, 8, 10}

C.8.2 Building new cities under BAU could result in the annual resource requirements for raw materials of 90 billion tonnes per year by 2050, up from 40 billion tonnes in 2010. Cities that are more resource-efficient in transport, commercial buildings, and building heating/cooling could reduce between 36–54% of energy use, GHG emissions, metals, land and water use (*xxx confidence*).{8}

C.8.3 While stringent mitigation scenarios show declines in buildings sector emissions of more than 80% in 2100, emissions remain positive for all scenarios. By the end of the century, more than 50% of final energy demand in the buildings sector is met by electricity in the highest temperature category, and low emission scenarios show shares of electricity of around 80% (*xxx confidence*). {9}

C.8.4 Buildings are moving from a passive to an active role in the energy system, becoming decarbonised power generators that can contribute to the flexibility of the energy system. Full decarbonisation of the building sector requires sufficiency measures that include efficient technologies and lifestyle changes to limit the demand for energy services; efficiency measures to reduce the energy consumption; and on-site renewables to address the remaining energy demand (*xxx confidence*). {9}

C.8.5 Building carbon emissions related to energy consumption and embodied carbon in construction materials can be reduced through life cycle and circular economy perspectives including extending the lifetime of buildings and their components, reducing waste and eco-efficiency. Using bio-based/wood based materials and nature-based solutions are opportunities for carbon storage in buildings (*xxx confidence*). {9}

C.8.6 A large share of emissions in buildings is indirect. Even in a scenario where electricity generation is fully decarbonized, improving energy sufficiency and efficiency in buildings is key in reducing the transition costs and the pressure on the power system (*xxx confidence*). {9}

C 8.7 *[Existing cities and buildings – options for large-scale built up interconnected infrastructure that makes any single change challenging (such as building cycle lanes that need space used for car parking which challenges car-reliant residents, etc.)]*

**C.9 The transport sector remains a significant source of GHG emissions, even in stringent mitigation scenarios. Transport system mitigation relies on a combination of** **technology and infrastructure (fuels, vehicles, smart systems) and demand (urban form, pricing, behaviour). Decarbonization of the transport system includes technology innovations in four key areas – batteries, hydrogen fuel-cells, biofuels and advanced Internal Combustion Engines.** **Mitigation options for land-based transportation have advanced rapidly in comparison to options for shipping and aviation which remain at lower readiness levels (*xxx confidence*).**

**[CH LEAD: 10]**

C.9.1 In higher warming scenarios, transport sector CO2 emissions increase by 15–120% between 2010 and 2050. In stringent mitigation scenarios, CO2 emissions are reduced by as much as 95% in 2050 and nearly 100% in 2100 compared to 2010. *(xxx confidence)* {3, 10}

C.9.2 Mitigation options for heavy land transport (road and rail) include a combination of technologies and strategies that avoid transportation demand, increase in efficiency and switch to cleaner vehicles. Electro-mobility with new technology batteries and smart control systems in combination with zero carbon power is a key mitigation option for light-duty vehicles (cars, vans, light trucks) (*xxx confidence*). {10}

C.9.3 Increasing deployment would require integration with demand programs and infrastructure improvements including smart city programs to enable transit, active transport, local shared mobility and associated urban planning, with a growing element of digital communication replacing the need to travel (*xxx confidence*). {11} [*Text from X-Chapter Box (5,8,10) on Urban Form, Transport & Demand*]

C.9.4 Transformative pathways for aviation depend on demand reduction and the phase-out of fossil fuel usage by 2050. They rely on technologies for zero-C synthetic fuels produced using renewable energy, wider system promotion and renewable energy sources including bio-based low carbon fuels. Short haul aviation would also be potentially powered by all- or semi-electric propulsion systems. Shorter aviation trips will need to be shifted to high speed rail unless significant inroads in mitigation are underway by 2030 (*xxx confidence*). {11}

C.9.5 Mitigation options for the international shipping by optimizing hull design and vessel shape, efficient power and propulsion systems, and improved operations could decrease emissions by 15–40%. Switching to alternative fuels and energy sources, for e.g. switching to sustainable biofuels could reduce as much as 80% of CO2 emissions, though such numbers are associated with large uncertainties (*xxx confidence*). {10}

**C.10 Emissions from industry decline substantially in [*all?*] mitigation scenarios, with some scenarios showing net negative CO2 emissions by the end of the century. A transition of industry towards zero emissions requires action across the whole value chain and across the whole range of mitigation options. This includes demand management, materials efficiency, circular material flows, energy efficiency, direct or indirect electrification and fuel switching, carbon capture and use (CCU) and storage (CCS). (*high confidence*) {11}**

**[CH LEAD: 11]**

C.10.1The scenarios with the most stringent reductions in carbon intensity rely on electrification, with up to 82% of final energy produced from electricity in 2100. Many of these scenarios include CCS on industry or industrial processes, with a maximum of 4.8 GtCO2 yr-1 captured in 2100 (*xxx confidence*). {3.4}

C.10.2 Light industry and manufacturing can be largely decarbonized through fuel switching to low GHG electricity (including electrothermal or induction heating), heat pumps, waste heat use, and hydrogen as necessary (*xxx confidence*). {11}

C.10.3 Demand management, materials efficiency and circular material flows are options that reduce the demand for the primary emissions and resource intensive extraction and processing of feedstock to produce basic materials (e.g., steel, cement, aluminum, and plastics) (high confidence).

C.10.4 Demand management (i.e., lower demand for products and services) and material efficiency (i.e., providing products and services with less materials use) are mitigation options that reduce demand for basic materials but they are less explored and utilized than other options (high confidence).

C.10.5 Moving towards a circular economy can reduce CO2 emissions from major industry sectors (plastics, steel, aluminum and cement) by 40% globally which will require sustainably produced lignocellulosic and woody fibers. The implementation strategies to achieve a more circular economy are diverse across countries and spans from micro (such as consumer or company) to meso (eco-industrial parks) and macro (provinces, regions and cities) (*xxx confidence*). {11} (Earlier C10.3 in SPMv1)

C.10.6 With combinations of direct and indirect electrification, biofuels, CCU and CCS, to replace fossil fuel and feedstock industry can reach zero emissions and contribute to negative emissions. Indirect electrification can contribute substantially to power system balancing.

C.10.7 A transition of industry towards zero emissions requires electricity, gas, recycling, and other infrastructure as well as, for example, the phase-out of blast furnaces and conversion of petrochemical clusters that currently use fossil feedstock and fuels

C10.x Deep decarbonisation in industry may take longer than in other sectors, thus making the share of industry in global emission growing. So industrial sector which presently poorly addressed by mitigation policies becomes dominant emission driver even if goes toward zero emission, but slower comparing with other sectors. This bring ME at the forefront as an important mitigation strategy. For deep decarburization pathways technologies, which are presently only in early pilot stages have to become dominant by mid XXI century.

**C.11** **Carbon Dioxide Removal (CDR) is an essential element of most mitigation strategies to limit warming to 1.5°C–2°C by 2100 (*medium evidence, medium agreement*). CDR options vary in their mitigation potentials, technology readiness, co-benefits and trade-offs with other societal goals.** **The requirement for CDR deployment largely depends on the amount of mitigation achieved in the energy supply and demand sectors. {12}**

[**CH LEAD: 12]**

C.11.1 CDR can be used to offset residual GHG emissions that are hard to abate (e.g. from aviation or agriculture) in the context of reaching net zero greenhouse gas emissions. It is also necessary for returning from temporary overshoots of carbon budgets and temperature thresholds by providing net negative emissions on the global level. Modelled mitigation pathways that include CDR technologies can have higher levels of CO2 emissions in the short-term (2030–2040), but then requires a greater application of CDR in the medium-to-long term, in order to compensate for overshooting a given temperature target mid-century (*xxx confidence*). {3}

C.11.2 All Integrated assessment model scenarios (IAMs) use land-based CDR in the form of afforestation /reforestation in meeting low-temperature targets of 1.5–2.0°C *(high confidence)*. A limited number of scenarios use removals via technological means (BECCS, DACCS), with some studies indicating none being needed.

As a median value [*give interquartile range from AR6 database*] across the scenarios examined, required cumulative CDR reaches xxx GtCO2 over the 21st century, with annual volumes of up to 14.9 GtCO2 yr-1 for BECCS/DACCS and 2.4 GtCO2 yr-1 for afforestation in 2100 [*for x°C*]. Across the different scenarios median required increase in global forest area throughout the 21st century is 7.2 million km2 between 2010 and 2100, and up to 6.6 million km2 may be required for second generation bioenergy crop production in 2100. [*Provide interquartiles rather than median; or median ± some defined percentile*] (*xxx confidence*) {7}

C.11.3 [*Diversity of CDR options; technological potentials, Cost of land based CDR, what this depends on, regional differences {12}*]

Reforestation and nature-based solutions are not taken up in IAMs in all their diversity. However, they can be deployed regionally diverse, adapted to local needs and local possibilities in line with other SDGs.

