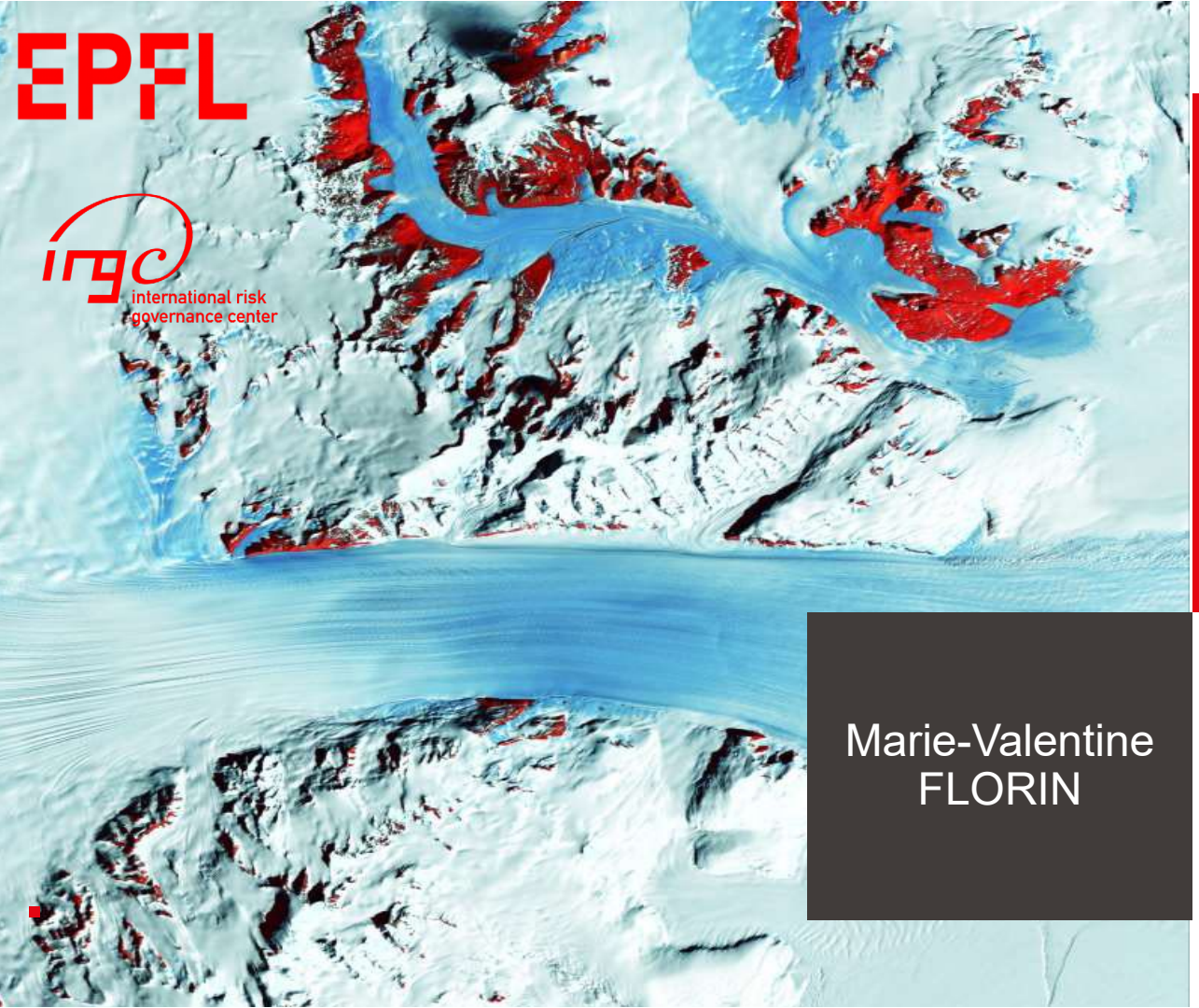


Climate Engineering

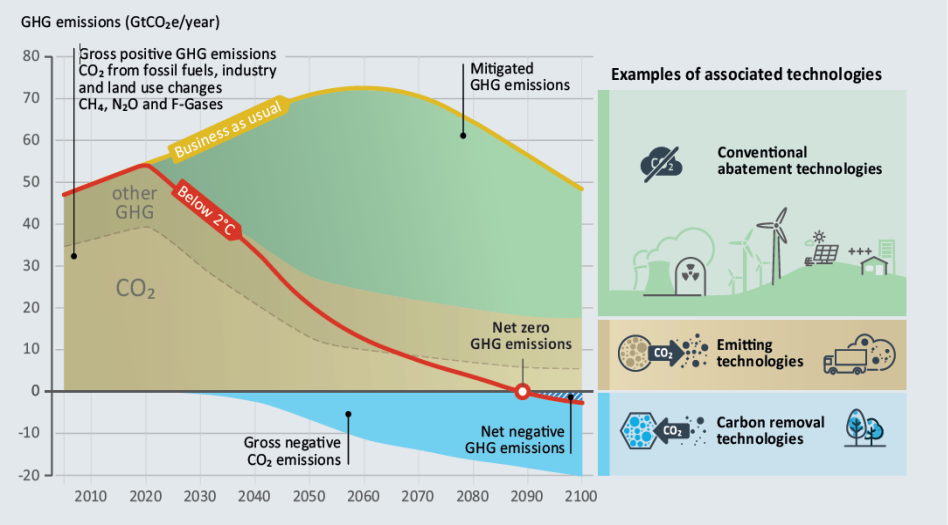
Marie-Valentine FLORIN

https://www.epfl.ch/research/domains/irgc/climate-engineering/

The climate problem: requirement to aggressively reduce GHG emissions, but additional actions to reduce GHG concentration *are also* needed

- need to cumulatively **remove from the atmosphere by 2100 more than 600 Gt of CO_2** (100-1000 Gt CO_2)*
- taking into account that **anthropogenic CO_2 emissions are today of the order of 40 Gt of CO_2 per year,** and depending on how soon the net negative emissions goal is achieved
- Priority: reduce GHG emissions

*IPCC Special Report on 1.5°C warming



(UNEP, 2017; NAS, 2019)

Climate engineering : need to differentiate between distinct technologies

Remove carbon from the atmosphere and permanently store it, to address the cause of climate change
(Carbon Dioxide Removal = CDR)

CDR

- **Nature-based approaches**: afforestation and reforestation, restoring wetlands, peatlands and coastal habitats; macroalgal cultivation
- **Hybrid approaches**: biochar production and deposition, ocean fertilization, enhancing ocean alkalinity with terrestrial weathering
- **Engineered approaches**: Direct air carbon dioxide capture and storage (DACCS);
  bioenergy with carbon capture and (BECCS)

SEQUESTRATION

- Sequestering carbon in the oceans; crop residues oceanic carbon sequestration, mineralization of injected CO_2 within geologic structures

'Cool the planet'
thus reduce some symptoms and risks of climate change, without addressing the cause
(**Solar Radiation Modification = SRM**)

SRM

- Stratospheric Aerosol Injection (SAI)
- Marine Cloud Brightening (MCB)
- Other techniques

uncertainty

Plans and regimes

- At the national level:
  - No national climate plan or policies that include CDR or SRM
  - No specific national regulation
  - CDR is not part of the Nationally Determined Contributions (NDCs)
  - SRM is not ready for deployment and there are large oppositions about it
- At the international level:
  - No overarching international regime that specifically addresses the governance and oversight of all climate engineering technologies
  - Patchwork of general norms, international conventions, international institutions and soft laws that are concerned with aspects of it
  - CBD, UNFCCC, London Convention, etc
- Currently, most of the focus is on
  - governance of research
  - research about possible international governance mechanisms
  - making plans that can be flexible and adapt as more scientific knowledge is collected

Role of civil society, effective access to information, Public participation in decision-making and access to justice, and in international forums dealing with environmental matters

- Which information?
  - Broad range of techniques (very few are mature) and of estimates
  - High uncertainty about direct and indirect consequences
- The technological systems do not exist yet, the social science perspective is still very incomplete.
- Participation and decision **under uncertainty**
- However, more and more people will consider climate engineering, which will come with the need for transparent and informed discussion, because the risks are potentially severe.

