Report

International governance issues on climate engineering

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Chapter 4 | Elements and steps for global governance

by Jesse Reynolds[1]

Abstract

This chapter evaluates options and approaches for future regimes on the international governance of climate engineering, that is, carbon dioxide removal (CDR) and solar radiation modification (SRM). Based on the previous chapters, it offers explicit criteria for the assessment of governance options. Possible governance sites – including but not limited to intergovernmental institutions – are then considered. The chapter then reviews a wide range of potential substantive options for governance. The author offers six specific recommendations: to distinguish between CDR and SRM as well as among the diverse CDR techniques; to undertake authoritative, comprehensive, and international scientific assessment; to encourage the research, development, and responsible use of some CDR techniques; to help build capacity for evaluating CDR and SRM in countries that lack the resources; to facilitate the elaboration and implementation of non-state governance; and to begin international processes that explore potential governance of SRM while remaining agnostic concerning its ultimate use.

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4.1. Introduction

There is a widespread consensus that decision-making regarding climate engineering – that is, carbon dioxide removal (CDR) and solar radiation modification (SRM) – would benefit from additional, dedicated governance. This chapter evaluates possible options and approaches for potential future regimes for the international governance of climate engineering. It focuses on steps that national governments can take in this direction.

What should such governance do? A few general objectives can be suggested. First, it should lessen the risks and negative impacts of climate change and the responses to it. Second, governance should be consistent with widely shared values. In particular, those who are affected by decisions should have the opportunity to appropriately participate in making them. Third, if and when CDR or SRM are used, governance should ensure that they complement greenhouse gas (GHG) emissions reductions and other responses to climate change and that they do not increase international tensions. The suggestions in the previous chapter offer somewhat more detailed prescriptions.

Any further international governance of CDR and SRM will arise in the existing international legal and political order. The absence of a centralized global lawmaker means that international governance is only weakly coordinated, with overlaps and gaps among mechanisms' objectives and institutions' scopes. In order to provide relevant knowledge, science-based guidance, and venues for effective and legitimate decision-making, new governance must consequently leverage positive aspects and attenuate negative ones of the multi-layered, polycentric global order. Moreover, the absence of a centralized global enforcer of international law means that it is (for the most part) binding only through states' consent. Any proposal must offer apparent net gains for those states that are expected to participate.

Climate change and the responses to it are intergenerational phenomena, and developing international governance of CDR and SRM – especially their large-scale use – will be a multidecadal and uncertain process. Nevertheless, meaningful steps can be taken soon to lay a foundation for this. Furthermore, some shorter-term actions with respect to international governance – including of CDR's and SRM's research – could be directly beneficial. This chapter considers options and approaches that could be pursued in a few years, while bearing longer-term governance objectives and processes in mind.

The next section offers some explicit criteria to assess governance options and approaches. The two thereafter lay out options along two dimensions: where in the international policy landscape such governance could arise, and what its substantive content could be. The final section recommends specific shorter-term actions that states should take to help develop international governance of CDR and SRM.

4.2. Assessment criteria of governance options

In order to structure the discussion on options and approaches for potential future international governance for CDR and SRM, explicit criteria are helpful. Building on the previous chapters, six functional criteria are offered here with the caveat that they do not constitute a definitive list. All but the final one are guided by agreements and statements which many countries have endorsed. Importantly, multiple criteria imply that trade-offs among them will be necessary (see chapter 3). Furthermore, the criteria must be considered in long, intergenerational timescales, even when assessing shorter-term governance. This is because certain governance arrangements could satisfy the criteria at one point in time while later working contrary to them.

4.2.1. Reducing climate change and its impacts

The prevention and lessening of climate change have been a widely shared international goal for almost thirty years. The objective of the 1992 UN Framework Convention on Climate Change (UNFCCC) is, in part, the 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would *prevent dangerous anthropogenic interference with the climate system*' (Article 2, emphasis added). Likewise, one of the Paris Agreement's goals is to limit warming to 2°C and to pursue efforts to limit it to 1.5°C, implicitly to 'reduce the risks and impacts of climate change' (Article 2.1(a)). And among the Sustainable Development Goals (SDGs) is to 'Take urgent action to combat climate change and its impacts' (United Nations General Assembly, 2015, goal 13), while limiting climate change is a central element in the pursuit of the other SDGs (Nerini et al., 2019).

Consequently, and as noted elsewhere in this report, one criterion for the international governance of CDR and SRM is the potential of the various technologies to reduce climate change and its impacts. Both CDR and SRM could help achieve this goal (chapter 1). This is clearer with the former (IPCC, 2018, p. 17), as safe, reliable, and affordable removal of carbon dioxide (CO_2) would have essentially the same net effects as carbon dioxide emissions reduction on the gas's atmospheric concentration and on climate change. Moreover, CDR is necessary to stay within the Paris Agreement's temperature-based global warming goal. Some SRM technologies appear able to lower climate change impacts (e.g., IPCC, 2018, p. 350; Irvine & Keith, 2020) but this would be imperfect and the evidence for it is less certain. Furthermore, SRM would not address the underlying causes of climate change but instead only its physical manifestations, although the extent to which policy must tackle the former – possibly at the expense of the latter – is unresolved.

The various responses to climate change have distinct characteristics. Emissions reductions are required to lessen climate change in the long term, but can only slow the increase in atmospheric GHG concentrations, not lower them. CDR can reduce net emissions, even making them net negative and thus lowering the concentrations. If atmospheric GHG concentrations become high enough to cause dangerous climate change – as probable future scenarios suggest – then SRM may be able to lower the rate and/or peak of climate change. We must also adapt our societies and, to the limited degree to which it is possible, the planet's ecosystems to a changing climate. What remains will be climate change impacts. In this way, and as already indicated in chapter 3, these various responses can be complementary and, ideally, would constitute a coherent portfolio (see Figure 6).

