# A Matter of Scale: Regional Climate Engineering and the Shortfalls of Multinational Governance

*Tracy D. Hester**

*Debates over climate engineering governance tend to assume this technology is an all-or-nothing affair that produces inherently global effects which intentionally can reach any nation or population. With the emergence of possible regional climate engineering methods that seek to limit their effects to relatively local areas, this governance debate may find itself left behind in some instances by disruptively novel technological options. If so, regional climate engineering may fit better under a combination of local transnational mechanisms and bilateral treaties rather than the existing broad-scale multinational frameworks available under multilateral treaties such as the United Nations Framework Convention on Climate Change (UNFCCC).*

## I. Introduction

The growing interest in climate engineering strategies has sparked a fierce debate over the best ways to govern research, deployment and legal responsibilities for possible damages caused by those technologies. These debates often share a common premise: climate engineering systems will strive to cause global effects that could potentially and unexpectedly injure nations and populations in far-flung and vulnerable locations. Given this assumption, most proposals to regulate or control climate engineering have focused on (i) crafting multilateral agreements to impose binding obligations on a broad community of consenting governments, (ii) establishing principles of international law to determine liability for damages prior to engaging in any climate engineering activity, and (iii) delineating duties under international human rights law to limit research or activities that would harm protected indigenous populations or ecological resources.

Technology, however, may soon outstrip the implicit assumptions of the current debate. Rather than requiring the use of solar radiation management strategies or carbon reduction techniques to affect planetary surface temperatures or atmospheric stocks of greenhouse gases, new climate engineering approaches might allow attempted alterations of climate on a regional level. For example, climate engineering technologies on this scale potentially could seek to protect especially vulnerable polar regions or preserve precipitation cycles that supply critical water supplies over subcontinental or regional areas.[1] Notably, while these techniques would focus on creating climate effects within a particular region, this local focus would not preclude the possibility of unanticipated consequences outside the targeted region. While limited goals and scope of regional climate engineering will likely pose difficulties for emerging climate governance frameworks suited for global efforts, this focused approach may open new ways to regulate climate engineering research through a cumulative bottom-up governance approach that would rely on networks of regional treaties, agreements and resolutions rather than a sweeping international convention.

* Professor of Practice at the University of Houston Law Center. Prof. Hester was previously a partner at Bracewell & Giuliani LLP and led the Houston office's environmental group. He currently sits on the governing Council for the ABA's Section on Environment, Energy and Resources (SEER) and he previously chaired SEER's Environmental Enforcement and Crimes Committee. Professor Hester's full biography is available on the Internet at <www.law.uh.edu/faculty/thester>.

1 See discussion infra at p. 6

## II. Current Assumptions in the Climate Engineering Debate

The arguments over climate engineering have settled into a fierce – but well-worn – pattern. Proponents for research into climate engineering technologies[2] frequently contend that governments have not taken the actions necessary to reduce emissions of greenhouse gases to levels that would forestall potential disruptive climate change. Moroever, they stress that the community of nations has failed to even reach a significant and binding international consensus on an effective path to reduce those emissions in the future.[3] Climate engineering advocates usually support expanded investigation of technologies to alter the climate in ways that could help offset the most damaging and disruptive effects of climate change. Even if they hope never to deploy such technologies, these researchers contend that we should more fully understand climate engineering principles and techniques in case we need them to address potentially catastrophic climate disruptions in the future.

Critics respond that large-scale climate engineering research itself could threaten significant damage, violate international legal commitments under existing treaties and customary international law, and leave vulnerable and less developed nations and peoples without a voice in decisions by wealthy nations or individuals to deploy climate engineering technologies.[4] This position has led to calls for limits or even a moratorium on climate engineering field projects or demonstrations until all affected parties can agree on how to govern those technologies when (or if) those restrictions ultimately end.[5]

In the face of these disputes, climate engineering research has proceeded slowly and haltingly. Some proposed projects to demonstrate basic principles of climate engineering have drawn heated criticism that contributed to suspension of the projects[6], and the Intergovernmental Panel on Climate Change addressed climate engineering options for only the first time in its upcoming Fifth Assessment Report on the state of the climate.[7] Other independent research or demonstration projects efforts by individuals have sparked outcries and allegations that such "rogue geoengineering" lacks necessary scientific grounding and rigor.[8] The governance debate has moved relatively slowly as well, and the initial forays into international laws to govern climate engineering have sought to extend existing treaty frameworks under the Convention on Biological Diversity, the London Convention and the London Protocol that might logically apply to initial climate engineering efforts (particularly ocean fertilization projects).[9]

While the general concept of climate engineering has sparked numerous broad criticisms and con-

2 These technologies are also often described as "geoengineering" or "geomodification." This article uses "climate engineering" where possible to avoid confusion with habitat construction and earth-moving technologies also called "geoengineering."

