



Carnegie Climate Governance Initiative

An initiative of **CARNEGIE COUNCIL** for Ethics in International Affairs

TECHNICAL BRIEF Considering climate-altering technologies in the IPCC AR6

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The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR6), currently in preparation, will play a key role in the formation of future climate change policy. This includes the governance of potential climate-altering technologies, such as Carbon Dioxide Removal (CDR) and Solar Radiation Modification (SRM).

This brief aims to:

1. Highlight opportunities to publish papers for consideration in AR6, before the June 2020 deadline for literature review, which can contribute to the governance of these technologies, and;
2. Brief policymakers and their advisers on the knowledge of these technologies that is likely to emerge in international policy discussions when AR6 is published in 2021/22.

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Summary

As the most authoritative intergovernmental assessment of the latest science on climate change, the forthcoming Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR6) will play a crucial role informing policy makers about the state of the climate and options to address it as they prepare for and undertake the first Global Stocktake on the implementation of the Paris Agreement in 2023.

The recent IPCC Special Report on Global Warming of 1.5°C dedicated considerable space to assessing global knowledge and understanding of climate-altering technologies including Carbon Dioxide Removal (CDR) and Solar Radiation Modification (SRM), and the important role the AR6 has to play in assessing these technologies and their governance was acknowledged during recent intergovernmental discussions in the fourth United Nations Environmental Assembly (UNEA-4).



To catalyse efforts to address knowledge gaps and strengthen the available literature around climate-altering technologies and their governance in the AR6, this brief identifies where CDR and SRM is being planned to be covered in the Assessment and where opportunities for further contributions exist. It also serves to highlight to policymakers the nature and extent of knowledge that AR6 will contribute to forthcoming international policy discussion when it is published in 2021/22.

The published outlines for the contribution of each of the three IPCC Working Groups of the Assessment include direct and indirect reference to CDR and SRM and a review of the chapter outlines identifies various areas where knowledge of CDR, SRM and its governance could be relevant.

The brief concludes that in light of the many uncertainties and knowledge gaps that exist around CDR, SRM and their governance, the coming months before the literature review cut off for the AR6 presents an important window of opportunity for researchers to address these knowledge gaps.

Introduction

The Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) provide the most authoritative and up to date intergovernmental agreement of the scientific understanding on climate change as well as options for adaptation and mitigation and provide key information for the international climate change negotiations under the UN Framework Convention on Climate Change (UNFCCC). The forthcoming Sixth Assessment Report (AR6) is due to be published in 2021/22 and will be ready for the first UNFCCC global stocktake on climate action under the Paris Agreement in 2023.

Historically, climate-altering technologies including Carbon Dioxide Removal (CDR) and Solar Radiation Modification (SRM) have featured in IPCC Assessment Reports and Special Reports (e.g. IPCC, 2018) and how these climate-altering technologies are covered in the forthcoming AR6 assessment could have important implications for international deliberation around their governance.

Recent intergovernmental discussions have acknowledged the importance of the IPCC in providing an assessment of global knowledge and understanding around these climate-altering technologies. For example, during the recent Fourth United Nations Environment Assembly (UNEA-4) in March 2019, governments proposed a global assessment to be undertaken by the UN Environment Programme (UNEP) of these technologies and their governance, which was subsequently withdrawn due to lack of consensus. Reports suggest that a key argument against the proposal was that such an assessment is already planned to be undertaken by the IPCC AR6 (Scientific American, 2019).

This Brief therefore aims to provide an ex ante summary of how AR6 is expected to cover content relating to these climate-altering technologies. It is based on a review of published documents linked to the development of the AR6 report including: the Panel Chair's vision paper (IPCC 2017a) that informed the May 2017 workshop to discuss the draft outline (including the breakout group reports); the workshop report (IPCC 2017b); and the three outlines approved by the Panel at its 46th Session in September 2017 (IPCC 2017c,d,e). It is provided to stimulate discussion among research and policy communities during the preparation of literature for consideration in the AR6 process.

Presented in two sections, Section I identifies where SRM and CDR have been specified as required contributions in the AR6 report outlines, and Section II identifies topics that are directly relevant to CDR/SRM.

What are CDR and SRM?

Carbon Dioxide Removal (CDR) and Solar Radiation Modification (SRM) are climate-altering technologies, referred to in some of the research literature as 'geoengineering' (IPCC, 2018). They broadly refer to two main approaches that aim to either reduce atmospheric concentrations of Carbon Dioxide (CO₂) and other greenhouse gases (CDR); or reduce global heating by reflecting more solar radiation into space or by allowing more heat to escape the earth's atmosphere (SRM).