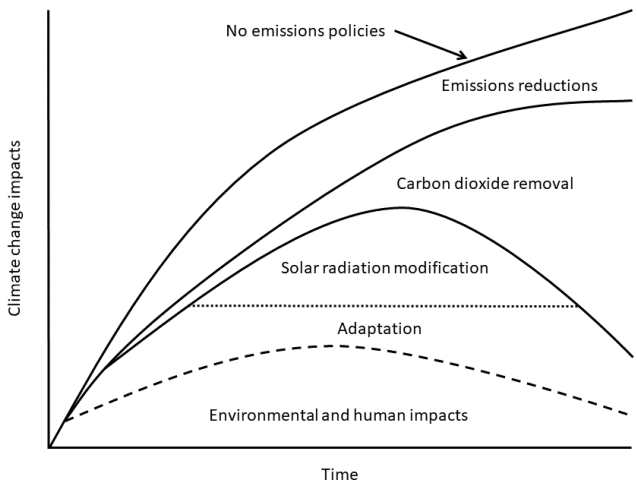

Figure 6 – Concept of an idealized portfolio of complementary responses to climate change. Originally developed by John Shepherd (Long and Shepherd, 2014, p. 765).

Furthermore, these responses to climate change also help manage uncertain risks. That is, climate change impacts might be more or less severe than expected, and the responses to it might be more or less effective or acceptable. In this context, a given response option could fill an unexpected but important 'gap' in the others' reductions of risk.

4.2.2. Contributing to sustainable development

Currently, the relevant overarching normative framework for international cooperation with respect to the environment and related issues is sustainable development. In the UN's 2030 Agenda for Sustainable Development, among the SDGs are ending poverty and hunger, expanding good health and well-being, sustainably using the oceans, and protecting terrestrial ecosystems (UN General Assembly, 2015, goals 1, 2, 3, 14, and 15).

On the one hand, CDR and SRM appear able to decrease climate change and its impacts, consequently helping enable sustainable development. On the other hand, they pose diverse physical risks and social challenges of their own, and their relationship with the SDGs is complicated and nuanced (Honegger et al., 2018). This is evident in chapter 3's assessment of physical trade-offs, synergies, and risks. Therefore, the international governance of CDR and SRM should not only strive to reduce climate change impacts, but be able to balance this with other environmental, economic, and social objectives, captured in the SDGs and elsewhere. This will require the capacity to generate and synthesize useful knowledge, to identify and bring together affected interests and other stakeholders, to enable CDR and SRM as appropriate, and to regulate and limit their potential negative physical and social impacts.

4.2.3. Supporting greenhouse gas emissions reductions

Many countries have committed to reducing GHG emissions as part of a long-term objective of achieving net-zero emissions. Not only are such reductions the leading means to combat climate change, but they also arguably constitute an independent objective. For example, in the Paris Agreement, parties aim to reach global peaking of GHG emissions as soon as possible (Article 4.1), while adaption and finance flows are to foster low emissions development (Article 2.1(b-c)).

Yet a widespread concern is that the consideration, research, and development of CDR and SRM would displace emissions reductions (as discussed in section 3.4.2 and 3.4.3). Although emissions reductions and CDR would have the same net effects on atmospheric GHG concentrations and climate change, the former remains essential, whereas the latter's various technologies are still somewhat uncertain.

The international governance of CDR and SRM should thus be able to support continued and strengthened GHG emissions reduction. Furthermore, developed countries should continue to take the lead in reducing emissions (Paris Agreement, Article 4.4) in line with the principles of equity, and of common but differentiated responsibilities and respective capabilities (Paris Agreement, Article 2.2).

4.2.4. Establishing and maintaining legitimacy

The expectation that governance be legitimate is almost universal. As such, the international governance of CDR and SRM should be perceived as legitimate, broadly conceived. Central to this is the fact that many states could be affected, especially in the case of SRM. At the least, this means that governance should be consistent with international law and other widely shared norms, including respect for human rights and democracy (e.g. Swiss Constitution of 1999, Article 54(2)). Along these lines, the UN Commission on Human Rights 'Calls upon States to provide transparent, responsible, accountable and participatory government, responsive to the needs and aspirations of the people' (United Nations Commission on Human Rights, 2000, paragraph 1). Legitimacy also requires trust, particularly among those whom the governance does or could affect. Establishing, building, and maintaining trust is commonly a resource-intensive process in which inclusion, communication, and assurance are key.

A long-standing challenge – notably for global governance – is that legitimacy's characteristics, sources and standards are unclear and not universally agreed upon. At a general level, one way to conceive of it is having

three primary forms (Schmidt, 2013). *Input legitimacy* requires that the governed have the opportunity to participate meaningfully in decision-making (that is, legitimacy through inclusiveness)[2]. In turn, governance should be responsive to the concerns of the governed and other stakeholders. This points toward the inclusion of the many potentially affected interests, appropriate assurances, and trust. Given that especially SRM could affect the entire globe, input legitimacy implies that diverse global representatives of many states – if not all of them – should be able to participate in decision-making. *Output legitimacy* is, more or less, dependent on governance's effectiveness, which calls for efficiency as well as bringing together and building expertise. And *throughput legitimacy* depends on whether procedures are fair, accessible, and open.

4.2.5. Fostering peaceful and stable international relations

International governance of CDR and SRM will be developed in an existing landscape of states, intergovernmental institutions, and important non-state actors. It could consequently have impacts on multiple political dynamics and objectives – such as the peaceful coexistence of nations (Charter of the United Nations, Article 1) – that precede and extend beyond sustainable development. As seen in chapters 1 and 3, many CDR and SRM technologies could have transboundary impacts, both positive and negative. Furthermore, SRM could, at least in theory, be implemented by one or a few states or maybe even non-state actors, affecting many countries and perhaps independently of any international consensus. As a first approximation, positive impacts would facilitate peaceful international relations while negative ones could create or amplify tensions. Even in the absence of negative impacts, some states might perceive themselves to have been harmed or to have been excluded from important decision-making. A particularly important dimension in the context of climate change and of CDR and SRM specifically is the relationships between developed and developing countries.

The international governance of CDR and SRM should not exacerbate international tensions that could arise, for example, from some states acting in ways that (are perceived to) harm others. Moreover, if possible, it should aim to improve international relations among them through transboundary capacity building, collaboration, and cooperation.

4.2.6. Reflecting current knowledge and adapting to changing conditions

To a large degree, SRM and CDR are technically complex, with relevant knowledge unevenly distributed and often difficult to synthesize. Yet decisions, including regarding governance, must be made. What's more, governance, especially that which is legal in character and international in scale, is generally slow to change whereas emerging technologies often develop rapidly. This presents a challenge in keeping it aligned with fast-evolving issues. Moreover, emerging technologies can be characterized by uncertainty or ambiguity. Governance that can anticipate, adapt, and keep 'connected' to the target phenomena is important when conditions change and new knowledge is generated (Marchant et al., 2011). In such cases, governance should learn from experience and update over time (IRGC, 2016).

