GEOENGINEERING IN INTERNATIONAL LAW AND POLICY: NEW CHALLENGES FOR ENVIRONMENTAL LAW

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Introduction

Anthropogenic climate change will likely pose grave risks to society during the course of this century. An increase in average global temperature of between 1.1 and 6.4 degrees Celsius from the year 2000 to 2100 is predicted.[1] Effects of climate change include a decrease in sea ice and glacier cover, accelerated sea level rise, more frequent extreme weather events such as heat waves, cyclones and droughts, and irreversible impacts on biodiversity including species extinction; significantly, these effects are already becoming evident.[2]

As efforts to limit greenhouse gas emissions stagnate, geoengineering techniques, which aim to manipulate the environment, are rising to the forefront of climate policy debate. Although historically geoengineering has been regarded as somewhat of a fringe topic, barely appearing in the 2007 report of the Intergovernmental Panel on Climate Change

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1 IPCC *Climate Change 2007: Synthesis Report* (Cambridge University Press, Cambridge, 2007) at 8.

2 ML Parry, OF Canziani, JP Palutikof, PJ van der Linden and CE Hanson (eds) *Contribution of Working Group II to the Fourth Assessment Report to the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, 2007) at 8-22.

(IPCC),[3] its status is fast changing. In the last few years it has been the subject of reports by the House of Commons[4] and the Royal Society, and has also received attention from the United Nations General Assembly.[5] In 2014 the IPCC in its Fifth Assessment Report will consider geoengineering across its working groups.

Geoengineering raises novel issues of law and policy that pose challenges for the established scheme of international environmental law. This article tackles these issues in four parts. First, a basic scientific understanding of the various schemes is provided. Then, the legal and policy challenges involved are outlined, before examining the current legal framework surrounding geoengineering. Finally, the future of geoengineering in policy and law is discussed.

A. The Science of Geoengineering

The term "geoengineering", or "climate engineering", refers to "the deliberate large-scale manipulation of the planetary environment to

3 B Metz, OR Davidson, PR Bosch, R Dave, and LA Meyer (eds) *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, 2007) at [11.2.2], which referred to geoengineering as being "largely speculative and unproven."

4 House of Commons Science and Technology Committee *The Regulation of Geoengineering* (Fifth Report of Session 2009-10, March 2010).

5 *Oceans and the Law of the Sea* GA Res 62/215, A/RES/62/215 (2007) at [98]; *Oceans and the law of the Sea* GA Res 64/71, A/RES/64/71 (2009) at [132]-[133].

counteract anthropogenic climate change."[6] Instead of conventional carbon emissions reduction techniques, geoengineering aims to alter the climate in a more direct, intentional and specific way. Scientists, engineers and entrepreneurs have proposed many different methods of geoengineering. Although there are some broad similarities between them, it is difficult to make generalisations in terms of policy issues; there are marked differences in terms of each method, its cost, the degree of international cooperation required for deployment of the scheme, and the degrees of risk and uncertainty involved. Due to the degree of scientific complexity involved, only a basic outline can be given here, but it is sufficient for this article's purposes.

A basic categorisation of geoengineering into two main types can be made:

(1) *Carbon dioxide removal*. In these methods, carbon is removed from the atmosphere or captured and sequestered before it is released into the atmosphere.
(2) *Solar radiation management*. This involves the limitation of the amount of solar radiation (sunlight) striking the Earth.

Several methods of geoengineering which fall into one or the other of these categories will now be examined.

1. Ocean iron fertilisation

An example of a carbon dioxide removal proposal is iron fertilisation. This method would introduce iron to nutrient-deficient areas of the upper ocean, triggering the growth of phytoplankton blooms which are essentially large clusters of phytoplankton, in that area. Phytoplankton

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6 The Royal Society Geoengineering the Climate: Science, Governance and Uncertainty (RS Policy Document 10/09, 2009) at 15.

are carbon-rich, and when they die at least 20 to 30 per cent of their biomass sinks and becomes suspended in deep currents. This means that carbon is thus effectively isolated from the atmosphere for centuries.[7]

There are, however, several disadvantages and sources of uncertainty involved in iron fertilisation. For it to work, centuries of sustained activity on a large geographical scale would most likely be required, which is rather impractical given the uncertainties and fluctuations of human society.[8] In addition, the potential and effectiveness of iron fertilisation depends strongly upon choice of location, and the variables that determine effectiveness have not been isolated. It is unclear how long the carbon would be isolated for, and how much of the phytoplankton would be isolated. Furthermore, field trials have not yielded particularly positive results: predominantly, the phytoplankton blooms were quickly devoured by zooplankton, krill, and fish.[9] Moreover, there are considerable side effects of iron fertilisation on ocean ecosystems, including increased ocean acidification,[10] and the production of toxic algae.[11] This method could potentially lead to an increase in the release of methane and nitrous oxide – worsening

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7 R Rayfuse and others "Ocean Fertilisation and Climate Change" (2008) 23 IJMCL 1.

