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Geoengineering and Global Security: The Geopolitics of Unilateral Climate Intervention

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Abstract

Geoengineering, in particular solar radiation management (SRM), is receiving more attention as a possible reaction to global warming as the effects of climate change worsen. SRM proponents frequently present it as a quick, affordable, and technically possible way to slow down global warming. However, SRM presents significant ethical, political, and security issues; it is by no means a neutral or solely scientific answer. If it is implemented unilaterally by strong nations or non-state actors without international agreement, it has the potential to drastically alter international relations. This essay critically examines the hazards connected with unilateral geoengineering, noting how such interventions may destabilize current power systems, increase geopolitical rivalries, and generate new kinds of environmental and social inequity. It highlights how SRM could transform the climate catastrophe from an environmental issue into a geopolitical one where issues of legitimacy, control, and accountability are central by examining the connections between security studies, international law, and climate ethics. The study makes the case that geoengineering may make the problems it aims to solve worse rather than better if there is a lack of strong global governance, open decision-making, and fair participation of vulnerable countries. In order to guarantee that any future climate initiatives do not jeopardise global security or justice, the report concludes by urging immediate international discussion and the creation of legally binding frameworks.

Keywords: Geoengineering, Geopolitics, Global Security, Solar Radiation Management, Unilateral Climate Intervention.

Introduction:

The accelerating pace of climate change has generated an urgent need for innovative strategies to mitigate its environmental, social, and economic impacts. Despite international efforts, including agreements such as the Paris Accord, global progress in reducing greenhouse gas emissions and adapting to climate-related hazards remains uneven and slow. This gap between climate ambition and action has intensified interest in alternative approaches, notably geoengineering, which involves deliberate, large-scale interventions in the Earth's climate system to counteract warming.

Among geoengineering techniques, Solar Radiation Management (SRM) has emerged as a particularly prominent, though still largely theoretical, option. SRM seeks to reflect a fraction of incoming solar radiation back into space through methods such as stratospheric aerosol injection or marine cloud brightening, promising the potential for rapid global cooling. Advocates often highlight its perceived cost-effectiveness and its potential role as a complementary measure to traditional mitigation strategies.

However, SRM is far from a politically neutral or universally beneficial technological fix. Its deployment raises significant ethical, legal, and security concerns, particularly if undertaken unilaterally by a single state or a coalition of actors. In the absence of broad international consensus, such interventions could destabilize global power dynamics, exacerbate mistrust between nations, and deepen inequalities between the Global North and South. Consequently, what might initially appear as an environmental solution could quickly escalate into a geopolitical challenge.

This paper critically examines the risks and implications of unilateral SRM deployment, situating geoengineering within the broader debates of international security and global governance. Drawing on perspectives from climate ethics, international relations, and security studies, the study explores how SRM could alter power relations, trigger conflicts, and challenge global cooperation. By emphasizing the intersection of technology, power, and politics, this research aims to advance understanding of who controls the climate, under what authority, and with what consequences for global security.

Literature Review

Integrating an International Relations and Security Theory Lens

Since Solar Radiation Management (SRM) goes beyond a technical climate intervention to have the potential to be a tool of global power, understanding its geopolitics requires an integrated lens of international relations and security theory. The climate crisis could become a contested arena of sovereignty, legitimacy, and control over the global atmosphere if unilateral or coalition-based SRM efforts to stabilize local climates unintentionally endanger other states, leading to suspicion, countermeasures, or strategic competition, according to security dilemma theory. Concerns about environmental justice and postcolonial equity are raised by this lens's illumination of the ongoing power disparities between the Global North and Global South, where developed countries with superior technology control decision-making while developing nations most at risk from climate change and the negative effects of SRM are largely left out.

Thus, from the standpoint of critical security studies, SRM governance is a geopolitical and environmental dilemma that calls for a collective security strategy based on openness, fostering trust, and upholding international law. To reduce unilateral risks and integrate SRM into larger frameworks of international stability, collaboration, and justice, mechanisms including independent verification, transparent data exchange, and participatory multilateral decision-making are crucial. Concerns about environmental justice and postcolonial equity are raised by the continued widespread exclusion of poor nations that are most susceptible to the consequences of climate change and SRM.

Geoengineering and Solar Radiation Management (SRM): Geoengineering encompasses large-scale interventions in the Earth's climate system designed to counteract anthropogenic warming (Caldeira et al., 2013). SRM, a subset of geoengineering, involves reflecting solar radiation back into space using methods such as stratospheric aerosol injection or marine cloud brightening**,** with the goal of rapidly reducing global temperatures (Crutzen, 2006; Keith, 2000). While SRM promises fast climate mitigation effects, it remains highly theoretical, and the scientific community emphasizes substantial uncertainties regarding its regional climate impacts, including precipitation changes, monsoon disruption, and extreme weather events (Robock et al., 2008; Tilmes et al., 2018).

Geopolitical Risks of Unilateral Deployment: Several scholars argue that unilateral SRM deployment could destabilize international relations by creating security dilemmas among states (Victor et al., 2009; McMartin et al., 2014). The capacity for a single actor to alter global climate unilaterally raises concerns over interstate mistrust, geopolitical tensions, and potential conflicts**.** Scholars highlight those unequal impacts, especially between the Global North and Global South, may exacerbate existing inequalities and trigger debates on climate justice (Moreno-Cruz & Keith, 2013; Gardiner, 2013).

