Geoengineering Research Governance: Foundation, Form, and Forum

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I. INTRODUCTION

As greenhouse gas concentrations rise, so do the effects of climate change. Scientists are concerned that "feedback" in the climate system will further compound the negative repercussions of climate change, potentially causing rapid and catastrophic effects.[1] Scientists fear this snowballing effect could

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[1] BIPARTISAN POLICY CTR., THE BIPARTISAN POLICY CENTER'S TASK FORCE ON CLIMATE

exacerbate threats to food and clean water supplies; accelerate loss of Arctic floating ice, Greenland's glaciers, and the West Antarctic ice shelf; and hasten destruction of ozone.[2] Mitigation and adaptation efforts have been insufficient to combat global warming.[3] The possibility of realizing a doomsday climate scenario — some tipping point from which the world cannot return — is increasing.[4]

Geoengineering may help reduce carbon dioxide in the atmosphere and combat the harsh effects of climate change. Geoengineering, also called "climate engineering" and "climate remediation,"[5] is the "deliberate and technological manipulation of the climate system to forestall the worst effects of global warming."[6] Scientists discussed geoengineering as a potential response to anthropogenic climate change as early as the 1960s and 1970s, but discussions subsided as climate arrived on policy agendas.[7] In 2006, Nobel-prize-winning atmospheric chemist Paul Crutzen reintroduced the topic through an editorial essay on the release of sulfates into the atmosphere to reduce solar radiation.[8] Crutzen, though reluctant to advocate for geoengineering deployment, called for active geoengineering research.[9] Many credit his essay with spurring the academic, political, and public debate surrounding geoengineering today.[10]

REMEDIATION RESEARCH, GEOENGINEERING: A NATIONAL STRATEGIC PLAN FOR RESEARCH ON THE POTENTIAL EFFECTIVENESS, FEASIBILITY, AND CONSEQUENCES OF CLIMATE REMEDIATION TECHNOLOGIES 8 (2011).

2 *Id.* at 8-9.

3 *See* Lisa Dilling & Rachel Hauser, *Governing Geoengineering Research: Why, When and How?*, 121 CLIMATIC CHANGE 553, 554 (2013) ("While nearly every scientific article written states the preference for mitigation of carbon dioxide through reducing emissions . . . many express skepticism that society will act in time to prevent significant change.").

4 David G. Victor et al., *The Geoengineering Option: A Last Resort Against Global Warming?*, FOREIGN AFF., Mar./Apr. 2009, at 64, 64-65.

5 The Bipartisan Policy Center rebranded "geoengineering" as "climate remediation," noting "the [former] term . . . is controversial because it is both broad and imprecise." BIPARTISAN POLICY CTR., *supra* note 1, at 3. The Bipartisan Policy Center describes climate remediation as "technologies that are intentionally designed to counteract the climate effects of past greenhouse gas emissions to the atmosphere." *Id.*

6 Sean Low et al., *Geoengineering Policy and Governance Issues*, *in* ENCYCLOPEDIA OF SUSTAINABILITY SCIENCE AND TECHNOLOGY 4104, 4104 (Robert A. Meyers ed., 2012). Though geoengineering has no formal definition, various similar definitions exist. *See, e.g.*, U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-903, CLIMATE CHANGE: A COORDINATED STRATEGY COULD FOCUS FEDERAL GEOENGINEERING RESEARCH AND INFORM GOVERNANCE EFFORTS 2-3 (2010) [hereinafter GAO REPORT 2010] (adopting The Royal Society's definition of geoengineering: "deliberate large-scale interventions in the earth's climate system to diminish climate change or its impacts").

7 Edward A. Parson & Lia N. Ernst, *International Governance of Climate Engineering*, 14 THEORETICAL INQUIRIES L. 307, 309-10 (2013).

8 *See generally* Paul J. Crutzen, Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?, 77 CLIMATIC CHANGE 211 (2006).

9 *Id.* at 217.

10 *See, e.g.*, Scott Barrett, *The Incredible Economics of Geoengineering*, 39 ENVTL. &

Scientists and policymakers alike are reluctant to deploy geoengineering techniques. At present, geoengineering is a potential "Plan B."[11] Even as a backup plan, however, geoengineering presents significant social and moral concerns. Accordingly, some environmental ethicists call for a presumption against geoengineering strong enough to make geoengineering deployment almost unthinkable.[12]

Though reluctant to implement geoengineering, scientists recognize a need for more geoengineering research.[13] Geoengineering research is in its early stages; research to date consists of climate modeling and small-scale tests.[14] While climate modeling is a necessary first step to climate research, it is insufficient for most geoengineering approaches. Climate models are "inherently uncertain;"[15] they cannot adequately represent key processes involved in climate change.[16] Academics call for more research to discover the feasibility and risks of geoengineering.[17] But scientists disagree whether the present need for research includes field testing. While some argue field testing is essential to move past the uncertainties of modeling, others claim such research is "far too premature" and might result in a backlash that could hinder future research attempts.[18]

As geoengineering research progresses, field experiments with transboundary effects will become a reality. Currently, no single instrument or oversight body exists to govern all potential geoengineering research with international effects. This paper will address this issue with a focus on ethical analysis and informed

RESOURCE ECON. 45, 46 (2008); Holly Jean Buck, *Geoengineering: Re-making Climate for Profit or Humanitarian Intervention?*, 43 DEV. & CHANGE 253, 253 (2012); Mike Hulme, *Climate Change: Climate Engineering Through Stratospheric Aerosol Injection*, 36 PROGRESS PHYSICAL GEOGRAPHY 694, 695 (2012); Parson & Ernst, *supra* note 7, at 310 n.12.

11 *See* ORRIN H. PILKEY & KEITH C. PILKEY, GLOBAL CLIMATE CHANGE: A PRIMER 110 (2011).

12 Christopher J. Preston, *Re-Thinking the Unthinkable: Environmental Ethics and the Presumptive Argument Against Geoengineering*, 20 ENVTL. VALUES 457, 464 (2011). Preston argues, however, for a reevaluation of this presumption. *See generally id.*

13 IAN S.F. JONES, ENGINEERING STRATEGIES FOR GREENHOUSE GAS MITIGATION 70 (2011) ("Few people advocate geoengineering the climate today, but there is an increasing number who advocate research and development to prepare for the types of geoengineering discussed in this chapter in the event of a catastrophic climate change.").

14 Mark G. Lawrence & Paul J. Crutzen, *The Evolution of Climate Engineering Research* 1 (Geoengineering Our Climate Working Paper & Op. Article Series, 2013).

15 Nancy Tuana et al., *Towards Integrated Ethical and Scientific Analysis of Geoengineering: A Research Agenda*, 15 ETHICS, POL'Y & ENV'T 136, 146 (2012).

16 Cat Downy & Sarah Cornell, *Editorial: Key Themes and Messages from the Earth System Science 2010 Conference*, 6 PROCEDIA ENVTL. SCI. 3, 5 (2011); *see also* Gabriele C. Hegerl & Susan Solomon, *Risks of Climate Engineering*, 325 SCIENCE 955, 956 (2009) ("Satellite data also suggest that climate models underestimate the magnitude of forced changes and of variations in precipitation extremes.")

17 Parson & Ernst, *supra* note 7, at 322.

18 Lawrence & Crutzen, *supra* note 14, at 4.

consent. Part I will provide a background of geoengineering research, discussing the differences between research and deployment and the risks associated with research.[19] Part II surveys current international governance of geoengineering research.[20] Governance gaps in the current international system allow research projects stemming from a small number of decision-makers to affect a large number of people. Part III proposes a foundation, form, and forum for geoengineering research governance.[21] Geoengineering research governance should have a human focus and work to ensure informed consent of those affected by geoengineering research experimentation.[22] In form, research governance should build on the human-centered foundation and direct research in a manner that ensures integrated scientific-ethical goals.[23] Based on the foundation and form, this paper suggests that an existing international governance body establish research protocols and facilitate governance via a top-down approach.[24] Potentially, a science-based organization could assist with implementation.[25] Within this international framework, advisory bodies and review boards can work to ensure public participation, ethical analysis, and informed consent.[26]

II. AN OVERVIEW OF GEOENGINEERING RESEARCH

A. *What is Geoengineering?*

Geoengineering techniques fall into two main categories: carbon dioxide removal (CDR) and solar radiation management (SRM).[27] CDR methods include ocean- and land-based efforts to remove carbon dioxide from the atmosphere via physical, biological, and chemical processes.[28] Carbon dioxide is the greenhouse gas primarily responsible for increasing atmospheric temperature; CDR methods thus seek to address the root causes of temperature

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19 *See* discussion *infra* Part I.

20 *See* discussion *infra* Part II.

21 *See* discussion *infra* Part III.

22 *See* discussion *infra* Part III.A.

23 *See* discussion *infra* Part III.B.

24 *See* discussion *infra* Part III.C.

25 *See id.*

26 *See id.*

27 KELSI BRACMORT & RICHARD K. LATTANZIO, CONG. RESEARCH SERV., R41371, GEOENGINEERING: GOVERNANCE AND TECHNOLOGY POLICY 9 (2013); *see also* Tina Sikka, *An Analysis of the Connection Between Climate Change, Technological Solutions and Potential Disaster Management: The Contribution of Geoengineering Research*, *in* CLIMATE CHANGE AND DISASTER RISK MANAGEMENT 535, 537 (W. Leal Filho ed., 2013) (noting that CDR techniques often employ carbon sinks or carbon sequestration).

