Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
12941	0	0	0	0	This Chapter could and should play a very important role, especially dfor policy formulation. However, as it stands, it is rather superficial. It lists a number of observations or recommendations which barely rise above mundane, and do not really provide any actionable policy suggestions. Essentially statements are either obvious or non-committal.	Taken into account. Text will be revised and comment will be reflected.	Prashant Goswami	Institute of Frontier Science and Application	India
39469	0	0	0	0	In general, Section 12.4 could benefit from some more organization/flow. Given such a complex topic, it's not clear why these issues were picked to be discussed and not others relevant to food systems. Food systems work is very holistic - not reflected in the way this is written. Section 12.4 is difficult to follow and many of the paragraphs do not have enough context and explanation of why they are being discussed. The Introduction could help to address this issue by more clearly presenting what dimensions of food systems will be discussed in the chapter, and why.	Taken into account. Section is revised and comments were taken on board.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
16365	0				In Chapter 12, consider adding a section that describes the global military sector and its potential to lead mitigation across manufacturing and transport sectors, as well as in agriculture based on provisioning. Including this will strengthen the section and be an aid to the reader.	Noted. The military sector is certainly interesting but unfortunately we currently don't have the right expertise or literature to include it as a section in chp 12.	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
28757	0				Please check: Under the land (soil) based mitigation, ecosystem carbon turnover time and nature of uncertainties (whether imparting positive/negative feedback to climate change and soil carbon stabilization-saturation or destabilization) under changed climatic condition needs to be dealt with in context of agriculture/forestry sector where high temperature and elevated CO2 concentration will prevail coupled with altered pattern of precipitation and aridity leading to shift in vegetation primary productivity/crop yield	Taken into account: permanence and saturation of land carbon sequestration and storage is addressed in 12.5. The issues raised in the review comment are in addition covered in Ch7.	Suvadip Neogi	TSU-WGIII-IPCC-Global Centre for Environment and Energy, Ahmedabad University, India	India
28759	0				Kindly check: Risk: Needing assessment on global warming and climate change vis-à-vis climatic anomalies (extreme events), pest infestation, tree mortality, impacts on primary productivity, adaptation and mitigation potential of vegetation under changing climatic condition	Taken into account. Discussion of risks related to mitigation is now more elaborated across the chapter and particularly in sections related to CDR, land-based, and food systems.	Suvadip Neogi	TSU-WGIII-IPCC-Global Centre for Environment and Energy, Ahmedabad University, India	India
28761	0				Please check: Having linkages with Ch7 AR6 WGIII and Ch5 AR6 WGII on policies addressing trade-offs, synergies and co-benefits with mitigation-adaptation efforts in agriculture/forestry in context of food-energy-water nexus and food, fibre, biodiversity and ecosystem services; needing coherent treatment across chapters	Taken into account. Coordination with ch7 and WGII started and will continue to align on these issues and remove overlaps.	Suvadip Neogi	TSU-WGIII-IPCC-Global Centre for Environment and Energy, Ahmedabad University, India	India
28763	0				Kindly check: Needing consistencies in GHGs fluxes from global models and country levels-needing assessment and reconciliation	Taken into account. Coordination with chapter 3 and setoral chapters will continue to ensure consistency in reporting GHGs fluxes	Suvadip Neogi	TSU-WGIII-IPCC-Global Centre for Environment and Energy, Ahmedabad University, India	India
34527	0				This chapter is an interesting read though I could only skim briefly. It does say explicitly that it follows the official approved outline, but I believe this still gives scope to consider the following. The chapter title is 'cross-sectoral perspectives', but it comes over as (a) compilation of costs and potentials and (b) things not well covered in other chapters, like CCS, CDR and DACC. To my mind, 'cross-sectoral perspectives' could and should include a lot more about interactions between sectors, and common and interacting processes, as flagged in my next two comments. Currently, it only seems to do this for the land-food-biomass interactions, and that partly in Annex.	Taken into account. In the revised version there is more focus on cross-sectoral synergies and trade-offs and more coordination with sectoral chapters to avoid duplication.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
34529	0				One of the most important cross-sector interactions happening at present is electrification, particularly in the light of the renewables revolution. This is already impacting transport – see Chapter 9. More fundamentally, much of the world – tropical and subtropical (eg. north Africa, Middle East, Pakistan & Rajastan, southern Africa) have huge and now highly cost-effective solar potential; temperate regions (especially) also have major economic wind resources. These are both variable (diurnal/weather/seasons), so there will be growing periods with excess electricity, almost free at the margin. This could spill over not just into transport, but buildings / urbanization, and industry at scale (eg. see Hydrogen section in Chapter 11). I think the interaction of electrification with renewables on one hand, and end-use sectors on the other, could be usefully introduced as a substantial theme in this chapter, in coordination with relevant sector chapters.	Taken into account. Section 12.6 now provide more indepth focus on electrification and hydrogen as cross-sectoral technology options and mitigation enablers.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
34531	0				The chapter could usefully consider cross-sectoral processes. One important development since AR5 is our growing understanding that mitigation really is not about the calculation and aggregation of static cost curves, but about the dynamics of sectoral transformation as new technological systems emerge and grow, with declining costs from economies of scale and learning. The cost curves constructed in some previous IPCC Assessments for 2030 are embarrassingly outdated because they neglected the fundamental dynamics of induced innovation and systems transformation. There is growing literature on this, chapter 1 touches on some of this (notably the multi-level transitions literature) but Chapter 12 could do this more systematically, in liaising also with Chapter 16. Aside from the theoretical/modeling literature, there is a major Systematic Review of evidence on induced innovation (M.Grubb + 12 other authors, an invited submission to Environmental Research Letters) and various case studies (most obviously. Solar: eg. Nemet 2019: How solar energy became cheap, which explicit lays out possible lessons for other technology-sector transformations.	Taken into account. The revised chapter focuses more on cross-sectoral interactions while trying to accomodate some cross-cutting technologies such as electrification and hydrogen. Sectoral transformations are addressed in the cost and potentials but accomodating dynamci features beyond that included in the sectoral chapter is not currently feasible since addressing innovation and dynamic aspects of technologies is now fully taken by chapter 16.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
34535	0				[Next chapter]	editorials will be applied	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
38165	1		91		The whole chapter is mainly about supply side technological solutions. Demand side are almost not assessed in the chapter. Similarly mitigation potentials of non-technological solutions are not assessed. Highly recommend having a look to CHapter 5. Furthermore, I was expecting the chapter to be more cross-sectoral focussed, instead the chapter follows the traditional reasoning sector by sector with a special focus on CDR and land-use which makes it bit repetitive with sectoral chapters.	Taken into account. Revisied chapter limited focus to cross-sectoral aspects of mitigation technologies and options including both supply and demand side options (see 12.2, 12.4 and 12.6).	Yamina Saheb	OpenExp, Ecole des Mines de Paris	France
47203	1	1	100	47	The complete absence of Solar Radiation Management from this chapter contradicts the promise from Chapter One that it would be addressed. SRM has major potential to prevent climate disaster, as a key stopgap while CDR ramps up, like an emergency tourniquet. Its absence from the IPCC analysis, despite extensive public and scientific interest, reflects a dangerous politicisation of this report.	Rejected. This is beyond the mandate of chapter 12. Further, SRM is considered as a cross-working groups issue in the AR6 cycle. WGI and WGII are doing the science and impacts assessment. WGIII is concerned with the policy and governance aspects of SRM, and in that respect chapter 14 addresses the governance issues related to SRM.	Robert Tulip	Australian National University	Australia
37845	1	1	131	30	This is a comment on the whole chapter. Except for the section on costs and potentials, the rest of the chapter is still in a rudimentary form. Although this is to be expected given the chapter'sd reliance on assessments from other sectoral chapters, several of the intersectoral linkages can be be examined independently from each sectoral chapter. These interlinkages are important to provide a system view of the sectoral potentials, their trade-offs and synergies. In particular I am missing clearer connections between climate change and sustainable development in the cross-sectoral interlinkages. Do interlinkages mitigate or exacerbate trade-offs with sustainable development? For example, how does food security concerns with respect to bioenergy deployment may affect mitigation potentials in other sectors? Does limitied bioenergy supply lead to challenges in CCS deployment?	Taken into account. The revised chapter focuses more on cross-sectoral interacitons including synergies and trade-offs and their implication for sustainable development.	ALEXANDRE KOBERLE	COPPE/UFRJ	Brazil
9663	1	1	150	70	different area have different background related to the emergence of same problem, therefor integrated and comprehensive planning ia difficult. the planning muat be saparated.	Rejected. It is true that geographical differences in cirumstances are important but Integrated planning is exactly meant to cater for both similarties and differences across sectors and regions, hence to maximize synergies and minimize trade-offs	Taufiq Ramdani Karim	University of Mataram	Indonesia
9691	1	1	150	70	different area have different background related to the emergence of same problem, therefor integrated and comprehensive planning ia difficult. the planning must be saparated.	Rejected. It is true that geographical differences in cirumstances are important but Integrated planning is exactly meant to cater for both similarties and differences across sectors and regions, hence to maximize synergies and minimize trade-offs	Taufiq Ramdani Karim	University of Mataram	Indonesia
8583	2	1	2	45	CO2 removal, Carbon Dioxide Removal Mixed use, Need to unify. Especially in the title.	editorials will be applied	Suyi Kim	Hongik University	Republic of Korea
8585	2	12	2	13	Align, edit	editorials will be applied	Suyi Kim	Hongik University	Republic of Korea
8587	2	26	2	26	Pleasse change title, it seems to be inappropriate. Impacts, risks and opportunities from land-based mitigation→land-based mitigation	Rejected. Yes, the title is lengthy but it better reflects the contents of the subsection	Suyi Kim	Hongik University	Republic of Korea
8579	2	29	2	29	Food Security Sector Should Move to Food System	Taken into account. The section on food system is revised and will consider moving food security to that section	Suyi Kim	Hongik University	Republic of Korea
8581	2	35	2	35	12.7 Cross-sectoral perspectives on governance in the context of sustainable development→ 12.7 Governance in the context of sustainable development.	Rejected. Yes, the title is lengthy but it better reflects the contents and differentiate it from chapter 14	Suyi Kim	Hongik University	Republic of Korea
16941	4	1	4	30	In this section, different mitigation actions are specified : CDR, DACCS, food systems,.. Surpringly, the most efficient lever is not mentioned. I strongly recommend to introduce an additinal paragraph at the beginning of the section calling to reduce the use of fossile fuels! Sustitution of fossile fuels, namely carbon, by low carbon electricity (Hydro, nuclear, PV, Wind, ...) will have a stronger effect than reduction of read meat for example or any action connected with food systems. In addition, this efficient lever can be used in the very short term if political decision are taken and keeping this in mind, I believe that IPCC AR6 Report must help policy makers in that perspective. Reading Chapter 3, I have had the same feeling : IPCC seem to promote mostly electrical renewables, discarding the rôle of nuclear energy, while previous IPCC reports have clearly demonstrated that nuclear is part of the solution to achieve Paris COP 21 goals in most scenarios.	Taken into account. The ES is under revision for the SOD. Your comments will be taken on board based on the literature and the new focus of the section on corss-sectoral interactions.	Michel SIMON	Vice Président SFENRAL	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
5933	4	2	4	5	It is not helpful in an Exec Summary just to describe what is in the chapter. For example, the Exec summary should present what the outcomes of the comparison are in this first paragraph.	Accepted. The statement will be revised based on the inputs from the sectoral chapters during the SOD revisions.	Ralph Sims	Massey University	New Zealand
34253	4	2	4	5	The first item should illustrate the whole chapter, maybe with a question mark such as "what can be done in the longer run to achieve negative emissions? This chapter…"	Taken into account. ES will be revised for the SOD taking on board your comments	Antoine BONDUELLE	Climate Action Network France	France
35035	4	2	4	5	This section can be better presented with an introduction of what the section will include, rather than what has been discussed in the previous sections. That is to say, the reader has a very good understanding of previous items, so no need to refer to previous discussions. I recommend this so that the reader can have a better grasp of what he/she will find in this chapter. The following chapters are very specific to themes that could have been identified here.	Taken into account. ES will be revised for the SOD taking on board your comments	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
39845	4	2	4	10	It's great that you compared results from different approaches. It would be informative if you can provide us with a sense of the magnitude of the differences. i.e. Are we getting similar numbers or greatly different numbers depending on the methods used?	Taken into account. Statement will be revised based on Chapter SOD version.	Hasegawa Toshihiro	National Agricultural and Food Research Organization	Japan
35037	4	5	4	6	There is a need to introduce here a discussion on the relevance of the different approaches presented right after. It is not clear why these elements are included and not others. Just because the following lines dive right into each approach/method, the relevance of the overall chapter is not addressed/presented clearly.	Taken into account. The statement is revised taking on board this and other comments.	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
44	4	6	4	7	As discussed in SR1.5 and in AR6 WG1 chapter 4 section 4.3.2 CDR and mitigation are different. Mitigation refers activities that lead to reduced emissions and CDR refers activities that remove CO2 that is already in air. I see this confusion erupting again and again. You can say "Carbon Dioxide Removal (CDR) is an essential element of response options to limit warming..."	Rejected. Mitigation is defined explicitly as human activity that reduces emissions OR enhances sinks (CDR acts as a sink)	Govindasamy Bala	Indian Institute of Science	India
28023	4	6	4	7	Synthetic CDR causes more damage than good and is not essential, so this conclusion should be removed. First, Jacobson, M.Z., The health and climate impacts of carbon capture and direct air capture, Energy and Environmental Sciences, 12, 3567-3574, doi:10.1039/C9EE02709B, 2019 found from actual plants that CCS/U and DACCS/U are both opportunity costs resulting in hardly any CO2 reduction, even before considering the disposition of CO2, and both result in air pollution and mining increases. Similarly, Sekera, J., and A. Lichtenberger, The carbon capture conundrum: Public need versus private gain, A public policy perspective on carbon dioxide capture, 2020, https://drive.google.com/file/d/1K-BIULOUtfSs5LVCS9ONaDzq7jeFmO-b/view conclude (1) many scientific studies pass carbon removal methods off as "climate mitigation" when in reality the methods in play today increase CO2 and (2) laws subsidizing carbon capture and direct air capture increase CO2. As such CDR does not work and readers should not be misled into thinking it works. Second, it is not necessary. An 80% elimination of emissions by 2030 and 100% by 2050 reduces CO2 to 350 ppmv by 2100 http://web.stanford.edu/group/efmh/jacobson/Articles/I/CountryGraphs/CO2ChangesWithWWS.pdf	Rejected. The wording has been changed to a statement that is factually indisputable: "Carbon Dioxide Removal (CDR) is an essential element in most scenarios that limit warming to 1.5°C–2°C by 2100 (high agreement, robust evidence)". We report what is in these scenarios and the wider literature.	Mark Jacobson	Stanford University	United States of America
3189	4	6	4	10	Please refer to line 31-33, page 60 of Chapter 3: "CDR ramp-up rates and absolute deployment levels are tightly limited by techno-economic, political and sustainability constraints". Also see line 27-42, page 7 of Chapter 4 of the Special Report on Global Warming o 1.5oC: "Most CDR options face multiple feasibility constraints". Please consider revision of the paragraph to avoid painting an overly optimistic picture.	Taken into account. No contradiction that a technology is essential but has feasiblty concerns. Will ensure consistency with chpater 3 and other chapters in this respect.	Sai Ming LEE	Hong Kong Observatory	China
5935	4	6	4	10	Needs a comment here on the current options for CDR. It is not clearly defined (eg that DACCS is a sub-sector; that it includes CCS and CCUS as well as afforestation and soil C. Also needs stating that major barriers are yet to be overcome.	Taken into account. Will consider revising the statement to make it more clear.	Ralph Sims	Massey University	New Zealand
14213	4	6	4	10	As said in the report ("The volumes of CDR deployment assumed in IAM-based global emissions mitigation scenarios are significant if compared to current volumes of deployment, given that the feasibility of rapid and sustained upscaling is uncertain" l1p15), there are many uncertainties with relation to the feasibilty of large-scale CDR deployment in the future, hence when refering to them it is crucial to keep always this in mind. However, this has not passed to the Executive Summary of the chapter, and it should be there.	Accepted. We added: "There is uncertainty about the extent of their future deployment."	Iñigo Capellán-Pérez	University of Valladolid	Spain
32681	4	6	4	10	Would it be helpful to explicitly mention that CDR will help meet Paris targets only work if other mitigation routes are also implemented? I get a lot of comments on tech/CDR/non-behavioural changes, and it seems like there's a lot of misconception that CDR can reach Paris targets without changes elsewhere.	Noted. Necessary editoials will be applied	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
40331	4	6	4	10	It would be useful to point out in Chapter 12 what is stated in Chapter 3: Not all 1.5°C-2°C require technological CDR such as BECCS. There are ecosystem-based approaches available to draw down CO2 that do not come with the large-scale adverse side effects of technological CDR.	Taken into account. Statement will be revised to be consistent with chapter 3 and other chapters	Linda Schneider	Heinrich Boell Foundation	Germany
40333	4	6	4	10	Chapter 12 should refer back to WGI findings on geophysical and biogeochemical uncertainties around CDR. There is significant uncertainty around returning from overshoots of carbon budgets or temperature thresholds, it would be useful to reflect these scientific uncertainties – and risks of missing temperature goals if these uncertainties materialize - in a more nuanced way than simply stating that „CDR can be used (...)" to that end.	Accepted. Wording changed from "can" to "could" to reflect these uncertainties	Linda Schneider	Heinrich Boell Foundation	Germany
43397	4	6	4	10	Suggest to add: …if residual emissions are very small	Taken in to account. The wording has been changed from "can" to "could" to reflect this. Wording "if small" was not added as this is not precise enough language to be meaningful.	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
14211	4	6	4	17	Please give a short synthetic definition of the concepts of CDR, DACCS, enhanced weathering and ocean-based approaches, it is very confusing and non-informative for the non-specialized reader, to which an Executive Summary is directed. Indicate also if these technologies are currently proven at commercial scale or it is an expected technological development for the future? how far in the future?	Taken into account. Editorials will be applied	Iñigo Capellán-Pérez	University of Valladolid	Spain

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
47199	4	7	4	10	The assertion that the need for Carbon Dioxide Removal to stop dangerous warming only has "medium evidence" is simply astounding. The evidence is compelling that emission reduction alone can do nothing to address committed warming from past emissions, which are the main driver of warming, and which can only be addressed through CDR. See eg Rohling The Climate Question. CDR has a far bigger role than "to offset residual emissions to reach net-zero emissions and to return from temporary overshoots." Net zero is only a milestone on the path to large net negative emissions. Methods to convert CO2 into useful commodities offer transformative economic potential to build major new industries that will establish a trajectory to return CO2 level to the amount that has stabilised the Holocene climate including sea level. The IPCC analytic framework simply ignores the committed warming from past emissions which should be central to policy.	Accepted. Wording has been changed in the main statement to make it more precise which allows the evidnce and agreement statement to be changed to high evidence/high agreement	Robert Tulip	Australian National University	Australia
28025	4	11	4	11	Synthetic DACCS causes more damage than good and is not essential, so this conclusion should be removed. First, Jacobson, M.Z., The health and climate impacts of carbon capture and direct air capture, Energy and Environmental Sciences, 12, 3567-3574, doi:10.1039/C9EE02709B, 2019 found from actual plants that CCS/U and DACCS/U are both opportunity costs resulting in hardly any CO2 reduction, even before considering the disposition of CO2, and both result in air pollution and mining increases. Similarly, Sekera, J., and A. Lichtenberger, The carbon capture conundrum: Public need versus private gain, A public policy perspective on carbon dioxide capture, 2020, https://drive.google.com/file/d/1K-BIULOUtfSs5LVCS9ONaDzq7jeFmO-b/view conclude (1) many scientific studies pass synthetic carbon removal methods off as "climate mitigation" when in reality the methods in play today increase CO2 and (2) laws subsidizing carbon capture and direct air capture increase CO2. As such synthetic CDR does not work and readers should not be misled into thinking it works. Second, it is not necessary. An 80% elimination of emissions by 2030 and 100% by 2050 reduces CO2 to 350 ppmv by 2100 http://web.stanford.edu/group/efmh/jacobson/Articles/I/CountryGraphs/CO2ChangesWithWWS.pdf	Taken into account. Literature provided will be combined with other additional literature and if warranted statement will be revised.	Mark Jacobson	Stanford University	United States of America
29445	4	11	4	11	Direct air capture and carbon storage should not be grouped with the other technologies in this list, i.e. ehanced weathering). DACCS uses mature technologies (capture units) and techniques (storage of CO2). At scale, the outcomes of the process of DACCS, drawing CO2 out of atmosphere and storing it permanently in geological formations is known. The outcomes and impacts of the other technologies are not known at scale.	Rejected. It is not grouped will other CDR by maturity of technology or premanence of storage. It is grouped with all other CDR not covered in sectoral chapters.	Eve Tamme	Global Carbon Capture and Storage Institute	Belgium
43399	4	11	4	11	DACCS is more commonly used as Direct Air Carbon Capture and Storage	editorials will be applied if warranted	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
3191	4	11	4	13	According to the main text, the amount of CO2 captured by the DACCS technology is in the order of ktCO2 yr-1 (line 10-28, page 16), while the total GHG emissions in 2018 was 55.3 GtCO2e (Ref.: UN Emissions Gap Report 2019). A big gap exists between "captured" and "emitted". Enhanced weathering is demonstrated in the laboratory and small scale field trials only, and the impact on ecosystems remains poorly quantified (line 19-28, page 18). The ocean-based approaches are demonstrated by a small number of field and laboratory experiments, and the impact of elevated alkalinity on ocean ecosystems are poorly understood (line 36 of page 21 - line 6 of page 22). Given the current status of these CDR technologies, it is strongly recommended to revise the basic tone of this paragraph to avoid painting an overly optimistic picture.	Taken into account. The statement is revised taking on board this and other comments.	Sai Ming LEE	Hong Kong Observatory	China
11869	4	11	4	14	Is the mitigation potential for DACCS not also limited by land and other resource use? If so, please consider highlighting such considerations.	Accepted. The word "only" has been replaced by "mainly" as land and water are secondary constraints	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
46	4	11	4	17	A potential of 100 Gt-CO2 per year appears extremely optimistic. I believe this will misled the public. AR5 WG1 Chapter 5 assessed a potential of only 10 Gt for weathering and most other approaches. I would suggest caution here.	Taken into account. The statement is revised taking on board this and other comments.	Govindasamy Bala	Indian Institute of Science	India
20491	4	11	4	17	DACCS cost can be as low as 50 EUR/tCO2 and less, as pointed out in detail in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) linked to Fasihi et al. (https://www.sciencedirect.com/science/article/pii/S0959652619307772)	Noted. Reference will be considered and added	Christian Breyer	LUT University	Finland
32565	4	11	4	17	DACCS may have a lower cost range than described here. See David Keith et al., A Process for Capturing CO2 from the Atmosphere, Joule (June 2018) ("Depending on financial assumptions, energy costs, and the specific choice of inputs and outputs, the levelized cost per ton CO2 captured from the atmosphere ranges from 94 to 232 $/t-CO2.").	Noted. Reference will be considered and added	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
40335	4	11	4	17	It doesn't seem appropriate for the top-level summary to simply refer to technical potentials of these technologies. In reality, they all come with large-scale risks and adverse side-effects that are well documented in the literature; it is in this context that such top-level statements should be made.	Taken into account. The statement is revised taking on board this and other comments.	Linda Schneider	Heinrich Boell Foundation	Germany
40337	4	11	4	17	DACCS: this statement doesn't seem to be very much connected to the real world. There are obviously many more implications and concerns, and potential and existing contraints on various levels that have an impact on the mitigation potential of DACCS. It does not seem very helpful to limit such a top-level characterization to the technical potential as it creates a misleading impression.	Taken into account. The statement is revised taking on board this and other comments.	Linda Schneider	Heinrich Boell Foundation	Germany
40339	4	11	4	17	Enhanced Weathering: The 100 Gigatonnes per year figure is entirely unrealistic and creates an extremely misleading impression of the potential of Enhanced Weathering. I would urge authors to doublecheck the quality of the underlying scientific material.	Taken into account. The statement is revised taking on board this and other comments.	Linda Schneider	Heinrich Boell Foundation	Germany
40341	4	11	4	17	Ocean-based approaches: Again, a figure of 100 Gigatonnes is excessively high, in particular against the background that Ocean Fertilization has a) been found to be rather inefficient, and b) has been prohibited by the London Protocol of the London Convention. The regulation implemented under the London Protocol of the London Convention is due to the risks and adverse impacts on the marine environment of such ocean-based technologies, which should be raised here. In fact, the IPCC should state the legal status of certain ocean-based approaches and ideally exclude those from their assessment that are banned.	Taken into account. The statement is revised taking on board this and other comments.	Linda Schneider	Heinrich Boell Foundation	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
43401	4	11	4	17	Is there really medium evidence and medium agreement on these extremely specific (although wide-ranging) numbers on cost and potential? My reading of the literature suggests less confidence.	Taken into account. The statement is revised taking on board this and other comments.	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
3193	4	14	4	14	The range of cost of DACCS (200-600 US$ tCO2-1) does not tally with the cost estimates discussed in line 29-40 of page 16.	Taken into account. The statement is revised taking on board this and other comments.	Sai Ming LEE	Hong Kong Observatory	China
3195	4	14	4	15	Re: "Enhanced weathering has the potential to remove <1 to ~100 Gt CO2 yr-1, at costs ranging from 24–578 US$ tCO2-1". According to line 33 of page 18, the cost could be up to 3460 US$ tCO2-1. Such large uncertainty should be highlighted.	Taken into account. The statement is revised taking on board this and other comments.	Sai Ming LEE	Hong Kong Observatory	China
47201	4	16	4	17	The recognition by the IPCC that ocean based approaches could potentially remove 100 GT CO2 per year at a cost of just $2 per tonne is highly welcome, even if this remains to be proved. This 100 GT figure, double total emissions, would deliver vital time to enable a slower transition away from fossil fuels and slower climate impacts, enabling rapid transition to net zero and then net negative emissions. Unfortunately, research on this central climate agenda has been largely stymied and unfunded for the last decade. The immense potential value of this approach suggests that the research failure is due more to politics than science.	Noted. This a statement rather than a specific question or suggestion for change	Robert Tulip	Australian National University	Australia
42341	4	18	4	19	I read: « Food system, which currently contribute some [...] are becoming increasingly carbon intensive » Since food include [non fossil] carbon, it would be less confusing not to forget, (as usual, unfortunately), the word fossil. (See also my comments on « decarbonisation » in Annex A.)	Taken into account. Statement revised to remove confusion	Raymond Zaharia	Le Club des Argonautes http://www.clubdesargonautes.org	France
32677	4	18	4	22	There's a bit of a disconnect between GHGs and malnutrition as current written. The overall point is excellent, but rephrasing/reorganizing will make help make this link a bit clearer.	Editorials applied. Statement revised to remove confusion	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
34993	4	18	4	22	suggest to consider composite of potential health impacts like infectious diseases could impact suceptible group of population associated with compromised immunity that arise from limited sources of proten-rich foods	Noted. synergies and trade-offs related to mitigation including health impacts are reflected on a later ES regarding SDGs	Adugna Gemeda	Ethiopian Public Health Institute	Ethiopia
32679	4	23	4	27	Would it be worth mentioning other environmental benefits even if IPCC is focused specifically on climate?	Taken into account. Synergies, trade-offs and co-benefits are dealt with in a later ES statement.	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
11871	4	28	4	30	Please consider adding a sentence that explains/examplifies "emerging food chain technologies"	Accepted. A sentence is added to explain what is emerging food chain technologies	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
28027	4	31	4	31	IPCC states, "The SR1.5 concludes that all assessed pathways that limit warming to 1.5°C require extensive land-based mitigation." This is not true. It is possible to get to 1.5 C by transitioning 100% of all energy to renewables, while reducing biomass burning, halogens, nitrous oxide, and methane without any BECCS or biofuels. For example, the abstract of Jacobson, M.Z., M.A. Delucchi, Z.A.F. Bauer, S.C. Goodman, W.E. Chapman, M.A. Cameron, Alphabetical: C. Bozonnat, L. Chobadi, H.A. Clonts, P. Enevoldsen, J.R. Erwin, S.N. Fobi, O.K. Goldstrom, E.M. Hennessy, J. Liu, J. Lo, C.B. Meyer, S.B. Morris, K.R. Moy, P.L. O'Neill, I. Petkov, S. Redfern, R. Schucker, M.A. Sontag, J. Wang, E. Weiner, A.S. Yachanin, 100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for 139 countries of the world, Joule, 1, 108-121, doi:10.1016/j.joule.2017.07.005, 2017 states "Transitioning should also stabilize energy prices because fuel costs are zero, reduce power disruption and increase access to energy by decentralizing power, and avoid 1.5□C global warming." See also getting to 350 ppmv with zero BECCS or biofuels: http://web.stanford.edu/group/efmh/jacobson/Articles/I/CountryGraphs/CO2ChangesWithWWS.pdf.	Taken into account. The ES statement is revised to take on board correctly the reviewer's concern. Se the new statement (ES-8)	Mark Jacobson	Stanford University	United States of America
43645	4	31	4	33	It may be that IAMs started their NET history with a focus on BECCS, while ohter non-land-based options, such as DACCS or EW, are only modelled now. Thus there is a bias towards land-based options in IAMs. The sentence might be tweaked a little to open for the possibility that future scenarios might be much less land based.	Taken into account. The statement is revised taking on board your observation by removing the 1.5C specific context.	Felix Creutzig	MCC Berlin	Germany
17369	4	31	4	36	According to discussions held during COP25 and lack of international consensus in IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels, the mentioned texts should appear to be reviewed.	Rejected. Presence or absence of international concesuss at COPs will not preclude citing the IPCC 1.5C approved report.	Zeyaeyan Sadegh	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
25587	4	31	4	36	Why is there a reference to SR1.5°C here but not to the SRCCL, which assessment land-based mitigation options ina far more comprehensive way that the SR1.5°C?	Taken into account. The top statement of the need for extensive land based mitigation is based on SR1.5C. The botttom statement of the trade offs involved is based on assessment of section 12.5, in which a reference to SRCCL is made.	Sarah Connors	IPCC WGI TSU	France
39847	4	31	4	36	Please be clear if this message is just from SR15 or based on new findings since SR15.	editorials will be applied.The top statement of the need for extensive land based mitigation is based on SR1.5C. The botttom statement of the trade offs involved is based on assessment of section 12.5, in new literature since SR1.5C is cited.	Hasegawa Toshihiro	National Agricultural and Food Research Organization	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
5357	4	33	4	33	We have to be careful when write about this aspect because of the competence for lands between plants that produces biodiesels and plants that produces human and animal foods, and the impacts over biodiversity.	Taken into account. That trade-offs is mentioned in the following lines of the statement.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
43403	4	37	4	43	This section needs to point out the two key issues around land-based mitigation: Permanence and the high-dependence on robust, locally appropriate policy design. The summary needs to point out differences in permanence (risk of reversal) between different removals, and it would seem that this is the place to do so.	Taken into account. ES statement revised taking on board the reviewer comment. The revised statement addresses explicitly the sustainability aspect of land-based mitigation as well as the policy design.	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
34995	4	37	4	44	limitations of a wide range land-based mitigation that aggravate infectious diseases including vector-borne and water-borne diseases	Noted. Reference is already made in the statement to human and ecosystem health implications	Adugna Gemeda	Ethiopian Public Health Institute	Ethiopia
32675	4	0	5	43	Comment for executive summary in general: Would it be useful to explicitly mention "behaviour" or "behavioural change"? Both supply and demand side can be interpreted as behaviour change, but simple non-jargon language will help reader comprehension.	Rejected. Demand side factors such as behavioral changes are well discussed in the text (see 12.4) and also in chapter 5. Nonetheless, there are no significant results in the context of chp 12 to be elvated to ES	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
3265	4	1	5	42	Congratulations to the wrting team of this chapter and executiuve summary: very well done and already in very good shape although a difficult task!	Noted.	Klaus Radunsky	retired from Umweltbundesamt	Austria
39721	4		5		Suggest including more explanation in the executive summary. It may be hard for executives to understand the major substance of the chapter by skimming over the executive summary.	Taken into account. ES revised taking on board this and other comments, providing more details when possible.	Jinsun Lim	International Energy Agency (IEA)	France
5931	4	6			It's not clear to me why once again Biomass/Bioenergy is an appendix rather than a standard section of the Chapter eg 12.4 Food Systems; 12.5 Biomass and bioenergy; 12.6 Impacts, risks and opportunities from land-based mitigation. It is probably locked in as an appendix from the original scoping meeting so cannot be changed - but it makes little sense to be located where it is. However, there is no mention at all of the appendix in 12.1.2 Chapter Content.	Taken into account. Bioenergy appendix is moved inside and replace by text where a new section is added.	Ralph Sims	Massey University	New Zealand
43991	4	11		20	here and elsewhere missing mentioning of nature-based solution options, espcially potential of ecosystem restoration. Looking at P1 of SR 1.5 this appears as the most important baseline CDR approach which would also benefit biodiversity.	Rejected. A number of CDR options can also be condsidered as nature-based solutions and are mostly covered in Ch7. "Blue carbon" is the only potential NbS considered in Ch12, so it is not appropriate to use the term in this sentence, as it covers mostly CDR that would not be considered NbS.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
43643	4	12			The central cost estimate for DACCS is not wrong but lacks context. Cost estimate for 2020? Or for 2050? Also EW. Possibly the full cost range is higher: more than $1000 now for first real deployments (although the companies claim differently), and even below $100 in 2050 as some literature claims (Breyer et al 2019)	Accepted. Context and time frame will be added.	Felix Creutzig	MCC Berlin	Germany
43925	4	23		27	Would be useful to mention dairy products here as well.	Noted. Meat (specially red meat) is mentioned here just for emphasis. Section 12.4 included discussion of implication of various food system ingridients including diary products.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
5937	4	28			Give an example of an "emerging food chain technology" as is not clear for many readers.	Taken into account. An example is provided.	Ralph Sims	Massey University	New Zealand
43927	4	31		36	here and elsewhere missing mentioning of nature-based solution options, especially potential contribution of the restoration of natural (!) ecosystems to mitigation under conditions of ambitious emissions reduction. Looking at P1 of SR 1.5 this appears as the most important baseline CDR approach which would also benefit biodiversity whereas increasing use of BECCS challenges biodiversity as correctly stated. It seems some biological expertise is missing and needs to be drawn into the chapter...	Rejected. Nature based solution is not considered as a separate group of CDR but rather a composite of a number of CDR options that are are discussed in either chapter 12 or chapter 7.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
5939	4	31			Why quote SR1.5 directly? Better to say: "Limiting warming to 1.5oC requires extensive land-based mitigation - thus confirming the findings of SR1.5."	Accepted. Statement is revised to take the comment on board. Reference to 1.5C is removed.	Ralph Sims	Massey University	New Zealand
43405	5	2	5	3	Rather than just 'renewable energy' this point seems to be about low-carbon power sources.	Accepted. Statement is revised taking on board this comment.	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
11133	5	3	5	3	Add "electrification" as an examples of mitigation actions used in more than one sector; "Examples of mitigation actions used in more than one sector include renewable energy technologies, electrification, carbon capture and storage (CCS) and fuel cells."	Accepted. Electrification is added as an example	Midori Sasaki	industrial organization	Japan