This is particularly important for CDR and SRM, for which significant uncertainty persists, including concerning their capacities, their opportunities, their risks, associated social preferences, and future climate change. The international governance of these technologies should be able to integrate useful knowledge, monitor relevant consequences, respond to feedback, anticipate change, and adapt to evolving conditions and new information.

[22] More suggestions relative to inclusive governance were given in section 3.3.1, as well as in section 3.4.5 on knowledge generation that would serves as a basis for legitimate governance.

4.3. Options for sites of international governance

This section considers possible sites of the development and/or implementation of international governance of CDR and SRM. It builds on chapter 2, which reviews existing international legal and institutional arrangements. The analysis is based on aspects such as core competence, expertise, function, how 'political' or 'scientific' the institution is, and the decision-making process. Because most – but not all – new international governance develops from an existing international institution that is associated with a multilateral agreement, these offer the primary way of organizing this section.

4.3.1. UN Framework Convention on Climate Change

CDR and SRM are matters first of climate change, as their intended and primary effects would be climatic. The central vehicle for international governance of climate change is the climate change regime, whose three treaties – UNFCCC, the Kyoto Protocol, and the Paris Agreement – are furthered by a Secretariat, Subsidiary Bodies for Implementation (SBI) and for Scientific and Technological Advice (SBSTA), and annual Conferences of Parties (COPs).

Numerous scholars and other observers have suggested the climate change regime as a site for the international governance of CDR and SRM (e.g. Rickels et al., 2011; Zürn and Schäfer, 2013). It has substantial widespread participation, legitimacy, and expertise. Furthermore, the regime's institutions are already aimed toward proactively reducing climate change and its impacts in the context of sustainable development. Governing CDR and SRM there could integrate the technologies with other responses to climate change, which could help keep decreasing GHG emissions as the top priority. Finally, the consideration and governance of international efforts to reduce climate change within a single site could be more effective (although this might also run risks of institutional capture). Ultimately, it is difficult to imagine the international governance of CDR and SRM without the climate change regime having a central role.

The UNFCCC already has a mandate to govern CDR, or at least some technologies thereof. It falls within the foundational agreement's objective of stabilizing atmospheric GHG concentrations (UNFCCC Article 2) and parties' obligations to enhance sinks and reservoirs of GHGs (UNFCCC Article 4.1(d); Paris Agreement 5.1; see Honegger et al., 2019) as part of mitigating climate change (UNFCCC Article 4.2(a)). As such, the UNFCCC agreements' obligations and incentives to reduce net emissions; its methods for measuring, reporting, verifying, and communicating emissions; and its provisions regarding technology transfer, capacity building, and climate finance could all encompass CDR. In addition, the COPs, SBSTA, and other bodies have helped clarify how to incorporate some CDR techniques, particularly nature-based approaches, into the regime's regulatory architecture through mechanisms such as those for land use, land-use change, and forestry (LULUCF).

Despite the climate change regime's emphasis on emissions reductions, it could also contribute to the governance of SRM. Although the UNFCCC's objective of stabilizing atmospheric GHG concentrations (UNFCCC Article 2) does not clearly include SRM, it could be interpreted as doing so. First, the objective offers characteristics of the stabilized concentrations' level and speed of its stabilization. If effective, SRM could increase both the acceptable GHG concentrations that would not dangerously interfere with the climate system and the amount of time available for this stabilization. Second, models indicate that SRM would indirectly reduce atmospheric GHG concentrations through preventing some carbon releases (greater ecosystem respiration, lower primary productivity, and lower oceanic uptake) that warming would cause (Keith et al., 2017). Third, the UNFCCC's scope could be interpreted liberally, focusing on its calls to protect the climate system (UNFCCC Articles 3.1, 3.4). Fourth, SRM could help keep global warming within the Paris Agreement's temperature goals. Finally, an amendment or protocol could broaden the UNFCCC's objective.

However, a serious challenge to governing SRM through the UNFCCC is political. Negotiations there, such as those at the COPs, are often polarized and protracted. This may be due to the important issues that climate change implicates, such as economic growth and development; to insufficient international trust; and to the issues' complexity. Regardless, adding SRM into this environment may be disruptive and divisive, especially

in the near term with significant scientific and normative uncertainty. Broaching the topic in the UNFCCC system might do more harm than good, at least in the short term.

4.3.2. Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has the mandate to comprehensively assess

> *The state of knowledge of the science of climate and climatic change; … Possible response strategies to delay, limit or mitigate the impact of adverse climate change; The identification and possible strengthening of relevant existing international legal instruments having a bearing on climate… (UN General Assembly, 1988; see also IPCC, 2013).*

Governed by representatives of its 195 member countries, its leading vehicles have been major Assessment Reports produced by international teams of hundreds of experts and occasional, more focused Special Reports, both of which have considered CDR and SRM. These are widely considered to be authoritative, informing international and national decision-making concerning climate change, sustainability, and more. The contributing scientists clearly have relevant expertise to assess CDR – such as how to report for removals in emissions inventories – and SRM – such as through modeling and understanding interactions among Earth systems. In fact, the IPCC held an 'expert meeting on geoengineering' in 2012. And as with the climate change regime, having the scientific assessment of CDR and SRM would likely be more effective within the IPCC, as doing so would capitalize on existing knowledge and relationships in the relevant epistemic communities. On the other hand, the organization's scope is limited to climate change and could thus fall short in assessing other salient aspects of CDR and SRM, such as effects on biodiversity and agriculture. Also, because it aims to be neutral with respect to policy, the IPCC can contribute to but not take the lead in governance.

4.3.3. Convention on Biological Diversity

Among the risks of climate change, those to biodiversity are among the most severe, and adapting ecosystems and threatened species to climate change is difficult. Furthermore, SRM and some CDR techniques could have significant impacts on biodiversity of their own. The Convention on Biological Diversity (CBD) is the leading international legal site for the conservation of biodiversity. Like the UNFCCC, the central framework treaty enjoys widespread ratification, with the notable exception of the US, and a Secretariat, annual COPs, and other supportive bodies, and its objectives and commitments are in the context of economic and social development and poverty eradication (CBD Preamble recital 19; Article 20.4). The CBD COP is the only forum where representatives of (nearly) all countries negotiated and approved decisions concerning CDR and SRM (see chapter 2). As such, the biodiversity regime is well-positioned to legitimately contribute to the international governance of CDR and SRM (Bodle *et al.,* 2014, p.22).