28 GAO REPORT 2010, *supra* note 6, at 7-9.

rise.[29] CDR techniques are generally more local than SRM methods and are, consequently, perceived to have more local risks and effects. In reality, various CDR techniques could have far-reaching risks and effects.[30] An especially effective "local" CDR method deployed broadly could affect carbon dioxide levels, and ultimately climate patterns, cumulatively. Further, ocean-based CDR techniques have potentially significant extraterritorial effects and implicate international concerns. Ocean iron fertilization — the "most infamous" CDR technique[31] — involves adding iron to the ocean to spur phytoplankton growth and ultimately promote carbon sequestration.[32] Other ocean-based CDR methods would "physically alter[] ocean circulation patterns to transfer atmospheric carbon to the deep sea" or increase ocean alkalinity through chemical additives.[33]

SRM methods reduce or divert incoming solar radiation by making the earth or atmosphere more reflective.[34] These methods do not have any direct effect on greenhouse gas emissions or atmospheric carbon dioxide concentrations;[35] they receive criticism for their inability to address the root causes of global warming. SRM techniques include various local and regional efforts, such as painting roofs white and brightening marine clouds to enhance albedo.[36] SRM methods also include the far-reaching, highly controversial technique of stratospheric aerosol injection.[37] Stratospheric aerosol injection, considered by some as "deliberate global dimming,"[38] would imitate the cooling effect of volcanic eruptions by pumping sulfur aerosols into the stratosphere to reflect sunlight back into space.[39] Stratospheric aerosol injection could potentially decrease the ozone layer, interfere with regional weather patterns, disrupt global food supplies, and have a myriad of other unintended environmental consequences.[40] Though less criticized than stratospheric aerosol injection, other SRM methods

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29 *Id.* at 3.

30 *See generally* Dilling & Hauser, *supra* note 3, at 554 (advising against "split[ting] out" CDR techniques from SRM techniques in research governance structures because some CDR methods "may generate worries on par with those of large-scale atmospheric SRM research").

31 Sikka, *supra* note 27, at 537.

32 BRACMORT & LATTANZIO, *supra* note 27, at 12.

33 Sikka, *supra* note 27, at 537 (internal quotations and citations omitted).

34 *Id.*

35 *Id.* at 537-38.

36 BRACMORT & LATTANZIO, *supra* note 27, at 16-17; *see* PILKEY & PILKEY, *supra* note 11, at 115 (discussing the U.S. Secretary of Energy's idea to paint roofs white and create white highways).

37 *See generally* BRACMORT & LATTANZIO, *supra* note 27, at 18-19. SRM also includes space-based reflectors, in which "shields positioned in space [ ] reduce[ ] the amount of incoming solar radiation." *Id.* at 19. But this method has been largely discounted as impractical and unrealistic.

38 Hulme, *supra* note 10, at 695 (internal quotation marks omitted).

39 PILKEY & PILKEY, *supra* note 11, at 110, 116.

40 *Id.* at 116. *See generally* PATRICK MORIARTY & DAMON HONNERY, RISE AND FALL OF THE CARBON CIVILISATION 168-70 (2011) (discussing unwanted impacts of geoengineering, including climate-related impacts and ocean acidification).

could have extensive direct and cumulative effects.

The two methods differ significantly in scope of impact, speed of effect, expense, and risk.[41] These differences may be assessed in terms of the technologies' "leverage," which is "the ability to exert large influence over global climate from relatively small inputs."[42] Most CDR methods have low leverage, since they involve large financial and resource investments for small, slow returns.[43] In contrast, some SRM techniques offer extremely high leverage.[44] Stratospheric aerosol injections and other SRM methods promise to cool the global climate rapidly for a small fraction of the global economy.[45] Though appealing for their high leverage, SRM technologies are much riskier to implement than CDR and often carry greater ethical concerns.[46]

B. What Distinguishes Geoengineering Research from Deployment?

Geoengineering research differs from geoengineering deployment in intent, scale, and duration. Nevertheless, it is difficult to draw a line between research and deployment.

Geoengineering research differs from deployment and operation in the intent of those carrying out the engineering activity.[47] Geoengineering research activities test specific hypotheses about the effects of a geoengineering intervention, whereas deployment activities primarily intend to reduce the effects of global warming.[48] For example, scientists pumping sulfur aerosols into the stratosphere with the intent to cool the globe are deploying geoengineering.[49] The same activity undertaken with the sole intent to measure the effects is research.[50]

Relatedly, geoengineering research differs from deployment in terms of scope

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41 Jesse Reynolds, *Climate Engineering Field Research: The Favorable Setting of International Environmental Law*, 5 WASH. & LEE J. ENERGY, CLIMATE & ENV'T (forthcoming 2014), at 5-6.

42 Parson & Ernst, *supra* note 7, at 313.

43 *Id.*; *see also* Reynolds, *supra* note 41, at 6.

44 Parson & Ernst, *supra* note 7, at 314. SRM methods have been described as "cheap, fast, and imperfect." BRACMORT & LATTANZIO, *supra* note 27, at 15.

45 Parson & Ernst, *supra* note 7, at 314.

46 *See, e.g.*,Toby Svoboda, *Sulfate Aerosol Geoengineering: The Question of Justice*, 25 PUB. AFF. Q. 157 (2011), *available at* http://www.aoml.noaa.gov/phod/docs/Svoboda_2011.pdf (discussing the elevated ethical concerns of stratospheric aerosol injection).

47 David R. Morrow, Robert E. Kopp & Michael Oppenheimer, *Toward Ethical Norms and Institutions for Climate Engineering Research*, ENVTL. RES. LETTERS, Oct.-Dec. 2009, at 1, 2, *available at* http://iopscience.iop.org/1748-9326/4/4/045106/ (analogizing the difference between geoengineering research and practice with the difference between biomedical research and practice on human subjects).

48 *Id.*

49 *Id.*

50 *Id.*

and duration. Geoengineers implementing geoengineering methods to combat climate change may need to maintain their geoengineering activity indefinitely and globally, or at least at much larger scales, to fulfill their intentions.[51] Correspondingly, geoengineering research would occur at a smaller scale than deployment and would have a fixed end-point.[52]

Some scholars caution, however, that geoengineering research is inherently goal oriented — that at its core, the intent of research cannot be separated from the intent of deployment.[53] They argue that geoengineers do not conduct geoengineering research to fulfill "fundamental curiosity," but rather as "an obligation to produce knowledge that could support future decision making on responding to climate change."[54] Indeed, geoengineering research could "arm the future" with knowledge and options for climate change management.[55]

The line between research and deployment becomes further blurred as large-scale field experimentation converges on deployment.[56] The lack of a precise line between geoengineering research and deployment parallels the biomedical field, where it is often difficult to cleanly separate research and therapy.[57] Scientists question whether geoengineering could effectively be tested without full-scale implementation.[58] For example, meteorologist Alan Robock argues that testing stratospheric aerosol injections would prove useless at a small scale.[59] The effects of small tests would be "indistinguishable from the noise of weather and climate variations."[60] Adequate testing, he states, would require regular sulfur injections into air already containing an aerosol cloud — essentially deployment.[61] Thus, while research differs from deployment in intent, scope, and duration, the line between the two is imprecise for all three factors.

C. What Are the Risks and Concerns of Geoengineering Research?

Geoengineering research poses a myriad of tangible and intangible risks. As

[51] *See id.* (noting that the distinction between intent of researchers and those deploying geoengineering is "normatively significant" for these more tangible factors).

[52] *See generally id.*

[53] Dilling & Hauser, *supra* note 3, at 555.

[54] *Id.*

[55] *Id.*

[56] Parson & Ernst, *supra* note 7, at 326.

[57] *See* Abu Bakar Suleiman & Joon-Wah Mak, *Research Ethics, Governance, Oversight And Public Interest*, INT'L E-J. SCI., MED. & EDUC., no. 2 (supp. 1), 2008, at S35, S36, *available at* http://web.imu.edu.my/ejournal/approved/eJournal_2.S1_35-38.pdf.

[58] *See, e.g.*, Alan Robock, *A Test for Geoengineering?*, 327 SCIENCE 530, 530 (2010); Tuana et al., *supra* note 15, at 145.

[59] Robock, *supra* note 58, at 530.

[60] *Id.* at 531.

[61] *Id.* at 530-31.

discussed above, geoengineering presents risks to the environment. As research intensity increases, direct impacts on the environment — especially climate patterns — similarly increase;[62] concerns associated with large-scale field experimentation mirror those of deployment. Apart from these tangible threats to the environment, geoengineering research implicates interrelated ethical, social, and political concerns. First, the possibility of geoengineering research presents a moral hazard. Second, and relatedly, geoengineering research may be a "slippery slope" to geoengineering deployment. Finally, public and private parties may act unilaterally and conduct independent research for financial gain, military advancement, or nefarious purposes. Ultimately, the risks suggest the potential for geoengineering research to affect a large amount of people while guided by a small number of elite decision-makers.

