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Geoengineering Revisited in the Shadow of Climate Crisis and Technocratic Control

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ABSTRACT. Ten years after the publication of *The Ethics of Geoengineering: Perspectives from Romania*, I revisit the ethical and epistemological questions surrounding climate intervention technologies. In the meantime, geoengineering has moved from being a speculative concept to becoming a central element in climate policy discussions. I argue that this shift has not been driven by transparent public debate or broad scientific consensus. Rather, it results from a deeper process of normalization that increasingly portrays techniques like Solar Radiation Management as rational and even necessary responses to the climate crisis. This framing is rooted in a technocratic worldview that prioritizes control, modeling, and predictive planning, often at the expense of ethical inquiry, democratic engagement, and respect for ecological complexity. I believe that the dominant assumptions shaping geoengineering foster a vision of governance where preparedness is mistaken for legitimacy, and responsibility is reduced to procedural compliance. As a result, critical questions about authority, knowledge systems, and the future we choose to pursue are frequently marginalized or deferred. In response, I advocate for a different ethical framework, one that emphasizes epistemic humility, justice across generations, inclusive co-design, and recognition of multiple ways of understanding the world. Geoengineering, in my view, is not a neutral technological fix but a manifestation of modernity's drive to impose order in response to planetary uncertainty. An adequate ethical approach must go beyond measurements and institutional procedures to question the kind of planetary future we are creating, whose voices are included, and which values guide our decisions in times of crisis.

Keywords: geoengineering, environmental ethics, intergenerational justice, procedural ethics, moral responsibility.

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1. A Decade Later- Rethinking the Ethics of Climate Intervention

It has now been a decade since I published *The Ethics of Geoengineering: Perspectives from Romania* (2015)[2], one of the first theoretical reflections on geoengineering from the perspective of environmental ethics to emerge within the Romanian scholarly context. At the time, geoengineering remained largely embedded within the speculative domains of climate modeling and technoscientific anticipation, occupying a conceptual space suspended between hypothetical necessity and institutional hesitation. My intellectual curiosity around this topic was not only shaped by philosophical concerns, but was also deeply sustained by the emergence of the first serious warnings regarding the alarming trajectories of the global climate, warnings that, even then, were more than abstract projections. They pointed toward risks that, far from being speculative, are now unfolding as concrete realities that impact societies across the planet. From the outset, my interest extended beyond assessing the technical feasibility of intervening in Earth systems, and focused instead on the underlying epistemic and moral assumptions that drive the very impulse to intervene. This impulse is far from ideologically neutral; it reflects a worldview in which ecological complexity is treated as governable, planetary fragility is rendered operational, and the Earth is interpreted primarily through the lens of models, protocols, and risk-managed possible futures. Seen through this lens, geoengineering appears not merely as a proposed response to climate change, but as a cultural expression of modernity's enduring aspiration for planetary control, an aspiration that conflates governance with mastery and transforms crisis into a design challenge to be engineered rather than a condition to be ethically confronted.

Over the past ten years, ideas that were once considered marginal or even controversial have slowly moved to the very core of climate policy. This shift did not happen because of major scientific discoveries or because people reached broad democratic agreement, but rather through a gradual change in how we talk and think about geoengineering. As Bellamy and Healey (2018) explain, this process, called "discursive normalization", has made previously unthinkable solutions seem more acceptable.[3] The way we speak about large-scale interventions in the climate has moved away from a cautious, ethics-focused language and toward a more practical, action-oriented one. Solar Radiation Management (hereafter referred to as SRM), in particular, has returned to public discussions under the more neutral

[2] Simion, Radu. 2015. "The Ethics of Geoengineering: Perspectives from Romania." *Annals of the University of Bucharest – Philosophy Series* 64 (2): 27–43.

[3] Bellamy, Rob, and Justin Healey. 2018. "Slippery Slopes and Steep Cliffs: Intervention Intensity, Decision-Making Heuristics and Moral Judgements of Climate Engineering." *Global Environmental Change* 49: 10–18.

label of "climate emergency response." It is now often presented as a temporary safety measure, something that could help buy time while we struggle to reduce emissions through other means.[4] But this new framing is not just a change in vocabulary; it shapes how SRM is perceived, making it seem like a logical and even necessary tool in the larger system of climate planning. At the center of this shift lies something deeper: a change in how we understand the role of these technologies. Even though SRM and similar ideas have not progressed enough to be implemented in the real world, they have become more "real" in another sense- through their constant presence in climate models, future scenarios, and strategic policy documents. These imagined futures give the technologies a kind of unofficial legitimacy, positioning them as tools of early planning that can guide decisions before they even exist. As Dannenberg and Zitzelsberger point out, even experts in climate science are more likely to support geoengineering when they feel personally threatened by climate risks.[5] This suggests that the language of emergency does not solve ethical doubts; it simply shifts the conversation so that quick action feels more acceptable, regardless of unresolved moral questions. When urgency takes over, ethical reflection often gets pushed aside. What once seemed morally unacceptable can quickly become politically reasonable, not because it is safer or fairer, but because our range of choices has been narrowed to whatever seems technically possible.

Behind the calm and calculated tone of today's technocratic approach to geoengineering lies a far more complicated moral landscape, one where fundamental questions about legitimacy, responsibility, and global ethics are increasingly marginalized in favor of technical thinking and procedural planning. In earlier debates, the focus was on whether it is morally acceptable to interfere with the Earth's climate at all, and whether such actions could violate the integrity of natural systems or undermine the principles of environmental justice. Today, however, these deeper ethical concerns are often set aside, replaced by discussions about how to manage risk, build regulatory systems, and prepare for future implementation. The debate has shifted from ethics to technical policy-making, where scenarios for deploying these technologies are based more on probability models than on public dialogue or democratic reflection (Bellamy and Healey 2018).[6]

This shift in how we talk and think about geoengineering is not just an abstract change in academic language. It is closely tied to new strategies that deliberately reduce public criticism. As Low, Sovacool, and Baum (2022) explain, geoengineering

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[4] Dannenberg, Astrid, and Sonja Zitzelsberger. 2019. "Climate Experts' Views on Geoengineering Depend on Their Beliefs About Climate Change Impacts." *Nature Climate Change* 9 (10): 745–749.

[5] *Ibid*., 747.

[6] Bellamy, Rob, and Justin Healey. 2018. "Slippery Slopes and Steep Cliffs: Intervention Intensity, Decision-Making Heuristics and Moral Judgements of Climate Engineering.", 14-15.

is now often wrapped in what they call "soft camouflage", a set of tactics that include labeling research as harmless "basic science," presenting SRM trials as purely exploratory, or avoiding politically sensitive terms like "geoengineering" altogether.[7] These moves are not accidental or neutral. They reflect a deeper effort to remove politics from the picture, separating scientific research from its real-world consequences and postponing serious ethical discussions until the moment of actual deployment, by which time it may be too late. This strategy has had another important effect: it has moved the debate over ethics away from public spaces into closed, expert-dominated circles. This trend can lead to a conceptual box, where only certain ways of thinking, especially those focused on cost-benefit analysis or managing climate risks, are seen as valid. At the same time, the number and diversity of people who have a say in shaping the future of geoengineering remains limited, often excluding those communities that are most vulnerable to its ecological and political consequences.

