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# Regulating Geoengineering: Applications of GMO Trade and Ocean Dumping Regulation

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# Notes

# Regulating Geoengineering: Applications of GMO Trade and Ocean Dumping Regulation


ABSTRACT

*Geoengineering—the deliberate, large-scale manipulation of the environment—is being increasingly considered as an emergency solution to curb global warming, as efforts to reduce greenhouse gas emissions have largely proved inadequate. This Note explores one form of proposed geoengineering: solar radiation management, which contemplates spraying reflective particles into the stratosphere to cause a global cooling effect. Geoengineering presents many challenges to regulators because of its potential to cause trans-boundary harm, its relative ease of enactment, and its unknown nature. Current international environmental treaties do not address geoengineering and would likely inadequately regulate it. But premature multilateral geoengineering regulations, if agreed to by states, would likely stifle geoengineering research. Instead, norms surrounding geoengineering must be developed by researchers at the forefront of the field before these new standards are codified into multinational treaties. This Note looks to international GMO trade and ocean dumping regulations for inspiration as to how future multinational geoengineering regulation could work. Principles and institutions from these regulations—including the polluter pays principle, a mandatory permit system, and research and monitoring systems—should be incorporated into future international geoengineering regulations once adequate norms surrounding the substantive research of geoengineering are established.*


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## I. INTRODUCTION

As efforts to reduce greenhouse gas emissions look increasingly inadequate, scientists have begun to consider geoengineering—the deliberate, large-scale manipulation of the environment—as an emergency solution to curb anthropogenic climate change. [1] Geoengineering presents many challenges for international law, mostly because of its unknown nature, relative ease of enactment by a single state or entity, and likelihood of causing trans-boundary

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1. *See* INT'L PANEL ON CLIMATE CHANGE, MEETING REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE EXPERT MEETING ON GEOENGINEERING 10 (2012) [hereinafter IPCC EXPERT MEETING ON GEOENGINEERING]; INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014 SYNTHESIS REPORT SUMMARY FOR POLICY MAKERS 77 (2014), http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf [https://perma.cc/WR8M-YH96] (archived Oct. 12, 2017) [hereinafter IPCC SYNTHESIS REPORT] ("Without additional mitigation efforts beyond those in place today, and even with adaption, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally."); *see also* Jesse Reynolds, *The International Regulation of Climate Engineering: Lessons from Nuclear Power*, 26 J. ENVT'L L. 271 (2014) (noting proposals for climate engineering as responses to climate change).

effects.[2] These challenges also raise ethical and social questions beyond the scope of geoengineering's technical feasibility.[3]

There are two main categories of geoengineering: Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM).[4] CDR proposals envision removing carbon dioxide from the atmosphere and storing it underground or in the ocean.[5] Examples of CDR technologies include carbon capture and storage,[6] enhanced weathering strategies,[7] and direct air capture.[8] Proposed SRM techniques aim to reduce the amount of solar radiation absorbed by the Earth by increasing the reflectivity of the Earth's surface or by imitating the global cooling effect caused by volcanic eruptions by spraying reflective participles into the stratosphere.[9] This technique would increase the reflectivity of clouds by sowing them with seawater droplets.[10] This Note focuses on regulating SRM due to the dilemma it presents to regulators: SRM is cheaper and faster acting than CDR, but risks causing further environmental harm to the planet.[11] Unilateral SRM implementation could affect precipitation

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2. *See generally* David G. Victor, *On the Regulation of Geoengineering*, 24 OXFORD REV. OF ECON. POL'Y, 322–36 (2008); *see also* Reynolds, *supra* note 1, at 272 (discussing the environmental and social risks of geoengineering).

3. *See generally* Adam Corner et al., *Perceptions of Geoengineering: Public Attitudes, Stakeholder Perspectives, and the Challenge of 'Upstream' Engagement*, 5 WILEY INTERDISC. REV.: CLIMATE CHANGE, 451–66 (2012).

4. Reynolds, *supra* note 1, at 271.

5. *See id.*

6. *What is CCS?*, CARBON CAPTURE AND STORAGE ASS'N, http://www.ccsassociation.org/what-is-ccs/ (last visited Oct. 12, 2017). [https://perma.cc/9ZQY-QA28] (archived Oct. 10, 2017) (carbon capture and storage is a technology that captures $CO_2$ produced from the use of fossil fuels and stores it underground, preventing it from entering the atmosphere).

7. Letter from Taylor et al., to Nature Climate Change (Dec. 14, 2017), http://www.nature.com/nclimate/journal/v6/n4/full/nclimate2882.html?WT.feed_name=subjects_climate-change-mitigation [https://perma.cc/BZ5A-UTVD] (archived Oct. 10, 2017) (subscription required). Enhanced weathering techniques contemplate distributing pulverized silicate rocks across the ocean floor and on land to speed up the carbon cycle, locking up carbonates in the process.

8. For a discussion of CDR methods and their potential effects, see A. NEIL CRAIK & WILLIAM C.G. BURNS, CLIMATE ENGINEERING UNDER THE PARIS AGREEMENT 2 (2016); *see also* Christa Marshall, *In Switzerland, a Giant Machine is Sucking Carbon Directly From the Air*, SCIENCE (June 1, 2017, 10:30 AM), http://www.sciencemag.org/news/2017/06/switzerland-giant-new-machine-sucking-carbon-directly-air [https://perma.cc/4AVA-3D9E] (archived Oct. 10, 2017). Direct air capture involves removing carbon dioxide directly from the air through a filtering and heating process.

9. Reynolds, *supra* note 1, at 271; *see also* IPCC EXPERT MEETING ON GEOENGINEERING, *supra* note 1, at 10.

10. CRAIK & BURNS, *supra* note 8, at 2. For a more detailed discussion of SRM methods, see William C.G. Burns, *Geoengineering the Climate: An Overview of Solar Radiation Management Options*, 46 TULSA L. REV. 283 (2012).

11. Reynolds, *supra* note 1, at 271 (explaining that SRM is "relatively fast, inexpensive, and high risk," while CDR is "relatively slow, expensive, and low risk").

patterns in other regions and "may not appropriately address the global scale" of climate change.[12]

One of the major political, ethical, and legal challenges of regulating SRM is that scientists believe it could disparately impact global temperatures and precipitation levels, potentially causing negative side effects in some regions of the world.[13] Geoengineering, because of its relatively inexpensive nature, provides states with the opportunity to act unilaterally in ways that may therefore disparately impact other states.[14] For example, SRM deployed in one country could unevenly alter global temperature and precipitation levels in other regions of the world, impacting other regions' ecosystems, agriculture, and industries.[15] Another challenge is that if SRM efforts were to be deployed and then discontinued, climate change would likely accelerate far beyond its current trajectory.[16] One estimate warns that failing to sustain geoengineering, once implemented, could result in global warming at a pace twenty times greater than today.[17]

Currently, there are no international laws that explicitly regulate geoengineering.[18] While geoengineering would likely lie within the purview of several international environmental treaties, including the United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement, the United Nations Convention on the Law of the Sea (UNCLOS), the Kyoto Protocol, the Convention on Biological Diversity (CBD), and the Environmental Modification Convention (ENMOD), these existing treaties would inadequately regulate geoengineering.[19] Existing regulatory frameworks would at most regulate geoengineering intended as a weapon and would not prohibit geoengineering research aimed at reducing harm to humans and the environment.[20]

A comprehensive regulatory framework must be enacted eventually to ensure that states adequately research, coordinate, and exercise mutual restraint before enacting geoengineering. Without

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12. IPCC EXPERT MEETING ON GEOENGINEERING, *supra* note 1, at 10.

13. CRAIK & BURNS, *supra* note 8, at 2 (noting that changes to average temperature would not be uniform, "imperiling food production in some regions of the world").

14. Victor, *supra* note 2.

15. CRAIK & BURNS, *supra* note 8.

16. IPCC SYNTHESIS REPORT, *supra* note 1, at 89 ("Additionally, if SRM were increased to substantial levels and then terminated, there is high confidence that surface temperatures would rise very rapidly (within a decade or two). This would stress systems that are sensitive to the rate of warming.").

17. Victor, *supra* note 2, at 324.

18. *See* Reynolds, *supra* note 1, at 273 (noting that there is "consensus that existing international regulation—broadly defined—of climate engineering is inadequate").

19. *Id.*

20. Victor, *supra* note 2, at 322.

comprehensive regulation, states may unilaterally undertake geoengineering in ways that could harm other states that may not have consented to the geoengineering efforts. While most scholars agree that specific geoengineering research and implementation regulation is needed, there is no consensus as to how to accomplish such regulation.[21] Some believe that geoengineering regulation should be developed through existing international legal institutions, such as the creation of a new protocol to the UNFCCC or of an entirely new international governance structure specifically for geoengineering.[22] Others believe norms should develop from the bottom up, as to avoid "premature, poorly-crafted binding rules."[23] These proposals often include coordinated research efforts and a ban on geoengineering research and deployment above a certain level.[24]

US scientists have already begun advocating for a ground-up regulation regime. In January 2017, researchers from the U.S. Global Change Research Program (USGCRP), a US executive office that oversees federally funded climate research, asked Congress to provide funding for a geoengineering research program.[25] The USGCRP's research program plans to "provide[] insight into the science needed to understand pathways for climate intervention or geoengineering and the possible consequences of any such measures, both intended and unintended."[26] In its report, the USGCRP supported the idea of scientist-directed norm creation, noting the importance of "laying a science and governance foundation that would allow potential future

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21. *Id.* at 330–33; Reynolds, *supra* note 1, at 286–87.

22. *See* Reynolds, *supra* note 1, at 273 ("The most-cited forum is the Conference of Parties to the UN Framework Convention on Climate Change (UNFCCC-COP), which could possibly work towards a new Protocol to the UNFCCC. Others argue that such forums would be unproductive and likely lead to stalemate or to premature, poorly crafted binding rules."); Martin L. Weitzman, *A Voting Architecture for the Governance of Free-Driver Externalities, with Application to Geoengineering*, 117 SCAND. J. OF ECON. 1049, 1064–66 (2015) (arguing for a permanent international governance structure for geoengineering).

