EMERGING ANTICIPATORY GOVERNANCE OF SOLAR GEOENGINEERING: ANALYSING ITS NATURE AND IMPLICATIONS

by

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ABSTRACT

Solar geoengineering, speculative technologies aimed at mitigating global temperatures by reflecting sunlight back into space, has garnered significant attention and debate within scholarly and political spheres. Despite being in its early stages, solar geoengineering as an addition to the climate policy portfolio has evoked considerable attention and remains a highly controversial matter, prompting calls for anticipatory governance. Navigating this anticipatory governance landscape is fraught with challenges amid normative and scientific uncertainties. This study delves into the emerging anticipatory governance of solar geoengineering, focusing on its nature and implications. Within this framework, both *de jure* and de facto forms of governance play roles in shaping the trajectory of these technologies. Examining Decision X/33 by the CBD in 2010 and a UNEA draft resolution on solar geoengineering in 2019 as key *de jure* governance attempts, this study highlights scholarly contestations surrounding their meaning and significance. Additionally, this study analyses three expert-led non-state initiatives as emerging de facto governance sources: the Solar Geoengineering Non-Use Agreement, the Climate Overshoot Commission, and the Call for Balance initiative. It explores their interventions, potential de facto governance effects, and implications for *de jure* governance. The findings reveal that each initiative seeks to shape and influence the trajectory of solar geoengineering in distinctive ways, (de)normalizing research and its consideration as a climate policy option, corresponding to their respective stance on specific controversies in the field. These overall findings of this study underscore the challenges in constructing anticipatory governance, particularly regarding the construction of formal governance frameworks, the potential influence of scholarly collectives on shaping governance discourse, and the recognition of the inherent uncertainties associated with solar geoengineering.

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LIST OF ABBREVIATIONS

CBD	Convention on Biological Diversity
CDR	Carbon dioxide removal
COMEST	World Commission on the Ethics of Scientific Knowledge and Technology
COP	Conference of the Parties
ETC Group	Action Group on Erosion, Technology and Concentration
IPCC	Intergovernmental Panel on Climate Change
SAI	Stratospheric aerosol injection
SBSTTA	Subsidiary Body for Scientific and Technological Advice
SCoPEx	Stratospheric Controlled Perturbation Experiment
SPICE	Stratospheric Particle Injection for Climate Engineering
SRM	Solar Radiation Management
UN	United Nations
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly

1. INTRODUCTION

The latest IPCC report shows that unless urgent and radical action is taken, the Paris Agreement's commitment to strive to limit global warming to below 1.5 degrees above pre-industrial levels is likely to be exceeded within two decades (Intergovernmental Panel on Climate Change [IPCC], 2021). In response to countries insufficiently cutting their GHG emissions, and the impacts of climate change becoming more serious, some are looking for solutions other than mitigation and adaptation measures (Jinnah et al., 2018; Keith, 2013; Parson & Reynolds, 2021; Reynolds, 2019a). Some see 'climate engineering,' deliberate large-scale climate interventions to address global warming, as a viable 'Plan B' policy option. These technological interventions are often categorized into carbon dioxide removal (CDR) and solar radiation modification (SRM) techniques (Shepherd, 2009). Where CDR methods aim to reduce global warming by removing carbon dioxide, SRM methods aim to alter the Earth's shortwave radiative balance with the goal of reducing global temperatures (IPCC, 2018). This study focuses solely on SRM technologies, also referred to as solar geoengineering. Various solar geoengineering technologies have been proposed, encompassing approaches such as marine cloud brightening, cirrus cloud thinning, space-based techniques, and stratospheric aerosol injection, among others. Despite being in the early stages of conceptualization and development, solar geoengineering as an addition to the climate policy portfolio has evoked considerable attention and remains a highly controversial matter (Gupta et al., 2020). While such technologies thus remain largely speculative, there has been considerable debate surrounding their potential application, implications, and desirable governance mechanisms (Gupta et al., 2020).

It should be emphasized that some scholars in the field advocate for explicitly distinguishing between SRM and CDR instead of using the broader terms 'climate engineering' or 'geoengineering'. Despite the focus of this study being on solar geoengineering, the terms 'climate engineering' and 'geoengineering' are also used to refer to solar geoengineering as a technology that aims to deliberately "alter the climate system in order to alleviate the impacts of climate change" (IPCC, 2013, p. 1454). The justification of the utilization of the term 'geoengineering' is in accordance with its current usage in international frameworks and, more importantly, to stress the magnitude of the proposed actions, which encompass *deliberate large-scale climate interventions*. Furthermore, the terms 'solar geoengineering' and 'solar radiation modification' are used interchangeably to describe activities that extend beyond the territory of the state responsible for them, encompassing large-scale field testing to global deployment of

solar geoengineering methods. Primarily, these terms refer to the most prominently discussed method known as stratospheric aerosol injection (SAI). This method entails intentionally spraying reflective particles into the stratosphere, to reduce incoming sunlight from reaching the earth's surface, thus reducing global temperatures (Irvine et al., 2016). Often parallels are drawn to the natural phenomenon of volcanic eruptions, which have historically led to temporary global cooling due to the scattering of sunlight by the sulphate aerosols, where SAI would mimic these cooling effects observed (Irvine et al., 2016). Implementing stratospheric aerosol injection would necessitate a substantial and potentially multi-decadal commitment, including injecting reflective aerosol particles potentially totalling "a million or more tonnes per annum" (Baskin, 2019, p. 2). The extent of this commitment is contingent on hypothetical deployment scenarios and the intended cooling effect. Importantly, terminating such activities might pose serious climatic 'bounce-back' risks, also known as termination shock (Baskin, 2019, p. 2). Beyond reducing the planet's overall temperature, other potential climatic effects encompass reduced precipitation, droughts, disruption of monsoons, and damage to the ozone layer (Baskin, 2019; Biermann et al., 2022).

The idea of solar geoengineering *as a climate policy option* emerged around the mid-2000s (Baskin, 2019). The idea of geoengineering the climate can be traced back to the post-Second World War period. A period characterized by a strong belief that it was possible and desirable to alter the environment on a global scale. This shifted in the early 1970s, due to several changes in the political, cultural, and economic landscape, and growing environmental awareness. As a result, discussions of climate engineering became largely taboo. The re-emergence of climate engineering as a policy option can be dated around the publication of Nobel prize winner Paul Crutzen's "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to resolve a policy dilemma?" in 2006 (Baskin, 2019). The subsequent period is characterized by a significant increase in assessment reports, scientific papers, indoor experimentation and modelling, and the planning of small-scale outdoor experiments (Baskin, 2019; Jinnah et al., 2018). Despite the renewed interest in solar geoengineering as a potential climate policy option, debates within scholarly and political spheres, along with associated research efforts, continue to be highly divided and contentious.

Advocates of this speculative technology, consisting of a small group of academics from elite institutions mainly in the Global North (as discussed by Bierman & Möller, 2019; Jinnah et al., 2018; Stephens & Surprise, 2020), praise solar geoengineering techniques, among others, for their potential low costs, effectiveness, and simplicity (Keith, 2013; MacMartin et al., 2018). The main argument put forward by proponents of SRM research and potential deployment is

often along the lines of it being "sadly necessary given the state of climate change" (Baskin, 2019, p. 3). The argument continues that SRM might help to prevent severe, potentially catastrophic, climate change risks and may 'buy time' for humanity to radically cut emissions. It is often portrayed as a 'lesser evil' or "a bad idea whose time has come" (Baskin, 2019, p. 3). Most scholars within this group emphasize that mitigation and adaptation should be given priority, with SRM having a supplementary role within the climate policy portfolio.

Opponents of this form of climate intervention have criticized solar geoengineering technologies for not addressing the underlying cause of climate change and for its potential to introduce new environmental, political, ethical, and social risks. According to leading climate scientists, the concept of "fixing" the climate by manipulating the Earth's albedo is "wildly, utterly, howlingly barking mad" (Pierrehumbert in Baskin, 2019, p. 3). Scholars question the legitimacy of solar geoengineering research and its possible future deployment (Biermann et al., 2022). They emphasize how the potential risks of large-scale deployment are poorly understood and most likely unequally distributed, disadvantaging those regions that are already more vulnerable to the impacts of climate change (Biermann et al., 2022). Furthermore, they stress how more research will not eliminate the known risks nor give solutions for addressing unknown risks that, as argued, will only become evident until there is full-scale deployment (Biermann et al., 2022). This group of scholars highlights how research efforts and funding in this area are a distraction from mitigation and adaptation efforts, often referred to as presenting a moral hazard (McLaren, 2016). Despite these different stances of scholars, there is a general call for the (anticipatory) governance of solar geoengineering research, development, and future deployment. The question of whether, how, by whom, and to what end the governance of solar geoengineering should take place is central in scholarly, policy, and popular disputes (Gupta et al., 2020; Reynolds, 2019b). It is important to highlight that governance can occur at regional, national, or international levels. However, considering the global scale and impact of most proposed methods, this study focuses specifically on the emerging global anticipatory governance of solar geoengineering.

Solar geoengineering can be characterized as an anticipatory governance challenge. One definition of anticipatory governance is "governance in the face of extreme normative and scientific uncertainty and conflict over the very existence, nature, and distributive implications of future risks and harms" (Earth System Governance, n.d.). As argued by Gupta et al. (2020), given that "the very contours of the 'object of governance' remain uncertain and largely even unknowable" the governance of solar geoengineering can be characterized as an anticipatory challenge (Gupta et al., 2020, p. 10). Similarly, Biermann et al. (2022) emphasize that "[e]ven

with more research, there is deep-seated disagreement about whether the risks and effectiveness of solar geoengineering could ever be fully understood before deployment, and whether specific effects could be attributed afterwards to such interventions" (p. 2-3). Given the extreme normative and scientific uncertainty that characterizes solar geoengineering, establishing (anticipatory) governance presents a significant challenge. This challenge extends beyond disputes about the technology itself and the potential impacts, to contentious issues related to whether, how, by whom, and for what purpose the governance of solar geoengineering should occur. These debates range from proposals advocating for restricting further consideration of solar geoengineering to those supporting its potential enablement and use (Gupta et al., 2020).

1.1 Problem statement

Despite some efforts to address the governance of solar geoengineering in formal state-led international policy forums, these endeavours are frequently described as both limited and contested. One notable attempt at establishing governance of solar geoengineering at an international level is the adopted Decision X/33 during the tenth meeting of the Conference of the Parties of the Convention on Biological Diversity (CBD) in 2010. This included a section on "climate-related geoengineering and its impacts on the achievements of the objectives of the CBD" (Convention on Biological Diversity [CBD], 2017). A second example of an attempt to discuss the governance of solar geoengineering internationally was during the fourth session of the United Nations Environment Assembly (UNEA) in March 2019, where delegates discussed a draft resolution on geoengineering and its governance. The significance of these two attempts at international political engagement with the governance of solar geoengineering is disputed according to scholars considering, among others, a lack of legally binding agreements, debatable institutional fit, or failed intended outcomes (Harvard University, 2019; Sugiyama and Sugiyama, 2010). Therefore, scrutinizing the nature and implications of these emerging *de jure* governance efforts, and how these have been interpreted and framed in academic literature so far, remains a key task for governance scholars.

Given these limited and contested formal (*de jure*) forms of governance, a key claim by various governance scholars is that solar geoengineering "remains a largely ungoverned space, with shared norms, institutional arrangements, and formal rules to regulate [climate engineering] not yet present" (Gupta and Möller, 2019, p. 480). In contrast to this claim, Gupta and Möller (2019) argue that climate engineering is an already governed space. They argue that apart from these limited and contested *de jure* forms of governance, alternative forms of

governance are emerging. In particular, they argue that emerging *de facto governance* of climate engineering, including solar geoengineering, is observable. They define de facto governance as "sources of governance that are unacknowledged and unrecognized as seeking to govern, even as they exercise governance effects" (Gupta & Möller, 2019, p. 481). They identify authoritative assessments as a key source of de facto governance in the case of climate engineering, where authoritative assessments are defined as "expert-led, multi-author assessments produced by eminent scientific bodies advancing state-of-the-art understandings of novel and politically contested environmental and technological fields" (Gupta & Möller, 2019, p. 481). These assessments are often viewed as neutral and legitimate sources of knowledge given the associated institutional context they emanate from. Gupta and Möller (2019) describe how these assessments de facto shaped climate engineering "as an object of governance through demarcating and categorizing this emerging field of inquiry," and more importantly how these assessments contribute to the normalisation and institutionalisation of climate engineering research (p. 480). Similarly, Owen (2014) has explored "the role of expert reports and expert-generated principles as sources of de facto [climate engineering] governance" (in Gupta & Möller, 2019, p. 483). Another example, as shown by Oldham and colleagues (2014), is how research funding and patent trends have the potential to "de facto shape the development of the field" (p. 1).

These examples highlight how unacknowledged de facto sources of governance have the potential to influence the context in which *de jure* types of governance emerge. Given a lack of openly stated goals and political oversight, scrutiny of de facto sources of governance in the case of solar geoengineering, and the potential implications for *de jure* governance, remains another main task for governance scholars (Gupta & Möller, 2019). To further substantiate the timely nature of this scrutiny, Hulme (2012) emphasizes that research into new technologies, such as solar geoengineering, influences the possibility of their deployment. He argues that "the consequences of 'just' researching such technologies need to be evaluated upfront" (Hulme, 2012, p. 697). Therefore, scrutinizing key sources of de facto governance of solar geoengineering and the potential political implications of these is urgent, timely, and significant. As Gupta and Möller (2019) put it "[w]e need to better understand who is empowered by specific acts of de facto governance, and what the geopolitical implications of such governance might be" (p. 497).

In addition to authoritative assessments, expert-generated principles, research funding, and patent trends that have been scrutinized as key sources of de facto governance, there is a growing number of non-state initiatives led by experts that can be characterized as such. These

initiatives may play an influential role in shaping the governance field of solar geoengineering, as their activities can be viewed as legitimate sources of knowledge given the associated 'expert' context they emanate from. While these initiatives have the potential to exercise governance effects, their informal and non-state-driven nature places them beyond political oversight. Therefore, the scrutiny of the nature of these emerging expert-led non-state initiatives as a source of de facto governance and an exploration of their potential governance implications remain critical tasks for scholars specializing in governance studies.

1.2 Research objective and questions

Seeking anticipatory governance of solar geoengineering is an ongoing challenge, subject to growing scientific and public debates. Existing *de jure* governance efforts are perceived to be limited and contested. Simultaneously, there is an increasing number of expert-led initiatives that have the potential to shape the solar geoengineering governance field. Based on the aforementioned problem statements, this study aims to capture the emerging anticipatory governance of solar geoengineering, by analysing its nature and implications. To achieve this, this study employs both a *de jure* and a de facto approach to capturing emerging governance. It provides: i) an examination of the nature of international *de jure* governance attempts for solar geoengineering; ii) an analysis of how these *de jure* governance attempts have been interpreted and framed in scholarly literature thus far; iii) an exploration of the implications of these *de jure* governance attempts; iv) an examination of emerging expert-led non-state initiatives as sources of de facto governance in the solar geoengineering context, analysing their de facto intervention, potential governance effect, and implications for (future) *de jure* governance. By addressing these aspects, the study aims to offer insights into the key anticipatory governance challenges for solar geoengineering at present. The general research questions (GRQ) and sub-research questions (SRQ) guiding this study are:

GRQ: How is solar geoengineering being governed globally at this juncture in time and with what implications?

SRQ1: How is solar geoengineering *de jure* being governed at a global level?
SRQ2: How is scholarly literature interpreting the attempts at *de jure* governance for solar geoengineering?
SRQ3: What (political) implications have arisen from the *de jure* governance efforts for solar geoengineering?

SRQ4: How do expert-led non-state initiatives as de facto sources of governance intervene in the solar geoengineering governance landscape?
SRQ5: What are the potential de facto governance effects of expert-led initiatives?
SRQ6: What are potential implications for future *de jure* governance of expert-led initiatives as de facto sources of governance?

To clarify, addressing the *general research question* is accompanied by a set of sub-research questions, each distinctly aligned with either *de jure* or de facto governance approaches adopted in this study. These approaches are grounded in conceptual considerations, recognizing that emerging anticipatory governance encompasses both *de jure* and de facto sources of governance, as is further elaborated on in the conceptual chapter. The initial sub-research question aims to outline the relevant, albeit limited, *de jure* governance attempts in the context of solar geoengineering. This inquiry is substantiated by sub-research questions two and three, which seek to empirically analyse how these efforts have been interpreted in scholarly literature, and explore the implications arising from these endeavours. Together, these objectives constitute the first empirical part of this research.

The fourth sub-research question examines the role of expert-led non-state initiatives as significant de facto sources of governance in the context of emerging anticipatory governance of solar geoengineering. The fifth and sixth sub-research questions contribute by empirically assessing the potential de facto governance effects and the implications for *de jure* governance concerning these initiatives. These objectives collectively form the second empirical part of this research. These empirical findings are then evaluated in relation to the broader conceptual framework of emerging anticipatory governance for novel technologies and the associated challenges.

1.3 Roadmap

The outlined research questions function as guiding principles throughout this study and are explored in detail throughout the subsequent chapters. In Chapter 2, a comprehensive conceptual framework is presented, introducing and justifying the two analytical lenses employed for the *de jure* and de facto approach to explore the emerging anticipatory governance of solar geoengineering. Chapter 3 outlines the general research design, including the case selection and descriptions, and research methods used. Chapters 4 and 5 present the empirical findings derived from the analysis, structured around the study's main aims and approaches. In

Chapter 4, the focus is on the two identified *de jure* governance attempts that address solar geoengineering within the international context. It examines the nature, academic interpretation, and implications of the two cases: Decision X/33 by the Convention on Biological Diversity in 2010 and the 'Draft Resolution on Geoengineering and its Governance' issued during the fourth session of the United Nations Environmental Assembly in 2019. Chapter 5 elaborates on the three identified expert-led non-state initiatives as sources of de facto governance, detailing their organizational features, including objectives, drivers, funding, and activities. It also explores how these initiatives attempt to intervene in the broader context of controversies within the solar geoengineering governance landscape, their potential de facto governance effects, and the potential implications for *de jure* governance. Chapter 6 provides the conclusion and discussion of this study, presenting a synthesis of the key findings and their interpretation within the context of existing literature. The chapter answers the overarching research question by elaborating on the current state of global governance of solar geoengineering. Subsequently, it discusses key insights into the primary challenges associated with emerging anticipatory governance in this context. These insights are followed by reflections on the methodological and conceptual aspects of this study, and concludes with suggestions for further inquiry.