3 James Hansen, Makiko Sato, Gary Russell and Pushker Kharecha, "Climate Sensitivity, Sea level, and Atmospheric $CO_2$", 2 April 2013, available on the Internet at <arxiv.org/ftp/arxiv/papers/1211/1211.4846.pdf> (last accessed 15 October 2013), at 1 ("[b]urning all fossil fuels, we conclude, would make much of the planet uninhabitable by humans, thus calling into question strategies that emphasize adaptation to climate change"); Eli Kintisch, "Overview of Climate Engineering", 42 *The Bridge Linking Engineering and Society* (Winter 2012) 5, at 5–6.

4 See, e.g., Clive Hamilton, "No, We Should Not Just 'At Least Do the Research'," 496 *Nature* (11 April 2013), 139 ("[i]n truth, this simple injunction [that 'we should at least do the research'] is part of the problem. It rests on a string of questionable assumptions and a naïve understanding of the world that owes more to the quaint ideal of the white-coated scientist dispassionately going about the process of knowledge generation than it does with reality").

5 For example the ETC Group, an environmental and technology policy advocacy group, has repeatedly called for a moratorium on any climate engineering research or deployment until the multinational community has established a comprehensive regulatory framework to assure the technology's safety and equity to all communities. See, e.g., Pat Mooney, Kathy Wetter and Diana Bronson, "Darken the Sky and Whiten the Earth: The Dangers of Geoengineering", *Development Dialogue Vol. III, Climate, Development and Equity* (2012), 210, at p. 211.

6 For example, the proposed Stratospheric Particle Injection for Climate Engineering (SPICE) project would have used an aerostat to test nozzle configurations to spray water at 1000 meters from a ground-based pump and hose system. The proposed project triggered a strong public outcry, and concerns identified during a subsequent stakeholder engagement process and uncertainties over intellectual property and patent claims led to the cancellation of the project. Jack Stilgoe, Matthew Watson and Kirsty Kuo, "Public Engagement with Biotechnologies Offers Lessons for the Governance of Geoengineering Research and Beyond," 11 *PLOS Biology* (2013), at 3–5.

7 Daniel Cressey, "Climate Report Puts Geoengineering in the Spotlight," Nature News, 2 October 2013.

8 See, e.g., Henry Fountain, "A Rogue Climate Experiment Outrages Scientists," The New York Times, 12 October 2012, available on the Internet at <www.nytimes.com/2012/10/19/science/earth/iron-dumping-experiment-in-pacific-alarms-marine-experts.html> (last accessed on 15 October 2013) (describing criticism of iron fertilization project by the Haida Salmon Restoration Corporation by scientists who claimed the project would yield little usable scientific data); Robert Service, "Legal? Perhaps. But Controversial Fertilization Experiment May Produce Little Science," ScienceInsider, 13 October 2012, available on the Internet at <news.sciencemag.org/scienceinsider/2012/10/legal-perhaps-but-controversial.html> (last accessed on 15 October 2013).

9 See discussion infra, at 7.

cerns,[10] the key objections to specific research efforts or demonstration projects tend to rely on several recurring premises:

*Climate Engineering Would Require Global Deployment Even for Some Types of Conceptual Testing.* One proposed method of climate engineering – solar radiation management – arguably would prove very difficult to deploy and test on a limited scale. According to this critique, the only scientifically reliable way to determine the effectiveness and risks of solar radiation management or other broad-scale climate engineering techniques is to actually deploy the technology at a global range.[11] While simulations or local tests might demonstrate relatively limited aspects of the principles of climate engineering, tests or demonstrations to detect effects on a global scale would offer the only verifiable path to assuring climate engineering's effectiveness and safety. As a result, some advocates have called for a ban on climate engineering field research as well as its actual use because of fears over negative consequences resulting from possible experiments to generate measurable data on a planetary scale.[12]