23. Reynolds, *supra* note 1, at 273; *see* Victor, *supra* note 2 at 331–32; *see also* Jesse Reynolds, *The Regulation of Climate Engineering*, 3 L., INNOVATION & TECH. 131 (2011) ("Some observers believe that binding regulations are not only unnecessary, but could do more harm than good. They emphasise the present lack of knowledge and the absence of incentives for countries with the capacity for climate engineering to endorse a binding agreement. Furthermore, detailed constraints on behaviour now may prevent valuable research from occurring. Instead, such writers thus recommend the development of norms from the bottom up.").

24. Reynolds, *supra* note 1, at 273.

25. Eli Kintisch, *U.S. Should Pursue Controversial Geoengineering Research, Federal Scientists Say for First Time*, SCIENCE (Jan. 9, 2017, 9:00 AM), http://www.sciencemag.org/news/2017/01/us-should-pursue-controversial-geoengineering-research-federal-scientists-say-first [https://perma.cc/8Z96-95S9] (archived Oct. 10, 2017).

26. U.S. GLOBAL CHANGE RESEARCH PROGRAM, THE NATIONAL GLOBAL CHANGE RESEARCH PLAN 2012–2021: A TRIENNIAL UPDATE 37 (2017), https://downloads.globalchange.gov/strategic-plan/2016/usgcrp-strategic-plan-2016.pdf [https://perma.cc/Z5DP-HNPW] (archived Oct. 10, 2017).

experiments to be conducted in ethical and responsible ways."[27] The report also noted "the need to understand the possibilities, limitations, and potential side effects of climate intervention . . . with the recognition that other countries or the private sector may decide to conduct intervention experiments independently from the U.S. government."[28] This push to research geoengineering from the scientific community will help establish norms that can later establish an international regulatory scheme, once it appears that large-scale geoengineering projects are imminent.

This Note proposes that once sufficient norms have been established from the ground up, geoengineering regulation should be modeled after aspects of both marine dumping and international genetically modified organism (GMO) trade regulations. Existing international GMO trade regulations mandate trans-boundary exporters of genetically modified organisms to adhere to a notification system. They also require exporters to register all relevant information with a clearing house. Additionally, ocean dumping regulations provide a useful analogy because of ocean dumping's relative ease and low cost, as well as its clear potential for harmful transboundary impacts. A compensation system for transboundary harms that result from unilateral geoengineering efforts should be created to discourage states from enacting geoengineering individually and prematurely.

## II. BACKGROUND

In the last century, the average temperature of the Earth's surface has increased by 0.78°C.[29] Climate change models predict that global surface temperatures will continue to significantly rise during the twenty-first century.[30] The majority of scientists believe that this global warming trend is mainly caused by human activities that release greenhouse gases such as carbon dioxide ($CO_2$) into the atmosphere, fueled by industrialization.[31] Greenhouse gases let sunlight into the atmosphere, but they prevent heat from exiting it, resulting in increased global and atmospheric temperatures.[32]

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27. *Id.*
28. *Id.*
29. STOCKER ET AL., INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS (TECHNICAL SUMMARY) 37 (2013).
30. *See id.* (projecting that the global surface temperature will rise between 0.5 to 3.1°F in the lowest emissions scenario and 4.7 to 8.6°F in the highest emissions scenario).
31. *See* IPCC SYNTHESIS REPORT, *supra* note 1, at 44, 47–48 (concluding that human influence, including economic and population growth, is "extremely likely" to have been the dominant cause of global warming since the pre-industrial era).
32. Reynolds, *supra* note 1, at 3.

Global warming presents many threats to the environment and to humanity. Unless climate change is mitigated, Earth is likely to continue to experience a myriad of environmental effects, including warming temperatures, rising sea levels, changes in precipitation, and glacial retreat.[33] Climate change is also likely to cause an increase in extreme weather events, such as droughts, heat waves, floods, and heavy snowfall.[34] These climate conditions might have further-reaching consequences, potentially resulting in species extinction, ocean acidification, lowered crop yield, food insecurity, and rising sea levels that could render certain areas of the world uninhabitable.[35]

Over the past twenty years, countries around the world have come together to discuss ways to mitigate and adapt to climate change.[36] Adaptation involves adjusting to the effects of actual or expected climate change, while mitigation involves limiting future climate change through "fundamental changes in the way that human societies produce and use energy services and land."[37] Adaption and mitigation implicate different timescales: adaption has the capacity to affect climate change risks in the near future, while mitigation has mostly long term benefits.[38] Reducing human fossil fuel consumption is a commonly discussed method of mitigation.[39] This can be accomplished by switching to different, non-carbon energy sources, such as wind, solar, and nuclear energy.[40] Other frequently discussed means of mitigating climate change include expanding forests to remove $CO_2$ from the atmosphere and making

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33. *See* IPCC SYNTHESIS REPORT, *supra* note 1, at 58 ("Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise.").

34. *Id.* at 56, 58 (noting the current effects of climate change and that "continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems").

35. *Id.* at 64–73. The report details the various regional and global future risks and impacts caused by climate change, ecosystem shifts, species extinctions, rising ocean temperatures, and rising sea levels. The report also notes that "climate change is projected to undermine food security" due to marine biodiversity reduction and impacts on crop growing conditions, combined with growing food demand.

36. *Id.* at 102 ("[I]nternational cooperation has helped to facilitate the creation of adaption strategies, plans, and actions at national, sub-national, and local levels . . . A variety of climate policy instruments have been employed, and even more could be employed at international and regional levels to address mitigation and to support and promote adaption at national and sub-national levels.").

37. *See* IPCC SYNTHESIS REPORT, *supra* note 1, at 76.

38. *Id.* at 77.

39. *Id.* at 76.

40. *Id.* at 85.

buildings more energy efficient.[41] These efforts, however, have not spurred nearly enough progress in mitigating climate change and reducing global warming.[42]

More drastic action is required to reduce carbon emissions and mitigate global warming. Geoengineering is being increasingly considered as a temporary (or emergency) solution to mitigate rising global temperatures.[43] The two primary methods of geoengineering are CDR and SRM.[44] Although CDR and SRM technologies are often grouped together, the two technologies raise different environmental and legal concerns. CDR proposals involve directly and indirectly removing $CO_2$ from the atmosphere through methods such as iron fertilization, large-scale afforestation, and direct capture of $CO_2$ from the atmosphere.[45] CDR proposals are relatively slow and expensive, and they are expected to have "potentially severe land use, water, and biodiversity consequences, as well as uncertain ecosystem impacts."[46] In contrast, SRM proposals seek to reduce the amount of sunlight absorbed in the climate system by deflecting sunlight away from the Earth's surface or by increasing the reflectivity of the Earth's surface and/or atmosphere.[47] There is significantly more scientific uncertainty surrounding SRM methods, but SRM would be faster and cheaper to implement than CDR methods.[48]

Scientists emphasize that geoengineering is not meant to be a long-term solution to climate change.[49] They assert that it only attacks the symptoms of climate change and does not attempt to fix its root cause (increased fossil fuel consumption).[50] However, it is important that regulation be put in place that allows for the safe research of geoengineering methods, in case emergency climate engineering action is needed at some point in the future. The United States' rejection of the Paris Agreement in 2017 highlights the growing need for more drastic solutions to global warming.

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41. *Mitigation*, NAT'L CLIMATE ASSESSMENT, http://nca2014.globalchange.gov/report/response-strategies/mitigation (last visited Oct. 13, 2017) [https://perma.cc/PP22-WVU4] (archived Oct. 13, 2017).

42. Victor, *supra* note 2, at 322–36; *see also* IPCC SYNTHESIS REPORT, *supra* note 1, at 81 ("Without additional efforts to reduce [greenhouse gas] emissions beyond those in place, global emission growth is expected to persist.").

43. *See* IPCC SYNTHESIS REPORT, *supra* note 1, at 89 (outlining possible roles, options, and risks of geoengineering).

44. *Id.*

45. IPCC MEETING REPORT, *supra* note 1, at 2.

46. CRAIK & BURNS, *supra* note 8, at 2.

47. IPCC Expert Meeting on Geoengineering, *supra* note 1, at 20.

48. *Id.*; *see also* IPCC SYNTHESIS REPORT, *supra* note 1, at 89 (noting that SRM is untested, but could "possibly provide rapid cooling in comparison to $CO_2$ mitigation").

49. JOHN SHEPARD ET AL., GEOENGINEERING THE CLIMATE: SCIENCE, GOVERNANCE AND UNCERTAINTY 58 (2009), https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2009/8693.pdf [https://perma.cc/H9KS-GC98] (archived Oct. 21, 2017).

50. *Id.*

The social and environmental risks of geoengineering are broad.[51] Countries and individuals may view geoengineering as the "easy way out," and stop taking steps to reduce carbon dioxide emissions, the root cause of climate change.[52] States may enter conflicts over issues of consent and control of geoengineering projects. States may also disagree over the scale and intensity of proposed geoengineering projects. Because SRM is relatively inexpensive, it could be feasibly deployed by individual countries or even by wealthy individuals or organizations.[53]

If SRM were implemented, changes in average temperature would likely be inconsistent around the world, impacting precipitation and potentially affecting food production in some areas of the world.[54] Additionally, it would be difficult to research the effects of geoengineering without conducting large-scale research, which may have negative environmental impacts of its own. Most significantly, if SRM efforts were to be deployed and then discontinued, climate change would likely accelerate far beyond its current trajectory, resulting in greater environmental damage than humanity would have faced if geoengineering had never been enacted at all.[55]

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51. Jesse Reynolds, The International Legal Framework for Climate Engineering 6 (working paper, 2015), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2586927 [https://perma.cc/79DY-C9BC] (archived Nov. 5, 2017); *see also* IPCC SYNTHESIS REPORT, *supra* note 1, at 89. If deployed, SRM could pose several shortcomings and unanticipated consequences, including a modest increase in ozone losses in the polar stratosphere. Furthermore, "if SRM were increased to substantial levels and then terminated, there is high confidence that surface temperatures would rise very rapidly (within a decade or two)," which would "stress systems that are sensitive to the rate of warming." SRM also raises "questions about costs, risks, governance and ethical implications of development and deployment," including "spatial and temporal redistributions of risks . . . introduc[ing] important questions of intragenerational and intergenerational justice." SRM deployment could fail a cost-benefit analysis on account of the range of its risks and side effects. Additionally, the "governance implications of SRM are particularly challenging, especially as unilateral action might lead to significant effects and costs for others." IPCC SYNTHESIS REPORT, *supra* note 1, at 89.

