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A New Security Framework for Geoengineering

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Abstract

As the national security ramifications of climate change grow more pronounced, climate manipulation technologies, called geoengineering, will become more attractive as a method of staving off climate-related security emergencies. Geoengineering includes methods of carbon dioxide removal and/or solar radiation management and can theoretically achieve significant reductions in warming-related environmental changes, but they are scientifically untested. Geoengineering technologies have the potential to disrupt the global ecological status quo and mount a potentially coercive threat with implications as serious as those in wartime. Several of these technologies can be deployed from the global commons, but international law provides no more than indirect guidance as to how they should be governed as a matter of international security. We argue that, lacking explicit scientific or legal guidance, just war theory provides a useful normative framework for restraining the use of environmental force. Modifying just war theory into "just geoengineering theory" will provide ethical standards for security decision makers as they consider whether or how geoengineering should be used.

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Academics, military practitioners, think tanks, and international organizations—even the UN Security Council—are increasingly concerned about the national security ramifications of a changing climate.[1] These range from direct physical effects such as loss of territory due to sea level rise, to higher order effects such as greater spread of infectious disease, geopolitical instability in a thawing Arctic, and climate change–driven migration. The increasing security toll of climate change is clearly recognized as a significant driver of civil unrest and conflicts such as the Arab Spring.[2] The US military has addressed climate change in both the 2010 and 2014 editions of the Quadrennial Defense Review, and other states around the world are likewise concluding that climate change is a threat multiplier.[3] Even the Intergovernmental Panel on Climate Change (IPCC) now recognizes the human security impacts of climate change and has addressed security in its Working Group II report.[4] With NASA's announcement that 2016 and 2017 will likely be the two hottest years ever recorded, it is clear that the international community is failing to control climate change at the global level.[5] Atmospheric concentration of carbon dioxide has reached a new high of 405 parts per million (ppm) and continues to climb.[6] The emissions restrictions and other climate change mitigation actions contained in the multilateral agreement signed in Paris in December 2015, even if fully implemented, will only result in limiting any global temperature increase to 3.5°C above preindustrial levels, rather than the recommended 2°C target.[7] The Trump administration has now withdrawn the United States, one of the largest emitters, from the Paris Agreement, placing even the 3.5°C result in jeopardy. Such ongoing and future security concerns will lead policy makers' attention to climate-modifying technologies, which are beginning to appear in scientific and policy discussions as viable alternatives to climate mitigation.

Considerations of the scientific, technological, financial, and ethical implications of geoengineering technologies have appeared in various reports since 2009,[8] but the implications of such technologies for security and defense have not been part of any recent analyses. However, geoengineering on any but the smallest scale means that one state may be able to substantially change the material conditions in another state or even globally on a unilateral basis. Given the lack of any specific laws, treaties, or norms governing planetary technologies of this type, states must look elsewhere for guidance on whether, when, and how to use them in the interest of national security. A modification of just war theory will serve as a framework for restraining the use of environmental force by states and provide guidance in setting ethical norms and standards for the deployment of climate-altering technologies. This article first explains the types of geoengineering technologies considered feasible for altering the climate. Next it analyzes existing legal guidance. Finally, the article presents a "just geoengineering theory" for considering deliberate climate modification.

Geoengineering Technologies

Currently, we have three options to address the changing climate and its second- and third-order environmental and security effects: adapt to the changes with improved infrastructure and other technologies, mitigate the phenomenon through global greenhouse gas (GHG) emissions reductions, or geoengineer the climate in an attempt to offset or "undo" the damage. Adaptation is the path of least resistance regarding climate change. However, this option requires states rethink the many climatic assumptions, such as stable temperatures and regular precipitation, upon which their economy, their culture, and their infrastructure are based. This type of fundamental change presents huge political and logistical challenges for large and small states.

Mitigation would provide the greatest long-term climate stability, but GHG emission reductions could be economically costly because they would require a massive shift away from fossil fuel use.[9] States have attempted to create a global climate change mitigation regime but have only generated piecemeal agreements, such as the Reducing Emissions from Deforestation and Forest Degradation in Developing Countries plan and the intended nationally determined contributions contained in the Paris accord.[10] Meanwhile, sovereign governments will continue to act in their own best economic and political interests rather than in a generalized global interest.