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
39037	5	3	5	3	Carbon Capture and utilisation (CCU) should be added in this sentence. Even if no exhaustive quantification exists today on the mitigation potential of CCU technologies, the key role of this concept should be considered as one building block in a portfolio of mitigation measures (e.g. GCI, 2016, Grüber et al., 2018, IEAGHG, 2019b, Detz and Zwaan, 2019). CO2 utilization will contribute to curbing CO2 emissions with an estimated potential impact of gigatons equivalent CO2 emissions, similar or even superior to the impact of CCS and biofuels, but with a lower cost for society (Ampelli et al., 2015). CCU technologies have the potential to utilize up to 8 Gt of CO2 per year by 2050 (GCI, 2016, Hepburn et al., 2019), this is equivalent to approximately 15% of current global CO2 emissions (GCI, 2016). Moreover, the key role of CCU as a vector to move away from fossil fuel resources and the potential move to a CO2 circular economy should be recognized and discussed adequately in this AR6 (e.g. Bruhn et al., 2016, Daggash et al., 2018). (REFERENCES: Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43./ Daggash et al., 2018, Sustainable Energy Fuels, 2, 1153-1169/ GCI, 2016: Global Roadmap Study of CO2U Technologies, LUX Research & Global CO2 Initiative./ Grüber et al, 2018: A low energy demand scenario for meeting the 1.5 C target and sustainable development goals without negative emission technologies', Nature Energy, 3, 6./Detz and Zwaan, 2019, Energy Policy, 133, 110938./ Hepburn et al., 2019: The technological and economic prospects for CO2 utilization and removal, 575, 87-97./IEAGHG, 2019b: Exploring Clean Energy Pathways: the role of energy storage, International Energy Agency/ Ampelli et al., 2015: CO2 utilization: an enabling element to move to a resource and energy-efficient chemical and fuel production, Phil.Trans.R.Soc.A, 373.)	Accepted. CCS is changed to CCUS. References provided are added to Mendeley and will be considered for citation.	Célia Sapart	Université Libre de Bruxelles et Co2 Value Europe	Belgium
11135	5	4	5	4	Hydrogen is more inclusive than the fuel cells and thus the word "hydrogen (coupled with renewable energy technology)" shall be used instead of "fuel cells".	Editorials will be applied. Fuel cell will be replaced by Hydrogen.	Midori Sasaki	industrial organization	Japan
5359	5	4	5	5	I think that would be included the application of sustainable production and consumption patterns in all sectors and their integration	taken into account. The cross-sectoral aspects of supply and demand responses to mitigation is reflected in ES-10	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
6295	5	7	5	7	add "and water"	Rejected. Land is inclusive of water in a sense but also the confidence statement does not apply to water if added separately	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
35039	5	8	5	11	The paragraph does not fully convey the relevance of the cross sectoral integrated policy frameworks. Maybe, a solution for that is changing the order of elements in the paragraphs to better convey the relevance of such approaches.	Accepted. Statement is revised and more details and better flow is provided.	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
39849	5	8	5	11	The sentence(s) seems incomplete. Please specify synergies and trade-offs between what. Between different mitigation measures or mitigation and adaptation?	Editorials will be applied. Statement is revised to provide more context and substance.	Hasegawa Toshihiro	National Agricultural and Food Research Organization	Japan
25253	5	9	5	9	Delete "literature"	editorial is applied.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
29339	5	9	5	9	"studies literature" appears to be a duplicate	editorial is applied.	Catharina Latka	University of Bonn	Germany
6297	5	12	5	12	"competitiveness"	editorial is applied.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
43853	5	12	5	12	carbon leakage is a very specific term, suggest adding a couple of words as a definition	Taken into account. Reference is now made to chapters 3 and 13 for framing and definition.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
39851	5	12	5	19	Please use plain language.	Accepted. editorial applied -- see revised text of ES.	Hasegawa Toshihiro	National Agricultural and Food Research Organization	Japan
25255	5	16	5	19	Delete "Part of the later result … (medium evidence, medium agreement)."	Taken into account. The results on "green pardox" are no longer in the Executive Summary	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
38155	5	20	5	20	why only to renewables? To decarbonise we need sufficiency measures which reduce the demand for energy services such as biking lines, efficiency measures to improve energy systems such as insulation of buildings and renewables to supply with decarbonised energy sources. By recommending to redicrect finance only to RE, we will not decarbonise because the demand will continue to go up	Taken into account. The statement is replaced with a broader statement focusing on cross-sectoral aspects and where the reference to specific low carbon options is removed	Yamina Saheb	OpenExp, Ecole des Mines de Paris	France
25257	5	20	5	23	Delete "Diversion of finance … (medium evidence, high agreement). {12.6.4}"	Accepted. The statement is removed from the Executive Summary	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
39719	5	21	5	21	"Yet, Agriculture" should be changed into "Yet, agriculture"	Noted. The statement is no longer in the Executive Summary	Jinsun Lim	International Energy Agency (IEA)	France
35041	5	24	5	27	Only two examples are given to discuss the broader issue of new financing models and approaches to leverage cross-sectoral synergies and manage trade offs. Although valid, more examples could better present the idea behind the new models, or otherwise, indicate that there are not many other models.	Accepted. Statement revised with broader reference to PPP and no specific examples	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
39853	5	24	5	27	Please reconsider the topic sentence to show how and/or why the "Result-Based Blended Finance" approach can enhance synergies and manage trade-offs among sectors.	Accepted. statement revised to focus on broader reference to PPP and no specific examples	Hasegawa Toshihiro	National Agricultural and Food Research Organization	Japan
47705	5	24	5	27	https://www.euractiv.com/section/climate-environment/opinion/mondaycop21-goals-an-alternative-path-to-success/	Noted. Reference is considered.	Jacques de Gerlache	GreenFacts	Belgium
25259	5	25	5	27	Delete "The World Bank group … addressing these issues (limited evidence, high agreement)."	Accepted. The statement is replaced with a broader one focusing on PPP	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
34997	5	28	5	42	co-benefits and trade-offs, the case of iwater-based development efforts (water harvesting, irrigation) to ensure food security require proper management in collaboration with the health sector	Taken into account. The focus of chapter 12 is the cross-sectoral aspects of co-benefits and trade-offs. Chapter 7 deals with co-benefits and trade-offs for development related to agriculture and land including water issues.	Adugna Gemeda	Ethiopian Public Health Institute	Ethiopia
46745	5	28	5	42	Besides improved understanding of co-benefits decision-making processes and cretieria need to be improved in order to better harvest existing co-benefits, which was one of the conclusions in a recent major review on climate policy co-benefits (Mikael Karlsson, Eva Alfredsson & Nils Westling (2020) Climate policy co-benefits: a review, Climate Policy, DOI: 10.1080/14693062.2020.1724070); thi ought to be reflected in the Executive summary.	Taken into account. Criteria for decision making processes are discussed in chapter 13 and it includes synergies and co-benefits. The reference is added to Mendeley and is considered for citation.	Mikael Karlsson	KTH Royal Institute of Technology	Sweden
34999	5	35	5	35	describe more potential side effects related to infectious diseases associated with vector-borne diseases	Taken into account. Synergies and trade-offs of mitigation related to SDGs including health impacts are discussed in more details in section 12.6.	Adugna Gemeda	Ethiopian Public Health Institute	Ethiopia
29341	5	35	5	38	These sentences appear repetitive and without much new information compared to the previous part of the paragraph. Could the statement either be summarized or could some new details be added?	Editorials applied. Sentences revised to remove repetition.	Catharina Latka	University of Bonn	Germany
35001	5	38	5	40	mitigation options in the health sector possibly consider vaccine for vaccine-preventable diseases	taken into account. Mitigations options in the health sector are dealt with in other chapters, for example see chapters 5 and 9.	Adugna Gemeda	Ethiopian Public Health Institute	Ethiopia
42343	5	40	5	41	I read : « Other considerations include society's future dependence on carbon-based energy and materials, [...] » Since such « carbon-based energy and materials, » may involve fossil carbon, non fossil carbon, or both… it may be valuable to provide this info. (See also my comments on « decarbonisation » in Annex A.)	Taken into account. Details are discussed in the sections referenced in the statement. For space constraint can't include in ES.	Raymond Zaharia	Le Club des Argonautes http://www.clubdesargonautes.org	France
29343	5	40	5	42	"requirement for negative emissions" - I am not sure how this shall be understood. The wording could be clarified.	Editorial applied. Wording fixed.	Catharina Latka	University of Bonn	Germany
38153	5	1	7	20	One of the examples of mitigation options which should be considered in all sectors are those that reduce teh demand for energy services and which are usually grouped under sufficiency measures. By focusing only on technologies RE and CCS, energy demand will go up and these technologies won't be able to deliver. See chapter 5 and 9 to better capture sufficiency measures in different sectors	Taken into account. Will consider reflecting synergies and trade-offs resulting from demand side options such as "sufficiency" based on chapters 5 and 9 assessments.	Yamina Saheb	OpenExp, Ecole des Mines de Paris	France
5941	5	9			Delete "literature"	editorial applied. Sentence fixed.	Ralph Sims	Massey University	New Zealand
43647	5	12			Coordinate with Chapter 14. They are also oin this, similar message.	Accepted. Focus now only on cross-sectoral aspects of governance	Felix Creutzig	MCC Berlin	Germany
43649	5	20			Coordinate with Chapter 15.	Accepted. Focus now only on cross-sectoral aspects of finance while other issues are moved to chapter 15	Felix Creutzig	MCC Berlin	Germany
43929	5	28		42	This is a rather vague concluding bullet where one wonder whether some ranking of mitigation options and their synergies could be provided.	Taken into account. Now more discussion of the comparability of the different options is included in section 12.6 but no substantive conclusion emerged yet to be elvated to ES.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
43651	5	28			Chapter 5 has an effort under way to code demand-side options in terms of wellbeing and SDG trade-offs and synergies. Quite a bias towards synergies. Could flow into 12.6.2. Please shoot an email to Ch. 5 CLAs.	Accepted. We are in discussion with chapter 5 on coordination.	Felix Creutzig	MCC Berlin	Germany
6299	6	12	6	12	extra space	editorial is applied.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
17371	6	16	6	20	According to discussions held during COP25 and lack of international consensus in IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels, the mentioned texts should appear to be reviewed.	Rejected. SR1.5C is an approved IPCC report that can legitimately be referenced and quoted for AR6 report.	Zeyaeyan Sadegh	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
35043	6	18	6	19	It will be important to address or at least clarify the knowledge gaps encountered. There are spaces in the document left blank where knowledge gaps are anticipated. Thus, it will be important to have a discussion on whether there are any kind of recommendation to deal with those gaps.	Accepted. More text is added to indicate and explain where there are knweldge gaps	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
29345	6	38	6	43	Reading through the content descriptions it comes a bit as a surprise that "implications for food security" (line 42) are assessed in section 12.5 and not mentioned in the description of section 12.4 on food systems. Maybe add a sentence on this to the 12.4 description or repeat once more that in 12.5 implications do not refer to direct food system consequences.	Taken into account. The section and texts revised along with restructuring of the actual sections. Now the discussion of food systems including food security is contained in one section.	Catharina Latka	University of Bonn	Germany
38157	6	21	7	13	You should add a section on non-technological mitigation options. Again, have a look to Chapter 5	Taken into account. More discussion of Demand side and other non-technological mitigation options are now better reflected in the chapter, e.g. elements related to ciruclar economy and dietary changes referencing chapter 5, but not a complete section on non-technological options.	Yamina Saheb	OpenExp, Ecole des Mines de Paris	France
45097	7	4	7	6	The definition of the cross-sectoral mitigation technologies based on (i)-(ii) can also be used to make referral to urban systems, including the linkages based on Figure 8.30 (page 61 of Chapter 8).	Taken into account. The section is revised to better reflect the cross-sectoral perspectives. In that respect other cross-sectoral mitigation options such as urban planning and other non-technological options are addressed	Siir Kilkis	The Scientific and Technological Research Council of Turkey	Turkey
5361	7	6	7	6	Add: ….interaction and integration between sectors,……	Rejected. Interaction is broad enough to include integration	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
35045	7	10	7	12	This paragraph discusses governance across various "means", technologies and options for implementation of mitigation efforts, described in detail in section 12.7. However, in the latter, there is not discussion of other means different from CDRm food systems and land-based mitigation, which are referred to in the paragraph being commented. This is, the word means is useless because there are not other means addressed in the appropriate section ahead in 12.7. One item that is not discussed and maybe here is the moment to address that is that governance should encompass the idea of providing opportunities to people being affected by decisions to be part of the decision process. In that regard, maybe effective governance could occur when all stakeholders - or interested parties for that matter- have the ability to take part in the decision process.	Taken into account. Section 12.7 is now revised to better reflect the cross-sectoral aspects of governance across all sectors and not limited to CDR, food system, and land-based while taking the coordination with chapter 14 on board. The paragraph is revised to reflect that restructuring.	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
45099	7	14	7	14	The referral to sectoral interactions between urban systems and energy systems in Table 12.1 is limited to energy demand and waste, which may be diversified. Related content can be contributed based on Figure 8.30 from Chapter 8.	Taken into account. The table is revised and use is made of Figure 8.30 to reflect other aspects of interaction with urban systems	Siir Kilkis	The Scientific and Technological Research Council of Turkey	Turkey
5943	7	12	8		The row and column headed Ch 12 are not useful here and should be deleted as they add nothing to the Table.	Taken into account. Table 12.1 is revised taking on board your comments and others as well.	Ralph Sims	Massey University	New Zealand
8589	7		8		In Table 12.1, The last row chapter 12, there is no contents.	Taken into account. Table 12.1 is revised taking on board your comments and others as well.	Suyi Kim	Hongik University	Republic of Korea
39723	8	12	8	13	Need clarification of the meaning of "Different type of potentials" and relocating the sentence before the sentence of "the term 'mitigation cost'…". It's a bit confusing since it refers to socio-economic or techno-economic potential, but located between the two sentences about costs. Does the different type of potentials refers to socio-economic or techno-economic potential (potential reduced emissions), or socio-economic / techno-economic costs?	Not relevant anymore. The definitions of mitigation potentials were too complex. We have completely redone them (also in the Glossary). Hope it is clearer now.	Jinsun Lim	International Energy Agency (IEA)	France
39725	8	14	8	16	Suggest rewriting "Private specific costs are based on market prices, while social specific costs reflect market prices, but also take externalities associated with the mitigation into consideration" to "Private specific costs are based on market prices, while social specific costs reflect not only market prices but also externalities associated with mitigation"	Not relevant anymore. The definitions of mitigation potentials were too complex. We have completely redone them (also in the Glossary). Hope it is clearer now.	Jinsun Lim	International Energy Agency (IEA)	France
29347	8	16	8	18	It reads as if you derive the social costs by applying a social discount rate only - but if the costs related to externalities are included by some kind of accounting, the wording could be changed to make this clearer.	Taken into account. Has been clarified now by completely redoing the definitions of mitigation potentials.	Catharina Latka	University of Bonn	Germany
46933	8	26			I would suggest an updating of the literature on how bottom-up marginal abatement costs are included in top-down models given in Weitzel, M., B. Saveyn, T. Vandyck. 2019. “Including bottom-up emission abatement technologies in a large-scale global economic model for policy assessments.”Energy Economics 83: 254-263 doi:10.1016/j.eneco.2019.07.004	Rejected. The comment and the literature reference is too specific about one modeling exercise, whereas the statement is rather about the whole universe of IAM models.	Taran Fæhn	rerserach institute	Norway
39727	9	5	9	14	The table 12.2 and the paragraph starts from line 5, compare SSP2-4.5 with WEO Currenty Policies Scenario. However, it will be more reasonable to choose a different scenario of the World Energy Outlook, the Stated Policies Scenario (STEPS), given the assumptions of the SSP2-4.5 and STEPS.	Rejected. Many potential estimates use a Current Policies scenarios, therefore we prefer to stick with that scenario, that was still reported in WEO 2019.	Jinsun Lim	International Energy Agency (IEA)	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
25261	9	5	9	15	IEA's WEO 2019 baseline is not the "current policy scenario" but the "stated policies scenario". Please revise accordingly	Rejected. Many potential estimates use a Current Policies scenarios, therefore we prefer to stick with that scenario, that was still reported in WEO 2019.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
42345	9	13	9	14	The words "primary energy" & "final energy" expressed in EJ yr-1, (as well as the third term of the energy cascade: "useful energy"), should be explained here, or included in annex A. (See also my comments on Annex A.) N.B Useful energy = final energy less waste & losses at end user level.	Rejected. Primary energy use, final energy use, and useful energy service are considered standard and widely known concepts that would not need to be defined here.	Raymond Zaharia	Le Club des Argonautes http://www.clubdesargonautes.org	France
28905	9	23	9	31	Please don't forget to add some parts that still empty	Taken into account. The table is now nearly completely filled. Only for a few options no data were available.	Marissa Malahayati	National Institute for Environmental Studies	Japan
8591	9	24	9	26	There is no contents.	Taken into account. The table is now nearly completely filled. Only for a few options no data were available.	Suyi Kim	Hongik University	Republic of Korea
43653	9	12			3.4% CAGR is an extrapolation of historical trends that is contested both by neoclassical scholars (Summers, secular stagnation) and by a large body of literature that suggest that policies should focus on wellbeing not on growth (see large body of OECD literature for example). Conisder also that the world's population growth is levelling off. If WEO 2019 is kept as benchmark, then also introduce an additional scenario that focusses on wellbeing not growth.	Rejected. We just follow WEO as this is the most widely used energy baseline. A wider range of economic developments is treated in Chapter 3.	Felix Creutzig	MCC Berlin	Germany
17421	9				It should be noted some cases that mitigation and adaptation contradict.	Rejected. This section is only about mitigation. I do not know concrete examples where adaptation and mitigation contradict.	Zeyaeyan Sadegh	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
8593	10	3	10	4	There is no contents.	Taken into account. This was a placeholder, is expanded in the SOD.	Suyi Kim	Hongik University	Republic of Korea
39039	10	6	10	6	In this table, CCUS should be replaced by CCU! And some more numbers and more updated references should be added. See e.g. Table 2 of Hepburn et al., 2019 (Hepburn et al., 2019: The technological and economic prospects for CO2 utilization and removal, Nature, 575, 87-97.)	Rejected. This is about mitigation potentials, CO2 utilization is not necessary mitigation. Also, the numbers in the Hepburn et al. paper are for 2050, not for 2030 as intended in this table.	Célia Sapart	Université Libre de Bruxelles et Co2 Value Europe	Belgium
8595	10	6	11	11	Table 12.3 and Table 12.4 is incomplete.	Taken into account. The tables are now nearly completely filled.	Suyi Kim	Hongik University	Republic of Korea
5945	10	6			This is an ambitious attempt to group technologies with high variability based on data from each technology chapter. Rather than title it "Detailed overview" it would be better titled "Indicative assessments of" since there are high degrees of uncertainty. Table 12.4 also presents the total mitigation potential from across all sectors for each cost category. This will be of interest given the AFOLU data alone gives a total potential between 46.6 and 58.4 Gt CO2e But is such a comparison realistic if the total potential significantly exceeds present or projected BAU total emissions?	Taken into account. The term detailed will be skipped. The term indicative assessment will not be used, as this doesn't justice to all the values in the table. But the text will deal with all the uncertainties. The AFOLU numbers have changed now. Note they to a large extent deal with sequestration, so can be larger than the emissions.	Ralph Sims	Massey University	New Zealand
28907	11	1	11	19	Complete the info for Table 12.4 and 12.5	Taken into account. Table 2.4 is now completely filled, and table 2.5 partly. The latter will be completed in the final version.	Marissa Malahayati	National Institute for Environmental Studies	Japan
29349	11	14	11	14	Maybe add to "with less quantitative details" that you use a qualitative approach here to remind the reader.	Accepted. Will add the wording.	Catharina Latka	University of Bonn	Germany
8597	11	16	11	19	Table 12.5 is also incomplete, Specially Energy sector, Agriculture, forestry and other land use, Buildings and Transport.	Accepted. Table 2.5 is now partly completely. The remainder will be completed in the final version.	Suyi Kim	Hongik University	Republic of Korea
8599	12	4	12	4	The specific description or references for IAMs should be added.	Partly accepted. We make reference to the AR6 database, more detail in Chapter 3.	Suyi Kim	Hongik University	Republic of Korea
29351	12	12	12	16	Figure 12.1 provides a good overview. I wonder if it should not be "CO2 e" in the legend rather than "CO2". Also, one could think of showing the emission reductions on a negative axis to show the decrease more intuitively.	Parlty taken into account, partly rejected. Completely new pictures are added, will take care that everywhere we refer to CO2-eq. Negative axis is not an improvement, we think.Completely new pictures are added, will take care that everywhere we refer to CO2-eq. Negative axis is not an improvement, we think.	Catharina Latka	University of Bonn	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
11429	12	1	13	8	Section 12.2.4 (Comparison between sectoral results and results from integrated assessment models): Mitigation targets/scenarios/pathways also need to take into account indirect emissions (scope 3) of sectors as these differe across sectors and have implications on how fast and how complete mitigation can be achieved. See e.g.: Li, M., Wiedmann, T. and Hadjikakou, M. (2020 Enabling Full Supply Chain Corporate Responsibility: Scope 3 Emissions Targets for Ambitious Climate Change Mitigation. Environmental Science & Technology, 54(1), 400-411. https://doi.org/10.1021/acs.est.9b05245	Rejected. This is a very interesting paper! But not relevant for the current discussion. Bottom-up/sectoral in Chapter 12 means technology-specific. That is different from the meaning in the Li et al. paper, in which they mean non-state initiatives.	Thomas Wiedmann	UNSW	Australia
18847	12		80		The concept of cryogenic removal of carbon dioxide uses heat exchangers and a design process developed as part of the cryogenic carbon capture.	Rejected, cannot locate this comment.	Michael Ugom	University of Nigeria, Nsukka	Nigeria
5947	12	12			The legend of Figs 12.1 (and 12.2) states CO2 whereas the y-axis label is CO2e. Also can cause confusion by quoting here "carbon price" in the x-axis whereas in Tables above the term "Cost categories" is used. Being inconsistent in terminology does not help the reader.	Accepted. Will correct both.	Ralph Sims	Massey University	New Zealand
43407	13	10	13	10	I would suggest to use the same definition as used in the Glossary (this one is missing "durably" or "permanently" or "over extended periods of time"; and the term "sequester" is not as common as "store".	Accepted	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
39601	13	10	13	11	All CDR technologies are not proven to really and or permanently remove or sequester GHG, so the sentences should be nunaced to say "supposed to" remove, sequester... etc.	Rejected - this is simply the definition of CDR, and there's no scientific evidence and publication provided to support changes suggested by the reviewer	SILVIA RIBEIRO	ETC Group	Mexico
43409	13	10	13	16	This section should clarify that a "CDR option" is not just the hardware, but comprises of the wide definition of "technology" thereby highlighting the intricate link between what's conceived as the technological hardware, the actual practice of putting hardware to work, and the policy that enables the practice and/or development of the hardware. I suggest to do that as follows: Most if not all CO2 removal approaches require a change in behavior, an investment in infrastructure and/or an operation of that infrastructure, which depend on regulation ad/or financial incentives. Success or failure of the above appears intimately connected to the design of policies meant to enable the correponding measures. Honegger, M., & Reiner, D. (2018). The political economy of negative emissions technologies: consequences for international policy design. Climate Policy, 18(3), 306-321. Cox, E., & Edwards, N. R. (2019). Beyond carbon pricing: policy levers for negative emissions technologies. Climate Policy, 19(9), 1144-1156.	Taken into account - some clarifications added in 12.3.1	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
48	13	10	13	21	The climate system response and carbon cycle response to CDR are assessed in Chapter 4 and Chapter 5 of WG1 report. A linking statement can be provided here. The various CDR options and their potential are also discussed there.	Accepted - link to WG1 ch 4&5 now provided in text	Govindasamy Bala	Indian Institute of Science	India
39603	13	14	13	16	This assessment is not proven or gounded. There is not any proof that is would be more "permanent" storage. Sentence should be deleted	Rejected - there's no scientific evidence and/or publication provided to support changes suggested by the reviewer	SILVIA RIBEIRO	ETC Group	Mexico
42439	13	14	13	16	Suggested rewrite: "....whereas the technological CDR options tend to have higher costs, higher research, development & demonstration (RD&D) needs but the potential advantage of more permanent CO2 storage, such as in geologic and ocean inorganic carbon reservoirs (Figure 12.3)."	Taken into account - general line of argument integrated	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
9603	13	17	13	18	The statement refers to descriptions of CDR technologies in Section 12.5 and Chapter 7 - but none of these sections contain a more elaborate description of BECCS. The report (AR6) needs a better and more exhaustive description of BECCS, especially in consideration of the crucial importance the technology has for emission scenarios meeting the Paris agreement. Such a description should focus on various point sources of biogenic CO2 and their potential to contribute to climate change mitigation.	Taken into account - BECCS extensively covered by chapter 6 & 7, now included as additional cross reference. Also mentioned that 12.3.3 synthesizes land-based CDR options	Jesper Kløverpris	Novozymes	Denmark
37847	13	17	13	21	I suggest that BECCS should be treated in more detail in this chapter than is indicated in this paragraph. BECCS potential depends also on developments in sectors other than AFOLU, especially transportation and power generation. There are clear dependencies across these 3 sectors and alternative pathways in any of them will have substantial implications on the others, and particularly so for IAM results. HIgher EV penetration will reduce the potential for BECCS liquids but drive up demand for electricity, while cost reductions in renewable power generation and storage options will reduce potential of BECCS electric. Neither of the individual sector chapters can capture these interlinked dynamics individually and ch 12 seems like the natural place to do so. It would be important to provide a bottom-up sectoral counterpoint to the ch3 analysis of these dynamics likley to come from the perspective of IAM results. A paper I am leading should be published soon explores these dynamics in the context of Brazil using a national IAM but bringing attention to potential sectoral interactions. We would be happy to share a draft if helpful.	Taken into account - BECCS extensively covered by chapter 6 & 7, now included as additional cross reference. Also mentioned that 12.3.3 synthesizes land-based CDR options. Bottom-up analysis would need to come from sectoral chapters. Even if one wouldn't need to differentiate between the respective feedstocks used, it doesn't make sense to look at BECCS 'as such' but only in specific sectors (like energy, transport, industry)	ALEXANDRE KOBERLE	COPPE/UFRJ	Brazil

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
16689	13	9	14	5	It seems we need to give more precise role of research and development (R&D) on CDR by providing applicable information.	Taken into account - intro of CDR section 12.3 is the wrong place for going into details on R&D. Briefly dealt with in 12.3.1 and 12.7.1, plus in chapter 16.4.3	Mostafa Jafari	Head of TPS for LFCCs/ and IPCC LA	Iran
16691	13	9	15	34	For forestry sector, if possible, I recommend to provide an excel table for natural and human made removal. Management and mismanagement/ addition or reduction.	Rejected - outside the scope of this chapter (falls into scope of chapter 7)	Mostafa Jafari	Head of TPS for LFCCs/ and IPCC LA	Iran
47421	13	9	24	2	This section is missing a discussion of Solar Radiation Management. Developments in both research and institutional activity since AR5 warrant treatment at the section (12.x) level. Following the template for DACCS: Status: SAI and MCB research is still early and very little technology has been developed - however, plans for field experiments (Keith 2014, Wood 2017, Dykema 2014) have matured substantially in the light of recent assessments (National Academies 2015) and modeling results (Tilmes 2018, Kravitz 2018). Two leading field experiment candidates (Harvard University SCOPEX and University of Washington LAFE) have received philanthropic funding but have not yet deployed. The 2015 National Academy of Sciences assessment highlighted the need for an integrated SRM research agenda, which led to the formation of a new NAS study panel in 2018 to formulate this agenda as well as a research governance plan. This work is still ongoing, with publication scheduled for Aug 2020. In 2019, an NGO successfully lobbied the United States Congress to include federal support for climate intervention research in its 2020 budget (Wanser 2019). Research efforts in other countries, primarily consisting of modeling studies and governance research, most with modest philanthropic or governmental support, including a substantial research effort in China (United States 2017). Several proposals have noted the 'dual-purpose' potential for solar radiation management research to reduce key climate uncertainties, such as aerosol-cloud interactions and stratospheric chemistry (NAS 2015, Wood 2017, Fahey 2020). Costs: Recent analyses of SAI incorporating aircraft engineering design considerations and payload/flight plan estimates from recent modeling studies have estimated an annual cost of $2.25B per annum in direct delivery costs to achieve a radiative forcing of -0.25W/m^2 per year (Smith 2018). Informal expert polling suggests an equivalent MCB system would cost $3-4B per year. Programmatic budgets estimates that layer in comprehensive support functions (such as observational platforms for monitoring deployment, model analysis, personnel, security, and governance and reporting) suggest a likely operational cost of a global SRM capability of $15-20B per annum using either SAI or MCB approaches (Wanser 2019). Potential: Recent modeling studies have suggested that SAI could feasibly offset most or all of the global temperature increase projected for an RCP 8.5 emissions pathway (Tilmes 2018), or support intermediate climate targets by partially reducing warming ("peak shaving") to reduce climate damages while other mitigation options are scaled (Tilmes 2019a). Global assessments of the potential for MCB approaches suffer from a lack of research in deployment strategies, but have bounded radiative forcing potential between- 0.6 and -4 W/m^2 per year (Stjern 2018, Jones 2009), including the potential for MCB to offset a doubling of CO2 (Jones 2009). Recent observational studies of the radiative forcing from ship tracks and other anthropogenic sources of tropospheric aerosol suggest that current inadvertent anthropogenic cloud brightening produces a significant effect, and that replacement of this inadvertent effect with a less pollutive intentional perturbation may be warranted. There is potential to deliberately replace the radiative cooling from tightening pollution controls with MCB methods (Shand 2020, Diamond 2020). A number of proposals have been made for applying MCB locally or regionally to mitigate warming impacts including cooling ocean temperatures to reduce heat stress on coral reefs and to cool ocean surface temperatures to reduce the force and precipitation of storms. (Royal Society, 2012, NAS, 2018) Shand, L., Roesler, E.L., Staid, A. and Lyons, D., 2019, December. Data-driven inferences for aerosol and marine low-cloud interactions using ship-based databases and open-source satellite imagery. In AGU Fall Meeting 2019. AGU. Smith, Wake, and Gernot Wagner. "Stratospheric aerosol injection tactics and costs in the first 15 years of deployment." Environmental Research Letters 13, no. 12 (2018): 124001. https://doi.org/10.1088/1748-9326/aae98d	Rejected - SRM is outside the scope of this chapter (mainly WGI, but als chapters 14 and 16)	Kelly Wanser	SilverLining	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
47421	13	9	24	2	Risks & Impacts: The mass and energy requirements to achieve substantial radiative forcing using SAI are not prohibitive and total contribution of SAI activities to GHG emissions are negligible (Wake 2018). Direct risks of solar radiation management are centered on the potential for unforeseen climate responses to changes in radiative forcing via SRM, including hard-to-predict changes in precipitation, circulation and cloud systems. Other risks include the influence of changes in the composition of inbound solar radiation on biological species and the effects of SRM materials on atmospheric chemistry, notably the potential for increases or decreases in stratospheric ozone. These must be weighed against the escalating risks of insufficiently mitigated climate trajectories (Irvine 2019), which include many similar concerns. Recent work has successfully demonstrated a degree of regional control of SAI to meet specific temperature targets in physically-plausible model simulations, illustrating the potential for additional research into SRM deployment strategies to meet multiple climate goals (Kravitz 2019). Engineering studies suggest there are significant cost-efficiency benefits to designing custom aircraft that are capable of delivering adequate mass to the required altitudes, suggesting that research could also contribute to cost-minimization and other innovation benefits. (Bingaman 2020). Co-Benefits: Many recent scenario analyses of SAI and MCB deployment focus on the social welfare advantages accruing from their inclusion in climate mitigation portfolios under technological and scientific uncertainty (Helwegen 2020, Heutel 2015, Roshan 2019). These analyses frame the role of SRM in terms of reducing the tradeoffs between sustainable development goals and climate risk and smoothing transitions to new socio-technical configurations (Macmartin 2014, 2018). Tradeoffs and Spillover effects: Modeling studies have found consistent but limited orthogonality in temperature and precipitation mitigation goals at global and regional scales (Irvine 2019, Roshan 2019). Concerns over governance and moral hazard are mitigated somewhat by the finding that informed public quickly grasp the "fast, cheap, and imperfect" character of SRM and understand their role in complementing other mitigation approaches (Mahajan 2018). Role in Mitigation Pathways: Economic models consistently find that including SAI as a policy option reduces the overall cost of mitigation and tends to postpone the timing of mitigation, due to their cost-efficiency versus CO2 mitigation (Heutel 2015, Roshan 2019). However, incorporation of “fat-tailed” distributions for potential climate risks outside the historical climate state temper the optimum amount of SRM used by an optimal planner (Harding 2016) suggesting that increased understanding of the risks of SRM could motivate mitigation. Current modeling efforts are investigating the ability of physically-plausible models of SAI to reduce damages in the P6 Overshoot Scenario SSP5-34-OS and SSP5-85 high emissions scenario, with the goal of enabling IAM analyses with comparable scenarios (Tilmes 2019b) but substantially more work is needed.	Rejected - SRM is outside the scope of this chapter (mainly WGI, but als chapters 14 and 16)	Kelly Wanser	SilverLining	United States of America
47421	13	9	24	2	Bingaman, Donald C., Christian V. Rice, Wake Smith, and Patrick Vogel. "A Stratospheric Aerosol Injection Lofter Aircraft Concept: Brimstone Angel." In AIAA Scitech 2020 Forum, p. 0618. 2020. https://doi.org/10.2514/6.2020-0618 Diamond, M., Director, H., Eastman, R., Possner, A. and Wood, R., 2019. Substantial Cloud Brightening from Shipping in Subtropical Low Clouds. Preprint 2020. https://www.essoar.org/doi/pdf/10.1002/essoar.10501145.1 Dykema, John A., David W. Keith, James G. Anderson, and Debra Weisenstein. "Stratospheric controlled perturbation experiment: a small-scale experiment to improve understanding of the risks of solar geoengineering." Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 372, no. 2031 (2014): 20140059. http://dx.doi.org/10.1098/rsta.2014.0059 Fahey, David. “Climate intervention (CI): A scientific perspective.” Presentation, ESRL Chemical Sciences Division Seminar, Boulder, CO, January 23, 2020. Harding, A. and Moreno-Cruz, J.B., 2016. Solar geoengineering economics: From incredible to inevitable and half-way back. Earth's Future, 4(12), pp.569-577. Helwegen, K.G., Wieners, C.E., Frank, J.E. and Dijkstra, H.A., 2019. Complementing CO2 emission reduction by solar radiation management might strongly enhance future welfare. Earth System Dynamics, 10(3), pp.453-472. https://pdfs.semanticscholar.org/99b4/a4062cdf050f90e32a6845ffdf24b7b457e8.pdf Heutel, G., Moreno-Cruz, J. and Shayegh, S., 2018. Solar geoengineering, uncertainty, and the price of carbon. Journal of Environmental Economics and Management, 87, pp.24-41. https://doi.org/10.1016/j.jeem.2017.11.002 Irvine, P.J., Kravitz, B., Lawrence, M.G., Gerten, D., Caminade, C., Gosling, S.N., Hendy, E.J., Kassie, B.T., Kissling, W.D., Muri, H. and Oschlies, A., 2017. Towards a comprehensive climate impacts assessment of solar geoengineering. Earth's Future, 5(1), pp.93-106. https://doi.org/10.1002/2016EF000389 Keith, David W., Riley Duren, and Douglas G. MacMartin. "Field experiments on solar geoengineering: report of a workshop exploring a representative research portfolio." Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 372, no. 2031 (2014): 20140175. https://doi.org/10.1098/rsta.2014.0175 Kravitz, Ben, Douglas G. MacMartin, Simone Tilmes, Jadwiga H. Richter, Michael J. Mills, Jean-Francois Lamarque, Joseph Tribbia, and William Large. "Holistic assessment of SO2 injections using CESM1 (WACCM): Introduction to the special issue." Journal of Geophysical Research: Atmospheres 124, no. 2 (2019): 444-450. https://doi.org/10.1029/2018JD029293 Kravitz, Ben, Alan Robock, Olivier Boucher, Mark Lawrence, John C. Moore, Ulrike Niemeier, Trude Storelvmo, Simone Tilmes, and Robert Wood. "The Geoengineering Model Intercomparison Project–introduction to the second special issue." Atmos. Chem. Phys. (2018) https://doi.org/10.5194/acp-special_issue376-preface MacMartin, D.G., Caldeira, K. and Keith, D.W., 2014. Solar geoengineering to limit the rate of temperature change. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 372(2031), p.20140134. MacMartin, D.G., Ricke, K.L. and Keith, D.W., 2018. Solar geoengineering as part of an overall strategy for meeting the 1.5 C Paris target. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2119), p.20160454. Mahajan, A., Tingley, D. and Wagner, G., 2019. Fast, cheap, and imperfect? US public opinion about solar geoengineering. Environmental Politics, 28(3), pp.523-543. National Research Council. Climate Intervention: Reflecting Sunlight to Cool Earth. Washington, DC: The National Academies Press, 2015. https://doi.org/10.17226/18988 Roshan, E., Khabbazan, M.M. and Held, H., 2019. Cost-risk trade-off of mitigation and solar geoengineering: Considering regional disparities under probabilistic climate sensitivity. Environmental and resource economics, 72(1), pp.263-279. https://doi.org/10.1007/s10640-018-0261-9	Rejected - SRM is outside the scope of this chapter (mainly WGI, but als chapters 14 and 16)	Kelly Wanser	SilverLining	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
43431	13	9	26	7	Entire section 12.3: The academic literature has barely started exploring potential implications of various CDR types across social objectives (such as captured by the SDGs). First attempts include Smith et al., 2018, Fuss et al., 2018, and Honegger et al., 2018. However none of these offer sufficient clarity on the degree to which policy instrument design will determine co-benefits or adverse side effects from CDR applications. This should be clearly stated as it represents a major challenge for climate policy design that is mindful of the broader objectives of the SDGs.	Taken into account - method specific SDG linkages dealt with in section 12.3.2 and 12.3.3. Broader governance and policy design issues on CDR-SDG link now integrated in section 12.7.1	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
34255	13	9	26	8	This chapter is innovative and relevant, but lacks a synthesis of the orders of magnitude between options (graphs?)	Accepted - dealt with in new 'CDR summary table'	Antoine BONDUELLE	Climate Action Network France	France
38095	13	10	26	7	Regarding the CDR options, most people are, in fact, not sure of or confident in the scaling-up of those even relatively applicable selections such as BECCS and AR, since they are mostly neither practical nor reliable as illustrated in the report. The concerns raised therein, however, remain to be well addressed and clearly explained. In addition, the IAM model itself focusing much on the CDR options, seems incapable of dealing with other possible choices, making the people even less assured of the conclusions or feasibility of implementing the CDR-based scenarios in the coming decades.	noted - no change (no action requested by reviewer, comment falls mainly in realm of IAM-produced knowledge, see ch3)	Xiusheng Zhao	Tsinghua University	China
43931	13	9			Chapter lacks consideration of CDR approaches combined with CO2 recycling through synthetic fuels or other uses? Also the capacities of these solution options in relation to the rate of anthropogenic emissions should be given.	taken into account - first issue now touched upon in opening sentence definition ('durably', "in products') and in DACCS section 12.3.2.1 (with Hepburn et al. 2019 reference); second issue (relation to rate of anthropogenic emissions) not entirely clear - dealt with by stating how much CDR is needed to reach net zero emissions	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
35047	13	17			Spell out A/R and BECCS this should be done consistently with other acronims across the document.	Accepted	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
41401	14	1	14	1	Figure 12.3. This figure is an over-simplification that does not give a correct representation of different CDR options. As the BECCS-case shows, the distinction between technical and natural/land-based is not meaningful. Moreover, biochar should also be represented as bioenergy-biochar systems which would also fall into the “combined” category. A representation like Figure 3 in Royal Society and Royal Engineering Society 2018 better explains the different CDR methods.	Taken into account. Figure 12.3 redesigned	Cecilia Sundberg	Swedish University of Agricultural Sciences	Sweden
42443	14	2	14	2	"Main Options……." should read "Primary options currently being considered for carbon dioxide removal….." so as not to imply that these are and will be the only options worth considering (see 16.4.3).	Taken into account. Figure 12.3 redesigned	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
50	14	2	14	5	"Ocean ion fertilization" is missing in the figure.	Taken into account. Figure 12.3 redesigned	Govindasamy Bala	Indian Institute of Science	India
28029	14	6	14	18	Please clarify that synthetic CDR methods hardly reduce carbon while increasing air pollution and mining, all at high cost, thus are opportunity costs: Jacobson, M.Z., The health and climate impacts of carbon capture and direct air capture, Energy and Environmental Sciences, 12, 3567-3574, doi:10.1039/C9EE02709B, 2019 found from actual plants that CCS/U and DACCS/U are both opportunity costs resulting in hardly any CO2 reduction, even before considering the disposition of CO2, and both result in air pollution and mining increases. Similarly, Sekera, J., and A. Lichtenberger, The carbon capture conundrum: Public need versus private gain, A public policy perspective on carbon dioxide capture, 2020, https://drive.google.com/file/d/1K-BIULOUtfSs5LVCS9ONaDzq7jeFmO-b/view conclude (1) many scientific studies pass carbon removal methods off as "climate mitigation" when in reality the methods in play today increase CO2 and (2) laws subsidizing carbon capture and direct air capture increase CO2.	taken into account - issue now dealt with in section 12.3.2.1, with the suggested paper cited	Mark Jacobson	Stanford University	United States of America
14215	14	7	14	9	"in the context of reaching and maintaining net zero emissions". Taking into consideration that all carbon sinks are limited within the biosphere, this sentence is wrong for the long-term and it should be rephrased	Rejected - CDR includes carbon sinks beyond the biosphere	Iñigo Capellán-Pérez	University of Valladolid	Spain
6117	14	7	14	12	Besides the 2 mitigation strategies mentioned, CDR can also be used to reduce atmospheric CO2 levels below current levels.	Rejected - no change since mentioning atmospheric concentrations would undermine the conceptual clarity of the argument (for 1.5C, end-of centrury atmospheric concentrations would need to be below current levels)	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
10681	14	7	14	12	How does CDR relate to mitigation? Is it one mitigation strategy, or what does the term 'complement' mean here exactly?	rejected - no change (CDR is - according to the UNFCCC - part of mitigation, but there's no need to highlight this in every sentence)	Felix Schenuit	University Hamburg	Germany
47205	14	7	14	18	The "overshoot" rationale for CDR is wrong. Net negative emissions are needed to prevent overshoot, not to respond to it. The overall best rationale for CDR is to prevent the committed warming from past emissions. There seems to be a mental block stopping recognition of this simple analysis.	Taken into account - added "to prevent or" to "return from" (there is not only one use)	Robert Tulip	Australian National University	Australia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
43411	14	9	14	9	Nothing about the return phase in peak-and-return scenarios is "quick". Please revise this sentence to reflect for the very serious issues associated with achieving and sustaining a net-negative emissions-balance! "Overshoot-and-return scenarios are highly problematic and the current text doesn't do justice to the issue: There are important intergenerational issues with putting the (potentially unfeasible) burden of Gt scale CO2-removals (on top of near-complete decarbonization) to the future generation along with the added climate impact of temporarily exceeding temperature targets and returning back (which in and of itself is expcted to cause adaptation needs). Geden, O., & Löschel, A. (2017). Define limits for temperature overshoot targets. Nature Geoscience, 10(12), 881-882. Lenzi, D. (2018). The ethics of negative emissions. Global Sustainability, 1(7). Nusbaumer, J., & Matsumoto, K. (2008). Climate and carbon cycle changes under the overshoot scenario. Global and Planetary change, 62(1-2), 164-172."	Taken into account - text revised (removed "quickly", together with the change demanded in comment 170, but this chapter is not well-placed to discuss overshoot scenarios and their potential Earth System effects, see WGI, ch 4 and 5, whereas issues of integenerational fairness are already being touched upon in the same section)	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
1261	14	10	14	28	The statement "These projects are supported by public RD&D funding" seems a little misleading, the governments supports are marginal at best and should be much higher - but negative emissions are clearly not yet on the political agenda, especially in Europe/EU. E.g. climeworks is by far mostly funded by private individuals, not institutions or the public. Quote: "... the company has attracted about $50 million in private investments and grants..." from https://www.nytimes.com/2019/02/12/magazine/climeworks-business-climate-change.html. Carbon Engineering has private individuals and companies as investors.	Noted: This comment belongs to the DACCS section (page 16 not 14) - reworded	Dirk Paessler	Paessler AG (a 300 people Software Company) and Carbon Drawdown Initiative GmbH (philanthropy/incubator/ angel investment company focused on negative emissions)	Germany
43419	14	11	14	11	There is no systematic broad-based effort to explore CDR across the board, this is too positive; I'd suggest: While a range of potential approaches are gradually being explored….	Taken into account - text revised ("While many methods are gradually being explored")	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
43413	14	13	14	13	I disagree with the qualification "many" – many governments have forest protection laws in place, some are effective others not. Very few nations have afforestation policies in place (and of the few even fewer are effectively implemented).	Taken into account - text revised (now referring to forestry measures in a broader sense, including their roles in NDCs)	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
15151	14	14	14	16	Those studies do not only have "concerns". They do demonstrate that there is such an effect. This report should use and mention the term that is used by those authors and in the governance debate, which is "mitigation deterrence", see N. Markusson, D. McLaren, D. Tyfield, 2018: Towards a cultural political economy of mitigation deterrence by negative emissions technologies (NETs). Glob. Sustain. 1, ; Gough, C., Mander, S. Beyond Social Acceptability: Applying Lessons from CCS Social Science to Support Deployment of BECCS. Curr Sustainable Renewable Energy Rep 6, 116–123 (2019).	Taken into account - text partly revised based on suggested and additional literature, but 'obstruction' stays because it's more neutral and not only used by a distinct group of researchers, who, in fact, cannot 'demonstrate' that 'mitigation deterrence' exists (hence, it's a concern). The term "mitigation deterrence' is also problematic because it treats CDR as not being a form of mitigation - in contradiction to established definitions.	Dana Ruddigkeit	German Environment Agency	Germany
6119	14	14	14	18	However, McLaren et al (2019) (quoted later in chapter 12), suggest that separate targets for gross emissions and for CDR could avoid these problems. They say "Separation would help minimize the negative impacts that promises and deployments of negative emissions could have on emissions reduction, arising from effects such as temporal trade-offs, excessive offsetting, and technological lock-in. Benefits for international, national, local, organizational, and sectoral planning would arise from greater clarity over the role and timing of negative emissions alongside accelerated emissions reduction".	taken into account - this is not to the place to write about how to address these concerns, added cross reference to 12.7.1	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
15153	14	15	14	15	The authors (Markusson et al.) do not use (and would reject) the term “conventional mitigation”. Here in this report the citation creates the impression that the authors would use such a term! The term “conventional mitigation” is not a scientific term and has the narrative that emission reduction is old fashioned and that there are better solutions. This report should stick to the term “emission reduction”.	Taken into account - text revised (but not because Markusson et al. don't use the term or emission reductions are deemed to be 'old fashioned' but simply because 'conventional/unconventional mitigation' only recently started to emerge in the literature	Dana Ruddigkeit	German Environment Agency	Germany
47207	14	15	14	15	"concern that the prospect of large-scale CDR could obstruct conventional mitigation efforts" is a key policy problem preventing needed CDR investment. This so-called "moral hazard" fails to recognise that large-scale CDR could deliver mitigation at a low price and faster than "conventional mitigation" and therefore should be pursued on economic grounds as a primary climate response.	taken into account - this is not to the place to write about how to address these concerns, added cross reference to 12.7.1	Robert Tulip	Australian National University	Australia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
43415	14	16	14	16	The problem is not the prospect of CDR, but the lack of systematic plannng and implementation efforts in face of an already evident necessity of CDR for achieving any temperature target discussed under the Paris Agreement. For an explanation how the UNFCCC and the Paris Agreement legally ask Parties to pursue CDR, see also: Honegger, M.; Michaelowa, A.; Poralla, M. (2019): Net-zero emissions: The role of Carbon Dioxide Removal in the Paris Agreement. Policy Briefing Report. Perspectives Climate Research, Freiburg.	taken into account - this is not to the place to write about how to address these concerns, added cross reference to 12.7.1	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
47209	14	16	14	16	The alleged "overreliance on technologies that are still in their infancy" is another rhetorical distraction from the real agenda of the politics of decarbonisation. R&D into new technology is likely to have higher return on investment than subsidy of decarbonisation, which should proceed without subsidy. At present we face the opposite problem - promising new technologies are starved of funds and policy engagement due to this perverse fear that they might work.	rejected - no clear demand for a change, claim not supported by literature, and following paragraph already mentions lack of dedicated CDR policy and low levels of R&D	Robert Tulip	Australian National University	Australia
47211	14	16	14	16	It is entirely possible that transformative technology could solve the climate crisis and deliver ability to regulate atmospheric composition. That is not possible through decarbonisation.	rejected - no clear demand for a change, claim not supported by literature, and following paragraph already mentions lack of dedicated CDR policy and low levels of R&D	Robert Tulip	Australian National University	Australia
47215	14	17	14	18	The fact that CDR "might be perceived negatively by broader publics" can only be addressed through intensive policy analysis, in order to enable governments to present solutions in a way that has a safe and effectiveand simple rationale. This bogey of perception is a very bad excuse not to engage in such analytic advocacy. Similar baseless arguments about misguided popular sentiment can apply to vaccination.	rejected - no clear demand for a change, claim not supported by literature, and the paragraph is not the right place to address this (cross reference added to 12.7.1)	Robert Tulip	Australian National University	Australia
42449	14	18	14	18	After ".....(Royal Society and Royal Academy of Engineering 2018)." Insert something like: "On the otherhand, humans have proven the wisdom of embracing multiple approaches to solving existential threats, such as the practice of both prevention and treatment in addressing disease and war. Prevention (emissions reduction) and treatment (CDR) should not be view as antagonistic in addressing the planetary CO2 problem, since it is now clear that both are needed (IPCC 1.5, etc)."	taken into account - this is not to the place to write about how to address these concerns, added cross reference to 12.7.1	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
43421	14	20	14	20	This makes it sound as though AFOLU research has newly emerged; suggest: In contrast to most of the other CDR approaches, the role of forestry and land-use change in (sub-)national and international climate policy has been studied for well over a decade…	taken into account - text revised by adding "long"	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
43417	14	22	14	23	The challenge is much more fundamental (beyond long lead times): In the absence of policy instruments most of the potential CDR approaches will not be pursued or developed at all. Honegger, M., & Reiner, D. (2018). The political economy of negative emissions technologies: consequences for international policy design. Climate Policy, 18(3), 306-321.	taken into account - text revised (integrated the lack of policy frameworks, using the suggested literature)	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
47213	14	22	14	23	The alleged "long time periods involved in scaling up and deploying novel technologies" primarily reflect lack of political will. When the USA wanted to develop an atom bomb and send a man to the moon and back, it did so rapidly due to top level support.	rejected - no clear demand for a change, claim not supported by literature, and the paragraph is not the right place to address this (cross reference added to 12.7.1)	Robert Tulip	Australian National University	Australia
15149	14	22	14	24	"there are huge challenges to be tackled in research" with regard to DACCS and BECCS. -This is a political conclusion, not a scientific fact. Moreover, the scientific question to be answered before such a conclusion can be justified, would be the question, whether those techniques are sufficiently effective. This should be assessed here in more depth. - The sentence beeing a conlusion that is a political claim should be deleted.	taken into account - text revised (by adding "in lines with broader societal objectives"; highlighting the need for research on technological CDR method is not policy prescriptive, since these methods are already included in mitigation pathways assessed by the IPCC)	Dana Ruddigkeit	German Environment Agency	Germany
42445	14	24	14	24	After "….costs (Nemet et al. 2018)." insert something like: "Furthermore, to make sure that cost-effectiveness and capacity are maximized in a timely fashion, RD&D on current CDR options must must not proceed without also encouraging and fostering the emergence of potentially better, disruptive approaches (16.4.3; Rau 2019 https://www.nature.com/articles/s41558-019-0445-5)."	Rejected - text unchanged (no space to expand on the R&D issue)	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
43423	14	26	14	26	"A major gap" is arguably quite the understatement.	noted	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
14389	14	26	14	28	Thank you for citing IEA ! But please cite IEA WEO 2019 here, which is the most recent publication also showing this link with air pollution and energy access.	Accepted - in section 12.2 IEA WEO 2019 has now been cited.	Arthur Contejean	International Energy Agency	France
6301	14		14		Authors are referring "biochar" as a "natural" CDR measure, but this could be confusing if no further explanation is added. Biochar produced (industrially) thorough pyrolysis is a high-tech and high energy consuming process thus potentially leading to GHG emissions. To be also noticed in sub-section 12.3.3.	Noted: Figure 12.3 redesigned	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain

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14217	14	6	15	33	The review and discussion of CDR options is too poor taking into account the substantial reliance on these technologies of IAMs for mitigation pathways. It is necessary to expand this discussion by detailing the factors which may facilitate the spread of these technologies in the future, as well as the factors tending to hamper it (social, economic, biophysical, etc.). It is now said that different CDR options are discussed in different parts of the report but this is very confusing since thus the information is dispersed and not clear for the reader.	taken into account - mainly addressed by new summary table on CDR options; societal and biophysical constraints are dealt with elsewhere (12.7.1 and WGI, ch 4 & 5)	Iñigo Capellán-Pérez	University of Valladolid	Spain
37571	14	6	15	33	This section misses a discussion of the reasons behind variations in the amount of CDR required between scenarios (e.g. model assumptions, discount rates, costs), and an upfront consideration of what risks need to be considered with respect to CDR deployment (e.g. issues of permanence, moral hazard, infrastructure scale-up, incentives). Introducing these elements and then linking to relevant sections later (or other chapters) would be helpful.	Noted: But space precludes a detailed analysis of all assumptions in every paper cited. We have drawn out the main dependencies	Michiel Schaeffer	Climate Analytics	Netherlands
26255	14	1			what about potential and scalability of these technologies and approaches in the table?	Accepted - see new CDR overview table	Sara Budinis	International Energy Agency	France
48151	14	1			BECCS isn't cheaper than enhanced weathering.	Taken into account: Figure 12.3 redesigned	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
48153	14	18			Paragraph ignores capacity of negative emissions to reverse historical emissions. This is important for sea level rise particularly	Rejected - reversing 'historical emissions' to levels consistent with meeting the Paris Agreement's long-term temperature goal of 1.5-2C is implicitly covered by mention of reversing overshoot of carbon budgets, there's no relevant literature looking at going back to far deeper levels. No mention of particular climate change impacts (like SLR) here	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
26257	14	21			there are currenlty around 23 (small and alrge scale) plants operating/operational worldwide	Taken into account - text revised by deleting the clause on the number of plants. Numbers given by reviewer are too high since it includes DAC without CCS. Currently, according to the IEA ETP Report on CCUS (2020), there's only one plant combining DAC with carbon storage (Carbfix project, Iceland). And to our knowledge, there's currently also only one BECCS plant with carbon storage (ADM, Decatur/USA)). Furthermore, there's no authorative source where we could constantly track current projects, we then would also need to track pilot plants and the growing project pipeline (like Drax or Stockholm Exergi)	Sara Budinis	International Energy Agency	France
42441	14				Fig 12.3 Reword: "ACCELERATED WEATHERING = Natural minerals react with CO2 to form solid or dissolved carbonate and bicarbonates." i.e., solid minerals may or may not be formed.	Accepted: Figure 12.3 redesigned	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
32567	15	1	15	10	BECCS is not carbon negative; on the scale of 10.6 GtCO2 yr-1 in 2100 it is not a serious approach and should be replaced in this analysis. Even if BECCS were net zero/carbon negative in the relevant next two to three decades, using BECCS to draw down the between 2 and 10 Gt CO2 annually that is mentioned in IAM reports would require the dedication of land equivalent to the size of India, and possibly even double this amount, to support biomass production, introducing daunting logistical issues. See Anderson K. & Peters G. (2016) The trouble with negative emissions, SCIENCE 354:182–183 (“Moreover, the scale of biomass assumed in IAMs—typically, one to two times the area of India—raises profound questions about carbon neutrality, land availability, competition with food production, and competing demands for bioenergy from the transport, heating, and industrial sectors. The logistics of collating and transporting vast quantities of bioenergy—equivalent to up to half of the total global primary energy consumption—is seldom addressed. Some studies suggest that BECCS pathways are feasible, at least locally, but globally there are substantial limitations. BECCS thus remains a highly speculative technology.”).	rejected - this is beyond the scope of this section (we are reporting on the IAM numbers here, we don't assess BECCS as a method, which is done in ch6 and in 12.3.3.)	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
32569	15	1	15	10	BECCS is not carbon negative in the near-term because bioenergy leaves a carbon deficit for several decades to a century—far longer than the window of a decade or two available for slowing feedbacks and avoiding crashing through the 1.5C guardrail. See, e.g., IPCC AR5 WG III (2014) 11.13.4 GHG emission estimates of bioenergy production systems ("The combustion of biomass generates gross GHG emissions roughly equivalent to the combustion of fossil fuels. If bioenergy production is to generate a net reduction in emissions, it must do so by offsetting those emissions through increased net carbon uptake of biota and soils…Hence, the total climate forcing of bioenergy depends on feedstock, site-specific climate and ecosystems, management conditions, production pathways, end use, and on the interdependencies with energy and land markets…For example, in the specific case of existing forests that may continue to grow if not used for bioenergy, some studies employing counterfactual baselines show that forest bioenergy systems can temporarily have higher cumulative CO2 emissions than a fossil reference system (for a time period ranging from a few decades up to several centuries"). Subsequent analysis since AR5 further strengthens the case that bioenergy is not carbon neutral in the critical next decade or two. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). In addition, the CCS part of BECCS has not been demonstrated at scale or at acceptable cost, nor has it won over the support it would need from the public. See Gregory Nemet et al., Negative emissions—Part 3: Innovation and upscaling, Environ. Res. Lett. (May 2018); European Academies Science Advisory Council, Negative emission technologies: What role in meeting Paris Agreement targets? (Feb 2018) ("CCS plans in Europe have been shelved so that whatever experience is being gained globally is outside Europe. The loss in momentum in implementing CCS technologies not only has serious implications for mitigation pathways, but also one of the most commonly cited NETs [negative emissions technologies] (BECCS) assumes the availability of cost effective 'off-the shelf' CCS, while another (direct air capture) relies on the widespread availability of CO2 storage. At present, economic incentives for deploying CCS are inadequate (whether through the very low carbon price or targeted government support), while those for NET development are lacking."); Andersen & Peters, The Trouble with Negative Emissions, Science (Oct 2016). One study estimates that current rate of increase in CCS is 100 times lower than needed to meet the 2C target. See Haszeldine et al. (April 2018), Negative emissions technologies and carbon capture and storage to achieve the Paris Agreement commitments, Philosophical Transactions of the Royal Society. Thus, BECCS should not be presented as a viable CDR strategy.	rejected - this is beyond the scope of this section (we are reporting on the IAM numbers here, we don't assess BECCS as a method, which is done in ch6 and in 12.3.3.)	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
35049	15	1	15	10	A figure (chart, pie chart or the like) can better present the information discussed here.	Accepted - figure added	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
47217	15	1	15	10	The considered scenarios for CDR scale to hold temperature below 2C are far too small, with just 0.06 GtCO2 yr-1 by 2030. Models should look at examples like growing algae on ten million square kilometres of the world ocean (3% of total area), as proposed by Ocean Foresters and supported by Tim Flannery in his book Sunlight and Seaweed. The failure of models to engage with such scenarios shows that the IPCC and modelers do not take CDR seriously. Only the world ocean has the area, energy and resources available to deliver CDR on the scale needed for climate stability.	Noted - we compare IAM options and bottom up costs potentials in Section 12.2	Robert Tulip	Australian National University	Australia
20681	15	6	15	6	It is not clear where the AFOLU numbers come from. Is this based on AFOLU emissions going negative? Does 0 GtCO2/yr AFOLU CDR in 2030 mean that no AFOLU options are employed in IAMs? In IAM projections AFOLU CDR options (a/reforestation) may be used but AFOLU emissions may be positive due to other activities. To the best of my knowledge the database does not separate Afforestation emissions from AFOLU....but i could be wrong.	Noted: New SOD AFOLU numbers are from the AR6 database. It is now made explicit that these numbers cover 'net' removals (as in the database). We aim to give numbers for 'gross' removals by afforestation/LUC in FGD	Vassilis Daioglou	Copernicus Institute of Sustainable Development	Netherlands
52	15	8	15	10	For which emission scenario does this number 149.3 Gt-CO2 of CDR removal by 2100 correspond to? By the way, do we need to specify the decimal in 149.3?	noted - numbers will evolve with scenario database, differentiating between selected IPs. Decimals not need for cumulative full century volumes	Govindasamy Bala	Indian Institute of Science	India
47221	15	11	15	19	Another promising CDR method that has not been modelled is iron salt aerosol, which should be included in this chapter. Oeste et al 2017 argued that iron salt aerosol may have potential to remove 12 GT CO2e/y, but there has since been little academic interest in modelling or testing this hypothesis, apart from a major public meeting at the London Institute of Mechanical Engineers in 2019. Iron Salt Aerosol seeks to restore atmospheric chemistry toward the conditions prevailing in the ice age as a low cost direct cooling method.	noted - this is the subsection on the treatment of CDR in IAMs, so if a method hasn't been modelled, it is beyond of the scope of this subsection	Robert Tulip	Australian National University	Australia
42447	15	19	15	19	after "mixed CDR approach is yet to emerge." insert something like: "Needless to say, the limited range of CDR options so far considered in IAMs, and the accuracy with which indiviual and collective cost-effectivenesss and capacity are represented greatly affects accuracy of IAM predictions. In general it is difficult to predict future technolgy advances and performance. Therefore in the interest of speeding the development of the most cost-effecitve,highest capacity CDR, it is essential that policies informed by present predictions not inhibit investigations of additional or alternative approaches that are likely to emerge (16.4.3)."	noted - if it is "needless to say" then we won't say it (plus: there are no indications that political decisions on potential national CDR portfolios are highly influenced by technology portfolios in global IAMs, this can be seen in policy documents both in the UK and in the EU27)	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America