52. IPCC SYNTHESIS REPORT, *supra* note 1.

53. CRAIK & BURNS, *supra* note 8, at 2.

54. *Id.*

55. Reynolds, *supra* note 1, at 272 ("Perhaps the greatest risk would be if, once deployed, SRM were to stop for some reason, causing the climate change that would have occurred in the absence of SRM to occur in less than a year. This very rapid rate of climate change would cause much greater damage relative to 'normal' climate change.").

## III. ANALYSIS: WHY EXISTING INTERNATIONAL LAW WOULD NOT ADEQUATELY REGULATE GEOENGINEERING

### A. *Existing International Laws*

#### 1. The United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC may implicitly sanction CDR methods of geoengineering, but probably could not justify SRM technologies. The UNFCCC is an international environmental treaty that entered force on March 21, 1994 to regulate climate change.[56] The treaty carries "broad legitimacy" because of its "virtually universal membership"[57]—197 countries are parties to the UNFCCC.[58]

Although the UNFCCC does not explicitly address geoengineering, its definition of climate change likely encompasses geoengineering.[59] The UNFCCC was enacted to achieve the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [human-caused] interference with the climate system."[60] Furthermore, Article 4 of the Convention requires states to "promote and cooperate" in the conservation of the environment and could be used to support CDR.[61] States are obligated to implement measures to mitigate and adapt to climate change.[62] Article 4 also requires states to cooperate and exchange "relevant scientific, technological, technical, socio-economic and legal information related to the climate system and change, and to the economic and social consequences of various response

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56. United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 165, 31 I.L.M. 849 (1992) [hereinafter UNFCCC]; Daniel Bodansky, *Governing Climate Engineering: Scenarios for Analysis* 13 (Harvard Project on Climate Agreements, Discussion Paper 11–47, 2011), https://www.belfercenter.org/sites/default/files/legacy/files/bodansky-dp-47-nov-final.pdf [https://perma.cc/D9BU-CRHF] (archived Oct. 21, 2017).

57. ROBERT STAVINS ET AL., INTERNATIONAL COOPERATION: AGREEMENTS AND INSTRUMENTS 1005 (2014), https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter13.pdf [https://perma.cc/BC99-KU7C] (archived Oct. 13, 2017).

58. *Status of Ratification of the Convention*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php (last visited Oct. 13, 2017) [https://perma.cc/LQT4-3V8K] (archived Oct. 13, 2017).

59. *See* UNFCCC, *supra* note 56, art. 1, ¶ 2 (defining "climate change" as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods").

60. UNFCCC, *supra* note 56, art. 2 ("[S]uch a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.").

61. *Id.* art. 4.

62. *Id.* art. 4(b).

strategies."[63] This provision would be beneficial to the geoengineering endeavor because it would require states to share scientific information about the consequences of geoengineering, which would result in well thought out geoengineering efforts and reduce potential harms.

Article 4 of the UNFCCC could potentially constrain geoengineering efforts.[64] Article 4 requires member states to "employ appropriate methods . . . with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change."[65] This provision could constrain geoengineering efforts because of geoengineering's potential to cause further harm to certain environments.

Although CDR may be sanctioned implicitly by the UNFCCC, SRM is less likely to be. The aim of the UNFCCC is to stabilize "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[66] CDR involves reducing concentrations of greenhouse gases in the atmosphere, and thus would be arguably consistent with the ultimate objective of the UNFCCC and could one day count toward a country's adaption or mitigation efforts.[67] It is less likely that SRM technologies would fall under the purview of the UNFCCC, because SRM techniques would lower global temperatures, but not stabilize greenhouse gas emission levels, and therefore would not be aligned with the expressed goal of the UNFCCC.

The preamble of the UNFCCC also could be used as an argument against SRM implementation. The preamble specifically refers to a principle derived from the 1972 Stockholm Declaration, which codified the international customary law against committing transboundary harm.[68] SRM techniques have the capacity to effect transboundary harm, and could therefore be limited by this provision.[69] However, the UNFCCC also calls for minimization of "the adverse effects of climate change" in a rapid and inexpensive manner "to ensure global benefits at the lowest possible cost," which could be interpreted to allow for the implementation of SRM methods.[70]

Ultimately, the UNFCCC does not provide a clear framework for regulating SRM. Scholars are widely in agreement on this point, though some have argued that a new Protocol to the UNFCCC could

63. *Id.* art. 4(h).
64. *Id.* art. 4.
65. *Id.* art. 4(f).
66. *Id.* art. 2.
67. *Id.* art. 4(b).
68. *Id.* at preamble.
69. For a discussion of SRM's potential transboundary risks, see Reynolds, *supra* note 1, at 272.
70. UNFCCC, *supra* note 56, art. 3.

be established to regulate geoengineering.[71] Others have argued that a Protocol established through an existing international legal institution such as the UNFCCC would "be unproductive and likely lead to stalemate or to premature, poorly-crafted binding rules."[72]

2. The Kyoto Protocol

The Kyoto Protocol, which requires parties to set greenhouse gas emissions reduction standards, would encourage CDR proposals but would not in any way address SRM proposals. On February 16, 2005, parties to the UNFCCC established the Kyoto Protocol within the framework of the UNFCCC to work toward the goals outlined in the UNFCCC.[73] The Kyoto Protocol was ratified by all Annex I parties to the UNFCCC besides the United States.[74] The Kyoto Protocol requires its parties to set greenhouse gas emission reduction targets and keep records of their actual greenhouse gas emissions, placing a heavier burden on industrialized countries to do so.[75] The Protocol uses registry, reporting, and compliance systems to ensure that countries accurately monitor and report their emissions.[76] The compliance arm of the Kyoto Protocol includes an enforcement branch that imposes strict penalties on countries whose carbon emissions exceed their assigned amounts.[77] Parties deemed to be non-compliant are declared as such and required to make up the difference between their actual emissions and assigned emissions during the next period, plus a deduction of thirty percent.[78] Non-compliant parties are also required to submit a compliance plan and are suspended from emissions trading until they are reinstated.[79]

Although CDR technologies could qualify for credit under the UNFCCC's Kyoto Protocol, SRM technologies do not contemplate the reduction of greenhouse gas emissions and therefore would not qualify for credit under the Kyoto Protocol. The Kyoto Protocol would

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71. *See* Reynolds, *supra* note 1, at 273.

72. Reynolds, *supra* note 1, at 273.

73. *Kyoto Protocol*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/kyoto_protocol/items/2830.php (last visited Oct. 13, 2017) [https://perma.cc/WFJ6-HL8C] (archived Oct. 13, 2017).

74. *Status of Ratification of the Kyoto Protocol*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE (Dec. 11, 1997), http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php (last visited Oct. 13, 2017) [https://perma.cc/RT4Q-MJ6D] (archived Oct. 13, 2017).

75. *Kyoto Protocol*, *supra* note 73.

76. *Id.*

77. *An Introduction to the Kyoto Protocol Compliance Mechanism*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/kyoto_protocol/compliance/items/3024.php (last visited Oct. 13, 2017) [https://perma.cc/49CU-8CBE] (archived Oct. 13, 2017).

78. *Id.*

79. *Id.*

not reward other forms of global warming prevention, such as SRM, and could even disincentivize SRM research and implementation.

3. The Paris Agreement

While the Paris Agreement's goals could be met by CDR methods, the agreement does not provide any justification for implementing SRM technologies and therefore would be inadequate to regulate SRM.[80] In 2015, at the 21st Climate Change Conference of the Parties, 195 countries adopted the Paris Agreement—the world's first broad climate agreement—within the framework of the UNFCCC to ambitiously mitigate and adapt to climate change.[81] The Paris Agreement was designed to "enhance[e] the implementation" of the UNFCCC by aiming to "strengthen the global response to the threat of climate change."[82] The Paris Agreement is "bottom-up" in nature, meaning that it relies on individual countries to determine their own methods and commitment levels to achieve the overall goals of the agreement.[83]

The parties to the Paris Agreement established a long-term goal of holding the global average temperature increase to "well below 2°C above pre-industrial levels," ideally holding the increase to 1.5°C.[84] The parties also agreed to establish nationally determined contributions (NDCs) to determine their individual contributions to the agreement's overall goal.[85] Article 3 of the Paris Agreement requires that parties set "ambitious" NDCs that increase over time.[86] Parties also agreed to act with transparency, reporting to each other and to the public about their progress toward mitigating climate change.[87]

However, the NDCs set by individual countries are not binding, and the Paris Agreement does not include mechanisms to enforce the contributions.[88] The lack of an enforcement mechanism has resulted in some criticism directed towards the structure of the Paris Agreement. A study published in *Nature Magazine* in 2016 concluded that current NDCs will not lead to a temperature increase of less than 2°C, although the authors found the progressive requirement to

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80. *See generally* CRAIK & BURNS, *supra* note 8 (outlining SRM technologies).

81. *U.S., China Formally Enter Climate Change Deal,* CBS NEWS (Sept. 3, 2016), http://www.cbsnews.com/news/us-china-enter-climate-change-deal/ [https://perma.cc/R4CW-CHUQ] (archived Oct. 13, 2017).