If the security problems resulting from climate change are severe enough, and if both mitigation and adaptation are seen as undesirable for time or cost reasons, then geoengineering may emerge as a credible method of responding to a national security threat. Geoengineering technologies fall into two distinct types, carbon dioxide removal (CDR) and solar radiation management (SRM). CDR includes any method of removing carbon dioxide, and possibly additional gases, from the ambient air with the intention of reducing the greenhouse effect and allowing more heat to escape the atmosphere. SRM methods attempt to bounce sunlight away from the earth before it has the chance to be absorbed and re-radiated from the surface as infrared heat, becoming trapped in the atmosphere and contributing to the greenhouse effect.[11] Most methods of SRM or CDR can be deployed from land and so would fall under laws and norms of national governance. However, three of the current CDR/SRM methods must be deployed from the global commons (oceans or atmosphere) and would require novel changes to our ideas of international governance because they cannot be implemented under current assumptions of international sovereignty and security. Those global commons three include:

1. Ocean Iron Fertilization (OIF)

Carbon dioxide can be pulled from the air and sequestered by natural processes in the ocean. Seeding high-nutrient, low-chlorophyll areas of the ocean with nutrients such as iron can stimulate plankton growth, which then absorb carbon dioxide via photosynthesis from the ocean. When the plankton die, the carbon sinks to the ocean floor. This method is estimated to capture between one and four gigatons of carbon dioxide per year, though it would take decades to scale up to that level of capture, and more still would be needed to achieve a 1.5°C climate target.[12]

2. Sulfur Aerosol Dispersal

Dispersal of sulfur dioxide particulates into the upper atmosphere is the most commonly discussed SRM method. Using airplanes, high-altitude balloons, airships, or other means, injected aerosol particulates would then create a global haze that would reflect sunlight, limiting the solar energy reaching the earth's surface and thereby cooling the planet. By way of example, the 1991 eruption of Mount Pinatubo in the Philippines spewed approximately 20 million tons of sulfur and other particulates into the atmosphere, resulting in a global average temperature drop of 1°C for about a year.[13] The equivalent of approximately one Pinatubo every four years would be needed to counteract the effects of climate change over the next few decades.[14]

3. Marine-Based Cloud Brightening

Since clouds are a natural method of reflecting sunlight, the stimulation of cloud formation may serve to reduce incoming solar radiation.

Using sea salt particles as cloud condensation nuclei could encourage clouds to form and reflect sunlight without the use of sulfur dioxide.[15] This method would require approximately 1,500 unmanned ships called Flettner spray vessels to release seawater micro-droplets into the lower atmosphere.[16] These ships could operate on the high seas, thus removing them from territorial interference from other states, and would be unmanned and unfueled, using wind power for motion. Since the cloud-brightening effect requires a constant input of sea spray, the process can be turned off relatively quickly if adverse effects appear.[17]

Costs and Implications

In terms of security-related changes to the environment, ecological collateral damage during combat is one of the most significant costs of war, because disruption or destruction of the environment and its resources hinders the recovery of the civilian population. The UN Environment Programme has conducted postconflict environmental assessments in Afghanistan, Iraq, Gaza, and Sudan. Sometimes the ecosystem can recover from the effects of a conflict, sometimes it does not.[18] Subsequent estimates of the ecological, economic, and human health costs of recent wars include $450 million to clean up dioxin in certain areas of Vietnam, $6.5 billion to fight fires and make repairs to oil infrastructure in Kuwait after the First Gulf War and $27 billion in lost oil/gas profit, and approximately $44 million in environmental damage in Gaza since the escalation of conflict in 2009.[19]

Any geoengineering technology on a scale large enough to shift the global climate has the potential to inflict damage of the same magnitude. Since these technologies have not been tested to scale, direct cost comparison can be difficult, but by way of proxy data, the eruption of the Eyjafjallajökull volcano in 2010 cost the Icelandic government $7.5 million in cleanup and repairs, and the global economy experienced an estimated $5 billion in lost airfare, tourism, and perishable consumer goods.[20] The total costs of the 1980 Mount St. Helens eruption in Washington State and the 1991 Mount Pinatubo eruption in the Philippines were estimated to be $1.1 billion (1980 dollars) and $700 million (1991 dollars), respectively.[21] Since governments have limited abilities to calculate ecosystem losses, there may be extended or synergistic damages that are not captured.[22]