Even though the public debate around geoengineering has become narrower and more expert-driven, public opinion remains deeply divided. Technologies like carbon dioxide removal are often presented in a positive light, as tools that can strengthen existing efforts to reduce emissions. In contrast, SRM continues to raise serious doubts among many people. Studies show that SRM is commonly associated with interfering in natural systems, creating risks of moral irresponsibility, and deepening global inequalities, not just in terms of who is exposed to harm, but also in who gets to decide.[8] These concerns are not simply the result of a lack of scientific knowledge. Rather, they express a deeper ethical position, one that rejects the idea of treating the Earth as a giant experiment, especially when decisions are made without real public participation. As Cox, Pidgeon, and Capstick (2018) have shown, how people view geoengineering has less to do with technical facts and more to do with their values: how they see nature, how they understand political responsibility, and how they relate to future generations.[9] This challenges the common assumption in science communication that opposition comes from ignorance. Instead, what we see is that public responses are shaped by broader concerns about fairness, power, and historical injustice. People are not just asking

[7] Low, Sean, Chad M. Baum, and Benjamin K. Sovacool. 2022. "Rethinking Net-Zero Systems, Spaces, and Societies: 'Hard' versus 'Soft' Alternatives for Nature-Based and Engineered Carbon Removal." *Global Environmental Change* 75: 8.

[8] Mahajan, Ashwin, Dustin Tingley, and Gernot Wagner. 2019. "Beliefs about Climate Beliefs: The Importance of Second-Order Opinions for Climate Politics." *British Journal of Political Science* 49 (3): 1279–1307.

[9] Cox, Emily, Nick Pidgeon, and Stuart Capstick. 2018. "Public Perceptions of Carbon Dioxide Removal in the United States and the United Kingdom." *Nature Climate Change* 8 (11): 928–936.

whether these technologies work; they're asking who benefits, who decides, and what kind of future is being built.

Despite this, the ways in which the public is included in geoengineering decisions are still limited and often superficial. Many current engagement efforts are designed more to build support than to allow for real debate. They often assume that geoengineering is inevitable, leaving little room for alternative ideas, such as focusing on reducing consumption, restoring ecosystems, or changing political and economic systems.[10] Public input in these cases is often treated as a tool for communication or institutional approval, rather than as a meaningful opportunity to shape or challenge the direction of climate action. Because of these dynamics, geoengineering remains caught in a state of confusion in terms of knowledge and political direction. It exists in a space where action is increasingly encouraged without clear public agreement, and where new technologies are developed without strong democratic legitimacy. From an ethical perspective, this is a troubling situation. What may appear to be a logical and forward-thinking path of technological development is, in reality, filled with deep unresolved tensions- both about how we understand the world and about the values we choose to prioritize. Geoengineering is not unfolding as a clearly defined project with specific goals and transparent rules, but rather, as Mike Hulme (2014) describes, as a *technopolitical imaginary*, a kind of speculative framework where possible planetary futures are imagined, rehearsed, and governed in advance, through simulations, institutional routines, and infrastructure planning.[11]

The status of geoengineering remains fundamentally unstable. These technologies are not fully real, yet they are no longer entirely imaginary either. They occupy a strange in-between space, a kind of exception zone, where the usual standards of caution, responsibility, and democratic oversight are set aside in favor of experimental thinking and governance through imagined scenarios. In this space, ethical questions are not directly answered but rather replaced by simulations and technical modeling. This leads to a culture of governance where ethical reflection is not absent, but becomes secondary, less about moral debate and more about managing uncertainty, which makes it harder to truly challenge or rethink the direction we're heading. For these reasons, this article suggests that geoengineering should not be viewed as just another technological option on the table. Instead, it should be seen as a symptom of a larger cultural and political condition, what might be called *planetary*

[10] Burns, Elizabeth T., Diana M. Rhoten, Aarti Gupta, and David W. Keith. 2016. "Politics of Participation in Climate Engineering Research." *Nature Climate Change* 6 (6): 562–566.

[11] Hulme, Mike. 2014. *Can Science Fix Climate Change? A Case Against Climate Engineering*. Cambridge: Polity Press.

modernity, marked by unequal risks, contested ideas of knowledge, and fundamental uncertainties about how we relate to the Earth. Rather than simply asking whether geoengineering can work or how it might be safely managed, the more important question is this: what cultural beliefs, knowledge systems, and institutions make geoengineering seem like a reasonable idea in the first place?

In the second section, I explore how ethical and knowledge-related perspectives on geoengineering have changed over time, tracing a movement away from simplified, control-driven models toward more relational approaches that take into account the complexity of systems and interconnections. The third section focuses on the global politics of intervention, examining how imbalances in power, vulnerability, and authority over knowledge influence who gets to decide, who is most affected, and how legitimate those decisions truly are. In the fourth section, I turn to alternative ethical perspectives that go beyond the usual technical and managerial thinking, drawing inspiration from ideas such as ecological care, humility in the face of uncertainty, and the recognition that there are multiple ways of understanding the world and our place within it. Looking at geoengineering today should not be limited to improving climate models or updating policy strategies. It calls for a deeper reconsideration of the ethical foundation of climate action itself. It invites us to ask, clearly and collectively, what kind of world we want to build, what values we are prepared to defend, and how we choose to live within the limits and uncertainties of a shared planet. The authors referenced throughout this article were chosen because of the depth and relevance of their contributions to the ongoing conversations about geoengineering, environmental ethics, and the broader philosophical questions raised by emerging technologies. This list is not intended to be complete. Geoengineering is a field marked by both theoretical richness and real-world complexity, with significant work taking place across many disciplines and regions. Due to the natural limits of access, especially to regionally published studies or non-mainstream materials, this article does not aim to capture every viewpoint. Instead, it focuses on presenting some of the most influential ideas that have shaped the ethical and political discussion on geoengineering in the last ten years.

2. From Reductionism to Systemic Responsibility

The ideas that shape how we understand and justify geoengineering today are not new, nor are they free from ideological influence. As Schubert (2022) explains, they come from what he calls the *science–state dispositif*, a long-standing alliance between scientific institutions and state power that took form during the Cold War and evolved through systems designed to measure the planet, simulate its behavior, and anticipate future threats. This close relationship brought together

atmospheric science, military research, and the early stages of digital technology, forming a kind of expert-driven framework that treated scientific knowledge as a tool not just for understanding the world, but for managing it in the name of national or global security.[12] In this way of thinking, knowledge is not something that follows action; it comes first, shaping the conditions in which action appears necessary, justified, and even inevitable.

The roots of this way of approaching the climate can be found in early weather modification efforts like Project Cirrus and Project Stormfury, which were launched in the mid-1900s as joint ventures between science and the military.[13] Although these projects did not produce reliable or repeatable results, they played an important role in shaping attitudes toward the atmosphere. They helped establish the belief that weather systems could, at least in theory, be controlled through the right mix of data, simulations, and expert planning. The Cold War did not just bring new technologies, but introduced a new way of thinking, one in which the global environment was no longer just something to observe, but something that could be shaped and managed for strategic purposes. The way of thinking about weather and climate during the Cold War was closely tied to the geopolitical goals of that era. Efforts to modify the weather were not just aimed at helping agriculture or reducing the damage caused by storms. They were also imagined as tools of power, methods for gaining strategic advantage over enemies, influencing populations, or controlling natural systems in regions formerly colonized.[14] This mindset treated nature not as something humans are part of or connected to, but as a resource to be controlled and programmed. These ideas were not passing fantasies. They laid the foundation for today's ways of thinking about climate engineering, in which planetary systems are seen through the lens of long-term stability, technical efficiency, and strategic planning for the future. This way of imagining control over the planet (technopolitical imaginary), is still present in how we design climate models and make policy decisions today. In this context, simulation is no longer just a helpful tool to explore possibilities.[15] It becomes a powerful method that shapes what futures seem possible or acceptable, even before any action is taken. Through climate models, imagined scenarios, and projections, the future is turned into something that can be managed. Once an outcome is predicted, it begins to look legitimate. In this

[12] Schubert, Christian. 2022. "Science–State Alliances and Climate Engineering: A Longue Durée Picture." *WIREs Climate Change* 13 (6): 790.