82. Adoption of the Paris Agreement, art. 2, U.N. Doc. FCCC/CP/2015/L.9 (Apr. 22, 2016) [hereinafter Paris Agreement].

83. CRAIK & BURNS, *supra* note 8, at 4.

84. Paris Agreement, *supra* note 82.

85. *Id.* art. 3.

86. *Id.*

87. *Id.* art. 4.

88. *See generally id.* (failing to provide for specific enforcement mechanisms).

be promising.[89] The World Pensions Council further criticized the Paris Agreement for resting on the assumption that countries will voluntarily reduce their carbon pollution without any binding enforcement mechanisms or fiscal penalties (i.e., a carbon tax).[90]

The Paris Agreement could provide an adequate framework for regulating CDR, as the Paris Agreement's goals could be met by CDR methods.[91] Inclusion of CDR technologies as part of a country's NDC likely would be allowed under Article 4, "which includes $CO_2$ removals as part of the mitigation commitments expected from parties" as part of their NDCs, but would "raise concerns regarding technological readiness and equity in effects."[92] Although the Paris Agreement does not explicitly address geoengineering, the Agreement's main objective of holding the global average temperature increase to below 2°C can likely only be met by utilizing geoengineering technologies.[93] The majority of modeled scenarios that result in $CO_2$ levels consistent with the goal of the Paris Agreement rely on the use of geoengineering technologies in conjunction with emissions reductions.[94]

Article 4 of the Paris Agreement does not provide any justification for implementing SRM technologies, however.[95] Unlike CDR, SRM envisions the injection of reflective particles into the stratosphere, and does not implicate the removal of $CO_2$ from the atmosphere.[96] Article 4 does not support including the injection of reflective aerosols in the stratosphere in a country's mitigation efforts.[97] Nevertheless, the procedural and institutional elements of the Paris Agreement would provide for opportunities to address the "transparency and public deliberation" that SRM research and implementation would likely demand.[98]

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89. Joeri Rogelj et al., *Paris Agreement Climate Proposals Need a Boost to Keep Warming Well Below 2°C*, NATURE (June 30, 2016), http://www.nature.com/nature/journal/v534/n7609/full/nature18307.html [https://perma.cc/U8ZW-SF4P] (archived Oct. 13, 2017) (subscription required) (concluding that NDCs "collectively lower greenhouse gas emissions compared to where current policies stand, but still imply a median warming of 2.6–3.1 degrees Celsius by 2100").

90. M. Nicolas Firzli, *The Real Fight Against Emissions is Being Waged by Markets*, FIN. NEWS (Jan. 22, 2016), http://www.efinancialnews.com/story/2016-01-25/un-climate-conference-cop21-laurent-fabius-carbon-emissions-calpers-calstrs [https://perma.cc/5HW8-JZEV] (archived Oct. 13, 2017) (subscription required).

91. CRAIK & BURNS, *supra* note 8, at 13.

92. *Id.*

93. *Id.*

94. *Id.* at 1; *see also* T. Gasser et al., *Negative Emissions Physically Needed to Keep Global Warming Below 2°C*, NATURE COMM. (Aug. 3, 2015), https://www.nature.com/articles/ncomms8958 [https://perma.cc/SWK9-HEQZ] (archived Oct. 21, 2017).

95. CRAIK & BURNS, *supra* note 8, at 13.

96. *See* Reynolds, *supra* note 1, at 271.

97. Paris Agreement, *supra* note 82, art. 4.

98. CRAIK & BURNS, *supra* note 8, at 13.

The lack of enforcement mechanisms in the Paris Agreement heightens the need for goodwill and party commitment to reducing carbon emissions. The influence of the Paris Agreement was threatened on June 1, 2017, when US President Donald Trump announced that the United States would be withdrawing from the Paris Agreement.[99] The United States will not be officially withdrawn from the Paris Agreement until fall 2020, but President Trump's announcement demonstrated his administration's lack of commitment to curbing global warming and to meeting carbon emissions reduction targets.[100] The United States' exit poses a risk to the future of the Paris Agreement, to the likelihood of other countries meeting their carbon emissions targets, and to reducing global warming more broadly. The United States' "leadership was essential" to the Paris Agreement, and its withdrawal increases the risk that other countries will follow suit.[101]

4. The Environmental Modification Convention

The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) would prohibit climate engineering used for military or hostile

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99. Michael D. Shear, *Trump Will Withdraw U.S. From Paris Climate Agreement*, N.Y. TIMES (June 1, 2017), https://www.nytimes.com/2017/06/01/climate/trump-paris-climate-agreement.html [https://perma.cc/N3BW-9BXS] (archived Oct. 13, 2017) (subscription required).

100. *See* Mythili Sampathkumar, *Donald Trump says 'something could happen with the Paris Agreement'*, INDEPENDENT (July 14, 2017), http://www.independent.co.uk/news/world/americas/us-politics/trump-paris-agreement-macron-france-visit-climate-change-something-could-happen-a7840021.html [https://perma.cc/7AJK-AT8E] (archived Oct. 13, 2017); *see also* Anthony Janetos, *Pulling out of Paris will harm the poor in the US and abroad,* CONVERSATION (June 1, 2017), https://theconversation.com/why-trumps-decision-to-leave-paris-accord-hurts-the-us-and-the-world-78707 [https://perma.cc/BPD6-QUVX] (archived Oct. 13, 2017) (noting that the U.S. will likely refuse to make additional contributions to the U.N. Green Climate Fund).

101. Kevin Trenberth, *A race to the bottom to destroy the planet,* CONVERSATION (June 1, 2017), https://theconversation.com/why-trumps-decision-to-leave-paris-accord-hurts-the-us-and-the-world-78707 [https://perma.cc/BPD6-QUVX] (archived Oct. 13, 2017) ("The U.S. leadership was essential in Paris. If the U.S. does not lead by example – and we have a moral and ethical responsibility to do so as the country that has contributed more than any other to accumulated greenhouse gas emissions so far – then why should anyone else go along?"); *see also* Travis N. Rieder, *Pulling out of the Paris Agreement is unconscionable,* CONVERSATION (June 1, 2017), https://theconversation.com/why-trumps-decision-to-leave-paris-accord-hurts-the-us-and-the-world-78707 [https://perma.cc/BPD6-QUVX] (archived Oct. 13, 2017) ("[A]nnouncing America's intention to withdraw from the agreement sends a clear message to the rest of the world that the second-highest emitting nation has no intention of doing its part to save the world's most vulnerable people from impending harm.").

purposes.[102] ENMOD entered force on October 5, 1978, and has seventy-six parties, including the United States.[103] ENMOD was enacted in response to a resolution by the US Senate encouraging an international agreement "prohibiting the use of any environmental or geophysical modification activity as a weapon of war" and subsequent discussions between the United States and the USSR.[104]

ENMOD likely would not constrain geoengineering conducted for reducing climate change.[105] The Agreement explicitly states that it "shall not hinder the use of environmental modification techniques for peaceful purposes," and even encourages such applications.[106] Furthermore, the Agreement is essentially inactive.[107] ENMOD did not create standing institutions or call for its parties to meet regularly, and no complaints have been filed under it.[108]

5. The UN Convention on the Law of the Sea

The UN Convention on the Law of the Sea (UNCLOS) could theoretically regulate research-based SRM that takes place at sea or that affects oceans, but would be ineffective at regulating non-research SRM methods.[109] UNCLOS was formed at the third United Nations Conference on the Law of the Sea and entered force on November 16, 1994.[110] UNCLOS details "a comprehensive regime of law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources."[111] It addresses a wide range of ocean space issues, including environmental control, marine scientific research, economic and commercial activities, and

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102. Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, May 18, 1977, 31 U.S.T. 333, 1108 U.N.T.S. 152 [hereinafter ENMOD Convention].

103. *Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD)*, U.N. OFF. FOR DISARMAMENT AFFAIRS, https://www.un.org/disarmament/geneva/enmod/ [https://perma.cc/JGR3-YA6Y] (archived Oct. 13, 2017).

104. *Id.*

105. Bodansky, *supra* note 56, at 14.

106. ENMOD Convention, *supra* note 102.

107. Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 8 ("Although ENMOD includes most industrialized countries among its parties, it has no supporting infrastructure and is essentially dormant.").

108. *Id.*

109. For further discussion on whether UNCLOS would regulate SRM or CDR, see Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 8.

110. *United Nations Convention on the Law of the Sea of 10 December 1982 Overview and Full Text*, U.N. OCEANS & LAW OF THE SEA, http://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm (last visited Nov. 5, 2017) [https://perma.cc/5ZV7-CWBK] (archived Oct. 23, 2017) [hereinafter *UNCLOS Overview*].

111. *Id.*

settlement of disputes relating to ocean matters.[112] As of October 10, 2014, 166 states have ratified the Convention.[113] Although the United States has not ratified UNCLOS, it recognizes the Convention as customary international law[114]—UNCLOS is "the globally recognized regime dealing with all matters relating to the law of the sea."[115]

UNCLOS theoretically could govern climate engineering that takes place at sea or that affects the oceans. Under Article 192 of UNCLOS, countries have an obligation to "protect and preserve the marine environment."[116] States must balance this obligation with their right to exploit their natural resources.[117] However, UNCLOS supports scientific research that does not harm the global marine environment or interfere with other countries' use of the sea.[118] Disputes can be settled by the International Tribunal for the Law of the Sea, by the International Court of Justice, or by arbitration.[119]

UNCLOS possibly could regulate CDR methods of geoengineering, but would not be sufficient to regulate non-research SRM methods. UNCLOS would likely support SRM geoengineering research.[120] A "key feature" of the Convention is that all states enjoy the traditional freedom of scientific research at sea, but are obligated to adopt (or cooperate with other states in adopting) policies to preserve ocean life and resources.[121] Marine scientific research on a continental shelf requires consent of the coastal state, but in most cases the coastal state is required to grant consent to the research when the research is conducted for peaceful purposes and fulfils certain criteria.[122] These features would be inadequate to regulate SRM because SRM techniques would have uncertain consequences on ocean life and resources, and therefore certainly could result in the

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112. *Id.*

113. Div. for Ocean Affairs & the Law of the Sea, Table recapitulating the status of the Convention and of the related Agreements (2017), http://www.un.org/depts/los/reference_files/status2010.pdf [https://perma.cc/Y7PN-AVUJ] (archived Oct. 23, 2017).

114. Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 8.

115. *UNCLOS Overview*, *supra* note 110.

116. United Nations Convention on the Law of the Sea, art. 192, Dec. 10, 1982, 1833 U.N.T.S. 396.

117. Meinhard Doelle, *Climate Geoengineering and Dispute Settlement under UNCLOS and the UNFCCC*, *in* CLIMATE CHANGE IMPACTS ON OCEAN AND COASTAL LAW: U.S. AND INTERNATIONAL PERSPECTIVES 345 (Randall Abate ed., 2015).

118. Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 8.

119. *UNCLOS Overview*, *supra* note 110.

120. Jesse Reynolds, *Climate Engineering Field Research: The Favorable Setting of International Environmental Law*, 5 WASH & LEE J. ENERGY, CLIM. & ENVIRON. 417, 456 (2014).

121. *UNCLOS Overview*, *supra* note 110.

122. *Id.*

harm of the global marine environment.[123] Additionally, the impacts of SRM would likely be experienced by states other than the coastal state.[124]

## B. *Unique Challenges of Regulating Geoengineering*

Geoengineering does not fit cleanly into any pre-existing international environmental treaties. This is mostly due to its novelty and unknown effects. The fact that both major geoengineering approaches (CDR and SRM) could cause further harm to the environment and to humans presents a challenge for its regulation.[125] The potentially uneven impacts of geoengineering on weather patterns and precipitation levels also presents a challenge to regulators. While geoengineering models demonstrate that SRM could stabilize global temperatures and precipitation levels, they also suggest that "it may not be feasible to stabilize the climate in all regions simultaneously using solar-radiation management," making "consensus about the optimal level of geoengineering difficult, if not impossible, to achieve."[126]

Geoengineering also involves a different economic structure than most of the actions regulated by environmental law.[127] Most actions regulated by international environmental law involve "negative externalities with the environment as their medium." [128] Activities that positively affect individual actors but negatively impact others or the environment fall into this category. Reducing greenhouse gas emissions also requires overcoming a collective action problem, because one actor's greenhouse gas emissions affect other actors globally as greenhouse gases "accumulate over time and mix."[129]

Geoengineering, on the other hand, involves positive externalities because countries and individuals other than the implementing actor would likely experience the geoengineering effort's positive impacts.[130] The reduction of climate change would not

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123. Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 8.

124. *Id.*

125. Victor, *supra* note 2, at 323 ("The option of geoengineering is riddled with danger. All the most promising geoengineering methods have likely side effects that are worrisome. The unknown harms from large-scale tinkering with the planet could be even more grave than the predictable effects.").

126. Katharine L. Ricke et al., *Regional Climate Response to Solar-radiation Management*, 3 NATURE GEOSCIENCE 537, 537–41 (2010).

127. Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 4.

128. *Id.*

129. Weitzman, *supra* note 22, at 1050; *see also* IPCC SYNTHESIS REPORT, *supra* note 1, at 76.

130. Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 5.

be entirely captured by the implementing actor—other people or countries would share the benefits, resulting in a "free rider" collective action problem.[131]

Geoengineering also presents an opposite problem: because of its low cost, it requires "free drivers" to exercise collective restraint.[132] Given SRM's inexpensive nature, a country believing itself to be in imminent danger could unilaterally launch a geoengineering effort, potentially harming other regions of the world in the process.[133] While an SRM regulatory framework must address traditional environmental legal problems such as preventing and compensating others for harm, SRM's ease of enactment demands a regulatory system that addresses "coordination, mutual restraint, and prevention of misuse."[134]

The fact that geoengineering can be enacted unilaterally with "planetary effect" also presents unique challenges for its regulation.[135] Geoengineering is markedly different from efforts to reduce greenhouse gas emissions, the method of reducing global temperatures contemplated by the UNFCCC and the Paris Agreement. Reducing greenhouse gas emissions requires international cooperation to be effective.[136] One country's (much less one person's) efforts to do so will not be nearly enough to enact meaningful change or meaningful harm.[137] The fact that geoengineering can be enacted by a single actor in ways that likely will have widespread, disparate effects presents challenges to its regulation.[138]

In addition, the lack of norms regulating geoengineering will make it difficult to create a regulatory structure. A system that regulates geoengineering must create norms and principles that restrain actors.[139] The first step to this system will be further research of possible geoengineering methods and the dangers they present.[140] These norms may be essential to determining when geoengineering technologies should be used, how harmed parties

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131. *Id*; Weitzman, *supra* note 22, at 1049–68 (Weitzman coined the term "free-driver" in relation to geoengineering).

132. Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 5; Weitzman, *supra* note 22, at 1049–68.

133. Weitzman, *supra* note 22, at 1050.

134. Reynolds, The International Legal Framework for Climate Engineering, *supra* note 51, at 5.

135. Victor, *supra* note 2, at 328.

136. IPCC SYNTHESIS REPORT, *supra* note 1, at 102.

137. *Id.* ("[E]ffective mitigation will not be achieved if individual agents advance their own interests independently, even though mitigation can also have local co-benefits.").

138. Victor, *supra* note 2, at 324 (theorizing that a single nation, or even a "lone Greenfinger, self-appointed protector of the planet and working with a small fraction of the Gates bank account," could justify and fund an effort on their own).

139. *Id.*

140. *Id.*

should be compensated, if and how enactment costs should be shared, and how to maintain geoengineering efforts once they are enacted.[141]

Generally norms are negotiated, codified, and enforced by treaties.[142] However, treaties are "inherently conservative" because the negotiation process ensures that countries only commit to the extent that they believe is practical and do not join treaties that they believe to be a risk.[143] Professor David Victor predicts that if a treaty on the regulation of geoengineering were to be negotiated today, the majority of countries would support an outright ban on geoengineering because most countries do not have the capability to unilaterally geo-engineer.[144] Thus, the creation of a treaty should wait until geoengineering is more thoroughly researched and norms are created from the bottom up. Thorough geoengineering research will involve actual geoengineering deployment, which will present vast risks of its own.

## IV. SOLUTION

Given how little scientists currently know about geoengineering, it would be imprudent to strictly regulate geoengineering in the form of a multilateral treaty at this time. Scientists, and, by extension, decision makers, do not yet know its form, the distribution or full extent of its risks and benefits, the reversibility of its effects, or if states would be willing to subject themselves to its risks.[145] Additionally, it is unlikely that countries would be able to reach a consensus on the contents of such a treaty in the near future, given the absence of knowledge surrounding geoengineering. Furthermore, it is unlikely that countries that have the capacity to conduct geoengineering unilaterally would sign on to a treaty banning geoengineering.[146] A ban on geoengineering would probably not be adhered to and could have the dangerous effect of actors pursuing geoengineering research without being bound by safety guidelines.[147]

141. *Id.* at 330.

142. *Id.* at 331.

143. *Id.*

144. *Id.*

145. *Id.* at 325, 334.

146. *See id.* at 331 (noting that while only a handful of countries have the territory size and reliable lift systems to unilaterally conduct geoengineering, these countries would likely refuse to join a treaty that banned geoengineering); Reynolds, *supra* note 1, at 285–86 (arguing that geoengineering is unlikely to be regulated by a binding international agreement at all, as states with the power to enact geoengineering research, as well as states that are particularly at risk of the adverse effects of climate change, would not sign such an agreement).

147. *See* Victor, *supra* note 2, at 325; *see also* Bodansky, *supra* note 56, at 22 ("[A] moratorium could thus have the perverse effect of leaving the field of

The current state of geoengineering research is not suited to a consensus-oriented regulation process.[148] Given these factors, scholars have suggested that regulating geoengineering via a multinational treaty at this point in time would be ill-fated.[149]

Although the traditional method of norm creation "looks to the treaty system to negotiate, codify, and enforce norms," geoengineering norms should be created from the bottom up, meaning that unrelated research bodies should regulate geoengineering through norm creation.[150] Norms are necessary to ensure that geoengineering research is not undertaken prematurely or undertaken without adherence to scientifically established principles. Norms also are needed to determine who can conduct geoengineering, to determine when and where geoengineering should take place, and to develop a compensation system for harmed parties.

The primary source of geoengineering norm creation should come from groups of scientists (geoengineers) funded by both states and private funding groups. Governments have already begun to earmark funds to research geoengineering.[151] In early 2017, the U.S. Global Change Research Program recommended that Congress pursue geoengineering research.[152] Geoengineering researchers will be in the best position to set geoengineering research standards going forward.[153] Often researchers are the strongest proponents of regulation and "best positioned within their governments to press for complementary efforts within pivotal nations."[154]

The processes and results of geoengineering research should be transparent and accessible to ensure that future geoengineers will adhere to the norms established by the initial group of researchers.[155] Additionally, researchers should meet frequently with one another to discuss their results and further solidify norms. The data collected

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geoengineering research to the less responsible countries that ignore the moratorium and engage in riskier activities.").

148. *See* Bodansky, *supra* note 56, at 22 (arguing that instead, small groups supported by active research programs should share competing assessments).

149. *See id.* ("A much better approach would be an active geoengineering research programme, possibly including trial deployments, that is highly transparent and engages a wide range of countries that might have (or seek) geoengineering capabilities. That approach would be designed to explore the safest and most effective options while also socializing a community of responsible goeengineers.").

150. *Id.* at 331; *see also* Reynolds, *supra* note 1, at 273–74; Victor, *supra* note 2, at 332 (both suggesting a "bottom-up" approach to norm-building).

151. Eli Kintisch, *U.S. Should Pursue Controversial Geoengineering Research*, SCI. MAG. (Jan. 9, 2017), http://www.sciencemag.org/news/2017/01/us-should-pursue-controversial-geoengineering-research-federal-scientists-say-first [https://perma.cc/AU9K-QRED] (archived Oct. 23, 2017).