Governance and Ethical Considerations: Global governance frameworks for geoengineering are still nascent, and legal structures remain inadequate to regulate SRM deployment (Bodle, 2013). Ethical debates focus on moral hazard, accountability, and the legitimacy of decisions affecting populations worldwide. Without inclusive multilateral governance mechanisms, unilateral geoengineering may compromise both environmental and human security (Chhetri et al., 2020; Vaughan & Lenton, 2011).

Understanding Geoengineering and Solar Radiation Management:

Definition and Types of Geoengineering: Geoengineering refers to deliberate, large-scale interventions in the Earth's climate system intended to mitigate the impacts of anthropogenic climate change. Broadly, two categories are recognized. Carbon Dioxide Removal (CDR) encompasses techniques aimed at reducing atmospheric greenhouse gas concentrations, such as afforestation, direct air capture, or ocean fertilization. Solar Radiation Management (SRM)**,** by contrast, seeks to reduce the amount of incoming solar energy in order to cool the planet (Lackner, 2017, pp. 1201–1234).

Technical Overview of SRM Methods: A variety of SRM methods have been proposed. The most prominent is stratospheric aerosol injection (SAI)**,** which involves dispersing reflective particles commonly sulfur-based aerosols into the stratosphere to increase Earth's albedo. Another approach, marine cloud brightening (MCB)**,** aims to enhance the reflectivity of low-lying clouds by spraying seawater droplets into the atmosphere. More speculative proposals include space-based techniques, such as deploying orbital mirrors to deflect a portion of incoming solar radiation (Lackner, 2017, pp. 1201–1234).

The Appeal and Controversy of SRM as a "Quick Fix"

Solar Radiation Management (SRM) attracts attention for its potential to deliver rapid cooling effects compared with the slower outcomes of emission reductions or carbon dioxide removal (CDR) methods. This perception of a "quick fix" has positioned SRM as an alluring but contentious climate intervention. Yet, its risks and uncertainties remain considerable. Projected side effects include uneven regional impacts such as altered rainfall patterns, monsoon disturbances, and ecological disruptions alongside the danger of a termination shock**,** a sudden rebound in global temperatures if SRM were abruptly discontinued.

Beyond technical uncertainties, SRM poses complex governance and ethical challenges. Methods like Stratospheric Aerosol Injection (SAI**)** could, in principle, be deployed unilaterally by a single state or coalition, circumventing global consensus. Such possibilities raise difficult questions about decision-making legitimacy, accountability for unintended harm, and the mediation of conflicting interests (Gardiner & McKinnon, 2018, pp. 557–563).

While this paper argues against unilateral SRM due to its geopolitical and ethical risks, it also acknowledges counterviews that merit attention. Some scholars contend that SRM might serve as a temporary emergency tool under extreme climate scenarios, while others propose controlled, cooperative experimental governance under strict international oversight. Recognizing these perspectives broadens the discussion, framing SRM as not merely a technological solution but a deeply political and ethical challenge requiring inclusive, transparent, and globally coordinated governance.

Methodology

This study adopts a qualitative, interpretive research approach to examine the geopolitical risks of unilateral SRM deployment. A desk-based, secondary data review forms the core methodology, drawing on peer-reviewed journal articles, climate policy documents, reports from international organizations (IPCC, UNEP), and relevant case studies.

Data Collection

This study employs a qualitative, desk-based research approach that synthesizes data from multiple secondary sources to explore the governance, ethical, and geopolitical dimensions of solar radiation management (SRM) within the broader context of geoengineering.

Literature Sources: Peer-reviewed scientific research, policy evaluations, and institutional reports on geoengineering, SRM technologies, and global climate governance were the main sources of the data. Because they offer reliable and pertinent information for policy, special attention was paid to publications from international organisations including the United Nations Environment Programme (UNEP) and the Intergovernmental Panel on Climate Change (IPCC).

Case Selection and Justification: Bangladesh and South Asia in particular were specifically chosen as priority locations because of their dense populations, monsoon-dependent economies, and high climate sensitivity. They are particularly vulnerable to the dangers and possible repercussions of geoengineering activities because of these considerations. As climate modelling studies increasingly emphasise South Asia's susceptibility to SRM-induced changes in precipitation and temperature patterns, the example selection also fits with regional importance.

Case Study Sources: Existing climate modelling studies, regional evaluations, and published literature analyzing the anticipated effects of SRM on rainfall, agriculture, and socioeconomic stability in Bangladesh and South Asia were used to gather empirical data.

Policy Documents: The study also examined national climate programs, international agreements, and United Nations resolutions that mention or control geoengineering research and use. These include frameworks established by the Convention on Biological Diversity and the UNFCCC, which influence the worldwide conversation about the ethical supervision and governance of climate initiatives.

Analytical Framework

The analysis adopts an interdisciplinary approach, combining insights from climate science, international relations, and ethics and governance studies to provide a comprehensive understanding of Solar Radiation Management (SRM):

Climate science: The study focusses on uncertainties, trade-offs, and the intricate environmental effects of large-scale interventions as it investigates the mechanisms of SRM and assesses their possible effects on regional climates.