1. Moral Hazard

Many scholars fear geoengineering presents a "moral hazard," as it may undermine strategies to reduce emissions and combat climate change.[63] If geoengineering is perceived as an easy fix to the problem of climate change, then there is little motivation to change "business as usual" practices and reduce emissions.[64] The low calculated cost of geoengineering factors into this risk as well. One estimate predicts climate change to cost the United States alone about $82 billion, or about $2.5 billion annually.[65] In contrast, offsetting *all* greenhouse gas emissions through geoengineering could cost as little as $8 billion per year — relatively "costless" when compared to climate change impacts and mitigation costs.[66] Rather than working alongside adaptation and mitigation strategies, geoengineering would become a substitute.[67] This mentality is flawed, however, as scientists widely agree that geoengineering is no "silver bullet" and cannot replace emission reduction strategies.[68]

The risk of moral hazard applies to geoengineering research as well. Simply pursuing geoengineering solutions to climate change — fueling the hope for a technological solution — plays into the moral hazard mentality.[69] And research

[62] *See* Low et al., *supra* note 6, at 4109.

[63] *See, e.g.*, Albert C. Lin, *Does Geoengineering Present A Moral Hazard?*, 40 ECOLOGY L.Q. 673 (2013); Steve Rayner et al., *The Oxford Principles*, 121 Climatic Change 499, 501-02 (2013); *see also* Stephen M. Gardiner, *Some Early Ethics of Geoengineering the Climate: A Commentary on the Values of the Royal Society Report*, 20 ENVTL. VALUES 163, 183-84 (2011) (arguing that The Royal Society report in 2009 underestimated the complexity of the moral hazard concern and urging scholars to view it as more than simply an empirical matter).

[64] *See* Buck, *supra* note 10, at 257.

[65] Barrett, *supra* note 10, at 50.

[66] *Id.* at 49.

[67] *Id.* at 46.

[68] Buck, *supra* note 10, at 258.

[69] Morrow, Kopp & Oppenheimer, *supra* note 47, at 3.

may exacerbate the moral hazard if it shows or appears to show that geoengineering is effective.[70] Research may thus threaten "the long-term welfare of the planet" by making it "harder to implement a fundamental solution to the problem of climate change."[71] To combat this risk, scientists must conduct research within a broader context of "climate change management that includes mitigation and adaptation measures."[72]

2. Slippery Slope and Technological Lock-In

Some academics fear geoengineering research is a "slippery slope" to deployment[73] — that simply allowing geoengineering research could be outcome determinative and lock in the future use of geoengineering technology.[74] Scholars advise against premature technological lock-in.[75] Often society cannot know "whether existing technological trajectories are sufficient to meet future economic, social[,] and ecological goals."[76] Thus, policymakers must take precautions at a technology's initial innovation and deployment stages to avoid locking in an inferior technology.[77] Academics frequently cite the history of the "QWERTY" keyboard as an example of path dependence and technological lock-in; there, "a history of early coincidences" gave rise to a "stable but sub-optimal regime."[78]

Geoengineering research may be outcome determinative and risk locking in geoengineering deployment. Simply beginning research on new technology increases the probability of eventual deployment.[79] The risk is more pronounced for stratospheric aerosol injection and other technologies for which field-

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70 *Id.* ("Unless scientists take great care in what experiments they do, what they publish, and how they explain their work, the public and policy makers may develop an optimistic bias in their assessment of [geoengineering's] possibilities."). *But see id.* ("It is possible, however, that the opposite could happen, since research may reveal that [geoengineering] is unworkable and that we have no practical alternative to mitigation and adaptation.").

71 *Id.*

72 Buck, *supra* note 10, at 258.

73 SOLAR RADIATION MANAGEMENT GOVERNANCE INITIATIVE, SOLAR RADIATION MANAGEMENT: THE GOVERNANCE OF RESEARCH 21 (2011) [hereinafter SRMGI GOVERNANCE REPORT]; Low et al., *supra* note 6, at 4109.

74 Morrow, Kopp & Oppenheimer, *supra* note 47, at 3 ("[I]t would be naïve to think that, once [geoengineering] research is undertaken, it could be terminated promptly if proven undesirable.").

75 Joern Hoppmann et al., *The Two Faces of Market Support—How Deployment Policies Affect Technological Exploration and Exploitation in the Solar Photovoltaic Industry*, 42 RESEARCH POL'Y 989, 990 (2013).

76 *Id.*

77 *See id.* at 1001 (discussing photovoltaic technology).

78 Mark C. Suchman, *Translation Costs: A Comment on Sociology and Economics*, 74 OR. L. REV. 257, 270 (1995).

79 Martin Bunzl, *Researching Geoengineering: Should Not or Could Not?*, ENVTL. RES. LETTERS, Oct.-Dec. 2009, at 1, 2, *available at* http://m.iopscience.iop.org/1748-9326/4/4/045104/pdf/1748-9326_4_4_045104.pdf.

experimentation converges on deployment.[80]

This risk directly relates to the complexity of climate change decision making. Climate change presents a complex problem: the elements involved in finding a solution are numerous and highly connected; the system is dynamic; "neither the decision structure nor its dynamics are fully disclosed" to the decision maker; and the problem's goals are difficult to set.[81] As in other forms of complex problem-solving research, climate change research is subject to "errors of the political problem-solver in his interaction with the situational demands of complex problems."[82] These errors are a "frequently neglected source of uncertainty."[83] Policymakers must be cautious when making geoengineering research decisions because, in this complex situation, "control is illusionary."[84] If geoengineering research has narrow goals and underlying models, policymakers may make uninformed decisions that reject non-geoengineering options, such as adaptation strategies.[85] Geoengineering research must instead define its goals and models broadly to avoid "premature (intellectual) lock-in to any specific technology."[86]

This risk of geoengineering lock-in may increase if early-stage research draws strong interest groups from the scientific or business communities.[87] Such groups would likely "resist efforts to abandon [geoengineering] research" or advocate for deployment "even if it proves to be unwise."[88] This risk relates to the concern of moral hazard. Serious government or private investment in geoengineering research may unintentionally suggest that the energy market will remain as is.[89] Public investment in geoengineering research may inadvertently indicate less pressure against fossil fuel use.[90] Consequently, these real or perceived market signals could even "increase investor confidence in extreme energy."[91] Increasing investment commitments in extreme energy may create a cycle "in which interested parties may call for geoengineering approaches to protect these new financial commitments."[92]

80 Hulme, *supra* note 10, at 697.

81 Dorothee Amelung & Joachim Funke, *Dealing with the Uncertainties of Climate Engineering: Warnings from a Psychological Complex Problem Solving Perspective*, 35 TECH. SOC'Y 32, 33 (2013).

82 *Id.* at 32.

83 *Id.*

84 *See id.* at 39.

85 *Id.* at 38.

86 *Id.*

87 *See* Morrow, Kopp & Oppenheimer, *supra* note 47, at 3.

88 *Id.*

89 Buck, *supra* note 10, at 258.

90 *See id.*

91 *Id.*

92 *Id.*

3. Unilateral Action by Public and Private Actors

Governments and private parties may research and deploy geoengineering projects unilaterally. Some geoengineering techniques are relatively inexpensive and can be researched or deployed by few actors.[93] In many ways, this is a benefit: a single country could undertake massive programs to combat climate change.[94] But not every unilateral actor has purely humanitarian motives; actors may research geoengineering techniques independently for private financial gain, military advancements, or nefarious purposes. Ultimately, the potential for unilateral action suggests the potential for geoengineering experimentation to involve few decision makers but affect a large number of people.

Public and private actors have various motives for undertaking unilateral experimentation and deployment. Likely, many actors truly wish to find climate change solutions. For example, actors in favor of ultimate deployment may desire to explore geoengineering unilaterally or within small coalitions to exclude those who would prevent implementation.[95] But both public and private actors benefit in other ways as well.[96]

Militaries and "nefarious" actors could use geoengineering techniques for non-peaceful purposes and would thus benefit from unilateral geoengineering research.[97] Geoengineering methods have varied effects on different regions, lending themselves to many "possible strategic military uses."[98] Geoengineering research could give militaries "new tools for weather control, such as the ability to induce droughts in enemy nations or to enhance storms to disrupt enemy operations."[99] But militaries are not the only actors who could benefit from relatively easy and affordable weather manipulation.[100] Indeed, "a rogue state, a terrorist group, or even a disgruntled billionaire" could render rivals helpless.[101]

93 *See generally* Barrett, *supra* note 10, at 49 (discussing the cost of geoengineering and the potential for a single country to conduct geoengineering).

94 *Id.*

95 Katharine L. Ricke, Juan B. Moreno-Cruz & Ken Caldeira, *Strategic Incentives for Climate Geoengineering Coalitions to Exclude Broad Participation*, ENVTL. RES. LETTERS, Mar. 2013, at 1, 1, *available at* http://iopscience.iop.org/1748-9326/8/1/014021/pdf/1748-9326_8_1_014021.pdf.

96 *See* Jason J. Blackstock & Jane C.S. Long, *The Politics of Geoengineering*, 327 SCIENCE 527, 527 (2010) (noting that new laboratory-based research "raises the prospect that national or corporate interests might try (or appear to try) to control or profit from these schemes" — especially if such research "were framed in terms of national security [and] . . . if the results were classified"). *But see* Buck, *supra* note 10, at 262 ("There are plenty of reasons why energy, aerospace and defen[s]e enterprises would not want to become involved in geoengineering: it is politically dangerous, its profitability is questionable, compared to the profits they already make, and it might not even work.").