C.11.4 [*Bullet/s on non-land/novel based CDR: technological readiness, land requirement, cost, quantifiable risks {12}]*

**C.12 *[Potential HS on systems perspective – emphasizing the interactions between sectors to achieve sustained and deep net reduction.*** *Examples could include food system, competition for resources, interactions between battery technology in vehicles and low-carbon energy (not just for recharging but also manufacture; LCA perspectives to inform bioenergy assessments etc.)]*

**[CH LEAD: 12]**

C.12.1 [*xxx*] Industry transitions entail new or stronger sectoral couplings between industry and other sectors, as well as between industrial sub-sectors. Material demand for stock building in other sectors, electrification, hydrogen, and CCU or sourcing of biogenic carbon for producing organic chemicals and materials are strong drivers of such new couplings.

C12.2 The cross-sectoral coordination of targets, strategies, measures and policies helps to minimise trade-offs and increase synergies {12}. Collaboration across value chains enables efficient service provision and circular solutions {11}. Policy sequencing, and policy portfolios and packages can deliver cross-cutting and system-wide benefits {5}. {13} {9} (*xxx* *confidence*) [*Elaborate – lessons learnt in practical terms, what persistent barriers have been, how to overcome barriers] (*Earlier E2.7 *in SPM v1)*

Section D: Mitigation, adaptation, and sustainable development

***INTERNAL note on scope of section***

*The actions and system transitions identified in Section C are intrinsically linked to the achievement of the 17 Sustainable Development Goals and adaptation to a changing physical climate. There are both synergies and trade-offs between mitigation actions and sustainable development.*

This section should provide empirical information on how the pathways and actions identified in Section C interact with adaptation and sustainable development (e.g., through the 17 SDGs). This is the place to identify synergies/trade-offs, costs/benefits etc. Since ‘just transition’ is closely related to SDG 8 this could be the place to locate it. This material is light at the moment and needs much more brought forward from the chapters. Chapters 3, 4, all the sectoral chapters and Chapters 13, 15 16 and 17, all have both links to adaptation and links to sustainable development within their scope.

**D.1 The way countries develop determines the scope for meeting mitigation and multiple development objectives simultaneously (*medium/high evidence, medium agreement*). Approaches targeting more sustainable outcomes open up a wider range of options and enables more effective implementation (*xxx confidence*). {4}**

**[CH LEAD: 4 & 1]**

D.1.1 Development pathways are formulated in response to national priorities and reflect a variety of framings and perspectives, such as economic growth, social wellbeing, shifts in industrial structure, technological innovations and sustainable development. Pathways in which policies are designed to reach multiple sustainable development objectives entail limited additional costs compared to the increased benefits. *(xxx confidence)* {4}

D.1.2 Influencing a societies’ development pathways is possible and draws upon a broader range of policies and actions beyond narrowly influencing mitigation pathways, to be able to achieve the multiple objectives of reducing poverty, inequality and GHG emissions, whilst also opening up broader opportunities for mitigation (*xxx confidence*). {4}

D1.x Enabling conditions in a wide range of areas need to come together in a co-evolutionary process to shift development pathways that could scale and accelerate transformative mitigation consistent with 2°C-1.5°C pathways and broader sustainable development goals (medium evidence, high agreement). High-level conditions that support shifting development pathways to achieve both mitigation and adaptation goals include higher levels of innovation, multilevel governance, transformative policy regimes, enhanced institutional capacities, scaled redeployment of finance and profound behavioural transformation. [4.4.2, and adaptation subsection]”

D.1.3 The achievement of climate and sustainable development goals will be facilitated if adverse or unanticipated consequences of technological transitions, such as rebound effects and livelihood loss, are taken into account. (*xxx* *confidence*) {16}

**D.2 Integrated approaches to adaptation and mitigation planning and implementation lead to more efficient and cost-effective policies provided unintended trade-offs between these are identified and addressed before implementation {13}. Synergies exist in relation to agriculture, human settlements, blue carbon, water, energy and ecosystems (*medium confidence*)** **{13}. Pathways in which policies are designed to reach multiple sustainable development objectives entail limited additional costs compared to the increased benefits {17}.**

**[CH LEAD: 17]**

D.2.1 Developing countries are more likely to suffer from an ‘adaptation deficit’ – when a country is unable to respond to the current impacts of climate variability – and therefore climate adaptation and mitigation need to be considered in the context of broader political, economic and development goals. (*xxx confidence)* {13}

D.2.2 In cities technologies such as green roofs and green facades, networks of parks and open spaces, protection of urban nature (e.g., forests and wetlands), urban agriculture, and water-sensitive design offer a wide range of adaptation co-benefits including flood mitigation, reduced pressure on urban sewer system, reduced urban heat island effects, and public health co-benefits. (*xxx confidence)* {8}

D.2.3 Restoration of mangroves and coastal wetlands increases carbon sinks, reduces coastal erosion and protects from storm surges, and otherwise mitigates impacts of sea level rise and extreme weather along the coastline (*xxx confidence*). {4}

D.2.4 Many land-related responses that contribute to climate change mitigation can simultaneously contribute to adaptation and combatting desertification and land degradation, enhance food security through increases in yields, and improve resilience by maintaining the productivity of the land. Careful integration of mitigation options with existing land uses helps to minimise trade-offs and maximise synergies (*medium evidence, high agreement*) {12}. Mixed crop-livestock systems can avoid deforestation on 76 million ha globally, while reducing the costs of adaptation in agriculture by 0.3% of total production costs *(xxx confidence)*. {4} *[Elaborate – at the moment it is repetition of SRCCL]*

D.2.5 *[Other specific examples and actions that are feasible, include quantification where possible. Consider explicit recognition of barriers and interdependencies – e.g “doing X is much more difficult if development relies on Y” ; how much more difficult?]*

D.2.6 Economic benefits of avoiding climate impacts increase with the stringency of the mitigation goal. The economic benefits and costs associated with mitigation co-benefits and trade-offs can be of the same order of magnitude as direct mitigation costs and benefits (*xxx confidence)*. {3}

D 2.x Climate change may have important implications for the energy system, particularly in countries reliant on hydropower and bioenergy.Research is increasingly demonstrating that climate will influence both energy supplies and demands. Most notably, climate projections suggest 5–20% increases in gross hydropower potential in high latitudes and 5–20% decreases in other areas connected with increased drought. Climate change will also increase cooling and reduce heating demands, and could increase the vulnerability of the power system. Incorporating these potential impacts into mitigation planning can alleviate potential future challenges. {6}

**D.3 Mitigation options are linked to Sustainable Development Goals (SDGs) in multiple ways, some synergistic and some in conflict with these goals. These are context specific, depend on the timing of mitigation actions, policy design and effectiveness. Many adverse linkages can be compensated or avoided with complementary policies and investments (*xxx confidence*).** **{7, 11}**

**[CH LEAD: 17]**

D.3.1 Co-benefits and trade-offs could result directly from mitigation action in a given sector or indirectly from the mitigation actions in other sectors {12}. Potential trade-offs between mitigation measures and sustainable development exist in areas such as employment, food deprivation, water stress, local building materials and energy access/affordability can be compensated or avoided with additional complementary policies and investments. (*xxx confidence*) {3} *[Include potential co-benefits to balance the statement]*

D.3.2 Achieving net-zero carbon emissions, and the timing of this achievement, can have implications in the short- and long-term. Ambitious mitigation can be considered a precondition for achieving the SDGs, especially for vulnerable populations and ecosystems, with little capacity to adapt to climate impacts. *(xxx confidence)* {3.7}

D.3.3 Land use mitigation is a least cost- or cost-effective option to address the adverse impacts of climate change and can promote conservation of biodiversity and ecosystem services, human well-being and sustainable development. {7}

D.3.4 Dietary choices play an important role in determining human health, food system emissions and land requirements, which has implications for other mitigation options that require land (including afforestation/reforestation, biomass plantations, solar farms) (*xxx confidence*). {12}

D.3.5 Sustainable transport offers considerable benefits in terms of air quality, health, improving access to education & financial services, promoting gender equality and increasing agricultural productivity. *(xxx confidence)* {10}

D.3.6 Mitigation options in industry such as demand management, materials efficiency, circular material flows, and energy efficiency have co-benefits with many SDGs. Other options, such as CCS and electrification, mainly benefit climate mitigation. (*xxx confidence)* {11}

Placeholder for bullet on energy system approaches, including energy supply options, and their linkages to sustainable development goals. {6}