Furthermore, this damage would be perpetrated knowingly upon other states without their consent. Global commons–based geoengineering is not synonymous with the use of violent force. But, depending upon the type of technology used, it could incur the same level of cross-border environmental destruction and loss of sovereignty as a war. War is waged with intent to harm; geoengineering might be deployed without that intent, but we argue that—when speaking of that scale of involuntary environmental change—that is a distinction without a difference. Since the global ecosystem and atmosphere are indivisible, one state can cause material changes in the environment of another that have the possibility to negatively affect the territory, economy, and security of that state. These changes would affect the security and material well-being of states, just as the use of violent force does. Thus, rules and norms about geoengineering have their parallels in rules and norms about use of force. Deploying geoengineering technologies raises issues of both national security and ethical treatment of the global environment.

Ecological and Economic Risks to Geoengineering

Research on these methods of geoengineering is not well developed, and it is easy to spot both ecological and economic risks. While OIF may have a positive effect on fish stocks, it may also result in changes to the structure of the marine food web and possible reduction of subsurface oxygen.[23] Previous OIF experiments have resulted in the production of greenhouse-enhancing gases such as dimethylsulfide, nitrous oxide, and methane.[24] Any type of geoengineering that does not remove carbon will allow for the continued acidification of the oceans.[25] Such effects will vary depending on where on the ocean and at what time of year the Flettner ships are deployed.[26]

The ecological risks of aerosol deployment are significant. Net primary productivity is a measure of the amount of chemical energy produced by plants and is directly related to the amount of sunlight they receive. If SRM reduces the amount of sunlight reaching the earth, then plants from crops to forests may become less productive.[27] Also, with a 3 percent drop in incoming sunlight under an SRM scheme, solar power from photovoltaic panels and dish collectors would become less effective.[28] Sulfur aerosols in particular may accelerate depletion of the stratospheric ozone layer, and since sulfur dioxide is the main corrosive component in acid precipitation, any sulfur artificially added to the atmosphere via geoengineering will eventually rain out in some form, causing localized ecosystem damage and human health concerns.[29] Additionally, early computer models suggest that cloud brightening may interfere with existing precipitation patterns.[30] If global GHG emissions are not reduced, then any method of SRM would have to be continued indefinitely once it is begun. If SRM is stopped and the full complement of sunlight reaches the earth through an atmosphere thick with GHGs, the global temperature would rapidly spike upward, a phenomenon known as the termination effect. This carries the more-than-likely risk of abrupt and dangerous warming, well outside twentieth-century climate variability bounds.[31] It should be noted that the potential benefits of geoengineering on the climate could also be significant, but just as in war, they would be unevenly distributed.

Perhaps the greatest concern regarding geoengineering is the moral hazard. Any type of geoengineering method could incur a moral hazard, but SRM is particularly dangerous; because SRM methods have the potential to work quickly, their effects can be felt quickly. This may lead the public to conclude that the global warming problem has been "fixed" and that the difficult and disruptive work of de-carbonizing the world's energy supply need not continue. Without public pressure, policy makers are unlikely to pursue further climate change mitigation measures, particularly if they are costly compared to an SRM regime. Already, with US participation in the Paris agreement stalled, lawmakers in Congress have introduced a bill to formulate a research agenda for "albedo modification strategies that involve atmospheric interventions" (SRM), citing the effects that climate change has on US national security![32]

Existing Legal Guidance

Since there are no international instruments that deal explicitly with geoengineering, international law only provides limited guidance to security policy makers. However, several environmental treaties and war conventions may have ancillary relevance.

Environmental Laws

International environmental laws assign responsibility and regulate behavior with respect to the environment as well as describe the norms and conventions that govern our relationship to the natural environment. Many of these laws address issues that arise in the global commons (ocean and atmosphere), and several may apply to geoengineering processes and technologies. The 1972 London Dumping Convention and the 1982 UN Convention of the Law of the Sea (UNCLOS) both contain provisions to address marine pollution; depending on the attempt, this may include iron particles used for OIF.[33] UNCLOS Article 140 states that activities carried out in the high seas area shall be for the benefit of mankind as a whole, irrespective of the geographical location of states. Although the article is intended to address the disposition of minerals and other resources on the ocean floor, it is relevant to our discussion because the exclusionary nature of security actions automatically prejudices the interests of one state over another. One state wishing to employ a marine-based geoengineering strategy may therefore have to demonstrate that the climate benefits they intend to bring about are intended to improve the climate generally and not merely for their own individual state. The 1979 Convention on Long Range Transboundary Air Pollution addresses air pollution and may outlaw the use of sulfur aerosols for SRM. The 1992 Convention on Biological Diversity addresses any process that affects ecological biodiversity; in 2010, the tenth conference of the parties issued a statement calling for states to abstain from attempts at geoengineering until further research into their effects on biodiversity might be assessed.[34] By 2016, the subsidiary body on scientific, technical, and technological advice issued an updated analysis pointing out the environmental and governance uncertainties still inherent in these technologies and noting that they are yet ungoverned.[35]