8 TM Lenton and NE Vaughn "The radiative forcing potential of different climate geoengineering options" (2009) 9 Atmos Chem Phys Discuss 2559 at 2591.

9 Rayfuse and others, above n 7, at 9.

10 HD Matthews and others "Sensitivity of ocean acidification to geoengineered climate stabilization" (2009) 36 Geophys Res Letters L10706.

11 CG Tricka and others "Iron enrichment stimulates toxic diatom production in high-nitrate, low-chlorophyll areas" (2010) 107 Proc Nat Acad Sci 5887.

climate change.[12] It is as yet unclear how these side effects could be mitigated.

There are several other carbon removal methods involving the oceans, including sub-seabed sequestration of carbon dioxide,[13] injection of carbon dioxide (CO_2) directly into the water column[14] and weathering techniques to increase the alkalinity of the oceans and therefore enhance the solubility pump.[15]

2. Carbon capture and sequestration

Another idea is to capture and sequester CO_2 emitted from coal-fired power plants. Options for places to store the CO_2 long-term include: depleted oil and gas formations, coal seams that are unsuitable for mining, and non-potable saline aquifers.[16] A limitation of this method is that so far it has only been tested on coal-fired power plants – to be effective, it needs to be applied to the many other industrial activities that emit CO_2.

The obvious risk in carbon capture methods is a CO_2 leak, which could be fatal to those in the surrounding area. It is also unclear how well it

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12 M Lawrence "Side-effects of ocean iron fertilization" (2002) 297 Science 1993.

13 A Weeks "Sub Seabed Carbon Dioxide Sequestration as a Climate Mitigation Option" (2007) 12 Ocean & Coastal LJ 245.

14 Rayfuse, above n 7, at 3.

15 L Harvey "Mitigating the atmospheric CO_2 increase and ocean acidification by adding limestone powder to upwelling regions" (2008) 113 J Geophys Res 113.

16 P Marston and P More "From EOR to CCS" (2008) 29 Energy LJ 421 at 437-439.

can be contained, and remain captured.[17] There is also the probable limit of CO_2 that can be stored. Nor does carbon capture address the ultimate problem: *emission* of CO_2. More real-world testing is needed: without this, it is impossible to know the answers to these key questions.

3. Reforestation

Reforestation is a popular option for CO_2 removal. Forests are a huge carbon sink; scientists estimate that if all deforested land were converted back to forests, atmospheric CO_2 would be reduced by 40 to 70 ppm. However, creating new forests is only the first step. A sustainable forest takes time to establish, and for reforestation to create a viable carbon sink forests must have proper protection and stewardship to prevent future deforestation or degradation that can lead to carbon emissions.[18] Biodiversity, species and ecosystems relevant to the native environment must be considered when planting.

Reforestation is likely the safest and least uncertain geoengineering method. One important caveat is that not all land is equal when it comes to reforestation. Tropical regions are in general much more suitable than the mid-latitudes for reforestation initiatives.[19] This is because of another significant effect that forests can have: a decrease in albedo, or the reflectivity of the earth, due to the dark colour of forest canopies. A decrease in albedo generally leads to an increase in temperature because more solar energy is absorbed into the earth.

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17 M Latham "The BP Deepwater Horizon" (2001) 36 Wm Mary Env L & Pol'y Rev 31 at 44.

18 JG Canadell and others "Managing Forests for Climate Change Mitigation" (2008) 320 Science 1456 at 1456.

19 At 1457.

However, the albedo effects vary by region: forests which substitute for snow-covered ground in boreal areas will ultimately decrease albedo, whereas in tropical regions more forests would result in increasing cloud formation, causing albedo to increase. Thus, reforestation is most effective in tropical areas.

4. Stratospheric aerosols

Sulfate particles, or aerosols, when injected into the stratosphere cause dimming as they scatter and absorb incoming sunlight. This leads to global cooling. These effects have already been studied via naturally occurring processes such as the emission of ash during the 1991 Mt Pinatubo eruption. In the 15 months following that incident the average global temperature measurably cooled, by about 0.6 degrees Celsius.[20] Studies suggest that a source 15 to 30 times that of the current non-volcanic sources of sulfur to the stratosphere would be required to balance warming associated with a doubling of CO_2;[21] a concerted global effort would be required.

Side effects of aerosol use include adverse consequences for the hydrological cycle potentially leading to drought,[22] and further ozone depletion,[23] although concerns about increased acid rain are demonstrably unfounded.[24] A practical issue is the short atmospheric

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20 J Zhao and others "A model simulation of Pinatubo volcanic aerosols in the stratosphere" (1995) 100 J Geophys Res 7315.

