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Authors

Gupta, Aarti

Möller, Ina

Biermann, Frank

et al.

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Anticipatory governance of solar geoengineering: conflicting visions of the future and their links to governance proposals

Aarti Gupta[1], Ina Möller[1], Frank Biermann[2], Sikina Jinnah[3], Prakash Kashwan[4], Vikrom Mathur[5], David R Morrow[6] and Simon Nicholson[6]

This article identifies diverse rationales to call for anticipatory governance of solar geoengineering, in light of a climate crisis. In focusing on governance rationales, we step back from proliferating debates in the literature on 'how, when, whom, and where' to govern, to address the important prior question of *why* govern solar geoengineering in the first place: to *restrict* or *enable* its further consideration? We link these opposing rationales to contrasting underlying visions of a future impacted by climate change. These visions see the future as either more or less threatening, depending upon whether it includes the possible future use of solar geoengineering. Our analysis links these contrasting visions and governance rationales to existing governance proposals in the literature. In doing so, we illustrate why some proposals differ so significantly, while also showing that similar-sounding proposals may emanate from quite distinct rationales and thus advance different ends, depending upon how they are designed in practice.

Addresses
[1] Wageningen University and Research, The Netherlands
[2] Utrecht University, The Netherlands
[3] University of California at Santa Cruz, United States
[4] University of Connecticut, United States
[5] Tandem Research, India
[6] American University, United States

Corresponding author: Gupta, Aarti (aarti.gupta@wur.nl)

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Introduction

Claims about a looming climate crisis resonate around the world. Student and civil society protests demand urgent action, and numerous universities, municipalities and even the European Parliament have formally declared a 'climate emergency' [1]. In the popular media, the 2018 special report by the Intergovernmental Panel on Climate Change on the Paris Agreement's aspirational 1.5-degree temperature target has been interpreted by some to mean that we have only twelve years left to avert a global climate catastrophe [2]. While the COVID-19 pandemic that began in early 2020 temporarily drew attention away from a posited climate crisis, the issue is now back on the agenda, with debates intensifying about how best to manage a COVID-related economic downturn to stimulate much-needed transitions to low carbon societies.

A crisis or 'climate emergency' framing has also, however, been criticized. There is concern that emergency framings can be misused to justify the setting aside of democratic decision-making to accommodate alleged exceptional situations. A climate emergency framing may also provide impetus for controversial strategies, such as solar geoengineering, to combat a posited crisis [3–6]. Solar geoengineering refers to largely speculative technologies that could be deployed in the future to reflect some incoming solar radiation back into space, to counteract adverse consequences of climate change [7]. The idea of solar geoengineering is much debated and remains highly contentious, even though these technologies are still at very early stages of conceptualization and development [8•,9,10].

At the core of these contestations are often different visions of how a climate crisis might evolve and divergent positions on whether solar geoengineering should ever be part of the response. These positions inform different *rationales* to seek to govern solar geoengineering, which range from enabling to restricting such technologies. Analyzing these divergent visions of the future and associated rationales for seeking anticipatory governance of solar geoengineering is the aim of this article.

We characterize governance of solar geoengineering as an *anticipatory* challenge here because the very contours of the 'object of governance' remain uncertain and largely even unknowable [11,12,13•,14]. The term 'anticipatory governance' was first used in new public management and environmental policy studies in the early 1990s [15], in relation to novel technologies such as biotechnology or nanotechnology (see also [11]). One prominent definition

understands anticipatory governance as 'a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible' [15, pp. 219]. Others have defined anticipatory governance as 'a flexible decision framework that uses a wide range of possible futures to prepare for change and to guide current decisions toward maximizing future alternatives or minimizing future threats' [16, pp. 496]. As both definitions make clear, the content of anticipatory governance is shaped by how future threats and opportunities are envisioned (also [17,18•]).

It thus becomes important to identify such distinct visions of the future, the role for solar geoengineering herein and associated implications for governance. An earlier analysis by Asayama [19] offers one useful typology of distinct future visions. He identifies two opposing views of a climate crisis: as a case of 'emancipatory' versus 'apocalyptic' catastrophism. Emancipatory catastrophism envisions a future threatened by climate change, but one where climate change is also an opportunity to enable transformative shifts in modus operandi, wherein sector diversification, reduction of inequalities and democracy are key elements. In such a vision, there is no need for solar geoengineering. Apocalyptic catastrophism, in contrast, sees a threatening climate-impacted future where solar geoengineering may be necessary. Such a vision portrays climate change as an existential threat in which large-scale and potentially risky geoengineering interventions may be a lesser evil in the future, even if this entails restrictions on democratic and human rights.