D.3.7 Mitigation actions in the building sector contribute to achieving almost all SDGs, generating significant multiple benefits, the value of which are equal or greater than the value of energy savings (*xxx confidence*). *[More detail needed on which SDGs and what the co-benefits or trade-offs are]* {9}

D.3.8 Increasing welfare and meeting SDG implies an increase in demand for materials, products and services. Decent living standards, encompassing many SDG dimensions, are achievable at lower energy use than previously thought. Meeting demands for renewable materials and products and access to services has positive impacts on human wellbeing and participation in mitigative action {5,11}. Mitigation strategies which focus on low-energy and land- based resources have overall lower trade-offs and negative consequences on sustainable development than pathways involving either high emissions and impacts, and those involving high consumption and high quantities of CDR. (*xxx confidence)* {X}

**D.4 Transitions pathways depend on resource endowments, equity considerations, existing development patterns, the speed of action, and context-specific issues that may enable or act as a barrier to transitions {17}. The distribution of economic implications of mitigation may imply large employment and economic structural changes, stranded assets and raises multiple types of distributional concerns *(xxx confidence)*. Perceptions of equity enable broader consensus for the transformational change implied by deeper mitigation efforts. {4}**

**[CH LEAD: 4]**

D4.x Climate mitigation is one of many goals that societies pursue in the context of sustainable development, as underlined by range of UN Sustainable Development Goals and more recently the COVID-19 pandemic. Countries have different priorities in achieving the SDGs as dictated by their respective national conditions and capabilities. Given the differences in historical and current responsibilities, impacts, as well as capacities within and between nations, equity and justice are important issues to address to get national and international support for deep decarbonization; failures to address such inequities over time undermine social cohesion and stability. International co-operation can enhance efforts to achieve ambitious global climate mitigation in the context of sustainable development. {1}

D.4.1 Meeting the Paris Agreement goals implies a reduction in the demand and value of fossil fuels, affecting industries, individuals, and societies that dependent on fossil revenues and fossil-related jobs. Fossil resources left in the ground will be substantially less valuable. Many new investments in fossil infrastructure, particularly coal generation, without CCUS, natural gas generation and refining are at risk of being ‘stranded’ or retired early. (*xxx confidence*) {17, 6}

D.4.2 A just transition to the workforce is possible with estimates showing larger employment opportunities associated with cleaner forms of energy {6}. Approaches to ameliorate the employment and other adjustments would accompany these near-term reductions. (*xxx confidence*)

D.4.3 The equity consequences of mitigation activities depend on how costs and benefits are initially incurred and how they are shared as per social contracts, national policy, and international agreements {4}. Lack of integration of environmental justice including inclusive participation and distribution of institutional capacities in climate mitigation activities pose a risk for growing inequality effects at all levels (*xxx confidence*). {13}

D.4.4 Design of mitigation policies is critical for more equitable distributional impacts (*high confidence*). {4} [*Elaborate on factors that contribute to equitable distributional impacts*]

D4.x Literature suggests a relation between the effectiveness of cooperative action and the perception of fairness of such arrangements, in that this enables broader consensus for the transformational change implied by deeper mitigation efforts. Hence, equity is an ethical imperative, but it is also instrumentally important. [4.4.5]

[Ch11 now has “phase-out” in section C10. It could also be placed here.]

Section E: Strengthening the response

***INTERNAL note on scope of section***

*The take-up of actions identified in Section C depends on the introduction of enabling institutional frameworks and policies at the international, national and sub-national level. These help to determine the feasibility of achieving ambitious limits to global warming. Well-designed institutions and policies can also enable the realisation of synergies with adaptation and sustainable development identified in Section D and help to avoid unnecessary trade-offs. Policies should also enable the engagement of business, finance and civil society whose role in climate change mitigation is indispensable.*

Section E concerns the actions and enabling conditions that will enable the actions identified in Section C from a techno-economic perspective to be taken up and the synergies in Section D to be exploited (and conversely the trade-offs to be minimised). The focus is on policies, institutions and related factors. Many of the statements here are bland in character and could do with sharpening up and specificity.The headline statements here draw largely on the cross-cutting chapters covering: social and institutional conditions; policies; international cooperation; finance and technology; and international cooperation. A Headline Statement covering feasibility is also included.

**E.1 Transformations will require major institutional, societal and technological changes. Governing for climate mitigation and shifting development pathways requires enhanced governance systems at all scales that enable strategic direction, coordination and engagement with a broad set of actors. Enabling system transformations to accelerate climate mitigation and sustainable development pathways requires attention to integrated policy responses, the presence of enabling conditions and attention to mitigation and adaptation synergies. Politics, culture, and economy play an important role in enabling and constraining aggressive mitigation action. {6} {10}. Reconfiguring the way services are provided while simultaneously changing social norms and preferences will help reduce emissions and improve accessibility {5}.** **(*xxx* *confidence*)**

**[CH LEAD: 5]**

E.1.1 The viable speed and scope of system change will depend on how well such change can support broader societal objectives and garner societal support {6}. Collective action by dedicated groups or communities can drive and resist policy change {5}. Public support is shaped by individual behavioural factors, and can be broadened through the potential for organised civic engagement, opportunities to utilise institutional channels such as the courts for civil action, and through the media {13}. (*xxx* *confidence*) Building broader public support for action on climate mitigation and shifting development pathways is shaped by individual attributes, the potential for organised civic engagement, the role of the media, and the opportunities to utilise other institutional channels like courts for civil action. Ensuring that mitigation and development actions are consistent with perceptions of justice and equity are also salient to building broad support for accelerated action.

E.1.2Ensuring mitigation and development actions are consistent with perceptions of justice, equity and fairness (procedural and in outcomes) can build public support for accelerated action {13}. Co-aligning wellbeing outcomes into mitigation policies increases inclusiveness and social trust, which in turn betters the quality of governance and the effectiveness of mitigation policies {5}. (*xxx* *confidence*)

E.1.3 Demand-side mitigation is about more than behaviour change but critically also involves socio-cultural, corporate, institutional, and technological forces. As societies work their way through the interplay of changes in individual agency and in the social and physical context of demand-side decisions, social practice and their consequences change *(high evidence, high agreement*).

E.1.4 Transformative demand-side changes can leverage emerging megatrends in the domains of digitalization, the sharing and the circular economy. They also require novel policy paradigms and governance to avoid potential demand growth through rebound or induced demand effects and enable demand reduction. Transformative changes require involvement of business, consumer and technological innovation accompanying or preceding national policies. Public participation fosters and underpins demand-side mitigation measures. Empowering women accelerates both mitigation and adaptation; women prioritize addressing climate change in their voting, purchasing, community leadership, and work both professionally and at home. Increasing voice and agency for those marginalized in intersectional ways by race, ethnicity, and other factors has similar effects *(High evidence, very high agreement)* {5.2}. Climate friendly choice architecture in the form of smart defaults, the salient positioning of green options, forms of framing, communication of social norms, and more can promote ASI changes [*medium evidence, medium agreement]*{5.4, 5.5}

**E.2 Policies (along with other enabling conditions) can shift development pathways, directly advance development goals, increase resources to meet goals, reduce emissions, and reduce negative distributional impacts {4}. Effective institutions support the acceleration of climate mitigation efforts {13}. (*xxx* *confidence*)**

**[CH LEAD: 13 ]**

E2.x Though development pathways result from the actions of a wide range of actors, it is possible to shift development pathways through policies and enhancing enabling conditions (*limited evidence, medium agreement*). [4.3.1.2] Influencing a societies’ development pathways draws upon a broader range of policies and other efforts than narrowly influencing mitigation pathways, to be able to achieve the multiple objectives of reducing poverty, inequality and GHG emissions, whilst also opening up broader opportunities for mitigation. {4}”

E2.x Nationally appropriate policy frameworks for mitigation and shifting development pathways should draw on a wide range of economy-wide and sectoral policy instruments, including carbon pricing, direct regulation and information and voluntary approaches. The literature increasingly emphasizes attention to assessing the impact of these policies across multiple criteria and how these policies can work together as packages and coordinated across sectors toward a strategic direction, with attention to their overlapping effects and their spillover effects on other jurisdictions

E.2.1Mitigationpolicies can be evaluated along multiple criteria, including environmental effectiveness, economic effectiveness, transformational potential, co-benefits and trade-offs with other objectives, and administrative requirements. Policy instruments differ in their economic effects, their stringency and their potential to achieve transformative change, as well as their impacts on income distribution. Instruments also differ on whether and how they achieve other policy objectives. (*xxx* *confidence*) {13, 14, 16}

E.2.2Emission pricing and market-based instruments have been shown empirically to be effective in reducing emissions. (*xxx* *confidence*) {13} *[Can be more specific. Can link to next suggested bullet - to what extent and under what conditions are pricing and regulatory policies advancing development goals*