21 PJ Rasch and others "An overview of geoengineering of climate using stratospheric sulphate aerosols" (2008) 366 Phil Trans R Soc A 4007 at 4013.

22 G Bala and others "Impact of geoengineering schemes on the global hydrological cycle" (2009) 105 Proc Nat Acad Sci 7664.

23 Rasch, above n 21, at 4031.

24 At 4032.

lifetime (one to two years) of aerosols; continuous deployment would be needed to maintain cooling. Conversely, aerosols cannot be removed from the atmosphere once they have been released, which means that their effects need to be comprehensively studied if they are to be released on a wide scale.[25] A positive effect suggested by some studies, however, is that more diffuse radiation allows plants to photosynthesise more effectively, increasing their carbon sink capacity.[26]

5. Cloud whitening

Spraying a fine seawater mist into low-level marine clouds causes them to reflect more sunlight and thus increases the Earth's albedo. One proposal would deploy this method using a fleet of around 1,500 unmanned ships, and it estimates this technique would be sufficient to reverse the warming effect of a doubling of CO_2.[27]

Advantages of this method are: it uses natural and renewable resources, it is considerably cheaper than many other proposals,[28] and it utilises already existing technologies. The major risk involved is that regional weather patterns could be disrupted in unpredictable ways. A critical drawback of this scheme, and indeed all solar radiation management schemes is that they only address the warming problem, and not any of the other problems associated with increased CO_2 concentrations such as increased ocean acidification.

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25 A Robock "20 Reasons Why Geoengineering May Be A Bad Idea" (2008) 64(2) Bulletin of the Atomic Scientists 14 at 17.

26 L Gu and others "Response of a Deciduous Forest to the Mount Pinatubo Eruption" (2003) 299 Science 2035.

27 J Latham and others "Global Temperature Stabilization via Controlled Albedo Enhancement of Low-level Maritime Clouds" (2008) 366 Phil Trans Roy Soc A 3969 at 3985.

28 At 3985.

6. Conclusions

It is clear that generalised thinking about geoengineering only yields limited conclusions. The methods vary widely: some are undeveloped or have proven negative side effects (such as iron fertilisation), while others (such as cloud whitening and aerosol injection) are comparatively well developed and plausible. No scheme is free of side effects.

There are also some commonalities. First, it is clear that for the successful deployment of any of these options some kind of international agreement would be needed, either because of the inherent trans-boundary effects or because of the practical need for geoengineering to be implemented around the globe. In addition, though the degree of risk varies between schemes there is an inherent measure of uncertainty involved: scientists acknowledge that although climate models are improving, the complexity and chaotic nature of the system means total confidence in any given scheme is impossible.[29] It should be noted, however, that although uncertainty can never be fully eliminated, it can be significantly reduced in many cases by further research and testing. Indeed, for all schemes more development is needed to create a viable proposal. Finally, another inherent disadvantage of all geoengineering techniques, when compared to the alternative approach of emissions reduction, is that if deployment stops (in the cases of iron fertilisation, cloud whitening, or aerosols), or if carbon escapes from sequestration, rapid warming is likely to ensue, which would have unprecedented catastrophic effects on the climate.[30]

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29 Robock, above n 25, at 17.

30 Lenton, above n 8, at 2595.

B. A Policy Basis for Geoengineering … And Some Issues to be Resolved

1. An argument for geoengineering

There is a strong argument for the development of viable geoengineering proposals. Scientifically, the problem of anthropogenic climate change is well-documented and agreed upon. Increasing CO_2 emissions lead to a rising global average temperature, which causes adverse consequences such as melting sea ice, rising sea levels, more frequent extreme weather events like drought[31] and wildfire,[32] increased ocean acidification,[33] and large-scale extinctions.[34] The scientific community is largely in agreement that climate change is occurring and will continue to occur, with only limited disputes arising as to the extent of the change and its regional consequences.[35]

International efforts to limit greenhouse gas emissions have thus far failed due to political, socio-economic and technological inertia, and the evidence suggests this trend will continue.[36] Even if the political will to limit emissions emerges there is a fast-closing window of opportunity

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31 C Schar and others "The Role of Increasing Variability in European Summer Heatwaves" (2004) 427 Nature 332 at 335.

32 T Brown and others "Assessing Climate Change and Fire Danger" (2008) 89 Bull Am Meteorological Society 788.

33 J Orr and others "Anthropogenic Ocean Acidification over the Twenty-First Century and Its Impact on Calcifying Organisms" (2005) 437 Nature 681.