2. CONCEPTUAL FRAMEWORK

This chapter elaborates on the conceptual framework of this research. First, by building on existing literature, the concepts of governance, anticipatory governance, and emerging technologies are explored to gain insights into the challenges of anticipatory governance posed by new and emerging technologies such as solar geoengineering. Second, this chapter elaborates on the significance of critically examining future imaginaries and related claim-making, and the role of vanguard visions in the context of the limited *de jure* governance attempts of solar geoengineering. This is followed by the introduction of the analytical lens employed for the *de jure* approach to explore the emerging anticipatory governance of solar geoengineering. Thereafter, the concept of *de facto governance* as distinct from *de jure governance* is conceptualized, followed by the introduction of the analytical lens used for exploring expert-led non-state initiatives as de facto sources of governance.

2.1 New and emerging technologies and the notion of anticipatory governance

New and emerging technologies are a challenge to governance (Rip, 2018). To understand the governance challenges associated with new and emerging technologies such as solar geoengineering, an understanding of the concepts and interrelationships of (global) governance, anticipation, and emerging technologies is needed. In the most general sense of the concept, as argued by Rip (2018), *governance* is "all structuring of action and interaction that has some authority and/or legitimacy" (p. 76). Foley et al. (2018) define governance as "a broad-based societal capacity to make collective decisions" (p. 225). While there is no unequivocal definition of (global) governance, common characteristics among definitions in the field of social sciences include the involvement of a combination of formal and informal processes and institutions that guide and regulate the collective activities of a group, addressing global issues (Renn et al., 2011). Governance viewed in this way is not limited to governmental or state actors but also encompasses international organizations, non-governmental institutions, economic forces, civil-society interests, and public-private interactions that are involved in addressing transnational problems and shaping practices at the global level (Foley et al., 2018). The concept of governance as understood here, suggests a shift in focus from the traditional top-down approach of (inter) government action to a broader notion of power and decision-making, including both public and private actors (Lo, 2018; Renn et al., 2011). Governance then, is the result of the dynamic interplay between a variety of actors who differ in their problem

definitions, goals, and strategies to achieve those (Rip, 2018). In contrast to a hierarchical structure, governance is characterized by a non-hierarchical structure and distributed power that includes both state and non-state actors who collaboratively establish regulation or policies without one dominant authority (Rosenau, 1992; Renn et al., 2011). According to Renn et al. (2011), non-state actors are increasingly playing a significant role in governance processes due to their informational and resource advantages over governmental agencies. Therefore, governance also involves conflicting interests and competition for dominance, where governance can take place in a variety of contexts that interact, such as research and academia, public discourse, companies, policy-making, and other venues (Rip, 2018). To understand the distinctive features of anticipatory governance compared to a more general approach to governance as outlined above, it is essential to comprehend the notion of anticipation.

Anticipation, as understood by Foley and colleagues (2018), "expresses a particular kind of disposition towards the future governance" (p. 226). They argue that all forms of governance necessitate "some explicit disposition towards the future" (p. 226). Anticipation is not about "seeing into the future (prudence) or saying what the future is going to be (prediction), or estimating the chances of a certain outcome (probabilistic forecasting)" (Foley et al., 2018, p. 225). Unlike prudence, prediction, or probabilistic forecasting, which begins with an understanding of the situation before acting—or as Sarewitz (2011) refers to a "knowledge first" approach—anticipation does not. Rather, anticipation is about doing something now "like building a capacity, in preparation for something that might occur in the future" (Foley et al., 2018, p. 226). Or as understood by Vervoort and Gupta (2018), anticipation is "a general term for formal or informal processes that attempt to make sense of uncertain futures" (in Muiderman et al., 2022, p. 1). Anticipation shares similarities with precaution but differs by not relying on a specific demarcation between action and inaction, and it does not necessarily wait for more research or data to ease uncertainty. In other words, precaution often implies a waiting game "that is potentially self-defeating," where anticipation recognizes that radical uncertainty is an inherent part of the decision-making process (Foley et al., 2018, p. 226). Anticipation differs from prediction in that it does not rely on ideas of "rational" decision-making nor considers the future as something that can be predicted, but rather as something that can be created through interactions among a variety of worldviews, technological advances, political activities, and others. Anticipatory governance attempts to make these interactions visible when making decisions about technological advances (Foley et al., 2018).

A broadly accepted definition by Guston (2014) is *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" (p. 217). Another definition as provided in global environmental governance literature, is "the attempt to govern under conditions of extreme scientific uncertainty and normative conflict over the very existence and nature of future environmental and technological risk and harm" (Muiderman et al., 2020, p. 5). Moreover, according to Muiderman et al. (2020), anticipatory governance involves directing or guiding present actions to interact with, adjust to, or influence uncertain futures. Muiderman and colleagues (2020) suggest that a significant portion of literature in social and sustainability sciences discusses anticipatory governance, whether the term is explicitly mentioned or not. Following this, and as conceptualized in this study, anticipatory governance differs from a conventional governance approach by specifically addressing highly contested issues characterized by (extreme) structural uncertainty, often associated with the distributive implications of future harms and risks related to emerging technologies. Risks are understood comprehensively, encompassing not only technical aspects but also social, economic, and ethical dimensions. Anticipatory governance is distinct from 'risk governance,' which applies governance principles to the management of (known) risks (Renn et al., 2011). To summarize, in this study, anticipatory governance is defined as the process of making decisions in the present based on imperfect information regarding potential future risks, while avoiding assumptions about the feasibility of managing, mitigating, and resolving such uncertain and unknown risks. However, it should be noted that anticipatory governance is subject to diverse interpretations and applications within academic communities. Various fields of study engage with anticipation, including Science and Technology Studies (STS), Responsible Research and Innovation (RRI), public administration and management, and environmental sciences. These fields of study engage with anticipation processes in different ways and vary in their conceptualization and engagement with the future, and consequently, the preferred approaches and tools relied on (Muiderman et al., 2020).

Why do emerging technologies, such as solar geoengineering, pose a challenge for anticipatory governance? According to Rotolo et al. (2015), emerging technologies are novel and rapidly advancing, holding the potential for significant socio-economic impact while carrying uncertain and ambiguous future outcomes. The inherent uncertainties associated with these technologies and their trajectory make adopting a predictive or precautionary approach to their governance difficult or undesirable, if not impossible. Rip (2018) argues that the primary challenge in governing new technologies lies in the uncertainty surrounding their functionalities and associated risks, often termed as presenting a technology control dilemma for decision-makers, also referred to as the "Collingridge dilemma". This dilemma involves the tension

between early regulatory control, where uncertainties are high but influence is possible, and the difficulty of implementing (state-based) control later when the technology is already embedded in societal structures (Oldham et al., 2014). The challenges of governing emerging technologies are underscored by their characteristics, making the design of formal and legally binding (*de jure*) governance a challenging task, specifically given the reactive nature of global governance (Foley et al., 2018; Jinnah, 2018; Rip, 2018). *De jure* governance is understood here as formal, legal, and officially recognized structures, rules, and regulations, encompassing institutional arrangements, laws, and norms that are openly stated and subject to political oversight. In other words, *de jure* governance refers to a structured and regulatory framework for managing the development, deployment, and impacts of emerging technologies.

In response to the challenges outlined above, the concept of anticipatory governance is increasingly applied to emerging technologies (Oldham et al., 2014). Notably, the origin of anticipatory governance is linked to the mid-1970s shift in "theory, practice, and policy towards an explicit commitment to anticipatory governance to address the uncertain futures of emerging technologies" (Foley et al., 2018, p. 227). These changes signify a recognition that technology in society cannot be reliably predicted and controlled. This ideally necessitates the integration of social and natural sciences, as well as forms of public engagement, to achieve a more comprehensive understanding of the complex relationship between emerging technologies and society (Foley et al., 2018). Despite the recognition of the importance of anticipatory governance, challenges persist. Foley et al. (2018) highlight that one of the key challenges relates to moving beyond a "knowledge first" approach and instead, initiating engagement that involves anticipatory knowledge without necessarily making predictions or probabilistic forecasts. However, in the context of solar geoengineering, Baskin (2019) notes that the epistemological implications of acknowledging radical uncertainty are often sidestepped, instead of dealt with.

Despite the considerable body of literature on anticipation and anticipatory governance, Jinnah (2018) argues that in practice there is often a failure to proactively establish regulatory frameworks in anticipation of potential issues arising from emerging technologies like solar geoengineering. This highlights the need for a critical examination of existing *de jure* governance endeavours in this domain. Moreover, a limited nature or perceived absence of *de jure* governance should not be misconstrued as an ungoverned space. Governance takes diverse forms, a point highlighted above, and informal mechanisms can be equally significant as formal regulations. The concept of de facto governance, aimed at understanding less acknowledged and informal steering mechanisms, is a crucial element within the broader anticipatory

governance framework, contributing distinctively to shaping the trajectory of emerging technologies, a topic further explored in section 2.6.

2.2 Anticipatory governance and the critical interrogation of future imaginaries

To comprehend the significance of scrutinizing interpretations of emerging *de jure* governance efforts in scholarly literature, it is essential to critically interrogate future imaginaries within anticipatory processes. As indicated by the aforementioned definition provided by Muiderman and colleagues (2020), the nature of emerging anticipatory governance is contingent, in part, on how future risks and harm associated with emerging technologies are imagined. A critical strand of research that engages with anticipatory governance emphasizes the need for the critical scrutiny of anticipatory practices and the (imagined) future visions underlying these, in both academic and political spheres. Anticipatory practices, as understood here, encompass not only established methodologies like scenario-building or participatory visioning but also actors engaged in contemplating (desirable) governance.

This approach to anticipatory governance criticizes the common lack of justification of and reflection on the underlying judgments of (dominant) desirable futures, as the extent to which the future is knowable and manageable (Muiderman et al., 2020; Vervoort & Gupta, 2018). Here, the future is characterized as one of irresolvable unknowns and uncertainties, and therefore not manageable as such. Any attempt to do so is "inevitably [privileging] particular ways of thinking and specific priorities" (Muiderman et al., 2020, p. 9). However, these often-contested framings of the future may have power over and shape present-day governance efforts in terms of resource distribution and other societal choices (Vervoort & Gupta, 2018). Claims about the future thus evoke specific imagined futures that can shape present choices and governance trajectories, including actions taken by decision-makers. For instance, McLaren and Corry (2021) illustrate that research constructing "futures" is inherently political, shaping expectations and constraining alternative policy options. Consequently, all statements about the future, whether in academic or political spheres, are regarded as political interventions, sometimes termed "fabrications of the future" (Jasanoff & Kim, 2015). From this standpoint, anticipation practices, concerned with constructing imagined futures, become arenas of political dispute and negotiation.

This understanding carries profound implications for present-day actions. The primary objective is to recognize and scrutinize the "discursive effects of frames or fabrications of the future as they are generated and advanced through practices of anticipation, and to study how

these exert power over the present" (Muiderman et al., 2020, p. 10). Scholars in this realm critically examine the implications of future imaginaries and related claim-making, exploring their impact on current governance choices (Muiderman et al., 2020). Specifically, this approach sheds light on how future visions "benefit or exclude certain policy choices, trajectories, sectors, investments, or interests of actors" (Muiderman et al., 2020, p. 10).

Therefore, this approach seeks to redirect the focus to the present, emphasizing the intricate political decisions that demand attention now rather than in an envisioned future. A central concern addressed in this approach, and as applied in this study, is the influence of expert knowledge and scientific expertise in shaping and engaging with diverse futures, questioning whether "expert-driven visioning is merely a technical process that can objectively and neutrally engage with the future" (Muiderman et al., 2020, p. 10). Therefore, scrutinizing expert-driven visioning on existing *de jure* governance attempts of solar geoengineering becomes crucial as it serves as an arena for political dispute and negotiation, as well as its potential to influence present and future governance trajectories. The examination is guided by the utilization of the concepts of *sociotechnical imaginaries* and *vanguard visions*, which are further elucidated in the following section.

2.3 The notion of vanguard visions and assertions on de jure governance attempts

Social scientists have extensively examined discourses, narratives, frames, and their constructive power concerning technology and its governance. Within this field, scholars have developed a comprehensive set of concepts to scrutinize the emergence of future visions as relevant narratives. These visions are mobilized by stakeholders with vested interests, subsequently informing and shaping present-day practices (Mager & Katzenbach, 2021, p. 224-225). Jasanoff and Kim (2015) term this phenomenon as "fabrications of the future," denoting how ideas and expectations of the future possess performative power and political implications in the present, by presenting certain futures as more desirable, conceivable, or even achievable than others (in Flegal & Gupta, 2018). As such, future visions, including those related to the potential role of solar geoengineering and what is viewed as desirable governance, may have performative power and carry political implications in the present. Related to this, the concept of *sociotechnical imaginaries* has become prominent in research that engages with describing and understanding "the co-production of technoscientific projects, social constellations, and politics," where it analyses the interplay of science, technology, and society (Mager & Katzenbach, 2021, p. 225). As defined by Jasanoff and Kim (2015), sociotechnical imaginaries

are “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology” (p. 4). These imaginaries, and the governance based on these, as argued by Jasanoff et al. (2007), “have the power to shape technological design, channel public expenditures, and justify the inclusion or exclusion of citizens with respect to the benefits of technological progress” (p. 1).

Similarly, Mager and Katzenbach (2021) describe how imaginaries matter in governing technology. They argue that sociotechnical imaginaries are multiple, contested, and commodified. First, sociotechnical imaginaries are multiple in the sense that several imaginaries are in circulation, varying in the extent to which they exert power. This multi-faceted and dynamic characteristic of sociotechnical imaginaries renders them the subject of contestation. Various actors “construct future expectations and strive to translate these into encompassing sustaining imaginaries” where some conflicting imaginaries run in parallel, and others seek dominance (Mager & Katzenbach, 2021, p. 226). In other words, there is an ongoing “process of negotiating the future” (Mager & Katzenbach, 2021, p. 227). Lastly, sociotechnical imaginaries are commodified meaning that not only state entities but also other actors, specifically commercial ones, can function as primary agents shaping influential imaginaries (Mager & Katzenbach, 2021, p. 227).

The concept that is closely linked to the performative power of imaginaries is *vanguard visions*, also referred to as *sociotechnical vanguards*. As understood by Hilgartner (2015), *sociotechnical vanguards* are “relatively small collectives that formulate and act intentionally to realize particular sociotechnical visions of the future that have not yet come to be accepted by wider collectives” (p. 34). These small collectives can be composed of academics, inventors, specific individuals, and corporations (Flegal & Gupta, 2018; Mager & Katzenbach, 2021). In the context of emerging technologies, such as solar geoengineering, these are typically dominated by academics, experts, and advocacy organizations. As Hilgartner (2015) emphasizes, vanguards are distinguishable from sociotechnical imaginaries in terms of scale. Where the former concerns a relatively small group of individuals, the latter is focused on the ambitions of larger collectives, such as nations. These concepts are related in a way that some vanguard visions can grow into sociotechnical imaginaries. However, as Hilgartner (2015) argues, these are considered to have done so when they become shared by larger and more stable groups. Flegal and Gupta (2018) similarly emphasize that vanguard visions “may play a vital role in the development, assessment, and governance of emerging technology, making scrutiny of their content and prospects for institutionalization urgent and timely” (p. 48).

For the purpose and scope of this research, scholars and academics actively engaged in the field of solar geoengineering governance are considered as constituting vanguard visions. Specifically, the term "sociotechnical vanguard" is used here to describe any researcher or 'expert' who addresses solar geoengineering governance in academic literature. Given the relatively early stage of the solar geoengineering governance debate and its controversial and contested nature, it is argued that vanguard visions on desirable governance in this field have not yet gained widespread acceptance. These circumstances allow for the observation of a collective of academics formulating and acting to realize a particular vision. Among others, this involves putting forth claims about the meaning and significance of the current *de jure* governance efforts. Moreover, considering the diverse, disputed, and commodified nature of sociotechnical visions (Hilgartner, 2015), it is expected that various interpretations concerning the meaning and significance of the governance attempts to date can be identified and should be, for the reasons mentioned above, critically interrogated. The examination of these emerging expert visions, and particularly the scrutiny of claims about existing *de jure* governance attempts, becomes crucial under the assumption that these vanguard visions can evolve into sociotechnical imaginaries. As such, they possess a degree of authority, potentially playing a crucial role in shaping emerging (anticipatory) governance of solar geoengineering (Flegal & Gupta, 2018). It is essential to highlight that Hilgartner's (2015) definition of vanguard visions incorporates an "intentional" aspect. Acknowledging the challenging nature of defining intention, it is presumed that scholars who publish research papers exert varying degrees of influence on the realization of a particular vision.

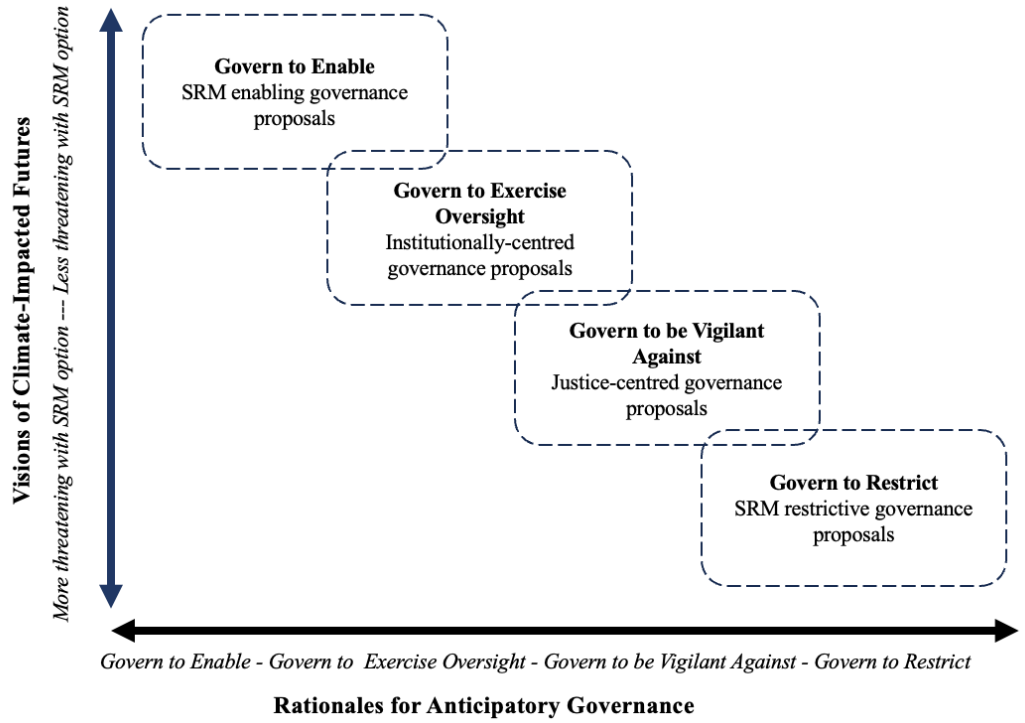
2.4 Rationales for anticipatory governance

To operationalize sociotechnical vanguards, and their vanguard visions on existing attempts at *de jure* governance, this study relies on previous work by Gupta and colleagues (2020). Gupta and colleagues argue that the core of controversies surrounding anticipatory governance of solar geoengineering is a result of divergent visions of "how a climate crisis might evolve and differing positions on whether solar geoengineering should ever be part of the response" (2020, p. 10). They note that "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" (2020, p. 11). Accordingly, these positions shape diverse rationales for seeking to govern solar geoengineering, ranging from enabling to restricting the technologies' research, development, and deployment. Based on these underlying visions of futures impacted by

climate change, the authors identify four ideal-type rationales for seeking governance of solar geoengineering, distilled from governance proposals found in literature: i) to enable the future prospect of solar geoengineering; ii) to exercise oversight if solar geoengineering is enabled; iii) to be vigilant against unequal harms if solar geoengineering is enabled; and iv) to restrict the future prospect of solar geoengineering (Gupta et al., 2020, p. 12-14). See Figure 1 for their synthesis of the interrelationship between these rationales, visions of a climate-impacted future, and governance proposals.