[13] Edwards, Paul N. 2010. *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge: MIT Press: 260-267.

[14] *Ibid*., 264-267.

[15] Schubert, "*Science–State Alliances and Climate Engineering: A Longue Durée Picture*." 787.

system, making forecasts becomes a way of exercising control. Simply put, planning becomes a form of governance.

This whole process depends heavily on what we might call the aesthetics of control- the persuasive power of graphs, maps, charts, and computer-generated images. These visual tools don't just show data, they give it authority. They influence how both policymakers and the general public imagine the future. For example, a graph showing possible climate outcomes might look objective, but it also suggests which futures are acceptable and which are not. The "cone of uncertainty" (a diagram often used in weather prediction) becomes not just a warning, but a moral excuse for certain decisions. A graph showing emissions paths may be read like a map for navigation. A risk curve can quietly define what levels of danger we are willing to tolerate. But behind these clean images is a system built on simplifying assumptions. It often hides disagreement, ignores complexity, and transforms open-ended futures into ones that look predictable and manageable. Understanding where this way of thinking comes from is not just a matter of historical interest. It helps us see the deeper mindset behind how geoengineering is discussed today, a mindset built on the belief that we can anticipate and control the future, that we can act on the climate before we fully understand how deeply interconnected and socially complex it really is. As I see it, this history also shows how decision-making about the planet is often handed over to models and expert panels, rather than being guided by public debate or shared moral values. In other words, governance becomes based more on prediction than on participation.

This background is crucial for understanding why geoengineering has gained traction. The idea that we can cool the planet by reflecting sunlight (through SRM), or that we can engineer new ways to absorb carbon from the atmosphere (through Carbon Dioxide Removal), is not based only on physical science. It also relies on a long-standing belief that the climate system can be controlled if we just have the right data and tools. That belief has been reinforced over decades, not through real-world testing, but through repeated modeling and simulation. So geoengineering today is not just a new set of tools, but is rather a part of a much older dream: to make the Earth understandable, manageable, and subject to human design. As I argued in earlier work, this approach comes from what can be called a *reductionist knowledge culture*- a way of thinking that breaks the planet down into separate pieces that can be measured and manipulated.[16] This is not just a shortcut for analysis; it's a deep shift in perspective that makes climate intervention seem both possible and necessary. Concepts like atmosphere, sunlight reflection (albedo), heat trapping (radiative forcing), or carbon storage are each modeled as isolated systems,

[16] Simion, "*The Ethics of Geoengineering: Perspectives from Romania"* , 29-30.

disconnected from the larger web of relationships that include ecosystems, social histories, and political structures. But when we gain clarity through simplification, we often lose sight of the ethical and ecological complexity that really matters. This way of modeling the world reflects what Paul Edwards calls a closed-world paradigm- a method of thinking inherited from Cold War science, which assumes that complex systems like the climate can be treated like machines, with inputs, outputs, and feedback loops. However, to make the math work, such models often rely on parameter insulation, a technique where unstable or unpredictable parts of the system are artificially held constant. The result is a smooth, simulated version of the world, where everything looks governable, even though the real, messy world often refuses to behave so neatly.

The narrowing of perspective caused by this type of modeling has been further reinforced by how deeply it has become embedded in institutions. Climate models today no longer just offer support for decision-making, they actively define what is seen as possible, reasonable, or acceptable policy. The future, once imagined and simulated in these models, becomes a guide for action. But these models do more than just predict risks, they also carry with them hidden assumptions about politics, science, and ethics. Because these assumptions are often invisible to those outside expert circles, simulation gains a kind of authority of its own. In this context, if something is not included in the model, it effectively disappears from the list of things that can be governed. Within this way of thinking, even uncertainty is treated differently. It is no longer seen as a signal to be cautious or a reason to question our knowledge. Instead, uncertainty becomes just another variable, something to measure, manage, and factor into planning. It gets translated into probabilities, built into decision trees, or absorbed into flexible planning strategies. This shift may seem small, but it changes everything: instead of asking "what don't we know?", the question becomes "how can we limit the risks of not knowing?"

But treating uncertainty this way comes with serious ethical consequences. As Biermann (2022) points out, the growing acceptance of solar geoengineering is not because we now know more or have stronger evidence. Rather, it reflects a change in the rules of how knowledge is used.[17] We are moving away from ethical discussions that focus on public debate, caution, and disagreement, and toward a more procedural mindset where legitimacy is defined by whether institutions are ready and plans look optimized on paper. The idea of climate emergency helps push speculative technologies forward, even before political or moral debates are resolved. As a result, serious ethical questions are reframed as technical problems to be managed. The conversation subtly shifts, from asking "should we do this?" to "how would we

[17] Biermann, Frank. 2022. "Solar Geoengineering: The Case for an International Non-Use Agreement." *WIREs Climate Change* 13 (1): 754.

do it?", from rejecting a risky path to regulating it, from questioning the premise to fine-tuning the details.

What is really at stake here is not just the future of a particular technology, but the very way we make ethical decisions. When simulation replaces real discussion, and when ideas like resilience are no longer connected to fairness or justice, climate governance starts to lose its moral depth. Geoengineering stops being treated as a controversial option that demands public reflection and becomes something that feels inevitable, just one more item in the policy toolbox, justified not by public agreement, but because it fits into the models and aligns with existing plans. In today's policy and research environment, geoengineering technologies are often treated as real and legitimate not because they are fully developed or tested, but because they are included in plans for the future. This process, sometimes called epistemic anticipation, means that the idea of these technologies gains credibility simply by being present in official documents, such as climate policy roadmaps, funding programs, simulation platforms or institutional reports. This appearance of readiness does not come from broad agreement between scientists, engineers, and society. Instead, it is built through repeated alignment between scientific narratives, policy expectations, and financial interest.[18] The more often these ideas are repeated in planning documents and research agendas, the more "real" and inevitable they start to seem, regardless of how ready they actually are.

This leads to a situation where the notion of deploying geoengineering technologies comes before their technical feasibility. What begins as speculative modeling or scenario planning slowly transforms into what McLaren and Corry (2021) describe as ontological staging- a process in which political and institutional imagination is prepared for a future that has not yet happened, but is already being justified and normalized. This preparation doesn't just happen through academic texts or projected scenarios; it takes shape through concrete actions like launching research programs, creating funding channels, conducting ethics reviews, or organizing small-scale experiments, all of which help establish geoengineering as a serious and actionable part of current climate policy.[19] But this future-focused logic does more than open up new possibilities. As I previously argued, evaluating geoengineering only in terms of risk or cost-benefit analysis is not enough. These tools are based on the assumption that the world is stable and that technology simply modifies inputs and outputs. But geoengineering does more than tweak the system, it reshapes

[18] Schubert, "*Science–State Alliances and Climate Engineering: A Longue Durée Picture*." 762.