*Climate Engineering Would Have Inherently Unpredictable and Dangerous Effects Because of Its Scale.* Another challenge to climate engineering argues that any deployment of such technologies would pose unpredictable and unacceptable risks because of their unprecedented global scale and complexity. For example, while global climate models may forecast the general effects of climate engineering projects at a planetary or continental scale, they arguably do not capture regional variations in a verifiable and reliable fashion. Such climate models may accurately reflect reductions in surface temperature but arguably fail to identify potential disruptions to regional precipitation that could prove to be of enormous importance. Under this critique, global climate engineering disruptions might include reductions in monsoon rains in subcontinental India as well as diminished river flows that provide critical drinking water resources to large populations.[13] As a result, these critics contend that climate engineering should not proceed until researchers obtain a much deeper and thorough conceptual understanding of its potential synergistic and emergent effects.

*Halting Climate Engineering After Its Deployment Would Risk Catastrophic Consequences.* While some types of climate engineering might successfully minimize disruptions from abrupt climate change, they would only abate manifestations of climate disruptions without addressing their underlying causes. Solar radiation management approaches, for example, might reduce solar insolation and control excessive temperature increases, but they would fail to control other aspects of climate change such as ocean acidification.[14] More importantly, solar radiation systems would only suppress climate warming effects without addressing the ongoing anthropogenic greenhouse gas emissions that caused those symptoms. As a result, if those greenhouse gas concentrations in the ambient atmosphere continue to grow while solar radiation management systems suppressed their effects, a cessation of the solar radiation management could result in a sudden and catastrophic increase in climate warming and disruptions due to the accumulated build-up of anthropogenic greenhouse gases.[15]

10 The scholarly debate over climate engineering proposals is long and passionate, and this article will not attempt to repeat it. For detailed summaries of the history of prior objections to climate engineering proposals, see Tracy Hester, "Remaking the World to Save It: Applying U.S. Environmental Law to Climate Engineering Projects", 38 *Ecology Law Quarterly* (2011), 851 et sqq.

11 See, e.g., Douglas MacMynowski, David Keith, Ken Caldeira and Ho-Jeong Shin, "Can We Test Geoengineering?", 4 *Energy & Environmental Science* (2011), 5044, at 5045 ("[o]f course, testing at any amplitude large enough to be detectable at a global scale presents substantial ethical and governance challenges").

12 See, e.g., Mooney et al., "Darken the Sky", supra, note 5, at 211. Of course, other notable researchers disagree with this position and have argued that climate engineering research efforts can produce useful data at smaller scales which can then be expanded to larger efforts on an incremental basis. David Keith, *A Case for Climate Engineering* (Cambridge, Mass.: MIT Press, 2013), at 80–88 (discussing scenarios for deployment).

13 Katharine Rickel, M. Granger Morgan and Myles Allen, "Regional Climate Response to Solar-radiation Management," 3 *Nature Geoscience* (August 2010), at 537.

14 Elena Couce et al., "Tropical Coral Reef Habitat in a Geo-engineered, High-$CO_2$ World," 40 *Geophysical Research Letters* (2013), at 40.

15 Andy Jones et al., "The Impact of Abrupt Suspension of Solar Radiation Management (Termination Effect) in Experiment G2 of the Geoengineering Model Intercomparison Project (GeoMIP)," 118 *Journal of Geophysical Research: Atmospheres* (16 September 2013), 9743–9752; Andrew Ross and H. Damon Matthews, "Climate Engineering and the Risk of Rapid Climate Change", 4 *Environmental Research Letters* (2009), at 045103, available on the Internet at <dx.doi.org/10.1088/1748-9326/4/4/045103> (last accessed on 15 October 2013).

*Governance of Climate Engineering Would Pose Significant Ethical and Equity Challenges*. Several institutions and governmental agencies have attempted to identify potential governance mechanisms for the deployment and use of climate engineering systems and the initial stages of research. All of these initiatives have pointed out major inherent challenges to efforts to, in effect, govern the climate. Some of these governance challenges include fundamental questions of equity and human rights posed by deployment of climate engineering systems by wealthy nations or entities without the support or consent of less developed countries that might suffer the consequences of those efforts. These equity challenges will grow more severe in light of the long-term intergenerational effects of decisions to deploy – or not deploy – climate engineering projects. In addition, some climate engineering projects may cost so comparatively little that they fall within the resources and capabilities of single countries, corporations, or even wealthy individuals.[16] Last, some climate engineering projects may have regional variations that cause local disruption or damages to regions or nations while still offering large benefits to a broader community of nations.[17] Climate engineering governance frameworks will need to address foundational issues of consent, cooperation and liability to respond to these circumstances.