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4947	15	22	15	22	Suggest to Baik et al. 2019 to the US BECCS list: Baik, E., D. L. Sanchez, P. A. Turner, K. J. Mach, C. B. Field and S. M. Benson (2018). "Geospatial analysis of near-term potential for carbon-negative bioenergy in the United States." Proceedings of the National Academy of Sciences.	accepted	Patrick Lamers	National Renewable Energy Laboratory	United States of America
34257	15	26	15	33	This paragraph on gaps with existing trend is very explicit. Maybe this lack of research and development could be said more clearly in the chapter summary, or even explicit the need for international or inter-governmental programs of large scale. How about an IPCC Special Report ?	noted - no substantial changes made since need for expanding RD&D already highlighted here, but some additions to 12.7.1. made. If R&D isn't a major issue in 12.3., it shouldn't go into the Executive Summary	Antoine BONDUELLE	Climate Action Network France	France
29353	15	30	15	32	Carbon removal approaches that cannot be related to a certain sector in the report, generally should nevertheless be accounted somehow in a sectoral CDR accounting, or are they not? If this point is taken up later, some reference could be added here. Else, some thoughts on this could be added, how these kind of emission savings are/ can be accounted for in sector-based emission saving balances.	Noted: This chapter deals with cross-sectoral perspectives and also CDR not accounted for in one emissions sector (e.g. ocean-based CDR)	Catharina Latka	University of Bonn	Germany
47219	15	32	15	33	The comment that "expectations for providing sufficient levels of research, development and demonstration cannot rely on existing industrial actors" is a core finding, but the situation may be changing as major industries ramp up their investment. IPCC should encourage investment in carbon offsets rather than direct emission reduction.	rejected - this would be policy prescriptive	Robert Tulip	Australian National University	Australia
42451	15	33	15	33	After "...rely on existing industrial actors." insert something like "Thus, predictions of furture individual and collective CDR availability, capacity and cost are presently highly uncertain, and polices informed by such predictions must have the flexibility to pivot as information from new modeling and RD&D become available."	noted - no substantial changes made since need for expanding RD&D already highlighted here, but some additions to 12.7.1. made.	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
42453	15	39	15	39	delete	Accepted - text revised.	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
20493	15	39	16	3	DACCU and DACCS could be better separated in logical terms, as suggested in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) - it also shows the rather low cost market introduction options, compared to solar PV, while DACCU leads to DAC phase-in in a first wave and DACCS in a second wave	Accepted - text revised	Christian Breyer	LUT University	Finland
32571	15	39	16	3	“Only permanent storage (either in geological reservoirs or through mineralization) can result in net removal of CO2” is incomplete and may be a bit misleading; storage in building materials can result in net removal for the critical near-term decades and centuries. A study published in Nature in November 2019 identifies utilization pathways for captured CO2: chemicals, fuels, microalgae, and construction materials, and argues that construction materials can both utilize and remove captured CO2. See Hepburn et al. The technological and economic prospects for CO2 utilization and removal, Nature (Nov 2019) (“CO2 utilization pathways in concrete building materials are estimated to remove, utilize and store between 0.1 and 1.4 Gt CO2 yr−1 over the long term—with the CO2 sequestered well beyond the lifespan of the infrastructure itself—at interquartile breakeven costs of−$30 to $70 per tonne of CO2. The high end might reflect a scenario (amongst other possibilities) in which CO2 is used as a cement curing agent in the entirety of the precast concrete market and in 70% of the pourable cement markets. The estimate also includes aggregates that are produced from carbonated industrial wastes, such as cement and demolition waste, steel slag, cement kiln dust, and coal pulverized fuel ash.”). Further, “Utilization of captured CO2 to produce synthetic fuels, building materials or plastics will only have a temporary removal effect” should clarify the length of “temporary” as current iteration implies extremely short-term. In fact, as explained in the study above, CO2 in concrete building materials is sequestered well beyond the lifetime of the materials. See Hepburn et al. The technological and economic prospects for CO2 utilization and removal, Nature (Nov 2019). Blue Planet, for example, is a cement company making light-weight building materials from concentrated CO2 captured at the smoke stack. Blue Planet incorporates a process using demolished concrete, which can be crushed into aggregate, and coated with extra CO2, making it more valuable for new concrete. See Bruce Watson, The surprising key to viable carbon sequestration: build more highways, The Guardian (2016).	Accepted - text revised by clarifying longevity of products and adding "with the lifetime varying from centuries for building concrete materials (Hepburn et al. 2019) to millennia for carbon fibre."	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America

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42455	15	40	16	3	Rewrite: "Aside from operating on air CO2 rather than more concentrated waste streams, DACCS shares with conventional CCS three basic steps: a) chemical absorption or adsorption by a liquid or solid sorbent, b) regeneration of the sorbent with heat, moisture and/or pressure and the release of CO2 in a concentrated form, and c) utilization or storage of the resulting CO2 stream. Long term storage of the CO2 can be achieved by injecting into carefully selected geological reservoirs, through mineralization or through the formation of long-lived materials such as certain plastics or building materials. The net CO2 removed depends on the carbon intensity of the energy input (electricity, heat, transporation) as well as that of the required materials and infrastucture. Utilization of captured CO2 to produce short-lived products (e.g., fuels and other consumables) reduces or eliminates the net CDR benefit of DACCS, though by substitution for equivalent, fossil-C-derived products, CO2 emissions reductions can be achieved (Lackner et al. 2012; Wilcox et al. 2017; Fuss et al. 2018; Gunnarsson et al. 2018; Bui et al. 2018; Creutzig et al. 2019; Royal Society and Royal Academy of Engineering 2018). Note that because surface seawater contains carbon in approximate equilibrium with the atmosphere but at a volumetric concentration some 140 times that of atmospheric CO2, engineered methods of extracting and sequestering CO2 from the surface ocean might provide a more efficient though "indirect" DAC method (de Lannoy et al. 2017 https://www.sciencedirect.com/science/article/abs/pii/S1750583617304322 ; Eisaman et al. 2018 https://www.scopus.com/record/display.uri?eid=2-s2.0-85042913170&origin=inward&txGid816282d3cdd23ea1409a9fab7f80066b) "	Rejected - while novel technologies are important, there isn't enough literature to warrant an assessment during this IPCC assessment cycle	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
47223	15	43	16	3	The assertion that "Only permanent storage (either in geological reservoirs or through mineralization) can result in net removal of CO2 from the atmosphere" can be contested. Large scale increase of ocean biomass may have potential to cause net removal even without permanent storage, while delivering essential ecosystem benefits. Large scale production of plastics similarly has potential for effective carbon storage.	Accepted - text revised by clarifying the longevity of storage and by adding a reference to Hepburn et al. (2019)	Robert Tulip	Australian National University	Australia
1265	15	39	18	5	I think it would be helpful to mention that DAC doesn't necessarily needs to be installed in large, massive plants. Instead a large number of smaller and possibly even household or small/medium sized business sized plants could also be used to scale up DAC to Gigatons while avoiding such massive capital investments into huge systems only - which will speed up the development of this technology. We should expect that carbon capture will start with small units and some of them scale in size, others by number. Oliver Geden writes that CDR "will primarily emerge 'bottom up' with companies, cities and countries, and not be comprehensively coordinated 'top down' globally." see https://doi.org/10.1038/s41561-019-0475-7 and https://twitter.com/Oliver_Geden/status/1189893486205689858	Accepted - text revised - Bellamy and Geden (2019) now cited	Dirk Paessler	Paessler AG (a 300 people Software Company) and Carbon Drawdown Initiative GmbH (philanthropy/incubator/ angel investment company focused on negative emissions)	Germany
6121	15	39	18	5	A new type of CCS has been proposed by the French Geological Survey (BRGM) called "CO2-Dissolved" that stores the CO2 entirely dissolved in the salt water of deep aquifers i.e. the CO2 is not compressed to a supercritical fluid. See http://co2-dissolved.brgm.fr/. However, there do not appear to be any peer-reviewed publications currently.	Noted - no change in text because of the lack of peer-reviewed publications	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
5363	15	38	20	34	I propose that these technologies (DACCS and Enhanced weathering) that are still expensive and not competitive, and need time for more research and innovation only it is mentioned and treated in short. The same for Ocean-based approaches (fertilization and alkalinity enhancement)	Rejected - the remit of our chapter dictates us to cover CDR options not covered in other chapters in a sufficient depth	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
10595	15	28	24	2	This section provides a good, balanced overview of DACCS, with particularly goood coverage of ocean-based options. It is great to see the opportunities and potential risks so clearly laid out.	Noted	David Schoeman	University of the Sunshine Coast	Australia
26231	15	13			Realmonte et al 2019 reports on DAC in 2 IAMs (WITCH and TIAM Grantham)	Accepted - text revised by citing Realmonte et al. (2019)	Sara Budinis	International Energy Agency	France
48155	15	41			Calcining DAC isn't really a sorbent process. It's an acid base reaction	Accepted - text revised	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
48157	15	46			Carbon products don't necessarily degrade. Eg carbon fibre.	Accepted - text revised	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
39729	16	4	16	5	Need to add explanation of accronym DAC	Accepted - text revised	Jinsun Lim	International Energy Agency (IEA)	France
1263	16	4	16	9	Would you consider mentioning other methods like "Faradaic electro-swing reactive adsorption for CO2 capture" https://pubs.rsc.org/en/content/articlelanding/2019/EE/C9EE02412C#!divAbstract and the Prometheus Project https://www.sciencemag.org/news/2019/07/former-playwright-aims-turn-solar-and-wind-power-gasoline ?	Rejected - the paper deals with CO2 concentration of > 6000ppm and doesn't fit with the DAC definition. The second one has not been published in the peer-reviewed literature.	Dirk Paessler	Paessler AG (a 300 people Software Company) and Carbon Drawdown Initiative GmbH (philanthropy/incubator/ angel investment company focused on negative emissions)	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
42395	16	5	16	6	"The main categories are a) liquid solutions with high-temperature regeneration" - seems important to point aout that hight teperature DAC usually burns natural gas to desorb and co-caputres the released fossil CO2, which reduces net atmopsheric capure efficieny (https://doi.org/10.1016/j.joule.2018.05.006)	Accepted - text revised by inserting "which reduces the efficiency" in the subsection on cost	Christoph Beuttler	Climeworks AG, Risk Dialogue Foundation	Switzerland
54	16	10	16	28	Transport of the captured CO2 and Storage also would be huge barriers to DAC.	Rejected - the literature suggests that these two are not primary barriers compared to conventional CCS.	Govindasamy Bala	Indian Institute of Science	India
28031	16	10	16	28	Please clarify that DAC hardly reduces carbon while increasing air pollution and mining. The Carbon Engineering plant is evaluated in Jacobson, M.Z., The health and climate impacts of carbon capture and direct air capture, Energy and Environmental Sciences, 12, 3567-3574, doi:10.1039/C9EE02709B, 2019. That study finds, from actual plant data, that CCS/U and DACCS/U are both opportunity costs resulting in hardly any CO2 reduction, even before considering the disposition of CO2, and both result in air pollution and mining increases. Similarly, Sekera, J., and A. Lichtenberger, The carbon capture conundrum: Public need versus private gain, A public policy perspective on carbon dioxide capture, 2020, https://drive.google.com/file/d/1K-BIULOUtfSs5LVCS9ONaDzq7jeFmO-b/view conclude (1) many scientific studies pass carbon removal methods off as "climate mitigation" when in reality the methods in play today increase CO2 and (2) laws subsidizing carbon capture and direct air capture increase CO2.	Taken into account - combined with the other comment (same content from the same reviewer on a different section); See the response to 28029.	Mark Jacobson	Stanford University	United States of America
15155	16	12	16	28	A scientific Report should not name individual start up companies.	Accepted - company names are now removed.	Dana Ruddigkeit	German Environment Agency	Germany
10683	16	13	16	15	And philantrophy as well as private sector money.	Accepted - text revised.	Felix Schenuit	University Hamburg	Germany
42397	16	13	16	15	"These projects are supported by public RD&D funding or 13sometimes serve for utilization niche markets (e.g., enhanced oil recovery, CO2for beverages or 14greenhouses)." delete enhanced oil recovery. The only two nice markets served at the moment are greenhouses and beverages (both by Climeworks). EOR is frequently discussed as a theoretical case, but not done in reality.	Noted - text revised by changint the order. Carbon Engineering is considering EOR. https://carbonengineering.com/news-updates/worlds-largest-direct-air-capture-and-sequestration-plant/	Christoph Beuttler	Climeworks AG, Risk Dialogue Foundation	Switzerland
42399	16	15	16	17	replace: "As of March 2019, there are 11 plants worldwide, whose scale is ~1 ktCO2yr-1, with 15the largest designed to capture 4 ktCO2yr-1in Alabama, USA (National Academies of Sciences 2019; 16Larsen et al. 2019)." by As of March 2020, there are 16 plants worldwide, whose scale is ~2 ktCO2yr-1, with 15the largest ones designed to capture 4 ktCO2yr-1in Alabama, USA (National Academies of Sciences 2019; 16Larsen et al. 2019) another 4kktCO2yr plant is currently in construction in Iceland by Climeworks. List of plants nd capacity availiable at Climeworks.	Taken into account - the number of plants has been updated with a more widely available report from IEA.	Christoph Beuttler	Climeworks AG, Risk Dialogue Foundation	Switzerland
43425	16	29	16	30	DAC should not be compared to CCS as it's climate effect is completely different; if anything the comparison should be between the DAC capture process vs. The point source capture process (without the S).	Accepted - text revised by replacing "CCS" with "carbon capture".	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
9599	16	29	16	31	The statement is correct but not complete. CO2 capture costs should also be compared to other options for capture, e.g. bioethanol fermentation where the capture and compression costs can be less than 25 USD/tCO2 (Sanchez et al. 2018: Near-term deployment of carbon capture and sequestration from biorefineries in the United States, PNAS).	Rejected - this section is a summary of CDR in Ch7. This should be addressed in Ch7	Jesper Kløverpris	Novozymes	Denmark
42401	16	29	16	31	"Costs: Since the process captures dilute CO2(~400ppm) from the ambient air, it is less efficient and 29more costly than conventional CCS applied to power plants and industrial installations (with a CO230concentration of ~10%)." Conventional CCS does only prevent the release of additional fossil CO into the Atmosphere whilst DACCS delivers Negative Emissions. Therefore a direct comparison is misleading. change to: Costs: Since the process captures dilute CO2(~400ppm) from the ambient air, it is less efficient and 29more costly than conventional CCS applied to power plants and industrial installations (with a CO230concentration of ~10%), it is however worth mentioning that convnetional CCS at fossil pount sources only limits the amount of new CO2 emissions entering the atmosphere, whilst DACCS can deliver Negative Emissions.	Accepted - text revised by inserting "which cannot serve as CDR"	Christoph Beuttler	Climeworks AG, Risk Dialogue Foundation	Switzerland
43427	16	41	16	43	I believe Lawrence et al., identify limited potentials; also "unlimited" is in direct contradiction to the above statement on energy and cost, which do amount to real-world potential limitations. Lawrence, M. G., Schäfer, S., Muri, H., Scott, V., Oschlies, A., Vaughan, N. E., ... & Scheffran, J. (2018). Evaluating climate geoengineering proposals in the context of the Paris Agreement temperature goals. Nature communications, 9(1), 1-19.	Noted - text revised by citing Lawrence et al. (2018) and clarifying that our discussion is limited to technical potentials, but Lawrence et al. (2018) also suggest that there is virtually no limit to technical potentials.	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
15157	16	41	17	2	To remove CO2 from the atmosphere for a long time, the CO2 would have to undergo energy-intensive processes in order to convert it into storable substance or product. There is lot of critical literature, which should be cited. One out of many studies is e.g.: Pete Smith/Steven J. Davis et al Biophysical and economic limits to negative CO2 emissions, in: Nature Climate Change volume 6, pages42–50(2016) This means the climate effectivity is highly problematic. Effective DACCS would primarily require renewable excess electricity, (Jan Wohland/ Dirk Witthaut/ , Carl-Friedrich Schleussner, Negative Emission Potential of Direct Air Capture Powered by Renewable Excess Electricity in Europe, in: Earth`s Future 2018, 1380-1384.- Those constraints are almost undisputed and cannot be put aside in the box "more research needed".	Noted - the suggested papers are already cited and the issues the reviewer raised are already covered (in the following subsection on risks and impacts)	Dana Ruddigkeit	German Environment Agency	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
20495	16	41	17	2	DACCS potential is is highlighted in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) and also linked to low-cost solar PV, based on Vartiainen et al. (https://onlinelibrary.wiley.com/doi/full/10.1002/pip.3189) and optimised in a full hourly resolution - which is a unique research piece so far, since in local-global resolution and concluding that cost of 50 EUR/tCO2 for captured CO2 and less is possible by 2050 - this would be a breakthrough for DACCS, compared to other options. Since DACCU is used in a first wave for synthetic fuels and chemicals cost scaling can be effective. Sustainable or non-avoidable CO2 point sources are much lower than CO2 raw material demand, since only cement (limestone part), pulp & paper, and waste incinerators would be left, others can be substituted by lower cost options (such as coal power plants by renewables) or the plant utilisation is too low for point source capture, or not part of a net-zero GHG emission society (as for fossil gas plants)	Noted - text revised in the cost subsubsection since Breyer et al. concerns the cost.	Christian Breyer	LUT University	Finland
39731	16	41	17	2	Suggest including economic potential (economically feasible potential) of DACCS. It seems it is only discussing technically and environmentally feasible potential, although one of the key issues of DACCS deployment could be economic feasibility.	Taken into account - added "Focusing only on the Maghreb region, (Breyer et al. 2019a) reported an optimistic potential 150 Gt-CO2 at < 60 euros /t-CO2 for 2050. "	Jinsun Lim	International Energy Agency (IEA)	France
34259	16	41	17	39	An interesting graph would compare the costs such developments in DACCS with energy costs from Renewable Energy in desert regions	Taken into account - added "Focusing only on the Maghreb region, (Breyer et al. 2019a) reported an optimistic potential 150 Gt-CO2 at < 60 euros /t-CO2 for 2050. "	Antoine BONDUELLE	Climate Action Network France	France
48159	16	6			Ignores electro swing processes https://pubs.rsc.org/en/content/articlelanding/2019/ee/c9ee02412c#!divAbstract	Rejected - the cited paper focuses on CO2 of >6000ppm	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
48161	16	14			Ignores offset market, to firms and public	Accetped - text revised by inserting "voluntary offsets"	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
26259	17	6	7		Socolow et al 2011 is a very old reference for a technology which has been substantially evolving in the past few years	Rejected - Socolow et al. (2011) presents a theoretical analysis, which continues to hold	Sara Budinis	International Energy Agency	France
43429	17	6	17	39	Not all energy is created equal; various designs have much lower power demand as they rely on (waste) heat. This matters and should be detailed here! Also: Not all DACCS designs are open water; in my understanding Beuttler and colleagues claim their process produces excess water. Beuttler, C., Charles, L., & Wurzbacher, J. (2019). The role of Direct Air Capture in mitigation of anthropogenic greenhouse gas emissions. Front. Clim. 1: 10. doi: 10.3389/fclim.	Accepted - text revised by citing Beuttler. The excess water has been already mentioned in the FOD. Also the issue is about temperature, not the amount of energy.	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
20497	17	7	17	8	an important detail is not mentioned, but important for proper DAC efficiency understanding. The used reference (Fasihi et al.) discusses that 80% of all energy is heat, and most applied technological routes and active companies follow the low-temperature routes of 70-100C. This however allows to use heat pumps, with a COP (coefficient of power) of about 3, which leads to much less overall energy demand via (low-cost electricity) which can be solar PV - this is discussed in a detailed model in Breyer et al. (https://link.springer.com/article/10.1007/s11027-019-9847-y) and in a more compact focus by Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1) - this important information is required for appropriate DAC discussion	Accepted - text revised by citing the sugeted literature.	Christian Breyer	LUT University	Finland
56	17	9	17	10	The current emissions are about 40-50 Gt-CO2 equivalent. This means that the energy cost of removal is as big as the global energy consumption today. All energy produced in CO2 emissions will be used for its removal. It could be actually more. If you include the cost of water and materials, the DAC proposal looks insane and ridiculous. I can understand the use of DAC for small scale CO2 use such as for carbonated water but proposal of DAC for solving the climate change problem looks absurd. This may be discussed in the text.	Noted - this point has been already covered in the FOD	Govindasamy Bala	Indian Institute of Science	India
20499	17	20	17	25	area demand and low risk of local CO2 depletion is also discussed in Fasihi et al. (https://www.sciencedirect.com/science/article/pii/S0959652619307772), please compare values to the ones listed	Rejected - the suggest literature gives a nice review but their estimate is based on Socolow et al. and other papers.	Christian Breyer	LUT University	Finland

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39041	17	26	17	32	Addings: To reach the goal of net zero emissions, fossil fuel-based energy demand could be mainly replaced by renewable electricity (RE) (e.g. DENA, 2017, Ram et al., 2019). However, there are sectors such as aviation, shipping, heavy transportation, energy intensive industries for which hydrocarbons cannot be replaced by electricity easily, or physically not at all (e.g. Fasihi et al., 2017, Hepburn et al., 2019, SDSN &FEEM, 2019). Biofuel production is faced with resource limitations and conflicts with food production and, therefore, offers no sustainable substitute (Koizumi et al., 2015, Tomei et al., 2016). Net zero emissions could be achieved by a defossilization of the energy system, whereby carbon from fossil sources is replaced by that which is created synthetically and sustainably from CO2 with the aid of RE. These CO2-based fuels can be emission neutral and be used in the current fossil fuel-based infrastructure (DENA, 2017, Fasihi et al., 2017, Artz et al., 2019, CONCAWE, 2019). Power to fuel is the concept enabling the production of hydrocarbon fuels (e-fuels) using RE. Two types of fuels can be generated: 1) Synthetic gas (e.g. e-methane) so-called Power-to-Gas and 2) Liquid fuels (e.g. methanol, ethanol), so-called Power-to-Liquid. In both cases, CO2 and green H2 (i.e. hydrogen generated by the electrolysis of water with RE) produce e-fuel (e.g. Breyer et al., 2015, Sternberg and Bardow, 2015, Dimitrou et al., 2015, Fasihi et al., 2017, Anwar et al., 2020). These e-fuels can be stored, transported and use as such or to produce electricity again. Liquid e-fuels are easier (and relatively inexpensive) to store and transport compared to electricity. They can be kept in large-scale stationary storage over extended periods, and mobile storage in vehicle tanks, which can compensate for seasonal supply fluctuations and contribute to enhancing energy security (CONCAWE, 2019). Artz et al., 2019 has shown that the largest reduction in the absolute amount of greenhouse gas emissions could be achieved by coupling of highly concentrated CO2 sources from CO2-emitting sectors with carbon-free hydrogen or electrons from renewable power in so called “Power-to-fuel” scenarios. Using power-to-fuel to meet the expected remaining fuel demand for aviation in 2050 would require renewable electricity equivalent to some 28% of Europe’s total electricity generation in 2015. However, with today’s technology, synthetic fuels are the only technically viable solution that would allow aviation to exist in a world that avoids catastrophic climate change” (Transport and Environment, 2018) The long-term use of carbon based energy carriers in a net zero emissions economy relies upon their production with renewable energy for low-cost, scalable, clean hydrogen production—for example via the electrolysis of water. The estimated potential for the scale of CO2 utilization in fuels varies widely, from 1 to 4.2 Gt CO2 yr–1, reflecting uncertainties in potential market penetration. The high end represents a future in which synthetic fuels have sizeable market shares, due to cost reductions and policy drivers. The low end—which is itself considerable—represents very modest penetration into the methane and fuels markets, but it could also be an overestimate if CO2-derived products do not become cost competitive with alternative clean energy vectors such as hydrogen or ammonia, or with direct sequestration (Grinberg Dana et al., 2016, Byrnolf et al., 2018, Hepburn et al. 2019, Anwar et al., 2020).	Noted - all the issues raised are covered in Chapter 6 energy systems."	Célia Sapart	Université Libre de Bruxelles et Co2 Value Europe	Belgium
20501	17	26	17	34	it is a misbelieve that DAC would be a good combination to excess electricity. This is clearly proven wrong in several reseach by Fasihi and Breyer (https://link.springer.com/article/10.1007/s11027-019-9847-y ; https://www.sciencedirect.com/science/article/pii/S0959652619307772 ; https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1), since the relative DAC investment cost find a cost optimum with high utilisation which requires high utilisation. DAC units could be run technically in high variability, but this is not part of a least cost solution, AND this is also not part of a least cost energy system solution, as shown in Ram et al. (http://energywatchgroup.org/wp-content/uploads/EWG_LUT_100RE_All_Sectors_Global_Report_2019.pdf) - see data supplementary and the full load hours of DAC. The Ram et al. energy system analysis is most likely the study with the highest DAC capacity use for Power-to-X (FT,CH4) available so far. Better to link this section to results of full hourly resolved system analyses with the target function of least cost.	Accepted - text revised by citing the sugeted literature.	Christian Breyer	LUT University	Finland
34261	17	26	17	34	Maybe mention if any of the IAMs take this in consideration	Accepted - text revised by inserting "These aspects are yet to be fully explored in IAMs. "	Antoine BONDUELLE	Climate Action Network France	France
39733	17	26	17	39	Suggest comparing co-benefits and trade-offs of DAC deployment in terms of SDG6 and SDG7. As a non-expert of DAC, I found it is very interesting to learn more about DAC, but I also felt confused about what the aggregated (total) impact of DAC deployment. Would it be a burden for the power system, particularly for some systems without flexibility to manage intermittent operations? Would it be a pressure on water availability aggravating the issue of competititve use of water, or contribute to water availability by delivering surplus water?	Noted - the current text covers the points already mentioned. The result depends on which DAC system is deployed and how. For water (SDG6), the text states liquid solvent technology consumers water while some solid sorbent technology produces water.	Jinsun Lim	International Energy Agency (IEA)	France
4949	17	37	17	37	List the SDG 6 in brackets like you do two rows below with SDG 7.	Accepted - text revised	Patrick Lamers	National Renewable Energy Laboratory	United States of America
42403	17	37	17	39	"Because of its very high demand for low-carbon heat and power, DACCS would 37compete with more basic energy needs and could therefore negatively affect SDG 7 (Affordable and 38Clean Energy)" This argument is not in line with bsic economics. DAC would cause for demand for renewables to rise and thus create more supply. If deployed at scale this could bring down the price of renewbles. In addition it might also bring renewables to new regions, and create spillover effects, this is why someauthors argue DAC could have a positive impact on SDG7 (e.g. https://doi.org/10.3389/fclim.2019.00010)	Accepted - text revised by highlighting the lack of analysis and adding "If sourced from renewables, a large energy demand drive further expansion of renewables (Beuttler et al. 2019), though detailed analysis is lacking. "	Christoph Beuttler	Climeworks AG, Risk Dialogue Foundation	Switzerland
48163	17	37			The idea of competition is false. Economics of renewable energy technologies are dominated by experience curve effects, meaning that extra demand decreases prices, rather than increasing them	Accepted - text revised by highlighting the lack of analysis and adding "If sourced from renewables, a large energy demand drive further expansion of renewables (Beuttler et al. 2019), though detailed analysis is lacking. "	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)

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42457	18	11	18	11	rewrite: "....spreading of these crushed rocks on soils (or in the ocean - 12.3.2.3) so that they absorb..."	Accepted	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
47455	18	19	18	28	As in the DAC section 12.3.2.1 "Status", Carbon Engineering, Climeworks and Global Thermostate are mentioned as on going projects. I would like to make sure the enhanced weathering section reserves space for scale deployments beyond small scale trials that will be completed in time for the final submissions of literature. There are projects in the Netherlands that have just received grants and our non-profit, Project Vesta, will deploy a large scale pilot project in 2020 (Monsterrat, Knops, Matzner 2019) (GC31I-1329 - Olivine Weathering From The Lab To The Beach: Evaluation of data and deployment plan for the accelerated weathering reaction of olivine on beaches for carbon dioxide removal and ocean deacidification). We will submit preliminary results and a review of coastal enhanced weathering by the 19 September literature deadline.	Noted. This is not a peer reviewed article. If one is available before the deadline, we will consult it.	Eric Matzner	Project Vesta	United States of America
47457	18	29	18	38	Costs and energy footprint can can be lowered by minimizing transport distance from mines. (Geoengineering potential of artificially enhanced silicate weathering of olivine. Peter Köhler, Jens Hartmann, Dieter A. Wolf-Gladrow Proceedings of the National Academy of Sciences Nov 2010, 107 (47) 20228-20233; DOI: 10.1073/pnas.1000545107)	Noted. Material transport distance is already mentioned in costs section. Paper already cited.	Eric Matzner	Project Vesta	United States of America
47459	18	29	18	38	By minimizing transport distance to within 300 KM and minimizing grinding energy by instead utilizing coastlines and high-energy coastal environements to carry out the final breakdown of the rock from milimeter size, it is possible to remain 94%-95% efficient in the process. We have a draft life cycle assement of coastal enhanced weathering utilizing these constraints, "Environmental life cycle assessment of CO2 sequestration through enhanced weathering of olivine" by Joris Koornneef and Evert Nieuwlaar, previously of Group Science, Technology of Utrecht University from 2010. Energy efficienies of both grinding and trucking has only improved since this time. A new LCA is currenlty being conducted, and the results will be published in a standalone paper or in our Coastal Enhanced Weathering Review paper, that will be submitted for the 19 September deadline.	Noted. If available in time for SOD it will be considered.	Eric Matzner	Project Vesta	United States of America
47461	18	29	18	38	In terms of costs, we documentation and invoices from a number of mines in Europe currently where olivine can be acquired for less than 15 euros a tonne FOB. There is a proposal out now, for millions of tonnes of olivine ground and delivered to the beach for around 19 euros a tonne. We can provide documentation on this if requested, but cost breakdowns will be included in our Coastal Ehanced Weathering Review paper.	Noted. If available in time for SOD it will be considered	Eric Matzner	Project Vesta	United States of America
20503	18	7	20	34	interesting may be the link of DACCS and EW, as shown in the CarbFix project in Iceland - this is also discussed in Breyer et al. (https://www.cell.com/joule/fulltext/S2542-4351(19)30413-1)	Rejected. Basalt is used to store CO2 - not the same as EW as used here.	Christian Breyer	LUT University	Finland
6137	18	7	24	2	I suggest that the paper by McCormack et al (2016) 'Key impacts of climate engineering on biodiversity and ecosystems, with priorities for future research'. Journal of Integrative Environmental Sciences 13, 103-128 https://www.tandfonline.com/doi/full/10.1080/1943815X.2016.1159578 would be worth referring to as it specifically addresses biodiversity unlike most papers on the impacts of climate engineering.	Noted. Paper consulted but not added as it outlines a framework of assessment rather than assessing the impact on biodiversity of EW.	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
16347	18	7			Section 12.3.2.2 Enhanced weathering lacks a cogent analysis of the required land area needed for deployment of this technology. If the required land area is large, then the ecological trade-off associated with it may be unsupportable. For example, using the entire Amazon basin for enhanced weathering would be associated with ecosystem collapse and therefore untenable. While the ecosystem risks are alluded to in this section, a more explicit quantification of areal extent requirements and concomitant scenarios of ecosystem impact would be a great benefit to the reader, and enhance the accuracy of this section.	Rejected. The land area used to spread rock is not as important for EW as for other CDR options (e.g. BECCS, aforestation) as it does not require land use change. Minerals can be spead on croplands for example, without changing its use.	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
43933	18	7			The discussion of enhanced weathering regardless of whether for land or ocean should clearly consider the quantitative dimension of mining needed beyond just cursory mentioning. Damage done to landscape and natural systems would need to be estimated depending on whether implemention occurs at local, regional or global scale!	Rejected. This is dealt with in the section "Risks and impacts"	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
48165	18	8			Ignores the use of slag and overburden, which avoids the need to mine anything. Also these rocks don't absorb CO2, they react with it. Ignores the use of wave comminution on beaches.	Taken in to account. Section reworded	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
42459	19	29	19	29	rewrite "For example, enhanced weathering on land could help counter ocean acidification....."	Taken in to account. Wording to this effect added	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
42461	19	41	19	41	after "...formation, protection and decontamination of soils and sediments." insert: "To more directly ameliorate ocean acidification while increasing CDR and reducing impacts on land ecosystems, alkaline minerals can be directly added to the ocean (12.3.2.3)."	Taken in to account. Wording to this effect added	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
903	19	9	20	21	Recommendation Include avoided LUC emissions associated with yield increases Reason Improving soil quality (via SOC sequestraton and mineral fertiliser additions) would increase crop yields. Increasing crop yields would reduce the need to expand agricultural lands to meet the increase in demands for agricultural products from an increasing global population. This would avoid LUC emissions. This is not mentioned.	Rejected. No space to describe secondary co-benefits	Aaron Simmons	NSW Department of Primary Industries	Australia
34263	19	9	20	34	The inclusion of the SDGs is useful, but this whole page maybe gives too much a positive impression. There should be more emphasis on the very early phase of all this, even if the positives do happen, this part may mislead policymakers on feasibility in the time horizon considered.	Noted. Section greatly reduced for SOD due to lack of space.	Antoine BONDUELLE	Climate Action Network France	France
29355	19	42	20	21	For consistency with chapter 12.3.2.1 you could add the respective "SDG+number" when referring to their short titles.	Noted. Section greatly reduced for SOD due to lack of space.	Catharina Latka	University of Bonn	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
47463	20	22	20	30	The 30% number here is way too high. Olivine in the natural environment weathers much more quickly than core shrinking models.	Rejected. The weathering rate will impact the amount of grinding that is required, so a faster weathering rate will reduce the grinding requirements and lower the impact of emissions on the efficiency. But it is stated 'up to' 30%, covering potential uncertainties with weathering rates - so the statement is correct.	Eric Matzner	Project Vesta	United States of America
42347	20	28	20	30	I read: « The emissions associated with this additional energy generation may reduce the net carbon removal by up to 30% with present day grid average emissions (IFASTAT 30 2018), but this efficiency loss would decrease with decarbonised power. » Using the words decarbonised power may be confusing since carbon removal (~1/3 fossil & ~2/3 non fossil…), may be achieved using non fossil carbon from biogas, wood, or Power to gas. If power from renewables is not convenient, it may be valuable to use instead « non fossil fuels power ». Incidentally, it seems to me that the word efficiency may be suppressed to give: « This loss would decrease using non fossil fuels power. » (See also my comments on « decarbonisation » in Annex A.)	Noted. No space to expand.	Raymond Zaharia	Le Club des Argonautes http://www.clubdesargonautes.org	France
1949	20	36	20	36	As for the mitigation potential etimates for ocean-based approaches, the following references seems integrated: Hoegh-Guldberg, O. Northrop, E., & Lubchenco, J. (2019a) The ocean is key to achieving climate and societal goals. Science, 365(6460), 1372-1374.	Taken into account. Suggested reference is cited.	Kuwae Tomohiro	Port and Airport Research Institute	Japan
42463	20	41	20	41	rewrite: "On long-timescales (~100–200 ka) the ocean and mineral weathering will reduce atmospheric CO2 to…"	Editorial - text revised	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
42465	20	44	20	45	rewrite "….meaning that additional anthropogenic carbon could be potentially stored, in the deep ocean or on the sea floor for at least near term if not permanet climate benefit."	Editorial - text revised	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
42467	20	45	20	46	Comment on: "Assessment of the wide range of proposed marine geoengineering (GESAMP 2019) catalogued six CDR approaches." You are ignoring the major review by Gattuso et al. (2018) https://www.frontiersin.org/articles/10.3389/fmars.2018.00337/full ?	Accepted - the rewiew article is reffered	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
58	20	45	21	2	The CDR sections of Chapter 4 and Chapter 5 of AR6 WG1 report should be referenced here	Accepted -Chapter 4 and 5 in WG1 AR6 are reffered in the introductory part of the ch.12.3 and also in the ocean-based CDR part.	Govindasamy Bala	Indian Institute of Science	India
37053	20	36	24	1	The reference mentioned has many upto date information relevant for the ocean sector based mitigation potential and Blue econmy Ocean as a solution to climate change: five opportunities for action Report Washington DC, World resources institute. http//www.oceanpanel.org.climate.	Accepted - the report was studied and referenced	Joyashree Roy	Asian Institute of Technology, Thailand. Jadavpur University, India	Thailand
43935	20	36	24	2	Chapter misses broad treatment of ocean solutions in "Ocean solutions to address climate change and its effects on marine ecosystems" by JP Gattuso, AK Magnan, L Bopp, WWL Cheung, CM Duarte, J Hinkel, ... Frontiers in Marine Science 5, 337 (2018). The section also misses out on what has been implemented after the IPCC SR on CCS for the ocean in the London convention and OSPAR, and further original literature on iron fertilzation etc. The treatment of blue carbon in the IPCC SROCC 2019 should also not be ignored. Good CAs might be Andreas Oschlies, Jean-Pierre Gattuso, Phil Williamson, Carlos Duarte.	Accepted - suggested references included into the assessment.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
16351	20	36			In Section 12.3.2.3 Ocean-based approaches (fertilization and alkalinity enhancement), strongly consider adding increased Arctic ocean downwelling to sequester surface-water dissolved carbon in the deep ocean for the sake of clarity and accuracy. See, e.g. Zhou & Flynn "Geoengineering downwelling ocean currents: A cost assessment" (2005) Climatic Change 71: 203–220, for a more complete description. Their most cost-effective model involves the creation of artificial sea ice which in turn has the benefit of preserving Arctic sea ice in addition to increasing the rate of sequestration of dissolved carbon in the surface water as temperature decreases lead to increased downwelling. For a further treatment discussing the side effect of this sequestration technology, i.e. preservation of Arctic ice by artificial means, see for example Desch et al. "Arctic ice management" (2017) Earth's Future, 5, 107–127. Including this approach to sequestration would be beneficial to the reader and give a clearer picture of another available option.	Taken into account - suggested CDR options are noted in the text	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
43855	20	36			see SROCC chp 5 section 5.5.1 for a point of departure and following SROCC distinguish between options for coastal ocean and for open ocean	Accepted - noted in the text	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
60	21	3	21	5	The values of ocean GPP and NPP may be quoted here. The numbers may be taken from chapter 5 of WG1 report.	Tacken into account -Chapter 4 and 5 in WG1 AR6 are referred in the introductory part of the ch.12.3 and also in the ocean-based CDR part.	Govindasamy Bala	Indian Institute of Science	India
42469	21	3	21	16	Poorly written and naïve. Please find someone who knows this topic and cares enough to write about it accurately and clearly.	noted - text is revised, section is written with invited CA	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
39605	21	9	21	16	Ocean fertilization is a very studied and also regulated technology (By London Convention and its Protocol), and the conclusion is that it shouldn´t be used. IPCC should insist in considering this as an option, as there is abundant proof of its lack of eficacy and damages related to its deployment (Strong et al 2015) . A 2020 article by the MIT researchers show evidence that fertilizing/seeding oceans with iron may not be an effective method of combatting climate change, and it could damage the existing capacity of the ocean for absorption. The study says “more iron in the sea would deplete ohter nutrients, cause plankton death adn have negative effects on marine life” Earth’s oceans contain just the right amount of iron; adding more may not improve their ability to	Taken into account - potential risks and side effects discussed in the text and also summarized in the new table added to the section.	SILVIA RIBEIRO	ETC Group	Mexico
39607	21	9	21	16	absorb carbon dioxide. (Maitland et al, 2020) Full references follow below	Taken into account - potential risks and side effects discussed in the text and also summarized in the new table added to the section.	SILVIA RIBEIRO	ETC Group	Mexico
39609	21	9	21	16	Ocean fertilization is a very studied and also regulated technology (By London Convention and its Protocol), and the conclusion is that it shouldn´t be used. IPCC should insist in considering this as an option, as there is abundant proof of its lack of eficacy and damages related to its deployment (Strong et al 2015) . A 2020 article by the MIT researchers show evidence that fertilizing/seeding oceans with iron may not be an effective method of combatting climate change, and it could damage the existing capacity of the ocean for absorption. The study says “more iron in the sea would deplete ohter nutrients, cause plankton death adn have negative effects on marine life” Earth’s oceans contain just the right amount of iron; adding more may not improve their ability to absorb carbon dioxide. (Maitland et al, 2020) Full references follow below	Taken into account - potential risks and side effects discussed in the text and also summarized in the new table added to the section.	SILVIA RIBEIRO	ETC Group	Mexico
39611	21	9	21	16	Strong, A., Cullen, J., Chisholm, S. (2015) Ocean fertilization: Science, policy, and commerce, Oceanography [online], 22 (3), pp236-261 Available at: https://tos.org/oceanography/article/ocean-fertilization-science-policy-and-commerce	Accepted	SILVIA RIBEIRO	ETC Group	Mexico
39613	21	9	21	16	Jonathan Maitland Lauderdale, Rogier Braakman, Gaël Forget, Stephanie Dutkiewicz, Michael J. Follows. Microbial feedbacks optimize ocean iron availability. Proceedings of the National Academy of Sciences, Feb. 18, 2020; DOI: 10.1073/pnas.1917277117	Accepted	SILVIA RIBEIRO	ETC Group	Mexico
47225	21	16	21	16	To state about ocean fertilization "knowledge so far is still inadequate to predict global consequences" presents an inadequate summary of a key climate problem. Given that this chapter has recognised that this method could potentially deliver 100 GT CO2/y at minimal cost, reference to the potential and the debate on issues is imperative. In addition, the IPCC should recognise that iron salt aerosol, by removing methane and other GHGs with iron chloride that then falls to sea in highly dilute form, may be an effective safe method to test the alleged problems with ocean iron fertilization such as anoxia and nutrient robbing.	Taken into account - potential risks and side effects discussed in the text and also summarized in the new table added to the section.	Robert Tulip	Australian National University	Australia
42471	21	17	21	30	Suggested rewrite " The direct removal of CO2 from the atmosphere and/or the storage of CO2 removed by land or ocean processes can be achieved by increasing ocean alkalinity (‘ocean alkalinity enhancement’ or ‘artificial ocean alkalinisation’). This added marine alkalinity can be derived from: 1) the dissolution of natural alkaline minerals that are added directly to the ocean, 2) the dissolutions o such minerals upstream from the ocean (e.g., soils - 12.3.2.2) and 3) the addition of manufactured alkalinity to the ocean. Note that in the case of 2) the dissolved alkaline bicarbonate and carbonate ions generated upstream in soils and freshwaters are delivered to the ocean. hence only the marine storage of this carbon from land CDR is achieved in this scheme. Nevertheless, such terrestrial mineral weathering and alkalinity delivery to the ocean, followed by subsequent sedimentation of carbonate to the ocean floor is the primary way that atmospheric CO2 transients are naturally mitigated on geologic time scales. In this process ocean residence time of delivered, dissolved inorganic carbon is around 100,000 years, forming the largest near-permanent C storage reservoir on the Earth's surface. It therefore follows that methods that even fractionally increase this reservoir can have a massive effect on atmospheric CO2, the reason this form of CDR deserves serious consideration. (new paragraph) In addition to enhancing mineral weathering upstream from the ocean, direct addition of finely ground carbonate and silicate minerals to ocean surface waters and coastal sediments have been considered (Renforth and Henderson 2017). Concerns with this approach include very slow reaction kinetics unless the mineral i finely ground, and the environmental impacts of adding large quantities of such material (and resulting soluble impurities) to the ocean. These issues might be avoided by the use of manufactured alkalinity including that derived from the calcination of limestone (forming Ca(OH)2; Kheshgi 1995) as well as electrochemical production from salts, for example by the chor-alkali process (forming NaOH, House et al. (2007)). It has also been shown that the hybrid approach of electrolyzing saline water in the presence of natural alkaline minerals can generate H2 and well as hydroxide for CDR (Rau 2008, Rau et al. 2013). When the preceding is powered by non-fossil electricity, the global potential for negative-emissions fuel (H2) production and ocean C storage as alkalinity is significant (Rau et al. 2018)."	Taken in to account- We have changed the text adopted the editorial suggestions made by author if the comment.	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
43857	21	31	21	33	see the glossary defintion for blue carbon in SROCC and also chp 5 section 5.5.1	accepted	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
42639	21	33	21	34	"More than 50% of the carbon dioxide absorbed by plants on Earth circulates into the ocean and more than half of that carbon is absorbed by shallow coastal ecosystems…" This sentence is at distinct odds with with IPCC's global C model in AR5 WG 1 Fig 6.1	Taken into account - the sentence is deleted	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
35053	21	36	21	42	The discussion could include the transportation of minerals from North Africa to South America. This is one of the most relevant phenomenon of this sort, but it is not addressed here.	Taken into account - status discussion is moved to the new table with the comparison of different CDR methods. Due to the lack of the space could be reflected	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
34265	21	40	21	42	Did really field experiments "confirm the method" ? At what scale and duration ?	noted - text is not changed. Detailes are provided in the references Trull et al. 2015; Williamson et al. 2012	Antoine BONDUELLE	Climate Action Network France	France
42473	21	46	21	48	Suggest rewrite: "An alternative method proposed the dissolution of carbonate minerals (e.g., CaCO3) in the presence of waste flue gas CO2 and seawater as a means capturing CO2 and converting it to ocean alkalinity (Rau and Caldeira 1999; Rau 2011 https://pubs.acs.org/doi/abs/10.1021/es102671x)."	accepted	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
32683	21	3	23	10	Are the potential knock-on effects of ocean fertilization understood? If so, I think it would be worth discussing these. I'm personally conerned about ocean fertilization until we know these knock-on effects--we've already done a great job destroying terrestrial ecosystems, and I'm really concerned ocean fertilization/other options could result in the same happening to the ocean.	Noted - yes, we share the concern of potential risks and side effects. This discussion is now included in the table	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
43859	21	3			see SROCC Chp 5 re ocean fertilisation, this says "The feasibility of climate mitigation by open ocean fertilisation of productivity is limited to negligible, due to the likely decadal-scale return to the atmosphere of nearly all the extra carbon removed, associated difficulties in carbon accounting, risks of unintended side effects and low acceptability."	Taken into account - refered in the table and text on mitigation potencial including additional information suggested in the comment	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
48167	21	3			Ignores capacity limits	Noted - discussed in the Potentials part	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
35051	21	31			The term (and subsequent discussion on) blue carbon should be placed on line 3. This, because blue carbon is being referred right before, so it is not consistent to mention the term and then bring it back three paragraphs later.	Noted - text structure is changed in SOD	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
6123	22	3	22	6	The paper by Köhler et al. (2013) has been missed - https://doi.org/10.1088/1748-9326/8/1/014009. The paper uses an established marine ecosystem model to predict changes in biogeochemical fluxes, plankton species composition and marine food webs due to the addition of 1 µm olivine particles to the surface layer of the ocean.	Rejected - yes, we considered this reference but could not reflect all	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
43861	22	7	22	13	see Chp 5 section 5.5.1 in SROCC, this assess blue carbon, coastal vegetation restoration and co-benefits	Accepted - SROCC assessment is referred	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
42485	22	13	22	13	After "….adapt to climate change (Kuwae and Hori 2019)." insert: "However, recent estimates show relatively limited CDR capacity for blue carbon approaches (<1Gt CO2/yr; NASEM 2019 https://www.nap.edu/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda)."	Taken into account - combined with other comments. NASEM 2019 is refered in the text. Comparative potential of CDR methods (<1Gt CO2/yr for BC) is summarised in the table	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
62	22	14	22	14	Please make sure that the potentials discussed here are consistent with what is discussed in Chapter 5 of WG1 report	Taken into account - we had cross-WG interaction and also refered Ch.5 WGI	Govindasamy Bala	Indian Institute of Science	India
29357	22	16	22	17	Verb is missing in "because when oxidation to CO2 in the upper ocean"	Editorial - text revised	Catharina Latka	University of Bonn	Germany
47227	22	22	22	22	GtCO2 not GgCO2. Other authors give much higher potential figures, due to challenges about analysis of permanence of carbon storage, and in the case of the iron salt aerosol method, removals of other GHGs in the atmosphere through photolytic release of chlorine atoms that remove methane, low level ozone and soot from the troposphere.	Accepted - units are changed	Robert Tulip	Australian National University	Australia
3197	22	22	22	23	Please double check whether there is any typo error with the unit "GgCO2". Normally, the unit "GtCO2" is used, and the two units differ in many orders.	Accepted - units are corrected	Sai Ming LEE	Hong Kong Observatory	China
6125	22	23	22	23	I could not find the reference Ryaboshapko and Revokatova (2015) on the internet from the very limited information provided about the source. Should it be quoted?	Taken into account - more details on this reference are added into Mendeley including english abstract	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
64	22	24	22	24	Ocean can store thousands of Gt-CO2 additional CO2, not hundreds of thousands. Note that ocean currently holds 40, 000 Gt-C of carbon.	Accepted	Govindasamy Bala	Indian Institute of Science	India
42475	22	26	22	29	rewrite:" The potential of increasing ocean alkalinity may be constrained by: a) the ability to extract, process, and react minerals (see Section 12.3.2.2), b) the production of manufactured alkalinity, c) the demand for co benefits (see below), or d) the need to minimise impacts around points of addition."	Accepted	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
963	22	30	22	35	This paragraph (or section) requires extension. There is a lot of new (partly government-funded) research and commercial interest in the Netherlands into seaweed, also for the production of alternative proteins.	Rejected - no reference	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
6127	22	30	22	35	This is a very limited review of the literature for the subject. I suggest this section should take into account the papers by Chung et al https://doi.org/10.1080/09670262.2017.1359678, DOI 10.1093/icesjms/fss206 and DOI 10.1007/s10811-010-9604-9; N'Yeurt et al (2012) http://dx.doi.org/10.1016/j.psep.2012.10.008; Raven (2017) https://doi.org/10.1080/09670262.2017.1362593; Sondak et al (2017) https://doi.org/10.1007/s10811-016-1022-1 and Duarte et al (2017) http://journal.frontiersin.org/article/10.3389/fmars.2017.00100/full.	Taken into account - not all references are included but all main findings was reflected in the new Table	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
16349	22	30	22	35	Consider adding a brief description of the protein content of seaweeds and its potential benefit for human nutrition or as fertilizer in terrestrial agriculture, or as an industrial or materials feedstock, as a way of enhancing the content of this section of text as an aid to the reader.	Noted - space limit do not allow to include this information in details	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of