E.2.3 Regulatory instruments play an important role in climate change mitigation [*Effectiveness of* *regulatory instruments and lessons learnt about complementarity with price-based measures. Cross-cutting climate strategies]* {13}{16, on tech and performance standards}

E.2.4Legislation, strategies and dedicated administrative organisations enable strategic action toward lower carbon and more sustainable pathways. Key roles of institutions include horizontal coordination across administrative units to ensure multiple objective are met, as well as vertical coordination across scales of action. (*xxx* *confidence*) {13} *[Elaborate on what makes institutions effective]*

E.2.5 Sub-national and urban actors are playing a growing role in climate governance by ensuring that local concerns are factored into decision-making and that implementation is tailored to local contexts. Sub-national action lead to experimentation, policy innovation, and establishment of new norms of action. However, the extent of these outcomes varies widely and the scope is uneven, with fewer initiatives in developing countries. (*xxx* *confidence*) {13} {8} {14}

E.2.6Governance for climate development outcomes is more effective when tailored to national contexts and circumstances, given different material endowments, national political systems, and culture and administrative traditions {13}. The effectiveness of governance is enhanced when it takes into account the different actors such as business, civil society, indigenous communities and political actors {13} {5}. (*xxx* *confidence*) [*Elaborate – lessons learnt in practical terms, what persistent barriers have been, how to overcome barriers]*

**E.3 Achieving climate and sustainable development objectives within the next [two to three] decades will rely on significantly strengthening the role of the financial sector and relevant innovation systems (*xxx* *confidence* ). {15, 16}**

**[CH LEAD: 15 and 16]**

E.3.1 Government policy and regulation can shift financial flows to heavily regulated sectors, where a significant share of financing needs exists (*xxx* *confidence*). {15} *[Elaborate on what kinds of policy and regulation would shift flows]*

E.3.2 Political leadership and intervention can strengthen the role of the financial sector, by providing signals, addressing political uncertainty, and to tackle the lack of public commitment to support transparent public finance, and policies and regulations. Central banks and financial supervisors have a role in fostering the assessment of climate-related financial risk by financial actors. (*xxx* *confidence*) {15}

E.3.3 Risk management strategies can maintain financial and economic stability, manage climate impacts, and close the climate finance gap. Transparency gaps and inertia need to be addressed to facilitate the implementation of robust risk management in financial and governmental institutions. A larger integration of climate scenarios in risk management can increase transparency regarding risks. New financing instruments, labelling schemes, and regulatory focus on transparency could also help shift inertia. (*xxx* *confidence*) {15} *[Elaborate and provide examples – what do risk management strategies look like? What are the barriers and how to overcome these?]*

E.3.4 [*Role of private vs public sector financing]*

E.3.5 *[More concrete information on e.g., how to raise the financing needed, differentiating financing (i.e., new money to address climate change) compared to redirecting financial flows]*

E.3.6 Greater investments in innovation, including research, development and demonstration (RD&D), market creation and diffusion, can strengthen the innovation system. Innovation systems can also be strengthened through enhancing the capacity of all innovation and societal actors, and improved institutional and governance arrangements. (*xxx* *confidence*) {16} *[More specific examples needed of successful innovation investments, collaboration models, examples of synergistic policies – also links to the next bullet]*

E.3.7 Holistic perspectives for innovation processes include policy portfolios that encompass technology-push and market-pull policies, overcoming other barriers in various stages of technology development and deployment, and tailoring policies based on local priorities and context. (*xxx* *confidence*) *[Elaborate with concrete ways to strengthen innovation systems – where to focus attention – what actors (including governments) can do to support innovation]* {16}

E.3.8 A transition in industry towards zero emissions is technically possible and economically affordable, the global scale but factors such as low profit margins in bulk commodity markets or capital intensity present challenges especially within some regions. Early action is important to prevent lock-in situations due to long investment cycles and equipment lifetimes. (*xxx* *confidence*){11}

**E.4 International cooperation is critically important to enable and strengthen national and sub-national action, at multiple levels and involving diverse actors.(*xxx* *confidence*) {14}**

**[CH LEAD: 14]**

E.4.1 International organizations contribute to the increased political attention to climate change and influence the adoption of climate mitigation policies, especially in developing countries.International cooperation increases the capacity of countries to contribute to the long-term goals of the Paris Agreement in the context of equity and sustainable development. It is a pre-requisite for the fulfilment of many national mitigation actions, especially those NDCs conditional on the provision of international support, and a driver of enhanced national ambition. (*xxx* *confidence*) {14}

E.4.2International cooperation in technology development and transfer can support developing countries in meeting their climate and development needs. The way such arrangements are developed and implemented determines their effectiveness. (*xxx* *confidence*). {16} *[Elaborate on what arrangements work to stimulate tech development and transfer]*

International cooperation is often related to land use sector ; to fulfill basic needs as clean and healthy water and food, xxxxxx

Here we could note the lack of international cooperation to decarbonize the emissions intensive industries. It can also go under B6.

E.4.3 The Paris Agreement strengthened the monitoring and transparency of national action in relation to mitigation and the provision of support, in particular by requiring states to provide detailed information, in line with the 2018 Paris Rulebook, while submitting their NDCs, as well as to demonstrate that they are on track to achieving their NDCs. This significant increase in the frequency, level of detail and scope of coverage of national reports enables adequacy assessments and comparisons by a diverse set of actors at multiple levels, thus creating a pull towards greater ambition.

E.4.4 Sectoral agreements, including trade agreements, have influenced climate mitigation efforts. This influence, however, has been mixed. Some agreements and institutions have focused on reducing emissions and pushing sectors into a low-carbon development pathway. The International Renewable Energy Agency, for example, has led to an increase in capacity for expanding low-carbon energy supplies. Other agreements and institutions, particularly in the trade and investment area, however, have reinforced the prominence of fossil fuels within particular sectors. The promise of REDD+ to institute reductions in emissions from deforestation has not been widely realized at national scale, although some smaller-scale efforts have achieved success. 

E.4.5 *[Statement on emission leakage, spillover effects]* {12}

**E.5 Stringent mitigation pathways are associated with rapid and unprecedented transformations that may raise feasibility challenges if not manage appropriately. (*xxx* c*onfidence*) {3}**

**[CH LEAD: 16]**

E.5.1 The speed, direction and depth of these transformations and transition are influenced by geophysical, environmental, technological, economic, socio-cultural and institutional constraints. (*xxx* *confidence*) {1}

E.5.2 The acceleration and the speed, scale and quality of the transition depends on the enabling environment {13, 17}. Enabling conditions include multi-level governance, institutional capacities, behavioural and lifestyles, technological innovation, policy, and financial systems {13}. Different pathways may be associated with different feasibility challenges. Feasibility of the pathways strongly depends on the regional context. Different enabling factors can reduce or avoid specific feasibility concerns and achieve broader sustainable development goals (*xxx* *confidence*) {3} {4}.

E.5.3 *[Feasibility assessment – including empirical content. Specify what system-level feasibility conditions are in place]*

High Level Messages received from Chapters (Pasted as received)