In short, actors who reject the need for solar geoengineering as a policy option and those who accept the need to prepare for it hold diverse visions of futures impacted by climate change. We build here on Asayama's typology to assess such diverse (and often implicit) visions in the governance literature, relating these to distinct rationales to demand governance and to concrete governance proposals. While numerous comprehensive reviews of solar geoengineering governance have been published recently [20••,21–24], none has linked governance proposals to underlying rationales to call for anticipatory governance and to visions of the future, as we do here. In addition, while there is extensive debate in the governance literature on *how and when* to govern and *whom* to involve, there is little explicit discussion about *why* govern solar geoengineering in the first place (but see [25]). One of the few studies of the 'why govern' question is Jinnah [26], who identifies functional, strategic and normative interests of states to seek governance (what she terms 'demand rationales'), which she then links to options for institutional design.

We approach the 'why govern' question differently here, by distinguishing a spectrum of rationales to govern solar geoengineering, ranging from *governing to enable* to *governing to restrict* its potential future use. This spectrum makes clear also that governance is not only restrictive of technological research or development. Anticipatory governance, particularly of novel technologies, can also be enabling. Enabling forms of governance are often demanded by advocates of the technologies themselves, because they see oversight mechanisms as necessary to develop and diffuse the technology in question (for the case of biotechnology, see [27]).

Our interest in the 'why govern' question also builds on our participation in a three-year assessment of solar geoengineering governance, as part of the international Academic Working Group on Climate Engineering Governance (2016–2018).[1] This 14-member working group called in its final consensus report for launching near-term governance of solar geoengineering, through establishing legitimate deliberation bodies, leveraging existing institutions, and making research transparent and accountable [28••,29]. The intense debates within this group highlighted, however, the existence of very divergent visions on how to navigate a possible future climate crisis, what role solar geoengineering should play, if any; and what ends anticipatory governance of these speculative technologies should further. This experience stimulated us to disentangle these understudied interlinkages in the broader governance literature as well.

We continue as follows: in Section 'Methodology and approach' we outline how we conducted our review. In Section 'Why govern solar geoengineering: to what end?' we identify four overlapping governance rationales that we distil from our review and link these to two distinct visions of the future — one that envisions a safer climate-impacted future if it includes the possibility of solar geoengineering; and one that envisions a safer future if this technology is restricted. We then link governance proposals in the literature to these visions and rationales. In Section 'Discussion and conclusion' we synthesize our findings and discuss how our typology of governance rationales also serves as an analytical lens for future conceptual and empirical analysis. We conclude with noting some research and policy implications.

Methodology and approach

As our main methodology, we undertook a critical interpretive review of recent literature on the governance of solar geoengineering. Our aim was to interrogate the often-implicit assumptions about *why* governance is desired, and how this relates to diverse underlying visions of the future. An interpretive review is most suitable to untangling these relationships and describing the scholarly landscape [30].

[1] Five of the eight authors of this article were part of this working group. For further information and the final report, see: http://ceassessment.org/publications-from-the-academic-working-group/.

When identifying the literature to be reviewed, we sought to be comprehensive in covering the full spectrum of perspectives, rather than all articles. Specifically, we included a broad array of recent academic publications that discuss the merits of promoting or restricting further research into solar geoengineering, and whether and how this technology should be governed. We also built on our assessment of the governance literature undertaken under the auspices of the Academic Working Group on Climate Engineering.

We then read this literature critically [31] with an eye to distilling and categorizing a spectrum of 'why govern' rationales. We began with two pre-identified ends of a possible spectrum: governing to *enable* the future possibility of solar geoengineering versus governing to *restrict* it. A critical-interpretative reading of the literature then allowed us to inductively expand these to identify four overlapping governance rationales (going beyond the two mentioned above) and link these to underlying visions and governance proposals.