Carbon Dioxide Removal (CDR)

Carbon Dioxide Removal refers to processes that remove CO₂ from the atmosphere by either increasing biological sinks of CO₂ or using chemical processes to directly bind CO₂ and is classified by the IPCC as a special type of mitigation (IPCC, 2018). The literature includes a host of potential techniques including (but not limited to):

- afforestation and reforestation;
- biochar;
- building with biomass;
- crop residue oceanic sequestration;
- direct air capture and carbon storage;
- enhanced terrestrial weathering;
- enhancing ocean alkalinity;
- macroalgal cultivation for sequestration;
- methane capture & processing;
- mineralisation of injected CO₂;
- mineral carbonation;
- ocean carbon capture & storage;
- ocean fertilization;
- ocean upwelling & down welling;
- placing liquid CO₂ in the mid/deep oceans, on the seabed & in sediments;
- soil carbon sequestration;
- wetland, peatland and coastal habitat restoration.

Solar Radiation Modification (SRM)

SRM refers to the intentional modification of the Earth's shortwave radiative budget with the aim of reducing warming, and according to the IPCC does not fall within the definitions of mitigation and adaptation (IPCC, 2018). In many cases, the term SRM has become synonymous with the technique known as Stratospheric Aerosol Injection (SAI) which is most well known in the research literature. However, the research literature also refers to a range of other potential techniques, including (but not limited to):

- enhancing surface albedo in human settlements, deserts, grassland and crops;
- floating silica spheres;
- growing sea ice;
- marine cloud brightening;
- microbubbles;
- promoting bright calcifying phytoplankton blooms;
- reflective foams;
- space-based methods.

Section I:

Where AR6 is expected to consider CDR and SRM

There appears to be a clear intention to include SRM and CDR in AR6. Not only was it expressly encouraged by the Chair in his briefing material and during the development workshops, but 'geoengineering' is explicitly referenced in the report framework documentation.

It is important to note that SRM and CDR do not fit readily into the IPCC Working Group structure. However, it appears that all Working Groups (WG-I: Physical science basis; WG-II Impacts, adaptation and vulnerability; and, WG-III Mitigation of climate change) are open to the inclusion of SRM and CDR literature and that AR6 will provide a broad assessment of SRM and CDR. This assessment will be both in terms of how they may mitigate the impacts of climate change and their wider effects, including on ocean acidification, ecosystems and human societies.

The inclusion of 'geoengineering' in the development phase

It is worth noting the extent to which 'geoengineering' was included in the debates that led to the final AR6 outlines. SRM and CDR were both discussed at length amongst breakout groups and in plenary at the development workshop, indicating not only a broad understanding of the need to include the techniques, but also an increasing willingness amongst the community to discuss them. The Working Group's recommendations for inclusion, arising out of the outline development process were as follows.

- WG-I identified SRM and CDR related topics as cross-cutting, referencing the need to include:
 - GHG mitigation;
 - knowledge emerging from the Geoengineering Model Intercomparison Project (GeoMIP); and,
 - issues related to land-based policies such as afforestation.
- WG-II recommended 'geoengineering' be included in the cross-cutting discussion of that report.
- WG-III developed the following suggestions:
 - the inclusion of CDR in sections on 'Land Use';
 - use a common set of terms for all forms and types of 'geoengineering' across all WGs;
 - agreement and definitional resolution as to whether CDR is a suitable umbrella term for all options aimed at removing greenhouse gases from the atmosphere;
 - SRM impacts should be treated as climate impacts; and,
 - governance, social acceptability and distributional effects of 'geoengineering' must be included.

WG-III also suggested the inclusion of some key questions about 'geoengineering' including if techniques work or not, monitoring, what associated risks or unintended consequences exist, and what will its governance look like.

In the light of the workshop and other discussions the AR6 outline was presented to and adopted by IPCC at its 46th session (IPCC 2017f). An analysis of where SRM and or CDR have been expressly included within the report outlines follows.

WG-I contribution to AR6

WG-I aims to assess the physical scientific basis of the climate system and climate change. SRM/CDR is explicitly referenced in two chapters as follows.

- **Chapter 4** will include climate responses to both greenhouse gas removal scenarios and SRM scenarios; and,

- **Chapter 5** will address the biogeochemical implications of land and coastal management mitigation options and greenhouse gas removal and the biogeochemical implications of SRM scenarios.