International relations theory: It highlights the geopolitical complexity of climate interventions by examining how SRM activities may lead to security quandaries and perpetuate power imbalances between nations, especially between actors in the Global North and Global South.

Ethics and governance studies: Used to evaluate issues with moral hazard, the validity of decision-making procedures, and the difficulties in creating just and responsible governance systems.

The study places these insights within specific theoretical frameworks, such as environmental justice approaches, Global South perspectives, and security dilemma theory, to increase analytical depth. A thorough evaluation of the hazards, governance issues, and wider social ramifications of SRM is made possible by this methodical methodology, which offers a cogent prism through which to view its scientific, political, and ethical aspects.

Data Analysis

The study adopts a structured analytical approach to explore the multifaceted dimensions of Solar Radiation Management (SRM).

- **Thematic Analysis:** it identifies recurring patterns and key issues, including potential SRM-related risks, geopolitical implications, governance gaps, and ethical considerations, providing a foundation for understanding the complex challenges involved.
- **Comparative Analysis:** It is conducted to evaluate how SRM impacts may differ across regions, with particular attention to disparities between the Global North and Global South, supported by illustrative examples from Bangladesh.
- **Synthesis:** A synthesis of the findings is undertaken to generate policy-relevant recommendations, aimed at strengthening governance frameworks and promoting coordinated global responses to SRM initiatives. This integrated approach ensures that the study not only highlights critical risks and ethical concerns but also informs actionable strategies for equitable and effective governance.

Case Examples: Monsoon & Regional Impacts

1. **Southeast Asia: SRM's Heterogeneous Effects on Monsoonal Precipitation** A study using GLENS (Geoengineering Large Ensemble) simulations finds that SRM induces highly spatially varied precipitation responses across Southeast Asia. In some areas (parts of Indonesia), rainfall frequency increases; in others (Vietnam, Thailand, Philippines) the number of wet days decreases and dry spells are prolonged. The effects vary by season and subregion, with important implications for flood and drought risk.
2. **Kelantan River Basin, Malaysia: SRM and Flood-/Dry-Season Trade-offs** Researchers modeled the hydro-climatic impacts of SRM for the Kelantan River Basin (a region strongly influenced by monsoonal rainfall). Under SRM, projections show reduced precipitation and lower streamflow during the flood season (November to mid-January)

relative to a high-emissions (RCP8.5) scenario. However, during the dry season (February to May), precipitation also decreases, which may exacerbate water scarcity despite reducing flood risk.

3. **South Asian Monsoon Responses under CO_2 Removal / Forcing Scenarios** While not an SRM case per se, experiments with CO_2 ramp-up/down (and related ocean/sea surface temperature changes) show that the South Asian Summer Monsoon (SASM) can exhibit asymmetric precipitation responses**.** When CO_2 levels are reduced, rainfall tends to overshoot or depart from baseline patterns in ways that weaken monsoonal circulation, reduce moisture transport, or shift rainfall distributions. This suggests how interventions altering global radiative forcing (including SRM) could destabilize monsoon rainfall.

Case Studies in South Asia / Bangladesh

1. **Risks of seasonal extreme rainfall events in Bangladesh under 1.5 and 2.0 °C warmer worlds how anthropogenic aerosols change the story** (HESS, 2022) This paper finds that increasing temperatures (1.5-2.0°C above pre-industrial) are projected to increase both mean and extreme rainfall during pre-monsoon and monsoon seasons in Bangladesh compared to current (actual) conditions. The study also shows that anthropogenic aerosols dampen rainfall: in certain subregions (northern Bangladesh), aerosols reduce daily rainfall by up to ~5-10% during the monsoon season.

   Relevance to SRM risk: SRM via aerosol injection might act similarly to anthropogenic aerosols in altering rainfall patterns. This suggests that SRM could reduce rainfall in some areas, possibly intensifying dry spells or causing localized water shortages.

2. **Impact of Climate Change on Precipitation and Temperature Changes in the Northwest Region of Bangladesh Using SDSM** (Journal of Engineering Science, 2023/2024)

   Using statistical downscaling with two different GCMs (CanESM2, HadCM3), this study projects decreases in annual precipitation (by ~4–12% depending on scenario and time horizon) in northwest Bangladesh under high emission scenarios, coupled with increasing temperatures.

   Relevance to SRM risk: If SRM reduces incoming solar radiation, it might offset some warming, but could also suppress precipitation further in regions already projected to have less rainfall, worsening water resource stress.

Discussion

Ensuring the safe and equitable governance of Solar Radiation Management (SRM) requires clear enforcement and cooperation frameworks grounded in international law and collective security principles. A legally binding global treaty supported by transparent verification and monitoring systems could help prevent unilateral deployment and strengthen accountability. Establishing an inclusive Global Climate Intervention Council (GCIC) under UN oversight would foster collaboration between the Global North and South, ensuring shared decision-making and risk evaluation. Drawing on collective security theory, such mechanisms would function similarly to arms-control regimes by promoting transparency, building trust, and deterring unilateral actions. Through coordinated enforcement and cooperative governance, SRM can be managed as a collective responsibility rather than a geopolitical contest, thereby safeguarding both global security and climate justice.

