I.15 Climate engineering and international law

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Abstract

In the face of dire forecasts of climate change and disappointing emissions abatement, some scientists and others are increasingly suggesting and researching intentional, large-scale interventions in natural systems in order to counteract climate change. These 'climate engineering' or 'geoengineering' proposals presently appear to hold the potential to significantly reduce the risks from climate change, but they also would pose environmental and social risks and would raise numerous legal questions, particularly at the international level. After introducing climate engineering, this chapter suggests why climate engineering is challenging for international environmental law and its scholars, briefly describes applicable international legal instruments and reviews the existing legal scholarship on the international environmental law of climate engineering, with particular attention to proposals for future international regulation. It closes with suggestions for future research.

Keywords

Climate engineering, geoengineering, climate change, global warming, international law, environmental law

Contents

I.15.1 Introduction

In response to increasingly dire forecasts for climate change and disappointing efforts towards emissions abatement and adaptation, some scientists have suggested and are researching large-scale, intentional interventions in earth systems in order to counteract climate change.[1] These 'climate engineering' or 'geoengineering' proposals are receiving growing attention and raise numerous legal questions, especially at the international level. This chapter introduces possible climate engineering methods, suggests why climate engineering is challenging for international environmental law and its scholars,

[1] Shepherd et al (2009); Keith (2013); McNutt et al, *Climate Intervention Intervention: Carbon Dioxide Removal and Reliable Sequestration* (2015); McNutt et al, *Climate Intervention: Reflecting Sunlight to Cool Earth* (2015).

briefly describes applicable international legal instruments, provides an overview of legal research to date – including proposals for future international regulation – and points towards opportunities for future explorations in the international law of climate engineering.

I.15.2 Climate engineering

Climate engineering consists of two distinct categories of proposed technologies. 'Carbon dioxide removal' (CDR, or 'negative emissions technologies') would remove the leading greenhouse gas from the atmosphere and sequester it for long time scales.[2] Examples include (1) bioenergy with carbon capture and sequestration (BECCS), in which plants would be grown and burnt to produce energy, and the resulting carbon dioxide captured; (2) direct air capture and sequestration, in which devices would process ambient air, capturing the carbon dioxide; (3) accelerated weathering, in which the natural processes that dissolve certain minerals would be enhanced; (4) large-scale afforestation and reforestation; and (5) ocean fertilization, in which the addition of the locally limiting nutrient would accelerate natural biological processes. The current evidence is that some proposed CDR methods could reduce net carbon dioxide emissions at reasonable costs, although the methods' capacities, reliabilities, environmental risks, co-benefits and costs vary widely.[3] CDR is slowly becoming part of the mainstream climate change discourse, although often under other nomenclature. For example, the more favourable scenarios in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change assumes large net negative emissions, primarily through BECCS.[4] Likewise, a recent report from the US National Academies concluded that 'It is increasingly likely that, as a society, we will need to deploy some forms of CDR to avoid the worst impacts of climate change'.[5] Compared to the other climate engineering category, CDR methods generally would be slow and expensive, and would have mostly low and localized risks.

The second category, 'solar radiation management' (SRM, or 'albedo modification') would increase the net reflectivity of the earth, counterbalancing the warming component of climate change.[6] Examples include (1) stratospheric aerosol injection, in which a fine mist would be spayed into in the upper atmosphere; (2) marine cloud brightening, in which the small salt particles remaining after ocean water sprayed into the air would make clouds whiter; and (3) space objects. The latest modelling indicates that some SRM methods, particularly stratospheric aerosol injection, could reduce net substantially and

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[2] For a review of recent scientific studies, including evidence of effectiveness, risks and costs, see McNutt et al, *Climate Intervention Intervention: Carbon Dioxide Removal and Reliable Sequestration* (2015).

[3] ibid.

[4] van Vuuren et al (2011).

[5] McNutt et al, *Climate Intervention Intervention: Carbon Dioxide Removal and Reliable Sequestration* (2015) 5.