152. *Id.*

153. Victor, *supra* note 2, at 330 ("Academies of science are probably the best place to begin the process because they are usually well connected to the setting of research priorities and political decision-making.").

154. *Id.* at 332.

155. *Id.*

through these initial research endeavors will allow countries to create domestic geoengineering regulations.[156] Researchers will eventually become experts in the field of geoengineering, further solidifying norms and leading the way for their codification in a multinational treaty.

One problem presented by bottom-up norm creation is that it does not preemptively provide a framework for harm compensation or regulation of large geoengineering efforts likely to cause transboundary effects. One way to deal with this problem would be for national governments to domestically regulate the process of geoengineering research. For example, states could create mandatory research boards to approve privately undertaken geoengineering projects, and require absolute transparency when such projects are carried out. Given its cost, geoengineering research likely will be publicly funded and supervised by governments. Still, countries should develop domestic regulations that control the process (but not the substance) of geoengineering research before major geoengineering research projects are undertaken in order to best prevent large-scale harm.

Once geoengineering norms are adequately developed, codifying them into a multinational treaty or protocol to an existing treaty will be much easier and more likely to garner support. Eventually a treaty that regulates both the process and substance of geoengineering will be necessary given the scale of its potential. A treaty will allow parties to create a cohesive regulatory structure based on developed norms and ensure that geoengineering research is conducted as safely as possible. A treaty could also gather and distribute information regarding geoengineering research, facilitate cooperation between governments (and punish governments for noncompliance), and push states to overcome the collective action problem.[157] A new protocol to the UNFCCC would be a natural fit for this treaty.[158]

This Note looks to GMO trade regulation and ocean dumping regulation for guidance and ideas to incorporate in a future strict multinational treaty. While the substantive regulations of geoengineering should be developed from the ground up, aspects of these multinational treaties provide inspiration for the future regulation of geoengineering.

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156. *Id.*

157. LASSE RINGIUS, RADIOACTIVE WASTE DISPOSAL AT SEA 50 (MIT Press 2000); *see also* Bodansky, *supra* note 56, at 19–20.

158. *See* Bodansky, *supra* note 56, at 20 (stating that several commentators have suggested that the UNFCCC is the appropriate forum for regulating geoengineering due to its large membership and ability to consider geoengineering alongside emissions mitigation).

### A. *Analogy to International GMO Trade Regulation*

There are two major international protocols that address the transboundary movement of genetically modified organisms: the Cartagena Protocol of 2000 and the Nagoya-Kuala Lumpur Supplementary Protocol of 2010, both of which are attached to the 1993 Convention on Biological Diversity (CBD).[159] The CBD entered force on December 29, 1993 and has 196 parties; it was not signed by the United States.[160] The CBD was created with the objective of promoting the conservation of biological diversity, the sustainable use of components of biological diversity, and the fair and equitable sharing of the benefits arising from the use of genetic resources.[161]

The internal regulation of GMOs differs from country to country. The Cartagena Protocol and the Nagoya-Kuala Lumpur Supplementary Protocol apply only to transboundary actions, not to internal use, consumption, or passage of GMOS within states.[162] The United States regulates GMOs in a relatively relaxed manner, while the European Union has some of the strictest GMO regulations in the world.[163]

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159. *Restrictions on Genetically Modified Organisms: International Protocols*, LIBRARY OF CONGRESS, https://www.loc.gov/law/help/restrictions-on-gmos/international-protocols.php#_ftn1 (last visited Nov. 5, 2017) [https://perma.cc/SH5W-PBPX] (archived Oct. 23, 2017) [hereinafter *International Protocols*].

160. *List of Parties*, Convention on Biological Diversity, https://www.cbd.int/information/parties.shtml (last visited Nov. 5, 2017) [https://perma.cc/MCJ9-6WTD] (archived Oct. 23, 2017).

161. Convention on Biological Diversity art. 1, June 5, 1995, 1760 U.N.T.S. 79.

162. *International Protocols, supra* note 159.

163. *See* DIAHANNA LYNCH & DAVID VOGEL, THE REGULATION OF GMOS IN EUROPE AND THE UNITED STATES: A CASE-STUDY OF CONTEMPORARY EUROPEAN REGULATORY POLITICS, COUNCIL ON FOREIGN RELATIONS (2001), https://www.cfr.org/report/regulation-gmos-europe-and-united-states [https://perma.cc/ZRY5-KEEQ] (archived Nov. 4, 2017) (comparing regulations in the United States with regulations in the European Union). EU member states have individual rules and regulatory agencies that govern GMOs. In addition, companies seeking to sell GMOs in an EU country must first obtain permission from that country. If approved, the company must notify other countries via the European Commission. If a member state objects, then the European Commission conducts additional evaluations, and the request is resubmitted to vote. The EU's extremely cautious and restrictive approach to GMOs is rooted in several economic and political reasons. Limiting the sale of GMOs protects domestic agricultural business. In addition, anti-GMO lobbying groups have significantly influenced European politics and policymaking. Anti-GMO public sentiment has led to rising consumer demand for GMO-free food products. These factors have resulted in the EU having the world's most restrictive GMO policy. This strict scheme has delayed the development of modern biotechnology and stalled research in the EU. *Id.; see also* Wendan Wang, *International Regulations on Genetically Modified Organisms: U.S., Europe, China and Japan*, FOOD SAFETY MAG. (June/July 2016), http://www.foodsafetymagazine.com/magazine-archive1/junejuly2016/international-regulations-on-genetically-modified-organisms-us-europe-china-and-japan [https://perma.cc/G2FW-G4UT] (archived Oct. 23, 2017).

The Cartagena Protocol became effective on September 11, 2003. It has 171 parties; the United States is not a member.[164] The Protocol aims to protect biological diversity and human life from GMOs, while acknowledging the potential of GMOs to increase food supply.[165] The Protocol was based upon the precautionary principle, which embodies "environmental action in the face of scientific uncertainty," but it does not impose substantive regulations on parties.[166] The precautionary principle encourages taking cost-effective measures to prevent imminent environmental damage, even when there is not scientific certainty that the measures would work.[167] The Protocol provides several mechanisms for regulating the international transportation of GMOs, including an advanced notification and permission system for intentional and accidental international GMO movements, as well as a clearing house to facilitate information sharing.[168] Although the Protocol does not penalize parties for improperly transmitting GMOs, it encourages parties affected by such transmissions to request payment from the offending party under the principle that polluters must pay for the damage they cause.[169]

The Nagoya-Kuala Lumpur Supplementary Protocol was adopted on October 15, 2010 and has been ratified by forty countries.[170] It has not been signed by the United States.[171] The Supplementary Protocol was created to address the problem of transboundary damage caused by international GMO trade.[172] The

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164. *Parties to the Protocol and Signature and Ratification of the Supplementary Protocol*, CONVENTION ON BIOLOGICAL DIVERSITY, http://bch.cbd.int/protocol/parties/ (last visited Nov. 6, 2017) [https://perma.cc/K35Z-L73Z] (archived Oct. 23, 2017) [hereinafter *Parties to the Protocol*].

165. *Id.*; *see also* Cartagena Protocol on Biosafety to the Convention on Biological Diversity art. 1, Jan. 29, 2000, 2226 U.N.T.S. 208, 39 I.L.M. 1027 [hereinafter Cartagena Protocol] ("[O]bjective of this Protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements.").

166. *See* Cartagena Protocol, *supra* note 165; Meinhard Schroder, *Precautionary Approach/Principle, in* MAX PLANCK ENCYCLOPEDIA OF PUBLIC INTERNATIONAL LAW (Rüdiger Wolfrum ed., 2014); *International Protocols*, *supra* note 159 (citing René Lefebar, *The Legal Significance of the Nagoya-Kuala Lumpur Supplementary Protocol: The Result of a Paradigm Evolution* (Ctr. for Envtl. Law & Sustainability Research Paper No. 2012-02, Amsterdam Law School Research Paper No. 2012-87, 2012)), http://ssrn.com/abstract=2151282 [https://perma.cc/YK6H-VRK3] (archived Oct. 23, 2017)).

167. *International Protocols*, *supra* note 159.

168. *Id.*

169. *Id.*

170. *Parties to the Protocol*, *supra* note 164.

171. *Id.*

172. The Supplementary Protocol defines "damage" as "an adverse effect on the conservation and sustainable use of biological diversity, taking also into account risks to human health," that . . . "is measurable or otherwise observable taking into account,

Supplementary Protocol is grounded in the polluter pays principle, although it is not clear whether liability extends to the state of origin or just the person or organization responsible for the damage.[173] Parties to the Supplementary Protocol agree to implement its provisions, which "provide for prompt, adequate and effective response measures in the event of damage caused by the transboundary movement of living modified organisms," into domestic law.[174]

Though not perfectly analogous, international GMO trade and geoengineering pose similar risks. While GMO trade may be easier to regulate from the perspective of the importing country, both GMO trade and geoengineering have the potential to threaten a non-acting country's biodiversity and food supply. Adverse effects resulting from the transboundary transfer of GMOs may still occur despite preventative measures.[175] The development and use of GMOs is considered by some to be inherently dangerous, especially in light of its relatively unknown nature.[176] Additionally, like geoengineering, its long-term effects cannot be assessed without extensive research (i.e., deployment).[177] The international transfer of GMOs presents a significant risk of causing transboundary harm to both public and private goods, including economic loss, environmental damage, and harm to human health.[178]

Several aspects of the Cartagena Protocol and its Supplementary Protocol could be incorporated into future geoengineering regulations. Although the overall GMO regulatory scheme should not be applied to geoengineering, certain aspects of it, including the mandatory notification system, clearing house, approval to conduct experiments,

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wherever available, scientifically-established baselines recognized by a competent authority that takes into account any other human induced variation and natural variation" . . . and "significant." The Supplementary Protocol provides a list of factors to use when determining whether an adverse fact is "significant," including whether it causes permeant or long-term change that will not be naturally recovered in a reasonable amount of time, the extent of qualitative or quantitative changes that adversely affect biological diversity, the reduction of the ability of components of biological diversity to provide goods and services, and the extent of adverse effects on human health. *Article 2. Use of terms, Kuala- Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety*, CONVENTION ON BIOLOGICAL DIVERSITY, http://bch.cbd.int/protocol/nkl/article2/ (last visited Nov. 7, 2017) [https://perma.cc/T33R-YS7Y] (Archived Oct. 23, 2017).