Laws of War

Legal agreements concerning norms of wartime behavior can also shed light on the security, political, and ethical implications of geoengineering in two ways. First, a few of those agreements directly address treatment of the environment during wartime. Second, since geoengineering technologies have the potential to disrupt the global physical status quo, they mount a potentially coercive threat with implications as serious as those in wartime. Thus, any review of the security ramifications of geoengineering technology warrants consideration of legal norms and agreements regarding war.

1977 Environmental Modification Convention

The 1977 Environmental Modification Convention (ENMOD) specifically prohibits "military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party."[36] This leaves open the possible argument that ENMOD is not applicable to geoengineering because it does not qualify as warfare since it has no stated intent to destroy, cause damage to, or injure any other state.

The prohibition of "military use" of environmental modification techniques appears to apply to the conduct of warfare only and leaves open to interpretation whether or not peaceful use could be carried out by military personnel or equipment.[37] Some of the atmospheric or ocean-based schemes would require substantial logistical capability to deploy successfully, and the national military may be the only state agency with the wherewithal to perform such a mission. Most state militaries are allowed and even expected to assist civil authorities when officially requested to do so; this includes carrying out disaster relief operations such as provision of emergency aid and evacuation of civilians. If deployment of a geoengineering scheme becomes a matter of national economic or scientific policy, then military involvement would be governed by the relevant national laws.

1977 Geneva Protocol I

Protocol I pursuant to the Geneva Conventions of 1949 addresses the protection of victims of international armed conflict, and several articles specifically address protection of the natural environment. Article 35 employs similar language to ENMOD in that parties are prohibited from employing methods and means of warfare that cause "widespread, long-term, and severe" damage to the natural environment. Though the two conventions use similar terms to describe prohibited environmental damage, ENMOD assumes "long-lasting" to mean a few months to a season, whereas "long-term" in Protocol I is understood to refer to decades.[38] Article 54 prohibits parties from attacking objects necessary for the survival of the civilian population, including food, water, and agricultural land and resources. Article 55 enjoins parties to protect the environment from widespread, long-lasting and severe collateral damage during war. Article 56 prohibits attacks on works and installations that contain dangerous forces (usually read to mean the built environment, such as dams and power plants).[39] The reasoning behind both ENMOD and Protocol I is that the health of the natural environment is critical to the survival of the civilian population and should not be prejudiced by war. If this injunction is significant enough to warrant consideration during warfare, when states are customarily granted the greatest legal and operational leeway in national security operations, then it should warrant consideration during peacetime when states have the ability to reflect and consult.

Geoengineering in International Legal Limbo

Of the three technologies that would be deployed from the global commons, each suffers from a certain kind of legal neglect. For example, nothing prohibits peacetime use of environmental modification technologies such as aerosol dispersal or cloud brightening. This means that any state or nonstate actor deploying such technology could claim (truthfully or not) that they were acting for the good of their country or of humankind and consequently had no hostile intent. Such a claim would render laws such as ENMOD or Geneva Protocol I inapplicable. These same actions might be illegal under domestic law, but since domestic laws differ in scope and specificity from international treaties, a particular technology such as ocean iron fertilization that may be illegal in territorial waters may not automatically contravene international law if deployed from the high seas. Consequently, any one of the Global Commons 3 technologies could be considered legal from a positivist perspective.

Finally, nothing in any law, convention, treaty, or custom prohibits a state from defending itself and its territory from a real threat to its national security. As disruption from climate change becomes more pronounced, and the international security threats arising from these effects become more apparent, a state may find itself considering an attempt at geoengineering for its own protection or preservation.