[19] McLaren, Duncan P., and Olaf Corry. 2021. "The Politics and Governance of Research into Solar Geoengineering." *WIREs Climate Change* 12 (6): 707.

the very world it intervenes in, along with the concepts, values, and frameworks we use to understand it.[20]

For this reason, a truly ethical approach must begin not with calculations of impact, but with a deeper examination of the assumptions that make such interventions seem logical or acceptable in the first place. We must ask: Who decides what counts as a "global risk"? What visions of the world are built into the models and simulations we use? Which perspectives and values are left out of the decision-making structures? If we fail to ask these questions, we risk falling into a kind of false neutrality, an ethics that looks impartial on the surface but is actually disconnected from power, politics, and justice. In such cases, ethics becomes more about following procedures than about truly reflecting on what kind of future we want to create. In the end, asking critical questions about how we come to "know" geoengineering means uncovering the deeper structures that make it seem like a reasonable or even necessary option. These structures, made up of knowledge systems and institutional authority, do not simply reflect the world as it is. Instead, they actively shape the kinds of futures that appear governable and worth pursuing. They influence not only what actions are technically possible, but also what is seen as logical, urgent, or inevitable. In doing so, they limit space for disagreement, reduce the diversity of viewpoints, and often bypass meaningful public debate. Under the banner of planning for the future, we risk accepting a future that has already been designed in advance by the very systems meant to explore it.

The ways in which geoengineering is imagined and made thinkable go far beyond simplified climate models. They are upheld by a broader network of expert systems and technologies- such as simulation tools, forecasting platforms, risk metrics, scenario planning models, and advisory committees, which create the impression that we understand and can manage the planet's complex dynamics.[21] These tools do not just describe reality; they help reshape it into something that looks manageable. They turn uncertainty into something that can be measured, categorized, and controlled. Through the repeated use of numbers, graphs, and future scenarios, the climate itself is turned into a system that seems predictable and open to intervention. But this is simply an illusion of prediction, a false belief that if we can simulate the future or run enough probabilistic models, we can make legitimate decisions based on them, even when the science is still uncertain. This belief doesn't come from having clear, tested results. Instead, it comes from the pressure of institutions that need to act, make plans, and justify decisions in a context marked by urgency and

[20] Simion, 2015, 33.

[21] Low, Sean, Benjamin K. Sovacool, and Cassidy M. Baum. 2024. "Taking it Outside: Exploring Social Opposition to 21 Early-Stage Experiments in Radical Climate Interventions." *Energy Research & Social Science* 90: 3.

competition over whose knowledge counts. In such an environment, the ability to present a coherent vision of the future becomes a kind of power in itself, giving models influence even when the systems they describe are fragile or speculative.

Nowhere is this more evident than in the growing attention given to SRM. The fact that SRM is now regularly included in climate discussions is not because it has been proven to work, or because there is broad agreement on its use. Instead, its visibility comes from the belief that it could deliver major climate effects at relatively low cost. In this logic, what matters is not ethical depth or long-term justice, but whether something can be measured, priced, or built into a system. This way of thinking favors abstract economic calculations and tends to ignore place-based knowledge, local values, or questions of fairness. This way of framing the conversation is especially visible in discussions about Stratospheric Aerosol Injection (SAI), a geoengineering method that involves spraying tiny particles into the upper atmosphere to reflect sunlight and cool the planet. The debate around SAI often focuses narrowly on questions like how easy it would be to deploy, how far the particles would spread, and whether the benefits would outweigh the costs. What I consider largely missing from these discussions are deeper ethical concerns: questions about who gets to decide, how global power imbalances affect climate decisions, and how non-Western ways of understanding the environment are excluded from the conversation. As shown by Low and colleagues (2024), studies of public opinion reveal that this kind of technocratic thinking, focused on technical performance and efficiency, tends to ignore or override people's concerns about fairness, representation, and responsibility for past harms. One of the most politically sensitive issues linked to geoengineering is what's called the *mitigation deterrence effect.* This refers to the fear that if geoengineering seems like a backup plan, it will weaken the push for cutting emissions in the first place.[22] This is not just a theoretical worry. Many studies and international consultations reflect the same concern. In focus groups held across countries in the Global South, participants often expressed skepticism or discomfort. Some saw geoengineering as a short-term fix that might buy time for poorer countries still dealing with poverty and weak infrastructure. Others saw it as a way for wealthier nations, the ones most responsible for climate change, to shift the risks and burdens onto communities that are already suffering from rising temperatures, droughts, or flooding.

These perspectives challenge the idea that scientific expertise is neutral or universally accepted. They reveal that geoengineering is not seen by all as a fair or inclusive solution to the climate crisis. Instead, it can appear as a tool shaped by

[22] Low et al. 2024, 14-16.

unequal power dynamics, a strategy designed and promoted by the most influential actors, often without consulting or even acknowledging those who would be most affected by its consequences. Rather than being a shared global effort, geoengineering emerges here as a political and knowledge-based system that tends to exclude the voices of the vulnerable. There are also new and increasingly popular ideas that combine advanced technologies like blockchain with geoengineering strategies such as SRM and CDR. These proposals suggest that emissions control could be coordinated globally using automated systems, specifically, through tools like smart contracts and distributed digital ledgers. The goal is to synchronize climate actions across different regions and timeframes by coding them into programmable sequences, essentially turning planetary governance into something that can be managed by algorithms and automated transactions.[23] At first glance, this may seem like an innovative way to increase efficiency. But what stands out is the deeper assumption behind this approach: *the belief that global agreement can be written into code, that uncertainty can be solved through technical compatibility, and that difficult ethical questions can be avoided by turning them into precise rules and contracts*. This model assumes a level of technological uniformity and institutional stability that does not reflect the real world, especially in the countries where resources, infrastructures, and governance capacities vary greatly. As a result, questions of justice, representation, and democratic input are pushed to the side. What matters instead is whether the system works smoothly at a technical level, even if it excludes the very people most affected by the decisions being automated.

In this way, the logic behind geoengineering goes beyond simply breaking the world into smaller, manageable parts. It actively builds a reality in which only those futures that can be calculated and controlled are seen as viable. Ethical coherence or democratic legitimacy become secondary, while computability becomes the primary condition for action. Scenarios, instead of helping us imagine a range of possible futures, begin to narrow our options, ruling out anything that cannot be easily measured, modeled, or programmed. Geoengineering, then, becomes something in-between: not fully real, not fully imagined. It occupies a kind of grey zone where the usual rules of responsibility and democratic oversight no longer apply. In this space, scientific modeling starts to replace moral thinking. Political decisions are reduced to technical infrastructure. Disagreement is reinterpreted as a risk to be minimized. And the principle of caution (so important when dealing with uncertainty), is seen as a barrier to innovation rather than a safeguard.

[23] Lockley, Andrew, Jian Mi, and David Coffman. 2019. "Integrating Blockchain and Smart Contracts into Geoengineering Governance." *Futures* 109: 37–48.