While categorization is often a key outcome of a literature review, our aim here is not to draw rigid boundaries between the four governance rationales, nor do we seek to link each to individual authors, disciplines or even whole research communities. Some aspects—for example, whether there is an alignment between specific disciplines and specific rationales—could be the subject of future empirical analysis. More generally, we see these rationales as ideal-types and as overlapping rather than wholly distinct. As such, we see the value of our categorization to lie in the broad mapping it enables of an expanding governance literature, but also as an analytical lens through which to ask important questions and enable further research.

Why govern solar geoengineering: to what end?

In this section, we present and discuss the spectrum of four 'why govern' rationales that we identified, and link these to different underlying visions of a future impacted by climate change and the role for solar geoengineering herein. These four rationales are: first, governing to *enable* the future possible use of solar geoengineering; second, governing to *exercise oversight over* solar geoengineering, if enabled; third, governing to be *vigilant against unequal harms* generated by solar geoengineering, if enabled; and fourth, governing to *restrict* solar geoengineering. We discuss each in turn.

Why govern: *to enable* the future prospect of solar geoengineering

The first vision of a climate crisis and the role for solar geoengineering herein is that a looming climate crisis cannot be overcome through mitigation, diplomacy or behavioural change alone. Instead, there is a need to develop a 'Plan B' that could be executed at some point in the future, should dangerous climate tipping points be exceeded, with unacceptably high levels of global warming [32,33].

In such a perspective, the future is highly threatening unless solar geoengineering is at least possible as a backstop option, regardless of whether it is ever deployed. This perspective is thus also pessimistic about the likelihood that current political efforts to cut greenhouse gas emissions will be sufficient and quick enough. Solar geoengineering is seen here as crucial to buy time for humanity to get its climate response act together, and as a fall-back option in case mitigation and adaptation activities prove insufficient to obviate the worst anticipated climate impacts. This position is exemplified by Nobel laureate Paul Crutzen [34], who called policy-based efforts to tackle climate change 'grossly unsuccessful' (p. 212) and argued for exploring solar geoengineering responses as a way to sidestep the messiness of climate politics. Crutzen's paper from 2006 is often seen as the first to break a *de facto* taboo against research on solar geoengineering and to spark a surge in further studies (for a review of this, see [9]).

The rationale for anticipatory governance flowing from such a future vision is to *enable* the future possibility of using solar geoengineering, should it become necessary at some point [33]. Many advancing this rationale are at pains to emphasize that potential use of solar geoengineering should not deter from ambitious mitigation. Others argue that solar geoengineering should be used only 'to shave the peak' from a climate impacts curve, offsetting the worst possible climate impacts and buying time for emissions abatement, adaptation and potentially carbon removal options to be further developed and implemented [7]. Sometimes this rationale includes evoking equity as justification to research solar geoengineering, given that the worst impacts of climate change are suffered by the most vulnerable [35].

Governance proposals associated with this rationale emphasize the need to foster an enabling research environment, with governance arrangements co-evolving with field tests that increase in scale and scope through time [36]. Proposals for *research* governance include defining technical and environmental thresholds to determine allowed zones for field testing [37], and ensuring that research programmes are transparent, diverse, and embedded in the wider portfolio of mitigation and adaptation research [38]. Also included here is the call to involve developing countries and marginalized societal groups in all countries in research and decision-making processes (e.g. [39]).

Governance proposals associated with this perspective also seek to ally a variety of concerns relating to potential

future *deployment* of solar geoengineering, such as the prevention of rogue deployment [40], the evolution of intellectual property and liability regimes [41,42] or free-driver problems [43]. Despite such diverse foci, the call is for anticipatory governance to remain rather light-touch, with a governance architecture that prioritizes and facilitates the advancement of scientific research and permits large-scale governance of potential future deployment to co-evolve as needed.

Why govern: to exercise *oversight* over solar geoengineering, if enabled

The second vision of a climate crisis and role for solar geoengineering herein has at its core a concern that an escalation of the climate crisis could incentivize the use of solar geoengineering, putting human rights and biodiversity at risk. At the same time, runaway climate change could at some point potentially warrant such an intervention, as long as it is done responsibly. This vision thus sees both threats and opportunities from including solar geoengineering as a possibility in combating a climate crisis. It is also anchored in resignation that research on solar geoengineering is ongoing anyway and may even pick up pace soon. If so, the world would be better off with effective governance mechanisms to control and steer research into, and potential deployment of, solar geoengineering, even if the hope is that these technologies will never need to be deployed.