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29359	22	30	22	35	Seaweed farming as one option under "blue carbon" is an exception to the earlier statement on page 15 that "Ocean-based approaches (see Section 12.3.2) cannot directly be attributed to distinct sectors" (line 31 f.) and could also be related to food system mitigation options.	Noted - food system is discussed in 12.5 section. Also, conception of sectors and cross-sectoral perspective is discussed in the introductory part of the chapter	Catharina Latka	University of Bonn	Germany
34267	22	30	22	35	This paragraph is to be rewritten with clear data and sentences	Taken into account - the paragraph is revised	Antoine BONDUELLE	Climate Action Network France	France
43863	22	30	22	35	see Chp 5 section 5.5.1 in SROCC, coastal blue carbon generally focuses on the protection and restoration of mangroves, saltmarsh and seagrass beds. Macroalgae are also considered but through farming/harvesting as macrolagae do not have substantial 'root systems' / carbon stocks in the sediment	Taken into account - section is significantly rewritten taking into account SROCC ch 5	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
47231	22	30	22	35	The 'blue carbon' concept includes marine permaculture, with expanded production of macroalgae (kelp and other seaweeds) and even potentially microalgae on the model of the NASA Offshore Membrane Enclosure for Growing Algae study. Ocean Foresters calculated immense carbon storage potential using marine algae, with far better carbon storage results than the "carbon neutral" result mentioned. Integrated Multi Trophic Aquaculture has potential to store carbon in shells.	Taken into account - "blue carbone" sub-section is revised, but not all aspects could be reflected because of page limits	Robert Tulip	Australian National University	Australia
66	22	34	22	34	Insert "emissions" after agriculture	editorial - accepted	Govindasamy Bala	Indian Institute of Science	India
42477	22	35	22	35	after "...strong climate policy." insert: "In any case using seaweed as a food source rather than some longer lived product would greatly limit C storage capacity and hence its CDR potential."	accepted	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
68	22	36	22	36	Please make sure that the co-benefits and side effects discussed here are consistent with what is discussed in Chapter 5 of WG1 report	Taken into account - we had cross-WG interaction and also refered Ch.5 WGI	Govindasamy Bala	Indian Institute of Science	India
47229	22	36	22	40	Drawbacks of ocean fertilization should be described as potential drawbacks. My understanding is that study of ice age sediment data has not corroborated all these theorised effects.	Accepted - text revised	Robert Tulip	Australian National University	Australia
42479	22	46	22	47	This seems to be a very misleading statement: "Given the relative sensitivity of species to changes in alkalinity, its use for mitigating the effects of ocean acidification in natural environments requires careful consideration." Implies that species are negataively impacted by alkalinity addition when the opposite effect is generally found in the few studies conducted (pg 22, lines 5-6). This sentence should be replaced with: "Given the paucity of research conducted on biological effects of alkalinity addition (cited above), further study is required to demonstrate the positive and negative impacts of alkalinity addition on marine ecosystems."	Accepted - text revised	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
43937	22	30			the term "substantial suitable area" needs further definition. Is this a global estimate of coastal areas available for this purpose?	Noted - yes, this is the area globally availabe for BC	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
43867	23	5	23	10	see Chp 5 section 5.5.1 in SROCC, cobenefits of coastal vegetation for blue carbon include coastal protection, increased biodiversity, goods such as firewood	Taken into account - reflected in the table	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
70	23	11	23	11	Please make sure that the risks and impacts discussed here are consistent with what is discussed in Chapter 5 of WG1 report	Taken into account - we had cross-WG interaction and also refered Ch.5 WGI	Govindasamy Bala	Indian Institute of Science	India
34269	23	11	23	18	This part on ocean fertilization could be linked or clarified with previous pages on enhanced wheathering in the previous pages. Maybe a table showing the options and their drawbacks or potentials would increase clarity	Taken into account - see table	Antoine BONDUELLE	Climate Action Network France	France
47233	23	11	23	18	The risks and impacts discussion repeats some points made at p22 line 36. The Iron Salt Aerosol method presents a safe and effective way to test these hypothetical risks, with the benefit of atmospheric GHG removal justifying experimental analysis of diffuse oceanic effects, which could prove to be overwhelmingly positive, contrary to these speculated side effects.	Taken into account - repetition is removed and also some information on risls and impacts is moved to the new table	Robert Tulip	Australian National University	Australia
6129	23	16	23	16	The reference to "anoxia in surface ocean" derived from Minx et al (2018) is incorrect. The main risk of anoxia is in subsurface waters e.g. Bakker (2004) https://books.google.com/books?hl=en&lr=&id=Fw-8BwAAQBAJ&oi=fnd&pg=PA453&dq=bakker+DCE+Storage+of+carbon+dioxide+by+greening+the+oceans%3F&ots=SmPHjzpuwH&sig=zm7BlwUHcr535obsell7x9FB22E; Fuhrmann and Capone (1991) https://aslopubs.onlinelibrary.wiley.com/doi/pdf/10.4319/lo.1991.36.8.1951. and Canadian Science Advisory Secretariat Science Advisory Report 2010/012 https://www.whoi.edu/fileserver.do?id=78144&pt=10&p=39435.	Taken into account - text is revised	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
42481	23	19	23	25	you mean: "For ocean alkalinity, the local impact of increasing alkalinity on ocean chemistry can depend on the speed at which the added alkalinity reacts with resident seawater CO2 relative the speed of seawater mixing and dilution, and the rate of ingassing of CO2 from the atmosphere (Bach et al. 2019). Seawater that is undersaturated in CO2 relative to air due to alkalinity addition will have a greater potential to perturb seawater carbonate chemistry. On the other hand the addition of alkalinity that has already reacted with CO2 upstream from the ocean (bicarbonate and carbonate ions not balanced by H+, e.g. derived from soil mineral weathering) will have little or no additional effect on surface ocean/atmosphere CO2. However, in all cases pH and carbonate ion concentration ultimately increase in alkalized seawater, a feature that counters the chemical effect of ocean acidification. The biological effects of adding alkalinity and modifying seawater chemistry, especially significantly beyond historical seawater ranges, requires further study."	Accepted - the text has been revised according to the suggestion in the comment	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
29361	23	34	23	35	It is not entirely clear to me how/ why mitigation ambitions in other sectors (which?) may be diluted as a consequence.	taken into account - this sentence is removed	Catharina Latka	University of Bonn	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
47235	23	34	23	35	The alleged risk of diluting mitigation ambition in other sectors is a meaningless deflection of the need for research. All methods to fix the climate should apply the common metric of unit cost of removed radiative forcing. The overall scale of required removals is far bigger than decarbonisation can achieve, making the need 'all hands to the pump'. The key problem with this risk analysis that criticises CDR is that the risk of not proceeding with research at large scale is far higher than the risk of conducting scientific research. Breakthroughs could enable carbon removal at larger scale than total emissions, which would solve the climate problem.	taken into account - this sentence is removed	Robert Tulip	Australian National University	Australia
47237	23	36	23	38	This costing is misleading. The $2 cost is for fertilization with iron, while the $457 cost is for nitrate. Development of new commodity markets based on algae could potentially make CDR commercially profitable.	Rejected - we give the range for different options	Robert Tulip	Australian National University	Australia
1947	23	36	24	2	As for the cost estimate of blue carbon, see the following reference: Board, O. S., & National Academies of Sciences, Engineering, and Medicine. (2019). Negative emissions technologies and reliable sequestration: A research agenda. National Academies Press.	Taken into account - combined with other comments	Kuwae Tomohiro	Port and Airport Research Institute	Japan
35055	23	29			The discussion on blue carbon should be kept in one paragraph. There are two separate discussions on that page, when they could be integrated only in one paragraph. Also, "Damage" on line 30 should be "Damaging" as it is a substantive and not a verb that is needed there.	Taken into account - editorial comment is accepted. We belive BC discussion is important, and other comments required more detail information.	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
43865	23	36			no costs for coastal blue carbon are included - estimates are available	Noted - no reference	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
42483	24	1	24	2	Rewrite: "Rau et al. (2018) estimate that electrochemical processes for increasing ocean alkalinity may have a net cost of 3–160 US$/tCO2, largely depending on energy cost and co-product (H2) market value."	Accepted	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
9601	24	7	24	8	It is problematic that BECCS is used as a very generic term when it in fact covers a range of opportunities (with different costs) in terms of carbon capture (ethanol, biogas, aerobic fermentation, power plants, etc.). This comment applies to the entire report. It is recommended to add a section that gives more detail on BECCS	Accepted-Added after BECCS a new sentence which covers a range of opportunities BECCS has to offer.	Jesper Kløverpris	Novozymes	Denmark
41403	24	10	24	12	This sentence is not a good summary of the status. There are positive side-effects as well, as described in p. 25, line 13-22, and this should be mentioned here as well.	Accepted	Cecilia Sundberg	Swedish University of Agricultural Sciences	Sweden
905	24	10	24	13	Recommendation Revise sentence Reason This sentence can be misinterpreted. Perhaps revise it so that it better reflects that the total quantum of mitigation potential is uncertain. At the moment is can read as though the potential for these options to provide climate change mitigation is uncertain.	Accepted	Aaron Simmons	NSW Department of Primary Industries	Australia
42487	24	13	24	13	after "….Mbow et al. 2019; Olsson et al. 2019)." insert: Such effects might be avoided and the global potential for cost-effective, negative-emissions biomass energy greatly extanded by considering marine sources of biomass (Hughes et al. 2012 https://onlinelibrary.wiley.com/doi/abs/10.1002/ghg.1319) or alternative methods of biomass energy extraction and resulting CO2 capture and storage (Zhou and Park 2020 https://www.sciencedirect.com/science/article/abs/pii/S0306261920301872 ; Rau 2011 https://pubs.acs.org/doi/abs/10.1021/es102671x)."	Accepted- Added a sentence that apart from the concerns expressed for BECCS, there also positive effects which are covered under benefits for BECCS later.	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
34873	24	20	24	21	It is important to note that renewable energy projects have social and environmental costs	Rejected Comments not applicable to subject matter	Cintya Berenice Molina Rodríguez	El Colegio de México A.C	Mexico
32573	24	22	24	24	BECCS is not carbon negative in the relevant window of the next two to three decades See next comment; see also Anna B. Harper et al., Land-use emissions play a critical role in land-based mitigation for Paris climate targets, Nature Communications (August 2018) ("Under the modelled land-use and climate scenarios we find that the accumulated carbon removed from the atmosphere through BECCS is largely offset by initial reductions in stored land carbon."). Moreover, the notion that 12 GtCO2 yr-1 for BECCS is a conservative estimate is undercut by the point made in this draft that IAMs have not focused on non-BECCS CDR options. This type of statement should be revised to say that 12GtCO2 yr-1 in 2100 is the assumption for BECCS absent the use of other CDR technologies. See the drafted language in above this quote in Section 12.3.3 of this draft "Among CDR options, BECCS and A/R are most commonly selected by IAMs to meet the requirements of temperature limits of 2°C and below. This is because of relatively lower estimated costs, flexibility, and the fact that IAMs may not have had capacity to model other options. Current IAMs do not represent soil carbon sequestration or biochar. Given the negative emissions potential of soil carbon sequestration and biochar and some potential co-benefits, efforts should be made to include these options within IAMs, so that their potential can be explored further in comparison with other CDR strategies for climate stabilization, along with possible impacts of bioenergy feedstock production on soil degradation (Smith et al. 2016; Rogelj et al. 2018)."	Noted. Text in question has been removed in SOD edit	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
32575	24	22	24	24	BECCS is not carbon negative in the near-term because bioenergy leaves a carbon deficit for several decades to a century—far longer than the window of a decade or two available for slowing feedbacks and avoiding crashing through the 1.5C guardrail. See, e.g., IPCC AR5 WG III (2014) 11.13.4 GHG emission estimates of bioenergy production systems ("The combustion of biomass generates gross GHG emissions roughly equivalent to the combustion of fossil fuels. If bioenergy production is to generate a net reduction in emissions, it must do so by offsetting those emissions through increased net carbon uptake of biota and soils…Hence, the total climate forcing of bioenergy depends on feedstock, site-specific climate and ecosystems, management conditions, production pathways, end use, and on the interdependencies with energy and land markets…For example, in the specific case of existing forests that may continue to grow if not used for bioenergy, some studies employing counterfactual baselines show that forest bioenergy systems can temporarily have higher cumulative CO2 emissions than a fossil reference system (for a time period ranging from a few decades up to several centuries"). Subsequent analysis since AR5 further strengthens the case that bioenergy is not carbon neutral in the critical next decade or two. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). In addition, the CCS part of BECCS has not been demonstrated at scale or at acceptable cost, nor has it won over the support it would need from the public. See Gregory Nemet et al., Negative emissions—Part 3: Innovation and upscaling, Environ. Res. Lett. (May 2018); European Academies Science Advisory Council, Negative emission technologies: What role in meeting Paris Agreement targets? (Feb 2018) ("CCS plans in Europe have been shelved so that whatever experience is being gained globally is outside Europe. The loss in momentum in implementing CCS technologies not only has serious implications for mitigation pathways, but also one of the most commonly cited NETs [negative emissions technologies] (BECCS) assumes the availability of cost effective 'off-the shelf' CCS, while another (direct air capture) relies on the widespread availability of CO2 storage. At present, economic incentives for deploying CCS are inadequate (whether through the very low carbon price or targeted government support), while those for NET development are lacking."); Andersen & Peters, The Trouble with Negative Emissions, Science (Oct 2016). One study estimates that current rate of increase in CCS is 100 times lower than needed to meet the 2C target. See Haszeldine et al. (April 2018), Negative emissions technologies and carbon capture and storage to achieve the Paris Agreement commitments, Philosophical Transactions of the Royal Society. Thus, BECCS should not be presented as a viable CDR strategy.	Accepted-Added a sentence after Mbow et al to illustrate that technical potential for BECCS is considered conservative because other CDR technologies are not yet taken account in the IAM assessment.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
5949	24	31	24	37	Data in this section has to match data in Tables 12.3. Take soil sequestration for example: Here it states 5 Gt CO2e potential at $45-100/t whereas Table 12.3 gives very different numbers for both costs and potentials.	Noted Table 12.3 is work in progress and has not fully captured the actual potentials and costs	Ralph Sims	Massey University	New Zealand
42489	24	32	24	32	after "...et al. 2018)." insert. "The preceding does not consider the expanded BECCS and biochar potentials available through the use of marine biomass for such CDR (Hughes e tal. 2012 https://onlinelibrary.wiley.com/doi/abs/10.1002/ghg.1319 ; Roberts et al. 2015 https://www.sciencedirect.com/science/article/pii/S0301479715300190?via%3Dihub)."	Accepted	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
37577	24	38	25	12	Within the risks, impacts & co-benefits for BECCS, no mention is made of the threat to biodiversity from large-scale energy crops, such as 2nd generation crops. However, later on in the risks for A/R, it is mentioned that A/R monocultures represent a threat to biodiversity. This gives a biased view and could potentiall falsely communicate that BECCS is less of a threat to biodiversity than large-scale A/R, which is not accurate.	Accepted-Added a sentence which explains that BECCS is also a threat to biodivesity	Michiel Schaeffer	Climate Analytics	Netherlands
37581	24	38	25	26	Seems like should be added here the progressions of the technological readiness of CCS technology over time to be able to scale up to the degree being called for in IAMs. Also uncertainties on the total lifecycle emissions resulting from transport, storage and fermentation of biomass on a large-scale for use in BECCS operations. Also, mentioning these uncertainties apart from the section just above on "Risks, Impacts, Co-Benefits" seems confusing. Uncertainties mentioned in that section trade-offs for nutrients, soil carbon sequestration, carbon leakage potential. Seems like it may make more sense to have a separate to include them in the risk section, or take out Risks as a separate section from impacts & co-benefits...	Noted This issue will be reconsiderd when the new section 12.5 on Impacts, risks and opportunities from land-based mitigation is written	Michiel Schaeffer	Climate Analytics	Netherlands
34271	24	4	26	7	An illustrative graph or at least a table could explain the range of potentials, of costs and of the state of play such as laboratory, experimental…	Noted This has been done for with Summary Table at the beginning of the section.	Antoine BONDUELLE	Climate Action Network France	France
72	24	6	26	7	Are these CDR options or mitigation activities? I believe there is overlap between mitigation and some CDR options such as afforestation. However, BECCS is clearly a CDR option. Also, negative emission is provided by CDR, not by mitigation. Overall, the clear distinction between mitigation and CDR options is missing in the discussion	Rejected CDR options are part of mitigation activities	Govindasamy Bala	Indian Institute of Science	India
37579	24	14	26	7	Headings separating the information on BECCS vs. information on A/R need to included. Currently only the paragraphs on each topic separate the sections, which makes it confusing when reading about potential threats and co-benefits for each one	Noted BECCS, A/R, SS, and Biochar have been indicated in Bold	Michiel Schaeffer	Climate Analytics	Netherlands
26233	24	16			" IAMs may not have had capacity to model other options" does this refer to resources i.e. man-hour?	Noted : No, IAMs simply do not represent these options	Sara Budinis	International Energy Agency	France

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
37569	25	23	12	26	The drivers of including BECCS in models could also be discussed here, e.g. see Köberle 2019, The value of BECCS in IAMs.	Accepted. A sentence and the suggested reference have been added: "The significant role of BECCS in meeting the climate goal target has been influenced by the use of IAMs, which only consider BECCS and A/R and use of high discount rates. Inclusion of other CDR options in the scenarios is likely to reduce the value of BECCS in contributing to the target (Köberle 2019)."	Michiel Schaeffer	Climate Analytics	Netherlands
11037	25	1	25	4	I do not see the relationship with the low level of innovation.	Rejected-There is no relationship of low level innovation mentioned in line 1 to 4 of page 25	PABLO DEL RÍO	Consejo Superior de Investigaciones Científicas (CSIC)	Spain
42491	25	12	25	12	After "….et al. 2018)." insert "Note that the preceding effects on land, water, nutrients and albedo associated with growing land plants for BECCS, biochar and other CDR purposes are avoided when marine plants and microbes are instead considered as the process inputs (Hughes e tal. 2012 https://onlinelibrary.wiley.com/doi/abs/10.1002/ghg.1319 ; Roberts et al. 2015 https://www.sciencedirect.com/science/article/pii/S0301479715300190?via%3Dihub Greene et al. 2017 https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2016EF000486)."	Taken into account- the preceding does not consider the expanded BECCS and biochar potentials available through the use of marine biomass for such CDR	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
34273	25	13	25	22	This paragraph is too biased in favour of BECCS without much justification	Taken into account- The text is an assessment of the literature. A new section on biomass resources will provide more detail on the nuances of the evidence'	Antoine BONDUELLE	Climate Action Network France	France
34275	25	27	25	27	"the only technology" ?	Accepted-Editorial implemented	Antoine BONDUELLE	Climate Action Network France	France
34277	25	34	25	36	the sentence is not a demonstration just an affirmation; maybe use the part on the AFOLU chapter with the idea that only a measurement and modelling at a meso-scale could be of significative for policy ?	Noted The text has been harmonised with relevant sections in Chapter 7	Antoine BONDUELLE	Climate Action Network France	France
8601	25	37	25	37	spill overs→spillovers	Accepted	Suyi Kim	Hongik University	Republic of Korea
29363	25	44	25	47	After "but there is potential for achieving co-benefits" (line 45), as a reader I was expecting the next sentences to be on these co-benefits. However, the following sentence refers back to the competition between mitigation and biodiversity. I suggest to adjust the structure for a more logical reading flow.	Accepted	Catharina Latka	University of Bonn	Germany
48169	25	13			Ignores biogenic aerosols, increased emissions when BECCS is compared to renewables, transport emissions, nutrient loss, and land use competition effects.	Noted. Text removed in rewrite of section	Andrew Lockley	Andrew Lockley	United Kingdom (of Great Britain and Northern Ireland)
965	26	1	26	1	According to Rockstrom et al.'s planetary boundaries biodiversity loss has been accelerated more than the carbon cycle, by no less than two orders of magnitude! Please see my main comment in the Food systems section.	Noted: A new section on biomass resources will provide more detail on the nuances of the evidence	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
42493	26	7	26	7	after "...biodiversity (Longva et al. 2017)." insert. "Again, impacts on the terrestrial environment can be reduced or avoid by the use of marine biomass to fuel BECCS, biochar and other biomass-related CDR processes."	Noted. A new section on biomass resource will deal with this comment	Greg Greg Rau	IMS/Univ. Calif. Santa Cruz	United States of America
29365	26	11	26	13	I suggest to reorganize the sentence starting with "Food needs to be grown (…)" (line 11), as the if-clause is not straightforwardly accessible	Accepted. The if-clause has been deleted as not required to convey the message of the sentence.	Catharina Latka	University of Bonn	Germany
39455	26	11	26	13	The first two sentences are vague and don't add much to the narrative. Suggest rewording or deleting them. If they remain, rephrase first sentence in line 11 to reflect that food and nutrition are not the same thing, therefore they are both fundamental human needs.	Accepted. First two sentences have been clarified.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
967	26	11	26	24	Two indispensable books delineating the food system are lacking: (a) Smil, V. (2000). Feeding the world: A challenge for the twenty-first century. ISBN 0-262-19432-5. Cambridge (MA), USA: MIT Press. (b) Tansey, G. & Worsley, T. (1995). The food system: A guide. ISBN 1-85382-277-4. London, UK: Earthscan.	Noted. These books are grey literature and not recent. We have cited the latest relevant defintions.	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
6305	26	12	26	13	difficult to understand.	Accepted. Sentence has been clarified	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
12441	26	13	26	13	Traditional food systems involved only few people and short supply chains (I suggest to use past to make the contrast between traditional and modern clearer. Albeit exceptions modern systems seem to be the norm to most readers?)	Taken into account. Combined with comment #39457.	Sandra Caldeira	European Commission	Italy
12445	26	13	26	13	prepared and consumed.	Accepted. Text revised.	Sandra Caldeira	European Commission	Italy
39457	26	13	26	16	Description of traditional vs modern food systems is oversimplified and not very helpful as a description. If they are included, should also mention the third category presented in the HLPE report (mixed food systems) and provide more context on why these distinctions are important.	Accepted. Text revised and reference to mixed systems included.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
5365	26	16	26	16	Add: ….production(organic and non organic), processing….	Rejected. This is not about details of food production systems, as it is not about specific types of any of the other food supply chain stages.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
5367	26	17	26	17	I propose after food loss and wastes include - part of the chain that is disappeared or have significant problems.	Rejected. Suggestion unclear.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
12443	26	17	26	17	and the management of inputs (to production for examples), food loss and wastes	Rejected. Production activities are already mentioned and this includes also their management.	Sandra Caldeira	European Commission	Italy
6679	26	21	26	24	food system outcomes also entail nutrition outcomes- not just diets and consumption patterns.	Accepted. Text changed to 'food and nutrition'. Obviously this entails a large number of consequences (ie. Food safety, NCDs, food security) which are further discussed.	Meredith Niles	University of Vermont	United States of America
39459	26	21	26	24	This is missing social outcomes of food systems in addition to health, environment, economic outcomes.	Accepted. Social outcomes were implicitly included but not explicitly mentioned.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6309	26	25	26	25	delete "and" before "in 2018".	Editorial.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
32685	26	25	26	28	If helpful, another way to phrase this is that there are more overweight/underweight/micronutrient deficient adults than there are adults that have a healthy body weight	Rejected. This is a good suggestion but we prefer current formulation.	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
29367	26	25	26	29	It could be good to add the food (in-) security concept referred to in this paragraph (i.e. do you refer to a energy based definition or a definition including nutrition security). The food system development of the last century potentially refers to attempts of reducing calorie-based food insecurity, especially as the following paragraph points at the neglected nutrition aspects. As some food security concepts subsume nutrition security as one component, one could be more clear in the definition referred to.	Accepted. Text has been changed.	Catharina Latka	University of Bonn	Germany
969	26	25	26	40	My main comment on this section - and on the whole chapter - is that (both nutritionally and environmentally) nitrogen and protein are strongly underaddressed in comparison with carbon, calories and climate change. First of all, human population size has always been nitrogen-limited (Smil, 2000; 2001; full references are available in my other comments). As indicated in FOD Chapter 12 itself (p. 29, line 20), a quarter of all GHG emissions is associated with food. In addition, Rockstrom et al.'s planetary boundary for biodiversity loss has been exceeded by over 900%, the nitrogen cycle by 245%, and the carbon cycle by 10-50% (just to facilitate an easy comparison of priorities, 100% has been deducted). Moreover, the anthropogenically accelerated nitrogen cycle is one of the main drivers of both biodiversity loss and climate change. Therefore, protein production drives the whole intertwined system of global environmental change, and it is the driver common to at least the top-3 planetary boundaries. Neither their strong links, nor their relative priorities, have currently been addressed in the text. A detailed account of the whole argument can be found in my review paper: Aiking, H. (2014). Protein production: planet, profit, plus people? American Journal of Clinical Nutrition 100(suppl), 483S-489S.	Taken into account. These are addressed to the extent they are relevant to climate and within the word limit constraints. Furthermore, we have explicitly addressed nitrogen co-benefits in Table 12.9 as revised in the SOD.	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
5369	26	27	26	27	Add: .....obese, through inadequate consumption patterns, ... with an upwardtrend globally	Accepted.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
6681	26	30	26	32	It would be good to mention here that yes the global food systems provides enough calories, but food insecurity persists in part because of access and distribution issues.	Accepted. Text added.	Meredith Niles	University of Vermont	United States of America
39461	26	30	26	32	As discussed in the Berners-Lee 2018 article, the problem is not just a lack of nutrient-dense foods, but a problem of unequal distribution and access to those foods. Suggest adding in mention of “access” in this sentence to acknowledge this important component.	Accepted. Text added.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
39463	26	36	26	37	“even more experience lack of vitamins or other essential nutrients” is vague- not sure what is meant by this, since stunting, wasting are also due to lack of essential nutrients.	Accepted. Sentence revised.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
39465	26	37	26	40	Why are these consequences singled out? And seems like there should be an explanation of why the current system has severe consequences. If this sentence is supposed to specifically explain consequences for health only, suggest rewording it to be clearer about that.	Accepted. Sentence deleted.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6683	26	41	26	42	This placeholder seems significant- how are all of these topics going to be woven together in the context of climate change?	Noted. The intention is to simply point to further aspects of health effect from food / food production. This has been done by adding few sentences and relevant references.	Meredith Niles	University of Vermont	United States of America
35003	26	41	26	42	suggest to address malnutrion aggravate susceptibility of children to various infectious diseases like parasites and bacteria that potentially affect their cognitive doman and school performance	Accepted. Text added.	Adugna Gemeda	Ethiopian Public Health Institute	Ethiopia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
5371	26	42	26	42	I agree that it is necessary include these aspects but in short and contundent in two or three paragraphs	Noted. The intention is to simply point to further aspects of health effect from food / food production. This has been done by adding few sentences and relevant references.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
6685	26	45	26	46	Be more clear about the asymmetric distribution of food influence- does the report intend to state them that multinational companies can have a huge influence on our food system and what is available?	Accepted. See comment #39467	Meredith Niles	University of Vermont	United States of America
39467	26	45	26	46	This sentence needs clarification. Suggested rewrite: "Modern food systems are highly consolidated due to increased vertical and horizontal integration. This consolidation has led to uneven concentration of power across the food value chain, with more influence concentrated among few actors in the post-farm gate food supply chain (eg. large food processors and retailers). While agricultural producers contribute a higher concentration of GHG emissions compared with other actors in the supply chain, they have relatively little power to change the system because large (often multinational) corporations exert high levels of control."	Accepted. Proposed wording used with small modifications.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6303	26		26		"food and nutrition are among the …" instead of "are one".	Editorial.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
39525	26	0	54	0	Section 12.4 overall: Given the attention paid to food waste in this section and in other chapters of the report, there seems to be a lack of focus on solutions to reduce food waste. Suggest including more mention and research on that in this section.	Accepted. We have included a focus on food waste across the different categories of food system mitigation opportunities discussed. In the revised Table 12.9 we have included a 'flag' on food loss and waste to highlight the possibility to reduce FLW throughout the food supply chain. Note however that a significant part of the discussion discussion on consumer policies in the FOD was already about food waste.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6307	26	13			I think there is a misunderstanding due to the use of "actors" and "people" as synonymous. Actually, "traditional food systems" may need (and employ) a larger number of PEOPLE, comparing to "modern food systems". Specially if the later is based on (e.g.) high-tech mega-farms. It is true that in these "modern" systems there are more "actors" acting as intermediaries.	Accepted. Definition of food system actors clarified	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
39471	27	0	27	0	Not easy to differentiate between “Influence arrows” and “Policies” arrows - maybe make them different colors, not both on a red scale. Also, hard to differentiate within Influence/Policies the different colors. Would help to have colors contrast more starkly.	Accepted. Policies now with solid line to differentiate from Influence	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6687	27	1	27	4	This sentence is confusing- are you meaning to say that higher GHG emissions come from post-farm gate? Or higher influence of actors comes from post-farm gate?	Accepted. This sentence referred to the influence of actors. As this is already discussed in the text, this part has been deleted from the caption.	Meredith Niles	University of Vermont	United States of America
30639	27	1	27	4	It is entirely unclear what this means.	Taken into account. Combined with comment #39467.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
12447	27	4	27	4	it is not clear what the constraining conditions are	Taken into account. Combined with comment #39467.	Sandra Caldeira	European Commission	Italy
6689	27	5	27	7	Confusing sentence- reword to break apart and make clear that the downward shifts (e.g. 6 to 3%) are the numbers of people employed in that industry in those places with the difference in two numbers being from the two dates listed.	Accepted. Sentence revised.	Meredith Niles	University of Vermont	United States of America
29369	27	5	27	13	That the 27% include employment in the food industry of the respective "food systems" could be repeated here so that the reader is reminded about the concept of food systems opposed to sectors	Taken into account. Combined with comment #6689.	Catharina Latka	University of Bonn	Germany
6691	27	7	27	13	Confusing here- above you mention that 27% of people are in agriculture, fisheries, and forestry, but the numbers listed below seem to include the food service sector- which would be things like restaurants? In other words, you aren't using comparable numbers- one seems to be about primary industries (the 27%) and the others seem to be about the entire food system supply chain.	Accepted. Sentence revised.	Meredith Niles	University of Vermont	United States of America
6693	27	14	27	15	Typo in processing in the figure. Very confusing with two categories of the same colors- would suggest changing the influence and policies arrows to be different colors and make the color hues significantly different- its hard to see the color differences in the tones of red. Why is environment management and NGOs its own pentagon? Should that instead read producers, consumers and environmental NGOS? And also- why only environmental NGOs? There are plenty of other types of NGOs that are influencing the food system.	Accepted. Policies now with solid line to differentiate from Influence	Meredith Niles	University of Vermont	United States of America
12449	27	14	27	15	great figure that would benefit from some more clarity: top right - inert nitrogen? Not mentioned at all and not clear why it would go here bottom left - why are NGOs here? acronym not defined, is it non-governmental organisations? Are they not included in civil society (top right) legend: arrows influence and policies look the same	Accepted. Changed to connected non-reactive nitrogen pools (and places at bottom as linked to the raw material extraction/pollution management sphere.	Sandra Caldeira	European Commission	Italy