97 Morrow, Kopp & Oppenheimer, *supra* note 47, at 3.

98 *Id.*

99 Robert L. Olson, *Soft Geoengineering: A Gentler Approach to Addressing Climate Change*, ENV'T: SCI. & POL'Y FOR SUSTAINABLE DEV., Sept./Oct. 2010, at 29, 37.

100 *See* Morrow, Kopp & Oppenheimer, *supra* note 47, at 3.

101 *Id.*

Further, many private actors invest in geoengineering research because of perceived financial gain.[102] For example, Bill Gates invests in Silver Lining, a marine cloud brightening program.[103] Similarly, Richard Branson encourages geoengineering innovation through the "Virgin Earth Challenge," offering a $25 million prize to the company able to create the best "environmentally sustainable and economically viable" CDR technique.[104] These and other private investors could financially benefit from patents on geoengineering technologies.[105] Further, big oil recently joined the geoengineering research lobby;[106] advances in geoengineering research could lessen pressures to reduce carbon dioxide emissions. Finally, some companies believe geoengineering can generate sellable carbon credits.[107] Most academic discussion in this area concerns the potential for ocean iron fertilization to generate carbon credits.[108] Recent modeling suggests ocean iron fertilization could generate a large amount of carbon credits and produce a high return on investments if such techniques ever became recognized in carbon trading markets.[109] Emissions trading systems are not likely to recognize geoengineering methods as carbon sources anytime soon,[110] but growing private interests indicate that pressure to consider the option will only increase.

Unilateral action with transboundary effects risks exacerbating political tensions.[111] While scientists may effectively design "[s]ubscale field

[102] *See* CLIVE HAMILTON, EARTHMASTERS: THE DAWN OF THE AGE OF CLIMATE ENGINEERING 74 (2013).

[103] *Id.* Hamilton criticizes Gates' affiliation with the "geoclique," a group of North American geoengineers who have advocated for geoengineering research and heavily influence the research debate.

[104] *The Prize*, VIRGIN EARTH CHALLENGE, http://www.virginearth.com/the-prize/ (last visited Mar. 3, 2014); *see* HAMILTON, *supra* note 102, at 77.

[105] *See generally* HAMILTON, *supra* note 102, at 75.

[106] *Id.* at 77.

[107] *Id.* at 78. *But see* Buck, *supra* note 10, at 261 ("In spite of fears that CDR techniques could be used to create credits to sell rather than to combat global warming, carbon trading has not taken off.").

[108] *See, e.g.*, Kerstin Güssow et al., *Ocean Iron Fertilization: Why Further Research Is Needed*, 34 MARINE POL'Y 911, 916 (2010) ("[I]ncluding [ocean iron fertilization] into a post-Kyoto climate agreement might provide new incentives for the negotiation process."); Margaret Leinen, *Building Relationships Between Scientists and Business in Ocean Iron Fertilization*, 364 MARINE ECOLOGY PROGRESS SERIES 251, 255 (2008) ("[I]f sequestration is demonstrated, carbon offsets from these [ocean iron fertilization] experiments can be validated, verified and marketed without impacting the quality of the science that is done or creating intellectual conflicts for researchers.").

[109] Wilfried Rickels et al., *Economic Prospects of Ocean Iron Fertilization in an International Carbon Market*, 34 RESOURCE & ENERGY ECON. 129, 143 (2012) ("Even if iron fertilization effectiveness is on a level equal to observed natural persistent iron fertilization near islands in the Southern Ocean, [seven] years of [ocean iron fertilization] are sufficient to obtain an amount of annual carbon credits that is sufficiently larger than the amount provided by forestry activity over [twenty] years.").

[110] HAMILTON, *supra* note 102, at 78.

[111] Blackstock & Long, *supra* note 96, at 527. *See generally* Parson & Ernst, *supra* note 7, at

experiments" to have "demonstrably negligible environmental and transboundary impacts," the same is less true of large-scale field experimentation.[112] As geoengineering research moves from modeling to larger field experimentation with transboundary effects, tests will likely evoke "political sensitivities."[113] Seemingly, both public and private action could spark international tensions.

The risk of unilateral action suggests a central concern in geoengineering experimentation: unilateral decision making. Ultimately, actors may deploy geoengineering methods unilaterally. This relates to the risks of moral hazard and technological lock-in. While careful decision making could lessen those risks, the potential for unilateral experimentation suggests that few actors — far less than will be ultimately affected — could make critical decisions and potentially exacerbate them. On one level, unilateral decisionmaking is a potential problem among nation-states. As discussed above, unilateral geoengineering action by a sovereign government (or by a citizen of one government) could exacerbate political tensions if it has transboundary effects. But on another level, unilateral action risks negatively affecting individuals and populations with no role in the decision-making process.

D. Geoengineering Research Demands International Governance

Geoengineering research is an international issue, with risks and benefits that demand international attention. Research in ocean iron fertilization, sulfur aerosol injection, marine cloud whitening, and other CDR and SRM techniques will likely have transboundary effects.[114] Even research projects conducted within domestic boundaries could have negative extraterritorial repercussions on climate patterns, ecosystems, and ultimately human health and well-being. Apart from these tangible effects, geoengineering research risks moral hazard and technological lock-in.[115] Further, actors may conduct geoengineering experimentation unilaterally.[116] Unilateral experimentation — regardless of the underlying motive — could exacerbate political tensions and affect numerous individuals with no voice in the research decision-making process.[117] Thus, the risks and potential effects of geoengineering research demand international governance for research projects with transboundary effects.

319 ("[Climate engineering] also has the potential to be a new and severe source of international conflict.").

112 Blackstock & Long, *supra* note 96, at 527.

113 *Id.*

114 *See* discussion *supra* Part I.A.

115 *See* discussion *supra* Part I.C.1-2.

116 *See* discussion *supra* Part I.C.3.

117 *See id.*

II. CURRENT OVERSIGHT OF GEOENGINEERING RESEARCH IS SPARSE

Few international agreements expressly address geoengineering research and deployment activities. Recently, the parties to a handful of multilateral environmental agreements issued decisions banning ocean iron fertilization, but leave exceptions for legitimate research.[118] First, the parties to the London Convention and London Protocol, a related set of conventions prohibiting marine pollution by dumping, decided the agreements prohibit ocean iron fertilization.[119] Legitimate scientific research, however, is permissible.[120] Additionally, the Convention on Biological Diversity (CBD) issued a similar decision in 2009 asking countries to abstain from ocean fertilization activities, except for small-scale coastal research.[121] In October of 2010, the CBD adopted further provisions calling for parties to abstain from geoengineering, including any solar reduction or carbon sequestration technology deployed "on a large scale that may affect biodiversity," unless the parties fully consider the risks and impacts.[122] As with other decisions, the 2010 decision allows for "small-scale scientific research studies that would be conducted in a controlled setting."[123]

Apart from these agreements, little international oversight exists for geoengineering research. Certainly, some international schemes have the potential to apply to geoengineering activities depending on the "nature, location, and actors" involved in the activity.[124] For example, parties to the Convention on International Liability for Damage Caused by Space Objects could read the agreement to apply to space-based geoengineering approaches.[125] Most current international regimes, however, fail to regulate the *specific* activities contemplated by geoengineering field research and future deployment.[126] The treaties arguably most relevant to geoengineering generally "impose obligations to reduce national emissions of relevant pollutants or related production."[127] And contemplated geoengineering experimentation would not violate these obligations.[128] One scholar interprets this lack of

118 GAO REPORT 2010, *supra* note 6, at 33.

119 *Id.* The United States is a party to the earlier London Convention and a signatory but not party to the later-dated London Protocol. *Id.* at 31.

120 *Id.*

121 *Id.*

122 Convention on Biological Diversity, Conference of the Parties Oct. 18-19, 2010, Decision X/33, para. 8(w), *available at* http://www.cbd.int/climate/doc/cop-10-dec-33-en.pdf.

123 *Id.*

124 GAO REPORT 2010, *supra* note 6, at 30.

125 *Id.* at 32.

126 Parson & Ernst, *supra* note 7, at 320.

127 *Id.* at 321 (discussing the United Nations Framework Convention on Climate Change, Montreal Protocol on Substances that Deplete the Ozone Layer, and Convention on Long-Range Transboundary Air Pollution).

128 *Id.*

negative oversight in international law to encourage geoengineering research,[129] but this interpretation is not yet widely accepted.

Current geoengineering research governance is insufficient and fragmented. It leaves gaps that allow research projects stemming from a small number of decision makers to affect a large number of people. Geoengineering research requires new governance to fill those gaps.

III. CREATING GEOENGINEERING RESEARCH GOVERNANCE

This paper proposes a foundation, form, and forum for geoengineering research governance to fill the current gaps in international law.[130] The international community should create geoengineering research governance with a human focus, founded on principles of ethical analysis and informed consent. Building on this foundation, governance should guide and coordinate research in a manner consistent with responsible innovation to ultimately ensure integrated scientific-ethical goals. Finally, the oversight forum should facilitate participation and consent at two levels: the nation-state level and among individuals and populations.