However, the biodiversity regime is limited as a site for developing the international governance of CDR and SRM. For one thing, the agreements do not focus on climate change, and its governance would largely be limited to impacts on biodiversity. Of course, biodiversity will be substantially affected by climate change and the CBD bodies regularly address it through, for example, COP decisions. In addition, the US – which is presently a leading location of the research and development of CDR and SRM – is not a party to the CBD.

4.3.4. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

Modelled on the IPCC, the relatively new Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) aims to 'strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development' (IPBES, 2020). That is, it is an assessment body, not a regulating one. And like the CBD, one limitation is the IPBES's focus on biodiversity, not on climate change. Nonetheless, it could complement the IPCC in exploring issues of the conservation of biodiversity related to CDR and SRM impacts.

4.3.5. United Nations Environment Programme

The UN Environment Programme (UNEP, recently rebranded as UN Environment) is 'the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system and serves as an authoritative advocate for the global environment' (United Nations General Assembly, 2012). Its original mandate includes promoting international cooperation, providing policy guidance for the UN system, reviewing the impact and implementation of policies and programs, monitoring environmental conditions in order to ensure that salient issues are considered, and promoting relevant scientific knowledge and information (United Nations General Assembly, 1972). Among international organizations, UNEP is able to consider the full range of environmental issues and relevant sectors. It also plays an important role in the identification of emerging issues and in the development and implementation of multilateral environmental agreements and institutions, including the UNFCCC, IPCC, CBD, and IPBES. In its work, scientific knowledge is essential for evidence-based guidance for policy. Besides having the capacity to identify issues through scientific review, promote and catalyze the development of policy, and provide a foundation for action, UNEP is arguably less politicized than other forums such as the UNFCCC and CBD institutions. It also has ongoing activities that are pertinent to international governance of CDR and SRM, such as the regular publication of pertinent reports, among which are the *Emissions Gap*, the *Global Environment Outlook*, and *Frontiers* (emerging issues of environmental concern).

In 2019, the UN Environment Assembly (UNEA) discussed (but did not submit to vote) a Swiss-submitted resolution that, substantively, would have created an expert committee to assess proposed technologies and existing governance of 'geoengineering'. The primary reasons that the resolution failed to gather sufficiently wide support appear to be (1) its joint consideration of CDR and SRM, particularly regarding CDR's implied potential global risks and adverse impacts; (2) its inclusion of the current state of the science and knowledge of potential impacts, which some perceived as conflicting with the IPCC's mandate; (3) its possible reference to precaution; and (4) its consideration of potential global governance frameworks.

4.3.6. World Meteorological Organization

The World Meteorological Organization (WMO) is the UN body that provides leadership and expertise in international cooperation concerning weather, climate and related sciences. It has long been involved in climate change, such as helping establish and formally hosting the IPCC. Furthermore, for decades it has worked on weather modification, which is related to SRM. Its Expert Team on Weather Modification Research provides a hub for encouraging research and promoting best practices. Its Commission for Atmospheric Sciences has investigated 'geoengineering' (WMO, 2016), and some WMO members have expressed interest in 'developing a science-based assessment on climate engineering, specify [*sic*] the gaps in scientific understanding and promote specific research activities to fill such gaps' (WMO, 2015). Together, this suggests that the WMO holds relevant expertise and capacity to contribute to the international research of, monitoring of, and guidelines for SRM.

4.3.7. International maritime law and institutions

State and non-state actors' actions on, in, above, and affecting the seas are governed through several international bodies and multilateral agreements. Supported by various expert bodies, these have the capacity and legitimacy to govern marine-related CDR and SRM.

The International Maritime Organization (IMO) is the UN agency responsible for facilitating international cooperation concerning states' 'regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade [and the] maritime safety, efficiency of navigation and prevention and control of marine pollution' (Convention on the IMO, Article 1). The IMO supports the implementation of several multilateral agreements.

One of these is the UN Convention on the Law of the Sea (UNCLOS), which provides for states' rights and obligations in and regarding the seas. As described in chapter 2, several of its provisions would apply to CDR

and SRM activities. In fact, because its definition of 'pollution' could encompass GHGs, climate change, and some forms of CDR and SRM, and because UNCLOS parties are to prevent, reduce, and control pollution of the marine environment from all sources, the treaty could apply to a wide range of CDR and SRM practices – not only those that occur at sea.

The London Convention and London Protocol are a pair of multilateral agreements that regulate pollution caused by dumping or incineration at sea. In 2013, the parties to the London Protocol – whose broader objective covers the protection and preservation of the marine environment from all sources of pollution – approved an amendment to govern 'marine geoengineering' in general (see chapter 2). However, because few states have ratified it, the amendment has not come into force. More generally, these agreements' modest degree of participation and relatively narrow scope would make them poor sites of governance of CDR and SRM other than those techniques that involve placement of matter into the seas.

4.3.8. United Nations

The United Nations (UN) is the central site of global cooperation. Its General Assembly (UNGA) consists of representatives of all widely recognized countries and can address almost any matter of international relations, implicitly including international governance of CDR and SRM. Although UNGA's decisions are not binding under international law, they are influential given the body's widely perceived legitimacy. Yet it is arguably among the most politicized of international forums and may be inappropriate for scientific and technical matters such as the governance of SRM and CDR, at least beyond general statements.

The UN Secretariat is the UN's executive branch. It is dedicating attention to, among other things, emerging technologies. Its head, the Secretary-General, recently developed a Strategy on New Technologies to help them contribute to fulfilling the SDGs and the UN mission more generally (UN Secretary-General, 2018). This includes commitments to increase the UN's engagement with the intersection of technologies and sustainable development. The Secretariat's Department of Economic and Social Affairs followed up with a project on frontier technologies for sustainable development (Department of Economic and Social Affairs, 2018). Both of these endeavors could address CDR and/or SRM.