Inferred Implications & Risks for SRM Unilateral Deployment in Bangladesh

From these studies, several risk implications for Bangladesh emerge if SRM were unilaterally deployed by others, or even domestically, without detailed regional modeling or governance:

- **Spatially uneven rainfall changes**: Some areas (north, northwest) already face declining precipitation under warming; SRM may further alter rainfall distribution, possibly reducing or delaying rains in some regions even if average global temperature decline.
- **Extreme event modulation**: Changes in aerosol loading or forcing could change intensity and frequency of heavy rainfall events (flash floods) or extreme rains in monsoon periods. SRM could reduce or shift extreme rainfall patterns, but unpredictably.
- **Water availability & agriculture stress**: Declining rainfall or shifts in monsoon onset / withdrawal could harm agriculture, groundwater recharge, and livelihoods in the delta (Bangladesh is highly sensitive due to its large population depending on consistent rainfall).
- **Potential for unintended side effects**: Even with global benefits (temperature lowering), regional side effects could include weakened monsoon systems, disruption of critical seasonal rainfall averages, or amplified droughts in some subregions.

Unilateral Climate Intervention: Concept and Risks

What Constitutes Unilateral Action in Geoengineering

Unilateral climate intervention refers to the deliberate deployment of geoengineering technologies particularly Solar Radiation Management (SRM) by a single state, private entity, or coalition without broad international consensus or governance. Unlike multilateral climate action frameworks (e.g., the Paris Agreement), unilateral action bypasses global negotiation and oversight, enabling one actor to impose climate modifications with transboundary consequences. The concern lies not only in the technical feasibility of unilateral deployment (especially of stratospheric aerosol injection, which could be relatively low-cost and rapidly scalable) but also in the political legitimacy of such actions.

Unilateral vs Multilateral Geoengineering Pathways

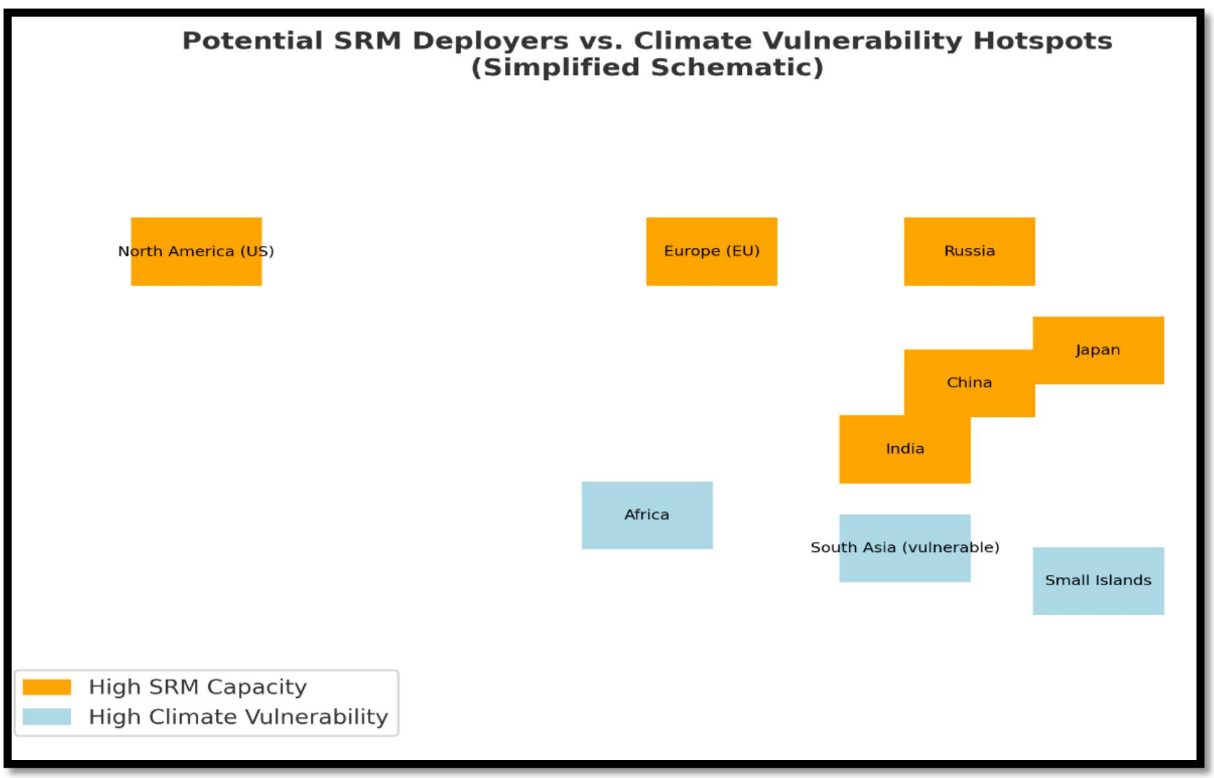
Unilateral Action	Multilateral Action
↓	↓
Actor (State/ Private/ Consortium)	Global Agreements (UNFCCC, Paris, CBD)
↓	↓
SRM Deployment	Negotiated Oversight
↓	↓
Transboundary Impacts	Shared Risk Management
↓	
Governance Void & Risks	

Comments on Flowchart: Shows contrast between unilateral and multilateral pathways. Highlights risks (red) vs shared governance (green). Useful for illustrating governance dilemmas.