The governance rationale associated with this vision thus moves away from actively seeking to enable the future prospect of solar geoengineering and calls instead for its strict oversight, should it be enabled. This rationale of 'governing to ensure oversight' underpins a wide range of governance analyses advocating for near-term (anticipatory) governance of solar geoengineering. A host of proposals relating to research governance, for example, are advanced by those ascribing to this governance rationale (for an overview, see [22,42]). Building on the widely cited Oxford Principles [44], these include suggestions on enhancing participation, transparency, technology assessment, and accountability of research. These oversight aims could be realized, for example, through developing codes of conduct, coordinating research programmes, building a clearinghouse of information, capacity building and technology review and assessment. Others call for setting up early warning mechanisms, and capacity enhancement through public deliberation and institution building to assess risks and exercise oversight (e.g [12,21,45–50]).

There are also multiple proposals for devising multilevel institutional arrangements to address 'whether and how' questions relating to potential future deployment of solar geoengineering. One dominant view is to advocate for *polycentric* forms of international governance. This prioritizes institutional arrangements that include an array of state and non-state actors and sites of decision-making in an international context, rather than relying either on 'mini-clubs' of influential countries, or on one core international institution such as the United Nations Framework Convention on Climate Change [51]. In general, governance debates are centrally concerned with identifying appropriate institutional (often expert-led) fora within which to embed anticipatory governance arrangements [28], with openness to these being voluntary as well.

Why govern: to be *vigilant against* unequal harms posed by solar geoengineering, if enabled

The third vision on the climate crisis and the role for solar geoengineering herein takes as its starting point that the poor and marginalized bear a disproportionate share of the costs of environmental pollution and burdens of environmental clean-up [52–54]. In such a view, the climate crisis might worsen entrenched inequalities and vulnerabilities, with solar geoengineering creating even more climate-related risks. These could include, for example, changes to precipitation, agricultural productivity or violations of human rights from use of these technologies, with the burden falling unequally on developing countries as well as marginalized groups in all countries [55–57].

The governance rationale associated with such a vision is thus to *be vigilant against unequal harms* resulting from research into, and potential future deployment of, solar geoengineering. Underpinning this rationale is also a view of solar geoengineering as constituting a 'rich man's solution' to the climate crisis, largely excluding the voices and perspectives of the world's poor and marginalized populations [58]. A key concern is that if solar geoengineering is enabled, it may exacerbate injustices and might even sustain elite interests in high-carbon energy economies [6,59]. Others note concerns, as voiced by Indian policymakers, about possible unilateral action on solar geoengineering by industrialized countries [60].

Governance proposals related to this rationale call thus for collectively deliberating *whether* the future possibility of solar geoengineering should even be contemplated. Anticipatory governance of solar geoengineering requires, from this perspective, building deliberative capacities and engaging with key stakeholders, especially vulnerable, poor and marginalized groups, to contemplate all options, including the option to limit or even fully prohibit further research (e.g. [55,61]). Support for broad-based, open-ended social deliberation also comes from those working in the field of responsible research and innovation [62,63], an approach to making technological innovation responsive to social values [64].

Additional governance proposals include calls for developing countries and marginalized groups to be actively

involved in shaping modelling, experiments and other research on solar geoengineering. McLaren [65] and Biermann and Möller [58] both point to apparent class biases of solar geoengineering research and debates, with McLaren [65] calling for radical changes to the design, deployment and interpretation of climate engineering models in trans-disciplinary research to mitigate these biases. Others caution against putting excessive faith in expert-driven approaches to anticipatory governance, particularly to realize more equitable outcomes. Flegal and Gupta [66] for example critique an equating of equity with an 'epistemic challenge' to be addressed through feasibility assessments or modelling the unequal distribution of risks. They argue that such 'vanguard visions of equity' sidestep the inequalities of access that prevent non-experts, especially the most vulnerable, from advancing their own perspective on equity in expert-driven visioning processes (see also [67,68]).