[6] For a review of recent scientific studies, including evidence of effectiveness, risks and costs, see McNutt et al, *Climate Intervention: Reflecting Sunlight to Cool Earth* (2015). Note that there is one climate engineering proposal that fits neither of the main categories but is more akin to SRM. In this, atmospheric interventions would cause cirrus clouds to be less frequent and intense. Because these clouds naturally have a net greenhouse effect, this cirrus cloud thinning would allow more heat to escape the earth. See ibid at 105.

rapidly climate risks.[7] In fact, due to the delayed effects of other response options, SRM appears to be the only potential means to reduce risks due to the climate change that has already occurred at a given point in time. When compared to CDR, proposed SRM methods would generally be fast and inexpensive, and pose greater risks. Furthermore, due to these low expected financial costs, a small number of actors could undertake some SRM methods, bypassing the collective action problem that hinders emissions abatement (and CDR) but also presenting the threat of potentially problematic unilateral or non-state implementation. Because SRM would not remove greenhouse gases, other negative effects of elevated carbon dioxide concentrations such as ocean acidification would persist. Numerous authoritative bodies have called for SRM research, including the Royal Society of London and the US National Academies.[8]

Although climate engineering presently appears to hold the potential to reduce climate change risks significantly, it would also pose environmental and social risks, some of which could arise in the case of large-scale field experiments and vary by the particular method. For example, ocean fertilization would alter marine ecosystems. Some proposed terrestrial CDR methods, including BECCS, would require great amounts of land, likely increasing food prices and impacting biodiversity. SRM would unevenly counteract climate change's temperature and precipitation anomalies, leaving residual climate deviations relative to pre-industrial conditions. Other environmental risks likely remain unknown. Perhaps the most pervasive social risk is that climate engineering might undermine emissions abatement efforts.[9] Another is that, because SRM would be inexpensive yet potentially affect the entire world's climate, decision making and managing disputes could be challenging. Finally, if SRM were to be implemented and subsequently stopped for some reason, the previously suppressed climate change would occur rapidly, with greater environmental harm.

I.15.3 The challenges of climate engineering for international environmental law

Because climate engineering presents risks of harm that may be transboundary or occur in areas beyond national jurisdiction, international environmental law is relevant. Indeed, international law's present ability and future potential to regulate climate engineering have thus far received the bulk of scholarly attention.[10] How to coordinate efforts and manage its potential benefits may be subject to international law as well.

Climate engineering is a challenging topic for international environmental law and its scholars, for at least five reasons. First, it is a new set of proposed technologies, which might be developed rapidly, whereas international law is slow-moving. Second, climate engineering could be of a global scale, and consequently invoke a multitude of legal agreements, customs and principles, all of which have the potential to conflict with one another. Third, climate engineering presents a certain tension, in that it would strive to reduce environmental risks, yet simultaneously create environmental risks of its own.

[7] Kravitz et al (2014).

[8] Shepherd et al (2009); McNutt et al, *Climate Intervention: Reflecting Sunlight to Cool Earth* (2015).

[9] For example, until 2006 this was the dominant justification for a taboo within the climate change community on publicly considering climate engineering. See Preston (2013) 25.

[10] See text to n 11–14 and 27–34.

Fourth, whereas most environmental problems can considered negative externalities with the environment as their medium, SRM climate engineering appears to offer large positive externalities, and thus generates governance issues that are outside the traditional core of environmental law, such as coordination, mutual restraint and prevention of misuse. Finally, modern environmental law grew out of a broader cultural realization that humans have failed to account for their actions' negative environmental impacts, particularly those that are large-scale or utilize novel technology. Climate engineering seems to run counter to this cultural foundation, which often calls for humility and scepticism of humans' knowledge and technology.

I.15.4 Existing international environmental law

International legal scholars have engaged the topic of climate engineering from an early date. Daniel Bodansky laid the cornerstone in a brief 1996 article, whose conclusions essentially remain valid today.[11] First, because international environmental law was written without climate engineering in mind, it says little specific regarding the topic. Interpretation will thus be important but difficult. Second, in the absence of a violation of a particular agreement or custom, climate engineering activities – including unilateral action – are presumptively permitted, provided that due diligence is practised in the case of risk of transboundary harm. Third, a new international regulatory regime could be beneficial but would be very difficult to create. Fourth, in the consideration of new international legal instruments, there is a genuine hazard of premature and counterproductive restrictions and prohibitions due to international political dynamics. Finally, climate engineering may ultimately not be a legal matter, but instead a political one.

Since then, the largest strand within legal scholarship has been descriptive: how existing international law would apply to climate engineering. Ocean fertilization has received the most attention, at least initially,[12] although other specific methods[13] and climate engineering more generally[14] have also been explored.

How would existing international law apply to climate engineering? Sovereign states are generally free to govern their people and their domestic environments as they see fit, assuming an absence of transboundary harm. If there were risks of transboundary harm, then the customary law concerning *ex ante* due diligence of prevention and *ex post* responsibility would apply. The former would include appropriate measures to prevent or reduce potential harm; review by competent national authorities; prior environmental impact assessment; notification of, consultation with, and cooperation with the public and countries likely affected; development of emergency plans; and ongoing monitoring. The latter, which requires that a state's actions be contrary to international law, would call for cessation of the activity; assurances of non-recurrence; reparations through

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[11] Bodansky (1996).