Historical Analogies for Unilateral Climate Intervention

1945	1967-1970	2009-2010	2020
First Nuclear Weapons Use	Nuclear proliferation Treaty	Crutzen processes SRM & National Research Programs	UN & CBD Governance Debates

Comments on Timeline: Draws parallels with nuclear proliferation and space militarization. Places SRM debates in historical context of governance challenges. Demonstrates acceleration of geoengineering discourse post-2000.



Comments on Map: Orange shows countries with high SRM deployment capacity. Blue shows regions with highest vulnerability to climate change. Highlights mismatch between deployers and those most at risk.

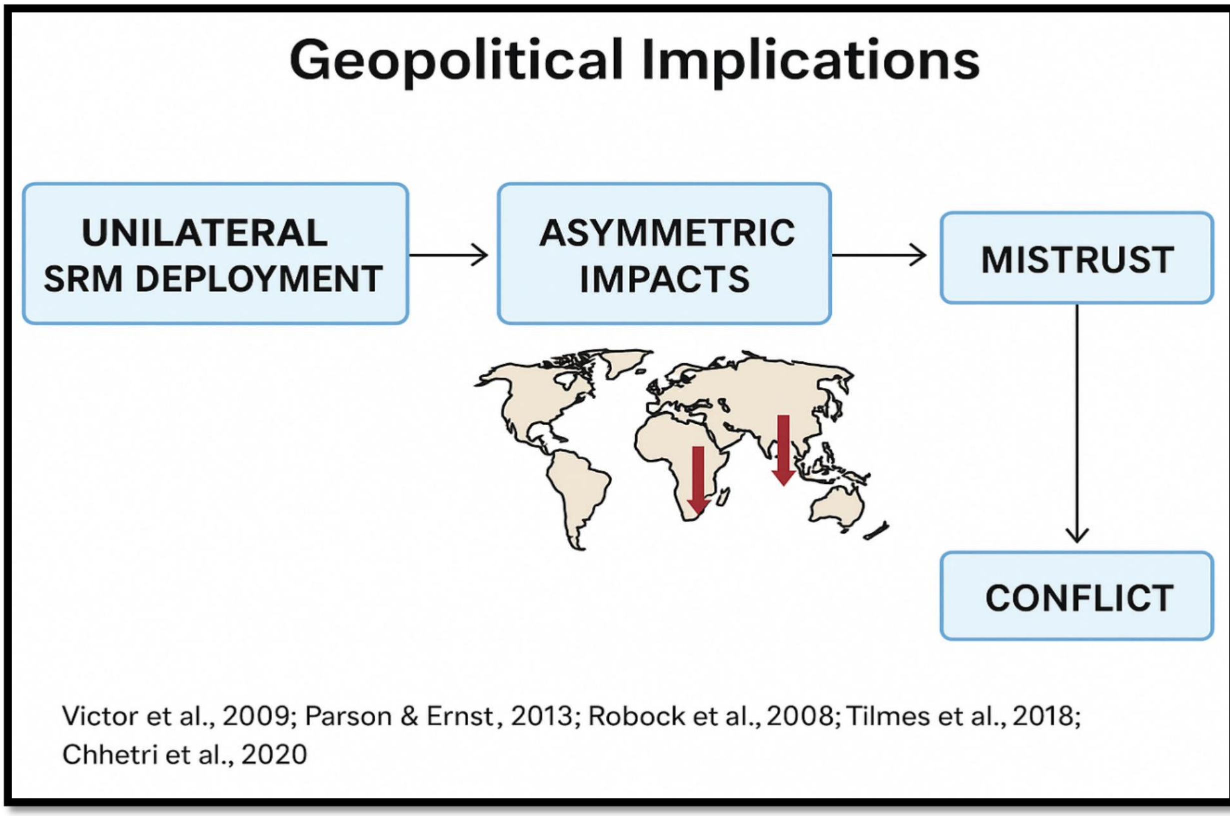
Geopolitical Implications

The prospect of unilateral Solar Radiation Management (SRM) raises complex geopolitical challenges that go far beyond its technical feasibility. At the core of these challenges lies a series of interrelated security, power, and justice concerns.

Security dilemmas: mistrust, retaliation, and escalation risks. Unilateral SRM deployment could trigger a classic security dilemma in international relations. If a state or coalition deploys SRM without broad consent, others may interpret the intervention as an act of environmental manipulation serving national interests rather than global welfare. This mistrust could foster retaliation in the form of counter-geoengineering efforts, cyber sabotage of delivery systems, or diplomatic and economic sanctions. Over time, such dynamics may escalate tensions, increasing the likelihood of geopolitical conflict rather than cooperation (Victor et al., 2009; Parson & Ernst, 2013).