Just Geoengineering Theory

Under every accepted theory of modern international relations, a state is allowed, even obligated, to protect its national security. If the physical effects of anthropogenic climate change produce or contribute to threats to national security, then abating it or offsetting its negative consequences may be viewed as a necessary security requirement, maybe even on a pre-emptive or preventive basis. Already, military forces from countries around the world are taking steps to address climate-related threats. The mounting security threats from climate change have been likened to World War III, and the need to mobilize on a nation-changing footing to produce renewable energy technology likened to the American industrial run-up to defeat the Axis Powers.[40] If geoengineering is to be considered as a defense option, and international law provides no specific prohibition, we can look to just war theory for further guidance.

Just war theory provides ethical guidance for decision making about the destructive forces of war. It helps define the concepts of "right" and "wrong" in warfare and made customary the idea that warfare is limited in scope and method.[41] Therefore, just war criteria can illuminate important ethical and security considerations for deploying geoengineering technology. Using geoengineering for defense and security means one of two things: either a state is manipulating the climate as "offense," as a means of war; or the national security problems engendered by the changing climate have become so severe that policy makers have begun to see geoengineering as a possible means of "defense." If the former, such actions are clearly prohibited by ENMOD and Geneva Protocol I. If the latter, decision making becomes a bit murkier. Consequently, we can view potential "defensive" attempts at geoengineering through the lens of just war theory and ask ourselves whether or not such attempts could be both ethically acceptable and a net security gain. In doing so, we make use of both jus ad bellum (law of resort to force) and jus in bello (law of war fighting) criteria. While not all the elements of just war theory relate directly to consideration of geoengineering, three of the criteria shed useful light on its utility as a possible option for national self-defense.

Competent Authority

This jus ad bellum criterion is generally understood to mean that war cannot be undertaken justly without the permission of a publicly recognized authority acting in accordance with the rule of law, divine right, or other relevant source of political legitimacy. Early Western notions of just war were articulated through Christian theology, but just war thinking has grown beyond that foundation. On questions of war, states share with intergovernmental organizations (IGO) such as the United Nations and NATO the ability to speak authoritatively about when the use of force is and is not permitted. Therefore, it is reasonable that states and IGOs, in consultation with climate experts, can speak with authority on the use of force through geoengineering.[42]

However, sovereign states, individually or in groups, are still the only actors that can legitimately use force in international relations, ostensibly in defense of their citizens. Therefore, they must make a significant and allied commitment to prevent any illegitimate geoengineering deployment by rogue or unauthorized actors.[43] Then, if geoengineering is deployed, it is done as part of a considered national plan, not from a grudge, hostile intent, or a misplaced sense of experimentation.

Proportionality

This same requirement for expert scientific judgment informs the jus ad bellum and jus in bello principles of proportionality. Here, proportionality means that the ecological good that the acting state intends to achieve through its use of geoengineering must outweigh any negative ecological consequences it brings about. Consideration of proportionality in geoengineering is complicated both because the changing climate is a moving ecological target and because meaningful tests of the technology are currently ineffective or impossible. This means that a "just" deployment would need to be reassessed regularly over its duration, because changing environmental conditions over time mean that geoengineering can make things worse, not better.

Discrimination

Finally, the principle of discrimination distinguishes between morally acceptable and unacceptable targets: combatants are legitimate targets; noncombatants are not. This distinction is not always easy to make, since guerrilla and insurgent warfare frequently involve irregular troops, civilians who willingly or unwillingly serve as weapons platforms, and tactics such as improvised explosive devices that can be difficult to attribute to a specific source. In such cases, it is difficult to discriminate between legitimate and illegitimate targets because the line has blurred between who is a combatant and who is not. The old categories do not easily fit the new reality of warfare, though the moral imperative of discrimination remains. However, there are two points to consider when applying this principle to geoengineering: how to identify "combatants" in this case, and whether global geoengineering technologies raise collateral damage questions similar to those raised by weapons of mass destruction (WMDs).

In considering geoengineering as a use of force, the principle of discrimination forces us to redefine who are considered combatants and noncombatants. Combatants are generally the armed forces of two or more warring nations, and are legitimate targets under just war theory; noncombatants are not legitimate targets. However, when the proper authority of a state is considering geoengineering, this policy is intended to benefit the government and its citizens. Since they are the ones taking the proposed action for their own benefit, they can be loosely termed to be the "combatants" in this parallel to war. Conversely, "noncombatants" are normally those civilians who are not party to the conflict; in this parallel, we might term everyone else on Earth to be the noncombatants, since the action is not taken for their benefit, nor are they necessarily even considered.