A. Foundation: A Human Focus

At its core, geoengineering research governance should have a human focus and work to ensure informed consent of those affected by geoengineering research experimentation. Geoengineering research risks affecting many people who currently have no voice in geoengineering research decision making. Large-scale experimentation may have disproportionate effects on the environment.[131] The populations most vulnerable to climate change, including indigenous people across the globe,[132] are likely most susceptible to

[129] *See* Reynolds, *supra* note 41, at 45 ("[I]t can be said that existing international environmental law is, on the whole, generally favorable toward climate engineering research. . . . [T]o the extent that the [multilateral environmental agreements] reviewed here seek to protect the environment, they favor at the least research into climate engineering as a potential means to reduce risks to the environment and humans from climate change.").

[130] Under "regime theory," international actors should create institutions by working from the basic principles outward. Milton Mueller, John Mathiason & Hans Klein, *The Internet and Global Governance: Principles and Norms for a New Regime*, 13 GLOBAL GOVERNANCE 237, 242 (2007). Skipping the principle-forming step can create a lack of consensus when attempting to build global rules and procedures. *Id.* at 238 (criticizing international Internet governance for skipping the necessary early foundational steps).

[131] *See, e.g.*, Wylie A. Carr, *Public Engagement on Solar Radiation Management and Why It Needs to Happen Now*, 121 CLIMATIC CHANGE 567, 569 (2013) ("[T]he uneven effects of SRM mean that some people living at the subsistence level may be worse off if such technologies are implemented.").

[132] *See generally* Barry Carin & Alan Mehlenbacher, *Constituting Global Leadership: Which Countries Need to Be Around the Summit Table for Climate Change and Energy Security?*, 16 GLOBAL GOVERNANCE 21, 27 (2010) ("It is generally agreed that climate change will impact most

experiencing the negative side effects of geoengineering research.[133]

Further, geoengineering is prone to decision making by a minority. Often, discussion of "highly technical" issues is "limited to a select few" who have the expertise needed to participate in active discourse.[134] This necessary expertise acts as a bar to participation, "effectively discourag[ing] entry and dialog by non-specialists" in technical issues.[135] Geoengineering research is an example of a highly technical issue requiring such expertise.[136] Indeed, one academic notes that "elite groups" within political, economic, and scientific-technological spheres monopolize geoengineering research and discussion.[137] These elite groups include university and individual scientists, scholars, and actors; governments and government-funded research bodies; think tanks; and individual corporate actors.[138] Research decision making by a minority may increase the risks of technology lock-in and unilateral deployment, discussed in Part I, and further marginalizes populations most vulnerable to geoengineering research side effects.

This marginalization is a problem. The populations most negatively affected by both geoengineering research and climate change — the driving force behind the research — are disenfranchised throughout the decision-making process. Research governance can address this issue through a framework built on "ethics, responsibilities[,] and standards"[139] that not only encourages but demands public participation. This research governance scheme should "place the protection of human subjects — particularly those populations most vulnerable to climate alterations of any kind — at its core."[140] This human-focused foundation would minimalize the marginalization of vulnerable populations in the decision-making process.

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those who had no part in creating the problem."); Vinita Krishna, *Indigenous Communities and Climate Change Policy: An Inclusive Approach*, *in* THE ECONOMIC, SOCIAL AND POLITICAL ELEMENTS OF CLIMATE CHANGE 27, 29, 30 (W.L. Filho ed., 2011) (discussing climate change impacts on indigenous peoples).

133 *See* Pablo Suarez, Jason Blackstock & Maarten van Aalst, *Towards a People-Centered Framework for Geoengineering Governance: A Humanitarian Perspective*, GEOENGINEERING Q. (Oxford Geoengineering Inst., Univ. of Oxford), Mar. 2010, at 2, 4, *available at* http://www.greenpeace.to/publications/The_Geoengineering_Quarterly-First_Edition-20_March_2010.pdf (discussing generally and noting a "problematic reality that the populations most at risk have next to no leverage within the current international debate").

134 Dilling & Hauser, *supra* note 3, at 556.

135 *Id.*

136 *See id.*

137 Tina Sikka, *An Analysis of the Connection Between Climate Change, Technological Solutions and Potential Disaster Management: The Contribution of Geoengineering Research*, *in* CLIMATE CHANGE AND DISASTER RISK MANAGEMENT, *supra* note 27, at 535, 536.

138 *Id.* at 537.

139 Suarez, Blackstock & van Aalst, *supra* note 133, at 2.

140 *Id.* (discussing geoengineering "experiments" generally and advocating "a people-centered approach for geoengineering governance").

This governance foundation with a human focus comports with the well-known Oxford Principles and Asilomar recommendations, high-level proposals for geoengineering governance. The five Oxford Principles, drafted by the United Kingdom's Oxford Geoengineering Programme, are a "draft framework to guide the collaborative development of geoengineering governance."[141] The Asilomar recommendations draw heavily on the Oxford Principles.[142] Both call for public participation and consent of those affected by geoengineering experimentation.[143]

But what does it mean to have a human-focused foundation? Scholars suggest research governance should broadly integrate ethical analysis — comprised of both substantive and procedural elements — into the decision making process. As the core component of ethical analysis, research governance should work to ensure informed consent of those affected by geoengineering experimentation.

In light of threats to human health and well-being, ethical analysis should play a greater role in geoengineering research governance than it has in past environmental policymaking. Emerging technologies today pose a myriad of ethical challenges to policymakers; ethical analysis can no longer take a backseat in environmental policy decisions.[144] In recent years, emerging

141 Rayner et al., *supra* note 63, at 503. In 2009, the Oxford Geoengineering Programme submitted a report to the United Kingdom House of Commons Science and Technology Select Committee containing the Oxford Principles. *Oxford Principles: History*, OXFORD GEOENGINEERING PROGRAMME, http://www.geoengineering.ox.ac.uk/oxford-principles/history/ (last visited Mar. 3, 2014). The United Kingdom government endorsed the principles and encouraged their further development. *Id.*

142 The Asilomar Recommendations are the product of a geoengineering research governance conference in March, 2010, in Asilomar, California. ASILOMAR SCIENTIFIC ORGANIZING COMMITTEE, THE ASILOMAR CONFERENCE RECOMMENDATIONS ON PRINCIPLES FOR RESEARCH INTO CLIMATE ENGINEERING TECHNIQUES 7 (2010) [hereinafter ASILOMAR RECOMMENDATIONS]. The conference attracted over 165 "experts from academic institutions, governmental and nongovernmental organizations, and the business community from fifteen countries on six continents. Their expertise covered Earth, environmental, and social sciences, risk assessment, public policy, ethics, philosophy, history, economics, international law, and more." *Id.* The geoengineering conference was modeled after the original Asilomar conference on GMO oversight. Eli Kintisch, *'Asilomar 2' Takes Small Steps Toward Rules for Geoengineering*, 328 SCIENCE 22, 22 (2010).

143 Oxford Principle 2 calls for "public participation in geoengineering decision-making" and states: "Wherever possible, those conducting geoengineering research should be required to notify, consult, and ideally obtain the prior informed consent of, those affected by the research activities." Rayner et al., *supra* note 63, at 502. The fifth Asilomar recommendation calls for "public involvement and consent," and elaborates, "Public participation and consultation in research planning and oversight, assessments, and development of decision-making mechanisms and processes must be provided. Approaches are needed to ensure consideration of the international and intergenerational implications of climate engineering." ASILOMAR RECOMMENDATIONS, *supra* note 142, at 23.

144 *See generally* Gary E. Marchant, Douglas J. Sylvester, Kenneth W. Abbott, *What Does the History of Technology Regulation Teach Us About Nano Oversight?*, 37 J.L. MED. & ETHICS 724, 727-28 (2009) (discussing ethical concerns of nanotechnology and noting that other emerging technologies, such as GM crops and foods, "likewise suggest a systematic problem of failing to

technologies have drawn recognition as an "important area of ethical analysis" — one in need of "novel theories and methodologies."[145] Ethics as applied to emerging technologies is thus gaining momentum worldwide.[146] For example, a movement in Europe called "Responsible Research and Innovation" promotes "responsible practices of research and innovation which involve both innovators and stakeholders."[147] Policymakers currently direct Responsible Research and Innovation toward various emerging technologies.[148]

Applying these principles to geoengineering research suggests that research governance should integrate ethical analysis into its decision-making process.[149] Rather than conducting ethical analysis as an afterthought, ethically significant decisions should be "embedded in the scientific analysis itself."[150] Governance must ask about the social and ethical repercussions and effects of research projects — before, during, and after conducting the experiment. For example, pre-experimentation governance should consider potential side effects and costs, whether an experiment will yield disproportionate harms to some regions over others, and what measures of impacts indicate an experiment should be halted.[151] An integrated approach will force scientists and policymakers to confront the ethical and social effects of research projects and make decisions that can alleviate risks of moral hazard and technological lock-in.

As an important subset of ethical analysis, geoengineering research governance should seek to incorporate informed consent into the decision-making process. Policymakers can look to biomedical research for guidance. Biomedical research oversight offers a model of integrating ethical concerns into research governance, and a central component of biomedical research governance is informed consent.[152] Informed consent is a "basic ethical protection" in human subject research, in which research subjects must verify their willingness to participate in a particular treatment after being informed of the experimental nature of the study.[153] The doctrine of informed consent is drawn from the Western principle of "personal autonomy" and rests on the

address the moral and social concerns expressed by many citizens").

[145] Philip A. E. Brey, *Anticipating Ethical Issues in Emerging IT*, 14 ETHICS & INFORMATION TECH. 305, 307 (2012).