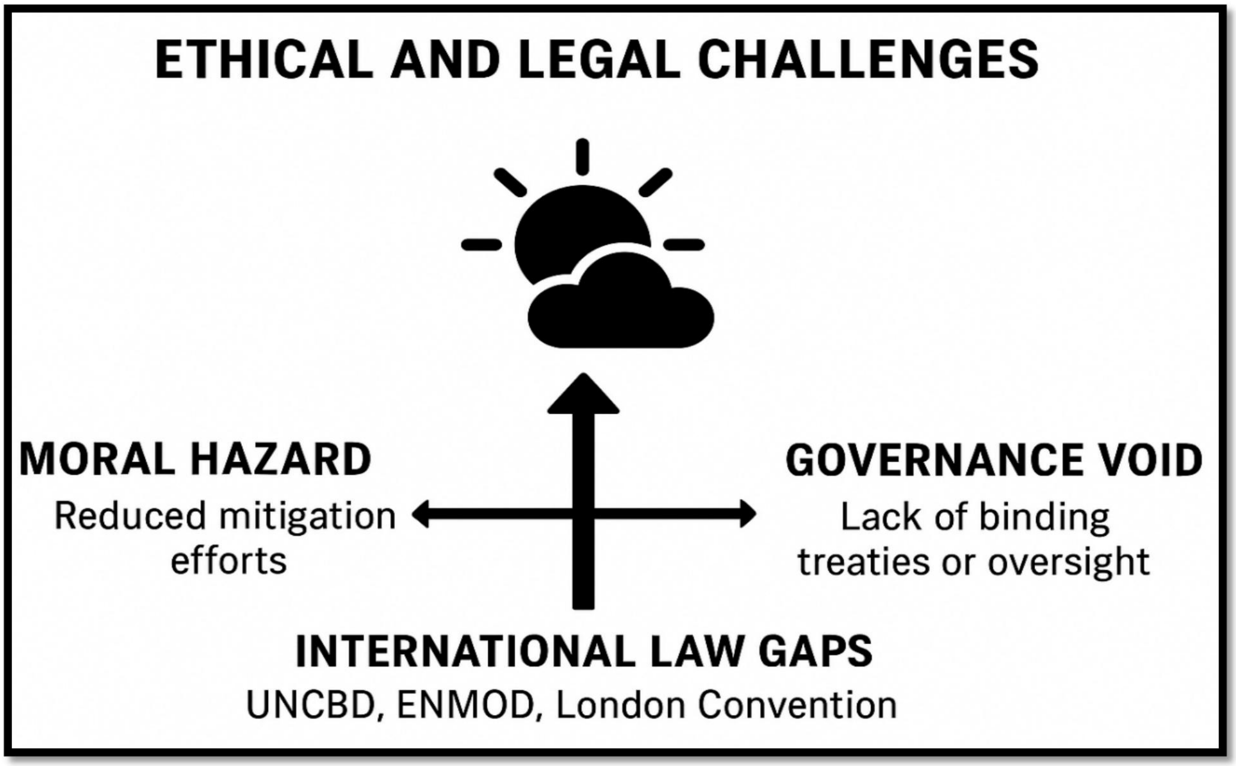
Global power asymmetries: who benefits and who bears the costs. Geoengineering interventions such as SRM are not globally uniform in their effects. Climate models indicate that while some regions may experience cooling or reduced extreme weather, others may face disruptions to precipitation patterns or monsoon systems (Robock et al., 2008; Tilmes et al., 2018). These uneven outcomes create a profound asymmetry: technologically advanced states with the capacity to deploy SRM may secure domestic benefits while externalizing risks to vulnerable regions. This raises questions of accountability, legitimacy, and compensation, especially when the affected populations have no voice in the decision-making process.

Impacts on the Global South vs. Global North (environmental justice dimension). The justice dimension of geoengineering is particularly salient for the Global South. Many countries in Africa, Asia, and Latin America, including Bangladesh, are acutely vulnerable to climate change yet have contributed least to cumulative greenhouse gas emissions. Unilateral SRM by major powers could alter monsoon rainfall, agricultural productivity, and water security in these regions, amplifying existing inequalities (Chhetri et al., 2020). Without an inclusive governance framework, SRM risks reproducing colonial patterns of environmental control—where powerful actors shape planetary conditions while marginalized communities shoulder the unintended consequences. This makes transparent decision-making, equitable participation, and multilateral oversight essential to prevent SRM from becoming a new instrument of geopolitical domination.



Comment on the Map: The map illustrates the geopolitical cascade that could emerge from unilateral Solar Radiation Management (SRM) deployment. Beginning with the unilateral action on the left, the diagram shows how SRM could produce asymmetric impacts across the globe. The world map highlights particularly vulnerable regions in the Global South such as South Asia and Sub-Saharan Africa where model projections suggest SRM might disrupt monsoon rainfall, agricultural systems, and water security (Robock et al., 2008; Tilmes et al., 2018). These uneven outcomes can generate mistrust among states, especially between those benefiting from SRM and those harmed by its side effects. This mistrust, in turn, increases the risk of conflict escalation, ranging from diplomatic tensions and sanctions to retaliatory counter-geoengineering measures (Victor et al., 2009; Parson & Ernst, 2013; Chhetri et al., 2020). By visually linking SRM deployment to geopolitical instability, the figure underscores the central argument of the article: that geoengineering, without robust international governance, risks shifting the climate crisis into a security and justice crisis**.**

Ethical and Legal Challenges



The figure summarizes the three main ethical and legal challenges associated with Solar Radiation Management (SRM):

1. **Moral Hazard Reduced Mitigation Efforts** SRM's perceived ability to rapidly cool the planet could reduce political and societal pressure to cut greenhouse gas emissions. This "moral hazard" means governments or corporations may rely on geoengineering as a substitute for decarbonization rather than a complement (Lin, 2013; Gardiner, 2010).