WG-II contribution to AR6

WG-II will assess the impacts of climate change, from a world-wide to a regional view of ecosystems and biodiversity, and of humans. As might be expected, given the Group's focus on impacts, the WG-II's report framework does not include any explicit reference to CDR/SRM. However, the inclusion of reference to technologies in the Concepts Chapter leaves the door open to consider the inclusion of CDR/SRM (see Section II).

WG-III contribution to AR6

WG-III focusses on climate change mitigation, assessing methods for reducing and removing greenhouse gas emissions from the atmosphere. It takes both a near-term and a long-term perspective that helps identify how high-level climate policy goals might be met. It addresses all aspects of mitigation including technical feasibility, cost and the enabling environments that would allow measures to be taken up. Enabling environments cover policy instruments, governance options and social acceptability.

Whilst CDR/SRM are not discussed explicitly in much of the structure, they are implied throughout **Chapters 6 to 11**. For example, within **Chapter 7** (Agriculture, Forestry, and Other Land Uses) it is noted that emerging technologies including anthropogenic removals in agriculture, forestry, other land uses, and non-managed terrestrial ecosystems, and their implications for mitigation pathways will be included. **Chapter 11** (Industry) will include mitigation technologies and efficient system options, including carbon capture and utilization.

Importantly, **Chapter 12** (Cross Sectoral Perspectives) will include aspects of CDR techniques not covered in **Chapters 6 to 11** (land based, ocean based and direct air capture) addressing: status; costs; potentials; governance; risks and impacts; co-benefits; trade-offs and spill-over effects; and, their role within mitigation pathways. The chapter will further include reference to impacts, risks and opportunities from large-scale land-based mitigation (which it is expected will include CDR) addressing water, land, food security; use of shared resources; management and governance.

Chapter 14, which covers international cooperation, will address the ethics and governance of SRM and associated risks. It is noteworthy that there is no reference to ethics and governance of CDR.

Section II:

AR6 topics where CDR and SRM could be relevant

Throughout the various frameworks, reference is made to inclusions that are either directly or indirectly related to CDR/SRM. This section explores these, picking out key elements from each report and noting why these are particularly relevant to CDR/SRM. It may be the case that CDR/SRM will not be included in these elements. However, the opportunity for their inclusion is offered for information.

WG-I contribution to AR6

Chapter 5 references exploring the effects of abrupt change and irreversibility of any such changes. This bears some relationship to the issues around the concept of SRM termination shock (e.g. Parker and Irvine 2018).

WG-II contribution to AR6

Chapter 1, the ‘point of departure and key concepts’ chapter, contains several issues that CDR/SRM could be linked to and research and other evidence about it shown to provide useful insights to the authors, including:

- work on enabling conditions for effective adaptation including governance, institutions, and economic aspects (i.e., evidence re: good governance of CDR and SRM and marketing the technologies); and,
- climate change responses and their interactions with sustainable development, including adaptation with mitigation co-benefits and trade-offs.

Chapter 1, covering terrestrial and freshwater ecosystems and their services, will address planned adaptation and mitigation for the management of risk within sustainable development and relevant policy contexts (e.g. the Sustainable Development Goals - SDGs), informed by cultural, ethical, identity, economic and behavioural dimensions. NBS based CDR and its potential implications for SDG implementation could be relevant here.

Chapter 2, which covers water, includes work on adaptation responses to water security risks with co-benefits for sustainable development, including consideration of impacts of adaptation and mitigation responses. CDR interventions, particularly afforestation, have the capacity to affect water security (including cross boundary security) and could be relevant here.

Chapter 5 includes food fibre and other ecosystems products. Competition for the use of land and ocean, including conflicts with indigenous rights to land and water bodies, and other trade-offs will be addressed in this chapter in the context of adaptation and mitigation responses. Various CDR techniques, and (to a lesser degree) techniques such as Marine Cloud Brightening (MCB) could have implications and represent governance challenges here, and could therefore be relevant.

Chapter 7 which covers health, wellbeing and the changing structure of communities, will explore adaptation options, limits to adaptation, and their social, environmental and economic implications in the context of sustainable development. Potential direct or indirect impacts of CDR or SRM techniques could be relevant for consideration here.

Chapters 9 to 15 cover various regions. Included in the coverage of these will be governance and economic aspects including legal, institutional, financing, price responses, and trade. Consideration of CDR and/or SRM and their governance could be relevant here.