Transparency, public participation and inclusiveness through stakeholder engagement will be critical to the success of any plan

- Re. CDR: competition with food security, underground storage
- Re. SRM: SCoPEx experimentation
- Role of:
  - the private sector and standard setting organisations
  - NGOs and think tanks (C2G, SRMGI,…)
  - Scientific institutions (Royal Society, US NAS)
- Social justice and inequality concerns, intra- & inter-generational equity
- Information, national conversations, capacity building
- Promotion of the principles of the Aarhus Convention

Climate Engineering

THANK YOU

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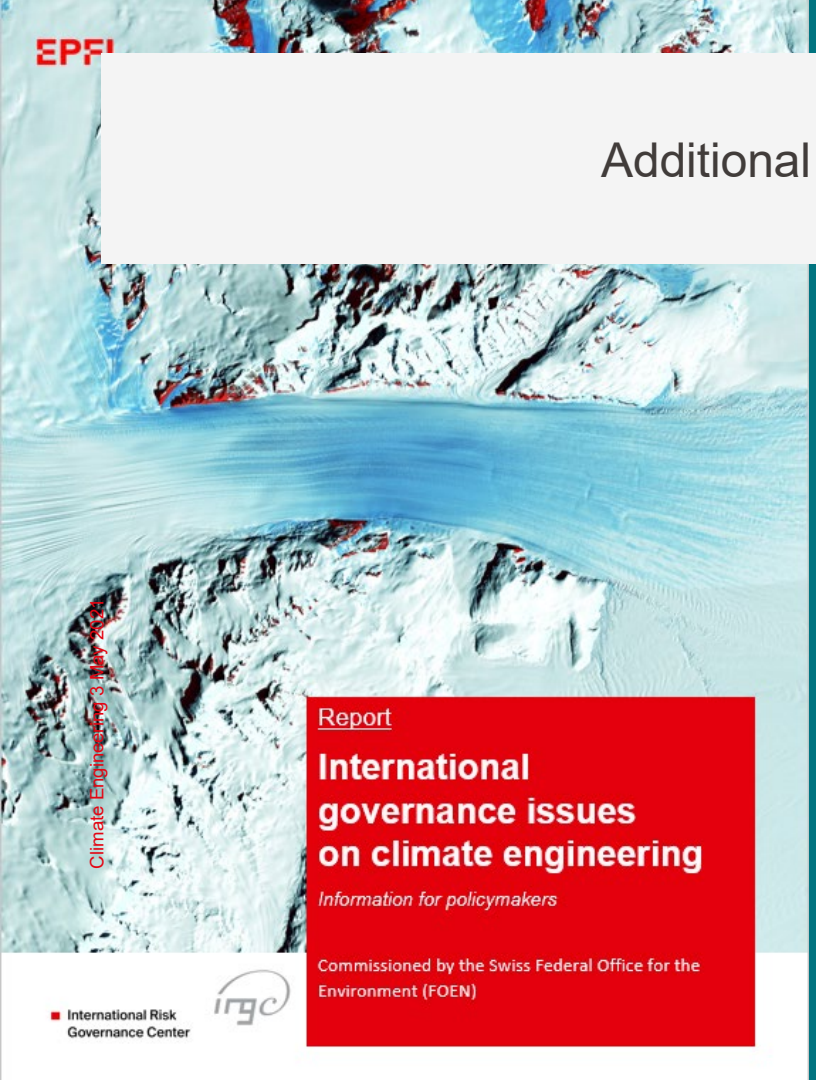
Additional information from the report