34 Hansen and others "Global Temperature Change" (2006) 103 Proc Nat'l Acad Sci US 14288 at 14292.

35 See IPCC, above n 1, at 5.

36 As documented in C Redgwell "Geoengineering the Climate" (2011) 5 CCLR 178 at 178-179.

to avoid a significant temperature increase.[37] In addition, climate change could be far more rapid and severe than we can predict, due to net positive feedbacks in the carbon cycle such as the release of CO_2 from the decomposition of peatlands, wetlands and permafrost,[38] the release of CH_4 from marine gas hydrates[39] and reduced albedo from melting of ice and snow.[40]

Therefore, the basic argument is that knowledge of geoengineering techniques, and plans to put those techniques into action, are needed in the (unfortunately likely) event that emissions reduction strategies fail.

2. A stop-gap measure

However, scientists and policymakers agree that geoengineering should be a temporary, stop-gap measure only.[41] This is imperative for three reasons. First, many methods (such as cloud whitening and stratospheric aerosols) only counter warming, not other effects of increased CO_2 concentration, which themselves can have devastating effects on the environment. Secondly, none of the proposals outlined above can be sustained indefinitely, meaning that when they end it is important the climate does not simply return to its non-altered state of carbon overabundance. Finally, in addition to climate change other

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37 See S Kallbekken and N Rive "Why Delaying Emission Reductions is a Gamble" (2007) 82 Climatic Change 27.

38 See EA Davidson and IA Janssens "Temperature Sensitivity of Soil Carbon Decomposition and Feedbacks to Climate Change" (2006) 440 Nature 165.

39 JG Fyke and AJ Weaver "The Effect of Potential Future Climate Change on the Marine Methane Hydrate Stability Zone" (2006) 19 J Climate 5903 at 5916.

40 See G Walker "The Tipping Point of the Iceberg" (2006) 441 Nature 802.

41 See Royal Society, above n 6.

problems remain and need to be addressed as part of a long-term solution, such as the depletion of resources, environmental pollution and ecosystem destruction. Put simply, even taking the possibility of geoengineering into account, human society cannot simply continue as normal: emissions reduction efforts must continue.

A common argument against geoengineering is that there is a high risk of it being viewed as a viable alternative to emissions reduction, rather than merely a supplement. This would mean states and individuals feel no imperative to make the long-term lifestyle changes necessary to address climate change.[42] Several counterarguments can be made. First, the prospect of actual implementation of geoengineering programs may well generate the political will necessary to implement more aggressive mitigation policies, rather than deploy a radical geoengineering proposal. Moreover, even if geoengineering would undermine mitigation, it may well become the only realistic option to deal with climate change: it would at least hold the temperature constant while buying time for the development of alternative technologies, and more gradual and less costly emissions limitations and adaptation measures. It is clearly "dangerously myopic" to discount geoengineering as a climate policy option altogether.[43]

3. The need for further research

It is equally clear that geoengineering proposals are largely speculative, with perhaps the exception of reforestation even the most developed schemes require significantly more research and testing before implementation. This supports the point already made that

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42 Robock, above n 25, at 17.

43 W Davis "What does "Green" mean?" (2009) 43 Ga L Rev 901 at 923.

geoengineering should only ever be a Plan B, a supplement to emissions reduction measures to be used as a last resort.

The precautionary principle, applied to geoengineering, states that in the face of risk and uncertainty geoengineering experiments and deployment must be treated with caution.[44] This is clearly justifiable. It should be noted, however, that there are inherent difficulties in applying this principle since "it forbids all courses of action, including regulation. Taken seriously, it is paralyzing, banning the very steps that it simultaneously requires."[45] It must be kept in mind the precautionary principle can be argued both ways: it requires us to take any step possible to avoid the dangerous and uncertain consequences of anthropogenic climate change. The precautionary principle must not scare us off geoengineering altogether.

In fact, further research must occur – having made the *negative* point that geoengineering schemes should not be deployed until there is sufficient research, the *positive* point is just as important. It is vital for law and policy to support geoengineering research and testing within the bounds of proper caution. Some level of regulation is necessary. The mere idea of geoengineering as having radical side effects and being highly likely to cause unintended consequences must not deter further research and development in order to overcome current scientific barriers.

If real-world testing does not occur, Davis puts forward a worst-case scenario: desperate countries faced with large-scale famine, economic

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44 JR Nash "Standing and the Precautionary Principle" (2008) 108 Colum L Rev 494 at 498.

45 C Sunstein "Irreversible and Catastrophic" (2006) 91 Cornell L Rev 841 at 850.

depression or war might well unilaterally decide to deploy a crash geoengineering project. In the absence of scientific information the project would probably be ineffective or actively counterproductive. Even if it was partially successful in mitigating climate change, the side effects might not be ameliorable without prior research.[46] Hence there is a vital need to engage in real-world experimentation. Further to this, a range of different proposals must be seriously looked into so as to diversify future options. It is clear that law is needed – but the challenge will be to build a legal regime through which the risks can be managed, but without inhibiting or stifling research.