In my interpretation of these phenomena, what we're witnessing here is more than a debate about technology. It's a transformation in how ethics itself is structured. Responsibility becomes blurred or spread thin across systems, disciplines, and timelines. In some cases, it is automated altogether. Instead of asking what is right or fair, we risk asking only what is technically possible. If epistemology is about what counts as valid knowledge, and governance is about how decisions are made and actions are taken, then questioning the way we produce knowledge is already an ethical act. To truly evaluate geoengineering, we must look beyond the surface and examine the deeper structures that make it seem like a plausible solution in the first place. This means paying attention to the assumptions built into climate models, the blind spots created by how risks are framed, the inequalities present in data collection systems, and the speculative tools used to justify future interventions in the name of climate security.[24] A strong ethical approach to geoengineering should not begin by asking how we should govern these technologies. It should start with a more fundamental question: who decides the rules of governance, and whose knowledge, values, and visions of the future are included (or excluded) from that process? What we need is not just more caution or better procedures. We need epistemic justice, a way of thinking that takes seriously which types of knowledge are valued, who produces them, and how they shape the future we imagine as possible or acceptable. This leads us to a striking paradox: geoengineering claims to bring stability to a planet in crisis, yet it relies on systems of knowledge and forecasting that are themselves unstable, incomplete, and shaped by political interests. When interventions are built into models and long-term projections, there is a risk that ethical reflection gets replaced by procedural rules, and that decisions about the planet's future are reduced to calculations about what can be simulated or optimized. If we accept that knowledge is never neutral, then the ethics of new technologies must start by asking who controls that knowledge and how it is used.

Recognizing this calls for a shift from simply criticizing the way knowledge is used in geoengineering to actively proposing what ethical frameworks should guide it. It's no longer enough to ask how geoengineering became thinkable. We must also ask how it should be governed, and based on which ethical commitments. That is why, in the next section, I propose we look at the politics behind intervention and begin to outline a possible ethical framework, a set of guiding principles, limitations, and shared responsibilities for acting in a world where climate, politics, and our understanding of reality are all intertwined.

[24] McLaren, Duncan P., and Olaf Corry. 2021. "The Politics and Governance of Research into Solar Geoengineering." *WIREs Climate Change* 12 (6): 719.

3. From Technical Legitimacy to Political Responsibility

If in the past climate engineering seemed like a distant idea, limited to speculative scenarios, futuristic speculation, or academic thought experiments, it has now moved to the center of political thinking about how to manage the climate crisis. This shift has happened quickly, but it has not been matched by an equally strong effort to build democratic legitimacy or reach broad ethical agreement. Instead of emerging through public discussion and debate, geoengineering has gone from being a marginal concept to an institutional reality without first passing through the necessary stages of public consent and accountability. This transformation raises serious ethical questions. As Grasso (2022) explains, geoengineering today functions as a high-impact tool that could be activated in moments of climate emergency. Yet the systems needed to ensure that such action reflects the will of the people or respects principles of fairness are still missing or underdeveloped. In many cases, the fact that institutions are prepared to act is treated as enough, readiness is mistaken for legitimacy, and the mere possibility of success is taken as moral approval. These problems are made worse by a deeper and ongoing imbalance in how knowledge is produced. Most of the information about geoengineering (how it might work, what risks it involves, and how much it might cost), is created in research centers located in the Global North. This knowledge is usually generated by narrow academic fields focused on climate modeling, economic analysis, and technical forecasting. These approaches tend to favor simplified, abstract, and highly controlled ways of thinking about the climate, while often ignoring local knowledge, historical experience, and more relational or community-based perspectives.[25]

Meanwhile, those who are most likely to feel the real effects of geoengineering, such as island nations threatened by rising seas, Indigenous people, and communities that depend on subsistence economies- are often left out of the decision-making process altogether. Their voices are missing from policy forums and research projects, their knowledge systems are ignored, and their concerns are reframed as technical problems to be solved later. What results is not a fair or inclusive system of expertise, but what should be recognized as a deeply political way of organizing knowledge, one that excludes the very people who have the most at stake. The issue we are facing goes far beyond questions of whether procedures are formally fair. At its core, it is about what kind of responsibility we have toward the planet and one another. An ethical approach to geoengineering should not start with technical calculations, like how efficient or effective a method might be. It should start with recognizing

[25] Grasso, Marco. 2022. "Justice in Solar Geoengineering: The Normative Foundations of International Legitimacy." *Humanities and Social Sciences Communications* 9 (1): 276.

our moral responsibility: the duty to offer justification, to include those affected in decision-making, and, when necessary, to say no. This is especially important because framing climate interventions as engineering problems to be solved often hides the deeper injustices that shape who is most vulnerable to climate change and who holds the power to act.

When complex social and ecological realities are simplified into model parameters and algorithms, the human dimension is lost. Those already living in fragile or unjust conditions, along with future generations who cannot yet speak for themselves, are reduced to numbers or labeled simply as "stakeholders." This is not just a case of unequal distribution of risks or benefits; it is a deeper form of erasure. Entire communities are stripped of their voice and their ability to influence decisions that will shape their future. There is also a serious risk that powerful actors, such as states, militaries, or large corporations- will dominate the governance of geoengineering. Many researchers have warned that SRM, in particular, could be especially vulnerable to such influence. These actors have the resources and institutional power to shape how and when these technologies are used, based on their own interests rather than the broader public good. In this context, scientific expertise stops being neutral. It can become a tool used to justify the authority of those already in power. The ability to model the climate becomes linked to the authority to intervene in it, blurring the line between scientific knowledge and geopolitical strategy.

Even when there are efforts to include the public in decisions about geoengineering, those processes often fall short. Consultations with civil society are frequently reduced to symbolic gestures, meant to create the appearance of openness while the real decisions have already been made. Participation is staged as a way to manage consent, rather than to invite real debate or imagine different paths forward.[26] This technical, box-checking approach to engagement fails to recognize that consent is not just about attending a meeting or filling out a survey, but is about building trust, ensuring accountability, and creating shared spaces where different kinds of knowledge and experience are genuinely valued. Given these realities, the core ethical challenge is not simply to draw a line around what kinds of geoengineering might be acceptable. The real task is to rethink the basic conditions under which large-scale intervention in the Earth's systems can even be seen as morally meaningful. As Neuteleers (2019) points out, climate ethics needs to move beyond what he calls moral minimalism: approaches that rely on thin, universal principles like maximizing efficiency or minimizing harm. These are often too simplistic to deal with the complex mix of values, ways of knowing, and lived realities that define global environmental

[26] Low et al., 2024, 14-17.

injustice.[27] Ethics must engage directly with the difficult questions of fairness across generations, cultural and ecological diversity, and the legacy of historical exploitation. It must reject the illusion that technology can be separated from politics, or that climate systems can be "optimized" without changing the deeper structures that created the crisis in the first place. Even in the face of climate emergency, we cannot justify shortcuts when it comes to knowledge and ethics. If we are to even consider technologies like Stratospheric Aerosol Injection, they must be embedded in institutional structures that prioritize fairness and legitimacy, not just speed or control. This means building systems where the voices of the Global South are fully represented, where serious public deliberation happens before, not after, research agendas are set, and where there are clear and enforceable limits that prevent powerful actors from dominating decision-making.[28] Without these safeguards, geoengineering cannot be defended on ethical grounds. At best, it can only be justified technically- but that is far from enough.

In the end, technical expertise and readiness must be guided by political responsibility. Institutions and technologies must be held to account not just for what they do, but for what they push aside, such as democratic debate, diverse moral perspectives, ecological worldviews, and traditions of care for the planet.[29] When governance is focused mainly on speed, control, and predictability, and ignores values like justice, meaning, and inclusion, geoengineering stops being a potential tool for repair. It becomes a symptom of a deeper problem: the tendency of modern thinking to believe that more knowledge and better tools can replace moral reflection. The ethical legitimacy of geoengineering cannot be judged only by looking at its predicted outcomes. What truly matters is whether the conditions exist for people to give meaningful consent- whether they can express their views, be heard, and have their perspectives built into actual decision-making structures. Technologies like SRM or SAI are designed to operate at a global level, yet the systems set up to govern them are still based on national interests and corporate power. This mismatch is not accidental, but it reflects a much deeper imbalance in how risks are shared, who takes responsibility, and who has the power to shape the conversation about the future. These imbalances, evidently, stretch across regions, social classes, and generations. In theory, actions that affect the whole planet should be backed by global

[27] Neuteleers, Stijn. 2019. "Moral Minimalism and the Problem of Motivation: A Critique of Moral Arguments for Climate Action." *Ethical Theory and Moral Practice* 22: 727–740.