Figure 1

Rationales for seeking anticipatory governance for solar geoengineering



Note. Adapted from "Anticipatory governance of solar geoengineering: conflicting visions of the future and their links to governance proposals," by Gupta, A., Möller, I., Biermann, F., Jinnah, S., Kashwan, P., Mathur, V., Morrow, D.R. & Nicholson, S., 2020, *Current opinion in environmental sustainability*, 45, p. 15.

To comprehend the line of conflict between the contested underlying visions of the future and associated governance rationales, a brief description of the spectrum of four 'why govern' rationales outlined by Gupta and colleagues (2020) is provided below.

At one end of the spectrum, a group of actors articulates a rationale for anticipatory governance to *enable* the future prospect of solar geoengineering. This governance rationale flows from a future vision where a potentially necessary role for solar geoengineering in relation to the climate crises is imagined. This rationale is based on the assertion that the climate crisis cannot be effectively managed through mitigation, diplomacy, or behavioural change alone and that a 'Plan B' is necessary. As such, solar geoengineering is seen as essential to buy humanity time to develop a comprehensive response to the climate crisis, and as a back-stop option in case mitigation and adaptation activities prove to be insufficient and inadequate. This group proposes that anticipatory governance should remain "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" (Gupta et al., 2020, p. 13).

A second governance rationale is to exercise *oversight* over solar geoengineering if enabled. This rationale acknowledges the potential of the climate crisis putting human rights and biodiversity at risk, yet recognizes that such crises at some point might necessitate such interventions in a responsible manner. It also acknowledges that research into solar geoengineering is ongoing and may accelerate, and thus emphasizes the importance of effective governance mechanisms to control and steer such research and potential deployment. However, it is hoped that such technologies will never need to be deployed. This vision and associated rationale therefore actively move away from the 'enable' governance rationale by calling for strict oversight instead. Numerous proposals regarding research governance stem from this rationale, emphasizing the need for increased participation, transparency, technology assessment, and accountability. These proposals suggest measures such as developing codes of conduct and coordinated research programs. Additionally, there are calls for institutional arrangements to address questions surrounding the "whether and how" of future deployment of solar geoengineering. Here, governance debates are generally focused on "identifying the appropriate institutional (often expert-led) fora within which to embed anticipatory governance arrangements, with openness to these being voluntary as well" (Gupta et al., 2020, p. 13).

The third rationale for anticipatory governance is "to be *vigilant* against unequal harms posed by solar geoengineering if enabled" (Gupta et al., 2020, p. 13). This rationale starts with the premise that the world's poor and marginalized populations bear disproportionate costs of environmental pollution and burdens of environmental restoration, and are often excluded from discussions on solar geoengineering. Within this rationale, some view solar geoengineering as a policy option as a 'rich man's solution' to the climate crisis (Biermann & Möller, 2019).

Moreover, some have concerns about the potential unilateral deployment of solar geoengineering techniques. From this perspective, anticipatory governance requires "inclusive international settings where all countries can participate," especially vulnerable and marginalized groups (Gupta et al., 2020, p. 14). The importance of multilateral deliberation within different United Nations (UN) institutions is underscored, prioritizing governance that is politically negotiated rather than expert-led.

At the other end of the spectrum, a group of actors articulates a rationale for anticipatory governance to *restrict* the future prospect of solar geoengineering. Solar geoengineering is viewed as unnecessary and "potentially highly risky and dangerous in tackling a climate crisis" (Gupta et al., 2020, p. 14). Those advancing this rationale are concerned that exploring solar geoengineering as a climate policy option could impede the required low-carbon transition and further aggravate existing injustices, while at the same time weakening the "collective will to tackle the climate challenge" (Gupta et al., 2020, p. 14). This perspective highly resonates with the 'vigilant against' governance rationale, yet emphasizes that democratic governance of solar geoengineering is impossible and that it is presumptuous to assume otherwise. Moreover, there is a concern that the already-existing extreme structural inequalities in which the climate crisis is embedded may be further exacerbated if technological solutions, such as solar geoengineering, are advanced by those in positions of power. Contrary to the 'govern to enable' rationale, this perspective holds a sceptical view of technocratic solutions. Those advocating this vision call for the discouragement of research, development, and future deployment if not an entire prohibition. From this perspective, anticipatory governance requires "legally binding international moratoria and prohibitions on outdoor research and deployment" (Gupta et al., 2020, p. 14).

2.5 Operationalizing expert vanguard visions of de jure governance

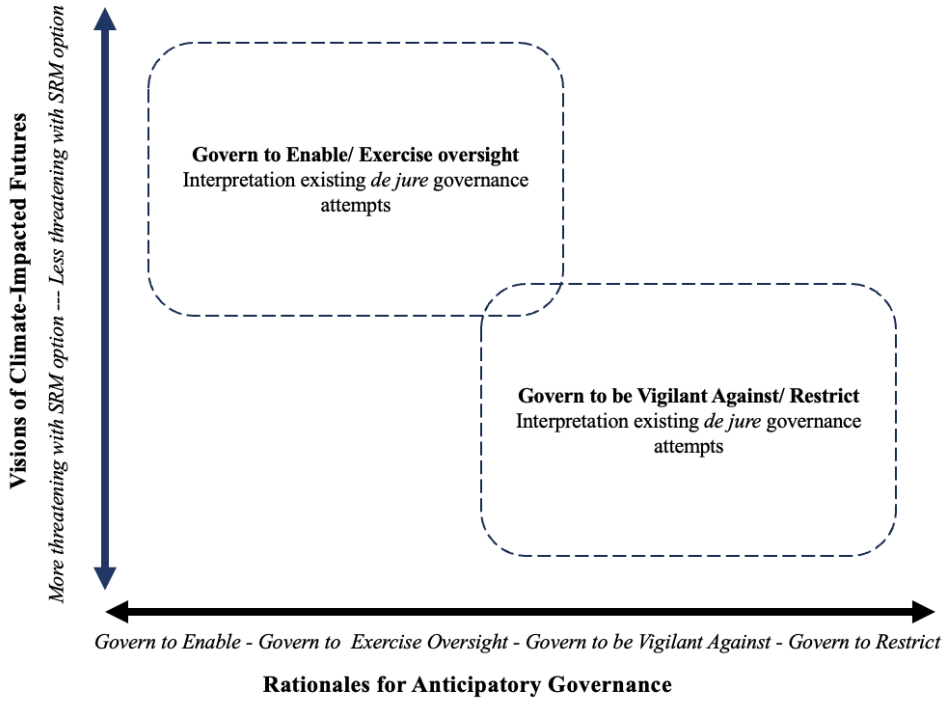
This study, specifically regarding the aim of scrutinizing interpretations and claim-making on *de jure* governance efforts as existing in the scholarly literature, builds on the classification of governance rationales provided by Gupta and colleagues (2020) in two ways. First, it explains why different interpretations and claim-making regarding the significance of the existing *de jure* governance of solar geoengineering in scholarly literature might exist. These differences are assumed to arise from the varying 'why govern' rationales and underlying visions held by scholars. Second, it groups these claims and interpretations accordingly, suggesting that scholars who advocate the 'govern to enable' rationale may interpret the significance of these

formal governance attempts similarly within this vanguard group, yet differ from those advocating a 'govern to restrict' rationale. In other words, it is expected that scholars advancing a 'govern to enable' rationale hold different assertions on the meaning and significance of these attempts compared to those advancing a 'governance to restrict' rationale. Therefore, this spectrum serves as an analytical tool to categorize and explain potential differences in interpretation and claim-making by academics as sociotechnical vanguards more broadly and examine how the academic literature falls within it. This examination is crucial as it brings to light the prevailing visions, governance rationales, and the specific claim-making related to *de jure* governance within scholarly literature, if any. Consequently, it could offer insights into which visions and rationales might play a performative role in directing and shaping the trajectories of emerging anticipatory governance.

In analysing the interpretations and claim-making on *de jure* governance efforts as existing in scholarly literature, an analytical lens was developed, presented in Figure 2. This figure, viewed from the author's perspective of this study, highlights the connection between the advanced governance rationales by actors, and the anticipated variations in interpretations and assertions about current *de jure* governance endeavours, building on Gupta et al.'s work (2020).

Figure 2

Analytical lens academic interpretation attempts at de jure governance



Note. Adapted from "Anticipatory governance of solar geoengineering: conflicting visions of the future and their links to governance proposals," by Gupta, A., Möller, I., Biermann, F., Jinnah, S., Kashwan, P., Mathur, V., Morrow, D.R. & Nicholson, S., 2020, *Current opinion in environmental sustainability*, 45, p. 15.

The figure broadly delineates how diverse assertions regarding current *de jure* governance endeavours are expected to originate from various advocated governance rationales. It is important to note that in this specific analysis, only a distinction is made between the two perspectives: scholars advancing the enable/oversight governance rationale and those advancing the restrict/vigilant governance rationale. This simplified categorization is employed given the overlap among the four governance rationales, rendering it difficult to classify scholars into four distinct groups. Furthermore, the primary goal of this analysis is not to impose rigid boundaries but, instead, to categorize and elucidate potential variations in interpretation and claim-making across a broader spectrum. This approach facilitates an examination of how the academic literature aligns within this spectrum, representing the extremes.

The preceding section provided a justification and explanation of the analytical lens used to address the *de jure* approach and related sub-research questions of this study. The following sections outline the conceptualization and associated analytical lens for the de facto approach and associated sub-research questions of this study.

2.6 De facto sources of governance

To analyse expert-led non-state initiatives as sources of de facto governance in the context of solar geoengineering, an understanding of the concept of *de facto governance* and its relation to *de jure* and anticipatory governance is needed. As previously mentioned, despite the challenges of establishing formal state-led governance structures for emerging technologies, and their perceived limited nature, alternative forms of governance are emerging. One concept aimed at comprehending these less acknowledged steering mechanisms is de facto governance. According to the Oxford Encyclopaedic Dictionary of International Law (2009), *de facto* is defined as "existing as a matter of fact," while *de jure* is defined as "existing as a matter of law." In legal terms, de facto often pertains to what actually happens, in contrast to *de jure*, which pertains to what the law prescribes should happen. Gupta and Möller (2019) define de facto governance as "sources of governance that are unacknowledged and unrecognized as seeking to govern, even as they exercise governance effects" (p. 481).

Their use of the concept draws on the work of Rip (2018), who examines this phenomenon in the context of nanotechnology. Rip (2018) refers to de facto governance as "the actions and interactions and how these add up to outcomes at the collective level that function as governance arrangements" (p. 75). It is crucial to emphasize that the reference point can encompass governance arrangements at both national and international governance levels, as applied in this study. As discussed earlier, the notion of governance has been used to capture the idea of distributed power and decision-making, as opposed to top-down government action which is more centralized. The distinctive feature of de facto governance in contrast to a more general approach to governance is, according to Rip (2018), the strong bottom-up character of de facto governance. Rip (2018) suggests that de facto governance does not emerge from a centralized arrangement becoming more distributive, rather, the bottom-up actions, interactions, and strategies that constitute governance arrangements (p. 75). Likewise, Rosenau (1992) describes how "patterns of order at the collective level evolve out of myriad interactions between individuals who are not explicitly understood to be, or acknowledged as, rule-makers themselves" (in Gupta & Möller, 2019, p. 482). Consequently, de facto governance introduces an ambiguous role for state actors since they are unable to guarantee governability as many aspects are beyond their control and power (Rip, 2018). To sum it up, de facto forms of governance refer to informal, often bottom-up, and less explicitly recognized ways of steering by non-state actors that are not subjected to political oversight, despite the potential influence on directing a field of inquiry toward specific paths, and consequently "shaping the context for *de jure* governance" (Gupta & Möller, 2019; Owen, 2014; Rip, 2018).

Then how do *de jure* and de facto forms of governance relate to the concept of anticipatory governance? *De jure* and de facto forms of governance are integral components within the broader framework of anticipatory governance, each playing distinct roles in shaping the trajectory of emerging technologies. As highlighted earlier, *de jure* governance involves formal, legal, and officially recognized structures, rules, and regulations. It encompasses institutional arrangements, laws, and norms that are openly stated and subject to political oversight. Therefore, *de jure* governance provides a structured and regulatory framework for managing the development, deployment, and impacts of emerging technologies. It represents the intentional and predefined efforts by governments, international bodies, and institutions to guide and control the trajectory of a technology within established legal and ethical boundaries. Establishing such *de jure* governance arrangements for emerging technologies like solar geoengineering poses a considerable challenge due to the radical uncertainty and contested nature of these issues. The absence or limited nature of formal regulations, shared norms, and

institutional arrangements does not equate to an ungoverned space, a point emphasized above. Governance can take diverse forms, some of which may carry equal significance as formal regulations (Owen, 2014). De facto governance, while less formal, plays a crucial role in shaping the context within which *de jure* governance operates. It reflects the dynamics driven by various actors, including experts, industry, and civil society. These influences may precede, complement, or even challenge formal governance structures.

Several scholars have shown how de facto sources of governance in the field of climate and solar geoengineering have the potential to shape the context for *de jure* forms of governance (Gupta & Möller, 2019; Oldham et al., 2014; Owen, 2014). Gupta and Möller (2019) show that acts of demarcation and categorization by scientific assessment processes serve to frame and construct an object of governance that in turn shapes the field of inquiry and context for formal *de jure* governance. They show that such acts of demarcation and categorization are fundamentally political in nature. Similarly, Owen (2014) suggests that de facto forms of governance which can be overt, tacit, or covert, can be influential in terms of "framing technologies and influencing their directions, trajectories and pace" (p. 222). His analysis shows that "some academics and others have attempted to legitimize SRM research as an object of governance, defining governance contours and thresholds, underpinned by normative principles" (Owen, 2014, p. 212). Oldham and colleagues (2014) show how author networks and research funding have the potential to "de facto shape the development of the field" (p. 1). In the context of nanotechnology, Rip and Van Amerom (2009) observe that the line between formal agenda-building by state actors and informal societal agenda-building has become increasingly unclear. Policy entrepreneurs, their skills, and networks can act on "policy windows and other opportunities to forge a new, or change the existing agenda […] without there being a clear authority deciding on the agenda" (p. 133). Consequently, these entanglements can become entrenched into a forceful agenda, and lead to a state of path dependency (Rip & van Amerom, 2009).

This prior research illustrates the active involvement of experts, author networks, and authoritative figures in shaping and influencing the trajectory of a contentious field of inquiry, such as solar geoengineering. This is accomplished through various means, including the strategic framing of the technology and the normalizing, legitimizing, and consequently institutionalizing of specific directions. These actions, in turn, shape the context for formal *de jure* governance. In other words, these examples highlight how de facto sources of governance have the potential to shape the context of, and influence, *de jure* forms of governance. Given a lack of openly stated goals and political oversight scrutiny of de facto sources of governance

and the potential implications for *de jure* governance in the case of solar geoengineering is important (Gupta & Möller, 2019). The analysis conducted in this study builds on this previous work by recognizing the importance of scrutinizing de facto forms of governance alongside the more conventional analysis of *de jure* governance in the field of solar geoengineering. This emphasis is justified by the need to bring greater attention to this phenomenon within governance analyses, especially in cases of "politically contested and novel technological trajectories, where the contours of an emerging field of inquiry are neither agreed nor wholly knowable" (Gupta & Möller, 2019, p. 483). Operating with such an understanding of de facto governance underscores the need to identify and analyse emerging de facto sources of governance in the case of emerging anticipatory governance of solar geoengineering.

2.7 Operationalizing de facto sources of governance

The previous section emphasized the significance of recognizing unacknowledged sources of governance in the realm of emerging technologies, such as solar geoengineering. These informal steering mechanisms should be scrutinized, as they may play a significant role in shaping the context within which formal governance arrangements arise by steering the debate in a certain direction. The focus of this study is on exploring one key emerging source of de facto governance: non-state expert-led initiatives active in the solar geoengineering domain. This is understood as any organized effort or undertaking that is not affiliated with a governmental entity but is instead driven by individuals recognized for their specialized knowledge, expertise, or eminence in a particular field. These initiatives are typically led by 'experts', which may include academics, professionals, or individuals with notable experience and authority in a specific domain. Furthermore, the focus of such initiatives is on proposing solutions or pathways in a contentious area of inquiry, operating outside direct governmental oversight, where impartiality and independence from political constraints are emphasized. These attributes align with the key characteristics outlined in the above-provided definitions of de facto sources of governance and imply that such initiatives may not be explicitly acknowledged as the primary 'rule-makers' themselves.

Prior research has shown that the active involvement of experts, author networks, and authoritative figures has the potential to shape and influence contentious fields like solar geoengineering. Consequently, it is expected that coordinated efforts by such expert-led initiatives can similarly shape the trajectory of solar geoengineering, requiring their scrutiny. It is important to note that unlike authoritative assessments, which are recognized as sources of

de facto governance according to Gupta and Möller (2019), these initiatives are expected to engage in more explicit and overt steering of the field. This may involve taking clear positions on various contentious issues related to solar geoengineering and its governance. Despite their more overt approach, their informal nature, association with an 'expert' context often perceived as neutral or legitimate, and the absence of political oversight may mean that their potential influence is not fully acknowledged by other stakeholders in the field as governance-seeking. These attributes are considered sufficient to categorize them as de facto forms of governance. In the analysis of emerging expert-led non-state initiatives as a source of de facto governance, an analytical framework was developed, as illustrated in Figure 3.