C. Governance Challenges

A range of issues exists. First, questions of global equity arise. Deployment of geoengineering on any significant scale will undoubtedly have trans-boundary effects, which may be positive or negative. The existing global playing field is wildly uneven both in terms of political power and wealth, and in relation to regional and local variations in potential vulnerability to the effects of climate change. Indeed, there are only a few countries that have technical capacity to engage in geoengineering, and many geoengineering techniques, such as iron fertilisation or cloud whitening, could potentially be carried out unilaterally by individual states or even companies or wealthy individuals. This raises questions of *who* would have the authority to undertake geoengineering in ways that might be advantageous to some but not others. Bronsen points out geoengineering offers a perfect excuse for industrialised countries to "evade historical responsibility

[46] Davis, above n 43, at 906.

rather than reducing emissions."[47] Geoengineering has a huge potential to disproportionately affect countries that generally lack political power and technological know-how. Furthermore, some states are likely to benefit from climate change due to, for instance, changing rainfall patterns or longer crop growing seasons – how are their interests to be represented in any regime?[48] Any system needs to be developed with global equity considerations at its core.

The issue of multinational companies is similarly fraught, as the profit motive makes it difficult for a company to have the global good at heart. As Robock puts it, geoengineering could pose issues "analogous to those raised by pharmaceutical companies and energy conglomerates whose products ostensibly serve the public, but who often value shareholder profits over the public good."[49] The global climate is too important to entrust to private hands. Thus, it is important for geoengineering development to be publicly regulated and transparent in research, rather than solely privately controlled.

The final issue arises in relation to a more general lack of scientific knowledge. For instance, it is difficult to know exactly how much geoengineering would be required to "offset" anthropogenic climate change. Moreover, we do not know Earth's "ideal" mean temperature. This issue can be somewhat reduced by ongoing research. We can see that a legal framework should be constructed to maximise the potential benefits and minimise the risks of geoengineering. However, these

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47 D Bronson "Geoengineering: A Gender Issue?" (2009) Women in Action 83 at 86-87.

48 K Scott "Marine Geoengineering" (paper presented at ANZSIL 18th Annual Conference, Canberra, 2010) at 7.

49 Robock, above n 25, at 17.

complex policy issues raise challenges that must be addressed in any such regime.

D. Current Regulation

The current legal picture is diverse, fragmented, and relatively sparse; it reflects how recently geoengineering has burst into global awareness and how little is understood. There is no single treaty or institution governing geoengineering; rather, there are a multitude of instruments that could be construed so as to apply to geoengineering. It is uncertain how far these existing rules can be adapted to regulate geoengineering actors and activities. Indeed, in some cases it is unlikely that the possibility of geoengineering to counter climate change was contemplated at the time of drafting. Nonetheless, some are potentially applicable to all geoengineering, whereas others can only apply to particular schemes.

1. 1977 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (the 1977 Convention)[50]

The 1977 Convention prohibits military or other hostile uses of "environmental modification techniques", which art II defines broadly as "any technique for changing – through the deliberate manipulation of natural processes – the dynamics, composition or structure of the Earth", having widespread, long-lasting or severe effects (art I). However, peaceful use of such techniques consistent with other

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50 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques 1108 UNTS 151 (opened for signature 18 May 1977, entered into force 5 October 1978).

applicable rules of international law is expressly permitted (art III). Geoengineering would appear to fall under these provisions.

The principal importance of this convention lies in its prohibition upon hostile uses of climate modification. However, it is institutionally weak, for instance offering no regulation around when "peaceful use" of environmental modification techniques might be allowed. Moreover, its approach is essentially prohibitory. These factors make it ill suited for adaptation as a geoengineering regulatory instrument.[51]

2. 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Convention)[52]

This convention applies to disposal of waste material in any area of the water column (arts III (1), (3)). The definition of dumping does not include placement of matter for a purpose other than mere disposal, as long as it is not contrary to the aims of the Convention (art III(1)(b)ii). On the face of it the convention would probably not cover iron fertilisation, and opinions are divided as to whether it would prohibit experimental injection of CO_2 into the water column.[53]

Later amendments have introduced provisions specifically relevant to geoengineering. Under a 1996 Protocol, which has limited participation,

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51 Redgwell, above n 36, at 183.

52 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1046 UNTS 120 (opened for signature 29 December 1972, entered into force 30 August 1975).

53 See R Warner "Preserving a balanced ocean" (2007) 14 AILJ 99 at 111.

direct injection of CO_2 into the water column is prohibited.[54] However, amendments permitting storage of CO_2 under the seabed were adopted on 2 November 2006.[55] Guidelines in respect of sub-seabed sequestration[56] would require parties to issue a permit for the sequestration subject to stringent conditions being fulfilled (s 9), including rigorous studies and geological assessments of the proposed site (ss 3, 4, 6).