[146] *Id.*

[147] *Id.*

[148] *Id.*

[149] *See, e.g.*, Tuana et al., *supra* note 15, at 141.

[150] *Id.*

[151] *See* Tuana et al., *supra* note 15, at 149 (discussing "coupled ethical-scientific concerns regarding field testing of SRM").

[152] It should be noted that informed consent in biomedical research differs from informed consent in medical practice. *See* Jessica Berg, *All for One and One for All: Informed Consent and Public Health*, 50 HOUS. L. REV. 1, 5 (2012).

[153] Jacob Schuman, *Beyond Nuremberg: A Critique of "Informed Consent" in Third World Human Subject Research*, 25 J.L. & HEALTH 123, 124 (2012).

"notion of inalienable and universal individual rights."[154] The doctrine assumes the research subject's "ability to exercise freedom of choice."[155]

Recently, academics have called for "informed consent" in geoengineering research.[156] The underlying rationale is similar to that for consent to biomedical research: in both, respect for individuals mandates that scientists obtain the consent of individuals affected by their research. In contrast, however, the underlying assumptions of biomedical informed consent concern individual choice and autonomy. These assumptions are difficult to transfer to informed consent for geoengineering research: geoengineering experimentation will likely affect people at a community to regional level, not just individually. Thus, informed consent in geoengineering research also must be rooted in broader principles of equity and justice in decision-making processes.[157]

In practice, informed consent for geoengineering would differ quite dramatically from informed consent in biomedical research. The individual approach to informed consent in biomedical research cannot directly translate to geoengineering research. In the context of transboundary geoengineering research, "meaningful public engagement" must similarly be "international in scope."[158] Consent for geoengineering research may depend on how the various affected groups perceive "participation" and "consent."[159] Some informed consent advocates suggest experiment review boards preapprove geoengineering projects, analogous to Institutional Review Boards' approval of biomedical research projects.[160] Theoretically, the biomedical Institutional Review Boards confirm and ensure informed consent of human research subjects. Alternately, legitimate international governance bodies could provide project approval and thus informed consent for those within their purview.[161] These proposals illustrate that informed consent for geoengineering would likely find legitimacy not in individual choice, but in high-level procedural and substantive

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154 *Id.* at 130.

155 *Id.* at 131.

156 Morrow, Kopp & Oppenheimer, *supra* note 47, at 4; *see* Carr, *supra* note 131, at 569 ("[P]eople simply deserve to be informed about and have a say in a technology that has the potential to affect their lives."). *See generally* MORIARTY & HONNERY, *supra* note 40, at 172 (stating that small-scale tests will not raise "significant ethical issues," but "large-scale climate engineering tests . . . [,] [a]s in medical experiments, . . . raise ethical questions of informed consent").

157 *See* Carr, *supra* note 131, at 569.

158 *Id.* at 570.

159 Rayner et al., *supra* note 63, at 506 ("Differences in political and legal cultures will shape the mode and extent of public participation around the world[, and] [d]ifferent ideas about democracy and the relationship between individuals and society will engender different understandings of consent."); *see* Carr, *supra* note 131, at 570.

160 Morrow, Kopp & Oppenheimer, *supra* note 47, at 4.

161 David R. Morrow, Robert E. Kopp & Michael Oppenheimer, *Research Ethics and Geoengineering* 2 (Geoengineering Our Climate Working Paper & Op. Article Series, Op. Article No. 4, 2013), http://wp.me/p2zsRk-7N.

requirements.

Geoengineering research governance must place ethical analysis and informed consent at its core. This human-centered foundation will not be easy to create and uphold. This foundation requires governance to guide research in a manner ensuring meaningful review and evaluation and well-thought-out policy recommendations.

B. Form: Guiding Ethical-Scientific Research

Geoengineering returned to scientific and political discourse in 2006 as a potential solution to the complex problem of climate change. Since then, scientists have struggled with the understandable tendency to see geoengineering research as goal-oriented — part of a broader potential, though unwelcome, solution to climate change. Further, many scientists and policymakers have since called for a geoengineering research agenda. In considering the call for a geoengineering research agenda, one must ask: should geoengineering research be *directed*? Relatedly, to what extent should geoengineering research governance guide geoengineering research?

Building on the human-centered foundation, geoengineering research governance should direct research and provide coordination in a manner that ensures integrated scientific-ethical goals. Guidance and coordination should exist in a middle ground between the "social contract" model of research oversight and goal-oriented research committees. In contrast to various government-heavy geoengineering research proposals, this paper advocates geoengineering research governance in accordance with new principles of responsible innovation.

Over the past century, scientific research flourished because of a stable, unwritten "social contract" between science and the rest of society.[162] Based on a "linear" or "instrumental" model of research governance, the social contract theory of oversight leaves science "to its own devices in the belief that it will then straight-forwardly deliver social benefits."[163] The arrangement is built on trust and a mutual understanding of expectations from the other group.[164] Often, the party conducting research receives funding and a "high degree of institutional autonomy" while providing fundamental knowledge or beneficial scientific applications for society.[165]

[162] ŽANETA OZOLIŅA ET AL., GLOBAL GOVERNANCE OF SCIENCE: REPORT OF THE EXPERT GROUP ON GLOBAL GOVERNANCE OF SCIENCE TO THE SCIENCE, ECONOMY AND SOCIETY DIRECTORATE, DIRECTORATE-GENERAL FOR RESEARCH, EUROPEAN COMMISSION 12 (2009); Michael Gibbons, *Science's New Social Contract with Society*, 402 NATURE C81, C81 (1999).

[163] OZOLIŅA ET AL., *supra* note 162, at 11-12.

[164] Gibbons, *supra* note 162, at C81.

[165] *Id.* (discussing the social contract between university science and society).

This research governance landscape is changing, though.[166] Since World War I, and highlighted in World War II, society became more aware of scientific innovation's potential for destruction.[167] The governance of scientific innovation became a "global, public issue"; for example, both biomedical experimentation and nuclear weapons research saw greater government oversight and public involvement.[168] Accompanying the growing mistrust in science is an expanding "culture of accountability" within academic science.[169] Research funding sources, traditionally hands-off, now take a greater role in shaping societal priorities through funding.[170] Despite the departure from the strict social contract model, society continues to clamor for beneficial applications of science and emerging technology.[171] The traditional social contract is still alive and well in some areas of scientific research, but it is more often than not renegotiated or eliminated for politically, socially, and ethically scientific research.

Opposite the social contract's hands-off approach is goal-driven research governance; the World Health Organization's (WHO) governance of smallpox virus research illustrates this type of governance. WHO convened the Advisory Committee on Variola Virus Research in 1999 to determine how to "reach global consensus on the timing for the destruction of existing [smallpox] virus stocks."[172] The destruction of virus stocks is an international security issue and an element of worldwide smallpox eradication.[173] The committee included eighteen scientists from various WHO member states, plus "experts in virology, public health, and regulation, mostly from Western countries, to serve as nonvoting advisors."[174] As the committee progressed toward its goals, the advisory committee decreased in number and opposing viewpoints.[175] One observer noted in late 2004 that "most of the people who questioned the value of

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166 OZOLIŅA ET AL., *supra* note 162, at 12-14; *see* LIDIA BRITO & MARK STAFFORD SMITH, STATE OF THE PLANET DECLARATION 2 (2012), *available at* http://www.planetunderpressure2012.net/pdf/state_of_planet_declaration.pdf ("The international global-change research community proposes a new contract between science and society in recognition that science must inform policy to make more wise and timely decisions and that innovation should be informed by diverse local needs and conditions.").

167 OZOLIŅA ET AL., *supra* note 162, at 13 (noting the Nazi death camps and atomic bombings in World War II).

168 *Id.*

169 Gibbons, *supra* note 162, at C81.

170 *Id.*

171 OZOLIŅA ET AL., *supra* note 162, at 14.

172 Jonathan B. Tucker, *Preventing the Misuse of Biology: Lessons from the Oversight of Smallpox Virus Research*, INT'L SECURITY, Fall 2006, at 116, 130 [hereinafter Tucker, *Preventing Misuse*].

173 *See* Jonathan B. Tucker, *The Smallpox Destruction Debate: Could a Grand Bargain Settle the Issue?*, ARMS CONTROL ASS'N, http://www.armscontrol.org/print/3544 (last visited Mar. 7, 2014).

174 Tucker, *Preventing Misuse*, *supra* note 172, at 131.

175 *Id.* at 133-34.

the research have either left or been diluted out," and the remaining members are simply "resigned to the fact that the research program will continue."[176] At the same time, the United States' financial support for the program grew.[177]

Biological weapons expert Jonathan Tucker criticizes the smallpox committee model and offers suggestions for future virus research oversight.[178] First, he calls for a more balanced committee membership and contends that scientists should not participate in voting and review for projects in which they have an interest.[179] Further, he argues, the committee lacked transparency and accountability to WHO and the public.[180] Finally, the committee's funding mechanisms — voluntary contributions outside the regular WHO budget — allowed the United States "disproportionate influence over the smallpox research agenda and undermined the objectivity of the oversight process."[181] Though smallpox research presents a "special case," Tucker suggests that the lessons from the smallpox research committee could apply in other areas of dual-use research. Arguably, the smallpox committee experience offers lessons in research oversight for all goal-oriented research endeavors.