Chapter 1 Headline Statements. 29 June 2020

* **Current GHG emission trends at the global level are still incompatible with the goals agreed in the Paris Agreement, which highlight the need for urgent and accelerated mitigation actions at all scales.** Since the AR5, important changes include the greater global ambition established in the Paris Agreement of 2015, alongside rising climate impacts and levels of social concern. However, while the Nationally Determined Contributions (NDCs) are an important step, the gap between realized emissions, the NDCs, and emissions pathways consistent with meeting Paris goals remains large. Meeting Paris goals requires emissions to peak and decline to zero or below. Continuing investment in carbon-intensive activities risks assets being stranded, and impeding the development of low carbon sectors and infrastructure. With all sectors’ emissions needing to reach net zero to stabilise the atmosphere, the window is closing.
* **Mitigation needs to be addressed in the context of sustainable development enshrined in 17 SDGs, recognizing there are synergies and/or trade-offs**. Climate mitigation is one of many goals that societies pursue in the context of sustainable development, as underlined by range of UN Sustainable Development Goals and more recently the COVID-19 pandemic. Countries have different priorities in achieving the SDGs as dictated by their respective national conditions and capabilities. Given the differences in historical and current responsibilities, impacts, as well as capacities within and between nations, equity and justice are important issues to address to get national and international support for deep decarbonization; failures to address such inequities over time undermine social cohesion and stability. International co-operation can enhance efforts to achieve ambitious global climate mitigation in the context of sustainable development.
* **Advances in technologies and policies, including transformative changes in some regions and sectors, has opened up new and large-scale opportunities for deep decarbonization, and for alternative development pathways, which could deliver multiple social and developmental goals.** The developmentand deployment of innovative technologies and systems at scale is key for achieving deep decarbonization in a politically, economically and socially acceptable manner. In recent years, several clean energy technologies have expanded rapidly and declined in costs, and significant numbers of countries have sustained emission reductions. The understanding and scope of options – in technologies, policies and behavior - has thus increased. The falling cost of some low carbon technologies enhances opportunities for mitigation, but extremely low fossil fuel prices, combined with institutional and political inertia, could pose challenges.
* **The speed, direction and depth of transition will be determined by choices in geophysical, environmental, technological, economic, socio-cultural and institutional realms.** Transitions typically are not smooth and gradual. They can be sudden and disruptive. The spread of new technologies and ideas and behavioural changes can start slowly, then diffuse rapidly. The pace of transition can be impeded by ‘lock-in’ from existing physical capital, institutions, and social norms. The interaction between power, politics and economy is central in explaining why broad commitment does not always translate to urgent action. At the same time, attention to and support for climate policies and low carbon societal transition has generally increased. Supporting policies in the realms of finance, regulation, institutions and societal norms are essential to accelerate low carbon transitions in multiple sectors, whilst addressing distributional concerns endemic to any major transformation. Given the trends since AR5 in technology and society, such policies could deliver the Paris goals. *[Last sentence to be discussed at cross-chapter SPM level and drawing on Feasibility section/assessment:]*
* **Overcoming the obstacles will require broadened assessment frameworks which combine multiple perspectives, applied in a context of multi-level governance.** Appropriate frameworks are needed to weigh the choices available, both in aggregate and taking account of strong sectoral and regional differences, and include equity and governance on appropriate scales. Frameworks describing technological, structural and behavioural changes in production and consumption and their carbon footprints are useful to analyse and address the implications of choices. Practical approaches to policy evaluation could usefully combine modeling at various scales with ethical and transitions analysis, through processes of aligning problem formulation, bridging of data and metrics, and iterative interactions between the different approaches.

Key High Level[[4]](#footnote-5) Messages from Chapter 5 for SPM

### ***1. Mitigation and Sustainable Development***

**The core of sustainable development is providing equitable access to services for human wellbeing, while increasingly minimizing resource inputs and environmental and social harm *(Very high evidence, very high agreement)* {5.1}. Sustainable development is not possible without changes in consumption patterns under the widely recognized constraints of planetary boundaries, resource availability, and the need to close development gaps.** People demand services for dignified survival, sustenance, mobility, communication, comfort and material wellbeing.

**Demand and provision of services that contribute to human wellbeing is fundamental, but not per se the provision of the physical resources (biomass, energy, materials, etc.) and technologies (e.g. cars, appliances).** Services are provided in culturally-appropriate ways, allowing for more flexibility in solutions than by treating energy demand alone.

**The greatest potential for mitigation lies in the efficient use of resources and low-carbon energy to satisfy basic needs; and in providing novel or alternative low-energy service provisioning systems for those with high energy demand while maintaining or improving wellbeing. Decent Living Standards indicators are tools to clarify this distinction. *(medium evidence, high agreement)* {5.2}**

**Mitigation, equity and wellbeing go hand in hand. Measures that build wellbeing and social trust strengthen governance and enhance mitigation. *(High evidence, high agreement) {5.1}.*** Demand-side measures are the single most important generic mitigation option as they cut across all sectors and can bring multiple benefits. One of the necessary conditions for acceleration in mitigation through demand side measures is wide participation and social trust.

### ***2. Trends and Scenarios***

Over the past decades the decoupling of energy use from economic growth (energy intensity improvements, i.e. demand-side developments) has contributed more to climate mitigation than supply side changes (decarbonization). **Despite some notable successes, demand-side mitigation options remain underrepresented in current policies and climate mitigation scenarios. {5.3}**

Current efforts **focus on** **incremental improvements in energy efficiency, ignoring the vast potentials of more radical shifts in service provisioning systems via structural change (e.g. moving to more public transport including shared mobility) or in avoiding unproductive activities altogether (e.g. teleworking avoiding commuting travel) {5.3}.**

**Demand-side policy success stories have been demonstrated in multiple service categories and in many countries**, {5.3} ranging from the diffusion of LED light bulbs in India (drastically improving the efficiency of lighting), the establishment of high-speed railway networks in China (shifting long-distance travel away from aircraft), the diffusion of super-efficient building designs with onsite renewable energy in Europe (avoiding heating/cooling energy inputs and shifting to distributed renewable generation) or the rapid uptake of teleworking options avoiding work-related travel in many countries under covid-19 induced confinement. Other trends, such as rapid growth in aviation and demand for digital services have potentials to negate technology-specific efficiency gains. {5.3)} A decline in unhealthy red meat consumption in some countries is balanced by an uptake of dairy products in other countries.

**Recent scenarios suggest that equitable provision of services is possible while at the same time reducing absolute energy, materials, and resource use (of up to 40 percent below current levels globally by 2050, or about two thirds compared to current trend scenarios by 2050).{5.3}**

### ***3. System Transformations to Limit Global Warming***

**Demand-side measures are the single most important generic mitigation options as they cut across all sectors and can bring multiple co-benefits.** Just as the extent of climate change is critically determined by the level of GHG emissions, the extent and feasibility of the climate mitigation challenge is critically determined by the scale of the energy, biomass, and raw materials demand: the larger the resource demand, the higher the mitigation challenge and required transformation of supply and distribution systems towards zero emissions.

**Demand-side policy approaches are thus also a critical component of supply side transformations as they reduce the need for supply-side zero-emission and negative emission technology transitions and associated costs.**

**Transformative demand-side changes can leverage emerging megatrends in the domains of digitalization, the sharing and the circular economy. They also require novel policy paradigms and governance to avoid potential demand growth through rebound or induced demand effects and enable demand reduction**.

**Ranking of mitigation potentials by activity or sector can be misleading due to the important sectoral and activity interdependencies**, but illustrative scenarios suggest that in order to reach net zero emissions globally by 2050 the largest potentials are in buildings (and associated upstream energy supply systems), novel shared mobility concepts in urban settings (and associated impacts on energy supply and the manufacturing sectors), dietary shifts, materials efficiency and recycling (and associated impacts on materials production, manufacturing, and goods transport) as well as in the digitalization of physical, analogue service provisioning systems. In such transformative changes both potential positive (cross-sector synergies) as well as negative (e.g. take-back) spillover effects will need careful monitoring and policy attention.

**Transformative changes require involvement of business, consumer and technological innovation accompanying or preceding national policies.**

### ***4. Opportunities and Challenges***

**Technologies, access and service equity factors sometimes change rapidly (medium evidence, *high agreement.* {5.2}.**

**Lack of access to services has detrimental impacts on human wellbeing and participation in mitigative action.** Required service levels for decent standards of living are increasingly quantified and can serve as reference points for integrative development strategies to meet sustainable development goals. **Higher levels of service consumption have diminishing returns for human wellbeing and turn into negative wellbeing impacts due to social and environmental externalities. {5.2}**

Changing social norms and preferences and reconfiguring the way services are provided helps to reduce emissions and improve service accessibility, e.g. by urban planning and building design. Digitalization has the potential to accelerate consumption of goods and services, with potentially harmful effects on wellbeing and GHG emissions. However, good governance of digitalization and limiting resource-intensive consumption leverages demand-side emission reductions. The governance of digitalization is relevant for social trust, well-being and direct and indirect implications for climate change mitigation.

Demand side solutions require both the motivation to change and the capacity for change, in the form of availability of and knowledge about novel options and the cognitive and material resources and skills to consider, initiate and maintain change. Capacity needs to be facilitated before increased motivation can be effective [*very high evidence, very high agreement*]. {5.4}

### ***5. Enabling system transformations***

**Transformative changes in demand-side climate mitigation call for new integrative policy perspectives and approaches away from isolated, sectoral approaches towards more strategic policy sequencing and policy portfolios and packages to deliver cross-cutting and system-wide benefits.** They also require the integration and coordination of actors, incentives, and policy frameworks to a much higher degree than has been traditionally the case and constitute another area for potential innovations. **Considerations of procedural fairness and fairness in access to basic services and actor participation are the key in crafting successful integrative policy packages.**

**Public participation fosters and underpins demand-side mitigation measures. Empowering women accelerates both mitigation and adaptation; women prioritize addressing climate change in their voting, purchasing, community leadership, and work both professionally and at home. Increasing voice and agency for those marginalized in intersectional ways by race, ethnicity, and other factors has similar effects *(High evidence, very high agreement)* {5.2}**

**Collective action by dedicated groups or communities drives policy change. {5.4}** ‘Green defaults’ are useful policy instruments, but require also support by incentives, regulations and the provision of adequate infrastructures for all.