[12] Freestone and Rayfuse (2008); Güssow et al (2010); Scott, 'Regulating Ocean Fertilization under International Law' (2013); Branson (2014); Wilson (2014); Ginzky and Frost (2014).

[13] Scott (2005); Parson (2006); Verlaan (2009); Proelss and Hong (2012).

[14] Bodansky (1996); Bodle (2010); Carlarne (2011); Redgwell (2011); Winter (2011); Scott, 'International Law in the Anthropocene' (2013); Wirth (2013); Reynolds, 'Climate Engineering Field Research' (2014).

restitution, compensation, and satisfaction; and victims' access to legal remedies. The matter of compensation and possible liability for harm is extremely complex because of both the large potential harm (and benefits) of climate engineering as well as the difficulty in attributing specific environmental phenomena to a particular climate engineering activity.[15]

Some multilateral environmental agreements would also be applicable to some or all proposed climate engineering methods. The UN Framework Convention on Climate Change (UNFCCC), its Kyoto Protocol and its Paris Agreement appear to include CDR within their means to abate emissions and stabilize greenhouse gas concentrations.[16] In fact, in the Paris Agreement, states explicitly commit to specific limits to global warming that will be very difficult to achieve without CDR, and they will do so by balancing emissions and removals of greenhouse gases.[17] However, the extent to which these methods could be included in a country's reporting and possibly exchanged in emissions trading systems is unclear. What the UNFCCC would mean for SRM is uncertain. These techniques would not contribute to the stabilization of greenhouse gas concentrations, the UNFCCC's objective, but could help achieve the Paris Agreement's aim of limiting global warming. Several hortatory statements, priorities and commitments in the UNFCCC imply at least calls for the consideration of SRM, perhaps through research.[18] The Environmental Modification Convention prohibits the hostile use of climate engineering but rhetorically encourages its peaceful application.[19] The Convention on Biological Diversity is worth highlighting because its Conferences of Parties have issued three statements on climate engineering, one of which is the only statement on climate engineering in general from an international legal forum with near-universal participation. This is a non-binding statement of caution, asking the Convention's parties to refrain from climate engineering that may affect biodiversity until there is scientific basis for such work and 'appropriate consideration of the associated risks'.[20] Under the UN Convention on the Law of the Sea (UNCLOS), states are obligated to protect and preserve the marine environment, including by preventing, reducing and controlling

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15 Kim (2014); Horton, Parker and Keith (2015); Reynolds, 'An Economic Analysis of Liability' (2015).

16 United Nations Framework Convention on Climate Change (UNFCCC) (adopted 9 May 1992, entered into force 21 March 1994) 1771 UNTS 107, Arts 2, 4.1(d), 4.2(a); Kyoto Protocol to the United Nations Framework Convention on Climate Change (adopted 11 December 1997, entered into force 16 February 2005) 2303 UNTS 148, Art 2.1(a)(iv); Paris Agreement, 'Report of the Conference of the Parties on its Twenty-first Session, Held in Paris from 30 November to 13 December 2015' UN Doc FCCC/CP/2015/10 (2016) Add.1.

17 Paris Agreement, ibid, Arts 2.1(a), 4.1.

18 See Reynolds, 'Climate Engineering Field Research' (2014) 437–41.

19 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (adopted 10 December 1976, entered into force 5 October 1978) 1108 UNTS 151, preamble, Arts I–III. The non-binding Provisions on Weather Modification of the UN Environmental Programme make similar exhortations. Provisions for Co-operation between States in Weather Modification, UNEP Dec 8/7/A, UN Doc UNEP/GC/8/7/A (1980).

20 'Report of the Tenth Meeting of the Conference of Parties to the Convention on Biological Diversity' UN Doc UNEP/CBD/COP/27 (2010) X/33/8(w). See also Secretariat of the Convention on Biological Diversity (2012).

pollution, whether from marine, atmospheric or terrestrial sources.[21] Its definition of pollution would include greenhouse gases, climate change and climate engineering activities, which will or are likely to have deleterious effects.[22] The parties to the London Convention and London Protocol, which govern ocean dumping, have developed a two-part regulatory system for ocean fertilization and other marine climate engineering. The first is a non-binding request for parties' national governments to allow only thoroughly assessed legitimate scientific research in the case of ocean fertilization.[23] The second is an approved, but not yet in effect, amendment to the London Protocol, which would regulate marine climate engineering more generally.[24]