Several cross-chapter papers will be produced. Consideration of CDR and/or SRM and their governance could be relevant here, in particular in relation to:

- deserts, semi-arid areas, and desertification;
- mountains;
- polar regions; and,
- tropical forests.

Chapter 16 explores key risks across sectors and regions and how to avoid impacts under a range of climate and development pathways. Consideration of CDR and/or SRM might be relevant for consideration as part of the pathways and risks analysis.

Chapter 17, which explores decision-making options for managing risk, will include topics which are highly appropriate for the consideration of CDR and/or SRM and their respective governance. The chapter will include drivers of decision-making, including values, perceptions, differential power and influence, behaviour, incentives, and financial opportunities. The Chapter will also examine how

governance for managing risk across multiple scales, institutions, and systems might develop. Within this section lessons will be drawn from case studies at different scales, including issues of governance and finance.

Chapter 18 will examine adaptation pathways, including transformation and economic diversification, technologies and strategies that strengthen resilience, reduce inequalities, and improve climate related human wellbeing. This Chapter will also draw from case studies (e.g., afforestation enhancing resilience to flooding and erosion whilst removing CO₂). Consideration of CDR and/or SRM and their governance could also be relevant here.

WG-III contribution to AR6

Within **Chapter 2**, which focusses on emissions trends and drivers, there is an intention to review technological choices and changes and the potential impacts of any technological breakthroughs. In addition, it will examine emissions associated with existing and planned long-lived infrastructure. Consideration of CDR and/or SRM and their governance could be relevant here.

Chapter 6 explores energy systems with a focus on energy efficient technologies. With some CDR techniques potentially creating energy products, consideration of CDR and its governance could be relevant here.

Chapters 8 and 9 cover urban systems and other settlements and buildings respectively. Whilst not explicitly referenced, consideration of SRM techniques such as albedo enhancement or CDR techniques such as carbon storage in buildings (along with their requisite governance) could be relevant here.

Chapter 16 covers innovation, technology development and transfer. While CDR and/or SRM are not directly referenced, the topics covered by the chapter are all potentially relevant for consideration around CDR and/or SRM and their governance.

They include:

- innovation and technology as systemic issues, evaluating literature on cases of technological innovation systems and innovation policy;
- assessment of international institutions, partnerships and cooperative approaches relevant to technology, innovation and R&D;
- capacity for transformative change, including capabilities for innovation, engineering, governance, R&D cooperation and deployment incentives;
- assessment of experiences with accelerating technological change through innovation policy for climate change at the national level, including successful case studies;
- acceptability and social inclusion in decision-making, communication and information diffusion; and,
- characterisation and implications of new disruptive technologies.

Chapter 17 takes a view on interrelationships between mitigation, including new technologies, and sustainable development. Whilst not explicitly referenced, consideration of CDR and its governance could be relevant here.

Conclusions

AR6 will play a key role in informing future policy makers, not only about the state of the climate but also, critically, about the potential options for mitigation, adaptation and the use (or not) of climate-altering technologies referred to as CDR or SRM. The Assessment outlines include the following direct references to CDR and SRM:

WG-I

- **Chapters 4 and 5** – the climate responses to CDR and SRM; and,
- **Chapter 5** – the biogeochemical implications of CDR and SRM scenarios

WG-III

- **Chapters 6 to 11** – CDR and its implications for mitigation pathways in agriculture, forestry and other land uses;
- **Chapter 12** – land and ocean-based techniques and direct air capture CDR, addressing: status, costs, potentials, governance, risks and impacts, co-benefits, trade-offs and spill-over effects, and their role within mitigation pathways; and,
- **Chapter 14** – ethics and governance of SRM and associated risks.

The IPCC 2018 Special Report on Global Warming of 1.5°C (IPCC, 2018) noted that, many uncertainties and knowledge gaps remain around the potential efficacy, impacts and governance of CDR and SRM. The months before the literature review for AR6 is completed therefore presents an important window of opportunity for researchers internationally to publish further literature addressing these knowledge gaps to strengthen the evidence base around CDR and SRM included in the Assessment. Such evidence will also provide crucial inputs to governments' and other stakeholders' growing considerations around many important, unresolved issues concerning CDR and SRM and their governance. If literature is to be considered by Working Group authors, it must have been submitted to publishers by the following deadlines: WG-I 31 December 2019 (IPCC 2019a); WG-II 1 July 2020 (IPCC 2019b); and, WG-III 15 June 2020 (IPCC 2019c).



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