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28909	27	14	27	15	Is there any meaning about the color of each pentagon, from the inner to the outer side?	Accepted. All inner pentagons represent food system spheres. They are now in the same color. The outer pentagons are connected system and are in a different color.	Marissa Malahayati	National Institute for Environmental Studies	Japan
29371	27	14	27	15	Spelling mistake in "Processing"; adapt colors in legend for "Biomass flows"; One could also remove the "Policies" label as the same message can be transferred only by the "Influence" label	Accepted. Suggestion on the 'policies label' noted, however both labels are maintained.	Catharina Latka	University of Bonn	Germany
35907	27	14	27	15	In Figure 12.4, it is not clear why "Inert nitrogen" is mentioned in the outer pentagon on top right. The word "processing" is misspelled in the fiture (procdssing). The arrows for biomass flows are back in the figure and blue in the index.	Accepted. 'Inert nitrogen' has been replaced by 'Connected non-reactive nitrogen pools'	Hanna Tuomisto	University of Helsinki	Finland
28911	27	16	27	26	Is this all caption? Please summarize it, make it shorter. If you need it to be explained, please put it on the paragraph	Accpted. Caption has been shortened.	Marissa Malahayati	National Institute for Environmental Studies	Japan
12451	27	25	27	26	description: this sentence is unclear to me	Accepted. Text deleted as caption had to be shortened.	Sandra Caldeira	European Commission	Italy
27117	27		27		Figure 12.4: top diamond spells "procdssing", typo of processing?. Also it is slightly confusing that the food system actors are described as e.g. "consumption" in the figure but as "food consumers" in the figure note.	Accepted.	Jan Bauer	Copenhagen Business School	Denmark
27119	27		27		Figure 12.4: The figure suggest strong power of media & education on consumers. In the area of health, the idea that education sustantially affects food consumption is debated. Additionally, are we not missing the link between policy makers, the food supply chain and the power on media & education element?	Accepted.	Jan Bauer	Copenhagen Business School	Denmark
5373	27	14	28	8	Figure 12.4 is well conceived and wise, but not good shown, it is very difficult to interpret among so many arrows each part of the system and their interrelations. I propose to seek colours more brilliants and differents or seek other forms different of arrows. This for SOD	Accepted.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
39475	28	0	28	0	"Food related FOLU" in leftmost column seems redundant -- shouldn't it say "food-related land use", since food is technically already part of the FOLU definition?	Rejected. This table was a re-production of SRCCL. However, it will not be included in the SOD.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
12453	28	6	28	8	description: I don't find the assymetry obvious in the figure	Noted. The asymmetries are shown by 'influence' arrows between two food system actors that have different strength in one direction as compared to the other direction.	Sandra Caldeira	European Commission	Italy
29373	28	6	28	8	If the asymmetry between GHG sources and influence shall be pointed out in the figure, I would suggest to change the color patterns, as the grey arrows get lost in the figure while the black biomass flows catch the viewer's attention	Accepted. We increased visibility of influence and policy arrows by increasing the width of the arrows.	Catharina Latka	University of Bonn	Germany
971	28	10	28	10	Another useful reference may be: Johnson, I., Dudley, N. & Alexander, S. (2017). Global land outlook. Available at http://www.unccd.int/ Accessed 28 September 2017. Bonn, Germany: United Nations Convention to Combat Desertification.	Accepted - with thanks. The study is cited in Section 12.5	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
39473	28	15	28	17	Should end with “…and waste of food are evaluated as a whole”	Editorial.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
12455	28	24	28	24	some clarity regarding this variation is needed - vary depending on what? the model?	Accepted. Text revised.	Sandra Caldeira	European Commission	Italy
5375	28	26	28	26	Eliminate one Table 12.6 because are written two	Editorial. This section has been shortened and Table 12.6 has been removed.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
25263	28	26	28	26	Delete "Table 12.6"	Editorial. This section has been shortened and Table 12.6 has been removed.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
5377	28	28	28	30	The Table 12.6 would be refined for SOD shown of where are produced these values, included the total, and accomplish of traditional agriculture and food-related land use change emissions values for see the differences	Noted This section has been shortened and Table 12.6 has been removed.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
29375	28	29	28	30	Please add an explanation on what is meant with "Pre- to post-production" - it sounds a bit like referring to the whole value chain, while the numbers and the table structure suggests that it does not include the other explicitly listed components	Noted This section has been shortened and Table 12.6 has been removed.	Catharina Latka	University of Bonn	Germany
35909	28	29	28	30	In Table 12.6, it would be good to separate pro- and post-production emissions if possible.	Noted This section has been shortened and Table 12.6 has been removed.	Hanna Tuomisto	University of Helsinki	Finland
5379	28	31	29	8	The paragraphs from page 28/line 31 to page 29/ line 8 are important and would have references or put as conclusions of the point 12.4.2.1	Accepted. Section 12.4.2.1 has been deleted and most of the text indicated has been merged with the introduction 12.4.1.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
14257	28	6			Sharing some thoughts here: While most GHG emissions are mainly from in-farm activities (could we have that comparison in-farm vs beyond-farm?) it is important to highlight the power of low GHG sustainable eating choices/food consumption as a driving force in the food system. These are main inputs in the system that support most environmental issues caused by the food production system. I feel this message should be well delivered, emphasizing the role of consumers choice on shaping the whole food system and how such behavior shift could be achieved (social norms, motivations,...). This is particularly relevant as within the consumerism paradigm there is strong resistance to address consumer behavior due to freedom of choice. Still, from a food policy perspective, shaping consumers food choice is often addressed by 1) consumer information (awareness, education) and 2) food environment. At 1) we can include a mix of tools: adequate GHG emissions impact labelling to national FBDGs which provide inclusive guidance for the whole population to help achieve healthy and urgently needed sustainable eating choices. Nevertheless, these need to be appropiatelly implemented. This should reflect on educational campaigns, public procurement, nutritionists/dietitians training, school/college syllabus programs, integrated in organizations sustainability values, strategies and reports... In addition, there is an increasing number of countries shaping food consumption through measures that target 2) food environment: marketing regulation (included here as the outcome is a lower exposure to particular foods), taxes and incentives, volunteering agreements with food industry. While these often focus in addressing unhealthy foods (successful cases studies include the recent Chilean food policy) future efforts could transfer the Finish model "health in all policies" to develop "environment in all policies" to engage to all ministeries in reducing GHG emissions from the food system (not only) and apply some of the above measures to achieve low GHG footprints from diets. Nevertheless, other factors such as social norms, cultural beliefs are also part of the equation. Shaping dietary behaviors can be, probably, the most important achievment to reduce GHG at a systems level and needs to be well addressed in the report (even consider integrating information from consumer behavior change models,...). As said, "producers and consumers need to hand in hand" but a lack of democracy and transparency compromises consumer understanding of its role in the food supply chain and production systems. While a combination of top down and bottom-up approaches can act independently to support change, top down policies need to facilitate local bottom-up initiatives.In addition, changing the way the connecting actors communicate and cooperate (ex producers and consumers in short food supply chains) is also needed to support agriculture resilience in weaker productive regions. Finally, the importance of integrating all measures through a shift at governance level (global to local) is crucial to guide and drive an effective system change	Noted. A thorough assessment of policies targeting consumer choices is given later in the section.	João Costa Leite	Universidade Fernando Pessoa	Portugal
6311	28	13			check the reference list. I guess the reference is missing in the reference list.	Editorial.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
6313	28	26			space to be added	Editorial.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
39477	29	1	29	1	The correct source for the "one third of all food…" statistic is a 2011 FAO report, not the IPCC SRCCL. Reference: FAO. 2011. Global Food Losses and Waste. Extent, Causes and Prevention (available at http://www.fao.org/docrep/014/mb060e/mb060e00.pdf).	Accepted. The estimate of total GHG emissions associated with food waste will be given in SOD-Chapter 7	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6695	29	1	29	2	Could you clarify if the food waste emissions were 8-10% of all global greenhouse gas emissions, or 8-10% of the food system GHG emissions?	Noted. The estimate of total GHG emissions associated with food waste will be given in SOD-Chapter 7	Meredith Niles	University of Vermont	United States of America
12563	29	17	29	17	accelerate the adoption of plant-based dietary patterns	Editorial.	Sandra Caldeira	European Commission	Italy
39493	29	20	29	30	Rephrase as “All sectors of the food system contribute GHG emissions.”	Noted. The meaning of the sentence was different (all IPCC sectors contribute to GHG emissions in food systems); to avoid confusion sentence has been deleted.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
39495	29	22	29	24	The largest contribution of food systems emissions is from agriculture (50%), followed by energy use (25%), waste management (14%) and industrial processes (5.8%).	Editorial. See also comment #14259	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
30641	29	24	29	25	This sentence is unclear. Where is the 50% or 42% coming from?	Accepted. Sentence was unclear and has been deleted.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
39479	29	33	29	33	43% of what? Here and throughout Section 12.4, there needs to be more clarification when percentages are used.	Accepted. Text revised.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
32577	29	33	29	42	More recent calculations conclude that climate emissions from cooling equipment—including CO2, black carbon, and fluorinated gases such as HCFCs and HFCs—are a significant contributor to climate impacts. Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING, Chapter 3: Energy-related emissions from the cooling sector and opportunities for mitigation; Sustainable Energy for All (2018) Chilling Prospects: Providing Sustainable Cooling for All; Carvalho S., et al. (2014) Alternatives to High-GWP Hydrofluorocarbons. Improvements in the cold chain are important to reduce food loss and waste and promote food security. Due to lack of an interconnected cold chain infrastructure, developing countries lose 23% of their food production while developed countries face a loss of 9% of the total food produced. In 2011, annual food loss amounts to 4.4 GtCO2e annually, and of this, 1 GtCO2e was attributable to lack of cold chains. India was the first country in the world to launch its National Cooling Action Plan, where it has identified cold chains as a major source for doubling farmer incomes and meeting its targets under the Montreal Protocol's Kigali Amendment to phasedown HFC refrigerants. Improving cold chains should involve promoting energy efficiency and efficiency within the system as a whole using Life Cycle Performance (Andersen S. O., Wolf J., Hwang Y. and Ling J. (2018) Life-Cycle Climate Performance Metrics and Room AC Carbon Footprint, ASHRAE Journal 25) as well as limiting greenhouse gas emissions through utilizing low-GWP refrigerants. The International Solar Alliance (ISA) Solar Cooling Initiative (I-SCI) focuses on meeting rural cooling demands that help in reduction of farm to fork losses by providing small and marginal farmers access to cooling and potentially doubling their income. The initiative aims on helping its member states develop an interconnected, solar powered cold chain network that use refrigerants in compliance with the Kigali Amendment to the Montreal Protocol to substantially increase the overall GHG mitigation potential. University of Birmingham (2018) A Cool World: Defining the Energy Conundrum of Cooling for All ("Introducing more affordable and readily available means of cooling in food supply chains and the built environment is not just a matter of adding cooling to the status quo; it will introduce major shifts to dynamic socio-technical systems as well as the wider environment and eco-systems."); World Resources Institute (2019) Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050, 54 (illustrating in Figure5-2 that food loss and waste emitted 4.4 GtCO2e annually in 2011); Mbow C. et al. (2019) Food security, in IPCC SPECIAL REPORT ON CLIMATE CHANGE AND LAND, 440; International Solar Alliance (ISA), Briefing Note: ISA Solar Cooling Initiative (I-SCI); National Institution for Transforming India (NITI) (2017) Doubling Farmers' Income: Rationale, Strategy, Prospects, and Action Plan, NITI Policy Paper No.1 COME.pdf; Ozone Cell, Ministry of Environment, Forest, and Climate Change, Government of India (2019) India Cooling Action Plan.	Accepted. Additional references and text added	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
32853	29	33	29	42	Improvements in the cold chain are important to reduce food loss and waste and promote food security; improving cold chains should involve promoting energy efficiency (and efficiency within the system as a whole) as well as limiting greenhouse gas emissions through utilizing low-GWP refrigerants. University of Birmingham (2018) A Cool World: Defining the Energy Conundrum of Cooling for All ("Introducing more affordable and readily available means of cooling in food supply chains and the built environment is not just a matter of adding cooling to the status quo; it will introduce major shifts to dynamic socio-technical systems as well as the wider environment and eco-systems. …For example, a cold chain will help reduce food loss, in itself a major source of CO2 emissions, and thereby potentially reduce the need for deforestation by ensuring an increased proportion of production reaches the market from existing land resources utilised for agriculture. It could equally allow farmers in developing economies to transition from staple to high value (but temperature sensitive) horticulture."); World Resources Institute (2019). Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050, 54 (illustrating in Figure5-2 that food loss and waste emitted 4.4 GtCO2e annually in 2011); Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING; Sustainable Energy for All (2018) Chilling Prospects: Providing Sustainable Cooling for All; Carvalho S., et al. (2014) Alternatives to High-GWP Hydrofluorocarbons; Mbow C., et al. (2019) Food security, in IPCC SPECIAL REPORT ON CLIMATE CHANGE AND LAND, 440 ("Reduction of food loss and waste could lower GHG emissions and improve food security (medium confidence). Combined food loss and waste amount to 25–30% of total food produced (medium confidence). During 2010–2016, global food loss and waste equalled 8–10% of total anthropogenic GHG emissions (medium confidence); and cost about 1 trillion USD2012 per year (low confidence). Technical options for reduction of food loss and waste include improved harvesting techniques, on-farm storage, infrastructure, and packaging. Causes of food loss (e.g., lack of refrigeration) and waste (e.g., behaviour) differ substantially in developed and developing countries, as well as across regions (robust evidence, medium agreement).").	Accepted. Additional references and text added	Kristin Campbell	Institute for Governance & Sustainable Development	United States of America
27121	29	33	30	16	An argument is made for an increase in refrigerators per capita in the developing world in terms of energy use, but this aspect is not mimicked in terms of waste reduction. It might be neglectable, but it could be mentioned to avoid people wondering about it.	Accepted. Added the words " and an overall reduction in food waste" in the paragraph related to refrigeration	Jan Bauer	Copenhagen Business School	Denmark
29377	29	43	30	3	The contribution of different transport means could be put in perspective if some information on footprints by product would be added (or refer to following chapter 12.4.2.3?)	Accepted. Example added.	Catharina Latka	University of Bonn	Germany
30643	29	43	30	3	Explain why the share of transport in total GHG emissions for individual food products can be so much higher than the overal share of transport for overall food system GHG emissions (I'm assuming this is because individual products with relatively low production-based emissions, e.g., certain types of seafood or produce, could be transported by less-efficient transit options and therefore have a larger proportion of their footprint coming from transportation). A brief explanation is worth reducing confusion over these seemingly contradictory statements.	Accepted. Text added.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
14259	29	22			The largest contribution of food systems' emissions is from the agriculture sector (50%) (see Chapter 7), followed by the use of energy (25%), waste management (14%),	Editorial. See also comment #39495	João Costa Leite	Universidade Fernando Pessoa	Portugal
42079	29	42			Add "This is a direct contribution to food security (in direct connection with SDG 2) and also reduced the waste of food and the associated reduction in emmissions."	Rejected. Mitigation options and co-benefits are assessed separately.	Francisco Javier Hurtado Albir	European Patent Office	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
39497	30	0	30	0	"Solvent/product use" and "other" catgories listed in Table 12.7 are not explained in the text from 12.4.2.2, so it is not clear what they are and why they are in the table. Suggest adding short section to explain what those categories represent, in the narrative or in the Table caption.	Noted. Solvent/product use is usual IPCC classification / terminology. 'Other' referred to indirect N2O emissions from other (non-agriculure) sectors. They have been grouped to the main sectors to be consistent with the data reported in agriculture.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
32687	30	1	30	3	Please contrast the high % GHGs from transportation for some foods with the low GHGs for many others. There's an ongoing discussion about food miles and how transportation is a major driver of food-related emissions. The IPCC is well-placed to address this, specifically that (a) at the whole food system, food transport isn't a major source of GHG emissions (this is already done well); (b) that this is also true for most foods (not done); and (c) that GHG emissions from transport for some foods are high (this is done). I think that explicitly mentinoing that most foods have low GHG transport emissions will help end this ongoing discussion.	Accepted. Text revised.	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
39481	30	2	30	2	Replace “individual” with “certain” or “specific,” so it doesn’t sound like that is the emissions from every individual food product. Could also provide an example of a higher-emitting food like ..	Editorial.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
907	30	5	30	5	Recommednation Revise Reason Refrigeration instead of refrigerant industry? Or does the production of refrigerants really emit 410MtCO2-e per annum? Or is it leakage of refrigerants?	Accepted. Indeed this refers to the leakage of refrigerants. Text clarified.	Aaron Simmons	NSW Department of Primary Industries	Australia
29379	30	6	30	8	What about plastics?	Noted. Plastics are only minor conributors to food system GHG emissions. Clarification added to the text.	Catharina Latka	University of Bonn	Germany
6699	30	7	30	8	More should be said about this issue of carbon sequestration of extensive production systems. Yes, this may be true, but there is also the likelihood that these systems are less efficient, so in fact these gains through sequestration may be offset by inefficiencies and increases in emissions elsewhere. You could look at Hayek and Garrett 2018 in Environmental Research Letters. As well, the climate and food systems report written for MEridian institute (disclaimer I was first author) has a nice overview on the complexity of grass fed versus grain fed beef found here: https://s31207.pcdn.co/wp-content/uploads/2019/07/CC-FS-Final-Report-November-2017.pdf (page 20).	Noted. Carbon sequestration and the agricultural production systems are covered in Chaper 7.	Meredith Niles	University of Vermont	United States of America
6697	30	13	30	16	Could you clarify what this waste category includes? Is this food waste or waste associated with food production including packaging, water, etc. It seems like this includes water waste and non food loss and waste estiamtes. It's not clear what this category encompasses or how it relates to food loss and waste.	Accepted. Clarification added	Meredith Niles	University of Vermont	United States of America
39483	30	13	30	16	Please clarify if the waste sector numbers are specific emissions only from food-related waste, or if food is included as a componenet of waste emissions in general	Accpted. Text clarified.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
30645	30	17	30	19	Add clearer description that "Share of total %" means share of food system related emissions as share of total sector emissions	Accepted. Clarification added	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
8603	30	18	30	18	Source: EDGARv5 (Crippa et al.) : move to Notes at the end of Table.	Editorial.	Suyi Kim	Hongik University	Republic of Korea
14255	30				Regarding table 12.7 on GHG emissions from food systems by sector, maybe it would be easier to the non-expert reader to have a visual graphic with % contributions.	Noted. It is important to provide quantitative information which is easier accessible in a table. However, a figure with graphical represenation of key numbers has also been included in the SOD (Figure 12.X).	João Costa Leite	Universidade Fernando Pessoa	Portugal
30647	31	4	31	6	I think the "high energy-intensive aquaculture" referred to here is confusing two relatively higher GHG foods: 1)) fish produced via recirculating aquaculture (Tilman & Clark 2014). Recirculating aquaculture systems are relatively new and rare 2) specific GHG-intensive species: trawled lobster (Nijdam et al 2012; Tilman & Clark 2014) and farmed crustaceans (e.g. shrimp, prawns) (Clune et al 2017; Poore & Nemecek 2018) Maybe this wasn't considering trawled lobster and farmed crustaceans at all and was just calling out recirculating aquaculture. If that’s the case, though, it’s odd to specifically highlight recirculating aquaculture, as it's only mentioned in Tilman & Clark. Nijdam et a (2012) actually refer to the highest footprints as “ruminant meat from extensive systems and seafood from energy-intensive fisheries” (the latter of which, they later describe as trawled lobster) NOT aquaculture. Granted, the GHG footprint of farmed shrimp and prawns are high, but I think it’s disingenuous to call out aquaculture generally when it’s mostly a few species. I’m not familiar with Holst et al 2014 and Hilborn et al 2018 but I would generally call the two highest GHG foods as ruminant meat and “certain crustacean species (e.g., trawled lobster; farmed shrimp and prawns).	Accepted. Text changed.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
30649	31	7	31	8	Though this potential is highly variable based on several factors, link to Chapter 7 discussions	Accepted.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
39485	31	7	31	8	This sentence oversimplifies the issue of the potential for carbon sequestration in extensive grazing systems because it depends on many factors and there is not one way that works everywhere. Suggest pulling som key references/conclusions on this topic from Chapter 7, Section 5. Also see Paige L. Stanley, Jason E. Rowntree, David K. Beede, Marcia S. DeLonge, Michael W. Hamm. Impacts of soil carbon sequestration on life cycle greenhouse gas emissions in Midwestern USA beef finishing systems. Agricultural Systems, Volume 162, 2018, Pages 249-258,ISSN 0308-521X, https://doi.org/10.1016/j.agsy.2018.02.003. (and other works by Stanley et al).	Accepted. Farm level emissions are discussed in Chaper 7. the sentence has therefore simplified giving the total range for beef, indicating to Chapter 7 for details.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
909	31	8	31	11	Recommendation The statement comparing beef from a dairy system to beef from a beef system should be removed. Reason Poore and Nemecek have used economic allocation to apportion impacts between co-products in a diary system. Allocating impacts between co-products in a multi-functional system is not the preferred method of handling co-production as stated in multiple international standards (EU JRC, 2010; ISO, 2006) and research (Cederberg and Stadig, 2003) has demonstrated that using economic allocation favoured the beef side of the dairy system. As such, the emissions intensity for dairy beef from Poore and Nemecek is likely to be underestimate the emissions intensity of that beef. Allocating impacts on an economic basis is also flawed because an increase in the price of dairy due to consumer demand would also increase the climate change impacts of dairy beef purely because a greater proportion of GHG emissions is attributed to it, not because the environmental impact of production has changed. Beef is not the determining product of a diary system, dairy products are, so if people preferentially select dairy beef because of a lower emission intensity there is little scope to increase dairy beef supply. This would make a price increase highly likely. Further, if dairy producers respond to price signals in the beef market and change their systems to increase beef production then beef becomes the determining product, and dairy the co-product, and the systems are no longer dairy systems. If dairy production expanded to increase the supply of dairy beef then the additional dairy production would displace existing agricultural systems and the impacts of this displacement (i.e. land use change) would need to be considered and would increase the GHG emissions intensity of dairy beef also. Cederberg, C., Stadig, M., 2003. System expansion and allocation in life cycle assessment of milk and beef production. Int. J. Life Cycle Assess. 8, 350-356. EU JRC, 2010. ILCD Handbook: General Guide for Life Cycle Assessment: Detailed Guidance. Publications Office of the European Union ISO, 2006. 14044: 2006.	Noted. The statement has been removed as farm level emissions are discussed in Chapter 7. The comment however as the text referred to different production systems for predominantly beef and milk production, which is independent on the method used for allocation between milk and beef.	Aaron Simmons	NSW Department of Primary Industries	Australia
30655	31	8	31	14	It would probably be clearer to the reader if the functional units of the GHG footprints of meats reported in the text matched those in the table 12.8 (right now the text reports kgCO2e per kg meat rather than per kg of protein)	Noted. Using different units might make the link between text and table more complex, but on the other hand gives additional information that might be beneficial for some readers.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30651	31	10	31	11	Also due to co-product allocation (e.g., overal GHG fooptrint of a dairy herd is attributed to both dairy products and the beef from the slaughtered dairy cow)	Noted. See comment #909	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30653	31	17	31	18	Most plant-based foods associated with LUC emissions still have significantly lower GHG footprints per serving than animal-source foods (e.g., compare the per-serving GHG footprint associated with palm and soy oils with the per-serving impacts of terrestrial meats in Kim et al 2019, or coffee and tofu with the impacts of terrestrial meats in Poore & Nemecek 2018). I think the main exception is dark chocolate.	Accepted. Sentence on per serving footprints added.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
911	31	17	31	19	Recommendation Acknowledge that Poore and Nemeck study is retrospective and may not represent the consequences of a change. Reason The chapter has a high reliance on the publication by Poore and Nemecek and as outlined in the previous, and following, comments there are issues with the methodological approach used. The approach used by that publication gives a historical perspective as opposed to estimating the consequences of a proposed change and as such the results can mislead policy makers (Plevin et al., 2013). If that publication is to be used then the deficiencies in the methods should be highlighted. Plevin, R.J., Delucchi, M.A., Creutzig, F., 2013. Using Attributional Life Cycle Assessment to Estimate Climate Change Mitigation Benefits Misleads Policy Makers. J. Ind. Ecol. 18.	Noted. The text makes sufficiently clear that the presented data are from existing systems and not consequential footprints. We added the word 'attributional' to avoid any residual confusion.	Aaron Simmons	NSW Department of Primary Industries	Australia
913	31	19	31	20	Recommendation The impacts of replacing other crops with citrus and almonds to sequester soil C need to be considered or noted as a trade-off with increasing nut and citrus crops. Reason The issue of SAY CURRENT PRODUCTION BY POORE AND NEMECEK footprints are also evident in the statement around nuts and citrus sequestering carbon. From a footprint perspective, that may be the case but the land (and other resources such as water) that are required to produce citrus and nuts means that other crops are no longer produced and the GHG impacts of displacing production needs to be considered. For example, in the Australian Murray Darling Basin almond production has increased 500% between 2006 and 2016 and converted 18 000 ha of cropping land to almond production and requiring an additional 1.5 GL of irrigation water. This change has displaced other irrigated industries such as dairy, cotton and rice.	Noted. Carbon sequestration associated with the conversion of arable to permanent crops is included in the footnotes. Co-benefits are assessed separately. Replacement of cotton with nuts is a specific case - also, cotton production might increase in consequence elsewhere with additional pressure on local water resources.	Aaron Simmons	NSW Department of Primary Industries	Australia
30657	31	27	31	28	Why are farmed crustaceans left out of this chart when it is included in the Poore & Nemecek study? They have one of the relatively higher GHG footprints among protein rich foods	Accepted. See comment #30647	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
35911	31	27	31	28	Table 12.8: the unit should be 100g of protein and not 1 kg as it is indicated.	Accepted. Corrected.	Hanna Tuomisto	University of Helsinki	Finland
12457	32	0	32	0	the * in the first row - Nuts - is not defined	Accepted. Missing footnote added.	Sandra Caldeira	European Commission	Italy
8605	32	3	32	3	SS: please revise	Accepted. Clarification added	Suyi Kim	Hongik University	Republic of Korea
39487	32	6	32	27	Not clear why authors decided to highight these particular categories. Also not clear what the purpose of classifying this way is — for GHG emissions or for looking at a food system more generally?	Accepted. Text modified not suggesting any specific classification of food systems.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6701	32	12	32	14	Citing an in prep paper as evidence is not appropriate.	Noted. Paper is submitted within IPCC deadline.	Meredith Niles	University of Vermont	United States of America
39489	32	29	32	33	Seems to me that the four "dimensions" shown in the figure are actually indicators or metrics of the food system dimensions or outcomes of environment, health, economy. Suggest tying this back to earlier discussion of "food system outcomes" from the Introduction of 12.4 (see page 26, lines 21-24). As elsewhere in section 12.4, it would be helpful to have more explanation of why these particular dimensions/metrics were selected, given that there are many different dimensions of food systems and ways of measuring their impact on various outcomes.	Accepted. This part has been shortened and the figure and indicators selected better introduced.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6703	32	34	32	36	the share of energy emissions of what? The share of food as a component of a country's energy emissions? As written this statement isn't clear.	Accepted. Text clarified. See also comment #39491	Meredith Niles	University of Vermont	United States of America
39491	32	35	32	35	38 and 98% of what? Why is energy presented in percentages but food system emissions presented in tCO2e?	Accepted. Text clarified. See also comment #6703	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6315	32	23			missing year for Springmann et al. It happens in other sections of the chapter	Noted. Paper is in review and does not have yet a year. If accepted/published at the cut-off date, this will be included. Otherwise the data from Springmann et al. used in the plot will not be used.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
6317	32				Maybe including a reference to "weight of the organic farming sector" in the 3rd point.	Rejected. Organic farming is mentioned in the first bullet.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
39499	33	0	33	0	Figure 12.5 - The "Other" category here is misleading because in earlier Table 12.7, "other" is a separate category that does not include transport, energy, etc. Could the "other" categories in 12.5 be divided up into the different categories that match Table 12.7, to align the two visuals better?	Accepted. Categories are made explicit.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
39501	33	0	33	0	Figure 12.6 - is the "cost for food" based on a standard diet, or a specific food item, or a market basket of foods? As written, this is not clear. Also somewhere in the actual figure/axes (perhaps in the title) it should be mentioned that the circles represent countrires - and if possible, show the names of the countries to provide more meaningful comparison. The title for the y-axis is confusing/unclear -- overall, this figure would be easier to understand if the titles were more descriptive OR if the food related risk factors were presented in a different figure. It's trying to show too much at once in the current format.	Noted. To improve readibilty of the figure, we have included annotations that explain the main 'features' shown in the figure.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
6705	33	2	33	3	Citing of an in prep paper again- hopefully this is temporary and the paper will be out when this is released?	Noted. Paper is submitted within IPCC deadline.	Meredith Niles	University of Vermont	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
28913	33	4	33	5	What does it means? And could you give a nice legend to explain the circle there?	Noted. To improve readibilty of the figure, we have included annotations that explain the main 'features' shown in the figure.	Marissa Malahayati	National Institute for Environmental Studies	Japan
6707	33	4	33	6	For the figure with the red, yellow and blue bubbles, could you have a key in the visual highlighting what the colors are? It's buried in the figure description right now. I also see that you may have a different visual for this- I would recommend that. This is really challenging to interpret as currently visualized.	Accepted. A key is added to the updated figure in the SOD.	Meredith Niles	University of Vermont	United States of America
29381	33	4	33	17	A legend could be added for the risk factors - one could also think of leaving out the differentiation of between risk factors in the figure; a link to an online version of that figure with the option to see the countries underlying the circles would be great (here, also the risk factors would be more informative in context with the countries)	Accepted. A key is added to the updated figure in the SOD. IPCC assessment does not go to the level of individual countries, therefore the updated plot uses regional aggregation.	Catharina Latka	University of Bonn	Germany
28915	33	6	33	18	this caption is too long, please summarize it, make it concise. If you need it to be explained, please put it on the paragraph.	Accepted. Caption has been shortened in the SOD.	Marissa Malahayati	National Institute for Environmental Studies	Japan
27123	33		33		Figure 12.6: I am not sure what this graph is helping me understand. I can see a downward trend. But what do I learn from this?	Accepted. We have included annotations to the updated figure in the SOD that supports interpretation of the plot.	Jan Bauer	Copenhagen Business School	Denmark
5381	33	4	34	2	It is better to place down of the Figure 12.5 a symbology explain what is the meaning of each colour. We have to avoid the large explanation down of the Figure in SOD	Accepted. A key is added to the updated figure in the SOD.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
17423	33				Figure 17.2 is not clear.	Accetped. Figure has been improved.	Zeyaeyan Sadegh	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
6319	34	7	34	11	I couple of references would be good.	Noted. Paragraph deleted as all statements are taken up later in the section (with references).	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
6709	34	12	34	13	two Table 12.9 in sentence	Editorial.	Meredith Niles	University of Vermont	United States of America
6711	34	12	34	24	The approach of calling practices incremental versus transformative isn't in line with the current thinking about these terms as it relates to climate change (adaptation). Transformative practices typically involve a completely new system, place, etc. In this case it seems like you are referring to transformative practices in some cases as things that just aren't yet realized. Food supplements for example is really not a transformative concept in my opinion, nor are insects- indeed, many cultures already rely on insects for their food source. It might be useful to at least acknowledge that the approach/definition you are using is different than that employed in the adaptation literature.	Accepted. Use of the terms incremental and transformative better explained.	Meredith Niles	University of Vermont	United States of America
38159	34	12	34	24	Not all the mitigation options included in Table 12.9 are technological solutions. However, the narratives is only about technological solutions. It will be good a clear distinction between the two because the first ones an dto rpovide the mitigation potential for each of them separately.	Noted. The options in Table 12.9 are more or less depending on technical solutions but are all requiring a shift in food demand. The text has been clarified.	Yamina Saheb	OpenExp, Ecole des Mines de Paris	France
1657	34	26	34	26	In the 'Emerging Food Products & Production system' row, should the final column read 'Improved energy efficiency of LIGHTING?'	Editorial.	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
35913	34	26	34	26	Table 12.9: Microbial proteins belongs to the concept of cellular agriculture. In the end of the "Improved energy efficiency of lightening", it might be good to add "for vertical farming" to specify why this is important for food production.	Accepted.	Hanna Tuomisto	University of Helsinki	Finland
915	34		34		Recommendation Remove "pulses" Reason Table 12.9. Pulses are a plant-based protein source so unsure why pulses are differentiated from plant based protein sources.	Noted. We have clarified this aspect. See details at comment #927	Aaron Simmons	NSW Department of Primary Industries	Australia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
917	34		34		Recommendation Remove "shift to organic production" Reason Table 12.9 It is highly unlikley that shifting to organic production will provide climate change mitigation. The recent publication (Smith et al., 2019) demonstrated that converting to organic production would increase the GHG emissions associated with food production. Yields from organic systems are up to 50% lower than yields from conventional systems (Seufert et al., 2012) so more land is required to produce the same amount of food. Further, suggesting that a shift to organic production will provide climate change mitigation is inconsistent with research (Burney et al., 2010; Tilman et al., 2011) that demonstrates intensification of agricultural systems is likely to provide climate change mitigation because it uses existing agricultural land more efficiently and avoids the GHG emisisons associated with deforestation to increase agricultural production. It also needs to be considered that the land use change impacts of moving to organic production systems will not become obvious for many years until adequate soil N has been exported in products and the maximum yield decline due to a loss of fertility has been reached. In the past, the timeframe for yield reductions to be noticeable has been the order of decades (e.g. Australian cropping systems; Dala and Mayer 1986). Burney, J.A., Davis, S.J., Lobell, D.B., 2010. Greenhouse gas mitigation by agricultural intensification. Proceedings of the national Academy of Sciences 107, 12052-12057. Seufert, V., Ramankutty, N., Foley, J.A., 2012. Comparing the yields of organic and conventional agriculture. Nature 485, 229-232. Smith, L.G., Kirk, G.J.D., Jones, P.J., Williams, A.G., 2019. The greenhouse gas impacts of converting food production in England and Wales to organic methods. Nature Communications 10, 4641. Tilman, D., Balzer, C., Hill, J., Befort, B.L., 2011. Global food demand and the sustainable intensification of agriculture. Proceedings of the National Academy of Sciences 108, 20260-20264. Dalal and Mayer, 1986. Long-term trends in soil fertility of continuous cultivation and cereal croppping in southern Queensland. Australian Journal of Soil Research 24, 265-279.	Accepted. This table does not intend to pre-judge on the co-benefits and trade-offs associated with mitigation opportunities. Organic farming and 'local and seasonal' was used as a proxy for increased awareness by consumers on the environmental consequences of their food choices. To avoid confusion, this bullet point has been changed to '- Shift demand to food products with low GHG footprints'. See also comment #921	Aaron Simmons	NSW Department of Primary Industries	Australia
919	34		34		Recommendation Remove "vegetarian, pescatarian diet" and "vegan diet" Reason Table 12.9. Robust evidence that moving to a meat free diet can allevaite climate change i syet to be provided. The report relies heavily on Poore and Nemecek however they used economic allocation to apportion impacts between co-products in multi-functional systems. Red meat production systems have many co-products/by-products that go into various markets (e.g. fats and tallow for human consumption, meat by-products for pet foods, leather, sheepskin and wool for apparel, manure) and by allocating impacts that study did not consider the GHG emissions associated with producing functionally equivalent products to replace these co-products. Many replacements are made from oil so impacts from oil production adn processing will increase and replacing these co-products with bio-based synthetics could be have very high climate change impacts due to the increase in agricultural land required to produce the raw materials (Weiss et al 2012). If these impacts were included then the conclusion the climate change benefit of ceasing red meat consumption would likely differ. Fresan et al did not also include any GHG emissions associated with producing functional equivalents of co-products so the conclusion drawn that converting to plant-based meat alternatives lacks sufficient rigour. Weiss, M., Haufe, J., Carus, M., Brandão, M., Bringezu, S., Hermann, B., Patel, M.K., 2012. A Review of the Environmental Impacts of Biobased Materials. J. Ind. Ecol. 16, S169-S181	Rejected. The reference indicated indicates GHG savings from biobased materials with respect to substitute materials of about 1 kg CO2eq per kg of material. This is clearly much lower than the GHG footprints of animal source foods reported by LCA studies, regardless allocation method. It is true that the substitution of by-products with oil-based products will reduce the GHG savings, and this has not been considered in many studies on food system changes (e.g. Willett et al., 2019). We have included this aspect in the SOD. Nevertheless, this row is removed in Table 12.9 in the SOD, as we have restricted to table to supply-side technologies (demand-side options are discussed in more detail in Chapter 7)	Aaron Simmons	NSW Department of Primary Industries	Australia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
921	34		34		Recommendation Remove "Shift to regional and seasonal produce" Reason It is claimed that using food produced regionally will provide climate change mitigation however tresearch has demonstrated that this may not be the case (e.g. Edwards-Jones, 2010; Nicholson et al., 2015). The same applies to eating non-seasonal food. There is no available evidence but it is highly likely that nutrition can be supplied on an energy or protein basis from non-seasonal produce produced non-locally with lower climate change impacts than in-season produce supplied locally. It may be an uncomfortable reality but modern large food systems, primarily via scale, are capable of producing and distributing energy and protein to a point halfway around the world with less climate change impacts than a local system can. Caution is required when making a blanket recommendation to eat local and/or seasonal produce to reduce GHG emissions in order to avoid potential unintended consequences of increasing demand for products from systems that are relatively GHG intensive on a global scale. Edwards-Jones, G., 2010. Does eating local food reduce the environmental impact of food production and enhance consumer health? Proc. Nutr. Soc. 69, 582-591. Nicholson, C.F., He, X., Gómez, M.I., Gao, H.O., Hill, E., 2015. Environmental and Economic Impacts of Localizing Food Systems: The Case of Dairy Supply Chains in the Northeastern United States. Environ. Sci. Technol. 49, 12005-12014.	Accepted. This table does not intend to pre-judge on the co-benefits and trade-offs associated with mitigation opportunities. Organic farming and 'local and seasonal' was used as a proxy for increased awareness by consumers on the environmental consequences of their food choices. To avoid confusion, this bullet point has been changed to '- Shift demand to food products with low GHG footprints'. See also comment #917	Aaron Simmons	NSW Department of Primary Industries	Australia
12459	34		34		in the row, food processing industries - instead or in addition to food supplements, I would refer to food or meal replacement products	Accepted.	Sandra Caldeira	European Commission	Italy
5383	34	26	35	3	Table 12.9 - Good Table	Noted.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
29383	34	26	35	3	The table provides a great overview of mitigation options. Maybe you could introduce the differentiation of incremental and transformative as approach a bit stronger in the introductory text above the table (e.g. in line 13 on page 34).	Noted. Introductory text has been rewritten.	Catharina Latka	University of Bonn	Germany
6321	34	13			"Table 12.9" is written twice.	Editorial.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
14249	34	13			table 12.9 in duplicate	Editorial.	João Costa Leite	Universidade Fernando Pessoa	Portugal
14251	34				Not clear why mitigation opportunities in table 12.9 don't address on-farm activities? Consider adding biotechnology applied to agriculture (ex: genetic modification of crops and animals to reduce GHG emissions at farm level; other mitigation potential opportunities include methane inhibitors) Reisinger et al. Future options to reduce biological GHG emissions on-farm: critical assumptions and national-scale impact; include short food supply chain	Noted. Farm level mitigation options are covered in Chapter 7. A footnote has been included.	João Costa Leite	Universidade Fernando Pessoa	Portugal
27403	35	6	37	4	The "Circular economy" approach in the food system applied to animal production could also be include here: 10.1016/j.gfs.2019.06.003, 10.1016/j.jclepro.2019.01.329, 10.1111/gcb.14321	Accepted. The recommended references are now included in Section 12.4, in Table 12.9 Food system mitigation opportunities	Karlheinz Erb	Institute of Social Ecology, Univ. of Natural Resources and Life Sciences Vienna	Austria
6713	35	5	43	24	In general the section on mitigation opportunities is quite variable and in many cases not highlighting ther esearch or lack of research that exists in quantifying the GHGs associated with these strategies. While some of these sections are highly cited, others are very limited in helping us understand the extent to which these strategies could reduce GHG emissions (e.g. insects, plant proteins). This is despite the fact that there has been some work done on this, but its not included. If there truly isn't research on these issues then it would be prudent to highlight that there is a lack of research. There has been several studies looking at the issue of insects for example (https://link.springer.com/article/10.1007/s13593-016-0392-8) but I don't see them listed.	Accepted. The paragraph on insects has been extended and literature added. A paragraph has been added summarizing the GHG intensities of the emerging food production technologies assessed, based on the latest meta-review (Parodi et al., 2018). An overall assessment of the potential of dietary shift is given in Chapter 7 and has been referenced.	Meredith Niles	University of Vermont	United States of America
5951	35	5			Section 12.4.3.1 has no cross-references to the appendix, or to specific sections in Chapters 6, 7 and others. Indeed for a cross-cutting chapter, more references to other chapter sections are warranted where there is similar text and discussion. This will also help ensure there is no conflict between text or data quoted in different chapters and avoid duplication.	Noted. There is no sub-section dedicated to circular economy approaches in the SOD version of Section 12.4. But as this comment concerns cross-referencing in Ch12 in general: the SOD version of Ch12 contains more extensive cross-referencing to other chapters as well as other sub-sections in Ch12.	Ralph Sims	Massey University	New Zealand