As a further note, it may be unwise to restrict the consideration of international law to agreements, custom and principles, but instead to also include all rules and norms developed by authoritative institutions that are intended to guide behaviour. Considering the challenges to environmental law described above, as well as the fact that the researching scientists are, in some ways, transnational actors, non-binding quasi- and non-legal instruments may be more effective, at least in the short term, than binding multilateral environmental agreements. A handful of diverse groups have developed norms to guide climate engineering, its research and its future regulation. These call for, among other things, public participation in decision-making; disclosure, open publication and independent assessment of results; and the development of climate engineering in a manner that benefits the collective public.[25]

I.15.5 Towards international regulation

The second dominant strand within legal scholarship has been the prescriptive matter of how climate engineering should be internationally regulated.[26] Although early writings on climate engineering lumped together its two primary categories, there is increasing recognition that CDR and SRM offer distinct regulatory opportunities and challenges.

For the most part, CDR methods do not present novel challenges for international regulation. Because their environmental risks would mostly be local, these are primarily the domain of national law. There are two exceptions, the first of which is CDR techniques that would pose environmental risks in the high seas, such as ocean fertilization. Marine CDR has always been within the purview of UNCLOS, which has a comprehensive scope, widespread participation and binding dispute settlement procedures.[27] The assessment mechanisms of the London Convention and London Protocol, and the approved amendment to the latter, are poised to fill this first gap. The second exception

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21 United Nations Convention on the Law of the Sea (UNCLOS) (adopted 10 December 1982, entered into force 16 November 1994) 1833 UNTS 3, Arts 117–18, 192–237.

22 ibid, Art 1.1(4).

23 Resolution LC-LP.2 on the Assessment Framework for Scientific Research Involving Ocean Fertilization, IMO Doc LC 32/15/Annex 6 (2010).

24 Resolution LP.4(8) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and Other Marine Geoengineering Activities, IMO Doc LC 35/15/Annex 4 (2013).

25 Long et al (2011); Leinen (2011); Rayner et al (2013).

26 Note that 'regulation' as used here includes intentional steering of behaviour, not only the restriction of behaviour through rules.

27 Doelle (2014).

is whether and to what extent CDR activities could be included in a state's accounting of its reported greenhouse gas emissions, and whether the reductions could be marketed in international emissions trading systems. Looking at the examples of forestry, agriculture and land use changes, agreeing upon rules for this will be a highly technical and political matter.[28]

Prescriptions for future international regulations of SRM vary widely.[29] To a large degree, this variance reflects how the authors frame SRM and its regulation. Some describe SRM as an environmental and social risk, and how regulation could restrict it. In contrast, other observers refer to SRM as a potential additional tool to reduce climate risks, and consider how regulation could facilitate its development, balancing SRM's risks with those of climate change. From this, a rough continuum emerges. Towards one end are those who call for new binding, detailed rules – or even a prohibition[30] – to be developed and enforced by international legal bodies with near-universal participation, such as through amendments to the UNFCCC.[31] Scholars towards the other end point variously towards general, procedural and non-binding rules or standards that clubs of states and non-legal institutions could promulgate – at least for the time being.[32] Part of this latter contingent's motivation is pragmatic. Many of them note that binding, detailed rules would be unable to adapt to emerging technologies whose capacities, risks, co-benefits and costs as well as what societies want from them remain uncertain and changing; that forums with universal participation would likely produce deadlock or low participation rates among those countries with the capacity to implement SRM; and that the political desire for new international environmental agreements is low. Scholars in related fields such as economics and international relations have helped inform the prescriptive discourse, especially from the more pragmatic perspective.[33] Of course, this description of a continuum obscures details within and differences among the proposals, and there are proposals that do not clearly fit upon this continuum.[34]

Some other international legal issues of climate engineering besides the development of a future climate engineering regulatory regime have received particular attention. As noted above, the most frequent concern regarding climate engineering arguably

[28] Abate (2011); Branson (2014).

[29] For an introduction, see Bodansky (2013); Carlarne (2011). This wide variance is arguably due in part to the multiple challenges that climate engineering poses for traditional international environmental legal scholarship, described in Section I.15.3. Note that many but not all of the writings cited in this paragraph consider international regulation of climate engineering in general, implicitly or explicitly including CDR. However, most of the problems that they address are those of the global, high-leverage SRM methods. Therefore, proposals for the international regulation of climate engineering in general and of SRM only are considered jointly here.

[30] Winter (2011).

[31] Lin (2009); Abelkop and Carlson (2013); Scott, 'International Law in the Anthropocene' (2013); Bodle et al (2014).