2. **International Law Gaps UNCBD, ENMOD, and London Convention** Current international law offers only fragmented coverage of geoengineering. The United Nations Convention on Biological Diversity (UNCBD) has issued non-binding decisions discouraging large-scale SRM. The Environmental Modification (ENMOD) Convention prohibits hostile environmental modification but is limited to military use. The London Convention/Protocol restricts ocean dumping but does not fully regulate stratospheric or atmospheric interventions (Bodle, 2013). This legal patchwork creates loopholes for unilateral actions.
3. **Governance Void Lack of Binding Treaties or Oversight** No comprehensive, binding international framework exists to govern SRM research, testing, or deployment. Without multilateral oversight, powerful actors could deploy SRM without global consent, risking environmental injustice and international conflict (Chhetri et al., 2020; Nicholson et al., 2018).

Towards Global Governance of Geoengineering

As geoengineering particularly Solar Radiation Management (SRM) gains visibility in global climate discourse, the urgent need for an inclusive, transparent, and binding governance framework becomes evident. Without such mechanisms, unilateral interventions risk exacerbating inequalities and destabilizing international relations. Three key aspects define this emerging governance agenda.

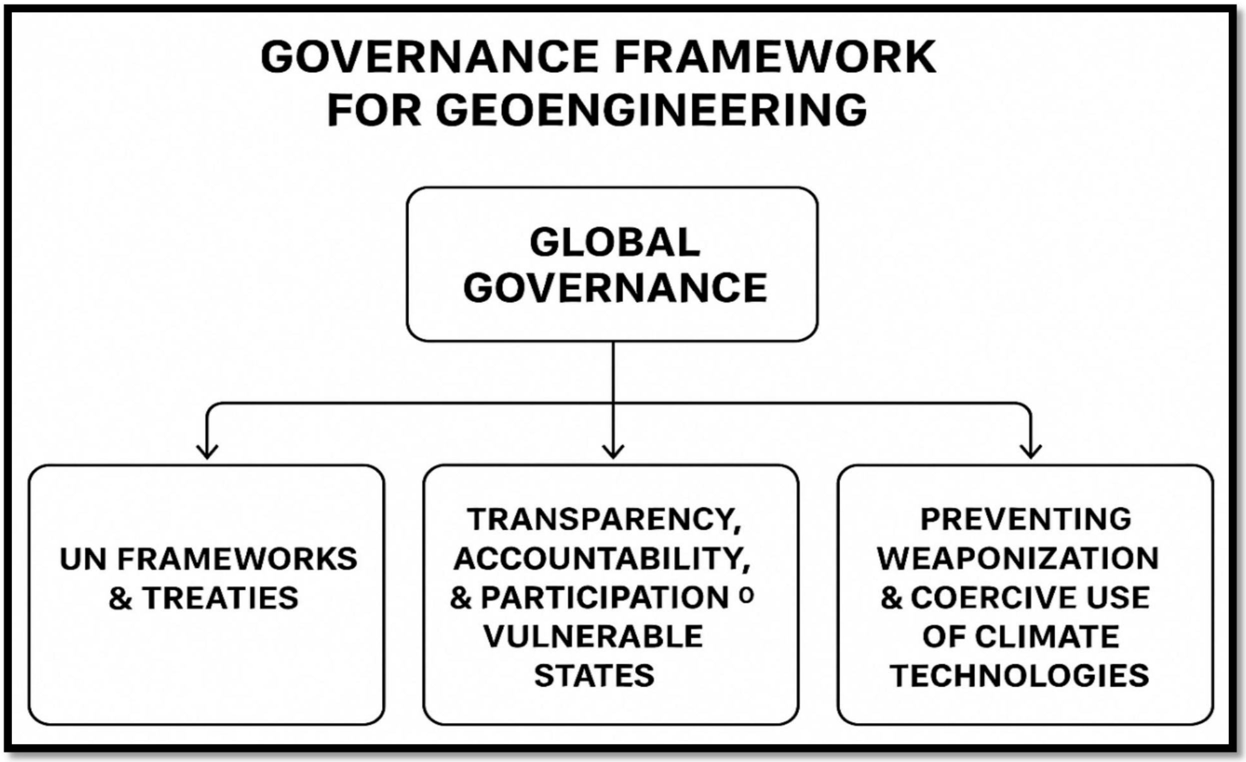
Proposals for Multilateral Regulation (UN Frameworks and Treaties). Scholars and policymakers have proposed embedding geoengineering governance within existing UN structures, such as the United Nations Framework Convention on Climate Change

(UNFCCC), the United Nations Convention on Biological Diversity (UNCBD), and the Environmental Modification (ENMOD) Convention (Bodle, 2013). Others advocate for a dedicated international treaty on geoengineering that would set clear norms for research, testing, and deployment. Such a treaty could define permissible activities, ensure environmental and social impact assessments, and provide mechanisms for dispute resolution (Chhetri et al., 2020).