[28] Flegal, Jane A., and Aarti Gupta. 2018. "Anticipating Future Governance: Normative Considerations for Solar Radiation Management Research and Deployment." *Climate Policy* 18 (7): 735.

[29] Baatz, Christian. 2019. "Can We Have It Both Ways? On Potential Trade-Offs between Mitigation and Solar Radiation Management." *Journal of Agricultural and Environmental Ethics* 32 (2): 294-297.

consent. But in reality, most of the authority to decide lies in the hands of a few technologically advanced countries and powerful institutions. Their goals often do not align with the needs or values of the communities most vulnerable to climate impacts. The danger here is clear: when decisions are made by the powerful, they can easily become decisions for the powerful. As Grasso (2022) points out, this is not just a procedural flaw, it is a moral failure, one that refuses to acknowledge the right of others, especially those historically excluded, to participate in shaping the future of the planet.[30]

That's why procedural justice cannot be treated as an optional extra or as a symbolic gesture added on top of technical analysis. It is essential to the ethical foundation of any geoengineering effort. As many scholars have emphasized, real justice in decision-making goes beyond simply holding consultations. It requires what philosopher Nancy Fraser calls parity of participation- the idea that everyone affected by a decision should have an equal chance to be involved in shaping it. This means they must have access to information, be protected from pressure or manipulation, and have the actual power to influence what is being decided, not just offer feedback after the fact.[31] Without these conditions in place, public engagement risks becoming something more than just performance alone. It may create reports or collect opinions, but it does not build real dialogue or shared ownership of decisions. In the context of geoengineering, where the consequences are global, long-term, and potentially irreversible, the absence of strong and fair participatory structures undermines not just moral legitimacy, but also the credibility of the knowledge and authority behind the interventions.

In many parts of the world, people continue to express a strong sense of powerlessness when it comes to how geoengineering is discussed and decided. Studies consistently show that what are labeled as participatory processes often feel superficial or symbolic, especially in regions that have historically had less influence in shaping global climate policy. In these contexts, communities are usually treated not as partners in shaping the future of the planet, but as passive recipients of technologies designed elsewhere. This is not simply a case of poor inclusion. It continues long-standing patterns of excluding alternative forms of knowledge and reinforcing ecological power imbalances, where decision-making remains concentrated in the hands of a few dominant institutions and regions. This imbalance becomes even

[30] Grasso, Marco. 2022. "The Politics and Ethics of Geoengineering." *Humanities and Social Sciences Communications* 9: 268.

[31] Nancy Fraser, "Social Justice in the Age of Identity Politics: Redistribution, Recognition, and Participation," in *Redistribution or Recognition? A Political-Philosophical Exchange*, ed. Nancy Fraser and Axel Honneth (London: Verso, 2003), 102.

more concerning when we consider the dimension of time. Climate interventions will affect not only today's societies but also future generations, those who cannot yet speak, vote, or protest, yet whose lives will be shaped by the decisions we make now. Thinking ethically about the future requires more than predictions or long-term planning. It calls for a deeper moral imagination, one that recognizes our duty to care for people and worlds that do not yet exist.[32] From this perspective, virtue ethics becomes especially valuable. It encourages the development of qualities like ecological humility, caution, and responsibility toward the future. These are virtues that help us resist the desire for control and instead affirm the dignity of what we do not yet fully understand.

This also means we need to rethink what we mean by "consent." If we truly want justice that extends across generations, then consent cannot be reduced to a one-time political decision made in the present. It must be seen as an ongoing, intergenerational practice, a shared responsibility to protect the interests of those who are not yet represented in our institutions. In this light, a truly ethical approach to geoengineering must take into account not just who gives consent, but when consent is meaningful, and whose future it is meant to protect. To address these challenges, several scholars have proposed the creation of independent, inclusive consultative bodies that could continuously assess and revise the legitimacy of geoengineering proposals like SRM. These forums would operate beyond the influence of national governments or corporate stakeholders and would bring together a wide range of participants. That would include civil society groups, interdisciplinary scientists, Indigenous leaders, frontline communities, and people from across the planet's diverse regions and contexts.[33] The goal is not simply to satisfy the formal requirements of fairness, but to build a more morally responsive system of governance, one that listens, adapts, and remains accountable as new information, risks, and perspectives continue to emerge.

In short, the ethical problem with geoengineering is not limited to the physical risks it might create. Just as serious are the ways in which it can institutionalize silence, exclusion, and marginalization. The real danger is not only that we might push technology too far, but that we might recreate deep inequalities in how decisions are made and whose voices are heard. When only some perspectives are consistently included while others are left out, we risk repeating the very injustices that geoengineering is supposed to solve. Any effort to intervene at a planetary

[32] Cadilha, Miguel, and Paulo Guedes Vaz. 2023. "Virtue Ethics for Intergenerational Climate Justice." *Climate Action* 2 (1): 1–6.

[33] Grasso, Marco. 2022. "The Politics and Ethics of Geoengineering." *Humanities and Social Sciences Communications* 9: 268.

scale must begin by bringing historically excluded communities to the center of the conversation- not just as affected populations, but as knowledgeable and active participants in shaping the future. If geoengineering is more than just a collection of new technologies, if it also acts as a powerful framework that shapes how we think about the planet and how we plan for the future, then it requires an ethical response that matches this complexity. Standard approaches to technology ethics, which often focus on safety, consent, or fairness in distribution, are still important but no longer enough. These frameworks must be rethought and expanded to reflect the deeper stakes of planetary intervention, not just its physical effects, but also the ways it reshapes our ways of thinking, the legitimacy of our institutions, and the moral horizons within which we imagine our responsibilities to each other and to the Earth.

What we need is not just an ethics that applies to technology from the outside, but an ethics that takes seriously the nature of technology itself, how it shapes our ways of knowing, imagining, and deciding. This means shifting the focus from simply evaluating the consequences of technologies like SRM to asking how such technologies become thinkable and acceptable in the first place. Ethical frameworks cannot remain distant, abstract, or disconnected from the real lives and contexts of the people they affect. Ethics needs to be grounded in relationships, emotions, and specific histories. It must speak directly to the fears, hopes, injustices, and experiences that are already woven into the speculative systems we use to plan climate futures.[34] Geoengineering, as a technology designed for future risks, involves more than technical risk, it reflects our attitudes toward uncertainty, our responsibilities to future generations, and our relationship with the natural world. A first step in building this kind of ethics is to acknowledge the deep inequalities that shape both knowledge and power. Decisions about technology are rarely made on equal ground. They often emerge in conditions of structural ignorance, situations where important perspectives are missing, ignored, or intentionally left out. In these conditions, ideas of urgency and technical efficiency help justify certain interventions, while alternative visions of how to respond to climate change are pushed aside. To respond to this, ethics must support a commitment to valuing different kinds of knowledge, encouraging slower and more reflective scientific processes, and making space for inclusive public debate. This is especially important when the potential impacts of an action are global, long-term, and unevenly distributed across communities and generations.[35] Without

[34] Müller-Salo, Jörg. 2023. "Motivational Gaps in the Ethics of Climate Change: On Moral Requirements, Psychological Possibilities, and the Problem of Motivation." *Climate Action* 2 (1): 1–8.