## III. A New Scale – Emerging Technologies for Regional Climate Engineering

Technological advances that could allow climate engineering to seek changes on a more localized basis and with greater precision may reshape this debate. If so, key precepts underlying criticisms of global climate engineering proposals may not fully apply, and several proposed governance requirements and mechanisms arguably would not effectively oversee such regional efforts. The current struggle over international legal requirements and governance for climate engineering, as a result, may need a thorough rethinking if future climate change mitigation and engineering efforts seek to work on a regional – rather than global – basis.

The technological options for regional climate engineering are undoubtedly in their infancy, and the following analysis makes two fundamental assumptions. First, these approaches actually must first succeed in the future in altering regional or local climate systems before their legal consequences become important. Bur second, if these projects succeed in their goals of altering regional climate they almost certainly will also affect climate systems outside the targeted region.[18] This delicate balance of these projects' focus desired local effects with the potential for unanticipated consequences in adjoining regions or other areas will pose difficult challenges for any governance framework aimed at regional climate engineering efforts.

The first generation of de facto regional climate engineering could possibly arrive in small-scale tests and experiments to test the functional principles of climate engineering in general. These initial research projects should yield results that are limited in scope and, almost certainly, geographic area. Some proposed tests, for example, would deploy high-altitude dispersal devices to prove the principles underlying several solar radiation management approaches that might use stratospheric aerosols or particulates.[19] Other proposed experiments have focused on dispersal of iron filings onto relatively small areas of ocean surface waters to determine whether they reliably and effectively spur algal growth that could ultimately be used on a larger scale to draw down atmospheric stocks of carbon dioxide. Experiments to demonstrate principles for both of these approaches have already occurred or been proposed.[20]

16 Paul Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Public Policy Dilemma?", 77 *Climatic Change* (2006), 211, at 211 (initial estimate of sulfur albedo project would cost from $25 to $50 billion every one to two years).

17 See, e.g., Daniel Bodansky, "The Who, What, and Wherefore of Geoengineering Governance", 9 September 2012, at 4–15, available on the Internet at <http://ssrn.com/abstract=2168850> (last accessed on 15 October 2013).

18 See discussion infra, at 10.

19 Eli Kintisch, "Dr. Cool," 342 *Science* 307 (18 October 2013), at 308–309 (describing proposed field experiment to assess physical processes underlying potential effects of water vapor and sulfuric acid vapor on stratospheric atmospheric chemistry).

20 Martin Lukacs, "U.S. Geoengineers to Spray Sun-reflecting Chemicals from Balloon; Experiment in New Mexico Will Try to Establish the Possibility of Cooling the Planet by Dispersing Sulphate Aerosols", The Guardian, 17 July 2012; Jeff Tollefson, "Ocean-fertilization Project Off Canada Sparks Furor", 490 *Nature* (25 October 2012), 458 *et sqq.*, at 458.

While these initial test forays may not have any specific intent to affect climate on a regional scale, their relatively limited scope may provide a platform for examination of governance principles and frameworks for future regional climate engineering projects. For example, the self-imposed ban on marine iron fertilization activities implemented by members of the London Convention and the London Protocol does not apply to scientific projects that satisfy the voluntary risk assessment framework adopted in 2010.[21] As a result, this limitation might provide an corollary framework to craft a workable and durable definition of scientific research that could offer a safe harbor for future regional climate engineering efforts. Other resolutions under the Convention on Biological Diversity would exempt small ocean fertilization climate engineering research projects from a ban or substantive regulation under the Convention.[22]