173. *See International Protocols*, *supra* note 159.

174. Lefebar, *supra* note 166.

175. *Id.*

176. *Id.*

177. *Id.* ("The introduction of a new technology to an activity tends to carry a higher risk, because the long-term effects cannot be assessed before gaining experience with that technology.").

178. *Id.* (noting that this is especially true for the transfer of living modified organisms, and that "[s]uch damage may manifest itself as traditional damage to private goods . . . It may also take the form of damage to public goods, notably the environment and human health").

and polluter pays principle would lend themselves well to regulating geoengineering.

1. Notification System

The Cartagena Protocol requires actors moving GMOs across state borders to obtain advance informed agreement from the importing state.[179] This means that states are given advance notice of any movement of GMOs into their territory.[180] States then have 270 days to decide whether to allow the transit and what conditions to impose if they approve the shipment.[181] If a GMO is accidentally moved across a border, and if that movement would "have significant adverse effects on the conservation and sustainable use of biological diversity," the offending party must notify any affected states, relevant international organizations, and the Biosafety Clearing House.[182]

This mandatory notification system would be useful for regulating geoengineering. States undertaking geoengineering research or projects should be required to notify other states party to the multinational agreement of any geoengineering projects above a predetermined scale. Because it may be difficult to conclude if and how much trans-boundary harm has occurred, a future multinational treaty should mandate transparency in geoengineering research. Furthermore, researchers should work together to catalogue the effects of geoengineering around the world, not just in the enacting country. Countries should also form internal agencies to which researchers should be mandated to report all geoengineering research to ensure that all research efforts are accounted for and reported.

2. Clearing House and Risk Management Mechanisms

The Cartagena Protocol established a mandatory Biosafety Clearing House designed to "facilitate the exchange of scientific, technical, environmental and legal information on, and experience with, living modified organisms," as well as to assist parties (especially developing states) in implementing the Protocol.[183] Parties are required to provide the Clearing House with summaries of their risk assessments of GMOs as generated by their regulatory processes.[184] The Clearing House also provides access to other international biosafety information exchange mechanisms.[185]

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179. Cartagena Protocol, *supra* note 165, arts. 6–8.
180. *Id.* arts. 6–8.
181. *Id.* art. 10, § 3.
182. *Id.* art. 17, § 1.
183. *Id.* art. 20.
184. *Id.* art. 20.
185. *Id.* art. 20.

The Protocol also details a risk management plan, requiring parties to "establish and maintain appropriate mechanisms, measures and strategies to regulate, manage and control risks identified in the risk assessment provisions of this Protocol."[186] Additionally, parties must observe GMOs for a specified period of time before putting them to their intended uses.[187]

A mandatory clearing house would further facilitate the transparency required to enforce geoengineering norms. Mandatory information sharing will enable cooperation among states. States should eventually be required to provide a geoengineering clearing house with their risk assessments.

### 3. Approval to Conduct Experiments

In some countries, including China and New Zealand, researchers must obtain permission from their governments before conducting experiments involving genetic engineering or the production of certain GMOs.[188] In the United States, genetically modified plants, pesticides, animals, drugs, and biological products are subject to premarket government approval.[189] Because geoengineering research efforts will probably require federal funding, it is likely that domestic geoengineering research will be federally approved before it is undertaken. However, it would be beneficial for countries to require geoengineering efforts to be approved from a national body to prevent affluent individuals from unilaterally enacting geoengineering.

Requiring approval from a multinational regulatory group and ethical committee would ensure that wealthier states refrain from enacting geoengineering at the cost of developing states, who do not have the resources to unilaterally fund geoengineering research. A mandatory clearing house and risk management mechanism would ensure that the international regulatory board is aware of all risks of transboundary harm, and would help protect poorer nations. The regulatory board should be made up of members from states both likely and unlikely to enact geoengineering to ensure that only the most utilitarian projects approved.

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186. *Id.* art. 16.

187. *Id.*

188. *Restrictions on Genetically Modified Organisms*, LIBRARY OF CONGRESS, https://www.loc.gov/law/help/restrictions-on-gmos/ (last visited Jan. 9, 2018) [https://perma.cc/V5XM-SY48] (archived Jan. 9, 2018).

189. *Restrictions on Genetically Modified Organisms: United States*, LIBRARY OF CONGRESS, https://www.loc.gov/law/help/restrictions-on-gmos/usa.php/ (last visited Jan. 9, 2018) [https://perma.cc/VR6U-UJFX] (archived Jan. 9, 2018).

4. Polluter Pays Principle

The Cartagena Protocol does not include penalties for the illegal (knowing) transboundary transmission of GMOs.[190] The treaty leaves it to states to "adopt appropriate domestic measures aimed at preventing and, if appropriate, penalizing [illegal] transboundary movements." [191] The Protocol allows parties affected by illegal transmissions to ask the party of origin to pay for the disposal of the improperly transmitted GMOs.[192] The Protocol also requires these cases to be reported to the Biosafety Clearing House.[193]

The Nagoya-Kula Lumpar Supplementary Protocol was enacted in 2010 to solve the question of who pays for GMO-caused damages.[194] Rene Lefeber, co-chair of the group that facilitated the negotiations of the Supplementary Protocol, could have been describing geoengineering when he described the need for the Supplementary Protocol: "Since adverse effects may occur in spite of risk-management measures or as a result of the failure to identify the risk of adverse effects, the allocation of the costs of such effects should be anticipated and regulated."[195] The Supplementary Protocol has only been ratified by eleven parties, however, and parties' reluctance to ratify a strict damages regime demonstrates that it may be difficult to convince states to do the same in the case of geoengineering.[196] However, its principles are worth discussing.

The Supplementary Protocol stands for the proposition that a GMO polluter must pay for any damage caused.[197] It is not clear whether this applies only to the individual or organization responsible for the polluting activity, or if liability extends to the state in which the activity occurred.[198] For the polluter pays provision

190. Cartagena Protocol, *supra* note 165, art. 25.
191. *Id.*
192. *Id.*
193. *Id.*
194. Press Release, Convention on Biological Diversity, The Nagoya–Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety (Oct. 16, 2010), http://bch.cbd.int/protocol/nkl_pressrelease.shtml [https://perma.cc/5YF9-GMXE] (archived on Oct. 23, 2017); *Text of Nagoya–Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety*, CONVENTION ON BIOLOGICAL DIVERSITY, http://bch.cbd.int/protocol/nkl_text.shtml (last visited Nov. 5, 2017) [https://perma.cc/W3AQ-7A9N] (archived Oct. 23, 2017).
195. Lefebar, *supra* note 166.
196. *The Cartagena Protocol on Biosafety, and its Nagoya—Kuala Lumpur Supplementary Protocol on Liability and Redress*, CONVENTION ON BIODIVERSITY, http://www.cbd.int/undb/media/factsheets/undb-factsheet-biosafety-en.pdf (last visited Nov. 5, 2017) [https://perma.cc/74QE-EAWH] (archived Oct. 23, 2017).
197. *Id.*
198. *Id.*

to apply, causation between the damage incurred and the GMO must be established.[199]

Parties to the Supplementary Protocol must require the individuals responsible for damages to "immediately inform the authorities, evaluate the damage, and take appropriate response measures." [200] The authorities must identify the individual or organization that caused the damage and determine the appropriate response.[201] An assessment as to whether damage is likely or unlikely must be based on scientific information, including data collected by the Biosafety Clearing House.[202]

The differences between transboundary GMO trade and geoengineering may make some of these features difficult to implement in future multinational geoengineering regulation. GMO trade involves private actors, whereas geoengineering likely will be carried out mainly by public actors. Additionally, the harm caused by allowing the transboundary movement of GMOs can be contained if it is spotted, whereas it is uncertain if the harm resulting from geoengineering will be containable or reversible at all.

Proving the causation and damages pieces necessary to receive compensation will also be difficult. The existence of transboundary harm as a result of geoengineering would take years to discover or may never be discovered or attributed to geoengineering at all. Proving that geoengineering caused a specific harm will also be problematic. It may be difficult to say with any level of certainty whether a geoengineering effort is directly responsible for reduced crop yield or increased flooding. These issues of causation and damages likely will be litigated if a country alleges the existence of transboundary harm as a result of geoengineering.

Despite this, a polluter pays principle—with liability extended to states—incorporated into future geoengineering regulation could encourage states to exercise caution when enacting geoengineering research and deployment. Codifying the polluter pays principle would also encourage states to collaborate in geoengineering efforts to spread the cost of damages should the geoengineering effort cause harm. The regulation would be particularly effective if geoengineering projects approved by a board associated with the multinational agreement received exemption from liability. This would encourage countries to abide by the permit process and would ensure that only thoroughly vetted geoengineering projects are approved.