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
6323	35				missing a reference to "peri-urban environment".	Taken into account. The category "options in urban environments" includes options that are also relevant in peri-urban environment	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
42081	35				In the table heading the page, second row, mid column, perhaps "consumption of locally produced products" should be included	Rejected. Consumption of locally produced products is not an 'emerging technology' though the reduction of the distances food is transported is one of the benefits of e.g. urban agriculture. This aspect is covered in the section on controlled-environment agriculture and the section on storage and distribution.	Francisco Javier Hurtado Albir	European Patent Office	Germany
30659	36	1	36	7	Concerns about antibiotic, pharmaceutical or hormone residues in treated sewage being applied to agricultural lands?	Accepted. There is no sub-section dedicated to circular economy approaches in the SOD version of Section 12.4. But the concerns raised in this review comment is covered in section 12.5	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
973	36	2	36	2	Please distinguish nitrogen from reactive nitrogen. Useful references may be: (a) Erisman, J.W., Sutton, M.A., Galloway, J.N., Klimont, Z. & Winiwarter, W. (2008). How a century of ammonia synthesis changed the world. Nature Geoscience 1(10), 636-639. (b) Smil, V. (2001). Enriching the earth: Fritz Haber, Carl Bosch, and the transformation of world food production. ISBN 0-262-19449-X. Cambridge (MA), USA: MIT Press.	Noted. This difference had been made clear in the text.	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
32689	36	9	36	16	Kummu et al 2012 would be a good citation here. In short, they estimate the environmental impcats embedded in food waste.	Taken into account. Ch7 covers mitigation associated with reduction in food loss and waste where Kummu et al 2012 is cited	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
39503	36	10	36	10	Also, mention the wasted resources used for food distribution/transport. (See Chapter 5 of FAO. The State of Food and Agriculture 2019. Moving Forward on Food Loss and Waste Reduction. Available at: http://www.fao.org/publications/sofa/en/	Accepted. Section 12.4 considers transportation and the recommended publication is now included in table in section 12.4.3.5 Storage and distribution	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
20293	36	13	36	15	The pargraph should reference the UNEP (2019) GEO6 Global Assessment (https://www.unenvironment.org/resources/global-environment-outlook-6) with regard global land degradation for food production (Globally 29% and increasing). It Is vital that the principle of circularity is adopted to ensure nutrients in food waste are returned to regenerate degraded land used for food production. The use of animal manure, food waste and green wastes (e.g. from glasshouse production) can provide a source high quality fertiliser (refugees in Palestine/Jordan use this to generate income from farmers). Where water retention is required, char from pyrolysis of degradable organic wastes can be added (This aspect discussed in an earlier chapter, and below line 30-37 - but fails to make link with water retention).	Accepted. There is no sub-section dedicated to circular economy approaches in the SOD version of Section 12.4. But biogas and biochar systems are covered in 12.5, together with associated benefits for land use. The UNEP report is cited in section 12.5	Paul Dumble	Paul's Environmt Lentd	United Kingdom (of Great Britain and Northern Ireland)
5385	36	18	36	19	and for cook too, usual in developing countries.	Accepted. There is no sub-section dedicated to circular economy approaches in the SOD version of Section 12.4. But the text about biogas is found in 12.5 where it has been added that biogas is also used for cooking	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
923	36	30	36	37	Recommendation More emphasis is placed on biochar as a climate mitigation strategy Reason I consider the climate change mitigation benefits of pyrolysis/biochar, that are well recognised (Woolf et al., 2010), to under-represented in the report. Pyrolysing organic materials offers excellent climate change mitigation potential and is a truly cross-sectoral approach. Pyrolysis stabilises C in biochar and permanently removes it from the atmosphere. It also produces syngas that can be used to produce energy (avoiding fossil fuel derived energy) or produce ammonia (avoiding the use of natural gas for the process). The biochar can be added to soil that increases crop yields and can also reduce N2O emissions from fertiliser use. Alternatively, biochar can be used in steel making and the avoid the emissions associated with the production and use coal in the process. Further still, biomass that is removed from unproductive lands to return it to productivity can be used thereby increasing the mitigation potential of pyrolysis because it avoids land use change elsewhere. Woolf, D., Amonette, J.E., Street-Perrott, F.A., Lehmann, J., Joseph, S., 2010. Sustainable biochar to mitigate global climate change. Nature Communications 1, 56.	Noted. There is no sub-section dedicated to circular economy approaches in the SOD version of Section 12.4. But biochar is covered in Ch7 and in Section 12.5	Aaron Simmons	NSW Department of Primary Industries	Australia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
5387	36	30	36	37	Need reference	Noted. There is no sub-section dedicated to circular economy approaches in the SOD version of Section 12.4. Pyrolysis processes are covered in section 12.5, with cross-reference to Ch6 that cover energy technologies	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
9605	36	40	36	41	It is correct that bio-refineries have the potential to play a significant role in a 'bioeconomy' society. This should not only be mentioned in the Section on circular economy. Refining of biomass represents multiple promising perspectives, including (but not limited to) displacement of fossil fuels in light- as well as heavy-duty traffic, stabilization of electricity grids, cheap capture of biogenic CO2, production of animal feed (e.g. protein from grass) as well as food for humans. Biorefining deserves a much more prominent position in the AR6. It could be in the Transport chapter (biofuels section), the Energy systems chapter, or in a separate section in chapter 12. For more information, the following report may be helpful: Novozymes (2018): Bridging the Gap to a Sustainable Future (available online).	Noted. Biorefineries are covered in 12.5, Ch6 (Energy) and Ch11 (Industry)	Jesper Kløverpris	Novozymes	Denmark
25265	36	40	36	42	Delete "Bio-refineries have thus … Cardona Alzate 2019)."	Taken into account. We understand this comment as concerning words choice rather than objecting against the fact that biorefineries can produce biofuels suitable for displacing fossil fuls. There is no sub-section dedicated to circular economy approaches in the SOD version of Section 12.4, but biorefineries are covered in other places in the report; 12.5, Ch7 and Ch11. The sentence proposed to be deleted is not present in the SOD version of the report.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
6327	36	30			When mentioning "pyrolysis" I miss a reference to potentially high energy costs and associated emissions of CO2.	Taken into account. There is no sub-section dedicated to circular economy approaches in the SOD version of Section 12.4. But pyrolysis is considered in 12.5 with cross-reference to Ch6 that covers energy technologies. Regarding the concern about CO2 emissions, please note that the text refers to pyrolysis of biomass, not fossil hydrocarbon resources	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
6325	36				I would suggest a reference to "agroecology" or organic-based production systems as good examples of "food circular systems" where, by definition and principles, there is a main aim of closing materials and energy loops. An organic production system, based on agroecological principles, is founded on circularity by definition (see, for example, https://doi.org/10.14452/MR-061-03-2009-07_8 ; https://link.springer.com/article/10.1007/s13593-015-0285-2	Accepted. The updated version of Ch12 contains a box titled "Mitigation and Adaptation via the Bioeconomy" where agroecology is covered.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
5389	37	1	37	4	I think that would be specified that we need to know which are the wastewater sources, because isn´t the same the domestic or industrial wastewaters(may contain heavy metals)	Accepted. The "pollution" referred to was nutrients causing eutrophication in lakes, streams and coastal areas. The text (now placed in 12.5) has been changed to avoid misunderstanding.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
30661	37	1	37	4	What type of "pollution" are you referring to in the water? Is there any risk of concentrating the pollutants in the livestock who eat the feed, as toxins tend ot accumulate in the fat of animals?	Accepted. The "pollution" referred to was nutrients causing eutrophication in lakes, streams and coastal areas. The text (now placed in 12.5) has been changed to avoid misunderstanding.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
975	37	16	37	22	Insects may be overrated. Please check our review: Aiking, H. & de Boer, J. (2019). Protein and sustainability - The potential of insects. Journal of Insects as Food and Feed 5(1), 3-7.	Accepted. The text on insects has been changed. Insects are presented as currenty discussed option, with both positive and negative aspects.	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
30663	37	23	37	30	This section implies that plant-based meat replacements are the only way to eat plant-based protein sources, though many people/cultures eat these foods in their minimally processed forms on a daily basis (and it's healthier and has a lower GHG footprint than eating processed meat replacements made from minimally processed legumes)	Accepted. Text added to clarify.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
12565	37	28	37	28	instead of milks I would rather say milk-alternatives or drinks	Editorial.	Sandra Caldeira	European Commission	Italy
29385	37	28	37	30	"similar GHG intensities" - to which comparison point?	Accepted. Across assesses protein sources. Clarified.	Catharina Latka	University of Bonn	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
30665	37	29	37	29	These GHG intensities are similar to what? Also should probably report them in the same unit as units in Table 12.8	Accepted. Across assesses protein sources. Clarified.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
925	37	29	37	30	Refer comment 9	Thank you for your comment. Unfortunately the line and page number did not match with a section of the FOD and we were unable to identify what this comment referred to.	Aaron Simmons	NSW Department of Primary Industries	Australia
35915	37	31	37	46	The concepts are a mixed up in this text. The concept of cellular agriculture covers acellular and cellular products. Therefore, microbial proteins belong to cellular agriculture too and should not be separated. Or alternatively, the section cellular agriculture could be renamed to cultured meat as it seem to cover only that. Also, the section about microbial proteins have some inaccuracies. Microbes can be used in cellular agriculture to synthesise acellular products, such as heme, milk- and egg proteins, but microbes can also be cellular products when the microbe itself will be used as food. For instance, the process that is described in Pikaar et al. 2018 is a cellular product, where the microbe (bacteria) fed by CO2, hydrogen taken from water molecule through electrolyses, Haber-Bosch nitrogen and other nutrients, is included in the final product as a whole organism (and not only the proteins, such as in the case of the acellular products). More information and results for land and water use of the bacterial product can also be found from Sillman et al. (2019). Bacterial protein for food and feed generated via reneable energy and direct air capture of CO2: Can it reduce land and water use?. Global Food Security 22 25-32.	Accepted. Text has been clarified	Hanna Tuomisto	University of Helsinki	Finland
35917	37	42	37	42	A possible reference for the challenges of scaling up cultured meat production is Tuomisto 2019, EMBO Reports (2019) 20: e47395 https://doi.org/10.15252/embr.201847395	Accepted. Reference added.	Hanna Tuomisto	University of Helsinki	Finland
5391	37	42	37	44	If exists any values would be written for know their emissions and can compare with other methods.	Noted. Published values are wide, with low agreement; therefore a qualitative assessment (level of poulty meat) is used.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
30667	37	42	37	44	Mejia et al. 2019 is not a study on cultured meat - it is about plant-based meat analogs. Alexander et al. 2017 and Post 2012 do not quantify the GHG emissions of cultured meat.	Accepted. Clarified.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
35919	37	42	37	44	I would expect that for this sentence the references would include only papers that actually quantified the environmental impacts of cultured meat. Only two of the papers that are listed are original assessments (Tuomisto and Teixeira de Mattos 2011 (note that this reference is misspelled in the text as Teixeira is missing from the second authors lastname) and Mattick et al 2015). Regarding the other papers that are listed, Alexander et al 20117 and Parodi et al. 2018 used the data from the previous studies to compare cultured meat with other food products, Mattick 2018 and Post 2012 only referred and discussed the estimates and Mejia et al. 2019 is completely irrelevant here as it about plant-based meat replacements only and does not include anything about cultured meat.	Accepted.	Hanna Tuomisto	University of Helsinki	Finland
977	37	42	38	19	A recent review is lacking here: Chriki, S. & Hocquette, J.F. (2020). The Myth of Cultured Meat: A Review. Frontiers in Nutrition 7(7), 1-9.	Noted. The proposed reference has been included in the assessment and the SOD chapter.	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
30669	37	45	38	1	It is alluded to that cultured meat currently only reduces GHG emissions as compared to beef (and even that potential is contested based on timeframe under consideration - see Lynch & Pierrehumbert 2019) - thus it does not necessarily offer a significant climate benefit over other meats. There should be more guarded language around the potential of cultured meat as a climate mitigation strategy, given that the few existing studies are all hypothetical and highly divergent in their conclusions.	Noted. It is beyond this section to engage in the discussion of climate metrics. However, a more cautious assessment is now done by assigning 'low' evidence and agreement (instead of medium in the FOD).	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
16353	37	6			In Section 12.4.3.2 Emerging food production industries, consider including a paragraph about the potential of sea algae (i.e. seaweed) for transforming food pathways. Like other algae food sources, it is about 50% protein by weight.	Accepted. Text included.	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
30671	38	1	38	2	Pesticides would still be used in the production of inputs for cultured meat (e.g., soy hydrosylate, corn for glucose and glutamine, feed for the livestock used to harvest the animal cells, collagen and fetal bovine serum). An article about this will be published in near future (Santo et al. Considering plant-based meat analogs and cell-based meats: A public health and food system perspective)	Accepted. The text has been changed to "with reduced losses of water and nutrients, and likely reduced risks from pesticide and antibiotics use and zoonotic diseases" to not convey the notion that no pesticides are required any more.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
30673	38	1	38	2	Antibiotics are still likely required inputs for the tissue culture medium, as sterile conditions would be near impossible to achieve. The nature of antibiotic use in this context is unknown. Thorrez, L., & Vandenburgh, H. (2019). Challenges in the quest for 'clean meat'. Nature Biotechnology, 37(3), 215-216. Stephens, N., Di Silvio, L., Dunsford, I., Ellis, M., Glencross, A., & Sexton, A. (2018). Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. Trends in Food Science & Technology, 78, 155-166.	Accepted. The references have been included in the SOD. The following text changes were made: "For animal product analogues, regulatory pathways and procedures (Stephens et al. 2018) and terminological issues (defining equivalence questions) (Carrenõ and Dolle 2018; Pisanello and Ferraris 2018) need clarification; but also their relation to religious rules (Chriki and Hocquette 2020)." and "with reduced losses of water and nutrients, and likely reduced risks from pesticide and antibiotics use and zoonotic diseases"	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
1659	38	1	38	3	Confusing sentence. Should it end with studied rather than studies?	Editorial. Yes.	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
5393	38	2	38	3	In the following months I suggest to seek studies and references where you can extract aspects related with allergenic effects in cellular agriculture	Rejected. Health aspects are covered in recent meta-reviews included in the reference list.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
5423	38	5	38	7	if you write that advanced refrigeration options using CO2 has a rank of energy savings, the same would be for refrigerant R404A besides GWP.Please if you can put GHG emissions of microbial proteins, cultured meat and poultry meat produced with current energy mix and using renewable energy	Noted. Mitigation potential when using renewable energy for cellular agriculture is included.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
35921	38	5	38	7	I don't think that the evidence for the GHG emissions from cultured meat production is medium level and medium agreement. I would say low evidence and low agreement. As the technology has not been scaled up yet, the estimates are based on many assumptions regarding how the large scale production system would look like. It is still highly uncertain, whether the technology even can be scaled up in a economically feasible way.	Accepted.	Hanna Tuomisto	University of Helsinki	Finland
30675	38	7	38	7	Mejia et al 2019 is not an article about microbial proteins or cultured meat - it assesses plant-based meat analogs	Accepted.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
35923	38	8	38	8	It is a bit unclear what is the point of this sentence. Also, plants serve as carbon capture technology. Pikaar et al. 2018 refers to the bacteria that can use CO2 directly as source of carbon, so there is no need to use plants to capture the carbon first and then feed the plants to the bacteria. However, from the carbon cycle point of view there is no difference whether the bacterial takes the carbon directly from CO2 or whether plants are used to capture the carbon first. The carbon will anyway be released back to the atmosphere once the bacteria has been eaten.	Accepted. Sentence deleted.	Hanna Tuomisto	University of Helsinki	Finland
12567	38	13	38	13	Animal-free meat analogues instead of products	Editorial.	Sandra Caldeira	European Commission	Italy
30677	38	13	38	19	This paragraph oscillates back and forth between cultured meat and plant-based analogs.	Accepted. Text clarified.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
39855	38	16	38	19	I could not understand the sentence. Please rephrase.	Accepted. Text clarified	Hasegawa Toshihiro	National Agricultural and Food Research Organization	Japan
5395	38	30	38	34	May you to revise and put more references demonstrating that in developing countries the most of the food waste is generated during production and processing and not in the households (if it is possible with references of authors living in developing countries)	Taken into account. The discussion on the mitigation potential of food waste is discussed in Chapter 7 - Section 7.4.5.2 - and there also the specific differences between developing and developed countries is discussed. In Chapter 12, the focus is on the nuanced discussion of how different food system actors can contribute to FLW reduction.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
34279	39	24	39	29	In this line as in other in these pages, no policy is suggested, only a choice relevant to individuals or vendors (choice of packaging). Maybe make a list of policies such as labels, regulations, limitation of trade, with for examples their present implementation and importance…	Noted. Not clear on what change is requested here. This section focuses on technological interventions in the food system, not policy options. That is in the next section	Antoine BONDUELLE	Climate Action Network France	France
30679	39	29	39	29	"Buy local" interventions do not necessarily reduce the GHG footprint of foods due to variances between transportation mode (i.e. ship, rail, truck, or plane) or lost economies of scale that come with larger processing, storage, and distribution systems. This is particularly relevant given the relatively low percentage of the overall GHG footprint of foods attributable to transportation. Additionally some local foods might actually increase GHG footprint (e.g., hothouse grown or air-freighted produce compared to regionally aggregated seasonal produce or produce shipped by more efficient transportation means). See: Wakeland, W., Cholette, S., & Venkat, K. (2012). Food transportation issues and reducing carbon footprint. In Green Technologies in Food Production and Processing (pp. 211-236). Springer US. ; Mariola, M. J. (2008). The local industrial complex? Questioning the link between local foods and energy use. Agriculture and Human Values, 25(2), 193-196.	Accpeted. Text adapted	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
29387	39	32	39	33	One could explicitly refer to the "last mile emissions" in the context of shifting from individual traffic to bulk transport (and that the mitigation potential of this aspect depends on how the individual transport was organized so far e.g. transport means, shopping trips combined with other duties/ or done on the way home).	Noted. The 'last mile' is considered to be included in mentioning improved 'logistics' of food transport.	Catharina Latka	University of Bonn	Germany
30681	39	38	39	44	Could highlight the Cool Food Pledge as another institutional food service policy shift that has a significant potential to reduce GHG emissions: https://www.wri.org/our-work/project/cool-food-pledge	Accepted. The cool food pledge is mentioned in the section on Voluntary Sustainabilty Standards	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
29389	39	40	39	41	Nudging and the retailers' influence on the "choice architecture" in supermarkets could be mentioned here.	Rejected. A full paragraph is dedicated to choice architecture later.	Catharina Latka	University of Bonn	Germany
32579	39	45	40	7	As noted, refrigeration systems, particularly supermarket refrigeration systems, are large consumers of energy in addition to being emitters of large amounts of high-GWP refrigerant. Domestic refrigerators and freezers have significant potential to improve energy use by about 50% to 60% for best available models on the market compared to average units in countries with existing energy efficiency policies. The stock of domestic refrigerators in developing and emerging countries is expected to grow from 1 billion in 2015 to nearly 2 billion by 2030, with most going into homes that didn't previously have a refrigerator. Developing countries could attain energy savings of more than 60% by discouraging dumping of inefficient equipment and adopting measures such as minimum energy performance standards. Shah N., et al. (2019) Benefits of Energy Efficient and Low-Global Warming Potential Refrigerant Cooling Equipment, Lawrence Berkeley National Laboratory (See table S7); bigEE (2012). The overall worldwide saving potential from domestic refrigerators and freezers (Figure 1); United Nations Environment Programme (UNEP) (2017) Accelerating the Global Adoption of Climate friendly and Energy-efficient Refrigerators ("Developing countries with unregulated markets dominated by old technology refrigerators can attain energy savings of more than 60 per cent."). Highly efficient, low-GWP models are widely available and are sometimes cheaper than lower-efficiency models, even on a first-cost basis. About 65% of the 100 million refrigerators produced worldwide in 2018 used HC-600a and 35% HFC-134a. Over 750 million refrigerators utilizing HC-600a have been sold in Europe, Asia, and South America by Chinese, European, Japanese and North American leading brands. See Perry M. (2012) The 'good old days' are now: Today's home appliances are cheaper, better, and more energy efficient than ever before; Energy Star (n.d.). Energy Star International Partners; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2018) 25 years Greenfreeze: A fridge that changed the world (See figure for Global market penetration of Greenfreeze technology).	Accepted. Comments have been addressed, new text and statistics added particularly around domestic refrigeration. Some of the references suggested have been included	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
32581	39	45	40	7	To significantly improve the life-cycle climate performance (LCCP) of commercial and industrial refrigeration systems, it is imperative to address both energy efficiency and refrigerant emissions. Neither can be examined in isolation. The authors may wish to note that commercial and industrial refrigeration and cold chains include a broad range of refrigeration equipment, from stand-alone refrigerated display cabinets to large commercial refrigeration equipment used in supermarkets, to pack-houses and small refrigerators for vaccines and medicines. It should be noted that a region's climate has a significant impact on energy consumption and therefore requires consideration of life-cycle climate performance of alternative refrigeration systems. For example, whereas supermarket systems using R744 have been demonstrated to save energy relative to R404A in European climates, the text should be careful not to imply that those efficiency savings could be replicated globally with the same approach. Recent demonstration projects for utilizing low-GWP alternatives to HFCs presented by the Climate and Clean Air Coalition (CCAC) calculated energy savings of 15% to 30% and carbon footprint reductions of 60% to 85% for refrigeration in commercial food stores; however, not all of the stores cited in these case studies chose to utilize R744. The authors may wish to examine these and other case studies documenting the efficiency and life-cycle climate performance of R744 and other types of low-GWP supermarket refrigeration systems. More information would be particularly useful about energy efficient low-GWP solutions for hotter climates, such as those found in India or other similarly situated A5 parties. UNEP/Climate and Clean Air Coalition (CCAC) (2014) Low-GWP Alternatives in Commercial Refrigeration: Propane, CO2 and HFO Case Studies.	Accepted. Changes have been made in response to this comment. See also response to comment # 32579	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
32583	39	45	40	7	Authors are right to note that there are a multitude of options to improve the efficiency an LCCP of supermarket refrigeration systems, including but not limited to advanced temperature control systems, installation of more efficient refrigerators, air curtains, and closed display refrigerators. Closed display refrigerators may be the single largest energy-saving option, relative to "open" supermarket refrigerated display cases, as refrigerators without doors use significantly more energy than a refrigeration system with doors. The US Department of Energy's Better Buildings Refrigeration Team developed guidance to help supermarkets retrofit doors onto refrigerated display cases, including case studies and savings calculators to help store owners and managers estimate the energy and money savings possible. The savings can be notable: During the period from September 2010 to April 2012, the Western United States market chain Fresh & Easy Neighborhood Market implemented display door retrofits on almost 30,000 linear feet of open medium-temperature display case in 174 of its California, Arizona, and Nevada stores. Since the completion of its retrofit projects, Fresh & Easy has enjoyed significant gas and electricity savings at the stores where doors were installed. These savings ranged from 16-23% electricity savings store-wide and averaged over 50% on gas bills. See US Department of Energy (2019) Guidance for retrofitting doors on open refrigerated display cases.	Noted. The reviewer appears to concur with what was already written in the text and so no specific change appears to be required. The proposed case study, as well as the document hghilighted in the comment, appears too specific for inclusion in the current chapter.	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
32585	39	45	40	7	Improving cold chains is also essential to reducing post-harvest food loss. In 2017, one out of nine people–821 million people–were undernourished, with greatest hunger in countries with a high proportion of the population dependent on climate vulnerable agricultural systems. The International Solar Alliance has launched the Solar Cooling Initiative to increase usage of solar and solar-hybrid linked cold-chain and cooling systems to utilize untapped renewables in meeting cooling demand. The International Solar Alliance (ISA) Solar Cooling Initiative (I-SCI) focuses on meeting rural cooling demands that help in reduction of farm to fork losses by providing small and marginal farmers access to cooling and potentially doubling their income. The initiative aims on helping its member states develop an interconnected, solar powered cold chain network that use refrigerants in compliance with the Kigali Amendment to the Montreal Protocol to substantially increase the overall GHG mitigation potential. One promising approach is the creation of "cooling hubs", aggregating demands to address the needs of rural farmers and fishers for cold chains, other local community needs, and access to medicines. Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, United Nations Children's Fund, World Food Programme, and World Health Organization (2018) The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition, v-vi ("In 2017, the number of undernourished people is estimated to have reached 821 million – around one person out of every nine in the world."… "Hunger is significantly worse in countries with agricultural systems that are highly sensitive to rainfall and temperature variability and severe drought, and where the livelihood of a high proportion of the population depends on agriculture."); International Solar Alliance (2019) Briefing note: International Solar Alliance Cooling Initiative (I-SCI); Ogden C. (2019) "University of Birmingham develops 'cooling hubs' to reduce food waste," June 25, 2019, Environment Journal; National Institution for Transforming India (NITI) (2017) Doubling Farmers' Income: Rationale, Strategy, Prospects, and Action Plan, NITI Policy Paper No.1 COME.pdf; Ozone Cell, Ministry of Environment, Forest, and Climate Change, Government of India (2019) India Cooling Action Plan.	Accepted. Additional references and text added	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
32855	39	45	40	7	Improvements in the cold chain are important to reduce food loss and waste and promote food security; improving cold chains should involve promoting energy efficiency (and efficiency within the system as a whole) as well as limiting greenhouse gas emissions through utilizing low-GWP refrigerants. University of Birmingham (2018) A Cool World: Defining the Energy Conundrum of Cooling for All ("Introducing more affordable and readily available means of cooling in food supply chains and the built environment is not just a matter of adding cooling to the status quo; it will introduce major shifts to dynamic socio-technical systems as well as the wider environment and eco-systems. …For example, a cold chain will help reduce food loss, in itself a major source of CO2 emissions, and thereby potentially reduce the need for deforestation by ensuring an increased proportion of production reaches the market from existing land resources utilised for agriculture. It could equally allow farmers in developing economies to transition from staple to high value (but temperature sensitive) horticulture."); World Resources Institute (2019). Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050, 54 (illustrating in Figure5-2 that food loss and waste emitted 4.4 GtCO2e annually in 2011); Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING; Sustainable Energy for All (2018) Chilling Prospects: Providing Sustainable Cooling for All; Carvalho S., et al. (2014) Alternatives to High-GWP Hydrofluorocarbons; Mbow C., et al. (2019) Food security, in IPCC SPECIAL REPORT ON CLIMATE CHANGE AND LAND, 440 ("Reduction of food loss and waste could lower GHG emissions and improve food security (medium confidence). Combined food loss and waste amount to 25–30% of total food produced (medium confidence). During 2010–2016, global food loss and waste equalled 8–10% of total anthropogenic GHG emissions (medium confidence); and cost about 1 trillion USD2012 per year (low confidence). Technical options for reduction of food loss and waste include improved harvesting techniques, on-farm storage, infrastructure, and packaging. Causes of food loss (e.g., lack of refrigeration) and waste (e.g., behaviour) differ substantially in developed and developing countries, as well as across regions (robust evidence, medium agreement).").	Accepted. Additional references and text added. Similar to other comments received	Kristin Campbell	Institute for Governance & Sustainable Development	United States of America
42083	39	22			Add "Food conservation using natural products (natural sugars, natural acids -vinegar, citric-, vegetal oils, salt, brine) or with off-grid thermal processing (sun drying, food smoking) have also energy savings potential".	Accepted. This proposal has been incorporate	Francisco Javier Hurtado Albir	European Patent Office	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
19793	40	3	40	4	Ammonia is not being explored to replace HFCs, it is still restricted to industry. Hydrofluoroolefins must be mentioned because of their low GWP and possibilities of mixture. I would not use information from Gullo to present the CO2 benefits, his theoretical papers are based on many significant simplifications and assumptions and final results can vary a lot.	Accepted. Hydrofluoroolefins has been added. Reference to Gullo has been deleted. However, this paragraph refers to both industrial and domestic refrigeration, and ammonia is being considered for industrial applications, and so is considered to be relevant to the paragraph and has not been removed.	Adrián Mota-Babiloni	University Jaume I of Castellon	Spain
5397	40	5	40	7	if you write that advanced refrigeration options using CO2 has a rank of energy savings, the same would be for refrigerant R404A besides GWP, in order to compare	Noted. Comment is unclear as to what change is recommended	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
32587	40	11	40	13	More recent calculations conclude that climate emissions from cooling equipment—including CO2, black carbon, and fluorinated gases such as HCFCs and HFCs—are a significant contributor to climate impacts. Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING, Chapter 3: Energy-related emissions from the cooling sector and opportunities for mitigation; Sustainable Energy for All (2018) Chilling Prospects: Providing Sustainable Cooling for All; Carvalho S., et al. (2014) Alternatives to High-GWP Hydrofluorocarbons. Improvements in the cold chain are important to reduce food loss and waste and promote food security. Due to lack of an interconnected cold chain infrastructure, developing countries lose 23% of their food production while developed countries face a loss of 9% of the total food produced. In 2011, annual food loss amounts to 4.4 GtCO2e annually, and of this, 1 GtCO2e was attributable to lack of cold chains. India was the first country in the world to launch its National Cooling Action Plan, where it has identified cold chains as a major source for doubling farmer incomes and meeting its targets under the Montreal Protocol's Kigali Amendment to phasedown HFC refrigerants. Improving cold chains should involve promoting energy efficiency and efficiency within the system as a whole using Life Cycle Performance (Andersen S. O., Wolf J., Hwang Y. and Ling J. (2018) Life-Cycle Climate Performance Metrics and Room AC Carbon Footprint, ASHRAE Journal 25) as well as limiting greenhouse gas emissions through utilizing low-GWP refrigerants. The International Solar Alliance (ISA) Solar Cooling Initiative (I-SCI) focuses on meeting rural cooling demands that help in reduction of farm to fork losses by providing small and marginal farmers access to cooling and potentially doubling their income. The initiative aims on helping its member states develop an interconnected, solar powered cold chain network that use refrigerants in compliance with the Kigali Amendment to the Montreal Protocol to substantially increase the overall GHG mitigation potential. University of Birmingham (2018) A Cool World: Defining the Energy Conundrum of Cooling for All ("Introducing more affordable and readily available means of cooling in food supply chains and the built environment is not just a matter of adding cooling to the status quo; it will introduce major shifts to dynamic socio-technical systems as well as the wider environment and eco-systems."); World Resources Institute (2019) Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050, 54 (illustrating in Figure5-2 that food loss and waste emitted 4.4 GtCO2e annually in 2011); Mbow C. et al. (2019) Food security, in IPCC SPECIAL REPORT ON CLIMATE CHANGE AND LAND, 440; International Solar Alliance (ISA), Briefing Note: ISA Solar Cooling Initiative (I-SCI); National Institution for Transforming India (NITI) (2017) Doubling Farmers' Income: Rationale, Strategy, Prospects, and Action Plan, NITI Policy Paper No.1 COME.pdf; Ozone Cell, Ministry of Environment, Forest, and Climate Change, Government of India (2019) India Cooling Action Plan.	Accepted. Additional references and text added. Similar to other comments received	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
32857	40	11	40	13	Improvements in the cold chain are important to reduce food loss and waste and promote food security; improving cold chains should involve promoting energy efficiency (and efficiency within the system as a whole) as well as limiting greenhouse gas emissions through utilizing low-GWP refrigerants. University of Birmingham (2018) A Cool World: Defining the Energy Conundrum of Cooling for All ("Introducing more affordable and readily available means of cooling in food supply chains and the built environment is not just a matter of adding cooling to the status quo; it will introduce major shifts to dynamic socio-technical systems as well as the wider environment and eco-systems. …For example, a cold chain will help reduce food loss, in itself a major source of CO2 emissions, and thereby potentially reduce the need for deforestation by ensuring an increased proportion of production reaches the market from existing land resources utilised for agriculture. It could equally allow farmers in developing economies to transition from staple to high value (but temperature sensitive) horticulture."); World Resources Institute (2019). Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050, 54 (illustrating in Figure5-2 that food loss and waste emitted 4.4 GtCO2e annually in 2011); Dreyfus G., et al. (2020) ASSESSMENT OF CLIMATE AND DEVELOPMENT BENEFITS OF EFFICIENT AND CLIMATE-FRIENDLY COOLING; Sustainable Energy for All (2018) Chilling Prospects: Providing Sustainable Cooling for All; Carvalho S., et al. (2014) Alternatives to High-GWP Hydrofluorocarbons; Mbow C., et al. (2019) Food security, in IPCC SPECIAL REPORT ON CLIMATE CHANGE AND LAND, 440 ("Reduction of food loss and waste could lower GHG emissions and improve food security (medium confidence). Combined food loss and waste amount to 25–30% of total food produced (medium confidence). During 2010–2016, global food loss and waste equalled 8–10% of total anthropogenic GHG emissions (medium confidence); and cost about 1 trillion USD2012 per year (low confidence). Technical options for reduction of food loss and waste include improved harvesting techniques, on-farm storage, infrastructure, and packaging. Causes of food loss (e.g., lack of refrigeration) and waste (e.g., behaviour) differ substantially in developed and developing countries, as well as across regions (robust evidence, medium agreement).").	Accepted. Additional references and text added. Similar to other comments received	Kristin Campbell	Institute for Governance & Sustainable Development	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
6717	40	15	40	34	It would be useful for the authors to consider McDougall et al. 2018 PNAS on its relationship to urban agriculture- https://www.pnas.org/content/116/1/129	Noted. However, as unconditioned urban farms are not proposed as GHG mitigation technology (also supported by the suggested paper), we address in the SOD only conditioned solutions (better termed as 'Controlled Environment Agriculture'). As the suggested paper deals with small-scale urban agriculture has therefore not been included in the assessment.	Meredith Niles	University of Vermont	United States of America
35925	40	16	40	16	The terms un-conditioned and conditioned are rarely used in this context and would require definitions. It is more common to see terms such as controlled-environment agriculture.	Accepted. The introduction of the terms 'conditioned' versus 'unconditioned' has been avoided as not essential for the text. See comment #30683	Hanna Tuomisto	University of Helsinki	Finland
30683	40	17	40	27	The definition of "unconditioned farms" are not just ground based but also do not have environmental control (e.g., heating, cooling or humidity), whereas "conditioned" ones do have some form of climate control. Might be worth emphasizing that difference in these descriptions, because it is currently unclear.	Accetped. See comment #35925	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
6715	40	18	40	18	typo- peri-urban	Editorial.	Meredith Niles	University of Vermont	United States of America
39505	40	21	40	22	Also, research has demonstrated benefits to social capital from community gardening and urban farming. See literature cited in Santo R, Palmer A, Kim B. “Vacant Lots to Vibrant Plots: A Review of the Benefits and Limitations of Urban Agriculture” 2016. Johns Hopkins Center for a Livable Future.	Rejected. An in-depth assessment of co-benefits of urban farming is beyond this paragraph. Sentence has been modified to make clear that the points mentioned are just examples.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
45101	40	28	40	34	Other recent publications on urban agriculture may be included as "Exploring nutrient recovery from hydroponics in urban agriculture: An environmental assessment" and others from 2020 (https://doi.org/10.1016/j.resconrec.2020.104683).	Accepted	Siir Kilkis	The Scientific and Technological Research Council of Turkey	Turkey
30685	40	32	40	34	The energy costs of aquaponics operations can be very high during the winter in cold regions. Love et al. (2015). Energy and water use of a small-scale raft aquaponics system in Baltimore, Maryland, United States. Aquacultural Engineering, 68, 19-27.	Accepted. Unclear environmental performance is already mentioned; there is no space to go more into depth, however, the suggested reference has been added to concretely point to energy use.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30687	40	41	40	42	And, importantly, energy demands. The overall energy and GHG implications of indoor/conditioned agriculture is underplayed in this section. See, for example, Kozai, T. (2013). Resource use efficiency of closed plant production system with artificial light: Concept, estimation and application to plant factory. Proceedings of the Japan Academy. Series B, Physical and biological sciences, 89(10), 447. and Hamm, M. (2015). Feeding cities - with indoor vertical farms? [blog post]. http://www.fcrn.org.uk/fcrn-blogs/michaelwhamm/feeding-cities-indoor-vertical-farms	Accepted. Energy demand is assessed in a separate paragraph (Line 15 ff of page 41)	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
39857	40	15	41	24	This is a great section. Can climate change adaption be a part of the co-benefits of vertical farms?	Noted. We include the following sentence in the SOD: "Food production from controlled environment agriculture is independent of weather conditions and able to satisfy consumer demand for locally produced fresh and diverse produce throughout the year (O’Sullivan et al. 2019; Al-Kodmany 2018; Benke and Tomkins 2017)." which points into the direction of climate change adaptation though we refrain of naming vertical farms to be a 'adaptation technology' explicitly.	Hasegawa Toshihiro	National Agricultural and Food Research Organization	Japan
30689	41	1	41	3	Source for this sentence? It is also kind of unclear - feed for livestock? Or does it mean "food"?	Accepted. Source was grey literature - sentence was deleted.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
30693	41	8	41	14	Rooftop operations (which are technically different from vertical farms, but this entire section seems to oscillate between discussing different forms of conditioned and controlled urban agriculture) could also lead to building energy savings from the reuse of waste energy. Specht et al (2014). Urban agriculture of the future: An overview of sustainability aspects of food production in and on buildings. Agriculture and Human Values, 31(1), 33-51.	Rejected. This sentence is not about rooftops operations. Unconditioned urban agricutlure was only mentioned in the first paragraph of the section. See also comment #35925	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30691	41	15	41	21	If emphasizing how energy intensive controlled agriculture can be (line 15), it is contradictory to be discussing its "migitation potential" in the next sentence. Additionally, the energy used for vertical farming is not just cooling - warming is also needed in cooler climates.	Noted. Energy needs for cooling are usually higher than for warming therefore the text saying 'mainly cooling' seems appropriate. The text has been restructured.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30695	41	23	41	24	It is also worth pointing out that you're not going to grow the bulk of human caloric needs (which usually come from more foods that require a lot more land to grow e.g., grains, pulses, most animal products) via urban farms	Noted. Page 40 - line 42ff already state that only few crops are currently produced.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
12569	41	27	41	27	… main co-benefits and trade offs in the environment. (I say this because the table does not really include effects on human health whch would be an interesting addition)	Editorial	Sandra Caldeira	European Commission	Italy
30697	41	34	41	34	For pulses: GHG effect: lowest GHG footprint per unit of protein or serving size among protein foods	Noted. For the SOD, we have merged Table 12.10 is with Table 12.9; 'pulses' has been removed as own category as the focus is on supply-side technologies.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30699	41	34	41	34	Pulses also beneficial for human health and animal welfare too	Noted. See comment #30697	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30701	41	34	41	34	Mussels and algae could potentially expose consumers to contaminants like heavy metals	Accepted. Text adapted.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
35927	41	34	42	1	Table 12.10: as an GHG effect for pulses, also emission reductions as a result of substituting livestock products could be mentioned. As in table 12.9, the grouping of microbial proteins and cellular agriculture should be rethought ór the term cellular agriculture could be changed to cultured meat.	Noted. For pulses, see comment #30697. Table 12.9 has been completely re-done in the SOD and the grouping aligned to the (improved) text.	Hanna Tuomisto	University of Helsinki	Finland
39897	41	40	42	9	This section is too much focused on ocean fertilization which is only one of many CDR technologies. Please reword as follows "Carbon dioxide removal (CDR) technologies if implemented at large scale generate governance challenges linked to uneven impacts of these technologies on sustainable development (Honegger et al. 2018). The current governance frameworks for CDR have inadequacies, gaps and limits (Liu and Chen 2015), but there is a need for governance (Pasztor 2017), and potential for global experimentalist governance in this field (Armeni 2015). For the potential CDR technology of ocean fertilization the London Dumping Convention and its 1996 Protocol, and the CBD have adopted a precautionary approach and imposed moratoria, except for small-scale studies or legitimate scientific research (Sands 47 & Peel, 2018). The London Convention/Protocol has also developed an Assessment Framework for Scientific Research Involving Ocean Fertilization (London Convention/Protocol 2010) and in 2013 adopted amendments (which are not yet in force) to regulate marine geoengineering activities, including ocean fertilization. Given the target of the Paris Agreement is to achieve a balance between eissions sources and sinks, the role of negative emissions technologies is relevant, but to date policy coordination is missing that would see any meaningful application beyond present-day natural sinks, not even in countries that have committed to reaching net-zero emissions (Honegger and Reiner 2018, Cox and Edwards 2019, McLaren et al. 2019). New references: Cox, E., & Edwards, N. R. (2019). Beyond carbon pricing: policy levers for negative emissions technologies. Climate Policy, 19(9), 1144-1156; Honegger, M., Derwent, H., Harrison, N., Michaelowa, A., & Schäfer, S. (2018). Carbon Removal and Solar Geoengineering: Potential implications for delivery of the Sustainable Development Goals. Carnegie Climate Geoengineering Governance Initiative, New York; Honegger, M., & Reiner, D. (2018). The political economy of negative emissions technologies: consequences for international policy design. Climate Policy, 18(3), 306-321; McLaren, D. P., Tyfield, D. P., Willis, R., Szerszynski, B., & Markusson, N. O. (2019). Beyond 'Net-Zero': A case fo separate targets for emissions reduction and negative emissions. Frontiers in Climate, 1, 4.	Noted. We initially included CDR technologies perceived as carrying major risks, in conformance with our mandate from the IPCC Plenary to look at SRM risks. Now the new introductory paragraph makes clearer that the CDR subsection is only about international governance, and that most of CDR governance (which tends to be national) is assessed in ch12.7. International governance tends to be focused on MRV issues (via UNFCCC) and treaties/conventions regulating the global commons, in the case of CDR there's therefore a focus on LP/LC and CBD	Axel Michaelowa	University of Zurich	Switzerland

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
43433	41	40	42	9	This section is too much focused on ocean fertilization which is only one of many CDR technologies. Please reword as follows "Carbon dioxide removal (CDR) technologies if implemented at large scale generate governance challenges linked to uneven impacts of these technologies on sustainable development (Honegger et al. 2018). The current governance frameworks for CDR have inadequacies, gaps and limits (Liu and Chen 2015), but there is a need for governance (Pasztor 2017), and potential for global experimentalist governance in this field (Armeni 2015). For the potential CDR technology of ocean fertilization the London Dumping Convention and its 1996 Protocol, and the CBD have adopted a precautionary approach and imposed moratoria, except for small-scale studies or legitimate scientific research (Sands47 & Peel, 2018). The London Convention/Protocol has also developed an Assessment Framework for Scientific Research Involving Ocean Fertilization (London Convention/Protocol 2010) and in 2013 adopted amendments (which are not yet in force) to regulate marine geoengineering activities, including ocean fertilization. Given the target of the Paris Agreement is to achieve a balance between eissions sources and sinks, the role of negative emissions technologies is relevant. However, to date policy coordination is missing, which would be necessary for adequate development and application. This is even the case for countries that have committed to reaching net-zero emissions (Honegger and Reiner 2018, Cox and Edwards 2019, McLaren et al. 2019). Cox, E., & Edwards, N. R. (2019). Beyond carbon pricing: policy levers for negative emissions technologies. Climate Policy, 19(9), 1144-1156; Honegger, M., Derwent, H., Harrison, N., Michaelowa, A., & Schäfer, S. (2018). Carbon Removal and Solar Geoengineering: Potential implications for delivery of the Sustainable Development Goals. Carnegie Climate Geoengineering Governance Initiative, New York; Honegger, M., & Reiner, D. (2018). The political economy of negative emissions technologies: consequences for international policy design. Climate Policy, 18(3), 306-321; McLaren, D. P., Tyfield, D. P., Willis, R., Szerszynski, B., & Markusson, N. O. (2019). Beyond 'Net-Zero': A case for separate targets for emissions reduction and negative emissions. Frontiers in Climate, 1, 4.	Noted. We initially included CDR technologies perceived as carrying major risks, in conformance with our mandate from the IPCC Plenary to look at SRM risks. Now the new introductory paragraph makes clearer that the CDR subsection is only about international governance, and that most of CDR governance (which tends to be national) is assessed in ch12.7. International governance tends to be focused on MRV issues (via UNFCCC) and treaties/conventions regulating the global commons, in the case of CDR there's therefore a focus on LP/LC and CBD	Matthias Honegger	Perspectives Climate Research gGmbH	Germany
927	41		42		Recommendation Remove "pulses" Reason Table 12.10. Pulses are distinguished from plant-based meta alternatives. "Pulses" can be removed. Pulses are and have been plant-based alternatives to meat for millenia.	Now the new introductory paragraph makes clearer that the CDR subsection is	Aaron Simmons	NSW Department of Primary Industries	Australia
929	41		42		Recommendation The increased demand for P and environmental impacts of increased P use should be included as a negative trade-off. Reason Table 12.10 Increasing pulse production may decrease the need for mineral N fertilisers however it will increase the demand for mineral P fertilisers. P is the limiting factor in pulse production and a lack or absence of P in the soil will mean pulse yields will be minimal and so will N fixation. Increased use of legumes for N supply, with subsequent increasein P use, will also increase other environmental impacts of P such as eutrophication. It is also critical to consider that unlike N that can be extracted readily froim the atmopshere, P is essentaillly a fossil nutrient with supplies needed to come from terrestrial deposits. An increase in pulse production needs to be coupled with the recycling of P from waste as part of a cicrular economy for it to be a true long-term climate mitigation option.	Accepted.	Aaron Simmons	NSW Department of Primary Industries	Australia
931	41		42		Recommendation Increase in demand for agricultural land should be included as a negative trade-off for increased pulse production Reason Table 12.10 Increasing pulse production will require additional croplands either directly through transforming land to grow more pulses or indirectly by displacing existing crop production to transformed land. This is an important consideration that has climate change impacts and needs to be included. It is important to note that there are many Mha globally are suitable for the production of red meat and it's co-products but are unsuitable for the production crops.	Rejected. The GHG benefit does not come from increased pulses production/consumption, but from the reduced demand of more GHG intensive protein sources. Therefore, an increased production of pulses replaces cropland used for feed production. See also comment #933	Aaron Simmons	NSW Department of Primary Industries	Australia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
933	41		42		Recommendation Increase in demand for agricultural land should be included as a negative trade-off for increased plant-based meat replacements. Reason Table 12.10 Increasing plant-based meat replacements will mean existing crops are diverted to the production of plant-based meat replacements so additional cropping lands will be required maintain supply of crops. Alternatively, additional cropping lands would be required if existing crops are not diverted to the production of plant-based meat replacements. This needs to be included.	Rejected. The GHG benefit does not come from production/consumption of plant-based meat replacements, but from the reduced demand of more GHG intensive protein sources. Therefore, an increased demand for crops to produce such replacements replaces cropland used for feed production. See also comment #931	Aaron Simmons	NSW Department of Primary Industries	Australia
935	41		42		Recommendation Impacts of and resource depletion from the production of co-products of meat production need to be included as a negative for pulses and plant-based meat replacements. Reason Table 12.10 Replacing meat with plant-based meat replacements and pulses requires the production of functional equivalents to co-products of meat production systems. These will deplete resources and emit GHG and need to be considered when recommending a shift away from red meat consumption.	Rejected. See comment #919	Aaron Simmons	NSW Department of Primary Industries	Australia
937	41		42		Recommendation Remove "Partly uses GMO" Reason Table 12.10. Caution is required when stating that the use of GMOs is a negative because, despite public perception, there is little vidence to support this. Rather, GMOs has played a critical role in ensuring ongoing sustainable food production for humanity. For example, Golden Rice is a GM rice with high levels of Vitamin A developed by Australian scientists that will be distributed globally for free. This will see massive improvements in the health of people in third-world countries where rice is a staple food. Further, incorporation of GM traits for pest resistance has led to yield increases, most notably in cotton and maize. Research (Mahaffey et al., 2016; Taheripour, 2017) has reported that a ban on the use of GMO in agricultural production would increase GHG emissions associated with food production due to land use change as more cropland would be required. It would also increase the use of pesticides that have negative environmental impacts. Further, GMOs will continue to play a role in the sustainabel produciton of food The use of GM to develop plants that can better tolerate water stress further improving yields (Condon, 2020) has considerable potential to reduce climate change emissions by using existing agricultural land more efficiently. This will become increasingly important as droughts in food producing areas of the world become more frequent and intense under climate change. Condon, A.G., 2020. Drying Times: Plant traits to improve crop water use efficiency and yield. J. Exp. Bot. Mahaffey, H., Taheripour, F., Tyner, W.E., 2016. Evaluating the Economic and Environmental Impacts of a Global GMO Ban, pp. 1-34. Taheripour, F., 2017. What Would Happen If We Don't Have GMO Traits?, in: Tyner Wallace, E. (Ed.), World Agricultural Resources and Food Security. Emerald Publishing Limited, pp. 53-67.	Accepted.	Aaron Simmons	NSW Department of Primary Industries	Australia
43869	41	34			mussels and algae - this is not discussed in the text? Efforts to restore mussels and other bivalve beds to filter water ie reduce eutrophication, mussel farms (commercial) are usually placed in areas with water flow - mussels are animals so the substitution for animal products is incorrect. Algae - does this macro or micro algae. If macro, then harvest as discussed in text for fertilisers, food products, feed etc. If microalgae - this really is developing, at present mainly freshwater strains being cultured but interest in marine strains - for animal protein substitute	Accepted. Text included.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
30703	42	0	42	0	For all the products that say "No direct (non-energy) GHG emissions from meat production" - is this just referring to the methane emissions from ruminant animals? Because they would still have other non-energy GHG emissions (e.g., N2O) related to growing the ingredients or inputs for the products.	Accepted. Yes, this was referring to emissions from animals. Clarified in the SOD.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30705	42	0	42	0	For insects: The higher efficiency of transforming biomass to protein-rich food is only in comparison to other terrestrial meats	Accepted.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30707	42	0	42	0	For insects, the energy intensity of operations depends on species and location under cultivation (e.g., tropical insects being grown in colder climates will require more GHG intensive operations)	Accepted.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
30709	42	0	42	0	For cellular agriculture, food safety is not necessarily improved. See Thorrez, L., & Vandenburgh, H. (2019). Challenges in the quest for 'clean meat'. Nature Biotechnology, 37(3), 215-216.	Rejected. Cellular agriculure improves food safety as production environments are controlled and less contamination possible. Also risk from zoonoses and AMR are reduced.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30711	42	0	42	0	Why does this table only include rooftops/greenhouses and controlled environment urban ag? What about unconditioned urban farms?	Noted. We have removed the explicit reference to rooftops/greenhouses and addressed only 'Controlled Environment Agriculture'. Un-conditioned urban farms are addressed under the (new) row on 'knowledge intensive and community agriculture'.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30713	42	0	42	0	Short transport distances are not necessarily a GHG benefit - see comment 69 about "buy local" interventions	Accepted. Text changed to make clear that this holds only ceteris paribus.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
39507	42	4	42	7	GHG and health benefits of dietary shifts do not just result from shifting to more plant-based proteins -- In many populations, protein sufficiency is not the problem, and there are health an GHG benefits simply from reducing animal protein intake ad increasing intake of micronutrient-rich fruits and vegetables. Likewise, health/GHG benefits can be achieved without total shift to vegetarian/vegan diets, and depending on what animal products are substituted with (such as more dairy), vegetarian can in some cases increase GHG impact. See "Brent F. Kim, et al.. 2019. Country-specific diet shifts to mitigate climate and water crises. Global Environmental Change, https://doi.org/10.1016/j.gloenvcha.2019.05.010"	Accepted. Text clarified.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
12571	42	5	42	5	instead of vegetable proteins, plant proteins to be consistent with the rest of the chapter	Editorial.	Sandra Caldeira	European Commission	Italy
20683	42	3	43	6	To provide a little bit of context and a systemic element to this section, it might be worth considering a recent study which attempted to scale down the results of different IAM mitigation scenarios into specific national targets. This showed that unless there are major technological transformations in the next decades which can vastly reduce the emissions from livestock (particularily for dairy production), dietary shifts may be a necessary pre-requisite of mitigation strategies. Gil, J.D., Daioglou, V., van Ittersum, M., Reidsma, P., Doelman, J.C., van Middelaar, C.E., van Vuuren, D.P. (2019). Reconciling global sustainability targets and local action for food production and climate change mitigation. Global Environmental Change, 59, 101983	Noted. This section has been removed from Chapter 12 in the SOD, as the assessment of the GHG mitigation potential of diet change is addressed in Chapter 7.	Vassilis Daioglou	Copernicus Institute of Sustainable Development	Netherlands
39509	42	13	43	2	Sentence is not accurate -- For example, the Dietary Guidelines for Americans in the United States do include recommendations for vegetarian diets. See U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2015 – 2020 Dietary Guidelines for Americans. 8th Edition. December 2015. Available at https://health.gov/our-work/food-and-nutrition/2015-2020-dietary-guidelines/.	Accepted. Text clarified.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
14253	42				Title Section: Diet Shifts (as in table 12.9) or Consumers?	Accepted.	João Costa Leite	Universidade Fernando Pessoa	Portugal
12573	43	1	43	1	propose to delete "currently do not include alternative diets and" . (it's not clear what"alternative diets" are, the meaning of the sentence remains and this may even be wrong depending on what is meant with/by alternative diets)	Accepted.	Sandra Caldeira	European Commission	Italy
12461	43	4	43	6	propose new sentence "Several national governmental and scientific bodies have concluded that well-planned balanced plant-based diets are healthy although exclusively vegan diets require monitoring and attention such as vitamin B12 supplementation (White and Hall 6 2017; Costa Leite et al. 2020).	Accepted.	Sandra Caldeira	European Commission	Italy
39511	43	7	43	9	To be more accurate, suggest also including the ranges that Willett et al provided for their reference diet. (See Figure 1 of Willet et al 2019.)	Accepted.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
39513	43	12	43	13	In addition to considering affordability of diets in different contexts, this section should acknowledge of ensuring nutrional adequacy of diets in all populations and the need to make sure diet shifts are country-specific and appropriate for cultural and nutritional needs of a population. See "Brent F. Kim, et al.. 2019. Country-specific diet shifts to mitigate climate and water crises. Global Environmental Change, https://doi.org/10.1016/j.gloenvcha.2019.05.010"	Accepted. Added nutritional adequacy.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
30715	43	15	43	15	Source for statement that livestock can reduce need for herbicide use?	Accepted. We agree that the sentence was incomplete and not sufficiently referenced. However, to reduce redundancy between Chapter 7 and Chapter 12, the whole FOD section on 'Consumers' was removed	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30717	43	15	43	16	Livestock only improve soil fertility under well-managed operation, and the increase in fertility would only happen if the soils were degraded to begin with	Accepted. Text clarified	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
30719	43	18	43	24	Emphasize that the amount of meat that could be attained from livestock fed leftovers is not enough to meet current demand for livestock products	Rejected. That the quantity that can be produced from left overs is insufficient becomes obvious from the number from Willett et al. (2019) provided some lines above.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
34281	43	27	44	46	The description of scenarios is tedious and difficult to interpret. A table would simplify and clarify	Noted. The section has been completely reworked and shortened.	Antoine BONDUELLE	Climate Action Network France	France
6329	43	14			lack of year in the reference	Noted. Paper is in review and does not have yet a year. If accepted/published at the cut-off date, this will be included. Otherwise the reference will not be used.	Alberto Sanz-Cobena	Universidad Politécnica de Madrid	Spain
29391	44	4	44	5	Maybe the wording could be adjusted, as it is of limited information to define SSP2 based on SSP3 which had not been introduced up to this point	Accepted. Text adjusted.	Catharina Latka	University of Bonn	Germany
39515	45	2	45	4	Critical gap in diet scenario modeling is that almost all of these studies use global or regional estimates that are not reflective of local context (exception is Brent F. Kim, et al.. 2019. Country-specific diet shifts to mitigate climate and water crises. Global Environmental Change, https://doi.org/10.1016/j.gloenvcha.2019.05.010."	Rejected. This section deals with the SSP framework, while the paper of Kim et al. (2019) does not. The section on food system transformation has been significantly shortened.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
27405	45	3	45	5	In Erb et al. 2016 (10.1038/ncomms11382) we show that a switch to less-AP-diets allows to reduce deforestation pressures and opens the option space for land use, including international trade. Such changes in diets are also the prerequisite for less harming farming systems that require more land (extensive systems, organic farming): 10.1038/s41467-017-01410-w, 10.1098/rsif.2015.0891. This could be included here.	Rejected. While being an important aspect, the trade-off between land demands and mitigation options are covered in a different section.	Karlheinz Erb	Institute of Social Ecology, Univ. of Natural Resources and Life Sciences Vienna	Austria
12575	45	11	45	11	I propose to add another sentence after … Antle et al, 2017). "Others have identified research priorities or (changes in) legislation needed to better cope with the different alternatives (Bock et al, 2014 ; Mylona et al, 2016) " the references are in the two cells below	Noted. The text was adepted as suggested. However, we used the peer reviewerd paper of Mylona et al. (2018) instead of the two JRC reports that is based on the Mylona et al. (2016) work.	Sandra Caldeira	European Commission	Italy
12577	45	11	45	11	Tomorrow's Healthy Society - Research Priorities For Foods And Diets 2014, JRC91330 Bock Anne-Katrin, Maragkoudakis Petros, Wollgast Jan, Caldeira Sandra, Czimbalmos Agnes, Rzychon Malgorzata, Atzel Bela, Ulberth Franz	See comment #12575	Sandra Caldeira	European Commission	Italy
12579	45	11	45	11	Delivering On Eu Food Safety And Nutrition In 2050 - Future Challenges And Policy Preparedness 2016, JRC101971, Mylona Kalliopi, Maragkoudakis Petros-Achillefs, Bock Anne-Katrin, Wollgast Jan, Caldeira Sandra, Ulberth Franz	See comment #12575	Sandra Caldeira	European Commission	Italy
31597	45	27	45	28	Although several opportunities would be consider in Food Access solutions, we should focus on all systems that are coming to take Food Production close to people. In particular, processes like Vertical Farming could be a valid alternative or solution to Urban Food Production that is not affected by any climate change, transport flows, logistics. Vertical Farming, spreading Indoor Farming, has a relevant role in reusing dismissed buildings and can be considered in different scale of process. On one side Vertical Farming and factories could supply Food Industry and Distribution with important huge buildings dedicated to growing. On the other side, we can assist in the coming future at a sort of network of Vertical Farms spaces that could feed small group of residents, from block to quartier and to areas of cities. If the industrial plants will be located in the first periphery or on a city border, the other smaller factories could insist in several areas of the cities, inside the cities, and become a sort of new networked food access point system. Vertical Farming as analyzed could be an alternative solution that would reduce the use of water to few percentage points -about to 4-6% of open land systems-, reset use of soil and pesticides, supply a complete Food Safety Process using seeding and growing positive cells and delete any possible contact between operators and plants, creating a complete aseptic chain that will lead consumer as the first one that will touch food. Vertical Farming could supply the right quantity of edible products all-year-round, unaffected by any uncertainty, climate change, infections, lacks, all due to the Indoor growing. Renewable energy systems experts could side the building team of the new Vertical Factories in order to solve two main issues: on one side a Vertical Farm needs an important supply of energy while on the other hand, it could introduce a significant mass of carbon dioxide produced by any other industry, due to the important necessity of dioxide to reduce growing cycles.	Taken into account. The section on 'controlled environment agriculture' has been re-written for the SOD. It is capturing the points raised in this comment. References are also provided.	Bernardo Cigliano	SIX srl	Italy
30731	45	28	45	28	This title doesn't make sense as is	Accepted. Title clarified	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
12581	45	31	45	31	consider including fiscal policies as well? it could read … health and food safety policies as well as fiscal	Accepted.	Sandra Caldeira	European Commission	Italy
12583	45	34	45	34	Consider including the following reference to back up this sentence - Mylona, K., Maragkoudakis, P., Miko, L., Bock, A.-K., Wollgast, J., Caldeira, S., and Ulberth, F.: Future of food safety and nutrition – Seeking win-wins, coping with trade-offs (2018). Food Policy 74:143-146, doi: org/10.1016/j.foodpol.2017.12.002	Accepted.	Sandra Caldeira	European Commission	Italy
39517	45	41	45	41	Add reference to: T Garnett. 2011. What are the best opportunities for reducing greenhouse gas emissions in the food system (including supply chains). Food Policy 36, S23-S32. doi:10.1016/j.foodpol.2010.10.010	Accepted.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
26125	45	40	50	36	Categorization of food system relevant policies could be better aligned with the taxonomy used in Chapter 13, sub-section 13.5.1 (i.e. economic or market-based instruments, regulatory instruments, and other policies) to strengthen consistency	Noted. The classification is already aligned to this taxonomy. However, this section goes more into the details, therefore 'other policies' have been split into 'informative' and 'behavioural' instruments. The term 'regulatory policies' does not comletely capture the instruments combined in this sub section ('administrative' fits better) - however, in order to improve alignment it has been re-termed to 'Regulatory and administrative instruments'.	Mykola Shlapak	N/A	Ukraine
11873	45	28			This section is particularly useful for our government - please retain	Noted.	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
16355	45	28			In Section 28 12.4.5 Food system policies related post-farm gate food chain actors and consumers, consider adding a description of the role global military procurement can place on transforming food systems as it sources provisions for its soldiers. This is a major sector and can be a direct driver of change.	Rejected. Military organizations have already been addressed as an example under 'Organizational procurement'.	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
35057	45	44			The discussion explaining voluntary or mandatory policies seems unnecessary.	Accepted. Explanation has been deleted.	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
6721	46	12	46	28	I think its important to discuss how these types of taxes could be regressive and affect low income consumers the most unless designed appropriately. Especially if there is discussion about taxing meat or other GHG emissions in food, doing so could adversely affect low income populations who may need these nutritional requirements.	Rejected. While it is important to stress that these taxes could be regressive, this is already mentioned in the paragraph starting line 39 (FOD page 46) and in Table 12.11. The regressive nature of taxes is also addressed in Sectin 12.6 (Cross-sectoral implications of mitigation).	Meredith Niles	University of Vermont	United States of America
12585	46	13	46	13	the references are modelling papers - the sentence should read " Targeted policies to improve both public health and reduce GHG emissions have been modelled to generate cost reductions in health care and labour force ….	Accepted. See also comments #30721 and #12463	Sandra Caldeira	European Commission	Italy
12463	46	13	46	15	the references are modelling papers - the sentence should read " Targeted policies to improve both public health and reduce GHG emissions have been modelled to generate cost reductions in health care and labour force ….	Accepted. See also comments #1285 and #30721	Sandra Caldeira	European Commission	Italy
30721	46	13	46	33	These studies are models not real world evidence. I would frame more carefully - "Studies have modeled the potential for targeted policies to generate cost reductions in health care".... Rather than "shown to generate cost reductions.."	Accepted. See also comments #1285 and #12463	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
12465	46	20	46	22	Propose alternative sentence " Food-based taxes have so far mainly been implemented to reduce problems with non-communicable diseases and focus on fat and sugars intake, such as taxation of sugar-sweetened beverages. Many health-related organisations recommend the introduction of such taxes to improve the nutrition quality of the products marketed and consumers' diets (reviewed in European Commission, 2019 https://ec.europa.eu/jrc/en/health-knowledge-gateway/promotion-prevention/nutrition/sugars-sweeteners).	Noted. Sentence has been adjusted. Link provided refers to a webpage.	Sandra Caldeira	European Commission	Italy
12467	46	22	46	28	I think this sentence gives a narrow view of the effects of food-related taxes; for example it omits the effects that it may have on the supply side, for example on reformulation of the product inc increasing its healthiness. This reference gives a good overview: https://academic.oup.com/jpubhealth/article/37/1/18/1558688	Noted. The reference has been included as it gives a good overview. However, the effects are not that simple as indicated ('reformulation increases healthiness') as the paper also describes other possible effects ('using cheaper ingredientes decreases healthiness').	Sandra Caldeira	European Commission	Italy
29393	46	23	46	28	Maybe shorten this sentence. "even though" is used twice which makes the line of thought not so easy to follow. It is not clear how "low socio-economic status" is defined. As the distributional consequences of taxes are not discussed at this point, one could also just refer to "population subgroups" or (as referred to income before) to "people with a low income" in this case.	Accepted. Sentence modified.	Catharina Latka	University of Bonn	Germany
12587	46	39	46	39	Propose alternative to sentence " Financial instruments have the potential to improve the nutritional quality of diets and reduce GHG emissions etc	Accepted.	Sandra Caldeira	European Commission	Italy
11875	46	39	46	44	Please provide some examples of 'financial instruments' here	Accepted.	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
34285	46	12	50	36	This part is long and informative, but lacks a better synthesis to understand and focus policy choices	Noted. Synthesis is provided in Table 12.11	Antoine BONDUELLE	Climate Action Network France	France
6719	47	11	47	11	"the Fiji"- Fiji government? Not a complete statement.	Editorial.	Meredith Niles	University of Vermont	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
34283	47	15	47	16	the wording "on the other hand" is misleading because the argument goes also against across the board trade agreements. In fact, most arguments in the text say that; IPCC should take a better stand that most arguments are agains wide agreements	Taken into account. "On the other hand" was following a sentence arguing that trade policies can help improving healthiness of food in a country on the example of the Fiji. It lead to a counter-argument that they could also counteract national efforts to imroved public health. As such, the use of 'on the other hand' in the FOD was appropriate. However, to avoid confusion it has been removed in the SOD version.	Antoine BONDUELLE	Climate Action Network France	France
30723	47	18	47	19	See also Kim et al. 2019. Country-specific dietary shifts to mitigate climate and water crises	Accepted. The reference has bee included.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
12469	47	38	47	39	Propose alternative: Currently, 16 countries regulate marketing of unhealthy food to children, mainly on television and schools (Taillie et al. 2019) and many other efforts are ongoing across the globe (European Commission, Joint Research Centre (2019): Database: Restrictions on marketing of food, non-alcoholic and alcoholic beverages to protect health. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/a5798df4-da80-4576-9502-218d6c2fff19 .	Accepted. Text has been changed accordingly	Sandra Caldeira	European Commission	Italy
12473	47	39	47	41	Propose alternative : They aim to counter the increase in obesity in children and target products high in saturated fats, trans-fatty acids, free sugars and/or salt. Worldwide, WHO, UNICEF and other organisations call for action to limit marketing of these products to children (reviewed in European Commission 2019 https://ec.europa.eu/jrc/en/health-knowledge-gateway/promotion-prevention/other-policies/marketing	Noted. Sentence has been adjusted. Link provided refers to a webpage.	Sandra Caldeira	European Commission	Italy
12471	47	43	47	44	Propose alternative: They can be informative, but can also be misleading if promoting unhealthy food (Ghosh and Sen 2019; Sussman et al. 2019; Whalen et al. 2018).	Accepted.	Sandra Caldeira	European Commission	Italy
11449	48	7	48	16	Organizations are key intermediaries in the food system and feed millions of people every day. Organizations are a heterogeneous group that includes workplaces, hospitals, schools, etc, operating in different socio-economic and environmental contexts and therefore tailored instruments are likely to me more effective. Goggins (2018) highlights the importance of contextual conditions in determining how, why and to what effect organizations provide food and identifies key contextual considerations including the primary function of the organizations and its consumer base, the sector in which the organization operates (e.g. public, private), catering contracts and procurement practices (e.g. outsourced/in-house, centeralized/noncentralized), prevailing organizational (food) culture and infrastructural conditions.Goggins (2018) identifies 12 areas where organizations can target to improve food sustainability, as well as economic and other barriers to change. REF: Goggins, G. (2018) Developing a sustainable food strategy for large organizations: The importance of context in shaping procurement and consumption practices. Bus Strat Env. 2018;27:838–848 https://doi.org/10.1002/bse.2035	Accepted. Text has been changed and reads : "To improve dietary choices and depending on the organizational context, organizations can increase the price of unsustainable options while decreasing the price of sustainable ones, or employ information or choice architecture measures (Goggins and Rau 2016; Goggins 2018)."	Gary Goggins	National Univeristy of Ireland Galway	Ireland
30725	48	9	48	10	Meatless Monday is a proper noun	Editorial.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
30727	48	13	48	14	Also organizational levels	Accepted	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
39519	48	14	48	16	…and to be most effective, they need to be implemented along with behavior change strategies to make it easier for consumers to make the healthier/more sustainable choice. Cross-reference "nudges" from Chapter 5 and refer to choice architecture strategies such as those reviewed in "Marcano-Olivier MI, Horne PJ, Viktor S, Erjavec M. Using nudges to promote healthy food choices in the school diningroom: a systematic review of previous investigations. J Sch Health. 2020; 90: 143-157. DOI: 10.1111/josh.12861"	Accepted. Link to Chapter 5 has been included. The text has been adapted based on the suggested reference as follows: "Behavioural change strategies have also been shown to improve efficiencies of school food programs (Marcano-Olivier et al. 2020)"	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
12475	48	15	48	16	There are many valid arguments for why "an effect on health" has not been detected and I would not necessarily feel the need to address that here. I would propose an alternative that also includes an additional effect of procurement rules. "Procurement rules on schools or public canteens increase the accessibility of healthy food and can improve dietary behaviour and decrease the purchase of unhealthy food (Cheng et al. 2018; Temme et al., submitted). In addition, they can affect the supply side and serve as potent stimuli for food product improvement (gennant Bonsman et al, 2017 http://www.euro.who.int/__data/assets/pdf_file/0003/357303/PHP-1109-PubProcurement-eng.pdf?ua=1 ."	Partly accepted. Agreed that the detection of a health effect is complex the the sentence was over-cautious. This part has been deleted. The indicated report though is grey literature.	Sandra Caldeira	European Commission	Italy
12589	48	26	48	26	what is meant by food system regulations?	Editorial. 'System' deleted.	Sandra Caldeira	European Commission	Italy