Figure 3

Analytical lens de facto governance by expert-led non-state initiatives

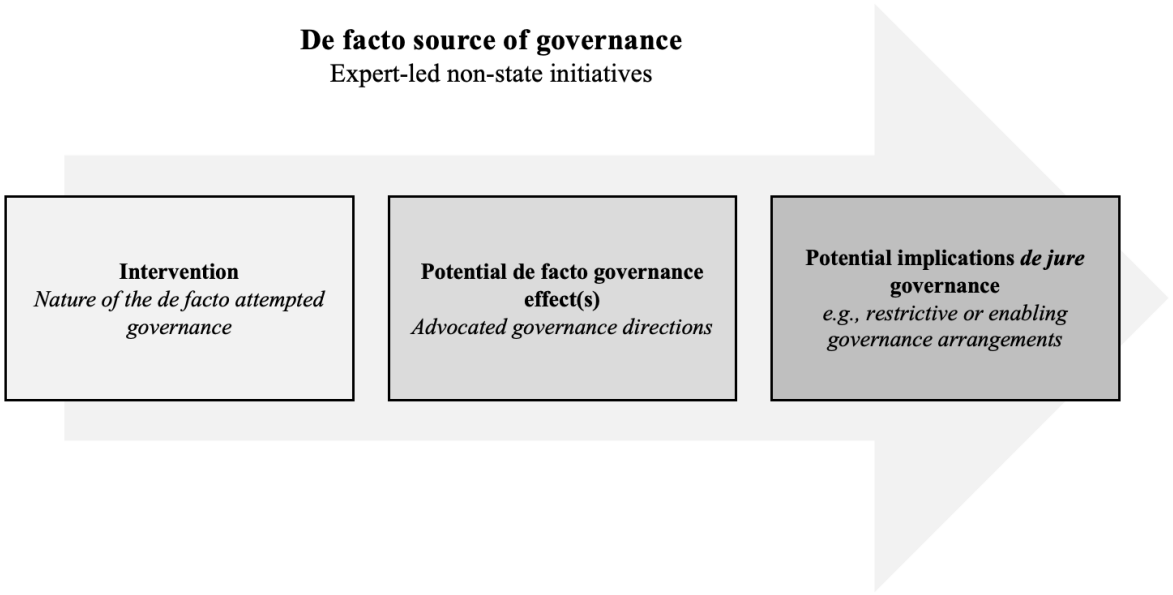


Figure 3 distinguishes between the initiative's de facto intervention, its potential de facto governance effect, and the potential implications for *de jure* governance. In the proceeding section, a more comprehensive explanation is provided for the various components of the analytical lens used for the de facto approach of this study.

De facto attempted intervention

Intervention here is used to describe how each initiative attempts to intervene in shaping the governance landscape: the way it seeks de facto governance. The intervention of each initiative

is expected to vary based on their goals, objectives, and rationale for their establishment. In other words, here the "how" of their involvement in the governance landscape is examined. Previous research has explored various approaches, such as research funding, agenda building, and boundary work conducted by academic networks that can generate effects (Oldham et al., 2014; Owen, 2014). Therefore, it is expected that each initiative employs distinct approaches inherent to its existence, potentially influencing the solar geoengineering governance landscape. These interventions are anticipated to yield de facto governance effects, as detailed in the following sections.

Potential de facto governance effect

Assessing the effectiveness of these initiatives in de facto steering the governance landscape may be premature given their recent establishment. However, it is crucial to closely examine these emerging sources of steering in their early stages. Therefore, the objective here is to infer 'potential' de facto governance effects based on their interventions. This scrutiny involves evaluating the possible consequences of the existence of these interventions, particularly regarding the advocated governance directions in this highly contested field. The aim here is to elucidate how the initiatives might shape the future trajectory of this contentious field of inquiry within the broader context of existing controversies, assuming their success.

In assessing the potential de facto governance effect, Rip suggests scrutinizing the repercussions on "legitimacy, governability, and the directions that are pushed" (in Gupta & Möller, 2019, p. 483). Aligned with this perspective, it is anticipated that the initiatives' interventions contribute to, and to some extent, actively try to shape the trajectory of this highly contested field of inquiry. This influence may manifest through the normalization and legitimization of particular research and governance pathways. Examples of such de facto governance effects may include the legitimization or delegitimization of solar geoengineering as a viable policy option, the normalization or legitimization of specific research directions, the redirection of author networks and research funding, as well as the normalization of particular governance directions. Furthermore, potential de facto governance effects could extend to influencing the framing and shaping of the broader discourse on these matters. The analysis thus includes scrutiny of the advocated governance directions of each initiative in this contested field.

Potential implications de jure governance

De facto governance effects have the potential to influence and shape the context of *de jure* governance (Gupta & Möller, 2019). By examining the potential de facto governance effects of the initiatives, particularly the advocated directions, inferences can be made concerning the implications for formal governance in the event of their success This analysis entails drawing conclusions, both in the short and long term, about the prospective implications for formal governance concerning the research, development, and deployment of solar geoengineering, in terms of either restricting or enabling it.

2.8 Chapter conclusion

This chapter introduced the conceptual framework for this study. It elaborated on the challenges for seeking (anticipatory) governance of new and emerging technologies, such as solar geoengineering. Subsequently, the approach for *de jure* governance was introduced by elaborating on the notion of vanguard visions and the importance of their scrutiny in relation to assertions on *de jure* governance attempts. To operationalize this, the analytical lens employed for the *de jure* approach was introduced, detailing a categorization tool for potential variations in interpretation and claim-making more broadly. Subsequently, the concept of de facto governance was introduced, as a significant source of steering shaping emerging technologies like solar geoengineering, emphasizing the necessity of drawing greater attention to this phenomenon in governance analyses. To apply this de facto approach to emerging non-state expert-led initiatives within the solar geoengineering debate, the second analytical lens used in this study was introduced. This lens distinguishes between the interventions, potential de facto governance effects, and the implications for *de jure* governance introduced by these expert-led initiatives.

3. RESEARCH DESIGN AND METHODOLOGY

This chapter elaborates on the research design and methodology, as the relevance of the research results is contingent upon them. Accordingly, this chapter introduces the general study design, followed by the case selection for both empirical parts of this research, and a brief description of each. Thereafter, the research method(s) used for each empirical part is elaborated on, including the process of data identification, selection, interpretation, and analysis.

3.1 Qualitative case study design

This study employed a qualitative research design to effectively address the research questions and employed two distinct approaches aligned with the analytical lenses outlined in the previous chapter. Following this, the study was organized into two empirical parts, Chapters 4 and 5, focusing respectively on scrutinizing *de jure* governance attempts and de facto sources of governance in the context of solar geoengineering, each accompanied by associated sub-research questions. The qualitative research approach utilized for both segments of this study is a case study design. Defined by Baxter and Jack (2008), this research approach allows for the in-depth exploration of a phenomenon, event, or organization within its context, drawing from diverse data sources. It enables the use of different lenses to reveal multiple facets of a phenomenon, offering in-depth descriptions of complex social phenomena (Baskarada, 2014). This approach is particularly relevant for scrutinizing rare or unique phenomena, as is the case with the emerging anticipatory governance of solar geoengineering. Furthermore, Baskarada (2014) emphasizes that case studies are the preferred research method when questions revolve around "how," the research has little control over events, and the emphasis is on "a contemporary phenomenon within a real-life context" (p. 2). These criteria align with the scope and objectives of this study.

Case studies come in various types, each serving distinct purposes. Intrinsic case studies aim to gain a deeper understanding of the specific case of interest (Stake, 1995). Baskarada (2014) categorizes exploratory, descriptive, or explanatory case studies. While exploratory case studies are often conducted before defining research questions and hypotheses, and explanatory case studies are used for examining causal relationships, this study specifically employed descriptive case studies. The selected cases are employed with the purpose of conducting a comprehensive examination to describe various aspects within the emerging anticipatory

governance of solar geoengineering. Each selected case in this study served to exemplify and contribute to the examination of the unifying element—emerging anticipatory governance—thereby establishing a clear connection to the overarching research question and the subject under examination. In the context of the *de jure* approach, the study examined cases of attempted formal governance related to solar geoengineering. Conversely, within the de facto approach, the focus shifted to cases of non-state expert-led initiatives actively engaging in the field of solar geoengineering and its governance. This choice of employing descriptive case studies positioned the research to provide a thorough, nuanced understanding of various aspects surrounding emerging anticipatory governance in the context of solar geoengineering.

Case studies, whether based on single or multiple cases, can utilize qualitative and/or quantitative data (Bellamy, 2011). Aligned with the objectives of this study and the nature of the (sub) research questions, both empirical segments in this study employed multiple descriptive cases and qualitative data. In the examination of attempted *de jure* governance of solar geoengineering (sub-research questions 1-3), aimed at providing a comprehensive representation of current *de jure* governance efforts considering their contested nature in scholarly literature and political implications, two cases were selected. In the exploration of expert-led non-state initiatives as de facto sources of governance (sub-research questions 4-6), to comprehensively capture key emerging initiatives, three cases were selected.

3.2 Case selection and description

3.2.1 Case selection and description: *de jure* governance

To achieve the first objective of this study, scrutinizing the nature, academic interpretation, and (political) implications of *de jure* governance attempts two cases were selected: i) the decision adopted by the Conference of the Parties to the Convention on Biological Diversity Decision X/33 paragraph 8(w) in 2010; and ii) the Draft Resolution on Geoengineering and its Governance considered during the fourth session of the United Nations Environment Assembly (UNEA-4) in 2019. These two attempts at *de jure* governance efforts were selected based on the limited attempts at *de jure* governance in the first place, and considering their broad and international scope related to solar geoengineering methods.

Decision X/33 was adopted during the tenth session of the Conference of the Parties to the Convention on Biological Diversity, held in 2010. The decision invites Parties to consider guidance to refrain from geoengineering activities, including solar geoengineering, that potentially impact biodiversity unless there is a scientifically justified basis for such activities.

An exception for small-scale research studies that are conducted in controlled settings for specific scientific data gathering and subject to thorough prior environmental impact assessments is made (CBD, 2010c). While this decision pertains to geoengineering more broadly, its relevance is particularly apparent as it encompasses "any technologies that deliberately reduce solar insolation" (CBD, 2010c).

During the fourth session of the United Nations Environmental Assembly, held in 2019, delegates deliberated on a draft resolution on geoengineering and its governance, submitted by Switzerland and supported by a coalition of countries. The resolution specifically tasked the Executive Director of the United Nations Environment Programme (UNEP) with preparing an assessment of the status of geoengineering technologies, focusing on carbon dioxide removal and solar radiation management, aiming to gather information and propose a preliminary governance framework for response options (Politico, 2021). Despite the draft resolution being ultimately withdrawn, it is noteworthy for its consideration within a universal international forum and the broad mandate of the United Nations Environmental Assembly. Additionally, the failure of this particular resolution has become a subject of frequent discussion in the academic literature related to solar geoengineering.

Another case that could have been selected is the resolution LP.4(8) adopted by the parties to the London Protocol in 2013, which provides for the regulation of marine geoengineering activities (International Maritime Organization, 2013). However, this case was excluded from this study based on its relatively limited scope, despite addressing some solar geoengineering technologies, it only addresses those that are marine-related.

3.2.2 Case selection and description: de facto governance

To achieve the second objective of this study, which involved examining emerging non-governmental, expert-led initiatives in the realm of solar geoengineering and their de facto role in governance, three specific cases were selected: i) The Solar Geoengineering Non-Use Agreement initiative; ii) The Climate Overshoot Commission; and iii) Call for Balance initiative. The selection of these cases was primarily based on their adherence to the criteria of being non-state-led and expert-driven. Several other cases, such as C2G, Silver Lining, the Degrees Initiative, SRM Youth Watch, and the Alliance for Just Deliberation on Solar Geoengineering, also fulfilled these criteria. However, they were excluded due to factors such as lower prominence, their relatively late establishment, comprehensive examination elsewhere, and time constraints. Each of the selected initiatives was chosen for its distinctive features, including a specific focus on governance issues, presentation of opposing views,

prominence in academic and media circles, and/or the absence of prior in-depth analysis. Further details on each case are briefly outlined below, with a more comprehensive description available in Chapter 5.

Launched in 2022 by a coalition of 16 scholars from diverse countries, the Solar Geoengineering Non-Use Agreement initiative aims to call for an international agreement opposing the normalization of the development and deployment of solar geoengineering technologies through the issuance of an open letter (Solar Geoengineering Non-Use Agreement [SGNUA], 2021). The initiative operates without external funding and has garnered support from over 450 scientists and governance scholars. Actively reaching out to academics, governments, and civil society organizations, it seeks backing for an International Non-Use Agreement while maintaining a politically independent stance. Notably, the emphasis is on individual endorsements rather than institutional representation. Given its significant representation, including notable governance scholars, the initiative's endeavours are considered a potentially influential source of de facto steering, capable of shaping the trajectory of solar geoengineering governance and research.

Launched in 2022, the Global Commission on Governing Risks from Climate Overshoot, also known as the Climate Overshoot Commission, brings together twelve prominent ex-global leaders dedicated to proposing an integrated strategy aimed at minimizing the impacts of climate change, including the consideration of solar geoengineering (Climate Overshoot Commission, 2023). With support from a Secretariat hosted by the Paris Peace Forum and funding from various philanthropic organizations, the Commission places its primary focus on developing a comprehensive strategy report. This report assesses the risks associated with surpassing the 1.5 °C temperature limit and explores governance policies related to climate overshoot. As this Commission is composed of high-profile ex-global leaders, operating without political restraints, the recommendations from its report are considered a significant source of de facto steering. It is anticipated that these recommendations may play a crucial role in shaping the trajectory of solar geoengineering governance and research.

Launched in 2023 by seven scholars from the Netherlands, Switzerland, and the United States, the Call for Balance initiative seeks to advocate for 'balanced' research in the realm of solar geoengineering and its governance (Call for Balance, 2023). This objective is conveyed through an open letter. The initiative argues to operate autonomously and free from political, commercial, or ideological affiliation, and is self-funded. Its primary objective revolves around expanding its network by involving scholars who align with their stance on promoting balanced exploration in this field. Given that this initiative is also comprised of scholars yet its efforts

diverge from the objectives outlined by the Solar Geoengineering Non-Use Agreement initiative, it is regarded as another potentially influential source of de facto steering. This suggests that the Call for Balance initiative may play a significant role in shaping the trajectory of solar geoengineering governance and research.

3.3 Research methods for analysing de jure governance

In exploring the nature, scholarly interpretation, and implications of *de jure* governance attempts, qualitative research methods play a crucial role in addressing the related research questions. A document analysis was carried out to capture the nature and implications of these attempts, while a literature review was conducted to understand how they have been interpreted in scholarly works. The following section provides a brief introduction to the various research methods employed in this study.

3.3.1 Document analysis

For examining the nature and implications of *de jure* governance attempts for solar geoengineering, a document analysis was conducted. Document analysis is a type of literature review that is defined by Bowen (2009) as a "procedure for reviewing or evaluating documents—both printed and electronic (computer-based and Internet-transmitted) material" (p. 27). As a research method, document analysis has been identified as a valuable approach for qualitative case studies, and integrates aspects of both content analysis and thematic analysis. Bowen (2009) argues that document analysis, similar to other methods in qualitative research, allows for the examination and interpretation of data to "elicit meaning, gain understanding, and develop empirical knowledge," which provides insights into a specific research problem (p. 27). Following this, documents are viewed as 'social facts' which are "produced, shared and used in socially organised ways" without the researcher's involvement (Bowen, 2009, p. 27). Documents are especially appropriate to gather data when events are not observable, and relevant in the context of this empirical part which examined two attempts in 2010 and 2019 respectively. Documents used for a document analysis can range widely in type and purpose, depending on the nature of the research (Bowen, 2009). The purpose of the documents used for this empirical part was to provide context, background information, and insights into the past events of the two selected cases. According to Bowen (2009), the analytical process involves finding, selecting, appraising, and synthesizing data found in documents.

In the process of finding and selecting documents for this purpose, no specific protocol is necessary, and there is no prescribed search and selection protocol for inclusion or exclusion (Bowen, 2009). The selected documents comprised primary sources, including treaty texts and agreements, additional institutional documents and reports, and secondary sources such as negotiation reports related to the two cases. These documents were obtained from official institutional websites, relevant online platforms and supplemented by published scientific literature. These together were considered a fundamental source of evidence. The deadline for document inclusion was January 2023. The documents were organized and stored in NVivo software, version 12 release 1.7.1, a qualitative data analysis program designed for organizing, analysing, and visualizing unstructured or qualitative data (Lumivero, 2020). To appraise and synthesize the data found in these documents, relevant information in the form of excerpts, quotations, or entire passages was categorized into key topics and themes. For both cases, these were grouped into categories including 'institutional structure', 'groundwork/background', 'negotiation process content', 'decision/resolution', 'implications', and a general category for the remaining relevant information.

3.3.2 Descriptive literature review

To examine interpretations and claims regarding selected *de jure* governance efforts found in scholarly literature, a literature review was conducted. As defined by Snyder (2019), a literature review is a "more or less systematic way of collecting and synthesizing previous research" (p. 333). In this study, a literature review was employed as a stand-alone method, aimed to comprehend existing literature by gathering, interpreting, and explaining previous research, rather than merely serving as background for an empirical study (Xiao & Watson, 2019). Stand-alone literature reviews can take various forms based on the study's purpose, such as describing, testing, extending, or critiquing (Xiao & Watson, 2019). In the context utilized here, a descriptive review, as defined by Xiao and Watson (2019), delves into the state of the literature concerning a specific research question, topical area, or concept. The primary objective was to provide a comprehensive overview of scholarly perspectives and interpretations regarding the two cases, as captured in academic literature. As such, published works that offer scholarly insights into these cases constitute a fundamental source of evidence. Additionally, publicly expressed opinions by scholars through various channels such as websites, position papers, blog posts, and media debates were considered. This served as a means to verify interpretations found in the literature. While methods like participant observation and interviews could have been deemed suitable, resource and time constraints necessitated their exclusion.

In addressing the process of data extraction, analysis, and synthesis within descriptive reviews, Xiao and Watson (2019) highlight its potential for variability. A detailed account of the process undertaken in this study is based on their framework. The initial phase involved identifying, screening, and determining eligible literature—a comprehensive overview of this process is presented in Figure 4 below. Considering publication dates, the year 2010 for the CBD decision and 2019 for the UNEA resolution were set as the starting point, aligning with the events' dates and extending until December 2022, when data gathering concluded. Articles published after that were excluded from consideration. For this review, searches were executed on Google Scholar, Scopus, PubMed, and Web of Science—four widely utilized databases spanning various disciplines (Xiao & Watson, 2019). These databases were chosen for accessibility through the Wageningen University library system. Google Scholar, renowned for its extensive coverage, served as the primary database, while the other three were used to ensure a thorough search and verify search saturation.