For the 'vigilant against' governance rationale, a crucial governance proposal is to discuss solar geoengineering in inclusive international settings where all countries can participate, also to avoid weakening solidarity in collective climate action and commitment to long-term mitigation (the 'moral hazard' challenge, [59]); or diverting resources away from adaptation and development. Thus, governance proposals emphasize the need for multilateral deliberation within various institutions of the United Nations, whether the United Nations Framework Convention on Climate Change, the United Nations Environment Programme, or even the United Nations General Assembly [69,58]. Broadly, they advocate for politically negotiated rather than expert-led governance at all levels.

Why govern: to *restrict* the future prospect of solar geoengineering

A fourth vision of the future is one where solar geoengineering is seen as not only unnecessary, but also as potentially highly risky and dangerous in tackling a climate crisis. Here the concern is that research into solar geoengineering will delay or derail the necessary low carbon transformations and exacerbate existing injustices, while undermining the collective will to tackle the climate challenge [70–73]. This perspective is thus closely aligned with 3.3 above on many points, even as it stresses that democratic governance of solar geoengineering may be inherently unrealizable and it is hubris to consider it [74–76].

The governance rationale associated with this vision of the future is therefore to *govern to restrict* the future prospect of solar geoengineering use. For those advancing this rationale, debating (let alone researching) solar geoengineering is a harmful distraction from the urgent task of deeply decarbonizing our socio-economic systems [77–79]. There is a concurrent fear that the extreme structural inequalities within which the climate crisis manifests itself will be exacerbated if technological fixes, such as solar geoengineering, are promoted by those with the power to do so [80]. Thus, in contrast to the 'govern to enable' rationale, this perspective views technocratic solutions with suspicion. Additionally, calls to consider solar geoengineering as a way to 'peak-shave' future temperature increases are critiqued, for example, as being a risky subprime mortgage approach to the climate challenge [81].

For many advancing such concerns, research on solar geoengineering must thus be discouraged, if not entirely banned. The vision of the future here is thus most pessimistic about solar geoengineering, while remaining optimistic about the political prospects of realizing large-scale low-carbon transformations. Climate change is seen as a potential opportunity for fundamental changes to the global political economy that may also redress persisting inequalities (akin to the 'emancipatory catastrophism' of Asayama [19]).

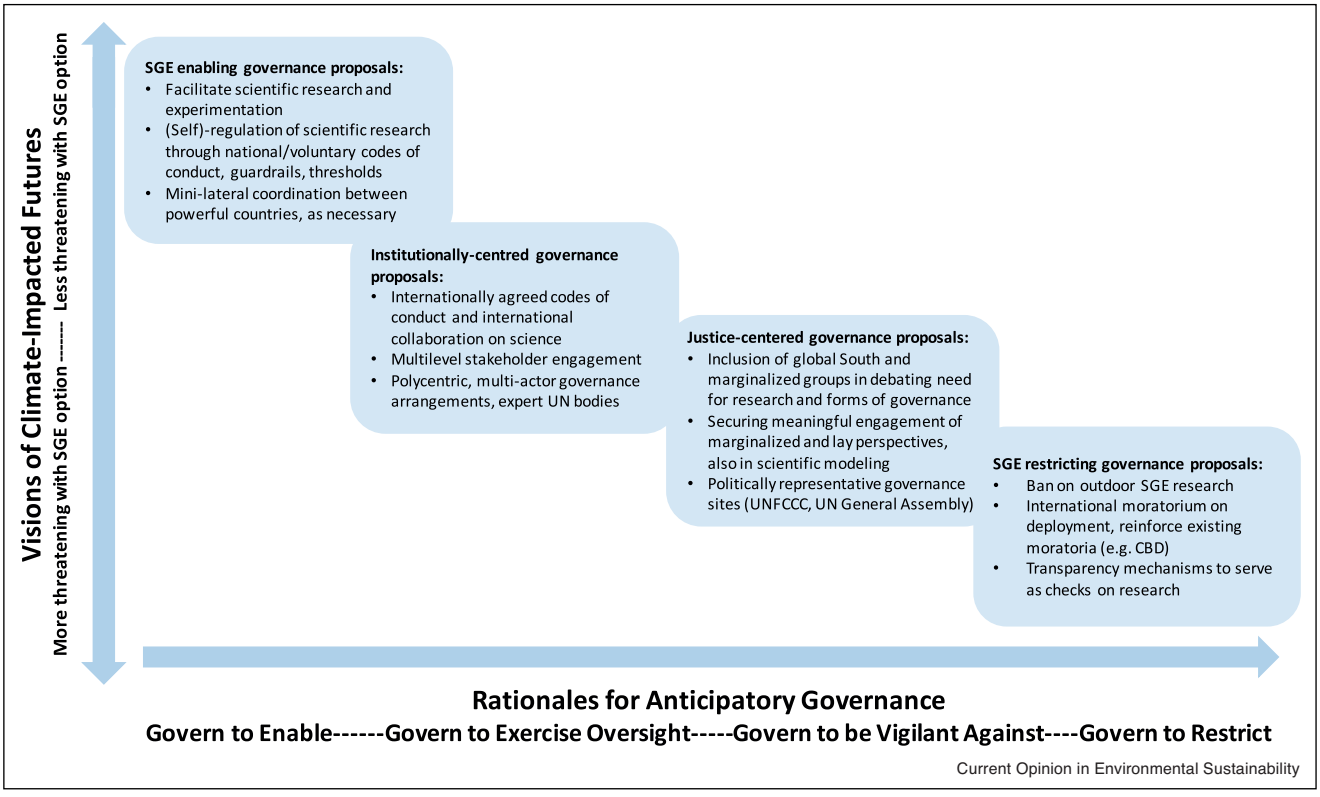
Such changes could be stimulated in a variety of ways: through protest, deep societal transitions, or transfer of more power to the people. Concrete governance proposals relating to solar geoengineering focus on placing restrictions on research, development and future deployment. This includes calls to oppose solar geoengineering research [82] and demand legally binding international moratoria and prohibitions on outdoor research and deployment [80–84]. These latter commentators refer to a 2010 decision under the Convention on Biological Diversity (CBD) as a much-needed 'de facto moratorium' on solar geoengineering activities, and as an important and effective step in the right direction.