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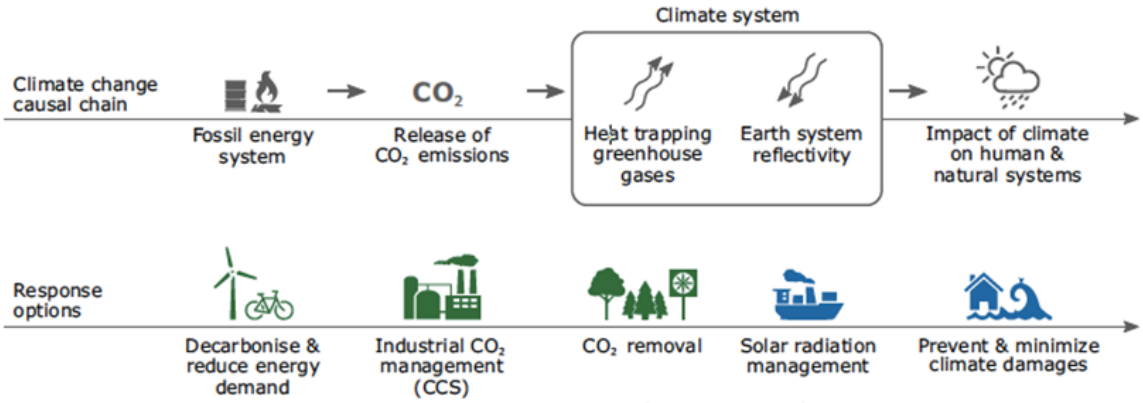
Revisiting the framing of climate engineering



Human response options to the climate problem.
Keith (2000), further developed by Minx et al. (2018). Adapted.

- None of the climate engineering options represent an alternative to GHG emissions reductions
- CDR is needed to complement the reduction of emissions
- SRM may be needed some time in the future to reduce temperature increase
- Both series of techniques incur negative adverse consequences

Portfolio approach to climate change and climate engineering

Technologies and approaches …	… with risks and adverse effects primarily at the:	
… with aim to target:	**Global** scale	**Local or regional** scale
Some **consequences** of climate change (symptoms)	**4 SRM** *- Could slow or halt warming* *- A way to 'buy time' to fight and adapt to climate change, or as 'an emergency measure of last resort', or to 'fill a gap' to avoid the climate system crossing a dangerous threshold, after which damage would be irreversible*	**3 Adaptation** *-Can help cope with some local consequences of climate change* *- but may not be sufficient to address all problems caused by altered temperatures, precipitation patterns and increasing extreme events*
Cause of climate change	**1 GHG emission reduction** *- Nr 1 priority*	**2 CDR** *- Remove CO2 from the atmosphere (GHG concentration reduction)* *- Risks and co-benefits tend to be local or regional, but upscaling is possible*

Process to elaborate this report

Introduction: context, interest for climate engineering, purpose of the report

Chapter 1
- Review of the technologies
- Paul Rouse, C2G

Chapter 2
- Review of current international arrangements
- Anna-Maria Hubert, University of Calgary

Chapter 3
- Trade-offs between risks
- Matthias Honegger, IASS

Chapter 4
- Policy options
- Jesse Reynolds, UCLA

Interdisciplinary and multi-stakeholder workshop

Conclusion: cross-cutting themes, roadmap for a conversation, specific research questions

Cross-cutting themes from the four chapters

- Noting the pervasive **uncertainty** that characterizes both CDR and SRM and their governance, **adaptive approaches** are advisable to reducing uncertainty and deploying the most appropriate technologies. Need to be very prudent and cautious, and avoid lock-ins.
- **Separation of CDR and SRM** in policy discussions and in communicating with the public.
- Acknowledgement that existing international arrangements lean toward –or even in some cases create an obligation– to **engage in further research and cooperation**
- Both **top-down and bottom-up** approaches will be needed to improve the national and international governance of CDR and SRM.