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
29395	48	26	48	26	Maybe add to "There are only few mandatory food system regulations" what it exactly refers to (regulations considering food waste? Sustainability?).	Editorial. 'System' deleted.	Catharina Latka	University of Bonn	Germany
30729	48	31	48	40	Mention Cool Food Pledge? https://www.wri.org/our-work/project/cool-food-pledge	Accepted.	Raychel Santo	Johns Hopkins Center for a Livable Future, Bloomberg School of Public Health	United States of America
6723	49	4	49	4	missing "of" between out and necessity	Editorial.	Meredith Niles	University of Vermont	United States of America
12477	49	6	49	9	to be more correct I would propose the following alternative: "An increase in consumption of plant based food is a recurring recommendation in FBDGs lowering the share of animal sourced proteins in the diet, though an explicit reduction or limit of animal source proteins is not often included, with the exception of red or processed meat (Temme et al., submitted).	Accepted. Text has been improved as suggested.	Sandra Caldeira	European Commission	Italy
39521	49	6	49	9	And in cases such as the United States Dietary Guidelines for Americans, reductions in intake of meat are recommended for specific groups -- in this case teen boys and men. Reference: "U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2015 – 2020 Dietary Guidelines for Americans. 8th Edition. December 2015. Available at https://health.gov/our-work/food-and-nutrition/2015-2020-dietary-guidelines/."	Rejected. This is interesting, but we feel this goes beyond the level of detail we can provide in the Chapter. We cited peer reviewed articles reviewing guidelines, but did not cite (other) national FBDGs.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
12591	49	18	49	18	"sustainable food alternatives" reads odd to me. What about the following alternative? " … lack of knowledge on how to cook or eat foods they have not consumed often."	Accepted. Text changed accordingly.	Sandra Caldeira	European Commission	Italy
12593	49	22	49	22	I propose the following alternative with a little addition: Early-life experiences are crucial determinants for adopting healthy and sustainable life styles (	Accepted. Text changed accordingly.	Sandra Caldeira	European Commission	Italy
12479	49	24	49	27	Propose alternative :" Though information and education may show little immediate effects (Apostolidis and McLeay 2016), investment into education might lower the barrier for other policies with a more mandatory character to be accepted and effective (McBey et al. 2019; Temme et al., submitted). (medium evidence, high agreement).	Accepted. Text changed accordingly.	Sandra Caldeira	European Commission	Italy
1661	49	35	49	37	Would it be worth including something like 'up to the end of 2019' in this sentence? As some companies (e.g. Quorn) now has carbon footprint labels on food and others might follow suit before the report is published.	Accepted. To avoid misunderstanding the sentence has been deleted.	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
6725	49	36	49	37	carbon footprint labels are also confusing to consumers, and this should be mentioned. See for example: https://www.sciencedirect.com/science/article/pii/S0959652613006215. The citation to Van Loo is also misleading, as the study found that the ALL of the labels they looked at would be ones supported by a majority of respondents (a small sample of 350 people).	Rejected. The study is from 2014, so might not be representative any more. The difficulty in interpreting carbon footprint as compared to FoP labels is already addressed (page 49, lines 44f).	Meredith Niles	University of Vermont	United States of America
1663	49	38	49	38	This sentence should say nutritional rather than neutral.	Editorial.	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
12481	49	38	49	42	propose alternative sentence: …" front-of-package labels instead can also interpret the information (like the traffic light system or the nutriscore label (Kanter et al, 2018)), promote a product (like the healthy star rating implemented in Australia and New Zealand) or warn against frequent consumption like in Finland already in the 90s or in Chile with the warning "High in..." labels to reduce non-communicable diseases (Corvalan et al, 2019)....	Accepted. Sentence modified.	Sandra Caldeira	European Commission	Italy
27125	49	44	49	48	While the text acknowledges examples such as the traffic light approach. One might highlight the fact that labels, at least in health, become more effective if they are normative and rather than descriptive. The green color conveys a judgement/recommendation, while descriptive labels are more demanding for the consumer as they have to translate this information into choice guiding preferences.	Rejected. We think that this has already been addressed in the wording '[...] and simple, interpretative summary indicator front-of-package labels (e.g. traffic lights) are more effective than more complex ones (Tørris and Mobekk 2019; Ikonen et al. 2019; Temple 2019; Bauer and Reisch 2019)'. One might chose different wording (normative vs descriptive) the wording simple, interpretative vs complex captures this in simpler language.	Jan Bauer	Copenhagen Business School	Denmark

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
14261	49	27			maybe explore more, provide more detail. ex: address the importance of renovating schools curriculum regarding sustainable development and climate change, sharing schools best practices, exploring a common approach to promote systems thinking; In addition, acknowledge the importance of future nutritionists/dietitians in driving behavioural change towards lower GHG emissions, and sustainable development from dietary choices and the importance of integrating food systems thinking and training in the academia of these professionals; https://doi.org/10.1080/13504622.2017.1360842 https://doi.org/10.3390/su11030719 https://doi.org/10.1016/j.jand.2017.10.024	Accepted. We included the following sentence in the SOD referring to the publications indicated: "Early-life experiences are crucial determinants for adopting healthy and sustainable life styles (McBey et al. 2019; Bascopé et al. 2019) and improved understanding of sustainability aspects in the education of public health practitioners and in university education is proposed (Wegener et al. 2018)."	João Costa Leite	Universidade Fernando Pessoa	Portugal
12483	50	8	50	11	I propose an alternative sentence - more correct in my view "Information campaigns and education so far were not able to succesfully enable long-lasting behavioural change in food choices. Information is more effective if accompanied by reinforcement through structural changes or by changing the food environment that allows the awareness to be put into effect ...." 11 and overcome the intention-behaviour gap (Broers et al. 2017; Bucher et al. 2016; Tørris and Mobekk 12 2019).	Accepted. Text changed accordingly.	Sandra Caldeira	European Commission	Italy
39523	50	15	50	17	Neff et al (2018) also found that personal health and money was more important motivator for reducing meat consumption in particular, compared to environmental reasons. See: Neff et al. 2018. Reducing meat consumption in the USA: A nationally representative survey of attitudes and behaviors. Public Health Nutrition, 21(10): 1835–1844. DOI 10.1017/S1368980017004190	Accepted. The paper has been considered in the SOD.	Erin Bieh	Johns Hopkins Center for a Livable Future	United States of America
12595	50	17	50	17	I propose an alternative sentence - more correct in my view "There is evidence that choice architecture (nudging) can be effective in influencing purchase decisions, but regulators do not normally exlore this option (Broers et al. 2017).	Accepted. Text changed accordingly.	Sandra Caldeira	European Commission	Italy
12485	50	18	50	21	I disagree that higher free offerings are green nudging - free offerings may contribute to waste. and reduced portion sizes are also not a nudge as I see it.	Accepted. To avoid misunderstanding free offerings and reduced portion size (intention was portion in canteens, not pre-packed sizes) have been omitted from the sentence.	Sandra Caldeira	European Commission	Italy
27129	50	21	50	21	Only a wording issue. I would argue that no nudge is acutally changing a social norm but communicating them/ make them salient in the moment of decision-making.	Accepted.	Jan Bauer	Copenhagen Business School	Denmark
12487	50	23	50	26	I find this sentence slightly misleading - in the health sector there are definitely studies and even interventions in practice (like no products high in sugar in check out counters).	Accepted. Sentence changed to refer to sustainable diets only.	Sandra Caldeira	European Commission	Italy
27127	50	29	50	29	The authors write "can potentially be effective". The recently published Meta-analysis Cadario R, Chandon P. Which Healthy Eating Nudges Work Best? A Meta-Analysis of Field Experiments. Mark Sci. 2019; doi:10.2139/ssrn.3090829 finds persistent and comparably strong effects for different nudge interventions.	Accepted. Based on this study we removed the word 'potentially'.	Jan Bauer	Copenhagen Business School	Denmark
12597	51	24	51	24	I would prefer it if this sentence were slighly "stronger" - for exaple: ".... that combine informative instruments with behavioural, administrative and/or market-based instruments and are attentive to the needs and engage all food system actors 25 including civil society networks and change the food environment (Stoll-Kleemann and Schmidt 26 2017; Kraak et al. 2017; Cornelsen et al. 2015; iPES Food 2019; Milford et al. 2019; El Bilali 2019; 27 Temme et al., submitted) (robust evidence, high agreement).	Accepted.	Sandra Caldeira	European Commission	Italy
27131	52		52		Maybe consinder adding the behavioural category to the food labels. There is argument to be made that front-of-package labels primarily work through the behavioural angle rather the information they convey. E.g. this is birefly discussed in: Bauer JM, Reisch LA. Behavioural Insights and (Un)healthy Dietary Choices: a Review of Current Evidence. J Consum Policy. 2019;42: 3–45.	Accepted. Even though a combination of food labels and nudging in Table 12.11 does not seem to be appropriate as food labels can also have non-behavioural aspects, the fact that food labels can be effective through nudging was missing and has been included.	Jan Bauer	Copenhagen Business School	Denmark
11877	52	1	54	1	This table is very useful - please retain	Noted.	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
29397	52	1	54	1	References to relate the statements in the table to their sources could be added	Accepted. References have been added to the updated Table 12.XX (combining the FOD tables 12.9 and 12.10).	Catharina Latka	University of Bonn	Germany
5399	52		54		Table 12.11 - very interesting Table	Noted.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
29405	55	1	67	16	Section 12.5 could have a stronger structure to guide the reader and a better connection of paragraphs. Also there are section levels with only one subchapter (e.g. 12.5.1.1, but no 12.5.1.2)	Taken into account. Section 12.5 has been restructured	Catharina Latka	University of Bonn	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
29399	56	1	56	5	I do not fully understand the classification of options listed under adaptation - isn't dietary change (or other behavioral changes) with the aim to reduce greenhouse gas emissions and in consequence contribute to reducing climate change severity also a mitigation approach? (if here it is meant the dietary adaptation to e.g. adapted agricultural production systems, this could be differentiated more explicitly)	Taken into account. The figure was a placeholder borrowed from the SRCCL and it is no longer included in Ch12	Catharina Latka	University of Bonn	Germany
18171	56	24	56	28	Please delete Sandström et al., because this paper concerns only deforestation and that is not part of forest management nor harvest, but land-use change.	Accepted. Sandström et al has been deleted	Joachim Rock	Thuenen-Institute of Forest Ecosystems	Germany
1665	56	31	56	31	I think another sentence here explaining what/where 'limited geographic coverage' refers to would be helpful.	Accepted. Added the information that Europe and N America are the most studied regions	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
17373	57	6	57	19	According to discussions held during COP25 and lack of international consensus in IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels, the mentioned texts should appear to be reviewed.	Taken into account. The paragraph has been updated based on information provided in Ch3 in this WGIII AR6 SOD	Zeyaeyan Sadegh	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran
34287	57	21	57	35	This paragraph feeds a key discussion for long term policy. There could be a table with both biological and non-biological storage potentials in regard to negative emissions budget requested in the AR6 WG1.	Taken into account - covered in Section 12.3	Antoine BONDUELLE	Climate Action Network France	France
5953	58	11	58	12	Load factors and intermittency (better termed "variability" as intermittent means on/off) apply to electricity whereas the figure is energy. Suggest delete the sentence. Also the point needs to be made that distributed energy resources (solar biomass, etc) are usually close to demand so require less transport in grids, pipelines etc	Accepted. Sentence deleted. We also extended text as suggested	Ralph Sims	Massey University	New Zealand
6549	59	32	64	4	What is entirely missing in this section is the mitigation options from water management and waste water treatment. Proper water management in combination with ecosystem managment can account for substantial mitigation effects, a.o., from healthy wetlands. Waste water has a high energy potential that is not used at all but which accounts for GHG emissions. Improved waste water treatment can capture the energy (and collect other rsources) from the waste water, reducing both energy production needs as well as reducing GHG emissions from untreated waste water. The World water Development Report 2020 on Water and Climate Chnage (to be published on 23 March 2020) gives several examples of mitigation options from water.	Accepted. We have added that wastewater treatment can reduce pollution loading and provide mitigation benefits, such as when anaerobic digestion of wastewater reduces methane emissions and produces biogas that can substitute natural gas.	Jos Timmerman	Waterframes	Netherlands
26127	60	5	60	7	Studies on the concept of sustainable removal rates for agricultural biomass residues could be mentioned here. Some references that could be used: Sustainable agricultural residue removal for bioenergy: A spatially comprehensive US national assessment, https://www.sciencedirect.com/science/article/pii/S0306261912005508; Estimating sustainable crop residue removal rates and costs based on soil organic matter dynamics and rotational complexity, https://www.sciencedirect.com/science/article/pii/S0961953413003036; How does crop residue removal affect soil organic carbon and yield? A hierarchical analysis of management and environmental factors, https://www.sciencedirect.com/science/article/pii/S0961953415300611	Accepted. References on residue removal rates added	Mykola Shlapak	N/A	Ukraine
34289	60	21	60	31	This paragraph concern very long term scenarios with high use of RE, not the present. It is not fair to present is beside the actual and present impact of a nuclear accident, well described in the next paragraph.	Taken into account. The Section indeed considers long term scenarios and covers effects that may arise in situations with high use of RE.	Antoine BONDUELLE	Climate Action Network France	France
29401	60	32	60	43	In the argumentation about the impacts following from nuclear accidents a discussion of the trade-off between land (and carbon) savings from leaving the contaminated area untouched for some time (which incorporates some chances for biodiversity recovery, plant growth and carbon storage) versus the (stated) land needs for resettlement etc. could be added	Accepted. Text added as proposed	Catharina Latka	University of Bonn	Germany
26129	60	34	60	35	Please, kindly use the correct reference to an independent country name as “Ukraine”, not “the Ukraine”	Accepted. This has been corrected	Mykola Shlapak	N/A	Ukraine
6545	60	44	61	3	Hydropower has substantial ecological effects, which in turn can affect communities depending on healthy ecosystems, like fishermen. Also reduced sediment flows can have substantial impacts on the river delta. Moreover, chnge of waterflow regime has substantial ecological effects and, e.g., in the Tonle Sap region substantial economic affects. Example is Mekong, undergoing severe affects from mainstream dams.	Taken into account - effects covered in this section where water related impacts are addressed	Jos Timmerman	Waterframes	Netherlands
1667	61	2	61	3	Can you include any references to support this sentence?	Accepted. References added.	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
6547	61	14	61	15	Most water' - the amount of water returned is highly dependent on the local situation and substantial amounts are withdrawn from the natural flow. This sentence should be better substantiated, estimates exist of mounts of water that are lost from agriculture.	Taken into account. The comment reflects a misunderstanding: the commented text concerns water use in industrial facilities where biomass is processed into biofuels. Not agriculture water use. The text has been revised to make this clear.	Jos Timmerman	Waterframes	Netherlands
1669	61	23	61	23	sited not cited.	Accepted. Corrected	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
28917	62	9	62	10	Figure no.? Caption?	Accepted. The same picture was mistakenly inserted in two different places in the section. This has been corrected.	Marissa Malahayati	National Institute for Environmental Studies	Japan

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29403	62	9	62	10	Figure seems to be displaced as reoccurring on page 64	Accepted. The same picture was mistakenly inserted in two different places in the section. This has been corrected.	Catharina Latka	University of Bonn	Germany
25267	62		62		Remove the graph as it is presented on p. 64	Accepted. The same picture was mistakenly inserted in two different places in the section. This has been corrected.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
5401	62		64		Figure 12.9 - Figure in page 64 is similar to figure in page 62	Accepted. The same picture was mistakenly inserted in two different places in the section. This has been corrected.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
39859	63	3	63	5	Some more assessment is needed for the introduction of perennial grain crops, including .feasibilit/profitability.	Accepted. Text added to acknowledge current yield gap	Hasegawa Toshihiro	National Agricultural and Food Research Organization	Japan
1451	63	37	63	41	Ecological restoration, when implemented effectively and sustainably, contributes to protecting biodiversity; improving human health and wellbeing; and supporting climate change mitigation, resilience, and adaptation. But it needs a good planning and implementaiton of restoraiton program. There are cases where ecological damages occur when projects are implemented with bad design but in the name of ecological restoration. In general, the success rate of ecological restoration is not high worldwide. This needs internationally accepted principles and standards for ecological restoration See Gann G.D., McDonald T., Walder B., Aronson J., Nelson C. R., Jonson J., Hallett J. G., Eisenberg C., Guariguata M. R., Liu J., Hua F., Echeverría C., Gonzales E., Shaw N., Decleer K., Dixon K.W., 2019. International principles and standards for the practice of ecological restoration Second edition. Restoration Ecology 27 (S1): S1–S46.	Accepted. Reference added in new LDN box.	JUNGUO LIU	Southern University of Science and Technology	China
28919	64	1	64	1	Is there any different between this figure with figure 12.8? I think those figure are exactly the same.	Accepted. The same picture was mistakenly inserted in two different places in the section. This has been corrected.	Marissa Malahayati	National Institute for Environmental Studies	Japan
939	65	16	65	16	Recommendation Wording needs to be changed to "have the potential to build SOC". Reasons Changes in SOC in grazing systems in response to changes in grazing management are highly uncertain. Under certain conditions (relatively low SOC stocks for a given soil type/climate combination) SOC stocks can be increased by changing grazing management however if the SOC stocks are already relatively high then a management change will not increase, and could decrease, SOC stocks. The ability for cover to crops to store SOC is also highly variable. SOC is linked to productivity and in some systems (e.g. Australian cropping systems with winter dominant rainfall) storing soil moisture in fallow paddocks over summer is the key to maximising crop productivity. Cover crops that use moisture can reduce total productivity and therefore SOC stocks. Further, management of these systems have already been changed over recent decades to ensure crop residues are retained for the purpose of reducing soil erosion and storing soil moisture so even if cover crops could increase SOC, the increase may be limited. The wording needs to be changed to reflect that the changes that could occur by including cover crops in a cropping system are highly uncertain.	Accepted. Edited as proposed.	Aaron Simmons	NSW Department of Primary Industries	Australia
12681	65	15			measures applied on land that is not used for intensive food production. Sustainable harvest of non-wood forest products.	Accepted. Added "Harvest of non-wood forest products can enhance food security"	Eray Özdemir	General directorate of Forestry	Turkey
11879	66	1	66	2	This table is very useful - please retain	Noted, thanks	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
941	66		66		Recommendation Remove "Crop rotations with grass crops" as a land-based mitigation option. Reason Table 12.12 Rotating crops with legume based pastures (alfalfa/lucerne) sequesters SOC (reference) because the legumes fix N from the atmosphere and the stiochometry of C:N in the soil (as noted in the report) means this increases SOC. Further, using grass based pastures in rotation will increase the need for pesticide use (in this instance pesticides refer to chemicals that control arthropod pests, weeds and diseases). Cereal crops are grasses, so grass-based pastures in rotation provide a host and allow pests and diseases of cereal crops to persist through the pasture phase of the rotation. If broadleaf (legume) pastures are grown in rotation there is no host for pests and diseases so using grass-based pastures would require more pesticide use than conventional legume based pastures in rotation. Broadleaf weeds are realtively easy to control in cereal crops with low-risk pesticides however controlling grass-weeds in cereal crops is epxensive and can require the use of more toxic pesticides. In contrast, using a legume-crop in rotation allows the use of grass-specific herbicides and alows the rotation of herbicides that reduces the development of pesticide resistance.	Accepted - the text has been changed and there is no longer reference to "crop rotation with grass"	Aaron Simmons	NSW Department of Primary Industries	Australia

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
943	66		66		Recommendation Note that increasing SOC will also increase yields and that this will increase efficeincy of existing land use and reduce the need for land transformation. Reason Increasing SOC, particularly where SOC is increased by improving soil fertlity, will also increase yields and this will provide an opportunity to use existing agricultural land more efficienctly and reduce the need to convert land to agricultural land to meet increasing demands for food from a growing global population.	Accepted. Point added to table	Aaron Simmons	NSW Department of Primary Industries	Australia
945	66		66		Recommendation Potential increase in demand for agricultural land needs to be included as a negative/trade off Reasons Table 12.12 Improving cropland and grazing land management for vegetation and SOC increases needs to consider the market effects of production changes. For example, reforresting pastures with trees can reduce animal production and shift the burdens of production elsewhere. The burdens of producing animal products elsewhere could be greater than the carbon sequestered as a result of the changes.	Noted. This row relates to practices that are integrated with ag production rather than displacing food production. Competition for land, leading to iLUC, is raised as risk for reforestation and biomass plantations.	Aaron Simmons	NSW Department of Primary Industries	Australia
947	66		66		Recommendation Include negative impacts of methods to improve SOC Reason Table 12.12 Improving cropland and grazing land management for vegetation and SOC increases needs to consider how these are done. This can be achieved through the application of N fertilisers because, as stated in the report, the C:N ratio in soil is relatively fixed. Hence, the application of any N source (including synthetic mineral N) will lead to an increase in productivity and the ability to store SOC that is added due to increased productivity.	Noted. Using N fertiliser, leading to N2O emissions, is now listed as a risk	Aaron Simmons	NSW Department of Primary Industries	Australia
34291	66	1	67	1	no mention of nuclear as in the text ?	Noted. Using N fertiliser, leading to N2O emissions, is now listed as a risk	Antoine BONDUELLE	Climate Action Network France	France
6551	66	1			Impact of hydropower dams is also biodiversity loss as well as substantial socio-economic affects	Accepted. Text is added about impacts on aquatic ecology and biodiversity, and also socio-economic effects	Jos Timmerman	Waterframes	Netherlands
6553	66	1			Re-/afforesttion can in the longer run have positive effects on water availability but little research has been done on this. A.o. Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp. https://www.ipcc.ch/publications_and_data/_climate_change_and_water.htm; Tubiello, F.N. and M. van der Velde, 2011. Land and water use options for climate change adaptation and mitigation in agriculture. SOLAW Background Thematic Report - TR04A. FAO, Rome, Italy. http://www.fao.org/fileadmin/templates/solaw/files/thematic_reports/TR_04a_web.pdf ; Wallis, P.J., Ward, M.B., Pittock, J. et al., 2014. The water impacts of climate change mitigation measures. Climatic Change (2014) 125: 209. https://doi.org/10.1007/s10584-014-1156-6	Noted. is addressed in section 12.5 where water related effects of mitigation options are covered	Jos Timmerman	Waterframes	Netherlands
6555	66	1			Biomass plantations: impact is also that biomass plantation requires energy to produce the biomass	Noted. Comment forwarded to Ch6 CLAs who have confirmed that Ch6 considers that energy inputs are needed when biomass and other energy resources are produced/extracted.	Jos Timmerman	Waterframes	Netherlands
31599	67	1	67	2	Vertical Farming could be an alternative solution that would reduce the use of water to 4-6% of open land systems, reset use of soil and pesticides, supply a complete Food Safety Process using seeding and growing positive cells and delete any possible contact between operators and plants, creating a complete aseptic chain that will lead consumer as the first one that will touch food. Planet Farms factory in Italy, the huger Automatic Vertical Farm Factory in Europe, Aerofarms NJ or Plenty CA are examples of alternative solutions to Food Access due to the modification of the urban design and cities. Vertical Farming could supply the right quantity of edible products all-year-round, unaffected by any uncertainty, climate change, infections, lacks, all due to the Indoor growing.	Taken into account. Vertical farming is addressed in Section 12.4.3.2 (Controlled Environment Agriculture), discussing also the mentioned co-benefits on reduced needs for land and agro-chemicals, higher water and nutrient use efficiencies and short supply chains, but also pointing towards higher needs of energy and the currently limited scope of food products	Bernardo Cigliano	SIX srl	Italy
46747	67	19	67	21	This is claimed in Mikael Karlsson, Eva Alfredsson & Nils Westling (2020) Climate policy co-benefits: a review, Climate Policy, DOI: 10.1080/14693062.2020.1724070.	Accepted. Reference has been added	Mikael Karlsson	KTH Royal Institute of Technology	Sweden
1673	67	19	67	26	References needed to support statements. You refer to a 'body of literature' but give no examples.	Accepted. Karlsson et al, which is a very large meta analysis of the literature, has been added to address this comment	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
46749	67	22	67	26	This is claimed in Mikael Karlsson, Eva Alfredsson & Nils Westling (2020) Climate policy co-benefits: a review, Climate Policy, DOI: 10.1080/14693062.2020.1724070.	Accepted. Reference has been added	Mikael Karlsson	KTH Royal Institute of Technology	Sweden

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16361	67	3			In Section 12.6 Other cross-sectoral implications of mitigation, consider adding a subsection that describes the global military sector and its potential to lead mitigation across manufacturing and transport sectors, as well as in agriculture based on provisioning. Including this will strengthen the section and be an aid to the reader.	Rejected. This would be better covered in the individual sections, of transport, manufacturing and agriculture	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
12683	67				effective pro and post fire management in forest land	Noted. The Table includes the category "Fire management in forest land" and we are uncertain whether this comment intended to propose a rephrasing of this category or to introduce a subcategory. The category name was not changed.	Eray Özdemir	General directorate of Forestry	Turkey
12685	67				New bullet for Forest Management: Soil conservation for Forests and other land uses	Accepted. The topic is added in the table in section 12.5 as suggested by reviewer	Eray Özdemir	General directorate of Forestry	Turkey
46751	68	13	68	13	This is shown also in: Mikael Karlsson, Eva Alfredsson & Nils Westling (2020) Climate policy co-benefits: a review, Climate Policy, DOI: 10.1080/14693062.2020.1724070.	Accepted. Reference has been added	Mikael Karlsson	KTH Royal Institute of Technology	Sweden
46753	68	21	68	21	Please add in the end of the paragraph: "In order to proved a straightforward and user-friendly taxonomy describing the various ways that synergies can occur, it has been suggested to label “climate policy co-benefits”, i.e. mitigation benefits in addition to avoided climate change, as Type 1, and “climate co-benefits”, i.e. climate mitigation resulting from a measure in another policy field, as Type 2, and benefit synergies of policies with multiple objectives as Type 3" (Mikael Karlsson, Eva Alfredsson & Nils Westling (2020) Climate policy co-benefits: a review, Climate Policy, DOI: 10.1080/14693062.2020.1724070).	Rejected. This recommendation is just one taxonomy proposed by one author - it is not felt that this particular taxonomy needs to be highlighted over others	Mikael Karlsson	KTH Royal Institute of Technology	Sweden
9957	68	24	68	24	Also: - Doukas, H., Nikas, A., González-Eguino, M., Arto, I., & Anger-Kraavi, A. (2018). From integrated to integrative: Delivering on the Paris Agreement. Sustainability, 10(7), 2299.	Accepted. Reference has been added	Haris Doukas	School of Electrical and Computer Engineering, National Technical University of Athens	Greece
11881	69	1	69	2	This is a very useful and engaging figure. Please retain. Some simplification would be beneficial.	Taken into account. Modifications have been made to the figure.	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
29407	69	1	69	9	While for the green circle (third level) the filling colour has a meaning explained in the footnote, for the first 2 circles the color differences do not contain additional information (at least not mentioned). As the figure is very colorful and full of indices that are not linked straightforwardly, the changes in the colorpattern for the first two circles could be removed. Also the connection between the circles could be visually improved, e.g. the referred to indices could be shown as an integrated inner circle of the respective field while the "own" field's index could be shown in the outer layer of the same field.	Taken into account. Modifications have been made to the figure. Regarding the second suggestion, on the linkages, this is quite difficult to to given the length of the words.	Catharina Latka	University of Bonn	Germany
5405	69	14	69	14	I suggest to write: ....in more than one sector	Accepted. Change has been made	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
5407	69	15	69	16	What about INTEGRATION among sectors ?	Accepted. Word has been added as suggested	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
28033	69	17	69	19	IPCC states, "A number of mitigation measures find application in more than one sector. Renewable energy technologies such as solar and wind may be used for grid electricity supply, as embedded generation in the buildings sector and for energy supply in the agriculture sector." Please include these papers, which address the use of renewable energy across all energy sectors (electricity, transportation, buildings, industry, agriculture/forestry/fishing, the military): Jacobson, M.Z., M.A. Delucchi, M.A. Cameron, S.J. Coughlin, C. Hay, I.P. Manogaran, Y. Shu, and A.-K. von Krauland, Impacts of Green New Deal energy plans on grid stability, costs, jobs, health, and climate in 143 countries, One Earth, 1, 449-463, doi:10.1016/j.oneear.2019.12.003, 2019. https://web.stanford.edu/group/efmh/jacobson/Articles/I/WWS-50-USState-plans.html and Jacobson, M.Z., M.A. Delucchi, Z.A.F. Bauer, S.C. Goodman, W.E. Chapman, M.A. Cameron, Alphabetical: C. Bozonnat, L. Chobadi, H.A. Clonts, P. Enevoldsen, J.R. Erwin, S.N. Fobi, O.K. Goldstrom, E.M. Hennessy, J. Liu, J. Lo, C.B. Meyer, S.B. Morris, K.R. Moy, P.L. O’Neill, I. Petkov, S. Redfern, R. Schucker, M.A. Sontag, J. Wang, E. Weiner, A.S. Yachanin, 100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for 139 countries of the world, Joule, 1, 108-121, doi:10.1016/j.joule.2017.07.005, 2017, https://web.stanford.edu/group/efmh/jacobson/Articles/I/WWS-50-USState-plans.html	Accepted. Jacobson et al, 2017 is cited and added to the references list.	Mark Jacobson	Stanford University	United States of America
38161	69	17	69	24	Options included here are all supply-side technological solutions. Cross-sectoral demand-side non-technological and technological solutions should also be included in this section.	Accepted. Additional information on demand side technologies added.	Yamina Saheb	OpenExp, Ecole des Mines de Paris	France
5403	69		69		Figure 12.10 -Which is the source of this Figure ? It is realized for the authors or taked of one reference. Need the page. Very well conceived	Noted. It was developed by the authors.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
35059	69	1			The figure needs a lot of work to clearly depict the correlation that it intends to show. For example, it is not comprehensive but nowhere the reader can find a mention in that sense.	Taken into account. Some changes have been made to the figure based on other reviewers' comments. A note has been made in the preceding paragraph that the figure is not meant to be comprehensive	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
2245	70	1	70	1	Please, add reference (Hoenig et al 2007): Hoenig, V.; Hoppe, H.; Emberger, B. Carbon Capture Technology—Options and Potentials for the Cement Industry, 1st ed.; European Cement Research Academy (ECRA): Düsseldorf, Germany, 2007; pp. 1–96.	Rejected. The suggested reference is earlier than the range of publications covered by AR6. However, another reference has been added to this paragraph which looks at cement specifically	Miguel Angel Sanjuán	Technical University of Madrid	Spain
34293	70	1	70	2	"fossil fuel electricity sector"(chapter 6) with CCS has shrinked nearly totally in IEA or IPCC scenarios since AR5, maybe mention someting like "less likely" or "in a lesser way" to show that their relative importance has waned.	Accepted. New text added to address this comment	Antoine BONDUELLE	Climate Action Network France	France
39043	70	2	70	2	CCU technologies are mitigation options that find applications in the transport, building, industrial and energy sectors, e.g. via the power to fuel/gas principle, thus a thorough discussion on the CCU concept should be added in this section. In the case of CCU, added value can be positive as a result of the cost savings from fossil raw material reduction. If the capture costs can be minimized, CO2 can be given a value and transformed from a liability into an asset (e.g.Ampelli, et al, 2015, Bruhn et al., 2016, Krey et al., 2019). The existing literature shows that the current benefits of CCU are numerous (VITO, 2018). CCU can: • Decrease CO2 emissions at relatively short-term • Replace fossil or biobased feedstock • Defossilize the process industry and transportation sector • Store energy • Contribute to a circular economy • Create a revenue stream for CO2 abatement from fossil fuel use based on consumer demand for CO2-containing products. • Be an alternative for CCS • Improve Energy security • Make use of specific attributes of CO2 in commercially competitive applications • Remediate inorganic wastes from industrial processes • Sequestrate significant quantities of CO2 in building materials • Provide revenues to fund (partially) CCS projects • Reduce the complexity of chemical reaction pathways • Control the cost for the supply of fuels • Relocalize the energy supply (REFERENCES: • VITO, 2018 (Miet van Dael), Market Study Report CCU, Flemish Institute for Technological Research NV./• Krey et al., 2019, Energy, 172, 1254-1267./• Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43.,/ • Ampelli et al., 2015: CO2 utilization: an enabling element to move to a resource and energy-efficient chemical and fuel production, Phil.Trans.R.Soc.A, 373.).	Accepted. Mention has now been made of CCU as well as CCS. However CCU is covered in detail in other chapters and so none of this detail is presented in Ch 12. Rather the reader is referred to elsewhere where detail can be found.	Célia Sapart	Université Libre de Bruxelles et Co2 Value Europe	Belgium
38163	70	3	70	6	Making buildings positive energy will also contribute to increasing the mitigation potential of elctric/hybrid cars	Accepted. Added to the section.	Yamina Saheb	OpenExp, Ecole des Mines de Paris	France
34295	70	30	70	30	This risk does exist but is not present in many technologies such as silicon based PV and most wind turbines, contrary to many IT devices. A task force of IEA has aslo concluded that it does not prevent a transition to RE. Maybe replace "different" by "some specific technologies"	Accepted. Proposed change has been made	Antoine BONDUELLE	Climate Action Network France	France
28923	70	45	70	45	I think it is better to write GPT as "General Purposes Technologies(GPT)" on the table header. Not all people familiar on this term	Noted. However this table has been moved to Ch 16. This suggestion has been communicated to then, it is likely that the table will be expanded extensively.	Marissa Malahayati	National Institute for Environmental Studies	Japan
8607	70	45	71	1	In Table 12.13, Examples of specific applications should be added in GPT(Biotechnology, Internert of Things, Robots)	Noted. However this table has been moved to Ch 16. This suggestion has been communicated to then, it is likely that the table will be expanded extensively.	Suyi Kim	Hongik University	Republic of Korea
16357	70	45	72	1	For Table 12.13 Cross-sectoral applications of General Purpose Technologies, consider adding geothermal as a GPT. Notably geothermal can serve both as an energy source and for heating/cooling. Hot dry rock geothermal also has a benefit of allowing for the transition of the drilling infrastructure of oil/gas companies to be used in a renewable energy context and thereby allow for transition away from oil/gas extraction.	Noted. However this table has been moved to Ch 16. This suggestion has been communicated to then, it is likely that the table will be expanded extensively.	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
18365	70	36	73	17	I agree to highlight the importancet of general purpose technologies. The progress of general purpose technologies such as ICTs, AI, batteriies, advanced plastics etc are the key enabler of deep emission cut. I recommned further elaboration for better understanding.	Noted. However this section has largely been moved to Ch 16, with a focus being placed here on the cross-sectoral aspects. This suggestion has been communicated to that chapter	Kazuhiko Hombu	Graduate School of Public Policy, The University of Tokyo	Japan

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16359	70	36			For Section 12.6.1.3 Cross-sectoral benefits of emerging general purpose technologies, consider adding geothermal as a GPT. Notably geothermal can serve both as an energy source and for heating/cooling. Hot dry rock geothermal also has a benefit of allowing for the transition of the drilling infrastructure of oil/gas companies to be used in a renewable energy context and thereby allow for transition away from oil/gas extraction.	Noted. However this table has been moved to Ch 16. This suggestion has been communicated to then, it is likely that the table will be expanded extensively.	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
5409	71		71		Table 12.13 - Additive manufacturing (3D printing): It is used in other sectors today: health, pieces for equipments and other applications, and in the future their use will be very large	Noted. However this table has been moved to Ch 16. This suggestion has been communicated to then, it is likely that the table will be expanded extensively.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
5411	71		71		Table 12.13 - Artificial Intelligence (AI): the same in the industry. biotechnology, and others	Noted. However this table has been moved to Ch 16. This suggestion has been communicated to then, it is likely that the table will be expanded extensively.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
5413	71		71		Table 12.13 - Biotechnology: In medicine too as in the different types of cancer. The vaccines don´t need in the majority of cases the use of other alternative method as chemical therapy or radiotherapy more invasive and . aggressive for the human body and more waste of energy. In water resources management too - wastewater treatment and other uses	Noted. However this table has been moved to Ch 16. This suggestion has been communicated to then, it is likely that the table will be expanded extensively.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
5415	71		72		Table 12.13 - Nanotechnology :In the water resources managementin the treatment plants of drinking water and wastewater treatment. In the industry	Noted. However this table has been moved to Ch 16. This suggestion has been communicated to then, it is likely that the table will be expanded extensively.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
39045	72	12	72	28	There is a lack of peer-reviewed references in the discussion of the role of hydrogen in the industry. The controversery effects as well as the timeline of such a large-scale depoyment of H2 are not discussed at all! e.g.: Kurtz al., 2019 (https://doi.org/10.1016/j.ijhydene.2019.03.027). Even with all possible efforts to reach the 2030 emission targets, the current gas infrastructure worldwide will not allow for a fast and global deployment of an hydrogen economy in the transport, energy and industrial sectors (e.g. Muratori et al., 2018, Gumber and Gurumoorthy, 2018). In contrast, e-CH4 can be used with the current natural gas infrastructure, especially in the energy and high heat industrial sectors (Deutz et al., 2018, EU report, 2018). In the transport sector, e-CH4 might not be the best solution as leaks are likely to occur, but methanol could be used efficiently with the existing infrastructures, especially for aviation and shipping (Schemme et al, 2017). At short-term, the role of hydrogen would first be to form methanol or other CO2 based fuels, e.g. (Gumber and Gurumoorthy, 2018). Both CO2-derived methane and methanol can provide climate benefits, but the use of low carbon energy for their production is critical. CO2 emissions can be reduced by 74% to 93% for methanol and 54% to 87% for e-methane as compared to conventional production routes (IEAGHG, 2019a). (RERERENCES:• Muratori et al., 2018, Energies 2018, 11, 1171./• Gumber and Gurumoorthy, 2018, Methanol, Chap. 25, 661-675./• IEAGHG, 2019a: Putting CO2 to Use – Creating value from emissions, International Energy Agency/• Schemme et al., 2017, Fuel, 205, 198-221./• Deutz et al., 2018, Energy Environ. Sci., 11, 331/• EU, A Clean Planet for All, 2018: A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, Communication from the EU commission.	Rejected (mostly). This comment is about a variety of topics. In general: this is about a global overivew, and many comments are about details. Building hydrogen infrastructure is an important issue, but the two papers mentioned about this topic are more about (relatifely!) short-term issues, not about long-term transition processes. Hydrogen-derived fuels like methanol and CH4 are discussed in Chapter 6 and discussed in the first paragraph of this text box now. Clean Planet for All is referred to earlier in the text box (EC, 2018).	Célia Sapart	Université Libre de Bruxelles et Co2 Value Europe	Belgium
34297	72	3	73	16	The paragraph on hydrogen is important and relevant. But in the global context of AR6, it would be very useful to understand if this increase in hydrogen is part of the "electrification" noted in the other chapters, i.e. because the new hydrogen is ex-electrolysis, or if it is accounted as another energy vector	Rejected. This whole section is mainly about hydrogen in final energy use. Next to that share of electricity in final energy use will also increase in most scenarios, but that is dealt with elsewhere (Chapter 3, section 12.2). Note that hydrogen not necessarily has to be produced from electricity.	Antoine BONDUELLE	Climate Action Network France	France
42979	73	1	73	5	In "Box 12.1 Hydrogen in the context of cross-sectoral mitigation options" I suggest to include on the IPCC AR6 scenario database the recent Hydrogen Council report “Path to Hydrogen Competitiveness: A Cost Perspective” [January 2020; available at <https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf >] and my M.V. Romeri “The history could repeat itself: hydrogen-oxygen fuel cell is the ‘game changer’” [published January 2020 in “4th AIEE Energy Symposium Conference Proceedings” Rome, available at <http://www.aieeconference2019rome.eu/documents/AIEE_Symposium_Proceedings_4.pdf>] that analyzes the possible future role of fuel cell in stationary power generation, an aspect mentioned in the Hydrogen Council work but still not considered in terms of analytical data.	Rejected. Regarding the report of the Hydrogen Council: it is the responsibility of the scenario producers to include their data in the AR6 database (and everyone can do so). But in this Box, we already mention the work of the Hydrogen Council explicitly. The paper by Romeri is too specific on (fuel cell) power generation, so should rather be discussed in Chapter 6.	MARIO VALENTINO ROMERI	Independent consultant	Italy
34299	73	13	73	13	The graph shows the large dispersion of studies on H2, this could be done with just a bracket, and include the share of electricity in final use to compare	Rejected. See reaction to comment 34297.	Antoine BONDUELLE	Climate Action Network France	France
17375	73	26	91	45	According to discussions held during COP25 and lack of international consensus in IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels, the mentioned texts should appear to be reviewed.	Rejected. SR1.5C is an approved IPCC report that can legitimately be referenced and quoted for AR6 report.	Zeyaeyan Sadegh	Islamic Republic of Iran Meteorological Organization (IRIMO)	Iran

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31609	74	35	74	37	To maximize synergies and deal with trade-offs in such a cross-sectoral context, evidence-based/informed and holistic policy analysis approaches like nexus approaches and multi-target backcasting approaches that take into account unanticipated outcomes and indirect consequences would be needed (Klausbruckner et al. 2016; Van der Voorn et al 2020)	editorials applied. References added	Tom van der Voorn	Institute for Environmental Systems Research	Netherlands
31611	74	38	74	42	Consequences of large scale land-based mitigation for food security, biodiversity, state of soil and water resources, etc. will depend on many factors, including economic development (including distributional aspects), international trade patterns, agronomic development, sustainable diets, land use governance and policy design, and not the least climate change itself (Fujimori et al. 2018; Hasegawa et al. 2018; Van Meijl et al. 2018; Winchester and Reilly 2015; Pedercini and Van der Voorn, 2013; UN DESA WESS, 2013). Pedercini, M., and Voorn, van der, T. Global food and nutrition scenarios, a background paper prepared for the World Economic and Social Survey 2013. UN World Economic and Social Survey 2013. Sustainable Development Challenges. United Nations publication. E/2013/50/Rev. 1. ST/ESA/344. http://www.un.org/en/development/desa/policy/wess/wess_current/wess2013/WESS2013.pdf	Rejected. The referenced UN report focuses broadly on sustainable development and least with cross-sectoral mitigation policy aspects related to climate change.	Tom van der Voorn	Institute for Environmental Systems Research	Netherlands
35005	74	38	74	45	suggest to underscore the relevance of irrigation schemes meant for improving food production could be risk factors for vector-borne diseases, e.g., malaria	Rejected. The relevance of irrigation schemes and their implication to SD including food and health are dealt with in other chapters (see chapter 7). The focus here on cross-sectoral policy aspects of climate mitigation	Adugna Gemeda	Ethiopian Public Health Institute	Ethiopia
34533	74		79		p.74-79: International trade spillover effects and competitiveness .... Note my comment to Chapter 11 in this area: one specific suggestion is that the authors collectively consider more deeply how to approach the issues around carbon leakage, investment and 'border adjustments'. First, this could usefully be coordinated with Chapters 12 (discusses leakage estimation) and 13 (which has a section on BCAs) and/or 14. In Ch.11 it is located in a section on carbon pricing, which indeed is how almost all the literature addresses it, though the issue could arise from other policies which may raise costs on mobile production activities. It would be useful to clearly distinguish the principles, notably, consumption-based measures and border carbon levelling, which are in principle non-discriminatory, vs potentially discriminatory trade measures. It could be useful if possible to set in wider context of trade and climate relationships. Pleased to see reference to Mehling et al, worth checking and citing the development of this work as now published in leading law journal: Mehling, M., Van Asselt, H., Das, K., Droege, S., & Verkuijl, C. (2019). Designing Border Carbon Adjustments for Enhanced Climate Action. American Journal of International Law, 113(3), 433-481. doi:10.1017/ajil.2019.22 It may be worth raising at WG-III level how AR6 should approach this issue across chapters.	Taken into account. A better division of work and coordination with chapters 3, 11, 13, and 14 is thought in the revised version where chapter 12 now is focusing narrowly on the cross-sectoral aspects of carbon leakage and spillovers leaving the framing, the sectoral level, the policy aspects, and international governance to the other chapters.	Michael Grubb	UCL - Institute of Sustainable Resources	United Kingdom (of Great Britain and Northern Ireland)
29409	75	8	75	14	The potential leakage effects in the agricultural sector are not mentioned in this chapter. These could occur e.g. from mitigation measures leading to a reduction in agricultural production (efficiency) which may lead to increasing production in (and exports from) other (maybe less emission efficient) regions. Trade effects are also relevant for the opposite case, considering a dietary change happening only in a certain region so that agricultural produce is increasingly exported.	Taken into account. No longer relevant. Now section 12.6.3 focuses just on the cross-sectoral elements of carbon leakage while leaving cross-national aspects and policy levers to chapter 13	Catharina Latka	University of Bonn	Germany
36501	75	17	75	18	Clarification of the definition of leakage here: Theoretically there are two types of relocation of emission installations; for instance, “the same amount of emission for producing the same amount of products is moved from A country to B country” is defined as leakage. How do you define the case that “less amount of emission for the same amount of products is moved from A country to B country”. It seems better to clarify for the readers.	Taken into account. Now no longer relevant. Definition of carbon leakage is left to Chapter 13 while section 12.6.3 focuses just on cross-sectoral aspects of carbon leakage	Takashi Hongo	Mitsui & Co. Global Strategic Studies Institute	Japan
2247	75	18	75	18	Please, add reference (Allevi et al 2017): Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. No longer relevant. All the text concerning intrasectoral aspects of carbon leakage was left to Chapter 13 and sectoral chapters while section 12.6.3 focuses just on cross-sectoral aspects of carbon leakage	Miguel Angel Sanjuán	Technical University of Madrid	Spain
12555	75	18	75	18	Please, add reference (Allevi et al 2017): Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. No longer relevant. All the text concerning intrasectoral aspects of carbon leakage was left to Chapter 13 and sectoral chapters while section 12.6.3 focuses just on cross-sectoral aspects of carbon leakage	MORA PERIS PEDRO	Profesor Titular de Universidad de la ETSI Minas y Energía de la Universidad Politécnica de Madrid	Spain
2249	75	35	75	35	Please, add the following text: "Allevi et al concluded that the Italian and the European cement markets are exposed to carbon leakage and this exposure is higher for coastal plants especially when the regulation is more stringent (Allevi et al 2017)." Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. No longer relevant. All the text concerning intrasectoral aspects of carbon leakage was left to Chapter 13 and sectoral chapters while section 12.6.3 focuses just on cross-sectoral aspects of carbon leakage	Miguel Angel Sanjuán	Technical University of Madrid	Spain