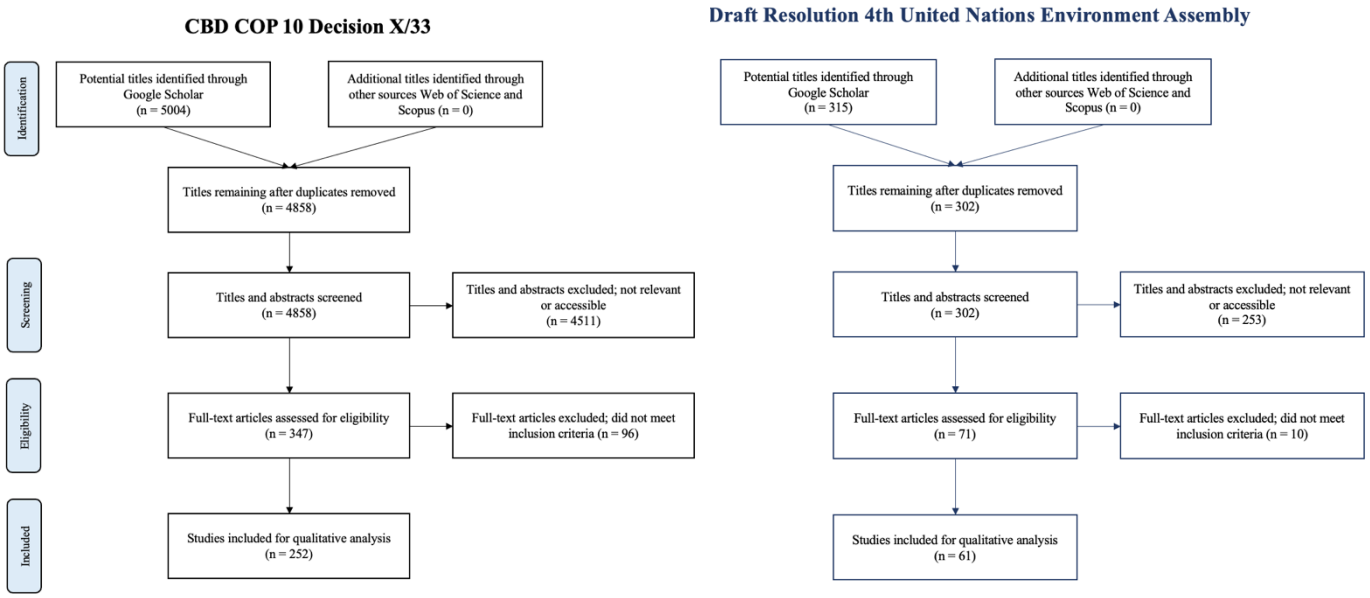
Initially, Google Scholar was searched using broad keywords for each case, such as "CBD" AND "climate engineering" or "UNEA" AND "climate engineering." The first ten pages of search results were reviewed, and potentially relevant articles were identified. Subsequently, the keywords were refined, resulting in eight distinct combinations for each case—see Appendix A for an overview. These keyword combinations generated a total of 5004 results for the CBD Decision X/33 and 315 results for the UNEA Draft Resolution. Duplicates were identified and removed. Following this, titles and abstracts underwent screening, with articles excluded based on language, availability at WUR-Library, and relevance criteria. In this context, articles that mentioned the query terms without relevance to the study requirements—for example, those discussing the CBD only related to ocean fertilization or sustainable research management (SRM)—were excluded. Moreover, an evaluation of the type of publication took place, where published Master theses or reports by external organizations were excluded.

After the initial screening, a total of 347 articles were included for the CBD case, and 71 for the UNEA case. The selected full-text articles were then imported into NVivo. In the second round of screening, the full text was evaluated based on relevance criteria including providing a description of the cases, text interpretations, and/or presenting arguments for their (in)significance. After this final screening, a total of 252 articles were included for the CBD case, and 61 for the UNEA case. Appendix B offers an overview of the included articles, with each article assigned a specific code for in-text referencing. It is important to note that the referencing style in Chapter 4 does not follow the APA reference style used in other parts of

this study. For clarity, references aligned with each code are used to refer to the articles. Moreover, it is crucial to emphasize that establishing a minimum citation threshold or requiring articles to undergo peer review was not employed as a criterion. This decision aligns with the literature review's objective of achieving a comprehensive overview of emerging scholarly visions and considering the field's relatively recent emergence.

Figure 4

Overview data collection literature review CBD Decision X/33 and UNEA-4



Data analysis and synthesis were conducted using NVivo software. In NVivo, *coding* is the process of categorizing related material and excerpts into a cluster, and each cluster is referred to as a *code*. Coding is an essential tool in qualitative data analysis and can be used by researchers to analyse large datasets (Elliot, 2018; Williams & Moser, 2019). In this study, a ground-up coding approach was used, allowing codes to emerge from the data itself rather than relying on an initial set of codes. In the initial phase, an open coding approach was used, which included reading the data and assigning codes to relevant excerpts. This approach allowed for flexibility in code alteration during subsequent phases. After this, codes were organized into categories that represented similar interpretations, articulations, arguments, or reasonings regarding both cases as found in the literature. In the second coding round, codes and categories formed underwent re-examination, involving renaming, recoding, merging, and re-

categorization to find recurring patterns and themes—the empirical chapter is structured according to these themes.

Finally, within each theme, scholars and their writings were, when possible, classified along the two sides of the 'why govern' spectrum. This process of assigning and grouping was informed by Gupta et al. (2020), where scholars are identified as advocating specific governance rationales, and Baskin (2019), which labelled key figures commonly recognized as knowledge-brokers and supportive of geoengineering as the 'geo-clique.' Additionally, authors were identified who publicly articulated positions on solar geoengineering through websites, position papers, advocacy efforts, and media debates. It is important to note that for various scholars and their writing, this allocation was not possible, but their inclusion offered relevant information on the two attempts more broadly, reflecting differences from those who were assigned to a category. Moreover, these categorizations were not intended to permanently link each author to a specific category but rather to serve as a tool to assess differences between these groups advancing different rationales. Moreover, it is important to note that not all included articles are explicitly used in the text due to repetition or saturation of information.

3.4 Research method for scrutinizing de facto governance

To scrutinize expert-led non-state initiatives as sources of de facto governance, a comprehensive document analysis was conducted. Document analysis was viewed here as the appropriate method due to the amount of publicly available documents, extensive coverage across a significant timeframe, various events, and diverse settings. Additionally, it offered accessibility to data that would be challenging or excessively time-consuming to collect through other research methods like interviews or observations (Bowen, 2009). As elaborated on in the preceding section, the documents used can range a broad spectrum in terms of type and purpose, contingent upon the nature of the study. Moreover, for the process of identifying and selecting materials no specific protocol is necessary (Bowen, 2009).

The primary objective was to comprehend the initiatives' interventions, assess their de facto governance impact, and explore potential implications for future *de jure* governance. As such, all documents and materials generated by the initiatives constituted a fundamental source of evidence that provided insights into their efforts to influence specific research and governance pathways. Considered primary sources, these documents include a variety of mediums such as reports, open letters, blogs, press releases, strategy documents, reports from events, and video materials. In addition to these initiative-produced materials, secondary

sources, such as documents, reports, and literature referencing the initiatives or containing statements made by the initiatives' representatives, were included as supporting material. All documents were sourced from the initiatives' official websites, relevant online media platforms, and supplemented by published scientific literature. The document inclusion deadline was set for September 2023, and an overview of the included documents is provided in Appendix C. It is important to note that the referencing style in Chapter 5 differs from the style used in other parts of this study, where references and in-text citations are represented by codes corresponding to documents found in Appendix C. Furthermore, scientific literature and grey literature were relied upon to provide a concise review of the existing controversies surrounding solar geoengineering governance and research governance, to evaluate and elucidate the potential directions advocated by the three initiatives under analysis.

To facilitate the data analysis process, the documents were stored and organized using NVivo software, given its ability to effectively manage the extensive document number. The selected documents were categorized into those directly issued by the initiatives and those published by other sources. To evaluate and synthesize the extracted data, relevant information in the form of excerpts, quotations, or entire passages was systematically categorized according to key topics aligned with the analytical lens: the intervention, potential de facto governance effect, and potential implications for *de jure* governance. The data analysis process is most accurately characterized as an iterative practice involving the examination of documents, coding relevant excerpts, and the identification of links to relevant concepts. This iteration was necessitated by the occasional emergence of new themes within the materials, prompting the addition of supplementary codes to the coding scheme during the ongoing process. The process served as the basis for the analysis described in Chapter 5.

4. DE JURE GOVERNANCE: CBD DECISION X/33 AND UNEA-4

This chapter provides a detailed description of the findings derived from the analysis of the two attempts at *de jure* governance of solar geoengineering. Specifically, it closely examines two prominent attempts: Decision X/33 by the Convention on Biological Diversity in 2010 and the draft resolution on geoengineering from the fourth session of the United Nations Environment Assembly in 2019. The analysis examines the nature of these governance endeavours, encompassing their institutional context, objectives, and negotiation outcomes. Furthermore, the chapter explores how scholarly literature interprets these formal governance efforts. This exploration is structured according to the themes derived from the literature review and organized in alignment with the governance rationales outlined in the conceptual chapter. Additionally, the chapter delves into some of the practical implications stemming from these governance attempts.

4.1 The Convention on Biological Diversity Decision X/33

The Convention on Biological Diversity is a multilateral environmental treaty that has been established with three main objectives: conserving biological diversity, promoting the sustainable use of its components, and ensuring the fair and equitable sharing of benefits arising from the use of genetic resources (CBD, 2012a). The Convention opened for signature during the Earth Summit in Rio de Janeiro on the 5th of June in 1992 and entered into force in December, 1993. The CBD enjoys nearly universal participation with 196 states that have ratified, except for the United States, which has only signed the Convention.

The Conference of the Parties (COP) is the primary governing body of the Convention. The COP comprises representatives of all governments, or Parties, that have ratified the treaty and meet biannually to set priorities, evaluate progress, and establish work plans (United Nations, n.d.). The decision-making process of the COP integrates both scientific and non-scientific knowledge (Boettcher and Kim, 2022). The Subsidiary Body on Scientific, Technical, and Technological Advice (SBSTTA) plays a pivotal role in offering scientific advice to the involved parties. Notably, while the CBD places importance on scientific assessments concerning activities impacting biodiversity, it also embraces insights from indigenous peoples and local communities, recognizing the significance of diverse knowledge sources in its considerations. Additionally, the Convention encourages participation from various stakeholders, including NGOs, businesses, and universities. The preamble of the Convention

emphasizes the importance of collaboration with NGOs, which is distinctive among multilateral environmental agreements (Boettcher & Kim, 2022). The CBD is guided by principles of international environmental law, where the precautionary approach holds a significant position (Boettcher & Kim, 2022; Florin et al., 2020). The precautionary approach, as articulated in the Convention's preamble, is interpreted as follows: "In cases where there is a threat of substantial reduction or loss of biological diversity, the absence of complete scientific certainty should not serve as a justification for delaying actions aimed at preventing or minimizing such a threat" (CBD, 2016a).

In May 2010, the fourteenth meeting of the Subsidiary Body on Scientific, Technical, and Technological Advice convened to discuss recommendations ahead of the tenth Conference of the Parties. The SBSTTA, characterized as an "open-ended intergovernmental scientific advisory body," provides timely advice to the COP and other subsidiary bodies regarding the implementation of the Convention (CBD, n.d.). During the fourteenth meeting, the SBSTTA deliberated on various recommendations, including a draft decision on geoengineering, which was called upon the parties to address during its tenth session (CBD, 2010a)—see Appendix D for an overview of the recommended decision. According to the Earth Negotiations Bulletin, an international environmental negotiation reporting service, representatives from various countries advocated for the application of the precautionary principle during discussions (Institute for Sustainable Development [IISD], 2010a). References were made to CBD decision IX/16C, which can be characterized as an implicit moratorium on ocean fertilization— a geoengineering technique that involves introducing nutrients into the ocean to stimulate the growth of phytoplankton. Some delegates suggested expanding the reference to encompass a broader concept covering all forms of geoengineering. Other delegates proposed evaluating geoengineering activities to determine their scientific justification, rather than prohibiting them until such justification exists (IISD, 2010a). Although the relevant recommendations regarding geoengineering remained in brackets, certain representatives acknowledged that geoengineering is an enduring issue, praising the SBSTTA for timely "flagging" it in anticipation of more extensive discussions in the future (ISSD, 2010a).

The CBD Decision X/33

The tenth meeting of the Conference of the Parties to the Convention on Biological Diversity was held in Nagoya, Japan, from October 18th to 29th, 2010. During this meeting, the parties made several decisions concerning the global conservation of biological diversity, including the establishment of internationally binding regulations for access to genetic resources (CBD,

2010b). Additionally, delegates discussed geoengineering as an emerging technology that aims to address climate change. The negotiation process unfolded within a Friends of Chair group (ISSD, 2010b). Delegates deliberated on key aspects, including the definition of geoengineering, the language concerning geoengineering activities, and the potential inclusion of an exception clause for scientific research (ISSD, 2010c; Sugiyama & Sugiyama, 2010). Delegates reached a consensus on the decision with various conditions and qualifiers, with a decision text as follows:

> Ensure, in line and consistent with decision IX/16 C, on ocean fertilization and biodiversity and climate change, in the absence of science based, global, transparent and effective control and regulatory mechanisms for geo-engineering, and in accordance with the precautionary approach and Article 14 of the Convention, that no climate-related geo-engineering activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts, with the exception of small scale scientific research studies that would be conducted in a controlled setting in accordance with Article 3 of the Convention, and only if they are justified by the need to gather specific scientific data and are subject to a thorough prior assessment of the potential impacts on the environment. (CBD, 2010c)

The complete text of the relevant sections of the decision can be found in Appendix E. Sugiyama and Sugiyama (2010) note five key modifications compared to the recommended decision by SBSTTA. The first change is the inclusion of a qualifier that acknowledges the absence of regulatory and control mechanisms for geoengineering. The second is the inclusion of a reference to CBD Article 14, “Impact Assessment and Minimizing Adverse Impacts,” requiring an environmental impact assessment for proposed projects that may potentially result in significant adverse effects on biological diversity. The third specifies that “geo-engineering activities” are qualified by the modifier “that may affect biodiversity.” Another modification relates to the exception for small-scale scientific research meeting certain criteria, among others “controlled setting” and justified by gathering specific scientific data. Delegates debated whether to confine such research to a controlled environment, subject to environmental impact assessment and justified by the need for specific data. Other countries advocated for permitting small-scale scientific activities within national jurisdiction without such qualifiers (IISD,

2010b). Ultimately, they agreed to use the term "controlled setting" and reference to Article 3 of the Convention, which obliges parties to ensure that "activities within CBD parties' jurisdiction or control do not cause damage to the environment of other states or beyond national jurisdiction" (IISD, 2010c). The fifth modification involved the addition of a tentative definition of geoengineering as a footnote of the operative text—as presented in Appendix E. This is noteworthy as it marks the first time that states have provided a tentative definition of geoengineering within the formal international setting of a COP and through a COP decision.

4.2 Academic interpretation CBD Decision X/33

Having established the institutional context, outlining the objective, content, and process of the CBD Decision X/33, this section delves into the academic interpretation of the decision as found in scholarly literature. Drawing insights from the literature review, the analysis has identified four key themes: the legal status and effect, the language employed in the decision, the institutional fit of the CBD, and the inclusion and interpretation of the precautionary principle. Each theme is explored in the subsequent sections, organized around the distinct governance rationales as advanced by scholars.

4.2.1 Legal status and effect: Prohibiting, restricting, expressing concern

In the literature, there is no consensus regarding the legal status and effect of the CBD decision X/33. Different scholars hold varying viewpoints, with some arguing that it establishes a moratorium, a de facto moratorium, or simply provides a statement of guidance. Related to this, there is ongoing debate about the significance and impact of the decision. These differing interpretations of the decision's significance and its implications are closely tied to scholars' positions along the spectrum of rationales for solar geoengineering governance.

Only those scholars who align with the enable/oversight governance rationale explicitly argue that the decision does not establish a moratorium and should not be interpreted as such (17 130 161 164 187 191 192 195 197 203). They emphasize that the decision lacks legal force, is non-legally binding, and has limited practical impact. These scholars present several arguments to support their viewpoint. First, they assert that the language of the decision is hortatory and non-binding, and therefore essentially functions only as an advisory statement or recommendation. Some scholars emphasize that the decision merely "invites" parties to consider refraining from geoengineering activities that impact biodiversity until specific criteria are fulfilled, such as an adequate scientific basis, risk assessment, and scientific justification.

This underscores in their view the advisory nature of the decision and therefore is seen as only expressing concern regarding geoengineering (162 163). Moreover, some scholars highlight that the decision indicates that it applies only in the absence of adequate regulation, implying that under certain circumstances, outdoor geoengineering activities, even those affecting biodiversity, could be consistent with the decision (192). Several scholars emphasize that given the non-binding nature of all decisions under the CBD, the decision lacks legal force (16 163). One scholar argues that such conferences of parties do not possess the power to create binding international law (192). Clarifying that such authority is confined to treaties and the customary behavior of states, or would require an amendment to the CBD (16 192). Furthermore, some scholars argue that CBD decisions have limited effects, both legally and otherwise, again referring to their non-binding nature. One scholar specifically emphasizes the reports issued by the CBD Secretariat that refer to the 2010 decision as a "non-binding normative framework" (195).

In addition, some scholars who fall within the enable/oversight governance rationale criticize those who interpret the CBD Decision X/33 as a general moratorium on geoengineering research and deployment. They argue that characterizing it as a binding international moratorium or ban on outdoor (solar) geoengineering research is inaccurate. According to these scholars, the decision is widely misrepresented as a moratorium, and argue that referring to it as such is an inaccurate characterization of its substance and intention (195 201 203). In terms of substance, the scholar argues that, without presenting clear evidence, the Conference of the Parties to the CBD explicitly rejected the use of the word "moratorium" in the decision (195). In terms of intention, the scholar refers to a first-hand report of the negotiations toward the 2010 decision and concludes that "the delegates were not well informed about geoengineering, and negotiations were conducted in haste without proper scientific consideration" (195). Another scholar acknowledges that the decision does provide guidance to countries on considering conditions for undertaking or abstaining from geoengineering activities, however, stresses that there is currently no international framework governing these emerging technologies, nor a moratorium is in place (165). Some scholars even argue that "[i]t was clear that the delegates were not agreeing on a moratorium on outdoor research" by stating that one of the authors was present for all geoengineering side negotiations at the Conference of the Parties (203). According to these scholars, this would also be evident from the references made to specific articles within the decision. Such as Article 14, which would clarify that geoengineering activities with no significant adverse impacts on biodiversity are not covered by the Convention or the decision, and Article 3 was included to remind parties of their

obligation to notify and consult with potentially affected states in case of planned activities with transboundary impacts (195). Related to this, these scholars contend that the decision explicitly permits small-scale research to proceed (192). Other scholars who align with the enable/oversight governance rationale argue that despite its perceived limitations, the decision holds some significance. They emphasize that the decision "represents the only negotiated consensus concerning climate engineering in general from representatives of most of the world's states" (195) and that the "substantive statements are ones of concern" (192). Additionally, some scholars posit that, though they perceive the decision to have had minimal substantive impact, it has played a crucial role in shaping subsequent discussions by framing the discourse on climate engineering (17 195).