**Co-aligning wellbeing outcomes with demand side mitigation policies increases inclusiveness and social trust, which in turn betters the quality of governance and the effectiveness of mitigation policies. There are well-documented synergies and positive feedbacks among equity, wellbeing for all, social trust, effective governance, participation, and well-designed climate policies which reduce emissions while contributing to equity and wellbeing.**

**Demand-side mitigation is about more than behaviour change but critically also involves socio-cultural, corporate, institutional, and technological forces. As societies work their way through the interplay of changes in individual agency and in the social and physical context of demand-side decisions, social practice and their consequences change *[high evidence, high agreement*].**

**Thus demand-side mitigation policies need to strategically combine economic, legal, and behavioural policy tools targeted at different actors *[very high evidence, very high agreement] {5.4}.*** Motivation to change to low-carbon sources of energy (Shift) or energy efficient devices (Improve) or to reduce energy use (Avoid) is triggered by different considerations in different demographics (age, education, financial status) and geographies (developed and developing countries). ASI changes in behavior vary in difficulty. Behaviorally easy Improve changes (e.g., purchase of energy efficient appliances) are more frequently seen, harder Avoid and Shift changes are infrequent, but appear when habits are reset (e.g., from commuting to home office), as experienced during the COVID-19 pandemic. Harder decisions can be facilitated by choice architecture interventions and changes in the physical, social, and economic infrastructure that can guide or nudge towards change.

**Climate friendly choice architecture in the form of smart defaults, the salient positioning of green options, forms of framing, communication of social norms, and more can promote ASI changes [*medium evidence, medium agreement]*{5.4, 5.5}** There is no neutral way to present energy-use related decisions, as every presentation format influences choice. Educating individuals, households, and policy makers about the effectiveness of choice architecture interventions and adding these behavioral tools to the existing market- and regulation-based tools in a transparent and consultative way can guide communities to desired outcomes with increased effectiveness, while avoiding charges of manipulation or deception.

**Climate Justice is crucial for mitigation. (*High evidence, very high agreement*). {5.2}**

Chapter 14 – For Section B6 and Section E4

**B.6 The role of international cooperation has changed, but not diminished, since AR5. There has been a shift from multilateral standard setting and enforcement to enabling and strengthening national action and regional cooperation (*high agreement, robust evidence*).**

B.6.1 The 1997 Kyoto Protocol was a milestone in international cooperation on climate mitigation, but also had important limitations. The Kyoto Protocol achieved high levels of compliance in its first commitment period, and was instrumental in developing capacity to account for and report on GHGs, as well as to support international carbon markets and voluntary cooperative mechanisms. The Clean Development Mechanism and Joint Implementation had positive effects, yet also failed to achieve many of the objectives set for them. There is evidence that in aggregate emissions targets for developed countries represented little departure from a business as usual scenario.  The Kyoto Protocol is yet to secure sufficient participation of countries in its second commitment period and to generate the ambition necessary to avoid dangerous anthropogenic warming.

B.6.2 The 2015 Paris Agreement aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by: (a) holding the global average temperature increase to well below 2°C above pre-industrial levels and by pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels (long-term temperature goal); (b) increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production (adaptation goal); and (c) making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development (finance goal). The Paris Agreement contains binding obligations for states to submit Nationally Determined Contributions (NDCs) towards this end. Achievement of the goals of the Paris Agreement depends upon effective international cooperation regarding means of implementation and support, namely sufficient finance flows, technology development and transfer, and capacity-building for developing country parties, particularly the least developed countries and those most vulnerable to the adverse effects of climate change (high agreement, robust evidence).

B.6.3 The Paris Agreement’s architecture differs from that of the Kyoto Protocol in that it is focused on catalyzing and strengthening national action for all states through a mix of procedural and substantive commitments at the international level, rather than on multilateral standard-setting for selected groups of states. Unlike the Kyoto Protocol, the Paris Agreement leaves considerable discretion to states on the content of their NDCs, and contains only a facilitative compliance mechanism focused on securing compliance with a core set of binding procedural obligations in relation to NDCs. International cooperation in this context is still a pre-requisite for the fulfilment of many national mitigation actions, especially those NDCs conditional on the provision of international support, and a driver of enhanced national ambition (high agreement, robust evidence)

B.6.4 International cooperation is also critically important to enable and strengthen action, at multiple levels and involving diverse actors. It is key to ensuring that all countries have the capacity to contribute to the long-term goals of the Paris Agreement in the context of equity and sustainable development (high agreement, robust evidence).

B.6.5 Emissions from international aviation and shipping, which represent a growing share of global emissions, are governed by international cooperative arrangements, rather than by national mitigation policies due to the international location of these emission releases. The Kyoto Protocol required developed country parties to pursue emissions reductions from aviation and marine bunker fuels by working through the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO). Since the conclusion of the Paris Agreement, IMO and ICAO have introduced new measures to control emissions from international shipping and aviation but these are limited in their ambition and face implementation difficulties. The absence of a provision in the Paris Agreement regarding the exclusive competence of IMO and ICAO for governance of international transportation emissions expands the scope for greater cooperative efforts on aviation and shipping emissions under the Paris Agreement, as well as within the IMO and ICAO.

**E.4 International cooperation is critically important to enable and strengthen national and sub-national action, at multiple levels and involving diverse actors.(*high agreement, medium evidence*)**

**[CH LEAD: 14]**

 E.4.1 Achievement of the objectives of the Paris Agreement depends upon effective international cooperation regarding means of implementation and support, namely sufficient finance flows, technology development and transfer, and capacity-building for developing country parties, particularly the least developed countries and those most vulnerable to the adverse effects of climate change.

 E.4.2 International cooperation is a pre-requisite for the fulfilment of many national mitigation actions, especially NDCs conditional on the provision of international support, and is a driver of enhanced national ambition (high agreement, robust evidence).

 E.4.3 Article 6 of the Paris Agreement, in particular the new market mechanisms and voluntary approaches, have the potential to become a key driver of international cooperation. Article 6 has the potential to motivate international flows of financial assistance and technical support to enhance the level of mitigation, to strengthen institutional capacity in developing countries, and to lower the cost of achieving near- and medium-term global emissions reduction. Although attractive in theory, a careful design is paramount for the success of Article 6. This means preventing double counting and ensuring environmental integrity, but also avoiding an excessively complicated system. Lessons from the Kyoto Protocol mechanisms and emissions trading systems globally can provide inputs for the new system (medium agreement, robust evidence).

 E.4.4 International cooperation can enhance the financial flows for low carbon development, both through governments’ direct provision of financial resources, and by improving the conditions for private sector finance. The agreement by developed countries to jointly mobilize by 2020 $100 billion per year to address the needs of developing countries, is critical to scale up mitigation actions. There is a further commitment in the Paris Agreement that mobilization of climate finance should represent a progression beyond previous efforts. However, international climate finance flows appear not to be on track to meet these goals, and this has the potential to undermine climate ambition and action.

 E.4.5International cooperation in technology development and transfer can support developing countries in meeting their climate and development needs. The way such arrangements are developed and implemented determines their effectiveness. (*xxx* *confidence*). {16}*[Elaborate on what arrangements work to stimulate tech development and transfer]*

 E.4.6 The Paris Agreement strengthened the monitoring and transparency of national action in relation to mitigation and the provision of support, in particular by requiring states to provide detailed information, in line with the 2018 Paris Rulebook, while submitting their NDCs, as well as to demonstrate that they are on track to achieving their NDCs. This significant increase in the frequency, level of detail and scope of coverage of national reports enables adequacy assessments and comparisons by a diverse set of actors at multiple levels, thus creating a pull towards greater ambition.

E.4.7 Given the comparatively recent conclusion of the Paris Agreement, *ex post* assessments are not yet feasible. *Ex ante* assessments exist, and yet are divided in their outlook. Those expressing pessimism base their assessment on factors seen as highly relevant under a global commons framing, such as: a lack of clarity in the expression of obligations and objectives; a lack of concrete plans collectively to achieve the temperature goal; limited incentives and enforcement provisions to avoid free-riding; US non-cooperation and the resulting gap in mitigation, finance and governance.  Studies reaching a more optimistic conclusion emphasize factors broadly consistent with a transitions or transformation framing, such as: the ‘logic’ of domestic climate policies driving greater national ambition, coupled to the falling cost of low-carbon technologies; provision for financial, technology and capacity-building support to developing country parties; the breadth of participation enabled by self-differentiated NDCs; the multiplicity of actors engaged by the Paris Agreement’s facilitative architecture; possibilities for voluntary cooperation on mitigation under Article 6; and the potential for progressive ratcheting up of parties’ pledges over time fostered by transparency of reporting and international scrutiny of national justifications of the ‘fairness’ of contributions.