Outside of the secretariat, the Environment Management Group (EMG) coordinates activities regarding the environment and human settlements across the many UN bodies. This role could be important in the governance of CDR and SRM, which implicates multiple international agreements and bodies. The EMG considered placing 'climate-altering technologies and measures' on the agenda of its most recent Senior Officials Meeting, but ultimately did not do so.

4.3.9. Other intergovernmental institutions

Several other specialized intergovernmental organizations will be relevant to the international governance of CDR and SRM. Among these are the UN Commission for Sustainable Development, the UN Educational, Scientific and Cultural Organization, the Food and Agricultural Organization (FAO), the International Civil Aviation Organization, the Executive Body of the Convention on Long-Range Transboundary Air Pollution, the regime for the protection of the ozone layer, the UN Commission on the Peaceful Uses of Outer Space, and the International Organization for Standardization. Although they may eventually have important roles to play, they offer neither initial nor central sites for the international governance of CDR or SRM.

4.3.10. De novo international process

As somewhat novel phenomena, CDR and SRM could be governed through a new mechanism or institution. Forums or bodies are sometimes created, often by one or more existing ones, to govern actors and actions across an emerging issue, especially if extant arrangements lack a clear institutional site with sufficient scope, expertise, and legitimacy to do so. For example, among the institutions discussed here, the newest is IPBES. It grew out of UNEP discussions, which were in turn endorsed by the UNGA.

A new forum or institution can include many states as well as other intergovernmental bodies, or only those states that are willing and able to act in a contested domain. The latter path may be pursued if consensus is

not attainable, perhaps because a small number of recalcitrant states are impeding action. A potential barrier with this approach can be insufficient legitimacy and the associated international political consequences. On the other hand, a body with fewer members can be more dynamic and adaptive.

4.3.11. Decentralized governance

Finally, international governance can be decentralized. For example, a report of Germany's Federal Environment Agency (*Umweltbundesamt*) states that 'It is not self-evident that a governance framework for all geoengineering technologies is needed at the *international* level. For instance, there are land-based geoengineering concepts that are unlikely to have a transboundary impact, and that could be addressed at national (or EU) level with no or minimal international guidance' (Bodle et al., 2014, p. 126, emphasis in original). One means of decentralized, international (in one sense of the word) governance would be the coordination of national policies through less formal channels and horizontal peer networks.

Another means would be for states to encourage the development, elaboration, and operationalization of non-state governance. Although a handful of general principles have been developed for CDR and SRM, the most prominent of which have been the Oxford Principles (Rayner et al., 2013), these have been only weakly operationalized. Such decentralized international governance can be advantageous when states are reluctant to act, lay the groundwork for future national and international processes, and offer greater adaptiveness in the face of changing circumstances, growing knowledge, and emerging risks and challenges (Reynolds and Parson, 2020). It has been relatively successful in contested environmental domains, as evident in the Forest Stewardship Council and Marine Stewardship Council. Sometimes, non-state governance is later assumed, in diverse ways, by state actors. For example, human reproductive and genetic technologies are strongly contested. In this case, governance began with professional society's guidelines and some national regulation, expanded to joint statements by leading national academies of science, and has now been taken up by the World Health Organization. However, non-state governance may be less effective and perceived as less legitimate. Despite its non-state nature, authoritative action may be necessary to elaborate norms, catalyze bottom-up implementation, and offer focal points.

4.4. Range of potential substantive options for international governance

This section considers the substance of options for international governance of CDR and SRM. The intention here is to consider a wide range of possibilities. These incorporate the suggestions from chapter 3, as appropriate.

4.4.1. Facilitate research

CDR at substantial scales will be necessary to keep global warming within the Paris Agreement's goals, and SRM may later also be justified to limit climate change impacts. But much uncertainty remains, some of which could be resolved through research. Consistent with the objective of reducing climate change and its impacts, international governance could facilitate the effective and responsible research and development of CDR and SRM. Specifically, it could ensure that the technologies' capabilities, limitations, requirements, secondary effects, physical risks, and social challenges are understood well enough to support informed decision-making (see Grieger et al., 2019). Along these lines, the Swiss Academies of Arts and Sciences concludes, 'More research on CDR and SRM is therefore indispensable so that the corresponding costs, risks and side effects are known in the case of specific application projects' (Swiss Academies of Arts and Sciences, 2018, p. 4).

Research should align with policy goals and constraints. To do so, it should not be limited to the natural sciences and engineering but instead be multi-, inter-, and transdisciplinary. In this regard, the most recent decision on 'climate-related geoengineering' by the CBD COP (see above) calls for 'more transdisciplinary research and sharing of knowledge among appropriate institutions' (CBD/COP/DEC/XIII/14.5). In particular,

research should encompass continued modeling of climatic and other physical processes, potential negative secondary effects, responsible outdoor experiments, delivery means and equipment testing, trade-offs with the SDGs and other goals, public opinion assessments and stakeholder engagement, and social challenges. Scientific research of the various CDR techniques – although diverse – can generally orient toward their capacity to scale up and safely sequester carbon, whereas that of SRM must focus for now on questions of efficacy, technical feasibility and risks.

Although most research is enabled through national and private funding, some international processes could help this be more effective, efficient, responsible, and equitable. For example, international governance could 'encourage national spending, develop cost-sharing arrangements, and incentivize private investment' (Bodansky, 2013, p.546).

For one thing, statements by authoritative international bodies would indicate the importance of further research and proactively catalyze action. This is arguably more important for SRM, where research remains modest due to weaker linkage with existing climate change policy, potentially severe physical risks and social challenges, the lack of profit motive for private research, and ongoing contestation. As noted, the CBD COP has already made such a decision; others such as the UNFCCC COP, UNEP, WMO, IMO, and even UNGA could follow.

Second, international governance could make research more effective through several means. It could identify existing institutional and personal expertise to leverage as well as establish channels of knowledge exchange. Some coordination could prevent duplication of efforts. An international body could emphasize priorities, such as knowledge from diverse disciplines and backgrounds, exploration of multiple CDR and SRM technologies, ongoing monitoring and impact assessment, and investigations of the technologies' limitations, risks, and challenges. The latter priority is important so that the research does not unduly bias future decision-making in favor of the technologies' use. These tasks seem better fit for the international institutions that have substantial scientific expertise, such as UNFCCC SBSTA, UNEP, WMO, and IMO. Given the benefits of coordination and prioritization, a single site – or one for each of CDR and SRM – would be more preferable. Existing international research collaborations, including Future Earth and the Belmont Forum, could have important roles here.