Chapter 1: need to differentiate between distinct technologies and emphasize uncertainty

CDR

- Nature-based approaches: afforestation and reforestation, carbon sequestration in soils; restoring wetlands, peatlands and coastal habitats; macroalgal cultivation
- Hybrid approaches: biochar production and deposition, ocean fertilization, enhancing ocean alkalinity with terrestrial weathering
- Engineered approaches: Direct air carbon dioxide capture and storage (DACCS); bioenergy with carbon capture and (BECCS)
- Other CDR techniques

SEQUESTRATION

- Sequestering carbon in the oceans; crop residues oceanic carbon sequestration, mineralization of injected CO_2 within geologic structures

SRM

- Stratospheric Aerosol Injection (SAI)
- Marine Cloud Brightening (MCB)
- Other SRM techniques

Potential sequestration capacity and costs of CDR techniques

Technique	Theoretical sequestration capacity (per annum)	Potential cost per tonne of sequestered CO_2 (CHF)
Afforestation and Reforestation	3 to 18 Gt	2.4 to 179
Carbon Sequestration In Soils	1 to 11 Gt	-3 to 12
Restoring Wetlands	1 Gt (+ 1 Gt of avoided emissions)	10 to 100
Macroalgal Cultivation	19 Gt	Not available
Biochar	2.6 to 4.8 Gt	17 to 158
Ocean Fertilisation	Up to 3.7 Gt	10 to 450
Enhancing Alkalinity With Terrestrial Weathering	Theoretically unlimited	51 to 460
Direct Air Carbon Dioxide Capture and Storage (DACCS)	0.5 to 5 Gt (by 2050)	30 to 950
Bioenergy With Carbon Capture And Storage (BECCS)	2.4 to 10 Gt	67 to 240
Artificial Upwelling	Less than 0.25 Gt	400 to 700

Chapter 2: patchwork of norms and treaties relevant to climate engineering as a whole or as distinct technologies

- Many existing instruments and institutions that have expressly addressed geoengineering regulation and governance to date, reflect a **"limited" approach** in line with their specific objectives, scope and mandate, leading to a one-dimensional perspective on climate engineering rather than a comprehensive and integrated approach to its governance. Examples: UNFCCC, CBD, London Protocol
- A number of general norms of international environmental law, treaties and soft-law instruments and international institutions have some relevance to geoengineering
- A complex '**patchwork' of overlapping norms and institutional mandates**, sometimes described as 'fragmentation'
- **Need for some degree of international governance** for climate engineering measures. And yet no treaty or institutional organization is likely to provide a 'one-size-fits-all approach' for climate engineering measures as a group.

Chapter 3: Trade-offs between risks

- Risk-risk trade-offs are inherent to the governance of CDR and SRM
- Some trade-offs involve *physical* risks
  - reduction of climate change with new environmental risks
- Some relate to policy design and governance
  - E.g. maximizing mitigation versus ensuring sustainable development
- Some relate to research
  - E.g. ‘moral hazard’ versus risk of ignorance