Transparency, Accountability, and Participation of Vulnerable States. A legitimate governance system must include meaningful participation by vulnerable states, especially those in the Global South that are most likely to experience disproportionate impacts from SRM. Transparency in research funding, experimental results, and decision-making processes would help build trust and prevent perceptions of “climate colonialism” (Jinnah & Nicholson, 2019). Accountability mechanisms such as independent oversight bodies or reporting requirements would further ensure that powerful actors do not dominate the agenda.

Preventing Weaponization or Coercive Use of Climate Technologies. Finally, any global governance framework must explicitly address the risk of weaponization. While ENMOD prohibits hostile environmental modification for military purposes, its scope does not clearly extend to non-military but coercive uses of geoengineering. A comprehensive treaty could reaffirm non-weaponization principles, prohibit coercive climate interventions, and establish sanctions for violations, thereby reducing the risk that geoengineering becomes an instrument of geopolitical leverage (Parson & Ernst, 2013).

By institutionalizing multilateral oversight, equitable participation, and explicit non-weaponization commitments, global governance of geoengineering can move from a fragmented, voluntary regime toward a robust system capable of safeguarding both environmental and human security.



While governance solutions for SRM have been outlined, effective implementation ultimately depends on robust enforcement and compliance mechanisms**.** To ensure accountability, international frameworks must establish transparent verification systems capable of monitoring SRM activities, detecting unauthorized interventions, and assessing environmental outcomes in real time. Equally important is the development of trust-building measures among nations, particularly between the Global North and Global South, to prevent geopolitical mistrust and unilateral action. This could include the creation of an independent international oversight body, periodic reporting obligations, and participatory decision-making processes that enhance legitimacy and mutual confidence. Strengthening these enforcement and verification structures would not only reinforce compliance but also promote equitable and cooperative global governance of SRM technologies.

Findings

This study highlights that while geoengineering particularly Solar Radiation Management (SRM) is often framed as a rapid and cost-effective means of addressing global warming, its potential deployment carries profound ethical, legal, and geopolitical risks. The findings reveal four interlinked challenges:

1. **Security Dilemmas**: Unilateral SRM interventions risk generating mistrust among states, prompting retaliation, escalation, or counter-geoengineering measures.
2. **Global Power Asymmetries**: The uneven distribution of benefits and harms between the Global North and South reinforces existing inequalities and undermines environmental justice.
3. **Ethical and Legal Gaps**: Moral hazards (e.g., reduced mitigation efforts), unclear international legal obligations under existing frameworks (UNCBD, ENMOD, London Convention), and an absence of binding governance structures create a regulatory vacuum.
4. **Governance Deficit**: Without multilateral agreements, transparency, and inclusive participation, geoengineering could shift the climate crisis into a geopolitical crisis.

Collectively, these findings underscore that geoengineering is not merely a technical issue but a profound political and ethical challenge that could reshape global security architectures.

Recommendations

1. **Establish a UN-Based Governance Framework**: Develop a binding treaty or protocol under the United Nations (e.g., UNFCCC or a dedicated body) to regulate geoengineering research, testing, and deployment.
2. **Enhance Transparency and Participation**: Require mandatory disclosure of all SRM-related experiments, and ensure meaningful representation of vulnerable states particularly from the Global South in decision-making processes.
3. **Strengthen International Legal Instruments**: Expand or adapt existing agreements (UNCBD, ENMOD, London Convention) to explicitly address SRM, clarify state responsibilities, and prevent harmful transboundary effects.
4. **Prevent Weaponization and Coercive Use**: Establish international monitoring mechanisms to prevent the misuse of geoengineering technologies for strategic or military advantage.
5. **Integrate Geoengineering into Broader Climate Policy**: Treat SRM as a complement not a substitute to mitigation and adaptation, and prioritize rapid emissions reductions to avoid moral hazards.

Conclusion

Geoengineering, particularly Solar Radiation Management (SRM), represents one of the most controversial and consequential frontiers in global climate policy. While often presented as a rapid and cost-effective response to escalating climate risks, this paper shows that unilateral SRM deployment would carry profound risks, including security dilemmas, destabilized power relations, environmental injustice, and a shift of the climate crisis into a geopolitical crisis. The geopolitical stakes of geoengineering are therefore inseparable from its technical feasibility.

Given these challenges, there is an urgent need for international dialogue and cooperative governance**.** Existing legal frameworks including the UN Convention on Biological Diversity (UNCBD), the ENMOD Convention, and the London Convention are fragmented and insufficient to address the scope of SRM. A robust, binding, and transparent multilateral framework under the United Nations or a new dedicated treaty is essential to ensure that geoengineering does not become an instrument of coercion, conflict, or climate colonialism. Equally important is the meaningful participation of vulnerable states and communities in shaping the rules of governance, thereby ensuring environmental justice and preventing the weaponization of climate technologies.

Finally, future research should deepen our understanding of SRM's regional and transboundary impacts, the ethical trade-offs of its deployment, and the political mechanisms needed to manage its risks. Interdisciplinary studies bridging climate science, international relations, and security studies are crucial to anticipate unintended consequences and to craft equitable and effective governance mechanisms. By advancing these lines of inquiry, the global community can ensure that geoengineering debates move from speculation to responsible and cooperative policy action.

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