Climate Change for National Defense

War involves unleashing powerful forces not only on the target population but also on the non-target population as well. Current norms of war permit some level of collateral damage during combat, but combatants must reasonably foresee and minimize such damage. While geoengineering technologies and WMDs differ in important ways, they are both instruments of force that cannot be targeted precisely. Furthermore, commons-based geoengineering will not be effective unless tested or deployed on a global scale, which adds another level of ecological uncertainty to any attempt to minimize collateral damage. Customary international law, as stated by the International Committee of the Red Cross and reaffirmed in the 1998 Rome Statute of the International Criminal Court, holds both that indiscriminate attacks are prohibited and that the use of indiscriminately targeted weapons constitutes a war crime.[44] It stands to reason, then, that a similar precaution would pertain to indiscriminately targeted instruments of massive environmental change. If states do consider geoengineering from the global commons as a method of national defense, we can construct a new framework to function in geoengineering decision making as just war theory functions in conflict decision making. Because of the global and possibly irreversible effects, all precautions must be taken by the decision makers to maximize transparency and represent all stakeholder views.

Jus ad climate

The state must be facing a major climate change–related security emergency in order to justify using geoengineering. In the same way that self-defense is an agreed-upon indicator of a just war, a major climate emergency would function as an agreed-upon precondition for geoengineering deployment. However, as in just war theory, this criterion is extremely subjective. While no financial or mortality estimates have been agreed upon as to what constitutes a major emergency, what would be a small scale natural disaster for one state might be an existential threat to another. Hence, geoengineering technology would be deployed when the damage became "bad enough," presumably as determined by the competent national authority. Such an estimation could include costs from drought, floods and storms, crop failures, heat deaths, and so forth.

We propose consideration of several additional factors for determining whether a situation is "bad enough." First, the estimated damage must meet some threshold in lives or dollars. There is no specific number to attach to such a factor, since relative damage varies by state, but the competent national authority should think about what those numbers might be and presume to set them high so geoengineering does not become the option of first resort. Second, the security threat must be publicly attributable to climate change. If policy makers want to geoengineer the climate, they need to admit that the security threat the state is facing stems from a climate change–related problem and not some random force majeure event. In this way, mitigation and adaptation measures are brought back into the discussion and not automatically dismissed in favor of the technological option.

Third, the real or assumed cost of equivalent climate change mitigation or adaptation efforts must be "too high" to afford or take "too long" to be effective. Meeting this threshold would permit the just use of geoengineering rather than, or in addition to, mitigation or adaptation measures. However, this is where the greatest moral hazard trap appears. As environmental conditions further degrade and the need to respond grows increasingly urgent, it will be easy for international actors to see geoengineering as a technological quick fix for the climate. This would be a grave error for two reasons. First, most of the technologies are in the early stages of research and development, so confidence in their effectiveness is low. Second, field testing the technologies at the planetary level will have the same impact as actual deployment, thus eliminating the option of experimentation. This greatly reduced margin of error argues for caution even beyond the normal level for scientific investigation.

Some analysts have argued for the preemptive early use of SRM, well before any such emergency threshold is reached. Such argument is usually attached to the justification that this use would temporarily stabilize the climate and buy the world's states enough time to switch from fossil fuels to noncarbon energy sources. However, the danger of preemptive use lies in its very potential for short-term success. The deployment of atmospheric sulfur may indeed lower global temperature a measurable 1.5°C for the span of a few years, similar to the eruption of Mount Pinatubo, but this veneer of success removes the urgency for making the switch; as most energy infrastructures and systems are path-dependent with a high level of technological lock-in, discouraging any shift to other modes of production as too expensive.[45]

Any decision to deploy geoengineering from the global commons (atmosphere or seas) must be made at the national level first, then subject to international consent. To guard against rogue actors, any decision to deploy geoengineering must be made by the competent national authority, presumably in conjunction with scientific advisors. This guarantees that such a decision represents the will of the nation, or at least its government, and not merely one faction or one individual. However, since the ecological changes brought about by geoengineering are global in scope and the likelihood of undesirable collateral environmental damage is high, there must be some level of international approval for an individual state's decision.