The second generation of regional climate engineering will likely consist of intentional and targeted efforts to alter climate systems on a regional level. As concerns and questions about global climate engineering projects have led to calls for moratoria and tight restrictions, some researchers have proposed that climate engineering efforts should instead focus on regions or localized areas that raise special concerns for damage or injury.[23] These projects would seek to straddle the gap between global climate engineering efforts to alter planetary climate systems and small-scale weather modification efforts that temporarily modify local precipitation patterns. Some regional climate engineering projects, for example, might include efforts to screen solar radiation influx to arctic regions through dispersal of engineered microparticles that would preferentially congregate in polar areas,[24] cloud brightening systems that would spray marine water into the troposphere to encourage cloud formation and increase regional albedo,[25] and projects that would attempt to alter marine acidity in regional areas to offset local damages from global oceanic acidification.[26] Regional climate engineering projects might also aspire to mitigate extremes of heat, drought or other weather risks that arguably require an immediate and localized response to protect human health or the environment. For example, one study has examined whether a hypothetical localized program to disperse aerosols in the California airshed to abate dangerous heat waves aggravated by anthropogenic climate change effects.[27] As discussed below, these intentionally local efforts will most clearly highlight the legal challenges posed by sub-global climate engineering initiatives.

The final generation of regional climate change engineering might appear in local mitigation efforts within a global climate engineering initiative (if one is deployed). As described above, some climate engineering approaches may yield regional variations that damage or disrupt individual areas or nations.[28] To respond to these fluctuations,

21 30th Meeting of the Contracting Parties to the London Convention and the 3rd Meeting of the Contracting Parties to the London Protocol, Resolution LC-LP.1 on the Regulation of Ocean Fertilization (2008); Assessment Framework for Scientific Research Involving Ocean Fertilization (14 October 2010 under Resolution LC-LP.2).

22 10th Meeting of the Conference of the Parties to the Convention on Biological Diversity, Decision X/33 (Oct. 2010) at Paragraph 8(w) (exempting small scale scientific research studies conducted in a controlled setting from the prohibition on ocean fertilization activities).

23 The regional nature of these climate engineering projects does not imply that they will not have effects in other regions. For example, a regional scale sulfate project designed to moderate local temperature extremes could still potentially have unanticipated effects on precipitation or temperatures in other regions. Cloud whitening projects in one region might also create transregional impacts. John Latham et al., "Marine Cloud Brightening", 370 *Philosophical Transactions of the Royal Society A* (1974): 4217–4262 (13 September 2012). The key point is that the designs of these projects intentionally aspire to have a localized ameliorative effect on climate in a particular region, even if that purpose might have unexpected or undesired impacts outside that region.

24 David Keith, *Photophoretic Levitation of Engineered Aerosols for Geoengineering*, 107 *Proceedings of the National Academy of Sciences* (21 September 2010), 16428 (aerosol particles could be engineered to migrate preferential to polar atmospheric regions and enhance regional climate engineering effects); Daniel Lunt et al., "Can Geoengineering Save the Greenland Ice Sheet?", 6 *IOP Conference Series: Earth and Environmental Science* (2009), 452009 (if sulfate climate engineering project is "assumed to be focused at high northern hemisphere latitudes," it can maintain all of the ice sheet except for a few centimeters of sea level equivalent").

25 Lynn Russell, "Offsetting Climate Change by Engineering Air Pollution to Brighten Clouds," 42 *The Bridge Linking Engineering and Society* (Winter 2012), 10, at 12–15; "Lift Off: Research Into the Possibility of Engineering a Better Climate is Progressing at an Impressive Rate – And Meeting Strong Opposition," The Economist, 4 November 2010, available on the Internet at <www.economist.com/node/17414216> (last accessed on 15 October 2013).

26 Eric Scigliano, *Sweetening the Waters: The Feasibility and Efficacy of Measures to Protect Washington's Marine Resources from Ocean Acidification* (Ojai, Calif.: National Fisheries Conservation Center, 2012), at 11 – 25.

27 D.N. Bernstein et al., "Could Aerosol Emissions Be Used for Regional Heat Wave Mitigation?", 12 *Atmospheric Chemistry and Physics Discussion* (2012), 23793, at 23807–09.

28 See discussion, supra, at 5.

global climate engineering systems may attempt to include mitigation efforts to offset regional disruptions. In effect, these corrective measures could function as regional climate engineering projects nested within a larger framework to alter global climate systems. For example, attempts to test a broad climate engineering program might include regional efforts to protect monsoons or to shield vulnerable arctic regions that might be disrupted by solar radiation management projects.[29]

All of these approaches highlight the central conundrum of potential regional climate engineering strategies: each method would expressly seek to create only a local or regional effect, but that desire cannot foreclose the possibility of broader unanticipated or damaging consequences in other regions.[30] As a result, regional climate engineering evokes concerns about similar types of unknown or unexpected risks the global climate engineering might pose. The legal issue and governance challenge, as a result, will center on the proper regulatory framework for regional climate engineering efforts under international and domestic laws while these risks remain unknown and field tests commence by regional partners or individuals have only begun to commence.