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199. *Id.*
200. *Id.*
201. *Id.*
202. *Id.*

### B. *Analogy to Ocean Dumping Regulation*

Ocean dumping is the disposal of chemical, industrial, or radioactive waste, trash, munitions, sewage sludge, or contaminated dredge material into the ocean.[203] Ocean dumping shares a key feature with geoengineering in that its effects are transboundary and therefore is regulated by domestic, regional, and international conventions. Ocean dumping negatively affects people around the world who rely on the ocean and its ecosystem for food.[204] Dumping contaminants in one part of the ocean can affect individuals who live thousands of miles away if they consume food that has been contaminated by the dumping.[205] Additionally, toxic chemicals dumped in the ocean can wash up on shore, harming the public.[206]

In 1972, the United States passed the 1972 Marine Protection, Research and Sanctuaries Act (MPRSA).[207] MPRSA was enacted in response to previous damage caused by ocean dumping.[208] Uncontrolled dumping contaminates areas of the ocean with harmful pollutants and causes a severe depletion of oxygen in other parts.[209] Disposal of waste into the ocean damages the marine environment and natural resources and poses risks to human health.[210] MPRSA regulates the disposal of waste in US marine waters.[211] Title I of the MPRSA contains permit and enforcement provisions, while Title II regulates marine research.[212]

The MPRSA was enacted at the same time as the central international ocean dumping treaty, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972 (the London Convention), and the two are very

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203. *Learn About Ocean Dumping*, U.S. ENVT'L. PROTECTION AGENCY, https://www.epa.gov/ocean-dumping/learn-about-ocean-dumping#importance (last visited Nov. 5, 2017) [https://perma.cc/4S95-6TN8] (archived Oct. 23, 2017).

204. *Id.*

205. *Id.*

206. *Id.*

207. *Id.*

208. *Id.*

209. *Id.*

210. *Id.*

211. CLAUDIA COPELAND, OCEAN DUMPING ACT: A SUMMARY OF THE LAW 2 (2010).

212. *Learn About Ocean Dumping*, *supra* note 203.

similar.[213] There are eighty-seven parties to the London Convention, including the United States.[214]

In 1996, parties to the London Convention created a new, freestanding treaty called the London Protocol, which was designed to more proactively protect the marine environment.[215] The London Protocol, which added a compliance mechanism, prohibits all forms of ocean dumping, except for a few exceptions on the "reverse list."[216] The Protocol requires parties take a precautionary approach to preventing harm caused by marine dumping.[217] Only forty-eight states are party to the Protocol.[218] The United States signed but did not ratify the London Protocol, most likely because it found the requirements of the London Protocol to be too stringent.[219]

Both geoengineering and ocean dumping implicate the "free driver" problem to some degree.[220] Geoengineering will only be undertaken unilaterally if the actor believes he or she will benefit, but such action will likely harm others globally. Similarly, ocean dumping breeds positive results for the dumper (they rid their ship of waste) but negatively affects the global marine environment.

Geoengineering and ocean dumping do have their differences. The economic incentive structures faced by the two are different: geoengineering would likely only be undertaken in an emergency, while ocean dumping is born out of laziness and the desire to rid the ship of weight. Additionally, the two present different levels of short-term risk to the environment and to humanity, though the long-term risk is arguably equivalent.

Geoengineering involves both positive and negative externalities, while ocean dumping implicates only negative externalities. Both the benefits and the harms caused by geoengineering could be experienced by non-acting states. Third parties do not enjoy a benefit of ocean dumping, but share equally in its costs. To curb ocean dumping, individuals must put the common good over their individual desires to rid themselves or their ships of waste.

Additionally, geoengineering involves a "risk–risk" tradeoff, in which the risk of executing wide-spread geoengineering efforts is

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213. *Id.*; *see also Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter,* INT'L MAR. ORG., http://www.imo.org/en/OurWork/Environment/LCLP/Pages/default.aspx (last visited Nov. 5, 2017) [https://perma.cc/8YDY-VVZ9] (archived Oct. 23, 2017) [hereinafter *London Convention*].

214. *Ocean Dumping: International Treaties*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/ocean-dumping/ocean-dumping-international-treaties (last visited Nov. 5, 2017) [https://perma.cc/5ST5-W8AF] (archive Oct. 23, 2017).

215. *Id.*

216. *Id.; see also London Convention, supra* note 213.

217. *London Convention, supra* note 213.

218. *Id.*

219. *Ocean Dumping: International Treaties, supra* note 214.

220. *See supra* Part I.

balanced with the risk of allowing global warming to continue unchecked. Ocean dumping is not undertaken to mitigate some other, greater risk. There is no positive global outcome that can arise from ocean dumping. Geoengineering, however, has tremendous possibilities for global benefit.

Despite these differences, aspects of the MPRSA and the London Convention and Protocol, including a permit system and a research and monitoring program, would be valuable tools in the future international regulation of geoengineering.

### 1. Permit System

The permit system outlined in Title I of the MPRSA provides useful lessons for geoengineering regulators. MPRSA prohibits all ocean dumping in US territory without a permit.[221] Permits for dumping certain materials that are not altogether banned can be applied for and are issued by the EPA.[222] The EPA must provide notice and comment opportunities once it decides that the proposed dumping will not unreasonably harm the marine environment, human health, or the economy.[223] MPRSA authorizes the EPA to fine violators up to USD 50,000 for violating the permit requirement.[224] MPRSA also authorizes criminal penalties and injunctive relief for knowing violations of the act.[225]

As norms develop, states could establish permit systems at the domestic level to ensure that wealthy individuals do not unilaterally conduct geoengineering research without adequate vetting from their domestic governments.[226] Once geoengineering norms are established from the bottom up, a multinational treaty addressing geoengineering could establish a permit system. Enacting permit-less geoengineering projects could result in fines or increased liability for damages, although enforcement of this provision may be difficult. The permit board should be comprised of people from countries with and without the capacities to unilaterally enact geoengineering.

### 2. Research and Monitoring Program

Title II of MPRSA directs US agencies to conduct research on the general marine environment and ocean dumping.[227] The National Oceanic and Atmospheric Administration (NOAA) is mandated to

221. COPELAND, *supra* note 211, at 2.
222. *Id.*
223. *Id.*
224. *Id.* at 3.
225. *Id.*
226. *See* Victor, *supra* note 2, at 324 (discussing the "Greenfinger" problem).
227. COPELAND, *supra* note 211, at 4.

research the long-term effects of ocean dumping and other human caused events on general ocean resources.[228] The EPA is directed to conduct research specifically with the end of ocean dumping of sewage sludge and industrial wastes in mind.[229] The MPRSA also authorizes nine regional marine research bodies to monitor marine conditions in those regions.[230]

A research and monitoring system at the domestic level could be implemented to facilitate the norm creation process. All geoengineering research at the domestic level should be logged, documented, and discussed among scientists to establish norms and adherence to them. Once large-scale geoengineering research efforts are deployed, states should direct internal agencies to conduct specific research on the various effects of the deployment. This long-term monitoring will be very important to the geoengineering effort, as quantifying the actual effects of geoengineering on different regions of the world will likely be more difficult than measuring the amount of pollutants in a specific area of the ocean.

## V. CONCLUSION

While geoengineering should eventually be internationally regulated to manage its transboundary risks, a regime to regulate geoengineering must be established from the ground-up. Although geoengineering has the potential to cause significant trans-boundary harm, premature multinational geoengineering regulations enacted before norms are established will be inadequate. States with the capacities to unilaterally enact geoengineering will not agree to the terms of a hasty treaty. Once norms are established, reaching a consensus on the terms of the international regulation will be easier.

Domestic research and monitoring boards should be transparent with geoengineering research data and share their findings with researchers around the world to help establish norms. States can ban geoengineering research efforts above a certain scale and collect and distribute geoengineering data to guide future geoengineering experiments and governance.

While it is too early to envision a comprehensive international regulatory scheme, this Note looks to features of international GMO trade and ocean dumping regulations for inspiration as to what future international geoengineering regulation could look like. A future multinational geoengineering regulatory regime could incorporate a permit system to ensure that only thoroughly vetted geoengineering projects are approved. It could also include a

228. *Id.*
229. *Id.*
230. *Id.*

notification system with a notice and comment period to ensure all parties to the future treaty can comment on the proposed geoengineering. An international research board should be established to gather and distribute geoengineering data.

A future multilateral treaty should also incorporate the polluter pays principle. The polluter pays principle already has some traction in customary international law and will ensure that those who are harmed by geoengineering will be compensated. Once more is known about geoengineering and large-scale geoengineering is close to being undertaken, a compensation system for trans-boundary harm that results from unilateral geoengineering efforts should be created to discourage states from enacting geoengineering unilaterally and prematurely.

Several issues remain, however, including the burden of proof, causation, and quantifying damages.[231] Additionally, enforcing a strict liability polluter pays regime may disincentivize geoengineering to the point that no single actor will want to undertake it, and it may prevent countries able to unilaterally fund geoengineering from agreeing to treaties with strict liability regimes. These problems can be mitigated by exempting permitted geoengineering plans from liability. This would encourage states to join the multilateral treaty and abide by the permitting process. Eventually, geoengineering projects could be carried out multilaterally to spread the costs of enactment and liability.

These principles and institutions should be established at the domestic level in the near future, as geoengineering research is imminent. In the spring of 2017, Harvard University launched a solar geoengineering research program to test SRM aerosols and methods, improve understanding of the health and climate risks associated with geoengineering, and develop governance theories for its testing and deployment.[232] The program's launch has sparked mainstream debate over the merits and risks of geoengineering. Despite its

231. Chen-Ju Chen, The Liability and Compensation Mechanism under International Marine Environmental Law (May 2012), https://www.law.berkeley.edu/files/Chen-final.pdf [https://perma.cc/R83P-X39A] (archived Oct. 23, 2017) (conference paper from the Law of the Sea Institute at UC Berkeley and the Korea Institute of Ocean Science and Technology Conference, held in Seoul, Korea).

232. Arthur Neslen, *US scientists launch world's biggest solar geoengineering study*, GUARDIAN (Mar. 24, 2017), https://www.theguardian.com/environment/2017/mar/24/us-scientists-launch-worlds-biggest-solar-geoengineering-study [https://perma.cc/H6JB-F47T] (archived Oct. 23, 2017); *Overarching Goals*, HARVARD'S SOLAR GEOENGINEERING RES. PROGRAM, https://geoengineering.environment.harvard.edu (last visited Nov. 7, 2017) [https://perma.cc/RBQ9-QPGH] (archived Oct. 23, 2017) ("The largest challenge for social geoengineering is not the technology itself, but rather the governance of its testing and possible deployment in a divided, multipolar world.").

potential pitfalls, geoengineering may very well be the only way to keep global warming from rising more than 2°C.

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