[32] Bodansky (1996); Schelling (1996); Victor (2008); Virgoe (2009); Benedick (2011); Redgwell (2011); Dilling and Hauser (2013); Hester (2013); Parson and Ernst (2013); Reynolds, 'The International Regulation of Climate Engineering (2014).

[33] Schelling (1996); Barrett (2008); Victor (2008); Virgoe (2009); Benedick (2011); Barrett (2014).

[34] Barrett (2008); Honegger, Sugathapala and Michaelowa (2013); Kuokkanen and Yamineva (2013); Zürn and Schäfer (2013).

is that its consideration, research, development and implementation might unduly hinder emissions abatement. Whether this so-called 'moral hazard' problem would manifest and to what extent international regulation might be able to minimize it has been the focus of considerable debate.[35] Another question is how the precautionary principle could be applied when both climate change and climate engineering present risks of irreversible harm and scientific uncertainty, with observers variously asserting that a precautionary approach would rule out high-leverage SRM climate engineering methods or that it would call for its research.[36] Third, some authors have distinguished the more urgent matter of regulating climate engineering research from the more distant one of implementation.[37] Finally, several recent articles consider the need for, feasibility of, and possible mechanisms of compensating victims of harm from climate engineering.[38]

I.15.6 The outlook

Where can and should legal research of the international law of climate engineering go from here? Most importantly, regardless of the particular research question at hand, scholars should be more explicit as to what they want out of climate engineering and its regulation. Of course, it is not for them to dictate society's preferences, but as public analysts and advisors of current and future policies, it is our responsibility to voice any unstated assumptions. Because I consider climate change to be a serious threat to vulnerable humans and ecosystems, and climate engineering to be a potential means to reduce these risks, I recommend two particular paths of enquiry. One is the recognition that law, including international law, has not only restrictive functions such as constraints and prohibitions, but also enabling and facilitative functions such as obligations, incentives and exhortations for states to take action. Researchers could explore how the latter side of the coin may shape the international law of climate engineering.[39] The other is to consider how states may be able to coordinate their efforts and to manage the benefits of climate engineering research and implementation.

Beyond these, I suggest five possible or emerging avenues of academic enquiry. First, the general principles of law provide guidance for the development of new international law. However, besides the precautionary principle, these have been underexplored.[40] How, for example, can we conceptualize climate engineering with respect to the principles of polluter pays, common but differentiated responsibility, and sustainable development? Second, future international regulation will develop in a political context, and thus must consider the distribution of benefits and costs. To this end, an integration of rational design of international institutions with economic and climate modelling could help illuminate what regime characteristics may be feasible and perhaps

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35 Lin (2013); Parson (2013); Morrow (2014); Reynolds, 'A Critical Examination' (2015).

36 Hartzell-Nichols (2012); Tedsen and Homann (2013); Reynolds and Fleurke (2013).

37 Craik, Blackstock and Hubert (2013); Dilling and Hauser (2013); Reynolds, 'Climate Engineering Field Research' (2014); Lin (2015).

38 Kim (2014); Horton, Parker and Keith (2015); Reynolds, 'An Economic Analysis of Liability' (2015).

39 Reynolds, 'Climate Engineering Field Research' (2014) 433–34.

40 Burns (2011).

effective.[41] Third, intellectual property will be key. The potential roles of patents will vary. Assuming that CDR is adequately regulated to reduce its negative environmental impacts and to verify a project's net carbon sequestration, patents could offer effective incentives for research and development to reduce the costs of CDR techniques. In contrast, some observers have expressed concerns that SRM patents could restrict the open publication of results and could facilitate the growth of influential private interests in altering the global climate, a process that should be governed as a global public good.[42] Yet to date there have been few investigations in how intellectual property law can guide climate engineering's development towards normatively desirable outcomes.[43] Fourth, human rights have shaped international environmental law in general and climate law more specifically. No scholars have thus far explored whether there is a human right be free of climate engineering, or one to climate engineering in order to reduce climate risks. Finally, despite the attention to international law, climate engineering will likely (and hopefully) begin with small-stage field research and demonstration projects with only local effects. Furthermore, international law typically must be implemented through domestic legislation. Thus, the laws of nations, subnational units and the European Union will initially be more relevant, and can be more rapidly adapted and better enforced than international law.[44] Indeed, what appears to be the first proposed law to regulate climate engineering specifically was recently introduced as a Bill in a US state.[45] The future will likely see more.

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41 Ricke, Moreno-Cruz and Caldeira (2013); Weitzman (2015).

42 See eg Long and Scott (2013); Rayner et al (2013).

43 Davies (2013); Chavez (2015).

44 Hester (2011); Craik, Blackstock and Hubert (2013).

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