National decisions concerning evaluation of just war criteria, and determination of national security in general, are not usually subject to international discussion before they are implemented. But geoengineering technologies are not like other weapons due to their unique combination of global reach, potential for nonlinear effect, and fundamental implications for the livability of our planet.[46] Any type of weapon used in modern conflict can be subject to the just war constraints of proportionality and discrimination; geoengineering technologies should be as well. Barring formation of a new body, the only standing body that could provide such consent, and hence legitimacy under our just geoengineering theory criteria, is the UN Security Council. This means that any discussion of deployment would be subject to the veto of the five permanent members, which may act as a restraining force on states seeking approval for deployment. However, if the UN or any agency it designates to make such decisions were to assess the risk of a proposed attempt and determine it to be acceptable, then such an action would have earned international approval and would not be considered "hostile" per ENMOD.

Any geoengineering attempt must have a reasonable chance of success, according to the best scientific and economic knowledge available at the time. If a particular method of geoengineering has some negative ecological consequences that in itself does not make it unjust. Rather, the competent national authority must clearly demonstrate how the ecological and financial good outweighs the bad, based on the best scientific knowledge available at the time the decision is made. This could be measured in a number of ways: temperature lowered, lives saved, money saved, disasters avoided. If this cannot be determined, then the precautionary principle applies: put down the sulfur and step away. The intent of the state deploying the technology is key: only defensive deployment aimed at avoiding or mitigating a security threat is permitted. Any attempt to use geoengineering for offensive purposes (to manipulate or threaten another state) would be considered hostile use and subject to the terms of ENMOD.[47]

Any geoengineering attempt must meet the double effect criteria: only the good result is intended, the bad result is not a means to the good result, and the actor foresees greater good than bad resulting from the deployment. In war, double effect is a matter of both jus ad bellum and jus in bello. An actor's reason for resorting to force may or may not violate the principle, though the actor's means of fighting incur a double effect. In either case, actors must ensure that they are not engaging in harm for harm's sake. In geoengineering, double effect is primarily a question of resorting to use, rather than one of using the technology once it is deployed. This is because effective geoengineering will alter the global climate, and any change on that scale will almost certainly have both good and bad results. In other words, it would be impossible to deploy geoengineering technology without incurring double effect. Therefore, the question of double effect arises in assessing not the use of force but rather in determining the ethics of resorting to using geoengineering force at all. This suggests that any decision-making about geoengineering should proceed with a high level of caution.

Jus in climate

The method chosen must be the least environmentally harmful one within the necessary time frame and designed to achieve the minimum ecological disruption necessary to offset climate change effects. This criterion echoes the just war criteria of proportionality and comparative justice, since it posits that just actors may use only the amount of force necessary to achieve their goal. However, this criterion also includes elements of the need for proper authority, because understanding the available time frame and levels of ecological disruption will require input from scientists and stakeholders. We caution that extreme care should be taken with the implementation of this criterion, since it relies heavily on subjective scientific and environmental judgment. If done hastily or with no ecological care, a reckless deployment attempt could be perceived as an act of war by one aggrieved or desperate nation or party against the rest of humanity or the earth. Therefore, transparency of negotiation, goals, and possible outcomes will be paramount to ethical geoengineering.

The method chosen must yield greater good than harm globally, not just to the country deploying it, and from the first year of deployment. If not, it must be discontinued as ineffective or unjust. Again relying on the obligation to refrain from transboundary environmental harm, not only the deploying state but also the world community must measure the effects of geoengineering for its benefits for the combatants and its harm to the noncombatants. The applicability of the double effect principle here in jus in climate means that both proportionality and discrimination must be reassessed on an annual basis for the duration of the deployment, and a workable regime must produce greater environmental good than harm.

A short time threshold to prove the viability of geoengineering technology is critical for jus in climate, because unjust or unworkable strategies that linger can cause significant environmental and economic damage on top of the climate change effects they are trying to mitigate. The important second-order effects of climate change are availability of fresh water, amount of agricultural output, and prevalence of infectious disease. Food and water security are significantly affected by climate-dependent conditions such as temperature and precipitation, and climate change results in outbreaks of infectious diseases due to shifting disease vectors.