Third, research could be improved through independent assessment, synthesis, and knowledge transfer. The IPCC and IPBES are well positioned for this.

Finally, international governance could help research be more equitable. It could encourage developed countries that have the means to do so to help build research capacity in developing ones, discussed more in chapter 3 (Textbox 8) and below.

4.4.2. Encourage the responsible use of CDR

CDR resembles GHG emissions reductions in that it lowers net emissions. It is necessary to meet internationally agreed-upon climate change goals, and parties to the Paris Agreement are obligated to 'take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases' (Article 5.1). Whoever undertakes CDR bears local financial and nonfinancial costs, while the entire world benefits from reduced atmospheric GHG concentrations. It is thus a global public good, which will be underprovided. Moreover, many CDR techniques face significant political and institutional headwinds. Some appropriate promotion of CDR is needed to overcome this collective action problem.

Encouraging and expanding the responsible use of CDR will require clarifying policy, including at the international level. For example, if states' leaders knew that they could meet their international mitigation obligations in part through specific techniques, then they would have the incentive to encourage CDR's research, development, and use. This suggests a need to integrate CDR into current standards of national emissions inventories (Paris Agreement, Articles 4.13, 13.7(a)). For the various CDR techniques, this would require both detailed provisions and clarity. The former would be for monitoring, reporting, verification of permanent removals and life cycle assessments. Clarity would regard parties' use of CDR in their Nationally Determined Contributions, long-term low emission development strategies, and use of the Article 6

cooperative mechanism. This should be done by the UNFCCC institutions – which have experience with LULUCF and reducing emissions from deforestation and forest degradation – in cooperation with the IPCC Task Force on National Greenhouse Gas Inventories. The UNFCCC institutions and IPCC could also, as part of the global stock-takes under the Paris Agreement, assess states' capacity to use CDR and progress in doing so.

4.4.3. Regulate risks for sustainable development

In order to help fulfil the SDGs, international governance should lessen negative secondary effects of CDR and SRM, from both their research and use (see IRGC, 2015). There is not a regulatory vacuum in this regard (see chapter 2). Instead, most of their risks, especially those of CDR, will be local and controlled primarily by national, subnational, and European regulation. Transboundary environmental risks, such as those from larger-scale CDR and SRM activities, are to some degree governed through existing international law, including the customary international law of transboundary harm. And risks to the marine environment – the most significant area beyond national jurisdiction – are subject to the widely-ratified and comprehensive UNCLOS.

Nevertheless, international governance could offer further guidance on how the SDGs, on the one hand, and the research, development, and potential use of CDR and SRM, on the other, can be pursued synergistically rather than in conflict. For one thing, governance could support the development, elaboration, and application of non-state principles, codes, and best practices. For another, international bodies could develop guidance for national regulation and the implementation of international law. Finally, it may be appropriate to develop international governance of SRM's significant transboundary risks. Either way, it should address more than only physical and environmental risks, but also other salient aspects such as transparency and public participation in decision-making. The amendment to the London Protocol that regulates 'marine geoengineering' could serve as a model in some ways (see section 2.3.6).

It is unclear at which site(s) such international governance concerning the physical risks and social challenges of CDR and SRM could be crafted. To the extent that this is limited to stimulating and coordinating national and non-state governance, then the UNFCCC, CBD, UNEP, WMO (for SRM only), and IMO, or a decentralized process, may be appropriate. International governance of large-scale SRM activities could be promulgated as a nonbinding decision by these institutions or might eventually warrant a new international instrument or body. In reality, governance will likely be developed and implemented in multiple international forums and institutions. This points toward a need for inter-institutional coordination and integration.

4.4.4. Further integrate with existing governance

CDR and SRM could be, to some extent, integrated with extant governance in order to make it more effective and legitimate and to work toward multiple objectives. Incorporation with climate change policy – described above in the context of encouraging the responsible use of CDR – is particularly important to manage the diverse responses and keep reducing GHG emissions as the top priority. Again, although much of this can occur in national policy, international governance could strengthen this by sending signals of priorities and coordination.

Relevant international institutions could assign the responsibility for interfacing with CDR and SRM to one or a small number of offices or, where appropriate, subsidiary bodies. They could then identify how the issues fit within the institutions' mandates, inventory and assess capacity, foster knowledge creation, strengthen engagement, and locate and describe challenges. Externally, these responsible offices and bodies could establish channels to strengthen inter-institutional communication and mutual learning. In this, the SGDs could serve as an integrative framework. These processes could possibly be catalyzed and arranged by the UN Environment Management Group or an independent multi-stakeholder forum.

4.4.5. Build governance capacity

Governance requires the capacity to, at multiple levels, effectively develop, monitor, and enforce as appropriate. However, states and other relevant actors may not yet have this capacity to govern novel emerging issues such as those of CDR and SRM. Some states could start building the requisite capacity for international governance domestically. Their relevant public departments could set aside resources, including dedicated staff, to take these matters on. Inter-agency coordination would also be beneficial. This will require substantial investment in learning about the technologies; their capacities, limitations, and risks; governance opportunities and challenges; and the associated politics.

Other states lack sufficient resources to build capacity domestically. Climate change research in general – of which CDR and SRM constitute only a small fraction -- is poorly funded in many parts of the globe. However, for multiple reasons including legitimacy and effectiveness, developing countries should participate in crafting and implementing international governance (Rahman et al., 2018). Efforts by developed countries to help build capacity in developing ones are consequently important. (The Solar Radiation Management Governance Initiative offers an example of effective non-state building of capacity in developing countries.) This would require investing both financial and intellectual resources, which could be done on a state-by-state basis or facilitated by international bodies, such as the UNFCCC SBSTA.