Chapter 3: Tradeoffs between risks - in the policy debate

Risk and trade-offs related to policy design and governance include

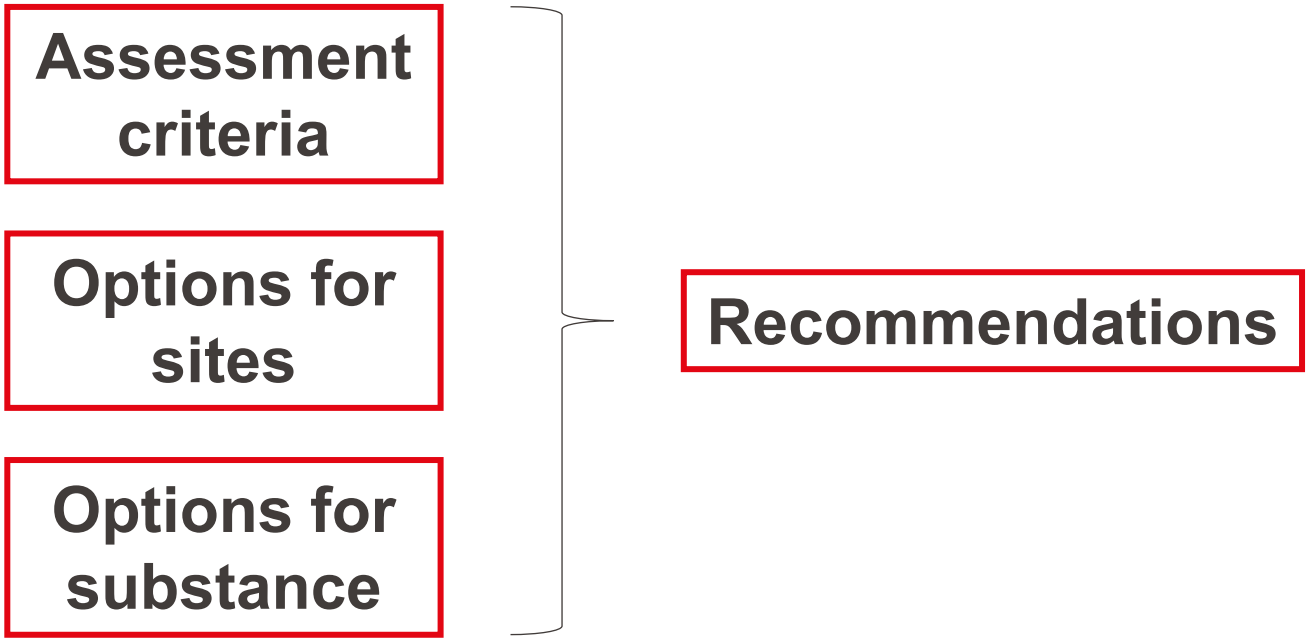
- The balancing of inclusive or participatory governance with efficiency and effectiveness
- The sovereignty of domestic policies contrasted to the need to address potential transboundary effects
- Maximizing mitigation versus ensuring sustainable development
- Centralized governance versus polycentric governance – effectiveness versus diversity
- Ensure that SRM is not deployed as long as the understanding of impacts remains insufficient and prevent uncoordinated SRM application in the long-run. Achieving both requires building a shared understanding of the potential effects of SRM applications and establishing a robust foundation of international cooperation

Chapter 3: Tradeoffs between risks - in research

Risks and trade-offs related to research include

- Focused authoritative knowledge generation versus a diversity of assessment approaches
- Research on CDR could displace attention to GHG mitigation
- Research on SRM could create moral hazard, versus risk of ignorance
- Risk of transboundary impacts from SRM research
- Lack of collaborative international research and uneven decision-making capacity may lead to the capture of the governance process by a small number of countries.

Chapter 4: Elements and steps for global governance



Chapter 4: developing policy options - assessment criteria

The chapter offers explicit criteria for the assessment of governance options, including to

- reduce climate change and its impacts
- contribute to sustainable development
- support greenhouse gas emissions reductions
- establish and maintain legitimacy
- foster peace and stable international relations, and
- reflect current knowledge and adapt to changing conditions.