In 1997, the Scientific Bodies to the Convention issued a "statement of concern" in response to field trials of iron fertilisation. They noted its potential to have negative impacts on the marine environment and human health, stated that "knowledge about the effectiveness and potential environmental impacts … currently is insufficient to justify large-scale operations,"[57] and stated that the London Convention is competent to address the issue of iron fertilisation, urging states to use "utmost caution".[58] This statement was highly significant in that it specifically recognised iron fertilisation as a method of geoengineering, and promoted caution among member states. It is clear that the Scientific Bodies recognised the current uncertainty and risks of iron

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54 1996 Protocol to the London Convention 1972 (opened for signature 7 November 1996, entered into force 24 March 2006).

55 International Maritime Organisation *Notification of amendments to Annex 1 to the London Protocol 1996* LC-LP.1(1)/Circ.5, 27 November 2006.

56 International Maritime Organization Specific Guidelines for Assessment of Carbon Dioxide Streams for Disposal into Sub-seabed Geological Formations LC 29/4 (2007).

57 International Maritime Organization *Statement of Concern Regarding Iron Fertilization of the Oceans to Sequester Carbon Dioxide* LC-LP.1/Circ/14 (2007).

58 International Maritime Organization *Report of the Twenty-Ninth Consultative Meeting and the Second Meeting of the Contracting Parties* LC 29/17 (Dec 14, 2007) at [4.23.1]-[4.23.5].

fertilisation. As such, it is undoubtedly a step forward in terms of sheer recognition of the issues. However, the Scientific Bodies essentially took a precautionary approach, without encouraging further research. Moreover, it should be noted this is only a soft law statement, rather than a rule binding on the parties to the Convention. Nevertheless, it is a valuable development.

3. 1992 Convention on Biological Diversity (the CBD)[59]

Under this Convention, parties must introduce environmental impact assessment procedures for proposed projects that are likely to have significant adverse effects on biodiversity in order to avoid or minimise such effects (art 14). Parties also have a duty to cooperate in the conservation and sustainable use of biological diversity beyond national jurisdiction, directly or through competent international organisations (art 5). Methods of geoengineering that affect biodiversity, such as iron fertilisation and reforestation, would fall under these broad provisions.

Although the parties debated adopting a moratorium on ocean fertilisation activities,[60] they ultimately (and rightly) followed the London Convention approach. Parties are urged to ensure ocean fertilisation activities do not occur until there is an adequate scientific basis and a "global transparent and effective control and regulatory mechanism is in place for these activities". An exception is made for small-scale research within "coastal waters" for scientific purposes only.[61] Further to this theme, a 2010 report under the CBD called on

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59 Convention on Biological Diversity 1760 UNTS 79 (opened for signature 5 June 1992, entered into force 29 December 1993).

60 Subsidiary Body on Scientific, Technical and Technological Advice Recommendation XIII/6 (2008).

61 Ninth Meeting of the Conference of the Parties to the Convention on Biological Diversity, Decision IX/16 (2008).

parties to ensure "that no climate-related geo-engineering activities take place until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts," with the exception of small scale research studies conducted in a controlled setting.[62] The sheer lack of scientific knowledge and uncertainty surrounding iron fertilisation was clearly a key influence behind this report.

These developments, along with the London Convention, may indicate an emerging norm discouraging geoengineering or at least geoengineering by iron fertilisation. This is an essentially precautionary approach, although the recognition of the need for small-scale, controlled research is a significant development. It is also only weakly precautionary in that there are no specific sanctions upon a state which does choose to undertake large-scale iron fertilisation.

4. 1985 Convention for the Protection of the Ozone Layer[63]

Under this convention there is an obligation to protect the environment against adverse effects resulting from human activities that modify, or are likely to modify, the ozone layer (art 1). It has a well-developed compliance procedure established pursuant to the 1987 Montreal Protocol.[64] This convention therefore has a limited effect. Although

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62 Report of the Fourteenth Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice UNEP/CBD/COP/10/3 (2010).

63 Convention for the Protection of the Ozone Layer 1513 UNTS 323 (opened for signature 22 March 1985, entered into force 22 September 1988).

64 Montreal Protocol on Substances that Deplete the Ozone Layer 1522 UNTS 3 (opened for signature 16 September 1987, entered into force 01 January 1989).

aerosol injection could potentially breach this obligation, as it has adverse effects on the ozone layer, no other geoengineering techniques discussed would be affected.

5. 1982 United Nations Convention on the Law of the Sea (UNCLOS)[65]

UNCLOS has several implications for ocean iron fertilisation and other marine methods of geoengineering. Parties have general obligations to protect and preserve the marine environment (art 192), and to take individual or joint steps to prevent, reduce and control the pollution of the marine environment from any source (art 194). In addition, there is an obligation not to transfer, directly or indirectly, damage or hazards from one area to another (art 195). States' parties must assess as far as practicable the potential effect of planned activities under their control which may cause substantial pollution or significant and harmful changes to the marine environment and to publish reports of their results (arts 204 and 206). Iron fertilisation schemes could potentially fall under each of these provisions.