4.4.6. Strengthen international cooperation

Some observers are concerned that CDR and especially SRM could worsen international relations. Both sets of technologies could cause negative transboundary impacts and be perceived in an unwelcome light. Establishing and maintaining international trust could help prevent such an outcome or even strengthen international cooperation (Davies 2010, p. 279). Four means could advance this. The first was described above: building capacity in countries that lack it, such as through mutual learning, financial support, and knowledge transfer. Second is international research collaboration, including joint research projects and the exchange of expertise and experts. Third, research and development activities should be transparent. Here, SRM should arguably satisfy higher standards than those of routine scientific research. Fourth, militaries could be discouraged from involvement in SRM research and development. The first two of these – capacity building and international research collaboration – could be accomplished through diverse bi- and multilateral mechanisms, both formal and informal as well as existing and new. Together with transparency, they are relatively technical matters and could thus be handled by international institutions such as UNFCCC COP and SBSTA, UNEP, and WMO. The final issue of military involvement in SRM is more political and better suited to the UNGA or, if possible, through the parties of the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD; see chapter 2).

4.4.7. Leverage the private sector

Most innovation occurs in the private sector, and one of the leading governance mechanisms to encourage it is intellectual property (IP) rights, mainly patents. CDR and SRM may warrant dedicated IP policies. The former might benefit from patent pools for the various CDR techniques, public-private partnerships, and alternatives to patents, such as prizes. In contrast, because SRM offers distinct incentives – especially the lack of a clear profit model – and is more contested, novel dedicated governance of IP may be particularly beneficial. In addition, there may be areas of research and development, particularly in SRM, where states wish to limit the private sector's role. But in other cases, an SRM research commons could, for example, maintain the motivation to profit from legitimate SRM activities, such as providing services to public agencies via procurement; facilitate transparency through open-source standards and more; and prevent patent thickets (Reynolds et al., 2017). Although IP law is a national responsibility, international governance catalyzes, coordinates, and harmonizes it. This would call for the involvement of international institutions with IP expertise, such as the World Trade Organization and World Intellectual Property Organization.

4.4.8. Implement breakpoints, stage gates and moratoria

There is some worry that early research and development of CDR and SRM will cause future decision-making regarding their use to be unduly favorable. International governance could establish criteria under which CDR and SRM work would or would not proceed. A *breakpoint* is a commitment to stop under certain circumstances, while otherwise defaulting positively to proceeding. A *stage-gate* is an agreement to go forward for now, coupled with an explicit later decision concerning whether to continue. And a *moratorium* is a temporary ban that could be ended under certain conditions – that is, a negative default (Parson and Herzog, 2016).

On the one hand, these mechanisms are, in a general sense, appropriate and presumably widely supported for the higher stakes, less certain CDR and SRM technologies. Furthermore, they may be wise for individual projects and institutions. For example, a funding agency could, as it begins supporting CDR and SRM, make explicit conditions under which it would stop doing so. Indeed, the UK's Natural Environment and Engineering and Physical Sciences Research Councils used such a stage-gate when they funded CDR and SRM (Engineering and Physical Sciences Research Council, 2012). However, a challenge arises when a body would attempt to implement a breakpoint, stage gate, or moratorium that governs other actors. In effect, it would be claiming authority over others, which might or might not be perceived as legitimate. Moreover, the implementation of a moratorium is an implicit claim of the authority to lift it and consequently open the door to the contested activity at hand. Another limitation is that these policies may not be sufficiently adaptative, as those who develop the breakpoint, stage gate, or moratorium may not foresee the ways in which circumstances may change in the intervening time. This is particularly the case as the policies become temporally longer.

4.4.9. Establish a foundation for future decision-making

Some decisions in the international governance of CDR and SRM could have significant impact but are not yet ready to be made due to scientific and normative uncertainty as well as lack of trust. This is especially the case with the full range of environmental, social, and political issues associated with whether to use SRM. Fortunately, these future difficult decisions need not be made soon. However, they often cast a shadow over and can impede the development of governance in the near term. It could thus be helpful to take steps to lay a foundation for such future decision-making.

There are at least four mutually nonexclusive possible means to begin this process. First is so-called 'track II diplomacy,' in which authoritative individuals who are not formally bound to a state – retired officials, academics, religious and nongovernmental organization leaders – participate in closed-door workshops and other low-profile dialogues in order to make progress with contentious international issues (Jones, 2015). Despite its unofficial nature, track II diplomacy could be catalyzed by a state that is perceived as neutral in the issue area.

The second possible means would be to catalyze the formation of an esteemed body of diverse experts in an independent and multi-stakeholder roundtable, such as a 'World Commission on Climate Engineering' (Parson 2017; Chhetri *et al.*, 2018). Like track II diplomacy, its members should not be state officials, but its activities would be more visible.

Third, international governance institutions could dedicate resources to identify their capacities to contribute to governance, explore related future needs and challenges, and to conduct an impact assessment of considered policies.

Finally, states could initiate international dialogues over these longer-term decisions. These could occur in an existing intergovernmental institution such as UNEP or the WMO. (The political atmosphere in the UNFCCC could be strained by doing so there.) Broad participation would be important given SRM's likely global effects.

4.5. Recommendations

This section offers recommended steps toward international governance of CDR and SRM. Unlike the previous sections, which sought to capture a wide range of possibilities, these reflect the author's assessment of what one or a few states could feasibly and effectively initiate. These are based on the various technologies' capabilities, limitations, and risks (chapter 1); the current international legal and institutional arrangements (chapter 2); the critical trade-offs regarding physical and environmental impacts, governance, and research (chapter 3); and the assessment criteria (above). These six recommendations are not mutually exclusive and are, in some ways, complementary. Finally, most of them call for action in international organizations and institutions, which due to their member-driven characters, would require initiative from one or more states.

The first recommendation is a general one that underlies the other five: **to distinguish between CDR and SRM as well as among the diverse CDR techniques in their additional dedicated governance.** A functional approach implies that the technologies should be governed by the same mechanisms to the extent that their characteristics, opportunities, and risks are in common and by distinct mechanisms to the extent that they differ. Chapter 3 concludes that CDR's most salient aspects, including its risks, are largely local and vary among the diverse technologies, whereas those of SRM are primarily international and global. The heterogeneity of CDR techniques is evident in the review of their means of operations, risks, and challenges in chapter 1 (see also Cox and Edwards, 2019). Along these lines, a recent report on CDR by the *Stiftung Risiko-Dialog* (Risk Dialogue Foundation) commissioned by the Swiss Federal Office for the Environment concludes: 'Discussions of CDR under generic terms such as geoengineering should be avoided because they combine [with SRM] two fundamentally different approaches and risk profiles and are thus not effective. The discussion of risks, opportunities, potentials etc. requires a clear definition of each of the approaches' (Beuttler *et al.*, 2019, p.21). This is consistent also with the separation of CDR and SRM and rejection of the term 'geoengineering' in the IPCC Special Report on 1.5°C warming (IPCC, 2018, p. 550) and the US National Academies reports (National Research Council, 2015a and 2015b).