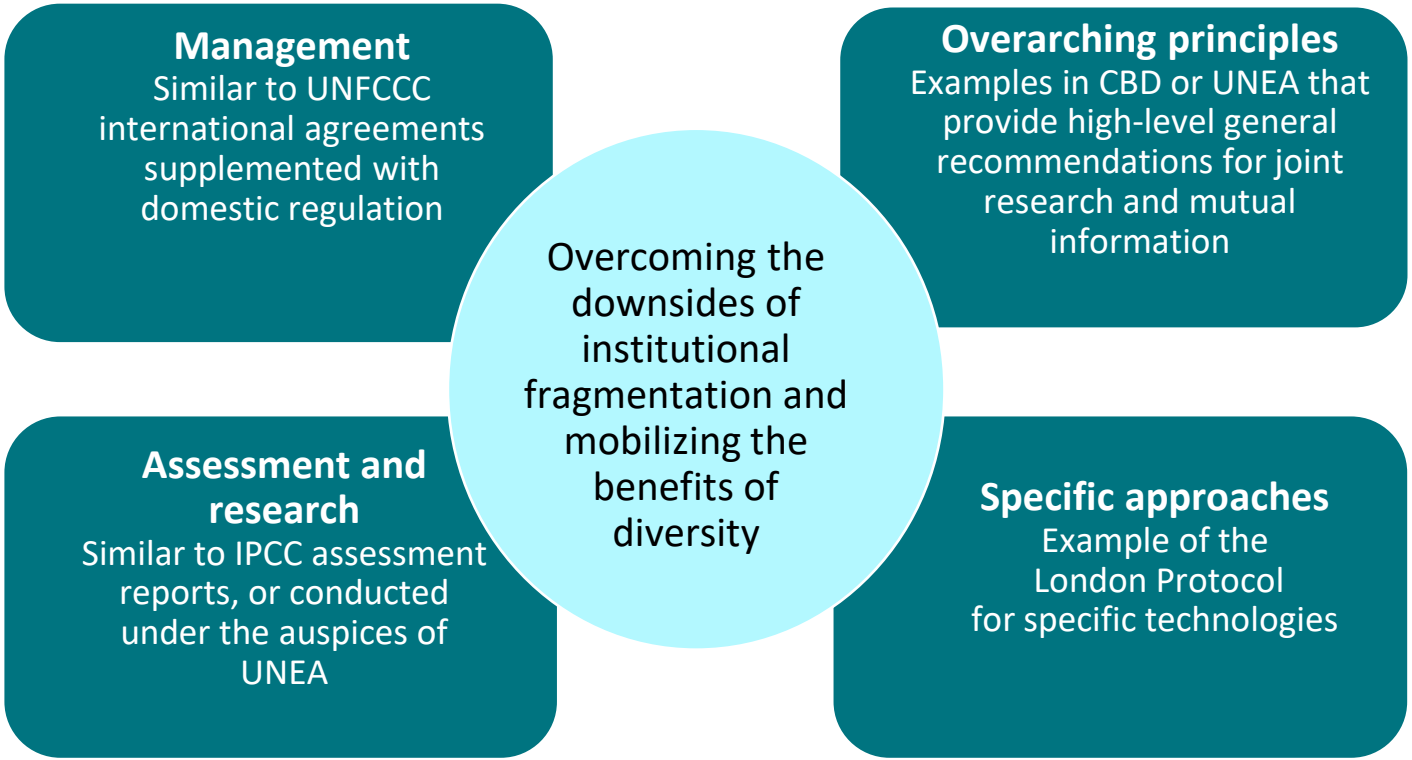
Chapter 4: developing policy options - options for possible governance sites

- It is difficult to imagine the international governance of CDR and SRM without the climate change regime having a central role.
- The biodiversity regime is well-positioned to legitimately contribute to international governance of CDR and SRM.
- UNEP's mandate and capabilities include identifying emerging issues, conducting scientific reviews, and catalyzing international governance across issue areas and sectors.
- The creation of de-novo international process and decentralized governance should also be considered.

Chapter 4: developing policy options - recommendations

1. distinguish between CDR and SRM as well as among CDR techniques in additional dedicated governance.
2. accelerate authoritative, comprehensive, and international scientific assessment of the various technologies.
3. encourage the research, development, and responsible use of some CDR techniques
4. help build capacity for evaluating CDR and SRM in some of those countries that lack the resources to do so.
5. facilitate the elaboration and implementation of non-state governance, in complement to state-governance.
6. explore potential further governance of SRM while remaining agnostic concerning its ultimate use.

Combining governance approaches to…



Roadmap for broadening the conversation between science, policy and society – supporting conditions

- Adopt a systemic ('systems') approach to risk and benefits
- Choose a neutral place for dialogue
- Organize national conversations with society
- Engage national policymakers on the fact that CDR can help achieve national climate targets.
- Enhance international and multilateral collaboration in multi-disciplinary research that involves a broad range of stakeholders from various countries

Six key issues for further specific research

1. Moral hazard of mitigation displacement
2. Complementarity between and combination of climate engineering technologies
3. For CDR: assessing the risks and benefits of the various distinct technologies
4. For SRM: avoiding the risk of unilateral deployment, and assigning objective
5. Collaboration between international institutions and conventions
6. Mechanisms for responsibility and accountability to create trust