The provisions that would require research into planned geoengineering activities are of particular interest. Based on the London Convention, the CBD and UNCLOS, it is arguable that a precautionary norm has developed around iron fertilisation. In varying degrees under these agreements states' parties are urged to be cautious in developing and deploying iron fertilisation.

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65 United Nations Convention on the Law of the Sea 1833 UNTS 3 (opened for signature 10 December 1982, entered into force 16 November 1994).

Under UNCLOS there is also a duty to cooperate on a global and regional basis in the protection of the marine environment, for the purpose of formulating rules, standards and recommended practices for protection, as well as promoting studies, undertaking scientific research programmes and encouraging the exchange of information (art 197). This could have significant implications for the development of marine geoengineering policy, but it would be better if this duty also existed in relation to other forms of geoengineering. Nevertheless, this is an important provision that shows international recognition of the need to cooperate in research around, and protection of, the marine environment. It recognises the marine environment is a shared resource at the centre of global dynamics.

Marine scientific research is a freedom of the high seas (arts 87(1)(f), 256, 257), and some argue that marine geoengineering activities should likewise constitute a freedom of the high seas.[66] This is accurate to the extent of geoengineering *research* activities. Even so, high seas freedoms must be exercised with due regard for the interests of other states (art 86) and in accordance with other provisions of the convention (for example, art 240), and marine scientific research must be undertaken for the benefit of mankind (art 140). These articles are highly applicable to marine geoengineering research.

UNCLOS could potentially also apply to aerosol injection, if such injection took place from ships or if it had an impact on the marine environment. In addition, launch of aerosols from foreign-flagged vessels in the 12-mile territorial sea would not be permitted without the express consent of the coastal state, because such activity does not constitute "innocent passage" (art 9).

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66 Scott, above n 48, at 7.

6. Regional Agreements

Some regional agreements could have limited application to geoengineering. For instance, the 1979 Convention on Long-range Transboundary Air Pollution for Europe and North America[67] regulates sulfur emissions and has evolved a compliance mechanism to address breaches of its provisions. It aims to address acidification from sulfur deposits created mainly by industrial sources. Nonetheless, it could have implications for geoengineering to the extent that geoengineering processes contributed to exceeding fixed national sulfur emissions ceilings: aerosols are sulfate particles.[68]

Another example is the 1986 Noumea Dumping Protocol to the 1986 Noumea Convention.[69] The dumping of CO_2 in high seas areas by a party would be subject to the issue of a general permit from the party to its flag vessel (art 6). This would in effect require parties to introduce an environmental impact assessment process before issuing a permit for an ocean geoengineering scheme.[70]

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67 Convention on Long-Range Transboundary Air Pollution 1302 UNTS 217 (opened for signature 13 November 1979, entered into force 16 March 1983).

68 Redgwell, above n 36, at 185.

69 Protocol for the Prevention of Pollution of the South Pacific Region by Dumping (signed 25 November 1986, entered into force 22 August 1990) to the Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (signed 24 November 1986, entered into force 22 August 1990).

70 Warner, above n 53, at 114.

E. Options for the Legal Future

It can be seen there are a plethora of potentially applicable instruments. International law hardly presents a blank slate. However, there is an alarming lack of principled regulation, which poses potential threats to marine and land-based ecosystems and the climate in general. In particular, the current law does not adequately address the necessity of further research and real-world testing, although the provisions in relation to iron fertilisation discussed above present a hopeful backdrop. Nor does it address the need for an agreement between as many countries as possible, and in particular with powerful countries, or the supplementary nature of geoengineering.

An international regime to regulate and manage geoengineering is desirable – perhaps necessary – to adequately tackle the problem of climate change. The deployment of some options, such as reforestation, would not require an international consensus in terms of safety. However, an international instrument would still be greatly helpful in relation to the effectiveness of such methods: reforestation is more likely to be effective if pursued in more states. Several options for the legal future will be considered below.

1. A multilateral geoengineering treaty

Some advocate for a global overarching instrument which would "provide both the catalyst and the forum for examining geo-engineering options at the international level,"[71] setting out common principles of application to both research and deployment activities. This instrument would need to include tools such as environmental impact assessment, monitoring, cooperation and liability, and would

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[71] Scott, above n 48, at 8.

also need to establish appropriate institutions that are to provide advice on science and engineering matters, take policy decisions on which technologies should be developed and how information should be shared, and resolve disputes. Scott advocates for this instrument to be developed as a protocol to the 1992 UN Convention on Climate Change, since geoengineering needs to be seen in the context of other measures including emissions reductions and adaptation.[72] Geoengineering fits well into this context. It would not be appropriate, conversely, for the instrument to be developed under UNCLOS, as the issue of geoengineering is far larger than the law of the sea.