Discussion and conclusion

The very call for anticipatory governance of solar geoengineering is linked to diverse visions of a future impacted by climate change. Such visions include seeing a climate-impacted future as more or less threatening, depending on whether it includes the possibility of solar geoengineering. As we have shown here, these visions underpin diverse rationales to seek anticipatory governance of solar geoengineering. These visions and rationales are not always explicit, however, nor have their political implications or implications for design of governance been adequately scrutinized.

We took a first step in this article to untangle these interrelationships. Our discussion is synthesized in Figure 1 below. The horizontal access depicts the four rationales for governance that we have identified, as a spectrum from 'to enable', 'to exercise oversight over', 'to be vigilant against' and 'to restrict' the future possible use of solar geoengineering. The vertical axis distinguishes between visions of climate-impacted futures seen as *more threatening with* the possibility of solar geoengineering,

Figure 1



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versus *more threatening without* the possibility of it. We then map governance proposals against these two axes. Our review helps to explain why different governance proposals exist, and reveals the importance of highlighting diverse visions of the future and rationales for governance in this controversial space.

As we noted at the outset, our categorizations are intended as ideal types rather than signalling hard boundaries. As do all typologies, ours too simplifies reality by presenting differences more starkly. In practice, the four rationales for governance overlap rather than being wholly separate and distinct, with differences between some of them being more of emphasis. Furthermore, some governance proposals can be listed under more than one rationale. Often (but not always) these relate to neighbouring boxes, as depicted in Figure 1. Thus, a call to enable the future prospect of solar geoengineering, should it be deemed necessary, often goes hand in hand with acknowledging the need for international codes of conduct or multi-stakeholder involvement. Those advocating for polycentric governance of solar geoengineering also emphasize the need to involve the Global South. And those calling for a ban on outdoor research or a moratorium on deployment often highlight the need for meaningful representation and empowerment of actors who are underrepresented in the debate and in the science.

However, even if ideal-typical or overlapping, our categorization is useful for the analytical and heuristic purpose it serves, in drawing attention to important questions meriting further empirical research. As one example: even if governance proposals associated with different rationales are similar, our typology highlights that their starting points may be qualitatively distinct. These starting points can range from a primary concern with designing effective institutions for oversight to a primary justice-oriented concern with guarding against unequal harms. A striking proposition deriving from our review is thus that similar governance proposals may emanate from *quite distinct underlying rationales* for governance and may thereby seek to further quite different ends in practice.