[35] Faber, Daniel, and Barbara Unmüßig. 2025. "Democratizing Climate Futures." In *Post-Growth Futures: Ethics, Justice, and Climate Repair*, edited by Müller-Salo and Faber, 73–94. Springer.

this kind of pluralism, the principle of precaution becomes empty, and ethics risks being reduced to a technical checklist for managing risk.

In addition, we must rethink what it means to be responsible toward future generations. It is not enough to rely on abstract economic models or distant calculations about costs and benefits. Ethical thinking about the future should be based on virtue ethics, on the idea that caring for the future is a matter of character and orientation, not just data. They introduce the idea of prospection, which means cultivating a mindset of care for a future we will never see, one that embraces uncertainty and accepts that not everything can be planned or predicted. Prospection invites us to act not just based on what we can measure, but also based on the kind of world we want to help shape through the choices we make today. To care for a planet we will not personally inhabit requires imagination, humility, and a richer ethical language than technical rules alone can provide. At the same time, any meaningful ethical approach to geoengineering must also address what Müller-Salo calls motivational disjunctions.[36] The issue is not just about what people and societies should do, but also about what they can do, especially when climate change and planetary crises feel distant, abstract, or disconnected from everyday life. Calls for justice, caution, or care for the planet often fail to move people precisely because they lack emotional depth, cultural relevance, or existential meaning. That's why an ethical framework for technology must also speak to how people feel, what stories they relate to, and how their identities shape their engagement with the future. Ethics must connect with people's lived realities, not just their reason.

Equally important is rethinking what we mean by consent and legitimacy. In a world marked by vast differences in power and access to decision-making, it is not enough to rely on formal tools like consultation sessions or stakeholder meetings. True legitimacy requires a commitment to giving historically marginalized groups a real voice, not just as targets of policy, but as active participants in shaping how decisions are made. This may mean creating new institutional structures that represent future generations (such as ombudspersons or commissions) that can intervene when ethical boundaries are crossed. It also requires strong, independent oversight bodies that have the authority to stop research or deployment if it fails to meet standards of fairness, caution, or inclusiveness. Together, these reflections point toward a richer and more grounded ethics for geoengineering, one that includes several key principles.

First, it must cultivate epistemic humility, which means recognizing the limits of what we can know and predict, and refusing to let models or simulations replace

[36] Müller-Salo, 2023, 5-6.

real ethical thinking. Even the most sophisticated climate model cannot tell us whose risk is acceptable or what cultural values deserve protection. These are moral questions, not technical ones, and they must remain open to collective reflection and debate. Second, any ethical framework for geoengineering must ensure that the most attention and moral responsibility should be directed toward those who are most vulnerable and have the least power in the decision-making process. This could mean, for example, giving priority to environmental and social impact assessments that are centered on Indigenous communities or creating complaint and redress mechanisms that are truly accessible to historically marginalized populations. Third, the framework must be built on participatory co-design. This means involving affected communities not just at the end of the process, when policies are finalized, but from the very beginning, helping shape the core questions, assumptions, and approaches that guide geoengineering research. Real inclusion of this kind takes time, careful communication, and a willingness to build trust, especially when people come from different cultural, geographic, or knowledge backgrounds. Fourth, the framework must include temporal justice, or fairness across time. This involves taking responsibility not just for today's impacts, but for how decisions affect future generations. Policies should be designed to keep options open for the future, favor solutions that can be reversed if needed, and avoid actions that might cause permanent ecological harm. Fifth, and perhaps the most transformative requirement, the framework must encourage questioning the deeply rooted belief that Earth is simply a system to be managed or controlled. Instead, we need to create space for ecological worldviews that see nature not as a passive backdrop, but as an active partner in shaping the planet's future. This shift asks us to rethink not only how we act, but how we understand our place in the world. In conclusion, what we need is not just better ethical checklists or stronger rules for managing risk. We need an entirely new moral architecture, a way of thinking that can deal with the scale, complexity, and unique challenges that geoengineering brings. Without this kind of ethics, we risk repeating the same patterns of control, exclusion, and overconfidence that brought us into crisis in the first place, only this time, under the label of innovation and planetary stewardship.

4. Concluding Remarks

To develop an ethics that truly matches the global scale and uncertain future of geoengineering, we need more than just adjustments to existing rules about regulation and risk management. What's needed is a deeper shift in how we imagine morality itself, one that embraces the idea that there are multiple ways of understanding the world (ontological pluralism), that we must act with humility

given the limits of our knowledge, and that genuine inclusion in political processes matters at every step. In this broader sense, ethics is not just about achieving fair outcomes within the limits of existing institutions. It is about building the conceptual and institutional foundations that enable justice to be imagined, articulated, and practiced in new and meaningful ways. As I see it, this calls for a transformation in how we understand our moral roles: from rule-enforcers to co-creators, from risk managers to builders of shared planetary futures. Seen this way, geoengineering is not merely an environmental tool. It is a deeply political and philosophical site of struggle, a space where science, desire, infrastructure, and emotion converge to stabilize or contest particular visions of the Earth, of nature, and of humanity. Decisions about how to engineer the climate are never just about numbers or reflective particles in the sky. They are decisions about whose knowledge is trusted, whose future is being protected, and what kind of relationships we are willing to sustain between people and the planet. For ethics to remain relevant in this context, it must be able to move at the same depth, scale, and complexity as the interventions it seeks to guide. It must be speculative, imaginative, and relational, willing to explore new moral horizons as climate governance becomes increasingly uncertain and contested.

Traditional ethical principles, like informed consent, minimizing harm, or ensuring fair distribution, are still important, but they are no longer enough. These ideas assume a world where everyone agrees on basic definitions of agency, risk, and fairness. But geoengineering takes place in a world where those very definitions are up for debate. Informed consent assumes a shared understanding of what's at stake. Harm minimization assumes we can measure future damage. Fairness assumes we know who the "stakeholders" are and how they will be affected. In reality, geoengineering unfolds in a space shaped by deep uncertainty, irreversible consequences, and many ways of understanding life and value. What's needed, then, is not abstract moral rules applied from above, but situated ethics: an approach grounded in the real experiences, cultural perspectives, and ecological relationships of different communities.

This means giving renewed value to forms of knowledge that have long been dismissed as anecdotal, spiritual, or unscientific. Indigenous perspectives, for instance, with their emphasis on relationality, reciprocity, and cosmological balance, offer not just different values but entirely different ways of understanding what it means to care for the Earth. These are not peripheral additions to scientific expertise, they are complete worldviews that challenge the dominant managerial mindset, which treats the planet as a system to be optimized and controlled through human intervention. An ethical approach that ignores this kind of ontological diversity risks reinforcing the very hierarchies of knowledge and power that geoengineering

should be questioning. At the same time, this ethical shift requires a deeper engagement with the emotional, motivational, and narrative dimensions of climate action. Abstract moral arguments, no matter how well reasoned, often fail to inspire action. One of the greatest challenges today is not just disagreement over facts, but a gap between what is morally prescribed and what feels emotionally or culturally meaningful. Urgent calls for justice or planetary care often clash with psychological distance, political disillusionment, or a lack of lived connection. In such cases, moral arguments don't fail because they're incorrect, but because they are disconnected from the everyday structures of meaning that people inhabit.