The smallpox research committee model stands opposite the social contract for science. The social contract is a hands-off approach to scientific innovation, in which society and funders trust that scientific research and technological application will result in public benefits. In contrast, WHO convened the smallpox research committee with the express purpose of researching medical defenses against smallpox and eradicating smallpox virus stocks.

Neither extreme suits geoengineering research governance. The social contract approach is arguably too lenient to serve as a model for geoengineering research governance.[182] First, it does not adequately address the place of geoengineering research as a potential solution to climate change. Geoengineering innovation already has not followed a linear science-to-policy model. Further, the social contract model ignores the possibility of nefarious actors and private beneficiaries in geoengineering research.[183] And most significantly, a hands-off approach would not actively ensure ethical evaluation of geoengineering research projects.

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176 *Id.* at 134.

177 *Id.* at 131, 134.

178 *Id.* at 146-48.

179 *Id.* at 146-47.

180 *Id.* at 147.

181 *Id.* at 147-48.

182 *See generally* Dilling & Hauser, *supra* note 3, at 555 ("Others have described research in areas like geoengineering where there exists deep uncertainty and high public stakes as 'post-normal science,' where we can no longer maintain the artificiality of separation between science and its potential uses in society."). Whether the social contract approach is still a valid option for geoengineering research is debatable. Indeed, academics already call for a research agenda.

183 *See generally* discussion *supra* Part I.D.

Goal-driven research, illustrated by the WHO smallpox research committee, is also an inadequate model for geoengineering. A goal-oriented research committee almost certainly ensures decision-making by a minority, as efficiency mandates quick and conclusive decision makers. Relatedly, goal-driven governance, especially if lacking meaningful review and evaluation, risks locking in future geoengineering deployment.[184] Setting geoengineering research priorities and goals is not inherently risky; rather, the risk stems from setting research goals too narrowly — effectively shutting out other possible climate change solutions.[185] For example, a geoengineering research committee tasked with determining whether geoengineering is an effective solution to climate change is too goal-oriented to avoid technological lock-in.

Instead, geoengineering research governance should function as a vehicle of responsible innovation — a middle way between the "social contract" theory and the smallpox research committee. Academics, policymakers, and international institutions broadly call for constructive governance of new and emerging technology research.[186] While this middle road is difficult to define, responsible innovation offers two vital characteristics for governance under this new model: inclusivity and responsiveness.[187] These characteristics should ensure a human-focused foundation and promote scientific-ethical innovation.

First, responsible innovation is inclusive,[188] involving both innovators and stakeholders in the decision-making process.[189] Geoengineering research is prone to exclusivity because geoengineering may be researched and deployed unilaterally. Geoengineering research governance must promote inclusion on multiple levels. Recall the smallpox research committee; though convened by the WHO and comprised of experts from various member states, the United States ultimately exercised the most decision-making authority because of the committee's funding mechanisms.[190] In the context of geoengineering, a similar scenario could have drastic political and environmental consequences if a single

184 *See* Part I.C. (discussing the "slippery slope" risk).

185 *See* Amelung & Funke, *supra* note 81, at 38 ("[T]o enable learning, goals as well as their underlying models should not be too narrowly defined . . . . A focus on too narrowly defined goals could lead to premature (intellectual) lock-in to any specific technology.").

186 *See, e.g.*, OZOLIŅA ET AL., *supra* note 162, at 14-17; Jack Stilgoe et al., *Developing a Framework for Responsible Innovation*, 42 RESEARCH POL'Y 1568, 1569-70 (2013) (discussing broadly "responsible innovation" as a new form of scientific governance and highlighting its "forward-looking" and "shared" nature).

187 *See* Stilgoe et al., *supra* note 186, at 1570-73. Stilgoe's article advocates four characteristics of responsible innovation: anticipatory, inclusive, responsive, and has "institutional reflexivity." *Id.* This paper focuses on inclusivity and responsiveness, as they are arguably most important to creating a governance scheme built on a foundation of environmental ethics and informed consent.

188 Stilgoe et al., *supra* note 186, at 1571-72.

189 *See* Brey, *supra* note 145, at 307 (discussing Responsible Research and Innovation, a new European model).

190 Tucker, *Preventing Misuse*, *supra* note 172, at 131, 134.

influential state decided to unilaterally conduct large-scale field experiments. Thus, a geoengineering research governing body must actively garner wide support at the nation-state level. Geoengineering research governance must be inclusive on other levels as well. Governance should facilitate information sharing among researchers. Importantly, governance should mandate public participation in a manner that ensures informed consent.

Further, governance must be responsive, which requires the governing institution to "change shape or direction" if prompted by changes in stakeholder values, new knowledge, or evolving societal norms.[191] This marks a drastic shift away from the social contract theory of governance. Not only should geoengineering research governance encourage inclusion, but also it must integrate the views and values of now-included groups into the decision-making process. Greater reflexivity would likely decrease risk of moral hazard and technological lock-in.

The characteristics of responsible innovation promote a more active, involved theory of governance than the social contract theory of governance. However, responsible innovation does not go so far as to mandate specific outcomes. Rather, it calls for governance institutions to adapt to changing situations through self-reflection, stakeholder input, and other means.

Responsible innovation calls for an inclusive, responsive system of governance; the Bipartisan Policy Center and other academics offer domestic geoengineering governance proposals ultimately incompatible with this model. The Bipartisan Policy Committee advocates research governance largely within existing governance structures.[192] The plan recommends the White House Office of Science & Technology Policy take the lead in coordinating geoengineering research.[193] A more recent domestic proposal by M. Granger Morgan and his colleagues echoes the call for federal support and funding.[194] The Morgan Proposal "would have the United States take the lead in developing a set of norms for good research practice for SRM."[195] These proposals contemplate geoengineering research governance embedded within the federal administrative state, with extensive federal involvement and steering. Even if we expand the basic framework of these proposals to the larger international arena — the subject of this paper — the proposals do not adequately ensure responsible, ethical innovation.

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191 Stilgoe et al., *supra* note 186, at 1572-73.

192 *See* BIPARTISAN POLICY CTR., *supra* note 1, at 16-21.

193 *Id.* at 17.

194 *See generally* M. Granger Morgan, Robert R. Nordhaus & Paul Gottlieb, *Needed: Research Guidelines for Solar Radiation Management*, ISSUES SCI. & TECH, Spring 2013, at 37, 43-44.

195 *Id.* at 44.

C. Forum

Responsible innovation calls for a research governance forum that can support meaningful public involvement and respond to scientific, social, ethical, and political concerns. Meaningful public involvement is necessary to ensure informed consent of those affected by geoengineering research experimentation. Responsiveness prompts governance to integrate ethical analysis into scientific analysis and acknowledge potential big-picture effects on society, politics, and climate change policymaking. Given these requirements, who or what should be responsible for creating and implementing such research governance? Further, how can such a scheme facilitate participation and consent for research projects not only at the nation-state level, but also from populations and groups affected by geoengineering research?

This Part suggests that an existing international body, perhaps in conjunction with an international scientific body, facilitate governance via a top-down approach. But within this framework traditionally dominated by nation states, advisory bodies and review boards must work to ensure public participation, ethical analysis, and informed consent.[196]

First, an international body with established legitimacy and considerable authority in international environmental matters should adopt research protocols providing adequate approval, review, and evaluation of research projects. Many international bodies and agreements are inadequate to house the contemplated research governance scheme because of their limited scope.[197] For example,

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[196] Multilevel governance, emphasizing "the connections between vertical tiers of government and horizontally organized forms of governance," is becoming popular in the international environmental arena. Michele M. Betsill & Harriet Bulkeley, *Cities and the Multilevel Governance of Global Climate Change*, 12 GLOBAL GOVERNANCE 141, 149 (2006) (discussing local city-level governance, but also advocating broadly for multilevel governance).

[197] For an analysis of existing international organizations and treaties potentially relevant to SRM, see generally SRMGI GOVERNANCE REPORT, *supra* note 73, app. 3, *available at* http://www.srmgi.org/files/2010/10/Appendix-3-SRM-The-Governance-of-Research.pdf. The report ultimately concludes that no existing scheme is adequate, and while "several treaties or institutes could be modified to regulate or prohibit SRM in a piecemeal fashion, most regimes would thus be distorted beyond their core mandates." *Id.* at 13. Various academics, however, criticize the current fragmented system of international environmental governance and advocate reorganization or complete overhaul. *See* DAVID HUNTER, JAMES SALZMAN & DURWOOD ZAELKE, INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 203 (2011) ("To many observers, the present UN institutional structure is inadequate to meet the global environmental challenges we now face."); *see, e.g.*, Daniel C. Etsy, *Revitalizing Global Environmental Governance for Climate Change*, 15 GLOBAL GOVERNANCE 427, 428 (2009) ("A successful global response to climate change will therefore require broad-scale revitalization of the global environmental governance regime."). Two decades ago, Sir Geoffrey Palmer of New Zealand found "yawning gaps in the organizational framework for carrying out effective monitoring and assessment regarding such concerns as climate change, ozone layer depletion, water quality, living marine resources, sustainable development in some areas and biodiversity." Geoffrey Palmer, *New Ways to Make International Environmental Law*, 86 AM. J. INT'L L. 259, 262 (1992); *see also* HUNTER, *supra*, at 204 (noting that Palmer's concerns are "still relevant today"). "[T]he only way to cure the problem," he noted, "is to create a proper international

while parties to the London Convention and Protocol have addressed ocean iron fertilization, the Convention and Protocol cannot extend to govern research for most land- and atmosphere-based geoengineering methods. Governance would be piecemeal at best and thus fail to address the most significant shortcomings of current international research. On the other hand, creating an entirely new international treaty or body would probably be too slow to address impending geoengineering research. Further, an entirely new governance system would likely involve few parties besides those currently involved in geoengineering research, namely, the United States, Britain, and Germany.[198]