## IV. Alternative Governance and Legal Frameworks for Regional Climate Engineering

Because of the substantive differences between global and regional climate engineering, proposed governance mechanisms for global climate engineering projects and research may prove ill fitted for regional climate initiatives. For example, the UNFCCC and its subsequent protocols and accords, the Convention on Biological Diversity, and the London Convention and Protocol have all been proposed as possible mechanisms to govern facets of global climate engineering efforts,[31] but each of these multinational conventions may prove too blunt a tool to effectively govern regional climate engineering efforts without either missing possible risks or squelching potentially beneficial research.

This mismatch arises from several potential causes. For example, the UNFCCC and subsequent protocols and commitments within its aegis expressly focus on climate change effects on a global scale and largely place the power to take action within the domestic powers of each signatory nation. As a result, actions by one nation to alter its climate within its own borders or on a regional basis with sovereign partners arguably might not transgress its obligations under a narrow interpretation of the UNFCCC, the Kyoto Protocol or the subsequent accords. As long as the signatory nation took the affirmative steps spelled out in its commitment to provide information related to its greenhouse gas emissions, restricted or reduced its greenhouse gas emissions per any obligations that the nation assumed under the UNFCCC or its subsequent protocols, and coordinated its activities with other signatories to avoid unnecessary and identifiable environmental damage, the UNFCCC and its corollary agreements may not impose direct substantive obligations that would limit that nation's affirmative actions to affect regional climate or within that nation's borders.

A broader interpretation of these treaties would arguably require States to avoid regional climate engineering efforts that would cause damage outside a signatory nation's territorial jurisdiction. For example, article 4(1)(f) of the UNFCCC obliges signatories to minimize the adverse effects of adaptation and mitigation efforts on "the economy, on public health and the quality of the environment", and this duty could arguably include adjoining areas outside the signatory's territory. In addition, the UNFCCC's Preamble notes that signatories must "ensure that activities within their jurisdiction or

29 Douglas MacMartin, David Keith, Ben Kravitz and Ken Caldeira, "Management of Trade-offs in Geoengineering through Optimal Choice of Non-uniform Radiative Forcing," Nature Climate Change, 21 October 2012, at 5.

30 Keith, *Climate Engineering*, supra, note 12, at 114 ("[i]f climate could be independently controlled in each region of the planet, then it might be fine [to] have each region choose their climate without central coordination. But this is impossible. Regional climates are strongly interconnected by flows of wind and water that carry heat and moisture from place to place. It is physically possible to imagine a system that enable fast-acting local control of radiative forcing, but this does not enable independent control of local climate").

31 See, e.g., Matthias Honegger, Kushini Sugathapala and Axel Michaelowa, "Tackling Climate Change: Where Can the Generic Framework be Located?", 7 *Carbon & Climate Law Review* (2013), at 125–135 (2013) (describing past and proposed uses of UNFCCC, the London Convention and the Convention on Biodiversity in attempts to impose limits on climate engineering experiments that arguably endangered ocean resources or threatened species).

control do not cause damage to the environment of other State or of areas beyond the limits of national jurisdiction." In response, a State wishing to undertake regional climate engineering may assert that this duty under the UNFCCC applies solely to commitments by parties to mitigate or adapt to prior sources of anthropogenic climate change, and as a result this obligation would not extend to efforts to offset or control climate change effects already underway caused by other actors. States conducting such projects might also conclude that their efforts are not causing "damage to the environment" of other States because regional climate engineering would reduce or counterbalance preexisting or ongoing damage caused by anthropogenic climate change. The UNFCCC and its successor agreements, if so, would likely provide little practical avenue for other parties to contest or halt that State's actions.[32]

On a more fundamental level, attempts to govern regional climate engineering activities through existing multinational conventions may result in paralysis of those efforts without regard to those projects' value or risk. Because the UNFCCC, its corollary agreements, and other multinational conventions vest decision-making authority in a large number of parties, the ability to reach consensus or to alter the agreements to reflect new circumstances posed by regional climate change projects may create an anti-commons effect.[33] By dispersing decisional authority among a large number of States who might not share an interest in allowing any climate engineering research (be it regional or global), this framework creates the possibility that the hurdles of reaching a collective decision would effectively preclude the ability to reach a decision at all. If regional climate engineering initiatives required any form of prior approval under multinational conventions, these dispersed decisional mechanisms would effectively create an anti-commons dynamic that would impede regional climate efforts on purely procedural grounds without evaluating the merits of the projects themselves.