E.4.8 Sectoral agreements, including trade agreements, have influenced climate mitigation efforts. This influence, however, has been mixed. Some agreements and institutions have focused on reducing emissions and pushing sectors into a low-carbon development pathway. The International Renewable Energy Agency, for example, has led to an increase in capacity for expanding low-carbon energy supplies. Other agreements and institutions, particularly in the trade and investment area, however, have reinforced the prominence of fossil fuels within particular sectors. The promise of REDD+ to institute reductions in emissions from deforestation has not been widely realized at national scale, although some smaller-scale efforts have achieved success.

Chapter 15 – storyline document

*[Note: confidence statements to come, language to be checked for policy neutrality – often rather a question of wording, to be shortened to 1000-1500 words]*

1. **Finance and its role in the transformation**

The Paris Agreement has recognized for the first time the key role of aligning financial flows to climate targets. As a consequence, investors and financiers have stepped up to center stage in the global policy conversation on climate change. However, an enabling role of finance in tackling climate change cannot be taken for granted without appropriate macroeconomic, fiscal and central bank’ regulatory and other enabling conditions. Well-coordinated action, combining ambitious targets with credible national and international commitments are needed to redirect investments and financing flows and portfolios. In addition, stepped-up reflection of rising climate risk in financial sectors and as well as long-term perspectives will be crucial elements in both public and private investment decision-making processes. Besides an alignment of commercial flows to sustainable development targets, national and international public funding will be required at significantly higher levels to address (inertial) market failures resulting in a limited supply of funding by commercial investors to bridge policy and ambition gaps at different levels, meet obligations under the UNFCCC and ultimately to ensure a just transition and global equity.

The Paris Agreement marked the consensus of the international community that a temperature increase of well below 2 degrees needs to be achieved and the SR1.5 has demonstrated the economic viability of 1.5. As such, the question on “How much can we afford” versus “Whatever it takes and what is the most appropriate and robust set-up and framework for that” should have been answered. However, in terms of increase of supply of in particular public finance, often the debate is still driven by the question on affordability and budgetary constraints against the background of macroeconomic headwinds – even more in the (post-)Covid world. Heavy investments in resilient economies in the next few years will be crucial to enable countries to accelerate transformations across all sectors and meet mitigation targets in the mid to long-term. While increased public spending offers a chance to facilitate disruptive changes and an accelerated transformation, policy coherence and complementarity also suggests that policy making on marginal improvements will be crucial. Substantially increased and predicable international public finance flows from developed to developing countries for financing the NDCs will be crucial to counterbalance different starting positions in terms of expected economic implications of climate change and the necessary transformations as well as existing fiscal spaces and current economic imbalances.

Climate related financial risk is massively underestimated by financial institutions and markets (including by public stakeholders), both in terms of risk arising from physical impact of climate change and risk of a late and disorderly transition to a low carbon economy. This is a fundamental reason for the currently observed misallocation of capital and is limiting the financial sector’s potential of being an enabler of the transition. Misleading, late or missing government action, partially driven by lobbying and influencing, fuels these inappropriate risk assessments in the private sector. Consequently, political leadership and intervention remains central to strengthen the role of the financial sector as enabler and to provide the required signals and enabling conditions for finance, in particular addressing political uncertainty and the lack of credible public commitments in terms of transparent public finances, policies and regulations. Taking into account that a substantial share of finance is conditional upon public sector facilitation, such missing political leadership may cause finance to becoming a barrier.

The delayed deployment of climate investments and financing and, consequently, very limited alignment of investment activity with the Paris Agreement will result in significant carbon lock-ins and stranded assets. This holds true for all major sectors, but in particular for energy, transport and urban infrastructure. A delay of alignment of related investment activity with Paris and the SDGs will have massive negative and in the mid-term hardly reversible effects on mitigation potentials and will further increase systemic risks within the financial sector but also a higher vulnerability for the global economy as a whole.

1. **Status quo and gaps**

Average annual climate financing needs have increased compared to AR5 levels driven by shorter period remaining until 2050/2030, relatively low mitigation investment activity in the past several years and rising levels of adaptation costs and losses and damages linked to climate-related extreme events. Average annual mitigation investments required come in between [xx – yy] trillion USD for 2020–2030 with annual adaptation action expected to add between [xx – yy] trillion USD. *[Message on regional split]*. The increasing frequency and intensity of extreme weather events related to climate change and resulting in billions of dollars of damage and costs to GDP in affected countries, and value chain impacts globally, exacerbate the diverse and rising needs for financing risk mitigation and climate resilient action across countries. The net zero carbon emission targets by 2050 in some countries are useful, but need a plan for financing and policies in the critical next decade.

Financing needs vary for the various scenarios (by roughly…) for mitigation action, however, lower needs in higher temperature scenarios will be overcompensated by higher adaptation and L&D needs in the mid- to long-term.

Climate funding, which has increased modestly over past years, remains significantly below required levels and adding up to approximately [546]USD bn in 2018. While the overall public and private funding split remained relatively stable over the past 5 years at roughly [40/60]%, private funding – to a large extent facilitated by some kind of public sector intervention – has outpaced public funding in the energy sector (>80% in 2017/18) with only one other sector, transport, attracting significant volume of private capital. Taking into account measurement issues, this concentration of private finance flows into the energy sector still flags the challenge of private sector mobilisation for sectors with less or not yet standardized and established financially viable business models under current policy environments and incentive systems, not the least the absence the low carbon pricing and more generally, absence of integration of environmental and social negative externalities.

Total investments in green and brown energy assets nearly match the average annual financing needs with a significant share of brown investments with the latter remaining supported by public finance and subsidies, which highlights the policy misalignment that underpins the financial misalignment. A more appropriate risk assessment, especially towards the risk of stranded assets and long-term perspectives will be crucial (and to a large extent sufficient) to align financial flows to climate targets as no additional sector allocations by investors appear necessary.

The detailed analysis of flows and gaps illustrates well the highly divergent developments across regions and sectors representing a major challenge for [less developed countries, specific sectors like AFOLU but also specific groups of stakeholders with restricted access to climate funding]. Significant gaps exist across all sectors and regions with varying dominance and outlook for accelerated deployment of funding as the ability to mobilize funding varies substantially on a country level*.*

1. **Challenges and opportunities**

Challenges and opportunities relate to the increased supply of climate finance to address needs discussed before as well as absorptive capacities including the translation of needs into investable opportunities.

Without detracting from the magnitude of the required overall changes to the investment landscape, climate financing needs, while large in absolute size, are relatively quite small compared to the total size of world incomes (GDP) and investments (GFCF) and the net amounts are even smaller (when netted against reallocations from alternative climate inefficient investments in fossil fuels and others) on a global level. Nevertheless, ambitious global policy coordination will be needed to counterbalance the effects of a generally deteriorating environment for stepped-up (public) climate financing over the next crucial decade (2020–2030) is expected because of rising macroeconomic uncertainty:

1) current sharply slowing global macroeconomic growth, and prospects for near-term recession, and hence rising financial risk, both from secular stagnation and cyclical reasons (independent of ongoing climate change) which are negatively impacting climate financing possibilities generally at the global and national levels in the ‘near-term’ plus more unstable and slowing GDP growth at individual country levels and in aggregate because of worsening climate change impact and quite likely in the aftermath of COVID-19,

2) increasing uncertainty with regard to the economic viability and growth prospects of selected macro-economically critical sectors which increases in the presence of some climate tipping points being reached in the near term,

3) rising public fiscal costs of adapting to rising climate shocks affecting many countries, which are negatively impacting already high public indebtedness and costs of financing,

4) rising financial and insurance sector risks and stresses and impacts of climate change systematically affecting financial institutions and raising their credit risks.

Covid-19 has sharply exposed common vulnerabilities of rising global inequality within and across countries and regions that were already evident in climate matters. Ensuring a just transition now requires a redesign of a new global and national social compact to address such fundamental inequities in current financing conditions for the most vulnerable countries, and for the most vulnerable populations within countries and regions: The costs and risks of financing for stakeholders at all levels including local communities and cities, and by gender and rural areas remain excessively high in many developing countries in addition to their general economic vulnerability and indebtedness, while even within relatively prosperous regions and countries, the social and economic vulnerability of the bottom half of their populations is increasingly in question, especially in the aftermath of Covid-19. The rising levels of income inequality, mismatch between capital and investment needs, home bias considerations and differences in risk perceptions between the rich and the poor, and developed and low and lower middle income countries, represent a major challenge for commercial funding. New models of redistribution and taxation will be needed to finance a just transition. Emerging from this, a significant need for international climate finance – most likely exceeding the Copenhagen commitment – exists, taking into account current effects of climate change on already stressed public budgets in vulnerable and poor countries. Renewed levels of credible public finance commitments among developed countries to increased cross-border flows of climate finance to developing countries, as well as to credibly expedite their own climate mitigation commitments, budgets, investments and actions are needed in the immediate near-term (2020–2030), and not just by 2050. In addition, sustainable lending approaches require mainstreaming. A strong alignment of recovery support with climate targets will be required to address financing needs efficiently and to reduce lock-in effects and resulting mid-term transitional risks. The involvement or enhanced involvement of new actors such as philanthropic organisations, social impact funds, the creation of gender-driven instruments, the rise of subnational and local government actors can contribute to bringing in new forms of both social and not-for profit financing initiatives that may contribute to enhancing mitigation (and resilience) on the ground, particularly in low-income countries and small island states.