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
12557	75	35	75	35	Please, add the following text: "Allevi et al concluded that the Italian and the European cement markets are exposed to carbon leakage and this exposure is higher for coastal plants especially when the regulation is more stringent (Allevi et al 2017)." Elisabetta Allevi, Giorgia Oggioni, Rossana Riccardi, Marco Rocco. Evaluating the carbon leakage effect on cement sector under different climate policies, Journal of Cleaner Production, Volume 163, 2017, Pages 320-337, https://doi.org/10.1016/j.jclepro.2015.12.072.	Rejected. No longer relevant. All the text concerning intrasectoral aspects of carbon leakage was left to Chapter 13 and sectoral chapters while section 12.6.3 focuses just on cross-sectoral aspects of carbon leakage	MORA PERIS PEDRO	Profesor Titular de Universidad de la ETSI Minas y Energía de la Universidad Politécnica de Madrid	Spain
8609	75	16	76	23	Add references, Climate change policy, market structure, and carbon leakage (Journal of International Economics Volume 65, Issue 2, March 2005, Pages 421-445), Trade Liberalization and Carbon Leakage (Onno Kuik, Reyer Gerlagh, The energy Journal 2003), Border adjustment for European emissions trading: Competitiveness and carbon leakage (Onno Kuik, Marjan Hofkes, Energy Policy Volume 38, Issue 4, April 2010, Pages 1741-1748), Carbon leakage revisited: unilateral climate policy with directed technical change (Corrado Di Maria & Edwin van der Werf, Environmental and Resource Economics volume 39, pages55–74(2008)), Kyoto and Carbon Leakage: An Empirical Analysis of the Carbon Content of Bilateral Trade (Rahel Aichele and Gabriel Felbermayr, Review of Economics and Statistics Volume 97 | Issue 1 | March 2015 p.104-115), CARBON LEAKAGE, THE GREEN PARADOX, AND PERFECT FUTURE MARKETS (Thomas Eichner, Rüdiger Pethig, International Economic Review/ Volume 52, Issue 3)	Rejected. Thanks for providing these references which are no longer relevant to this section but will be shared with relevant chapters. All the text concerning intrasectoral aspects of carbon leakage was left to Chapter 13 and sectoral chapters while section 12.6.3 focuses just on cross-sectoral aspects of carbon leakage	Suyi Kim	Hongik University	Republic of Korea
35061	75	28			The section refered on line 28 (12.3.3.2) does not exist in the document.	Taken into account. Thank you. Now this text is deleted	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
34301	76	6	76	23	This part is interesting for the carbon price theoricians or economists. Maybe rephrase and synthesis for policy use ?	Taken into account. The summarizing statement is added: “The existence of green paradox is an additional argument in favor of more decisive climate policy now: any postponements will lead to additional consumption of fossil fuels and consequently the need for more ambitious and costly efforts in future”	Antoine BONDUELLE	Climate Action Network France	France
8611	77	27	78	5	Add references, Knowledge spillovers from clean and dirty technologies: a patent citation analysis (Antoine Dechezleprêtre, Ralf Martin and Myra Mohnen September 2013 Centre for Climate hange Economics and Policy Working Paper No. 51 Grantham Research Institute on Climate Change and the Environment Working Paper No. 135)	Rejected. Thanks for the references but unfortunately, neither this paper nor its updated version of 2017 cover trade aspects of technology spillovers which is the focus of this sub-section. Further, based on other comments the focus of this subsection is narrowed to only cross-sectoral aspects and the title of the sub-section is changed to “The cross-sectoral trade-related knowledge and technology spillovers” to empahsize the new direction. in order to underline its now narrower focus	Suyi Kim	Hongik University	Republic of Korea
8613	77	27	78	5	Add references, Environmental and Technology Policies for Climate Change and Renewable energy(https://ageconsearch.umn.edu/record/10789/), The Role of R&D and Technology Diffusion in Climate Change Mitigation: New Perspectives Using the Witch Model (FEEM Working Paper No. 14.2009, CMCC Research Paper No. 63, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1397076)	Rejected. Thanks for the references but unfortunately, these papers do not cover trade aspects of technology spillovers which is the focus of this sub-section. Further, based on other comments the focus of this subsection is narrowed to only cross-sectoral aspects and the title of the sub-section is changed to “The cross-sectoral trade-related knowledge and technology spillovers” to empahsize the new direction.	Suyi Kim	Hongik University	Republic of Korea

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
8615	77	27	78	5	Handbook of Green Growth, Chapter 4: Path dependence, innovation and the economics of climate change (Philippe Aghion, Cameron Hepburn, Alexander Teytelboym and Dimitri Zenghelis, DOI:https://doi.org/10.4337/9781788110686.00011)	Rejected. Thanks for the references but unfortunately, this paper does not cover trade aspects of technology spillovers which is the focus of this sub-section. Further, based on other comments the focus of this subsection is narrowed to only cross-sectoral aspects and the title of the sub-section is changed to “The cross-sectoral trade-related knowledge and technology spillovers” to empahsize the new direction. in order to underline its now narrower focus	Suyi Kim	Hongik University	Republic of Korea
35063	77	8			It is important to address the negative effects of increased transportation of goods, most notably in countries where air quality is already an issue	Taken into account. Paragraph devoted to emissions from transportation is added to sub-section 12.6.3.1	Marco Heredia-Fragoso	National Institute of Ecology and Climate Change	Mexico
43941	77	15		25	GDP loss in Russia feels misplaced in a section on carbon leakage?	Accepted. The text on Russia was shortened and re-focused towards leakage-related issues	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
25269	78	25	78	26	Delete "Diversion of finance … low-carbon transitions."	Taken into account. Section revised. Text no longer relevant	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
20685	78	25	78	29	This has also been highlighted by IAM studyies, with the 'flip-side' that other important financial flows arise. A recent inter-model comparison which looked into the supply and demand of bioenergy in mitigation scenarios of IAMs and the implied international trade of this commodity, highlighted a large increase in financial flows, primarily towards Latin America and Sub-Saharan Africa. Muratori, Matteo, et al. "Global economic consequences of deploying bioenergy with carbon capture and storage (BECCS)." Environmental Research Letters 11.9 (2016): 095004. DAIOGLOU, V., MURATORI, M., LAMERS, P., FUJIMORI, S., KITOUS, A., BAUER, N., JUNGINGER, H. M., KATO, E., KOBERLE, A., LEBLANC, F., MIMA, S., WISE, M. & VAN VUUREN, D. in review. Implications of climate change mitigation scenarios on international bioenergy trade. Climatic Change.	Rejected. Section revised and referenced text removed.	Vassilis Daioglou	Copernicus Institute of Sustainable Development	Netherlands

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
39047	78	30	78	33	Here again, CCU should be added as it is largely discussed as mitigation option in the literature as well as CCS Here some addings:. CCS is seen worldwide as a technology in the global portfolio of mitigation options that can contribute to mitigation and is taken into account in many climate scenarios based on the Integrated Assessment Models (IAM's). However, significant drawbacks exist about CCS options amongst which the risks associated to geological storage, the possibility of leakages, long-term liability issues, problems with public acceptance of onshore storage locations and limited cost-effective storage capacity in some essential regions (Styring et al., 2011, Bruhn et al., 2016, Arning et al., 2019). To date, the IAM's have failed in simulating the complexity of the different CCU options to realize net zero or negative CO2 emissions (e.g. Detz and Zwaan, 2019). Consequently, CCU technologies are unfairly considered to have limited and predominantly indirect abatement potential and are not discussed as mitigation options in the different IPCC reports. As stated in the Annex C of this first order draft, IAM's are missing important dynamics, e.g. with regard to carbon dioxide removal (Smith et al. 2016), rapid technological progress in the renewable energy sector (Creutzig et al. 2017), actor heterogeneity, and distributional impacts of climate change and climate policy. This has given rise to criticism that IAM's lack credibility in set of crucial assumptions, among which stands out the availability of carbon dioxide removal technologies (Bednar et al. 2019; Anderson and Peters 2016). This recognized failure of the IAM's to represent specific technologies should not prevent the integration of updated scientific discussions on all existing important technologies to mitigate climate change. It should also be noted that Energy System Models (EMS) are able to simulate the major CCU routes and other specific technologies and therefore a discussion on EMS and on their key results should be added in the report (e.g.Ram et al., 2019, Krey et al., 2019). The capture and conversion of CO2 into valuable products require the use of important renewable energy sources, an aspect that is often considered as a drawback to use these technologies. However, the prices of the different renewable energy options as well as an adequate evaluation of the future evolution of these prices (especially the cost of the solar energy) is crucial to assess the viability and climate mitigation potential of CCU technologies (Creutzig et al., 2017, Breyer et al., 2019, Haegel et al., 2019, Vartiainen et al., 2019, Krey et al., 2019). Even if no exhaustive quantification exists today on the mitigation potential of CCU technologies, the key role of this concept should be considered as one building block in a portfolio of mitigation measures (e.g. GCI, 2016, Grüber et al., 2018, IEAGHG, 2019b, Detz and Zwaan, 2019). CO2 utilization will contribute to curbing CO2 emissions with an estimated potential impact of gigatons equivalent CO2 emissions, similar or even superior to the impact of CCS and biofuels, but with a lower cost for society (Ampelli et al., 2015). CCU technologies have the potential to utilize up to 8 Gt of CO2 per year by 2050 (GCI, 2016, Hepburn et al., 2019), this is equivalent to approximately 15% of current global CO2 emissions (GCI, 2016). Moreover, the key role of CCU as a vector to move away from fossil fuel resources and the potential move to a CO2 circular economy should be recognized and discussed adequately in the IPCC AR6 (e.g. Bruhn et al., 2016, Daggash et al., 2018). REFERENCES:• Arning et al. 2019, Energy Policy, 125, 235–249./• Bruhn et al., 2016, Environmental Science & Policy, 60, 38–43./• Styring et al., 2011, Carbon Capture and Utilization in the Green Economy. Centre for Low Carbon Futures, York/• Smith et al. 2016, Nature Climate Change, 6, 42-50./• Detz and Zwaan, 2019, Energy Policy, 133, 110938. /• Creutzig et al. 2017, GCB, Bioenergy./• Bednar et al. 2019, Nat. Commun., 10, 1783/• Anderson and Peters, 2016, Science, 354, 182–183./• Ram et al., 2019 EWG&LUT, 2019: Global Energy System Based On 100% Renewable Energy, Energy Watch Group & LUT University./• Krey et al., 2019, Energy, 172, 1254-1267./• Vartiainen et al., 2019, Progress in Photovoltaics, Wiley, 1-15./• Haegel et al., 2019, Science, 364, 836-838/• Breyer et al., 2019, Joule, 3, 2053-2057./• Grüber et al, 2018: A low energy demand scenario for meeting the 1.5 C target and sustainable development goals without negative emission technologies', Nature Energy, 3, 6./•	Rejected. Section revised and referenced text removed.	Célia Sapart	Université Libre de Bruxelles et Co2 Value Europe	Belgium
35829	78	30	78	35	Cross-sectoral perspectives (especially across the 17 SDGs) are very important. In this context, it is worth recalling the aim of IAEA : "help ensure that nuclear energy is available to contribute to meeting the energy needs of the 21-st century in a sustainable manner". IAEA indeed plays an active part in helping the international community with the achievement of the 17 Sustainable Development Goals (SDGs), in particular, in connection with poverty, hunger, human health, clean water, affordable and clean energy, industry and innovation, and climate change, to name just a few. These are all areas in which nuclear science and technology (including isotopic techniques) have much to offer. Sources: "Atoms for Peace & Development" or "How the IAEA Will Contribute to the Sustainable Development Goals", 25 September 2015 by Nicole Jawerth and Miklos Gaspar, IAEA Office of Public Information and Communication - IAEA website: https://www.iaea.org/newscenter/news/how-iaea-will-contribute-sustainable-development-goals and "Atoms for Peace & Development", a special edition of the IAEA Bulletin on peaceful uses of nuclear technology (IAEA Bulletin, Vol. 56/1, March 2015, 40 pages) - https://www.iaea.org/sites/default/files/bull561_mar2015.pdf As far as nuclear fission and applications of ionizing radiations in emerging countries, it is worth recalling the INPRO of IAEA programme: "International Project on Innovative Nuclear Reactors and Fuel Cycles", a millennium year 2000 initiative, focusing more on assessment methodology for developing country needs. INPRO produced in the early 2000's a methodology to assess the sustainability of Innovative Nuclear energy Systems (INS) as part of the general IAEA Nuclear Energy System Assessments (NESA). In 2005, INPRO produced an assessment manual in 9 volumes: an overview volume (no 1), and eight additional volumes (available on the IAEA website) covering the areas of economics (Volume 2), infrastructure (Volume 3), waste management (Volume 4), proliferation resistance (Volume 5), physical protection (Volume 6), environment (Volume 7), safety of reactors (Volume 8), and safety of nuclear fuel cycle facilities (Volume 9). https://www.iaea.org/INPRO/inpro_methodology/index.html INPRO's membership consists of 42 Members, namely: 41 IAEA Member States and the European Commission (EC): Algeria, Argentina, Armenia, Bangladesh, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, Egypt, France, Germany, India, Indonesia, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, Republic of Korea, Malaysia, Mexico, Morocco, Netherlands, Pakistan, Poland, Romania, Russian Federation, Slovakia, South Africa, Spain, Switzerland, Thailand, Turkey, Ukraine, United States of America, Vietnam and the EC. Above list of 42 countries is interesting because it contains some emerging countries that have officially expressed to IAEA a clear interest in nuclear fission-based technologies, thus demonstrating the economic, social and environmental attractiveness of these technologies (cross-sectoral perspectives across the 17 SDGs).	Here again, CCU should be added as it is largely discussed as mitigation option in the literature as well as CCS Here some addings:. CCS is seen worldwide as a technology in the global portfolio of mitigation options that can contribute to mitigation and is taken into account in many climate scenarios based on the Integrated Assessment Models (IAM's). However, significant drawbacks exist about CCS options amongst which the risks associated to geological storage, the possibility of leakages, long-term liability issues, problems with public acceptance of onshore storage locations and limited cost-effective storage capacity in some essential regions (Styring et al., 2011, Bruhn et al., 2016, Arning et al., 2019). To date, the IAM's have failed in simulating the complexity of the different CCU options to realize net zero or negative CO2 emissions (e.g. Detz and Zwaan, 2019). Consequently, CCU technologies are unfairly considered to have limited and predominantly indirect abatement potential and are not discussed as mitigation options in the different IPCC reports. As stated in the Annex C of this first order draft, IAM's are missing important dynamics, e.g. with regard to carbon dioxide removal (Smith et al. 2016), rapid technological progress in the renewable energy sector (Creutzig et al. 2017), actor heterogeneity, and distributional impacts of climate change and climate policy. This has given rise to criticism that IAM's lack credibility in set of crucial assumptions, among which stands out the availability of carbon dioxide removal technologies (Bednar et al. 2019; Anderson and Peters 2016). This recognized failure of the IAM's to represent specific technologies should not prevent the integration of updated scientific discussions on all	Georges VAN GOETHEM	Royal Academy of Overseas Sciences of Belgium (ARSOM - KAOW)	Belgium
25273	79	7	79	18	Do not use terms such as "green activities" and "greener land-use practices"	Rejected. That is a term used commonly in the relevant literature reviewed.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
25271	79	8	79	8	Delete "beyond fossil fuel divestment"	Taken into account. Section revised and sentence removed.	Eleni Kaditi	Organization of the Petroleum Exporting Countries (OPEC)	Austria
45159	80	2	80	8	The first sentence quoting the World Bank, (& some of its susbsidiaries like IFC & IDA), carries several policy prescriptive statements such as « The approach is called Result-based Blended Finance (RBBF) and is meant to strengthen accountability through result-based verifiable performance coupled with blending of scarce public funding with private sector commercial capital to realize high impact climate-smart financing of investments across sectors. » This complementing another statement at the bottom of page 79 : « Some of the innovative alternatives to address the climate financing gap include public-private partnerships. » When looking to what may be the IFC & IDA susbsidiaries of the World Bank, one find statements such as : « A strong and engaged private sector is indispensable to ending extreme poverty and boosting shared prosperity. » Such statements do not comply with the requirement « Not policy prescriptive » 60 years ago, in the USA as well as in Europe, the first launchers & the first telecoms satellites where not built and tested by the private sector. Such endeavours may be rather CAPINT... As a result the private sector may not be able to get the necessary funding. Today, the Modern Monetary Theory, (which may be a powerful tool to fund rather CAPINT projects), is discussed in many places, and should be quoted here : central banks backed by strong & robust economies, (as it is the case for the top 10 GHG emitters), may fund swiftly mitigation & adaptation. These programs are much more critical to humankind than were launchers & satellites during the last century.	Taken into account. Section revised and the indicated prescriptive language removed	Raymond Zaharia	Le Club des Argonautes http://www.clubdesargonautes.org	France
11883	80	22	80	25	We're pleased to see 'polycentric climate governance' included here, as this is a growing and important literature. Please retain.	noted - thank you very much	Maria Malene Kvalevåg	Norwegian Environment Agency	Norway
28035	80	38	80	42	IPCC states, "Both mitigation targets laid down in the Paris Agreement – holding the increase in the global average temperature to well below 2°C and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels and to achieve a balance between anthropogenic emissions by sources and removal by sinks of GHGs in the second half of this century – are impossible to achieve without CDR (see section 12.3)." This is not correct. It is possible to get to 1.5 C by transitioning 100% of all energy worldwide to renewables, and simultaneously reducing biomass burning, halogen use and emissions, nitrous oxide emissions, and methane emissions without any BECCS or biofuels. For example, the abstract of Jacobson, M.Z., M.A. Delucchi, Z.A.F. Bauer, S.C. Goodman, W.E. Chapman, M.A. Cameron, Alphabetical: C. Bozonnat, L. Chobadi, H.A. Clonts, P. Enevoldsen, J.R. Erwin, S.N. Fobi, O.K. Goldstrom, E.M. Hennessy, J. Liu, J. Lo, C.B. Meyer, S.B. Morris, K.R. Moy, P.L. O'Neill, I. Petkov, S. Redfern, R. Schucker, M.A. Sontag, J. Wang, E. Weiner, A.S. Yachanin, 100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for 139 countries of the world, Joule, 1, 108-121, doi:10.1016/j.joule.2017.07.005, 2017 states "Transitioning should also stabilize energy prices because fuel costs are zero, reduce power disruption and increase access to energy by decentralizing power, and avoid 1.5C global warming." See also getting to 350 ppmv with zero BECCS or biofuels: http://web.stanford.edu/group/efmh/jacobson/Articles/I/CountryGraphs/CO2ChangesWithWWS.pdf. Please change working so it doesn't claim that CDR is. needed or imply that synthetic CDR works.	rejected - cited article only deals with energy sector emissions whereas related section 12.3 (based on scenario data from ch3) takes all emission sources into account, including hard to abate non-CO2 from agriculture. Furthermore, cited article does not give any global carbon budget calculation	Mark Jacobson	Stanford University	United States of America
47239	80	38	80	45	The recognition by the IPCC that holding the increase in temperature to well below 2°C is impossible to achieve without CDR, making the core governance question which CDR options should be deployed by whom, by when, at which volumes, in which ways, and with what incentives, is of decisive importance, and should be a consistent headline message of AR6.	rejected - CDR is certainly an important component of (future) climate policy, but not the most important one (in the sense that it would deserve to be part of "a consistent headline message of AR6)	Robert Tulip	Australian National University	Australia
37573	80	37	81	31	This section on CDR governance should include more discussion of the MRV challenges that CDR poses (e.g. ensuring permanence and non-leakage, providing accurate estimates of carbon flows, developing robust accounting rules to count CDR towards mitigation targets). The section should also cross-check against the CDR governance section in chapter 14 to avoid too much repetition or inconsistencies	taken into account - half sentence on permanence added (with 2 refs); better streamlining with ch14 (specifically on inconsistencies)	Michiel Schaeffer	Climate Analytics	Netherlands
16363	80	15			In Section 12.7 Cross-sectoral perspectives on governance in the context of sustainable development, consider adding a subsection that describes the global military sector and its potential to lead mitigation across manufacturing and transport sectors, as well as in agriculture based on provisioning. Including this will strengthen the section and be an aid to the reader.	rejected - beyond the scope of this chapter	Daniel Helman	College of Micronesia-FSM	Micronesia, Federated States of
43943	80				Ocean based mitigation missing from Section 12.7	taken into account - section 12.7 only deals with the CDR methods explored in 12.3., the latter covering not all ocean-based mitigation methods (as in SROCC, 5.5.1). Since there's not much of a detectable practice (incl. in governance) on marine CDR and due to space constraints, 12.7. only mentions the international governance mechanisms (LC/LP), but now refers explicitly to their treatment in ch14	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
6139	81	1	81	1	"Mclaren" should be McLaren"	accepted - thanks a lot for spotting this	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
15159	81	4	81	5	"conventional mitigation" is not a scientific term, Please use instead the term "emission reduction"	rejected - it is indeed an established term in the CDR literature and has been in use by dozens of papers since at least 2006. Recent one include Gasser et al. 2018, Geden/Peters/Scott 2019, McLAren/Markusson 2020, Pozo et al. 2020, Waller et al. 2020. The terminology is even used in AR5 WG3	Dana Ruddigkeit	German Environment Agency	Germany
47241	81	6	81	12	The call for political commitment to accelerate CDR through formal integration into climate policy frameworks should be integrated into the overall AR6 messaging. As I have noted above, some text in the opening chapter does not fully align with this clear statement. The huge challenges to be tackled in research, development and demonstration in order to advance innovation and bring down costs can so easily be undermined by political opposition, given the fragile and confused public understanding of these essential themes.	rejected - CDR is certainly an important component of (future) climate policy, but not the most important one (in the sense that it would deserve to be part of "a consistent headline message of AR6)	Robert Tulip	Australian National University	Australia
6133	81	17	81	18	The text about the London Convention and the London Protocol is incorrect in several respects. They are standalone separate international treaties. The London Protocol is not a conventional protocol to an international treaty and it will eventualy replace the London Convention. They are not IMO treaties. However, the IMO hosts the Secretariat for the London Convention and the London Protocol. Also, only the London Protocol has legally binding provisions to regulate ocean iron fertilization etc . I suggest revising the text to "...far only been developed in the context of the London Protocol (LP), which explicitly regulates...".	accepted - text revised accordingly	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
9469	81	17	81	19	The text about the London Convention and the London Protocol is incorrect in several respects. They are standalone separate international treaties. The London Protocol is not a conventional protocol to an international treaty and it will eventualy replace the London Convention. They are not IMO treaties. However, the IMO hosts the Secretariat for the London Convention and the London Protocol. Also, only the London Protocol has legally binding provisions to regulate ocean iron fertilization etc . I suggest revising the text to "...far only been developed in the context of the London Protocol (LP), which explicitly regulates...".	accepted - text revised accordingly	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
10685	81	20	81	31	How does the issue of governing CDR is linked to already existing offsetting schemes? In particular: (1) Would Art. 6 be an entry point for CDR governance at multilateral level? (2) Should national/ regional… removal targets always adress 'domestic' removals or are imported negative emissions equally credible	rejected - no changes to the text since answering the questions posed here would either be speculatative (Art 6 PA negotiations not concluded yet) or policy prescriptive	Felix Schenuit	University Hamburg	Germany
6131	81	27	81	27	"Mclaren" should be McLaren"	accepted - thanks a lot for spotting this	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
34305	81	28	81	29	Maybe suggest "credible" by a more objectif term such as "with emissions objectives sanctioned by a credible legal system" ?	taken into account - text revised, but with different wording ('legally binding'	Antoine BONDUELLE	Climate Action Network France	France
32691	81	34	82	5	I think it would be helpful to discuss integration and harmonziation of policies across departments of government will be necessary. For instance, environmental agencies aim to reduce impacts, but ag agencies often support increasing high-input production. These goals are often directly antagonistic with each other, and need to be harmonized so that there is a single clear direction for the government.	accepted - text will be revised accordingly, this issue is now highlighted in the case study on the Finnish Food Strategy which is connected to this section	Michael Clark	University of Oxford	United Kingdom (of Great Britain and Northern Ireland)
18791	82	5	82	45	In this section the authors should emphasize the problem of getting a sufficiently broad international agreement on sufficientlu high carbon prices.	rejected - this is a very fundamental and broad statement that would apply to all sectors dealt with in chapters 6-12, 12.7/12.7.3 focuses on issues specific to the governance of land-based mitigation, CDR and the food system	thomas Sterner	Univ of Gothenburg	Sweden
45103	82	6	82	31	It may be clarified whether referral can be given to urban planning as a land-based mitigation measures as also discussed in the Special Report on Climate Change and Land based on pages 63 and 706 as well as others.	taken into account - section 12.7.3. now refers explicitly to spatial planning several times (with reference to SRCCL), incl. housing, but not specifically on urban areas	Siir Kilkis	The Scientific and Technological Research Council of Turkey	Turkey
34303	82	13	82	31	Interesting principles, but what concrete choices can be made? Examples of successful countries?	taken into account - section 12.7.3 has now been expanded, going much more into details, but without giving country details (there's only one case study in 12.7, but not on land-based mitigation)	Antoine BONDUELLE	Climate Action Network France	France
5417	82	21	82	27	sustainable management of lands maybe mentioned : sustainable management of lands, water, forests, biodiversity, that is an initiative of UNCCD, and it is included in the national and local soil policies	taken into account - Land Degradation (Neutrality) has been moved entirely to section 12.5.2, "sustainable land management" is explicitly mentioned there	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
34307	83	8	83	8	the difficult "comminution" could be replaced by "fractioned" or "reduced in powder" ?	Accepted. But "comminution" replaced with "grinding"	Antoine BONDUELLE	Climate Action Network France	France
47243	83	16	83	23	This FAQ needs to address the conceptual distinction between emission reduction and carbon removals. It is wrong to say that carbon removal contributes to decarbonisation.	Rejected. There is no statement in the FAQs that carbon removal contributes to decarbonisation	Robert Tulip	Australian National University	Australia
34309	83	28	83	29	"food that satisfies dieatry requirements" maybe "are disigned to" or "should satisfy"?	Accepted. Sentence clarified.	Antoine BONDUELLE	Climate Action Network France	France
39049	84	2	84	2	CCU should be discussed in this section in taking all the comments above into account.	Rejected. The figure to which this material refers is meant to be representative only and so cannot include all mitigation actions across all sectors	Célia Sapart	Université Libre de Bruxelles et Co2 Value Europe	Belgium
5419	84		84		SM 12.A Table 1: Fuel changes - Transport: maybe included the electric vehicles	Rejected. After much consideration it was decided to put this in the row on renewable energy (for EVs coupled with renewables). Acknowledging that EVs could equally well have gone under fuel changes.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
5421	84		84		SM 12.A Table 1: Industry - and other renewable energies as solar (photovoltaic), of wind, hydroelectrics	Rejected. This is captured under renewable energy.	CRISTOBAL FELIX DIAZ MOREJON	Environmental Directorate/Ministry of Science, Technology and the Environment	Cuba
46755	84	1	87	2	Please consider the various categories of co-benefits presented in the review by: Mikael Karlsson, Eva Alfredsson & Nils Westling (2020) Climate policy co-benefits: a review, Climate Policy, DOI: 10.1080/14693062.2020.1724070.	Accepted. This paper is now referred to in this figure	Mikael Karlsson	KTH Royal Institute of Technology	Sweden
43945	84				missing discussion of synthetic fuels or CO2 recycling under topic fuel changes.	Accepted. These have been added.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
9959	85	2	87	1	II Energy Security: Another reference: - Forouli, A., Doukas, H., Nikas, A., Sampedro, J., & Van de Ven, D. J. (2019). Identifying optimal technological portfolios for European power generation towards climate change mitigation: A robust portfolio analysis approach. Utilities Policy, 57, 33-42. VIII Energy Access: A reference for the first point: - Van de Ven, D. J., Sampedro, J., Johnson, F. X., Bailis, R., Forouli, A., Nikas, A., ... & Doukas, H. (2019). Integrated policy assessment and optimisation over multiple sustainable development goals in Eastern Africa. Environmental Research Letters, 14(9), 094001. XI Health: Another reference for the first point: - Van de Ven, D. J., Sampedro, J., Johnson, F. X., Bailis, R., Forouli, A., Nikas, A., ... & Doukas, H. (2019). Integrated policy assessment and optimisation over multiple sustainable development goals in Eastern Africa. Environmental Research Letters, 14(9), 094001.	Accepted. References added here or in the main body of the text.	Haris Doukas	School of Electrical and Computer Engineering, National Technical University of Athens	Greece
979	88	1	88	1	Are you aware of this paper: Dornburg, V., van Vuuren, D.P., Van de Ven, G., Langeveld, H., Meeusen, M., Banse, M., Van Oorschot, M., Ros, J., Van den Born, G.J., Aiking, H., Londo, M., Mozaffarian, H., Verwey, P., Lysen, E. & Faaij, A. (2010). Bioenergy revisited: Key factors in global potentials of bioenergy. Energy & Environmental Science 3, 258-267.	Noted. The publication is known but may not be included among cited publications in AR6 since being published 10 years ago.	Harry Aiking	Institute for Environmental Studies, Vrije Universiteit	Netherlands
3263	88	1	91	45	The outline of the Cross Chapter Appendix on Biomass is much appreciated and it is expected that the main findings of this appendix will be also reflected in the executive summary of the second draft.	Noted. This appendix is not included in the SOD. The content is instead covered in chapters 3,4,6, 7, 12	Klaus Radunsky	retired from Umweltbundesamt	Austria
36503	88	1	91	45	It is better to include analysis of barriers for biomass energy, particularly biomass feed stock supply. IRENA's report "Advanced Biofuels: What holds them back?" summarizes barrier analysis of various report and analysis including IRENA's survey (please see Table 1). It seems that demand for biomass feed stock supply from various sectors such as gland transportation, aviation, maritime ad plastic is bigger than its supply, particularly when other global constraints, forest CO2 containments, food supply, paper and pulp supply, and bio diversity, are considered.	Noted. This appendix is not included in the SOD. Chapter 6, which covers energy, have been notified about this comment	Takashi Hongo	Mitsui & Co. Global Strategic Studies Institute	Japan
32589	89	32	89	36	This section should take note of an approach to carbon accounting of biomass that avoids some of the pitfalls of zero pollution assumptions (see next comment) by listing net emissions (direct emissions minus alternative fate emissions) as a percent of direct emissions (called Net Emissions Impact (NEI)). In other words, NEI calculates the percent of direct biomass CO2 emissions that contribute additional warming effects over a 50-year period. Since direct emissions from biomass can be higher than coal, one study's findings of 20-95% NEI from biomass burning shows the significant carbon impact of bioenergy, even with replanting and utilizing leftover biomass waste and even over 50 years. Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, ENVIRON. RES. LETT. 13 (21 February 2018).	Rejected - outside the scope of the chapter. The appendix will not be included in the SOD and comprehensive assessment of methodologies for calculating carbon balances is outside the scope of the chapter	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America

Comment ID	From Page	From Line	To Page	To Line	Comment	Response	Reviewer Name	Reviewer Affiliation	Reviewer Country
32591	89	32	89	36	BECCS is not carbon negative in the near-term because bioenergy leaves a carbon deficit for several decades to a century—far longer than the window of a decade or two available for slowing feedbacks and avoiding crashing through the 1.5C guardrail. See, e.g., IPCC AR5 WG III (2014) 11.13.4 GHG emission estimates of bioenergy production systems ("The combustion of biomass generates gross GHG emissions roughly equivalent to the combustion of fossil fuels. If bioenergy production is to generate a net reduction in emissions, it must do so by offsetting those emissions through increased net carbon uptake of biota and soils…Hence, the total climate forcing of bioenergy depends on feedstock, site-specific climate and ecosystems, management conditions, production pathways, end use, and on the interdependencies with energy and land markets…For example, in the specific case of existing forests that may continue to grow if not used for bioenergy, some studies employing counterfactual baselines show that forest bioenergy systems can temporarily have higher cumulative CO2 emissions than a fossil reference system (for a time period ranging from a few decades up to several centuries"). Subsequent analysis since AR5 further strengthens the case that bioenergy is not carbon neutral in the critical next decade or two. Danielle Venton, Core Concept: Can bioenergy with carbon capture and storage make an impact?, PNAS (2016); Mary S. Booth, Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, Environ. Res. Lett. 13 (21 February 2018); Sterman J. D., et al. (2018) Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy, Envtl. Research Letters 13(015007):1–10, 1 ("We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions. Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO2 relative to coal. The payback time for this carbon debt ranges from 44–104 years after clear-cut, depending on forest type—assuming the land remains forest. Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO2 impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, projected growth in wood harvest for bioenergy would increase atmospheric CO2 for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue. Instead, explicit dynamic models should be used to assess the climate impacts of biofuels."). In addition, the CCS part of BECCS has not been demonstrated at scale or at acceptable cost, nor has it won over the support it would need from the public. See Gregory Nemet et al., Negative emissions—Part 3: Innovation and upscaling, Environ. Res. Lett. (May 2018); European Academies Science Advisory Council, Negative emission technologies: What role in meeting Paris Agreement targets? (Feb 2018) ("CCS plans in Europe have been shelved so that whatever experience is being gained globally is outside Europe. The loss in momentum in implementing CCS technologies not only has serious implications for mitigation pathways, but also one of the most commonly cited NETs [negative emissions technologies] (BECCS) assumes the availability of cost effective 'off-the shelf' CCS, while another (direct air capture) relies on the widespread availability of CO2 storage. At present, economic incentives for deploying CCS are inadequate (whether through the very low carbon price or targeted government support), while those for NET development are lacking."); Andersen & Peters, The Trouble with Negative Emissions, Science (Oct 2016). One study estimates that current rate of increase in CCS is 100 times lower than needed to meet the 2C target. See Haszeldine et al. (April 2018), Negative emissions technologies and carbon capture and storage to achieve the Paris Agreement commitments, Philosophical Transactions of the Royal Society. Thus, BECCS should not be presented as a viable CDR strategy.	Taken into account. This appendix will not be included in the SOD. Bioenergy and BECCS, and aspects related to land use and carbon balances, are covered in Ch7 that comprehensively addresses land use and carbon balances. Ch7 also addresses the fact that studies come to different conclusions about the mitigation contribution of bioenergy and BECCS due to that different methodology approaches are used in analyses	Durwood Zaelke	Institute for Governance & Sustainable Development	United States of America
28921	90	1	90	1	what is "set-aside"? And the "net reduction atmospheric CO2" is need to be rewritten.	Noted. The figure has been deleted. FYI: "set-aside" in this context refers to when an area is taken out of productive use and reserved for other purposes such as protection of natural ecosystems	Marissa Malahayati	National Institute for Environmental Studies	Japan
37575	91	2	91	5	Important uncertainty regarding biofuels: recent studies show that when the entire environmental footprint is taken into account (including land and water footprints, not only carbon footprint) the performance of biofuels is often much lower than electrification (both from electricity via biomass or via nonbiomass renewables). This represents a major uncertainty in the long-term sustainability of biofuels for decarobnization and should be mentioned as an uncertainty somewhere in the chapter. See, e.g., The Environmental Footprint of Transport by Car Using Renewable Energy. Holmatov et al. (2020)	Taken into account. Water and land aspects of bioenergy are covered in Ch12. Ch7 extensively covers AFOLU activities including carbon balances associated with biomass production. Relative performanmce of EVs and biofuelled vehicles is covered in Ch10.	Michiel Schaeffer	Climate Analytics	Netherlands
5955	91				Overall the 91 pages contain a lot of text that is not specifically on cross-cutting issues and often duplicates what is already presented in the sector and other chapters. Heavy editing to remove text that does not relate specifically to cross-cutting issues would help cut the chapter length significantly.	Noted. The revised chapter places more emphasis on cross-cutting issues, while not leaving out any of the topics that has been assigned to the chapter in the scoping of the WGIII report. We find that some overlap with sectoral chapters is nesessary and at the same time hope that we now have found a reasonable degree of overlap	Ralph Sims	Massey University	New Zealand
6135	115	38	115	38	"Mclaren should be McLaren"	Accepted, change made.	Christopher Vivian	Retired from Cefas	United Kingdom (of Great Britain and Northern Ireland)
35301	131	5	131	6	i.e. usage of (First to third), instead of (i) to (iii)	Editorial	Reyneir Tasico	UpScale PH/ Psychological Association of the Philippines (Member)	Philippines

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8577	Chapter 12				ETS and Carbon tax is a critical cross-sectoral and cross-country outcome of differentiated climate policy. The emission trading system is subject to emission trading in various sectors such as power generation, industry, buildings, and waste. Add description for EU-ETS, Korea-ETS, China-ETS	Rejected. Detailed assessment of policy regimes and insturments such as EU-ETS, Korea-ETS, and China-ETS is within the domain of chapter 13 on policy insturmnets. The cross-sectoral implications of policy instruments such as carbon tax and emissions trading is explained in section 12.6.2 and the cross-sectoral implications of differentiated policies including regimes involving carbon pricing are reflected in section 12.6.3.	Suyi Kim	Hongik University	Republic of Korea
949					Recommendation Note that using P for ocean fertilisation will remove P, a fossil nutrient, from the food production system. Reason P is a fossil based nutrient that is ciritical for agricultural production so increasing demand for P as part of ocean fertilisation programmes will reduce availabilty for food production. P needs ot be recovred from existing waste streams and should be a key focus of circular economy approach.	Accepted. It has been added in section 12.3 that long term availability of P reserves/resources needs to be considered	Aaron Simmons	NSW Department of Primary Industries	Australia
951					Recommendation Include sub-soil amelioration of sodic soils as a climate change mitigation strategy Reason Sub-soil amelioration of sodic soils with organic amendments (e.g. poultry manure) has the potential to significantly increase crop yields (Sale et al., 2019). Intensification of agricultural systems has provided climate change mitigation in the past (Burney et al., 2010) and is a key strategy for reducing the climate change impacts associated with increasing food production to meet the demands of an increasing global population (Burney et al, 2010; Tilman et al., 2011). Sub-soil amelioration has the benefit of intensifying crop production whilst avoiding the impacts of other methods of intensification (e.g. eutrophication associated with increased synthetic fertiliser applications). Sub-soil amelioration is an emerging area of interest but the significant technical potential of applying this strategy across the ~ 200 Mha of sodic soils around the world indicates that is it worthy of inclusion in the report. Burney, J.A., Davis, S.J., Lobell, D.B., 2010. Greenhouse gas mitigation by agricultural intensification. Proceedings of the national Academy of Sciences 107, 12052-12057. Sale, P.W., Gill, J.S., Peries, R.R., Tang, C., 2019. Crop responses to subsoil manuring. I. Results in south-western Victoria from 2009 to 2012. Crop and Pasture Science 70, 44-54. Tilman, D., Balzer, C., Hill, J., Befort, B.L., 2011. Global food demand and the sustainable intensification of agriculture. Proceedings of the National Academy of Sciences 108, 20260-20264.	Taken into account. The recommendation will be shared with chapter 7 since the recommendation is specifically related to emissions mitgation strategies for agriculture .	Aaron Simmons	NSW Department of Primary Industries	Australia
1671					Figure 12.9 is included twice	editorials fixed.	Jenkins Rhosanna	University of East Anglia	United Kingdom (of Great Britain and Northern Ireland)
6019					My top-level concern with this chapter is that it is quite heavily reliant on negative emissions technologies. It would seem to me that this chapter warrants inclusion and discussion of Low-Energy Demand scenarios, such as by Grubler et al: https://www.nature.com/articles/s41560-018-0172-6 LED scenarios are capable of achieving rapid emissions reductions from industry by scaling down material throughput, without relying on NETs. Relevant literature is also reviewed in this 2019 article: https://www.tandfonline.com/doi/abs/10.1080/13563467.2019.1598964	Rejected. It was specified in approved scope outline for WGIII contribution to AR6 that Ch12 should cover CDR options not covered in other chapters. This is what has been done. We do not agree that Ch12 is heavilly reliant on NETs. CDR is covered in one out of 7 sections. Low energy demand scenarios can indeed be less reliant on CDR. And/or less reliant on renewable energy supply and/or mitigation in the AFOLU sector. Ch3 covers mitigation pathways compatible with long-term goals, including implications of different levels of energy demand	Jason Hickel	Goldsmiths, University of London	United Kingdom (of Great Britain and Northern Ireland)

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9423					ok chapter 12	Noted	ANNA LAURA PISELLO	DEPARTMENT OF ENGINEERING - UNIVERSITY OF PERUGIA, ITALY	Italy
25535					Please take care not to use value-judgement terms such as 'important', 'significant' and also prescriptive terms such as 'need' and must'. Some readers will interpret these statements as policy prescriptive.	Accepted. The revised draft tries to avoid policy prescriptive language and value judgement	Sarah Connors	IPCC WGI TSU	France
25569					As a reader who isnt familiar with all the topics being discussed in your chapter, it might help many Exectutive Summaries to include subheadings to cluster the statements by topic or overarching chapter themes.	Editorials are addressed.	Sarah Connors	IPCC WGI TSU	France
28815					The coverage of the many potential CDR methods is rather thin. Of those that are discussed, there is a lack of information regarding their governance, but also their current technological preparedness, costs, removals potential, risks and impacts, co-benefits, trade-offs and spill-over effects.	Rejected. There are space limitations which will not allow the discussion of CDR to go beyond the current level.	Paul Rouse	Carnegie Climate Governance Initiative	United Kingdom (of Great Britain and Northern Ireland)
34251					This chapter is extremely useful and relevant to long term action by governments. But its introductions are not clear beyond the terms of reference as a patchwork. Maybe a few question marks starting the introduction would illustrate its aim better, such as: "What can be done beyond urgent action as described in the previous chapters? What choices are available to develop negative emissions ?..."	Taken into account. The introduction is undergoing a complete overhaul that is taking onboard this comment.	Antoine BONDUELLE	Climate Action Network France	France
39717					This chapter reads very well, and captures most of the critical points raised in the previous comments.	Noted.	Uwe Fritsche	IINAS	Germany
43939					A large part of this chapter is dealing with the terrestrial food sector and one wonders why the marine (both fishing and aquaculture) has been left out. Authors should also note that the information in this chapter should briefly summarize and then build on SRCCL and update it.	Taken into account. Revisions have taken on board this comment paraticularly with respect to reference to SRCCL and reflection of marine ecosystem issues in relation to mitigation potentials based on availability and relevance of the literature.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
43951					Coordination with WGII chapters such as 2, 5, regional chapters as well as development of a Cross Working Group Box on Food Systems should be investigated.	Taken into account. Coordination with WGII resulted in a cross working group box titled "Mitigation and adaptation via the bioeconomy". It is placed in Ch5 in WGII SOD and in Ch12 in WGIII SOD.	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
43961					Coordination with WGII chapters 2,3,5 as well as development of a Cross Working Group Box on Biodiversity and ecosystem services should be investigated.	Taken into account. Coordination with WGII resulted in a cross-chapter box titled "Nature-Based Solutions for climate change mitigation and adaptation". It is placed in Ch2 in WGII SOD. Several WGIII authors contribute to this box	Hans Poertner and Elvira Poloczanska	Alfred-Wegener-Institut	Germany
46295					The options of geoengineering and BECCS discussed by the IPCC are illegal with regard to Article 2 Paris Agreement and human rights. See https://www.mdpi.com/2071-1050/10/8/2812/htm und http://www.sustainability-justice-climate.eu/files/texts/Sustainability-Springer.pdf and Ekardt et al. 2020, submitted to Global Sustainability (see attachment)	Rejected. This is a wide-ranging claim and in this case, we would feel more comfortable to see the published and peer-reviewed version of the article. A search in the Global Sustainability journal 19 Dec 2020 indicate that the manuscript is still in review, as no published article was listed. Further, we note that the Panel at the 46th Session of the IPCC, that adopted the chapter outline for the WGIII contribution to AR6, included CDR in the scope for Ch12.	Felix Ekardt	Research Unit Sustainability and Climate Policy	Germany
48069					What is new regarding ocean-based carbon dioxide removal compared to SROCC? Please also consider the international framework (London protocol) regarding marine based geoengineering interventions. I am really surprised by the numbers provided for ocean-based interventions (up to 100 GtCO2/year, really? in a warmer climate?). Coordination with WGI chapter on ocean carbon cycle (chapter 5) seems very relevant here.	Taken into account. The SROCC assessment of Ocean based CDR options are updated based on the available literature. The international governace of CDR options including ocean-based is discussed in chapter 14 and so not included in chapter to avoid repetition.	Valérie Masson-Delmotte	CEA, IPSL/LSCE	France
48071					ES : I am surprised by the emphasis on red meat and not on dairies which also have a high carbon footprint	Taken into account. ES will be revised for the SOD taking on board your comment	Valérie Masson-Delmotte	CEA, IPSL/LSCE	France
48073					ES statement on the potential biomass productivity / availability for multiple uses in changing climate could be expanded depending on levels of warming (SR15, SRCCL and also AR6 WGI) in close coordination with WGI (biogeophysical limitations of land based options with further warming).	Noted. Coordination on land use and biomass is currently running with Chapter 7 and WG1.	Valérie Masson-Delmotte	CEA, IPSL/LSCE	France

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48075					General comment on chapter 12 = where are options in the management sector addressed? I would expect to see them quite prominently here, relying on management science literature.	Taken into account. Management options that are cross-sectoral in nature such as those related to land use, food sytems, circularity, etc are addressed in ch 12 based on the available literature, but management options specific to given sectors are addressed in other chapters such as management options related to demand and consumption behavior are dealt with in chapter 5.	Valérie Masson-Delmotte	CEA, IPSL/LSCE	France