Besides scholars who explicitly argue that the CBD decision is not a moratorium, there is a substantial body of academic literature that refers to the decision as a "de facto moratorium" or expresses similar viewpoints (e.g., 23 61 66 112 143 144 152 156 180 209 217 219 232 243 241 249 251). The term "de facto" is commonly used in legal discourse to refer to practices or circumstances that exist in reality, as opposed to what is officially established by laws and regulations. The distinction between disregarding the decision as establishing a moratorium and interpreting it as a de facto moratorium highlights differing perspectives on the actual effects and practices that exist in reality, thereby underscoring the significance of the decision. In addition to the term "de facto," other related or similar terms are used in the literature, such as "attempted moratorium," "recommended moratorium," "limited moratorium," "partial moratorium," "implicit moratorium," or "non-binding moratorium".

Notably, for those who advocate the restrict/vigilant governance rationale emphasis or elaboration on the exact legal status or effect of the decision was not found. Most scholars within this view refer to the decision as a 'de facto moratorium,' or similar terms, while also acknowledging its non-legally binding nature. Despite acknowledging its non-legally binding nature, the use of this terminology suggests the perceived significance of the decision in practice. One illustration of this perceived significance is highlighted by scholars within this governance rationale who underscore the consensus among countries associated with the Convention on Biological Diversity. They argue that the decision signifies the necessity for caution due to the absence of a global regulatory mechanism, indicating a shared perspective that views geoengineering as both risky and unnecessary. Furthermore, they commend the decision as an "important and effective step in the right direction" (14).

4.2.2 The language of the decision

The literature review reveals a consensus regarding some aspects of the decision text and the language used that is viewed as open for debate. Notably, scholars advancing the restrict/vigilant governance rationale refrain from articulating a conclusive judgment on these aspects. In contrast, scholars advancing the enable/oversight governance rationale tend to characterize the decision's language as soft, vague, weak, and lacking clear mandates.

Various aspects of the decision text have been identified, among all scholars, as using language that is open to debate. First, certain scholars emphasize that the decision simply "invites" parties "to consider" the associated risks to the environment and biodiversity of solar geoengineering, rather than mandating such consideration (e.g., 16 18 44 76 145 149 252). This use of soft wording is understood by some as providing guidance on geoengineering as a general concept rather than imposing a strict requirement (e.g., 76 252). Second, scholars raise inquiries regarding the interpretation of "may affect biodiversity," expressing concerns about how to determine this (44). They underscore the absence of clear threshold criteria, introducing ambiguity regarding the specific point at which an activity would be categorized as causing such an effect (176). Third, scholars emphasize the ambiguity surrounding the terms "adequate scientific basis" and "appropriate consideration of the associated risks," highlighting that these concepts remain undefined and are perceived to lack thorough exploration (18 44). This lack of clarity, as argued by some, generates uncertainty about the precise meaning and implications of the decision (44). Additionally, it is perceived to remain unclear whether these terms imply that the conceptual framework of a specific activity must be rooted in scientific principles, whether authorization to conduct the activity must come from scientists, or whether the management and execution of the activity must be overseen by scientists (18 120). Furthermore, the ambiguity extends to whether the associated risks must be manageable from a scientific standpoint. Finally, various scholars emphasize the ambiguity surrounding the exemption for small-scale research within a controlled setting in accordance with Article 3 of the Convention (16 72 100 118 120 130 158 238). This specific provision, defined under Article 3, reaffirms the duty to prevent transboundary environmental harm outlined in Principle 2 of the 1992 Rio Declaration (18). Notably, scholars stress that the decision lacks clarity in crucial terms such as "small-scale scientific research" and "controlled setting" providing in their view limited guidance to member-states on its implementation. Regarding small-scale scientific research studies, various authors note that the CBD has not provided criteria for small-scale research or specific conditions under which it is permitted (18 100 118 156 120). Despite the decision applying restrictions to experiments with adverse transboundary impacts that are not small-

scale, the definition of what is considered large-scale remains unclear and needs to be settled, according to some scholars, on scientific, technical, and political grounds (100).

Notably, only those advocating for the enable/oversight governance rationale have been found to consistently characterize the language used in Decision X/33 of the CBD as soft, vague, weak, attenuated, non-mandatory, hortatory, and/or qualified (16 28 72 145 176 189 190 195 196). Here it is frequently emphasized that the decision merely "invites" states to "consider the guidance" as far as possible and as appropriate. Therefore, according to these scholars, the decision fails to provide states with clear, concrete obligations regarding (solar) geoengineering activities (28), resulting in their view in a poorly worded, restrictive statement (196). Similarly, some stress that it is crucial to note that this language is only an "invitation" and, therefore, holds no enforceable legal weight. Furthermore, some emphasize the decision specifically employs non-mandatory language, such as "consider," and "guidance" (16 190). In this context, it is stressed that the CBD reports on the topic also refer to the decision as being 'only' a "comprehensive non-binding normative framework" (176). Some scholars emphasize that significant ambiguities persist concerning small-scale scientific research studies in a controlled setting. As the term "controlled setting" remains undefined, scholars question whether research activities are limited to indoor activities or could include low-risk and/or well-contained outdoor experiments (195).

4.2.3 The scope of the Convention on Biological Diversity

The literature review reveals another contentious aspect that concerns the scope of the Convention on Biological Diversity in addressing geoengineering, specifically solar geoengineering. While some scholars perceive the CBD's scope as adequate, others emphasize its inadequacy. Advocates of the enable/oversight governance rationale consistently underscore the CBD's limited scope, providing various arguments to support their assertion. Notably, no arguments related to the scope were identified for the restrict/vigilant governance rationale.

In general, various scholars advocate for utilizing existing institutions for the governance of (solar) geoengineering, with the CBD emerging as a prime candidate. They emphasize its broad mandate, asserting its suitability to address all geoengineering concepts relevant to biodiversity protection (3 18). The CBD's significance is accentuated by the clear link between solar geoengineering and potential threats to biodiversity, along with its numerous provisions that could apply to solar geoengineering. Within this context, scholars identify two principles and commitments of the CBD as particularly relevant. First, the CBD underscores states' sovereign right to responsibly exploit natural resources while preventing transboundary

harm and adopting a precautionary approach. This approach could entail restrictions to prevent the reduction or loss of biological diversity, particularly in the context of solar geoengineering deployment (36 208). Second, the CBD commits parties to identify, assess, and monitor activities with significant adverse impacts on biodiversity. This commitment supports the conduct of environmental impact assessments for proposed solar geoengineering activities. As such the CBD's role is seen as relevant, given its potential to establish normative categories and procedures for monitoring, assessing, and evaluating the potential impacts of geoengineering technologies on biodiversity, which could result in imposing restrictions on activities.

Various scholars identify limitations considering the scope of the CBD regarding its role in governing solar geoengineering, highlighting various inadequacies (3 15 18 118 176 182 183 207). A substantial portion of these arguments originates from those advancing the enable/oversight governance rationale. Scholars advocating this viewpoint assert that overseeing solar geoengineering surpasses the CBD's primary objective of biodiversity preservation. They contend that such governance would transcend addressing biodiversity impacts and would broaden the CBD's mandate to develop detailed regulations for mitigating climate risks, considering solar geoengineering's perceived potential role in this regard (95 176 196 197). In this context, some argue that if the CBD were to engage in governance in this realm, it would necessitate close collaboration with other conventions, such as the United Nations Framework Convention on Climate Change (UNFCCC), and involve discussions in alternative forums (95 196). Moreover, caution is expressed against regulating solar geoengineering technologies under different treaties, such as the CBD and the London Convention. According to these scholars, such an approach could result in an inconsistent framework, potentially obstructing research, enabling unwanted private-sector involvement, and hampering the establishment of an efficient and effective global strategy to address climate change, with solar geoengineering being considered as a component (95). Similarly, some scholars posit that the CBD is an unsuitable forum for technology governance, lacking the requisite remit and expertise in technology and climate change (161). Others express concerns that the CBD's decision may be influenced by opposition to the technological practice itself, drawing parallels with the political dynamics surrounding genetically modified organisms (196). Lastly, scholars emphasize the non-party status of the United States with respect to the CBD, viewing it as necessary given its activities in the field (196 161).

4.2.4 The role of the precautionary principle

The literature review reveals a consensus regarding the presence of a strong version of the precautionary principle in the decision. However, while a judgment on the appropriateness of the principle was not found for those who advance the restrict/vigilant governance rationale, those advocating an enable/oversight governance rationale tend to criticize the decision and the inclusion of the principle as being one-sided.

Various scholars highlight the emphasis on a strong precautionary approach in the CBD Decision X/33 regarding geoengineering (e.g., 23 25 26 39 67 70 76 141 211). According to some scholars, this cautious approach aligns with the way the CBD has incorporated and upheld the precautionary principle (67). Various scholars note that the use of the precautionary principle in the context of geoengineering is subject to contestation since it can be interpreted in different ways. On one hand, it can be seen as a justification for taking measures to minimize the risks of climate change by advancing geoengineering technologies. On the other hand, it can be used to argue that unless all the implications are known and proven to be safe, activities such as solar geoengineering should not be pursued. There is consensus in the literature that the decision expressed this latter perspective (3 25 76 70 26 39 67 141 152 211 222). For instance, some scholars note that the parties to the CBD have taken early steps to govern "climate engineering technologies […] framed around a precautionary approach in the face of potential harms from the technologies' development" (154). Moreover, this precautionary approach taken by the CBD is suggested by some to indicate the emergence of an international norm discouraging such activities (25).

Only scholars who fall within the enable/oversight governance rationale criticize the perceived one-sided interpretation of the precautionary principle in the decision (95 185 188 201). They argue that despite the potential risks of solar geoengineering, its future deployment could also potentially reduce risks. Therefore, some scholars highlight that the CBD decision text fails to acknowledge the potential role of climate engineering in mitigating the impacts of climate change. By neglecting the adverse effects of insufficiently mitigated climate change on biodiversity, the CBD's use of the precautionary principle is perceived by some to be one-sided (96 190). One scholar substantiates this argument by specifically referring to a 2012 published CBD report on geoengineering that, in the scholars' view, concluded that climate engineering could also potentially reduce the magnitude of climate change and its impacts on biodiversity, but is not reflected in the decision (190). Similarly, other scholars are skeptical regarding the CBD's role so far, which according to them has been primarily preventative and cautious regarding taking action, "rather than providing pathways for progress" (96). The scholars point

out that restricting the CBD's focus to merely limiting the application of technologies overlooks the impacts on biodiversity that can be expected from inadequately addressing climate change. As they put it: "A precautionary approach only favoring inaction runs the risk of preventing measures that could be beneficial to biodiversity" (96). Lastly, some scholars argue that the precautionary principle specifically supports conducting further research on solar radiation management. They assert that a precautionary approach favors "improving knowledge about [solar geoengineering] options through research, including field experiments, but in a manner that recognizes risks" (185).

4.3 Implications of CBD Decision X/33

Having outlined the scholarly interpretations of the CBD Decision X/33 as documented in the literature, this section elaborates on the developments and implications of the decision both within the Convention and beyond. It explores some of the practical implications and political consequences since the 2010 decision. Specifically, this section explores whether the decision has resulted in restrictive or enabling effects, if any.

4.3.1 Reaffirmations and ambiguities post-2010 CBD Decision X/33

Since the 2010 CBD Decision X/33, subsequent developments have stirred some debate and raised questions about the direction and significance of the decision. While the CBD reaffirmed its 2010 decision in 2012 (Decision XI/20) and 2016 (Decision XIII/14), some observers argue that these reaffirmations may have weakened the restrictive and precautionary nature of the original decision.

The CBD Decision XI/20 in 2012 reaffirmed its previous stance related to the persistent absence of science-based, global, transparent, and effective control mechanisms for climate-related geoengineering (CBD, 2012b). Moreover, it emphasized the inadequacy of current geoengineering methods in meeting fundamental criteria for effectiveness, safety, and affordability. The decision notes that significant gaps in understanding the impacts of climate-related geoengineering on biodiversity remain. In addition, the decision authorized facilitating voluntary reporting by participating parties through a clearinghouse mechanism for information exchange (CBD, 2012b). Specifically, the parties are to report on measures and scientific findings related to the application of the 2010 decision. While voluntary, submissions from some countries, such as Estonia, France, Canada, and Bolivia have been received since (CBD, 2017). However, the implications of this voluntary reporting remain indeterminate.

Some scholars argue that this decision added little substance to the 2010 decision, contending that it failed to provide normative content and clarity on which, mainly research, activities are intended to be restricted or allowed (Bodle et al., 2013; Rabitz et al., 2020). Another critical aspect of contention is the evolving definition of geoengineering. Decision XI/20 listed four possible options, including the preliminary definition from 2010, a definition from expert groups, and two different definitions from the IPCC. The lack of a clear preference for a specific definition has led to ambiguity and uncertainty regarding the scope of activities that should be regulated. Scholars have noted that this ambiguity represents a step backward in terms of clarity, even as the follow-up decision has taken small steps toward providing elements of a governance framework (Bodle et al., 2013).

In 2016, the CBD, through COP decision XIII/14, once again reaffirmed the key paragraph of its 2010 decision. However, the decision also noted the need for more "transdisciplinary research and sharing of knowledge among appropriate institutions is needed in order to better understand the impacts of climate-related geoengineering on biodiversity and ecosystem functions and services, socio-economic, cultural and ethical issues, and regulatory options" (CBD, 2016b). This has been interpreted by some as endorsing the call and necessity for further research (Rabitz et al., 2020; Reynolds, 2018), or as suggesting a slight policy shift away from the highly precautionary tone of previous CBD decisions (Flegal et al., 2019). While others emphasize that it should not be interpreted as negating the original 2010 decision (Brent et al., 2019).

These instances indicate that the CBD may be retracting from its initial restrictive decision. Whether this is due to deliberate efforts by opposing actors to diminish its significance or if advocates for less stringent regulations are watering down the CBD's efforts to align with their interests, remains unclear.

4.3.2 Implications of CBD Decision X/33

While existing literature presents various interpretations of the significance of CBD decisions and ongoing developments within the CBD concerning solar geoengineering, it i crucial to touch upon some of the tangible implications of the initial decision. Certain instances underscore the real-world implications of this decision. Through an examination of specific examples, it becomes evident that Decision X/33 has arguably imposed several restrictive implications.

A first notable instance involves the integration of Decision X/33 into the strategies of civil society campaigns and non-governmental organizations. Organizations such as

Biofuelwatch, ETC Group, and the Heinrich Böll Foundation have strategically utilized the decision, actively seeking leverage and legitimacy within the UN institutional context from which the decision originated. Specifically, the "Hands Off Mother Earth: Manifesto Against Geoengineering" initiative, established in October 2018, is a prime example (HOME, 2018). Endorsed by over 100 organizations globally, the initiative explicitly incorporates the decision while advocating for a comprehensive ban on all geoengineering field experiments and deployment. The manifesto represents a significant demonstration of the decision's substantial influence in civil society spheres, referring to it as a moratorium and playing a pivotal role in shaping the positions of NGOs as they advocate against geoengineering initiatives.

An illustrative case of one of the driving forces behind the Hands Off Mother Earth campaign lies in the efforts of the Action Group on Erosion, Technology, and Concentration (ETC Group), a Canadian non-governmental organization. ETC Group has played a significant and effective role in leveraging the CBD decision, arguably resulting in restrictive implications. Particularly in its engagement with the planned Stratospheric Particle Injection for Climate Engineering (SPICE) experiment. The SPICE project, focused on solar radiation management, included an outdoor field experiment component, featuring a proposed experiment to test the feasibility of a balloon deployment system in the United Kingdom in 2012 (SPICE, 2024). ETC Group strongly opposed the field test planned by SPICE, expressing their dissent through an open letter and actively campaigning for the cancellation of the SPICE project (ETC, 2011). This opposition garnered support from several environmental groups, collectively contending that the SPICE experiment was likely to undermine the decision by the Convention on Biological Diversity and should therefore not be authorized. Referring to Decision X/33, ETC Group argued that the SPICE project failed to meet the criteria as it could not occur in a "controlled setting," considering the proposed equipment's significant size, reaching one kilometer in the sky. Moreover, they asserted that the test was primarily designed to engineer equipment aimed at developing the technology for injecting chemicals into the stratosphere, therefore lacking justification for gathering specific scientific data (ETC Group, 2011). Recalling the CBD decision, it states an exception for small-scale scientific research studies, "only if they are justified by the need to gather specific scientific data." The project in question was canceled in May 2012 due to a conflict of interest related to patenting (Stilgoe et al., 2020). Although it remains uncertain whether the efforts of the ETC Group directly influenced this cancellation, this case underscores the influential role of the ETC Group in strategically leveraging the CBD decision in a restrictive manner. Thereby playing an active role in the restrictive implications of geoengineering (research) activities.

Another noteworthy example where the CBD decision has been invoked relates to the 'Stratospheric Controlled Perturbation Experiment' (SCoPEx), initiated in 2015. Funded by Harvard University, the project aimed to explore forms of solar radiation management. The SCoPEx project intended to release water, finely ground chalk, and sulfur particles into the upper atmosphere from a high-altitude balloon, assessing the effectiveness of resulting clouds in blocking sunlight and monitoring any potential impacts on the upper atmosphere (Harvard University, 2024). Upon the revelation of the scheduled test flight near Giron/Kiruna, Sweden, situated in the area inhabited by the Saami people, the Saami Council, an indigenous peoples' organization, expressed objections. Through an open letter directed to the SCoPEx Advisory Committee, the Swedish Space Corporation, and the Swedish government, the Saami Council raised concerns about the lack of consultations with the Saami people and the project's objectives (Saami Council, 2021a). In a 2021 open letter addressed to Harvard University, reference was made to the CBD decision, asserting that "Under the Convention of Biological Diversity, the Parties to the Convention decided in 2010 at COP10, X/33 paragraph 8 (w), on a de facto moratorium on climate-related geoengineering. This moratorium is still in place, and it clearly shows that there is a need for a global conversation before any testing of this technology is approved" (Saami Council, 2021b). The experiment was eventually canceled. This incident highlights another tangible impact of the CBD decision in influencing and guiding restrictive implications related to solar geoengineering activities.