Last, the sheer size and pace of existing multinational frameworks for climate change efforts may not match the scale and speed of regional climate engineering efforts. Because a regional effort would, by definition, involve a smaller commitment of resources and potentially constricted scope of consequences to evaluate, a nation or party could have the technical and economic capacity to undertake a project on a relatively quick pace. For example, a decision to undertake iron fertilization of regional oceanic waters may take only weeks or months to mount. By contrast, collective decision-making under the UNFCCC framework, the Convention on Biological Diversity or the London Protocol typically require years of deliberation and effort prior to any collective approval. The consent process itself can last for years as parties submit their individual assent to the decision.[34] As a result, applying multinational decisional frameworks on a global scale to an action that, by definition, is regional or even solely domestic could constitute a stark mismatch of scale. This incongruity can spark mischief on several levels, including conflicts with domestic laws and a possibly reduced sensitivity of the multinational process to the local needs and concerns of the nation or party that wished to undertake the regional climate engineering effort.

Given the potentially poor fit between existing multinational governance mechanisms and regional climate engineering activities, the international community may wish to explore alternative approaches to assure that regional climate change

32 UNFCCC art. XIV (Dispute Resolution) simply provides that parties will attempt to resolve their disputes "through negotiation or any other peaceful means of their choice" unless they have previously acceded to mandatory jurisdiction of the International Court of Justice or other arbitral body. Subsequent protocols and understandings have incorporated the same or similar dispute resolution provisions. See, e.g., Kyoto Protocol to the United Nations Framework Convention on Climate Change, Kyoto, 10 December 1997, in force 16 February 2005, 37 *International Legal Materials* (1998), 22, at Art. 19.

33 An anti-commons arises when ownership or control of an asset or natural resource is dispersed so broadly that obtaining consensus from multiple owners becomes difficult or impossible. This situation can paralyze needed action to protect the resource which might impose costs on any individual user. In this sense, an anti-commons situation can parallel many of the infirmities that plague management of traditional commons where no individuals hold separate ownership of the resource. For the seminal article outlining this concept, see Michael Heller, "The Tragedy of the Anti-Commons: Property in the Transition from Marx to Markets," 111 *Harvard Law Review* (1998), 622, at 667–679.

34 For example, the parties to the London Protocol began discussions about potential limits on ocean fertilization experiments in 2007, produced an initial resolution in 2008, accepted a proposed scientific framework to assess risks of ocean fertilization scientific research, and finalized its adoption of the scientific framework and its accompanying implementing resolution in 2011. International Maritime Organization Briefing, "Assessment Framework for Scientific Research Involving Ocean Fertilization Agreed", 20 October 2010, available on the Internet at <www.imo.org/mediacentre/pressbriefings/pages/assessment-framework-for-scientific-research-involving-ocean-fertilization-agreed.aspx> (last accessed on 15 Oct. 2013).

research and projects receive an appropriate degree of oversight. If regional climate engineering has relatively local scale and effects, for example, it may be much more suitable for governance through regional or bilateral agreements. These arrangements could arise from specific treaties or agreements to expressly address regional climate change.[35] To some extent, this approach would parallel ongoing efforts to supplement the UNFCCC process through the assembly of a constellation of bilateral treaties and agreements.[36] A model bilateral agreement or treaty could provide some degree of consistency and integration among a series of agreements between nations potentially affected by, or engaged in, regional climate engineering research or efforts. This model agreement might also receive the prior review and input of UNFCCC parties in a fashion that would help integrate governance of regional climate engineering efforts with the global project to mitigate and adapt to climate change effects.