In drawing attention to this, we preempt the risk of seeing more consensus than dissent in the many near-term solar geoengineering governance proposals in the literature. Instead, we show that surface similarities may elide quite distinct aims underpinning governance proposals. Thus, calls for participatory processes, codes of conduct or

deliberative engagement may be supported by those situated at quite different points along the 'why govern' spectrum. Our categorization helps to make this clear and provides an analytical hook for further empirical analysis. In particular, it draws attention to the fact that the devil will lie in the details. In other words, how governance proposals will actually get designed *in practice*, and to further what governance ends, remains an important question for future analysis.

We conclude by noting some additional implications of our analysis for future research and policy directions.

First, while our typology of rationales helps shed light on differences and similarities in governance proposals, it does not as yet fully unpack the *confluence of factors* that help explain these diverse visions and rationales themselves. Clearly, different ontologies, epistemologies, worldviews and values underlie diverse visions of a climate-impacted future and associated calls to enable or restrict future use of solar geoengineering. The confluence of factors may include, for example: divergent perspectives on the possibility of successful international cooperation, effectiveness of multilateral approaches, or whether markets, technologies or institutions are the best way forward in redressing the worst exigencies of the climate crisis. Identifying these meta-explanatory factors underpinning our categorization is beyond the scope of this present review, yet our analysis provides an important entry point for studying these questions further.

Second, most actors currently discussing solar geoengineering are natural scientists, climate modelers and social scientists writing about governance; policy makers are only beginning to be involved [85]. Yet such expert visions are important, since they have the power to *de facto* shape the future governance and policy landscape for solar geoengineering [86]. If so, further empirical analysis can shed light on which scientific disciplines and/or actor networks are associated with the diverse future visions and governance rationales we identify here (for example, social network analysis could be used to document actor coalitions subscribing to specific rationales). Such an analysis can help to shed light on *whose* visions and rationales are *performative* in steering and shaping emerging anticipatory governance trajectories [87,88].

Third, this leads to an important related question: which of these governance rationales dominates in the scholarly literature, in scientific assessment processes and policy practice to date, if any? While answering this question too requires additional empirical analysis, a first indication is provided by our review. As it currently stands, the rationale of 'governing to restrict' is relatively marginalized in scholarly debates, as are associated governance proposals for research restrictions, or bans and moratoria on deployment. Much more attention is paid instead to debating the design of anticipatory governance arrangements to limit harm, ensure participation, exercise oversight or enable the future possible use of solar geoengineering. Further empirical work to confirm this finding would also help to illustrate how specific visions and governance trajectories *co-evolve*, and how solar geoengineering thus comes to be constituted as an object of governance [89,86].

With a number of political and research-related developments now underway (including small-scale experimentation with solar geoengineering techniques in the United States[2] or the discussion of climate engineering within the United Nations Environment Programme),[3] debates about the need for solar geoengineering and its governance may move from the fringes of climate research and policy to becoming more 'normalized'. Continued evocation of a climate crisis may also lead some policy makers to consider solar geoengineering as a potential policy option in the foreseeable future, as evident from discussions in the United States Congress.[4] This greatly increases the political stakes in understanding diverse perspectives on anticipatory governance of solar geoengineering, given that these perspectives have important consequences for policy choices in the present and the near future.

Conflict of interest statement

Nothing declared.

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Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

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Asayama *et al*. place solar geoengineering in a context of global environmental change research, explaining how so-called 'solutionist' approaches (encouraged by the Anthropocene narrative) are leading to extreme solutions, and how such solutions often meet resistance. To move forward, they suggest switching to an 'experimentalist' approach, in which the process of deciding research agendas becomes inclusive and thereby decreases polarization. This is one of the few governance proposals that places solar geoengineering research in a wider (but concrete) scientific and political context, making it interesting for a broader audience.

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Foley, Guston and Sarewitz provide an introduction to the concept of anticipatory governance and identify three important conditions for its realization. They then analyse various climate engineering governance proposals, concluding that the three conditions are superficially present but not fully developed nor harmonized. The chapter gives a good definition of what anticipatory governance can mean and how it has been applied to date in various climate engineering governance proposals.

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