Most states that avail themselves of a modicum of international trade can recover from a one-year disruption in agricultural output, water supplies (though this is harder), and food and resource markets. Aid agencies such as the World Food Programme or Oxfam can make accommodations for one year, and the WHO and other international medical authorities can get medicines and personnel in place within one year, should they need to respond to an outbreak. However, for food and water constraints or disease outbreaks lasting longer than that, adaptation becomes more problematic. Consequently, for a geoengineering method that is expected to take longer than one year to provide benefits, we should assume that the net environmental effect will be neutral, pending a positive outcome. Otherwise, insisting against evidence that a technique will work in the undetermined future can become a cover for faulty technology, scientific experimentation, or profit seeking.

Jus post climate

The third category of just geoengineering theory, what we might call jus post climate, would have as its equivalent principles those of ending the geoengineering deployment as soon as possible and restoring the ecosystem to its previous state. However, elucidating this further would be premature at this point due to the specific technological nature of geoengineering. If the technology deployed is a type of SRM, then not only can it not be stopped without concomitant removal of atmospheric GHGs, in fact it must be continued indefinitely in order to provide the desired global cooling effect. Otherwise the temperature would rise rapidly, the previously mentioned termination effect. This means that regardless of what SRM methods are used, the world community must work to reduce GHG concentrations in the atmosphere at the same time. Additionally, the process of geoengineering is not designed to restore the climate and the environment to its original state but merely to hold off damage and buy time until noncarbon forms of energy have replaced fossil fuels. Since the climate always exhibits some degree of variability, knowing when a particular deployment had "reset" the climate would be near impossible.

Jus post bellum does include a principle stating that those individuals guilty of war crimes and crimes against humanity perpetrated in the course of a war should be tried in accordance with international law. In parallel, states embracing jus post climate could also consider rogue geoengineers to be guilty of crimes against humanity. This is not a completely new concept. The 1998 Rome Statute of the International Criminal Court (ICC) includes environmental damages as outlined in the Geneva Protocol I as a possible war crime.[48] Until now, the ICC has not pursued environmental crimes, though the current prosecutor may expand the range of the court's cases.[49] Although geoengineering is not explicitly enumerated among customary crimes against humanity or war crimes, the extensive environmental alteration inherent in any scale geoengineering attempt could easily result in "widespread, long-lasting, and severe" damage if it has unintended effects.

Conclusion: It's Not Nice to Fool Mother Nature

States that are threatened by the security effects of climate change and considering geoengineering as a result face an unpalatable choice: refrain from deploying and run a dangerous or even ruinous security risk or deploy some method of geoengineering, gamble that it will not result in a climate catastrophe, and face criticism from the international community if this decision does not have UN approval. Either of these choices entails risks for a state, since climate change-driven security threats are often multiyear, multisystem hazards that are not easily quantifiable and may not result from a direct adversary.

If addressing climate change–related threats has become part of the security decision-making process, does it make sense to try to operationalize the principles behind just geoengineering theory? In traditional defense and security decision making, the principles behind just war theory are formalized in treaties such as the Geneva Conventions and in customary international law, and put into practice in the form of rules of engagement (ROE) that military forces must follow in combat. Since international law does not address geoengineering as a security measure, could we build an international convention on climate manipulation technologies and construct the relevant ROEs from there? This is problematic for two reasons.

First, there would likely be resistance from the scientific community, which has argued for experimentation on the grounds that, should this be needed in an emergency, we would be unwise to deploy untested technology.[50] It is true that small-scale experiments may yield valuable local data on how particular technologies perform, but these results may not scale up to planetary level. If a larger-scale deployment were attempted under the guise of "experimentation," the data yielded might be more useful, but the risk to the ecosystem is proportionally greater. To this end, there would be no justifiable distinction between experimentation and actual use.

Second, the growing strain of nationalism in the world is pointing toward fewer treaties and less cooperation on global issues and signals a retreat from the liberal international order needed to make a geoengineering convention work. What we hope to achieve with this development of just geoengineering theory is to create a set of norms and customs that can be used to guide decision making by states and the international community in the absence of explicit international law.

Right now, climate change–related security threats are increasing, while mitigation and adaptation efforts are not keeping pace. Eventually, geoengineering (especially the three global commons methods discussed herein) will start to look like viable climate manipulation measures cloaked in national security. However, law and custom require states to keep environmental harm from negatively affecting other states, and these three methods of geoengineering offer no possibility of limiting effects to one country or region. These methods are indiscriminate, nonproportional, and possibly irreversible, and the global environmental stakes are too high for anything less than deliberate ethical decision making. Consequently, we offer these just geoengineering guidelines as essential to deployment.

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