A more recent and final example involving the invocation of the CBD decision arguably contributed to restrictive outcomes that took place in 2022. A United States-based startup 'Making Sunsets' conducted an unauthorized experiment in two locations within the northern Mexican state of Baja California. The company, which markets 'Cooling Credits' claiming to "offset one ton of CO2 warming for a year," executed this by launching balloons containing sulfur dioxide particles into the atmosphere (Make Sunsets, 2023). Responding to this unauthorized experiment conducted without prior notification or consent, Mexico declared to implement a series of measures to prohibit solar geoengineering experiments within its borders (Gobierno de México, 2023). In the official statement by the Mexican government, declaring that "Experimentation with solar geoengineering will not be allowed in Mexico," reference is made to Decision X/33 by the CBD. The statement emphasizes, "The Convention on Biological Diversity of the United Nations, of which Mexico is a party, established in 2010 a moratorium that remains in force against the deployment of geoengineering" (Gobierno de México, 2023). This incident underscores another concrete impact of the CBD decision a in influencing national policy and legal measures related to solar geoengineering activities.

The preceding sections elaborated on the nature, scholarly interpretation, and implications of Decision X/33 by the CBD. In the following part of this chapter, the draft resolution on geoengineering and its governance tabled during the fourth session of the United Nations Environment Assembly in 2019 is discussed.

4.4 The UNEA-4 Draft Resolution on Geoengineering

The United Nations Environment Assembly, comprised of all 193 UN member states, functions as the highest-level decision-making body exclusively dedicated to addressing environmental issues within the UN system, and acts as the governing body for the United Nations Environment Programme (United Nations Environment Programme [UNEP], n.d.-a). The assembly convenes biennially, providing a platform for political representatives to collaborate on environmental protection and sustainable development, addressing issues such as climate change, biodiversity loss, and pollution. One of UNEA's primary aims is to strengthen UNEP's coordinating mandate, conducting periodic environmental reviews, identifying global challenges, and shaping environmental policies and international law (Boettcher & Kim, 2022; Jinnah & Nicholson, 2019; UNEP, n.d.-b). UNEA's decisions, achieved through consensus, require the agreement of all member states for the final adoption of resolutions or agreements. Despite being non-legally binding, UNEA's ministerial declarations and resolutions carry significant authority (Boettcher & Kim, 2022). Its authority is a primary result of enhanced legitimacy through a UN General Assembly resolution that established universal membership of the former Governing Council (Boettcher & Kim, 2022; UNEP, n.d.-c). Therefore, resolutions adopted by UNEA embody the current collective perspective on prominent environmental issues, indicating consensus among all member states (UNEP, 2022). Furthermore, the assembly considers input from diverse experts and stakeholders, for example by consulting the IPCC for scientific expertise or establishing expert or working groups (Boettcher & Kim, 2022)

During the fourth session of the United Nations Environment Assembly in Nairobi in 2019, delegates discussed a draft resolution on geoengineering and its governance—see Appendix F for a version of the draft resolution. The draft resolution was submitted by Switzerland and supported by a coalition of developing and developed countries, including Burkina Faso, the Federated States of Micronesia, Georgia, Liechtenstein, Mali, Mexico, Montenegro, Niger, the Republic of Korea, and Senegal (Politico, 2021). The primary objective

of the draft resolution was to initiate an assessment of the current scientific and governance status related to geoengineering technologies. The operational part of the draft resolution included a request to the Executive Director of UNEP to prepare "an assessment of the status of geoengineering technologies, in particular, carbon dioxide removal technologies and solar radiation management" (Politico, 2021). The proposed assessment would, among others, review the current state of science, the knowledge of impacts, risks, benefits, and uncertainties for each geoengineering technology, and an evaluation of the current state and challenges of governance frameworks. Switzerland contended that UNEP was well-suited to undertake such an assessment given its fundamental role in monitoring the environment and identifying globally emerging environmental issues, coupled with its expertise and credibility (Perrez, 2020).

The preambular part of the draft resolution recognizes that climate change is one of the most significant challenges of this time. It also acknowledged the need for further reduction of global greenhouse gas emissions and emphasized that geoengineering should not replace mitigation efforts. Furthermore, the draft resolution expresses concern about the potential risks and adverse impacts of geoengineering and highlights a current lack of multilateral control and oversight. It acknowledges other relevant operations of UN bodies, such as the Convention on Biological Diversity, the IPCC, the Montreal Protocol on Substances that Deplete the Ozone Layer, and the London Protocol. Despite undergoing multiple revisions, the resolution was eventually withdrawn due to a lack of consensus among the participating parties. The following section provides a brief overview of the negotiation process.

Concise overview of the negotiation process

On Monday, March 4, the draft resolution was presented, outlining its objective to assess the status of geoengineering technologies, including their risks, benefits, and uncertainties. Delegates raised concerns, such as the potential duplication of efforts already underway by other entities like the Intergovernmental Panel on Climate Change. Additionally, questions were raised about the scope of technologies covered by the draft resolution (IISD, 2019a; IISD, 2019g). While some delegations expressed support for the resolution, underscoring the urgency of gathering information and viewing UNEP as the appropriate overseeing body for this (IISD, 2019a; IISD, 2019g), others suggested various amendments during Tuesday's discussions. For example, a developed country proposed referencing the IPCC Special Report on Global Warming of 1.5 degrees, while a developing country called for the inclusion of Common But Differentiated Responsibilities (CBDR) and emphasized the role of the UN Framework

Convention on Climate Change (IISD, 2019b, p. 3). Some delegates questioned the appropriateness of the proposed assessment without a scientific consensus (IISD, 2019b).

On Wednesday, March 6, informal discussions continued, leading to heavily bracketed text. Similar discussions occurred on Thursday, March 7 (IISD, 2019c; IISD, 2019d). Throughout the following days, informal talks persisted, resulting in a modified, more concise resolution presented on Sunday, March 10. Some advocated for a "global report" rather than an assessment (IISD, 2019g, p. 13). On Monday, March 11 delegates started working on the heavily bracketed operative text, requesting UNEP's collaboration with other stakeholders to prepare a report on the "state of play and potential gaps" in the field (IISD, 2019e, p. 3). Disagreements arose over which stakeholders to mention, their inclusion, and whether the report should be commissioned. Informal discussions resumed on Tuesday (IISD, 2019f). By Wednesday, March 13, Switzerland withdrew the draft resolution, expressing regret that a final compromise proposal could not be accepted due to a vocal minority, including the United States and Saudi Arabia, blocking the resolution. Some countries regretted the inability to reach a compromise, while others praised Switzerland's efforts and expressed determination to reintroduce the topic at UNEA-5 (IISD, 2019g).

4.5 Academic interpretation UNEA-4 draft resolution

After providing context on the objective, content, and process of the UNEA-4 draft resolution on geoengineering and its governance, this section delves into the academic interpretation of the resolution, drawing insights from the literature review. The analysis has identified six themes: the start of international deliberation, the timing of the resolution, the institutional fit of UNEA, the defined object of governance, the role of precaution, and a lack of understanding, or 'knowledge deficiencies,' by state delegates. Each theme is discussed in the following sections, organized around the distinct governance rationales as advanced by scholars.

4.5.1 The start of international deliberation

The first discernible feature of the UNEA-4 draft resolution on geoengineering and its governance that did find consensus, evidenced by the literature review, is its role in initiating international deliberation on the subject. Despite the withdrawal of the resolution, scholars on both ends of the governance rationale spectrum view the initiative as a significant step towards the beginning of global discussions on the governance of solar geoengineering (19 26 28 34 45 47 41 45 47 49 60).

The draft resolution is described as "a political opening" (19), "important" (45), and the start of "the start of the serious international deliberation on governance that has been needed for years" (60). Further, it is seen as a "highly constructive" step (47), and a welcomed development "in advancing the international community's understanding of these complex approaches and potential governance frameworks to manage them" (49). Furthermore, it is viewed as a "helpful way to introduce the topic of 'geoengineering' for formal consideration by governments" (41). Notably, the resolution is acknowledged for indicating a growing interest in geoengineering among specific actors, including leading nation-states and international institutions (34). According to some, this underscores a broader recognition of the significance of the UNEA resolution in bringing geoengineering within international fora (35).

Despite the apparent consensus among scholars at both ends of the spectrum regarding the initiative being a significant step towards initiating international discussions on the governance of solar geoengineering, the reasons for considering it as such vary significantly. The following sections delve into these specific contested aspects, illustrating how this variation is linked to scholars' positions along the governance rationale spectrum.

4.5.2 The timing of the resolution

A prevailing contested aspect of the UNEA-4 draft resolution, as arising from the literature review, is related to the timing of the resolution to address the issue of geoengineering and its governance. Some scholars view the timing of the resolution as appropriate, whereas others criticize it for being too premature. This divergence in interpretation of the appropriateness of the resolution's timing is closely linked to scholars' positions along the governance rationale spectrum.

Only those scholars who fall within the enable/oversight side of the spectrum criticize the timing of the resolution for being premature (47 38) The general argument for this prematurity is that the questions that need to be addressed at this juncture in time are "scientific rather than policy in nature" (38). Here it is argued that the current lack of scientific knowledge on geoengineering, specifically solar geoengineering, needs to be addressed prior to engaging with the question of how it should be governed. Therefore, it is stressed that the IPCC is the appropriate international assessment body at this juncture in time, rather than UNEP (38). This argument is similar to the objections of the United States and Saudi Arabia during the negotiations, where delegates argued that discussions on geoengineering should be under the auspices of the IPCC (22). Again, substantiated by the argument that such an "analysis would be constrained to science rather than governance" (22). Moreover, objections are raised by

UNEP conducting an assessment of SRM and CDR prior to the IPCC's sixth Assessment Report which was expected in 2021 (19).

Scholars falling on the restrict/vigilant side of the governance rationale spectrum do not criticize the timing of the resolution for being premature. Instead, those within this category who do comment on the timing of the resolution view it as appropriate, and as the beginning of global geoengineering governance rather than the end of it (40 54 52). This 'appropriate timing' is primarily supported by the argument emphasizing the urgent necessity to establish international governance for (solar) geoengineering. This argument asserts that a well-timed governance framework is crucial to ensure that the global community remains ahead of technological advancements and that all research and potential development consistently align with the public interest (50). Similarly, some emphasize the resolution being timely given the urgent need for discussing the issue within the UN and at the highest level to prevent commercial conflicts of interest from influencing the governance debates (40).

Some scholars advocating the enable/oversight governance rationale also consider the timing of the resolution as appropriate, yet their justifications markedly differ from those supporting the restrict/vigilant governance rationale. They contend that the *urgency to address climate change* justifies exploring all possible options, making the resolution timely, albeit not necessarily for the immediate establishment of international governance for solar geoengineering technologies (37 38). As one scholar puts it: "Time is running out to deal with climate change, so we need to explore all options, rather than rule any out" (38). Similarly, another scholar deems the timing of the resolutions appropriate due to the urgency of preventing dangerous climate change (37). This scholar argues that relying solely on emission cuts is highly unlikely, and the substantial scientific evidence supporting the effectiveness of some forms of geoengineering in reducing climate change underscores the need for exploration. Additionally, one scholar underscores the significance of the IPCC report as a reminder of the massive scale of the climate crises, advocating that understanding solar geoengineering approaches is a timely and crucial component of a strategy to limit harm (49).

4.5.3 The institutional fit

Another prevailing contested aspect of the resolution, as revealed by the literature review, revolves around the suitability of the United Nations Environment Assembly in addressing (solar) geoengineering and governance concerns. While some scholars assert that UNEA is the fitting platform for evaluating (solar) geoengineering technologies, others express doubts or

criticisms about its appropriateness. Diverse interpretations of UNEA's and UNEP's institutional fit were identified within and between each governance rationale category.

Various scholars advocating the enable/oversight governance rationale contend that the UN Environment Assembly is not the suitable platform for evaluating the current state of science—an aspect they deem presently essential, as mentioned briefly in the preceding section. Instead, they argue that scientific inquiries are best addressed within the purview of the IPCC, given its in their view inherently scientific rather than policy-oriented nature (37 38). Within this enable/oversight governance rationale, some scholars acknowledge UNEP's role in addressing governance-related questions, citing its mandate and capabilities (38). However, most underscore that addressing such questions prematurely may be counterproductive. Others, recognizing the controversial nature of the issue, propose that UNEP is better positioned to foster and coordinate the efforts of existing assessment processes, notably those by the IPCC. For example, they envision a positive outcome of a UNEA resolution as a message to the IPCC leadership, urging the prioritization of solar radiation management in their forthcoming assessment report (56 58). One scholar suggests that "UNEP could encourage an in-depth examination of solar geoengineering in the IPCC's 6th Assessment Report" or advocate for a UNEA recommendation for an IPCC special report on solar geoengineering (56). Furthermore, advocates of this rationale stress the necessity of an international assessment of climate engineering to complement assessments conducted in national forums, such as the evaluation conducted by the US National Academy of Sciences and the Royal Society. Related to this, to garner the support of the United States, one scholar proposes that a UNEA resolution could have acknowledged the country's ongoing domestic efforts, including the establishment of a National Academies committee responsible for developing a research agenda and recommending governance approaches for solar geoengineering (58).

Various scholars positioned at both ends of the governance rationale spectrum perceive the UN Environment Assembly as a suitable platform for discussing solar geoengineering technologies, albeit with varying degrees of endorsement (39 43 47 49 54 57). The dissimilarity in their arguments revolves around the why, when, and to what end UNEA is viewed as an appropriate venue. Advocates of the enable/oversight governance rationale assert that UNEA is fitting due to its broad mandate, encompassing environmental protection and sustainability issues, along with its pivotal role in driving international environmental governance. They highlight its global perspective on environmental matters, which extends to addressing challenges like biodiversity loss and ocean acidification, rendering it conducive to discussions on solar geoengineering. Moreover, they underscore the UNEP's competence, credibility, and

authoritative standing as a producer of reliable work (39 43 48). Some contend that UNEA provides a 'less politicized' and more constructive platform for addressing solar geoengineering compared to alternative institutions (43). One scholar, for instance, suggests that placing the issue under UNEP's authority could engage leaders from both industrialized and developing countries, challenging assumptions that have shaped the (restrictive) treatment of the issue within the IPCC (47). Furthermore, some scholars make explicit reference to the decision adopted by the CBD, comparing the appropriateness of forums. They emphasize the CBD's limited mandate, focused solely on biodiversity conservation, could potentially restrict its ability to comprehensively govern solar geoengineering. Arguing that a UNEA resolution could elevate geoengineering governance to a broader consideration by states beyond issue-specific treaty bodies, some scholars point to the significance of this approach (39).

Scholars advocating the restrict/vigilant governance rationale assert the suitability of UNEA more decisively compared to those advocating the enable/oversight governance rationale. Notably, their articulation and reasoning are marked by a clear stance on the institutional fit. For instance, one scholar contends that the United Nations stands as the *only* legitimate multilateral setting for addressing the imperative and governance of speculative and high-risk geoengineering options (54). Another scholar emphasizes that despite its imperfections, UNEA offers an opportunity for a more inclusive and respectful discussion, which is viewed as advantageous compared to implicitly preserving existing political and economic structures (46). Moreover, skepticism is expressed toward those proposing the IPCC as a more appropriate forum, as suggested by advocates of the enable/oversight governance rationale. These scholars argue that, given the inherently political nature of solar geoengineering, the notion of a non-politicized setting is elusive (54). Therefore, they assert that scrutiny is essential to discern which 'politicized' setting is favored and by whom. Additionally, one scholar underscores the nuanced role of the IPCC, noting how proponents of geoengineering seem to prefer its 'non-politicized' setting while simultaneously criticizing its 'science-based' assessment if outcomes diverge from their perspective (54). According to this scholar, this raises questions about the avoidance of debates in a UN context.

Lastly, several scholars advocating the restrict/vigilant governance rationale draw attention to the significance of the previous CBD Decision X/33. Some express reservations about a UNEA resolution on geoengineering, contending that it does not adequately incorporate or acknowledge decisions on geoengineering made by other UN bodies, particularly referencing the CBD decision (28 40). These concerns echo concerns raised by some delegates during UNEA deliberations. Here, some voice apprehensions that UNEP's activities might potentially

undermine or weaken ongoing efforts to restrict solar geoengineering under the CBD, thereby creating a framework perceived as more enabling to geoengineering (28 29 40 44). In other words, the shift to UNEA as a forum for offering governance recommendations is seen by some as a potentially undermining of what they perceive as a robust and established prohibition against speculative solar geoengineering approaches. This viewpoint is reinforced by the assertion that UNEA's involvement could weaken the existing stance against such approaches. In contrast, one scholar advocating the restrict/vigilant governance rationale suggests avoiding the CBD due to its perceived framing by some academics in the field as being influenced by "anti-geoengineering interests" (46). While disagreeing with this characterization, the scholar suggests distancing the debate from such framing to foster a more neutral and objective discussion.

4.5.4 The object of governance

An additional pivotal factor influencing the perceived 'failure' of the resolution revolves around the contentious issue of the proposed *object of governance* (3 16 19 20 24 25 28 37 38 39 43 61). Boettcher and Kim (2022) underscore a discernible split between broad versus narrow object of governance. The former involves encompassing geoengineering as a whole under the object of governance, while the latter focuses solely on specific types of geoengineering activities. The resolution's preamble explicitly acknowledges being "[m]indful of the varying definitions of geoengineering and the general distinction of technologies in solar radiation management and carbon dioxide removal, and taking into account their varying state of development with respect to science, their application, and potential risks" (Politico, 2021). Despite efforts to differentiate between various geoengineering methods, the grouping of solar radiation management and carbon dioxide removal under the overarching term 'geoengineering' has raised substantial concerns. This categorization has led to apprehensions that various technologies falling within this umbrella term might be treated alike, as revealed by the literature review. Notably, only scholars advocating for the enable/oversight perspective express concerns or criticism about this 'lumping' together, with no identified arguments from those advocating the restrict/vigilant governance rationale.

The main concerns to categorizing them both as 'geoengineering' as raised by these scholars relate to the fundamental differences in problem structures, methodologies, potential risks, and related governance challenges of the two categories of technologies (19 20 38 43 61). Some scholars emphasize that this "forced marriage" between CDR and SRM is problematic given their fundamental differences in terms of problem structure (20). According to one

scholar, this difference suggests that states are likely to have different preferences for how to govern each technology in the near future. Categorizing them together could therefore potentially limit the development of appropriate governance since it "undermines potential state engagement with the governance and science of SRM and CDR options" (20). Thereby suggesting that states are more likely to engage and adapt governance proposals when these two technologies are split. Another scholar presents a similar argument, emphasizing the distinct problem structures and risks associated with SRM and CDR options. As a result, this scholar argues it would be counterproductive to engage in a discussion that treats the two approaches interchangeably (38).