Treaties and international agreements need not provide the sole source of international law to govern regional climate change initiatives. If nations have already entered into international commitments to resolve disputes under other frameworks, the initial governance framework for regional climate engineering may emerge from traditional international dispute resolution mechanisms such as arbitration, claims tribunals or demands for international compensation.[37] Nations potentially affected by another nation's regional climate engineering efforts, for example, might seek relief from the International Court of Justice or similar tribunals under regional multinational bodies.[38] Other regional entities devoted to disparate goals such as international trade regulation or water supplies could also provide fora to address regional climate change engineering side-effects that emerge on a local level.[39]

Last, the localized effects of regional climate engineering projects may also make them more amenable to regulation through domestic courts of affected nations. Because regional climate engineering initiatives arguably may provide a closer and more discernable link between the project and its effects on nearby micro-climates, parties allegedly injured by a regional climate engineering project may have an easier burden of proving justiciability, standing and redressability under local laws.[40] For example, businesses or individuals in an adjoining nation might sue in their local courts to seek redress for damages allegedly caused by parties or nations in an adjoining nation's regional climate engineering project. The availability of expanded relief in some domestic legal frameworks for environmental damages as well as the constitutional guarantees provided for protection of national resources and environmental protection could buttress these local efforts to impose liability or constraints on regional engineering efforts that spill over national borders. These remedies could include expansive tort remedies and novel class action claims.

35 Nations in Southeast Asia, for example, might enter into a treaty to limit regional climate engineering initiatives that might affect vital monsoon patterns, snowpack and other precipitation. Nations that share interests in Arctic resources might adopt a similar regional agreement or treaty to limit any local climate engineering activities to assure protection of the Arctic environment (including tundra and sea ice).

36 See, e.g., Taishi Sugiyama and Jonathan Sinton, "Orchestra of Treaties: A Future Climate Regime Scenario with Multiple Treaties Among Like-Minded Countries," 5 *International Environmental Agreements: Politics, Law and Economics* (2005), 65–88, at 65–66.

37 The long-standing practice of nations to resort to arbitration as a tool to resolve damage claims is exemplified by the Trail Smelter Arbitration case, which provided the seminal decision to buttress the principle of liability under customary international law for inappropriately allowing conduct in one nation that causes environmental damage in another. See, e.g., The Trail Smelter Arbitration Case (United States v. Canada), 1941 U.N. Rep. Int'l Arb. Awards 1905 (1949).

38 See, e.g., Petition to the Interamerican Commission on Human Rights Seeking Relief from Violation Resulting From Global Warming Caused by Acts and Omissions of the United States, 7 December 2005 (seeking relief for human rights violations caused by climate change disruptions due to United States' failure to control greenhouse gas emissions). The Interamerican Commission ultimately declined to rule on the petition, but it did convene hearings to take testimony by affected persons.

39 For example, concerns about environmental damage from regional climate engineering projects in Canada, the United States or Mexico may lead parties to submit petitions for review under the environmental side agreement of the North American Free Trade Agreement. North American Agreement on Environmental Cooperation, 1 January 1994. Under this process, the NAFTA Commission on Environmental Cooperation's Submission of Enforcement Matters process could yield a factual record on whether the nation had enforced its domestic environmental laws in a fashion that satisfied its obligations under the NAFTA CEC side agreement.

40 For a discussion of using local or domestic environmental and tort laws to seek compensation for injuries caused by international actions that allegedly contributed to damaging climate change, see Tracy Hester, "A New Front Blowing In: State Law and the Future of Climate Change Public Nuisance Litigation," 31 *Stanford Environmenal Law Journal* (2012), at 49.

## V. Conclusion

Climate engineering research may focus first on efforts to modify climate on a regional scale for many reasons. In comparison to a full-fledged effort to modify climate on a global scale, a regional project would offer lower resource demands, simpler design needs and a smaller number of affected parties who would need to participate in its governance. Similarly, a ban on global climate change engineering research or initiatives may leave a gap in coverage that would allow regional climate engineering projects to proceed in the interim, or even after a complete global governance framework emerged.

Given the likelihood of regional climate engineering efforts in comparison to global initiatives, nations should begin now to develop parallel governance frameworks dedicated to regional research and projects. These efforts can rely on – and even fully exploit – the existing international and domestic frameworks that will likely guide regional climate engineering initiatives in the absence of full multilateral action. If so, regional climate engineering science may provide a fertile forum to develop successful new methods for international and domestic laws and agreements to effectively address global climate change.