Second is **to accelerate authoritative, comprehensive, and international scientific assessment.** There is still no such assessment of the capabilities, limitations, impacts, risks, and governance needs of CDR and SRM. These assessments should be neutral with regard to which CDR and SRM technologies, if any, should be used. The preferred lead site for this is the IPCC, given its mandate, wide participation, and perceived legitimacy. It should dedicate substantial effort toward SRM, for which the knowledge base remains relatively limited and the need for outdoor testing and experimentation seems to be an obstacle. If the IPCC does not do so in its Sixth Assessment Report, then its Plenary Panel should thereafter devote special reports to CDR and to SRM. This could arise internally or be externally instigated, as the UNFCCC COP invited the IPCC to provide a special report on global warming of 1.5°C. Otherwise, assessment by UNEP and/or the WMO (for SRM only) may be justified. Because the scopes of the IPCC and WMO are limited, any assessment there should be complemented by work at IPBES and the Food and Agriculture Organization for effects on biodiversity, ecosystem services, and agriculture.

The **third** recommendation for the future governance of CDR and SRM is that the international policymaking community should **encourage the research, development, and responsible use of some CDR techniques**. This should be geared toward meeting the Paris Agreement's global warming goals and the SDGs. Specifically, the UNFCCC institutions should elevate CDR's visibility in the climate change regime's processes and activities; push for greater systematic consideration of parties' obligations to pursue CDR, under the rubric of enhancements of sinks and reservoirs; and work toward realistic and viable financial incentive systems. Any actions should be based on the best available scientific evidence and, as stated above, differentiate among the various CDR techniques. A COP decision should call for more transdisciplinary research, for parties and other intergovernmental institutions to establish a point of contact for CDR matters, for international information sharing and cooperation, and for GHG emissions reduction to remain the top priority. It could also establish an Ad Hoc Technical Expert Group on the enhancements of sinks and reservoirs that could, for example, regularly assess the potentials, risks, and social challenges of the techniques and

'scan the horizon' for new developments. As part of a COP decision, the UNFCCC's SBSTA should be directed to develop standards for the monitoring, reporting, and verifying of all permanent removals, as well to help build capacity in developing countries. At a later date, the 'Paris Rulebook' could be modified to clarify the extent to which parties may and should use CDR techniques in their Nationally Determined Contributions, their long-term low GHG emission development strategies, and the Article 6 cooperative mechanisms. Any COP decision should be in the context of the UNFCCC's principles including common but differentiated responsibilities and respective capabilities, full consideration of developing countries' specific needs and special circumstances, precaution, effectiveness and efficiency, and sustainable development.

Fourth, states should **help build capacity for evaluating CDR and SRM in some of those countries that lack the resources to do so**. A broad, diverse set of states will need to engage in order for any international governance to be effective and perceived as legitimate. Specifically, developed countries interested in CDR's and SRM's international governance should launch programs to partner with developing and climate-vulnerable ones, providing funding and academic partnerships that allow developing countries to address their own research priorities and build their own expertise. This would also constitute important 'science diplomacy,' creating peer-to-peer networks of experts, providing an intellectual foundation for subsequent governance work. Although one or a few developed countries' ability to help internationally build such capacity may seem limited, the resources required are modest, and initial steps by some states could catalyze action by others and by international institutions.

Fifth, states and intergovernmental institutions should **facilitate the elaboration and implementation of non-state governance**. In the absence of state action – often due to contestation and steep learning curves – non-state actors can further the international governance of CDR and SRM, which can help prepare for state governance at a later stage. This relatively bottom-up process would complement the other top-down ones. It should have an inclusive and deliberative approach and strive to advance widely shared norms of governance such as transparency, engagement with potentially affected stakeholders, and prior assessment of impacts. An ad hoc coalition of a few states and funders – both public and private – of climate change research could undertake this. They could begin by convening discussions of respected scientists in related fields, research institutions, and professional societies.

The **final** recommendation is for international processes that **explore potential further governance of SRM while remaining agnostic concerning its ultimate use**. This should be unrushed, stepwise, and open so that trust and knowledge can be established and assessments can be produced. The primary purposes of the process would be to engage more numerous and diverse states, allow them and the relevant international institutions to learn about and develop the capacity to address SRM, establish common understandings, and to build trust. A diverse international expert committee should be created. The output should include a report that lays out the current status, needs, opportunities, challenges, and options for the international governance of SRM, with specific reference to intergovernmental institutions' capacities to contribute. Although its substance would not be new – and not entirely unlike this current document – its origin would give it greater authority and visibility.

One path for this would be through an international institution. UNEP is the preferred site for such a process. Its mandate and capabilities include identifying emerging issues, conducting scientific reviews, and catalyzing international governance across issue areas and sectors. Moreover, it has a reputation for expertise and relatively low politicization. Independent of this processes' home, it should coordinate as appropriate with other relevant international institutions such as the UNFCCC and CBD.

Any action at UNEP would need to address the reasons that the 2019 resolution there was insufficiently supported. Four explanations are identified above (section 4.3.5 on UNEP). The proposed resolution jointly considered CDR and SRM and called for assessing the state of the science and knowledge of potential impacts. In contrast, the recommendation here is to begin an international dialogue on only SRM's governance. This leaves two remaining issues. Regarding precaution, its legal status and precise substantive content are not settled (German Research Foundation (DFG) Foundation's Priority Programme 1689, 2019, pp. 64-65; Bodle et al., 2014, p. 129), and precaution may be a poor guide in the context of high-stakes risk-

risk trade-offs. States' divergent preferences in this regard could be managed through a perambulatory passage in the resolution that recognizes well-established principles in international environmental law, including those in the UNFCCC, without explicit reference to precaution. Finally, concerning the objective of considering global governance frameworks, this could likewise remain implicit in order to garner sufficiently broad support. After all, the suggested process's primary purposes would be engagement, learning, and trust, not establishing international governance per se, even though these purposes are necessary for eventual governance.