A more grounded approach lies in the ethics of virtue, which shifts focus from external rules to internal dispositions, from obligation to orientation. What's needed is not just more regulation, but more cultivated ways of being. Dispositions such as humility, caution, responsibility, and care for those who are yet to be born become ethical anchors in a world marked by uncertainty and long temporal horizons. These are not abstract ideals but practiced ways of living- habits of holding space for the unknown, of moving carefully rather than forcefully, of responding with attentiveness instead of control. In a time when the future feels increasingly unstable, these virtues offer a way to act meaningfully without pretending we have all the answers.

What comes into view here is not a fixed plan for how geoengineering should be governed, but rather a reorientation of ethical thinking, a call to build systems that are not just designed for deployment, but also for reflection, for refusal when necessary, and for repair where harm has already occurred. A truly sustainable ethics of geoengineering would not limit itself to regulating technologies. It would go deeper, reaching into the space of political imagination. It would not act as a barrier to innovation, but as a creative force that expands our sense of what can be just, what can be livable, and what is worth protecting.

In the delicate context of today's international relations, marked by hegemonic aspirations, tunnel-vision thinking (narrow, self-interested, and biased), and superficial communication between major powers, it is increasingly difficult to identify competent political actors who are willing to engage in genuine, responsible dialogue grounded in reason, science, and culture. This makes the pursuit of a truly sustainable ethics even more urgent, an ethics capable of fostering not only technological responsibility, but also diplomatic imagination, cultural awareness, and a shared sense of planetary care. Such an ethics would push back against the urge to rush into the future under the pressure of technical urgency. It would open up room for many possible futures, for non-linear understandings of time, and for more radical forms of responsibility, ones grounded in humility rather than control. From this perspective, geoengineering no longer appears simply as a technical fix or a last resort. Instead, it becomes a

kind of mirror- one that reflects the deeper failures of our political and economic systems. It reveals the inequalities that shape who is vulnerable to climate change, the silences built into how knowledge is produced and used, and the assumptions that have made it seem natural to treat the Earth as something that can be engineered.

Ethical thinking, then, must begin not with ideas of optimization, but with a deeper sense of repair. That means listening before acting, including others before deciding, and taking the time to question before moving forward. This is not about romanticizing inaction or underestimating the seriousness of climate collapse. Rather, it is about recognizing that the rush to act must itself be held up to ethical scrutiny. In a world marked by ecological fragility, doing less may sometimes be more meaningful than doing more. This is not a form of ethical withdrawal. It is a practice of care, grounded in the awareness that our entanglement with the planet runs deep, and that our confidence in solutions often hides the real cost of acting without reflection. Confronted with multiple overlapping planetary crises, our most pressing task may not be to assert greater control over the Earth, but to relearn how to live in harmony with it. We need to cultivate forms of ethical attention that remain attuned to interdependence, to vulnerability, and to the limits of what we can truly know and control. Perhaps the most radical form of care, then, is not to push harder or faster, but to pause, to listen carefully, and to ask again what it really means to be responsible on a global scale.

As I reach the end of this reflection, I find that I am neither more hopeful nor more discouraged than I was ten years ago. What I feel instead is a deeper awareness, an understanding of how complex and tightly woven the mechanisms behind climate breakdown really are. I am also more realistic about what is possible. As long as fossil fuels remain central to how we power our world, as long as critical researchers continue to be marginalized, and as long as some of the most powerful political leaders ignore or deny the weight of this responsibility, I believe we will continue to slide deeper into crisis. And as that happens, the ways we imagine the future will shift, moving away from grounded hope and toward visions that feel more distant, more abstract, and more dystopian. That drift is not inevitable. It is a consequence of failing to act with care, with humility, and with imagination while we still had the chance.

REFERENCES

Baatz, Christian. 2019. "Can We Have It Both Ways? On Potential Trade-Offs between Mitigation and Solar Radiation Management." *Journal of Agricultural and Environmental Ethics* 32 (2).

Bellamy, Rob, and Justin Healey. 2018. "Slippery Slopes and Steep Cliffs: Intervention Intensity, Decision-Making Heuristics and Moral Judgements of Climate Engineering." *Global Environmental Change* 49.

Biermann, Frank. 2022. "Solar Geoengineering: The Case for an International Non-Use Agreement." *WIREs Climate Change* 13 (1).

Cadilha, Miguel, and Paulo Guedes Vaz. 2023. "Virtue Ethics for Intergenerational Climate Justice." *npj Climate Action* 2 (1).

Dannenberg, Astrid, and Sonja Zitzelsberger. 2019. "Climate Experts' Views on Geoengineering Depend on Their Beliefs About Climate Change Impacts." *Nature Climate Change* 9 (10).

Edwards, Paul N. 2010. *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge: MIT Press.

Faber, Daniel, and Barbara Unmüßig. 2025. "Democratizing Climate Futures." In *Post-Growth Futures: Ethics, Justice, and Climate Repair*, edited by Müller-Salo and Faber, 73–94. Springer.

Flegal, Jane A., and Aarti Gupta. 2018. "Anticipating Future Governance: Normative Considerations for Solar Radiation Management Research and Deployment." *Climate Policy* 18 (7): 728–738.

Grasso, Marco. 2022. "Justice in Solar Geoengineering: The Normative Foundations of International Legitimacy." *Humanities and Social Sciences Communications* 9 (1).

Grasso, Marco. 2022. "The Politics and Ethics of Geoengineering." *Humanities and Social Sciences Communications* 9.

Hulme, Mike. 2014. *Can Science Fix Climate Change? A Case Against Climate Engineering*. Cambridge: Polity Press.

Lockley, Andrew, Jian Mi, and David Coffman. 2019. "Integrating Blockchain and Smart Contracts into Geoengineering Governance." *Futures* 109: 37–48.

Low, Sean, Benjamin K. Sovacool, and Cassidy M. Baum. 2024. "Taking it Outside: Exploring Social Opposition to 21 Early-Stage Experiments in Radical Climate Interventions." *Energy Research & Social Science* 90.

Low, Sean, Chad M. Baum, and Benjamin K. Sovacool. 2022. "Rethinking Net-Zero Systems, Spaces, and Societies: 'Hard' versus 'Soft' Alternatives for Nature-Based and Engineered Carbon Removal." *Global Environmental Change* 75.

Mahajan, Ashwin, Dustin Tingley, and Gernot Wagner. 2019. "Beliefs about Climate Beliefs: The Importance of Second-Order Opinions for Climate Politics." *British Journal of Political Science* 49 (3): 1279–1307.

Müller-Salo, Jörg. 2023. "Motivational Gaps in the Ethics of Climate Change: On Moral Requirements, Psychological Possibilities, and the Problem of Motivation." *npj Climate Action* 2 (1): 1–8.

Neuteleers, Stijn. 2019. "Moral Minimalism and the Problem of Motivation: A Critique of Moral Arguments for Climate Action." *Ethical Theory and Moral Practice* 22: 727–740.

Schubert, Christian. 2022. "Science–State Alliances and Climate Engineering: A Longue Durée Picture." *WIREs Climate Change* 13 (6).

Simion, Radu. 2015. "The Ethics of Geoengineering: Perspectives from Romania." *Annals of the University of Bucharest – Philosophy Series* 64 (2): 27–43.