Three sources of international law have the broad scope, authority, and legitimacy to potentially provide comprehensive governance for geoengineering research: the United Nations Framework Convention on Climate Change (UNFCCC),[199] the United Nations Environment Programme (UNEP),[200] and the World Meteorological Organization (WMO).[201] The UNFCCC has "near universal participation," but a "slow decisionmaking process and overburdened agenda."[202] The UNEP, a United Nations (UN) body, "coordinates all UN bodies and member states on environmental issues."[203] The UNEP could be a fitting forum, as climate change is one of the institution's six official priority areas.[204] The UNEP receives criticism, however, for its inability to break free of power struggles and politics with other UN bodies.[205] Finally, the WMO is a "specialized agency" of the UN with authority to speak on the state of "the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources."[206] The WMO has experience

environmental agency within the United Nations system that has real power and authority" while restructuring and reorganizing "other environmental components within the UN system." *Id.* Such reorganization may benefit geoengineering research governance, but this paper seeks to offer a governance proposal within the current international system.

198 Currently, geoengineering research occurs primarily within these three countries. Clive Hamilton, *Geoengineering: Our Last Hope, or a False Promise?*, N.Y. TIMES, May 26, 2013, http://www.nytimes.com/2013/05/27/opinion/geoengineering-our-last-hope-or-a-false-promise.html. The geoengineering debate is thus largely Western-centric. China, however, "recently added geoengineering to its research priorities." *Id.* These countries would have an incentive to maintain a small coalition and exclude any dissenters. *See supra* note 95 and accompanying text.

199 *See generally* United Nations Framework Convention on Climate Change, May 9, 1992, 31 I.L.M. 849.

200 *See generally A Voice of the Environment*, UNITED NATIONS ENVIRONMENT PROGRAMME, http://www.unep.org/About/ (last visited Mar. 10, 2014).

201 *See generally* Convention of the World Meteorological Organization, Oct. 11, 1947, 77 U.N.T.S. 143; *WMO in Brief*, WORLD METEOROLOGICAL ORG., http://www.wmo.int/pages/about/ (last visited Mar. 10, 2014).

202 SRMGI GOVERNANCE REPORT, *supra* note 73, app. 3 at 6.

203 *Id.* app. 3 at 1.

204 *UNEP Priorities*, UNITED NATIONS ENV'T PROGRAMME, http://www.unep.org/about/Priorities/tabid/129622/Default.aspx (last visited Mar. 10, 2014).

205 *See* SRMGI GOVERNANCE REPORT, *supra* note 73, app. 3 at 1.

206 *WMO in Brief*, *supra* note 201. *See generally* Dilling & Hauser, *supra* note 3, at 562

guiding research, facilitating information exchange, and contributing to international policy formation.[207] While the scope of its authority is narrower than that of the UNEP or UNFCCC, geoengineering research arguably falls within its purview.[208] Unfortunately, the WMO Congress meets only once every four years, and its Executive Committee meets only once a year.[209] This timeframe suggests the WMO may be less responsive than necessary for a responsible innovation scheme.[210] Still, the WMO's legitimacy, scope of authority, and record of scientific research all suggest the WMO is the most appropriate international forum for geoengineering research governance.

After creating research and review protocols, the international institution could then cosponsor implementation with a science-based nongovernmental or hybrid organization, such as the International Council for Science (ICSU). Recently, hybrid and nongovernmental organizations have come to play a prominent role in law- and policy-making on the international stage.[211] International institutions often look to hybrid organizations to cooperate on "highly technical questions."[212] The ICSU is a hybrid international organization comprised of both global scientific unions and National Scientific Members (representing countries).[213] The ICSU already cosponsors various climate- and environment-related councils and programs with international institutions, including the World Climate Research Program, Intergovernmental Panel on Climate Change, and International Human Dimensions Programme on Global

(suggesting geoengineering researchers link together through an international research organization, such as the WMO).

207 *See WMO in Brief*, *supra* note 201.

208 *See generally* Convention of the World Meteorological Organization, *supra* note 201, art. 2 (Purposes), art. 8 (Functions).

209 *Structure of the Organization*, WORLD METEOROLOGICAL ORG., http://www.wmo.int/pages/about/wmo_structure_en.html (last visited Mar. 10, 2014).

210 *See* SRMGI GOVERNANCE REPORT, *supra* note 73, app. 3 at 2 (discussing institutions potentially to govern SRM research and suggesting that the WMO's meeting times are "too infrequent to effectively govern a novel topic like SRM").

211 *See* PETER WILLETTS, NON-GOVERNMENTAL ORGANIZATIONS IN WORLD POLITICS: THE CONSTRUCTION OF GLOBAL GOVERNANCE 72 (2011) (discussing hybrid organizations); Barbara K. Woodward, *The Role of International NGOs: An Introduction*, 19 WILLAMETTE J. INT'L L. & DISP. RESOL. 203, 216-17 (2011) (noting nongovernmental organizations' roles in identifying important issues, helping to draft treaties, and assisting with treaty administration, amendment, and review). While most textbooks distinguish between intergovernmental organizations and nongovernmental organizations, British global politics professor Peter Willetts acknowledges that not all organizations fall within this "simple, straightforward dichotomy" and argues hybrid organization form a third category. WILLETTS, *supra*, at 72. A hybrid international organization is one "that includes in its membership both states, represented by government ministries and/or other governmental institutions, and transnational actors, which may be from a single-country and/or multi-country, international non-government organizations." *Id.* at 73 (emphasis omitted). Hybrid organizations, such as the ICSU and International Labour Organization, are currently "present as the focal point for the global politics of some major issues." *Id.*

212 WILLETTS, *supra* note 211, at 75.

213 *Id.* at 75-76.

Environmental Change.[214] The international institution, in conjunction with the ICSU, could house geoengineering governance within one of these existing programs or create a new program for geoengineering research specifically.

This top-down framework would arguably lend legitimacy, authority, and broad participation among nation states. Such a governance structure may successfully integrate ethical analysis into scientific review. As it stands, however, it does not facilitate broad public participation or ensure informed consent. To ameliorate this issue, the international body should convene work groups, advisory bodies, or review boards to approve, review, and evaluate projects.

Drawing on the biomedical research model, the international body could convene one or more geoengineering research review boards or councils "resembling in function the Institutional Review Boards established within universities for the approval of research on human subjects."[215] The boards could conduct substantive review of proposed geoengineering projects and approve or disprove projects based on compliance with the new international standards.[216] The groups could also perform or commission scientific review of pending and completed projects. The review board should have authority to halt projects whose negative effects exceed projected effects. In addition to facilitating public participation, this procedure would ensure individualized, integrated scientific-ethical review of research projects.

Review board or advisory committee membership could help ensure informed consent of those affected by geoengineering research projects. The international institution could convene review boards or committees for different geographical regions. Each board or committee could consist of both scientists and members of civil society.[217] Scientists should include both social scientists and natural scientists,[218] while other participants could include academics, members of environmental nongovernmental organizations, and business leaders.[219] The review board should also include local and regional government

[214] *See Human Dimensions of Global Environmental Change (IHDP)*, ICSU.ORG, http://www.icsu.org/what-we-do/interdisciplinary-bodies/hdp/ (last visited Mar. 10, 2014); *Summary of WMO co-sponsored programmes*, WORLD METEOROLOGICAL ORG., https://www.wmo.int/pages/summary/cosponsored_summary_en.html (last visited Mar. 10, 2014).

[215] Morrow, Kopp & Oppenheimer, *supra* note 47, at 4 (calling the board an "International Climate Engineering Research Review Board").

[216] *See id.*

[217] *Cf.* David E. Winickoff & Mark B. Brown, *Time for a Government Advisory Committee on Geoengineering Research*, ISSUES SCI. & TECH, Summer 2013, at 79, 82-83 (proposing a domestic advisory committee for geoengineering research and suggesting various non-government actors to sit on the advisory committee).

[218] *Cf. id.* (advocating participation in geoengineering research decisionmaking by scientists from various fields).

[219] *Cf. id.* (advocating participation from "[a]cademic research administrators with expertise in emerging technologies," business leaders, military leaders, environmental NGOs, and "[f]ormer

officials representing potentially affected populations. Review boards comprised of members of affected regions would ensure discussion of local and regional values and ultimately provide informed consent from affected groups within the larger international framework.

IV. CONCLUSION

The risks and potential transboundary effects of geoengineering research mandate international governance. But current oversight for geoengineering research is sparse and leaves significant governance gaps. The international community should create oversight to fill those gaps, creating governance centered on ethical analysis and informed consent. In form, governance should build on this foundation and guide research using principles of responsible innovation. The forum should facilitate participation at both the nation-state level and among individuals and populations. This paper suggests that an international body provide top-down governance, but also convene advisory bodies and review boards to ensure broad public participation, ethical analysis, and informed consent.

government officials with experience in diplomacy and administration”).