Regionally, the current focus of the global climate investment needs policies and opportunities tends to be on the big four (China, USA, EU-28 and India) and the G-20 generally. But attention must accelerate on low-income Africa. This large continent (equivalent to size of China, USA, India, Europe combined) currently contributes very little to global emissions, but its rapidly rising energy demands and renewable energy potential versus its growing reliance on fossil fuels and ‘cheap’ biomass (especially charcoal use and deforestation) amid fast-rising urbanization makes it imperative that institutional investors and policy-makers recognize the very large 'leap-frog' potential for the renewable energy transition as well as risks of lock-in effects in infrastructure more generally in Africa that is critical to hold the global temperatures rise to well below 2°C in the longer-term (2020–2050). Overlooking this transition opportunity, rivaling China, India, US and Europe, would be costly. Policies centered around the accelerated development of local capital markets for energy transitions - with support from external grants, supra-national guarantees and recognition of carbon remediation assets - are crucial options here, as in some other low-income countries and regional settings. Yet the trend in the development of local capital markets remains slow and piecemeal.

Increased financial flows to support cross-border low-carbon investment in developing countries of sufficient pace and scale are required, since much of the rising GHG emissions will happen there otherwise, and since much of the world’s global capital pool is on the other hand is located in the developed world. Recognition of the explicit and positive social value of such global cross-border mitigation activity (SVMAs as already reflected in the Paris Agreement) may be crucial to create an entirely new class of investment assets, for which a network of governments, central banks and financial regulatory authorities will need to devise suitable arrangements, and eventually to allow the bankability of and support, including through sovereign fiscal guarantees and monetary policy measures such as ‘green monetary stimulus’ to such increased financing. Central banks and financial regulatory authorities are increasingly recognizing the risks of the status quo and placing more emphasis on recognition of such risks on the balance sheets of global financial institutions but they may need to do more to recognize the positive value of shifting financial allocations significantly towards low-carbon investments in climate. Carbon pricing is the first-best option, but is increasingly under stress as it has other notable drawbacks, including its regressive impacts and political economy constraints to raising carbon taxes and prices to levels required, and because a global carbon price is very far from possible.

Significant transparency gaps and inertia with regard to physical and transition risks need to be addressed quickly to facilitate the implementation of robust risk management in financial and governmental institutions to maintain financial and economic stability, manage climate impacts and close the climate finance gap. To avoid an underestimation of risk a key element will be a stronger and more credible use of climate scenarios, in a wide enough range, and a closer cooperation of the financial industry with the academic and scientific community.

Innovative financing instruments, such as sovereign and other de-risking guarantees, greater inclusion of support to low-carbon investments under expanded monetary policy tools of central banks, attaching greater weight to the risk of stranded assets, more robust green labelling and disclosure schemes, and regulatory focus on transparency could help shift this inertia. Innovative financial products may not necessarily increase financial flows for climate solutions in the near term, however they can help build capacity on climate risk within institutions and companies to pave the way for increased flows over time.

The focus on private sector funding and its mobilization has further increased in recent years. While the private sector has been a key driver of increased financial flows towards the renewable energy sector, it is uncertain whether other sectors can attract as much investor appetite and offer viable investment opportunities to the extent seen in renewable energy because the risks are higher, appropriate models of risk-sharing are missing, and technology costs are bigger in initial conditions. More appropriate public structures, support and competencies to steer and facilitate and manage private sector involvement efficiently needs to be built quickly.

As highlighted in AR5 de-risking approaches are crucial instruments to address viability gaps and (perceived) unattractive risk-return profiles but also to reduce societal costs of projects. An increased consensus can be observed across the investor and policy maker community with regard to the potential of and willingness to enter into blended finance facilities to address transaction costs, limited track record of commercial investors in crucial sectors and regions as well as (perceived) investment risks.

In order to increase the demand for a massively increased level of climate funding supply and diversion from financing climate detrimental activities, needs will have to be translated into more concrete opportunities with sector transitions becoming better understood and more visible among financial sector stakeholders. Besides the strong role for the public sector in creating more tangible long-term visions and concrete short- to mid-term pathways for sectors and regions/countries, standardized financial products and new, convening asset classes allowing a smooth integration into existing asset allocation models as well as offering a substantial absorptive capacity will foster demand from investors looking for an alignment of significant asset portfolios with climate targets. It also requires public-private cooperation to allow private sector to create a track record in new segments/regions, within a context of safeguards, standards and integrated into national climate change policies and plans.

There is strong evidence of a negative correlation between per capita incomes, credit ratings, institutional capacity of countries and international private climate finance flows, and positive correlation to their sharply rising costs towards those economies. While limited pipelines, limited absorptive capacities as well as restricted institutional capacity of countries in low income settings are often stated as challenge for an accelerated deployment of (commercial) funding, well-structured patient interventions and funding for capacity building for low carbon and climate resilient development and consequently increased ambition levels in and a stronger steering character of NDCs are possible with the public sector needed to play an important role and require sufficient funding from international donors / climate finance institutions.

Key Messages SPM Chapter 17

1. Sustainable development can serve as a means to achieve Paris Agreement goals when it creates synergies and avoids trade-offs between economic, social, and environmental dimensions of development.
2. Transition pathways have implications for justice and equity, especially for countries, communities, and individuals who are already at the lowest rungs of the energy poverty ladder and are managing the consequences of other forms of injustices – climate change impacts, food insecurity, limited access to health care etc.
3. Integrating the responses - human, technology, energy systems, infrastructure etc. – and adopting cross-sectoral policies can accelerate the transition, and in the process avoid maladaptation and mitigation.
4. The acceleration of transitions is not going to be uniform – they will depend on equity considerations, choices of development pathways, the speed of action, and context-specific issues that may enable or disable the transition. Some regions will experience swift transitions while in others encounter delays due to various limitations including finance, technology, lock-ins, etc.
5. Embedding climate change mitigation policies into the context of sustainable development policies and initiatives can facilitate wide global participation, and factoring in equity will be particularly important for the pursuit of sustainable policies and for partnerships.
6. The relationship between mitigation and adaptation also merits reflection when contemplating transition pathways. Transitions to low carbon societies can imply both synergies and tradeoffs between key sustainable development goals and climate change policies. These can e.g. include potential tradeoffs between energy, food, and water security, which can create a barrier for policy implementation. Both synergies and tradeoffs need to be addressed in coordinated cross-sectoral policies.
7. The acceleration and the speed, scale, and quality of the transition will depend on the enabling environment – individual behavior, beliefs and actions, a proactive role of the private sector, finance, social community building, social and technological innovations, governance, policies, institutions policy instruments etc. - Moving a transition forward will require drawing on a hybrid system of practices, experiences, policies, measures, and learnings.
8. Accelerating a transition is not simply about moving quickly to achieve climate goals. It is about improving the well-being and livelihoods for those participating in the transition. A failure to account for well-being and livelihoods could derail efforts to achieve climate goals.
9. Digitalization technologies along with behavior changes, and well-designed  
   policies including international cooperation, will support the sharing and circular economies. These economic approaches induce great improvements in effective uses of energy in end-use sectors and reductions in embodied energy for products and services. They also achieve global reductions in basic materials, energy consumption, and GHG emissions without declines in well-being.

1. The three Special reports are: *Global Warming of 1.5°C: an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty; Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems; the Ocean and Cryosphere in a Changing Climate.* [↑](#footnote-ref-2)
2. The assessment covers literature accepted for publication by [5 April 2021] [↑](#footnote-ref-3)
3. Each finding is grounded in an evaluation of underlying evidence and agreement. A level of confidence is expressed using five qualifiers: very low, low, medium, high and very high, and typesets in italics, for example, medium confidence. The following terms have been used to indicate the assessed likelihood of an outcome or a result: virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%. Additional terms (extremely likely 95–100%, more likely than not >50–100%, more unlikely than likely 0 –<50%, extremely unlikely 0–5%) may also be used when appropriate. Assessed likelihood is typeset in italics, for example, very likely. This is consistent with IPCC AR5. [↑](#footnote-ref-4)
4. Each high-level message will be supported by additional more detailed supporting messages drawn from Chapter 5, regrouped under the 4 headings of the high-level messages. [↑](#footnote-ref-5)