It is important this instrument not only incorporates the interests of those states well-equipped to carry out geoengineering research and deployment, but also vulnerable states that would be adversely affected by geoengineering or climate change in general. A broad state membership is important, and global equity concerns must be at the heart of any such international instrument.

2. An international research body

To be effective, the treaty would have to create an institutional structure for a centre for research, development and deployment of geoengineering technology. A multilateral research program would make the use of geoengineering feasible scientifically by determining which options best offset global mean temperature increases with minimal side effects. A range of geoengineering schemes should be investigated with an eye to precisely ascertaining their effects, fully investigating and countering all possible side effects, and making the scheme technically and economically possible. Outdoor testing, although crucial, should be highly controlled and on as small a scale as

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[72] Scott, above n 48.

reasonably possible, and should be preceded by notice and consultation with other countries that could conceivably be affected.[73]

International collaboration on geoengineering research is vital not only scientifically but to develop norms of cooperative transparency which would build mutual confidence and trust, ameliorate political tensions and lend political legitimacy to the project. Mechanisms for the provision and acquisition of information about parties' capabilities, planning, intentions and decision-making processes would be desirable.[74]

This would also set the stage for development of more norms and decisions surrounding the actual deployment of geoengineering, if any.

3. A norm discouraging geoengineering?

Others advocate for a norm discouraging geoengineering altogether, and this is severely problematic. This view could preclude the use of geoengineering as even a last resort in the event of catastrophic climate change, or could result in the equally catastrophic use of a poorly researched geoengineering scheme.[75] Although geoengineering should be approached with extreme caution, it should not be actively discouraged as geoengineering research is key to mitigating climate change. The provisions in the London Convention, the CBD and UNCLOS may be taken as a guide to an advisable level of caution.

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73 Davis, above n 43, at 944.

74 At 941.

75 At 936-937.

4. Soft law

Some see a multilateral treaty as "neither likely nor desirable":[76] unlikely because the appetite for law making in the climate change context is low and undesirable because a "one size fits all" approach cannot be taken beyond the identification of key guiding principles or concerns of general application. Redgwell thinks a more realistic step forward would be adoption of guiding principles for geoengineering governance, which could be embedded in soft law and used by the key geoengineering stakeholders to guide decision-making on geoengineering research in particular.[77] Another advantage of a soft law approach is that the lack of binding provisions could make powerful, technologically advanced states more likely to cooperate.

I disagree. It is true that climate change law has been slow to progress. Of course, it is not inconceivable that geoengineering regulation would suffer the same global collective inertia. However, one only has to look at the speed at which the parties to the London Convention and Protocol issued a "statement of concern" to see that the will and impetus for geoengineering regulation very much exists. And, unlike carbon mitigation efforts, geoengineering development would involve small, achievable steps and would not run against the flow of international economics.

It is also fair to say that no single approach can be taken to all methods of geoengineering. An integrated and concerted approach to research and the development of geoengineering policy *can* be taken. Indeed, such an overarching approach is necessary to deal with all the interrelated and overlapping effects of various types of geoengineering.

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76 Redgwell, above n 36, at 188.

77 At 188.

Although soft law guidelines could be a good starting point, and indeed could usefully be incorporated into a treaty, ultimately something more is needed, in the form of an international agreement.

F. Conclusion

Geoengineering cannot be society's Plan A to mitigate the effects of anthropogenic climate change. However, if conventional efforts to counter climate change fail, we will need an insurance policy. Currently several methods of geoengineering have been proposed or tested; none, however, are presently viable and all are troubled by uncertainty as to both effectiveness and potential for negative side effects.

It is vital that viable forms of geoengineering are developed. For this to occur, we need real-world research and experimentation to occur. Thus, international law must remain open to research, and indeed must actively promote and facilitate it, while maintaining caution around actual deployment of geoengineering. A multilateral effort is clearly needed, due to the inherently trans-boundary effects of geoengineering, global equity concerns, and the difficulties and costs of effective large-scale implementation.

The current law proves inadequate to effectively regulate geoengineering. Although several existing instruments could be applied to geoengineering, and it is arguable that a precautionary principle is developing in relation to iron fertilisation, the law is ultimately piecemeal and insufficient. A precautionary principle alone is not enough; positive support for geoengineering research and policy development is needed.

An overarching international framework to provide a centre for geoengineering research and policy is recommended. A multilateral treaty, possibly as a protocol to the 1992 UN Convention on Climate Change, would be ideal as the structural basis for such an organisation. Although at this point it is only possible to speak in aspirational terms, the increasing level of awareness, debate and discussion surrounding geoengineering gives hope for these aspirations to become a reality.