In terms of potential risks, some argue that the proposed resolution is ambiguous and has consequently resulted in the lumping of technologies that "pose no novel risk" together with those "that may pose substantial novel risks" (61). Moreover, it is argued that despite the proposed resolution claiming to be 'mindful' of the distinction between CDR and SRM, it "fails to make meaningful distinctions" given a lack of clearly defined definitions (61). Similarly, two other scholars argue that "[s]mall changes to the language in the operative part could clarify that an assessment should examine governance challenges of CDR technologies as a group and, *separately*, of SRM technologies as a group" (43). They refer to the operative part of the resolution that requests "conclusions on potential governance frameworks for each geoengineering technology," which in their view could lead to blurring of the fundamental distinction.

A few scholars who advance the restrict/vigilant governance rationale acknowledge the concerns regarding the use of the term 'geoengineering,' although perceive it as less problematic (39). Some scholars argue that using the term could benefit states as it serves as a common language and reference point for engaging with SRM and CDR activities across international environmental entities. Here, it is emphasized that while the term carries negative connotations and its use may result in undesirable strict regulation of research and experimentation, the potential benefits of using the term may outweigh the potential risks (39).

4.5.5 The precautionary approach

Another contentious issue, as identified by the literature review, is the incorporation of a reference to the precautionary principle in the draft resolution. Scholars on both sides of the governance spectrum argue that the attempt to include the precautionary principle has played a pivotal role in the resolution's withdrawal (12 18 19 28 29 54 55 56 57). However, these scholars differ in their attributions of responsibility and interpretations of the implications

stemming from the resolution's withdrawal due to the precautionary approach. To comprehend the diverse perspectives of scholars, it is essential to briefly highlight the contestations that emerged during the resolution negotiations and the broader context of international environmental law.

The term "precaution" emerged in response to the acknowledgment that science may not always provide all the necessary information to understand the environmental impacts of certain measures or technologies before decision-making (Perrez, 2020). In other words, precaution serves as a guide for formulating and implementing policy in the face of scientific uncertainty. In this case, a revised draft of the resolution explicitly incorporated a mention of precaution in the preambular section to address concerns about initiating discussions on geoengineering that could potentially lead to an enabling governance framework. Delegates advocating for a precautionary approach were concerned that the resolution might be perceived as endorsing a controversial set of climate change response options without its use. Conversely, delegates opposing the inclusion of the precautionary approach argued that the resolution could be overly restrictive, limiting the scope of research into these technologies (Jinnah & Nicholson, 2019). The European Union and Bolivia insisted on including a precautionary reference, while the United States objected, rejecting any text containing such a mention by arguing that it would preempt the content of the report. This dispute reflects the persistent division in international environmental law between the European Union and the United States on the role and status of the precautionary principle (Jinnah & Nicholson, 2019).

From this standpoint, as posited by Perrez (2020), the relevance of the precautionary principle would only manifest upon the completion of a UNEP report addressing the potential impacts of geoengineering. Consequently, the inclusion of a reference to this principle in the draft resolution, which advocates for such an assessment, would be superfluous and risk imparting an "over-politicized framing of the work of UNEP" (Perrez, 2020, p. 13). This view of precaution creating an 'over-politicized framing' was only found by those scholars advancing the enable/oversight governance rationale. Here, some scholars question the motivation of the EU and Bolivia to modify the resolution in manners that were, in their view, already likely to result in its failure (56). Moreover, one scholar emphasizes that the resolution with the inclusion of a precautionary approach takes "one side on a multi-sided issue" (38). Criticizing the resolution for taking a biased stance on a complex matter by only expressing concerns about the risks and adverse effects of geoengineering, while disregarding the potential benefits of these technologies specifically in mitigating the risks and impacts of climate change. Despite acknowledging that certain technologies may entail risks, the scholar highlights the importance

of considering the risks posed by a three or more degrees warming scenario, which according to this scholar the resolution failed to do. Furthermore, one scholar blames advocacy groups active during the negotiation, that call for a ban on geoengineering for pushing for a decision emphasizing the precautionary principle and the CBD decision. The scholar criticizes their narrative and influence on certain states to adopt a more skeptical or precautionary view of geoengineering, which in this scholar's view is inadequately supported and misleading (48).

Scholars advocating the restrict/vigilant governance rationale generally acknowledge the inclusion of a precautionary approach as being the downfall of the resolution. However, they attribute different explanations and implications to this outcome. For instance, one scholar critiques those who attribute the failure of the resolution to environmentalists opposing geoengineering, asserting that interpreting their proposals as deliberate attempts to obstruct agreement overestimates the influence of environmentalists and is, therefore, misguided (57). Instead of blaming environmentalists, this scholar contends that the support for a precautionary approach aligns with countries' recognition of substantial uncertainties surrounding solar geoengineering, along with the potential future risks and injustices associated with impeding or delaying the deep emissions reductions outlined in the Paris Agreement. Another scholar underscores that labeling a UN-led assessment as politicized or illegitimate, as suggested by opposing views, places more emphasis on the message itself than on the messenger (54). In other words, this scholar argues that if a potential UN-led assessment supports a technology-enabling message, it would be welcomed by advocates of such a framework, and the UN's multilateral legitimacy would be highlighted. Conversely, a more skeptical and precautionary message, like the one present in the draft resolution, would be considered illegitimate or overly politicized by those favoring a technology-enabling stance. This scholar asserts that the resolution's failure, attributed to the inclusion of a precautionary approach, thus underscores the necessity for a politically legitimate UN setting and an assessment capable of "shedding light on the precautionary actions that the global community should most urgently contemplate" (54).

4.5.6 Knowledge deficiencies

Only a few scholars, notably those advocating for the enable/oversight governance perspective, draw attention to and critique the perceived lack of understanding among state delegates regarding SRM and CDR technologies during the UNEA-4 deliberations (19 20 49). Their criticism highlights what they perceive as significant confusion surrounding the foundational knowledge of SRM and CDR options, emphasizing the necessity for knowledge-building and

sharing to avoid definitional uncertainties and factual inaccuracies hindering future political discussions (19). One scholar contends that states' preferences regarding SRM are likely to undergo evolution and change over time, given the current nascent state of their understanding. This scholar asserts that many states presently lack a fundamental understanding of solar geoengineering, predicting a shift in their future preferences (20). Adding a note of caution, another scholar suggests that international discussions on (solar) geoengineering, especially when negotiators possess limited knowledge of the subject, might lead to the implementation of counterproductive regulations. This concern is illustrated by citing the premature engagement of the CBD in geoengineering, specifically referring to Decision X/33 in 2010 (48). According to this scholar, the CBD's early involvement resulted in the formulation of a decision that was poorly articulated and widely misunderstood.

4.6 Implications of UNEA-4

Having outlined the scholarly interpretations of the UNEA resolution as documented in the literature, this section delves into the implications and political consequences of the UNEA draft resolution. The absence of assessment following the withdrawal during UNEA-4 introduces challenges in determining direct implications. However, what becomes evident is the intricate interplay of international developments, including various reports published post-UNEA-4, and how actors utilize specific UN fora for their advocacy efforts within the solar geoengineering governance domain.

In the aftermath of the lack of a member state-led and agreed-upon assessment resulting from the proposed UNEA resolution, a significant development has taken place within UNEP. In early 2022, UNEP initiated the formation of a 'multidisciplinary expert panel' tasked with reviewing the current state of scientific research on solar radiation modification—importantly, not mandated by states. The resulting publication, titled 'One Atmosphere: An Independent Expert Review on Solar Radiation Modification Research and Deployment,' was released in February 2023 (UNEP, 2023, p. 1). While the report does acknowledge the "many unknowns and risks" associated with SRM techniques and adopts a cautionary stance on immediate implementation, its authors emphasize the urgent need for establishing an international scientific review process. This process would aim to systematically identify scenarios, consequences, uncertainties, and knowledge gaps related to SRM deployment (UNEP, 2023). It is essential to note that the composition of the author team, including individuals known for their SRM research advocate stances, raises questions about the report's content and potential

influence from specific advocacy groups within UN fora. Despite lacking a mandate from states or official UNEP status—only being sponsored, not formally endorsed by UNEP—the report has gained substantial attention, particularly in the media. A notable concern revolves around the framing and utilization of the report as an official "UN" or "UNEP report" (e.g., Guesgen, 2023; Hiar & Fialka, 2023), suggesting a formal endorsement at least in the context of advancing research into solar geoengineering technologies.

The report's call for an international assessment of solar geoengineering has sparked diverse interpretations. Some advocates of SRM research and its consideration as a climate policy option perceive the report as an implicit endorsement, contending that "when the UN says something is important, people pay attention" (in Guesgen, 2023). Conversely, critics of SRM research and deployment express disappointment with what seems like support for research within a UN context. They argue that the report neglects the perspectives of social scientists, indigenous communities, and other groups, predominantly emphasizing the viewpoints of physical scientists. Moreover, these scholars are concerned that the proposed global review process stemming from the report might perpetuate this bias. According to one scholar, the report is "almost misleading" as it presents a predominantly pro-solar geoengineering standpoint, leaving certain voices struggling to be heard (in Guesgen, 2023).

Another noteworthy example involves a report issued by the United Nations Human Rights Council (Human Rights Council, 2023). In response to resolution 48/14, the Human Rights Council tasked its Advisory Committee with conducting a comprehensive study, resulting in the publication of the report titled "Impact of New Technologies Intended for Climate Protection on the Enjoyment of Human Rights: Report of the Human Rights Council Advisory Committee" released in August 2023 (UNHRC, 2023). The assessment encompassed solar geoengineering technologies within the category of "new technologies intended for climate protection." This report, grounded in various legal concepts and human rights obligations, recommends that states "should adopt and implement restrictive regulations on solar radiation modification experiments, where necessary, including a ban on outdoor experiments, while only allowing conditional and controlled research for a moratorium on all solar radiation modification activities" (p. 19).

The cautious stance taken by the report has elicited criticism from some advocates of SRM research and its consideration as a climate policy option. For instance, some contend that it presents a "highly skewed case against SRM" and fails to adequately address the human rights issues associated with the potential benefits of solar geoengineering technologies, accusing the report of lacking impartiality (Irvine, 2023). In contrast, the Center for International

Environmental Laws, a public nonprofit environmental law organization recognized for its critical stance toward solar geoengineering, welcomes the report as a pivotal contribution to advancing human rights-based climate action (Center for International Environmental Law, 2023). They underscore the importance of a precautionary approach and emphasize states' obligations to protect, respect, and fulfill human rights. Furthermore, they assert that existing legal frameworks already impose a duty not to deploy or develop solar geoengineering technologies due to the high risks associated with the rights of present and future generations.

What these post-UNEA-4 developments reveal, and how they have been received, is a persistent struggle over the way forward regarding research, development, and deployment of this technology, differing within various UN institutions. While these reports hold institutional significance, it is crucial to critically evaluate them, taking into account their authorship, potential biases towards disciplines, and the drivers behind their initiation. Furthermore, it suggests the strategic utilization of these reports to validate varying perspectives among scholars and other actors. For example, the reception of certain reports varies significantly based on the stance they take, either endorsing or restraining solar geoengineering research, development, and deployment. This underscores how advocates or proponents adeptly leverage specific UN fora to align with their particular message, be it supportive or restrictive, shaping the discourse to suit their objectives.

Finally, future implications may involve a renewed attempt at a UNEA resolution. Despite Switzerland expressing determination to reintroduce the topic at UNEA-5 during UNEA-4, such efforts did not materialize. Nevertheless, Switzerland has resubmitted a draft resolution focused on "Solar Radiation Modification" for consideration during the forthcoming sixth session of the United Nations Environment Assembly scheduled from February 26 to March 1, 2024. This occasion is likely to become yet another arena for the ongoing battle over the narrative surrounding the governance of research, development, and deployment of this technology.

4.7 Chapter conclusion

This chapter examined the *de jure* global governance attempts of solar geoengineering, addressing sub-research questions; "How is solar geoengineering *de jure* being governed at a global level? How is scholarly literature these *de jure* governance attempts? And what (political) implications have arisen from these?" (SRQ1-3). It focused on two identified key

attempts: the CBD Decision X/33 and a submitted draft resolution on 'Geoengineering and its Governance' presented at UNEA-4.

The CBD Decision X/33 stands out for its precautionary and restrictive approach to solar geoengineering, explicitly stating that no climate-related geoengineering activities, encompassing "any technologies that deliberately reduce solar insolation," that may affect biodiversity take place, albeit with several qualifiers. Scholars advancing the enable/oversight rationale view the decision as an advisory statement rather than a (de facto) moratorium, emphasizing its non-binding nature and vague language. Moreover, they underscore the CBD's limited scope and criticize the one-sided interpretation of the precautionary principle in the decision. In contrast, scholars advancing the restrict/vigilant governance rationale generally refer to the decision as a de facto moratorium, emphasizing its significance and reflecting nearly global consensus. The draft resolution negotiated during UNEA-4 stands out for its withdrawal and lack of state consensus, with scholars offering divergent views on its timing, inclusion of the precautionary principle, and understanding of geoengineering technologies. In summary, this chapter has illustrated the contested meanings and significance of both these attempts in scholarly literature. Despite varying interpretations, certain tangible impacts of the CBD decision have emerged, influencing restrictive actions like Mexico's prohibition of solar geoengineering experimentation. While the withdrawal of the UNEA-4 resolution complicates the assessment of its implications, subsequent developments, such as UNEP's expert panel authoring the 'One Atmosphere' report, signal ongoing deliberations within international forums on the direction of solar geoengineering governance.

5. DE FACTO GOVERNANCE: EXPERT-LED INITIATIVES

This chapter provides a detailed description of the findings derived from the analysis of three identified expert-led non-state initiatives as sources of de facto governance. Specifically, it examines three prominent initiatives: the International Non-Use Agreement on Solar Geoengineering initiative, the Call for Balance initiative, and the Climate Overshoot Commission. First, a concise overview of the existing controversies surrounding solar geoengineering governance and research governance is provided, drawing from existing literature to establish the foundation for subsequent sections. This is followed by the analysis of each initiative. The analysis examines the nature of these initiatives, detailing their organizational features, including objectives, drivers, funding, and activities. Additionally, it explores the primary de facto attempted *intervention* for each case, followed by the *potential* de facto governance effects that have been identified. Finally, for each case inferences concerning the potential implications for *de jure* governance are discussed.

5.1 Controversies in solar geoengineering discourse

To evaluate and elucidate the potential de facto governance effects, in terms of the advocated governance directions by the three initiatives under analysis, it is essential to provide a concise overview of the existing controversies surrounding solar geoengineering and its governance. This section offers a brief overview of the relevant contentious issues within the solar geoengineering governance debate, intending not to be exhaustive but to highlight some key contestations in the literature. The insights derived from this overview lay the groundwork for the subsequent section of this empirical chapter, where the initiatives were expected to articulate their positions on specific controversies, and related to this, advocate for certain governance directions.

5.1.1 Navigating the controversies of solar geoengineering research

The debate on solar geoengineering research centres on the question of whether and how to advance this field. Some advocate for increased research endeavours, while others advocate for a more cautious approach, suggesting a delay in advancing research until robust governance frameworks are in place. Moreover, pivotal aspects of research, including interpretations of uncertainty, the “slippery slope” argument, the value of models and outdoor experiments, and

the framework for research governance stand as central points of contention driving this discussion, several of which are further elucidated below.

Various scholars underscore the potential social-political repercussions of advancing research and development in solar geoengineering technologies, particularly concerning future decision-making processes. One notable concern is the potential of research creating a "slippery slope" towards deployment (Bellamy & Healey, 2018). The slippery slope argument posits that engaging in mere research on geoengineering may "create institutional momentum, ultimately leading to the deployment of a technology that is untested and perhaps morally objectionable" (Callies, 2019, p. 675). While some argue that research inevitably paves the way for deployment or at the very least heightens its likelihood, others question this assertion (Tang, 2023). Those who are concerned with such a likelihood of research as an initial step toward eventual deployment, emphasize that researchers may lack control over the technology's deployment once it is there (Tang, 2023). In this context, scholars stress that political interests are likely to guide decision-makers, particularly politicians and government officials rather than scientists. In a hypothetical scenario where researchers oppose the deployment of solar geoengineering, there is no guarantee that their preferences will prevail (Tang, 2023). Conversely, some argue that research into these technologies does not inevitably lead to deployment (Callies, 2019), citing precedents involving other emerging technologies. For instance, Smith and Henly (2021) the validity of the slippery slope argument, challenging the evidence supporting such a trajectory, challenging the evidence supporting such a trajectory. They contend that the slippery slope concern is equally plausible for various technologies, and emphasize the history of social resistance and controversy regarding solar geoengineering research. Tang (2023) counters these arguments, asserting that while a slippery slope may be a concern for various technologies, the critical distinction lies in the direct control that solar geoengineering holds over Earth's climate. Additionally, Tang (2023) underscores that current resistance does not guarantee the absence of future changes, especially if researchers continue to present an optimistic and idealized perspective of solar geoengineering technologies.

The question of whether more research is needed is intricately connected to the interpretation and framing of uncertainty surrounding solar geoengineering technologies. Numerous scholarly publications and authoritative reports highlight the considerable uncertainty related to solar geoengineering, among others regarding technical feasibility, effectiveness, and overall impacts. Advocates for more research often characterize these uncertainties as challenges that can be overcome through intensified research efforts, thereby transforming uncertainties into a research agenda (Stilgoe, 2015). This perspective is frequently

supported by emphasizing existing "knowledge gaps" related to solar geoengineering that need filling or uncertainties that require reduction (Cairns, 2017). The promise of reduced uncertainty through scientific endeavours is often linked with the expectation of facilitating well-informed decision-making (Cairns, 2017). However, some regard treating uncertainty as a manageable risk as a way to evade the implications associated with acknowledging radical uncertainty. From this standpoint, such a perspective overlooks the potential unknowability of specific aspects of solar geoengineering within the climate system, asserting that despite intensified research efforts, these uncertainties may persist (Baskin, 2019; Cairns, 2017; Stilgoe, 2015). For some, framing knowledge production in terms of a 'gap' in knowledge is a risky fiction constructed on questionable assumptions, especially when dealing with contentious socio-technical imaginaries like solar geoengineering (Cairns, 2017). Presenting uncertainty as a concept to be "reduced" through more research implies a false sense of clarity and closure about the best course of action, ignoring the inherently irreducible uncertainties associated with the social, political, and physical dimensions of solar geoengineering (Cairns, 2017). In other words, it challenges the notion that uncertainty can be solely managed through increased research efforts.

The academic debate surrounding solar geoengineering extends beyond the mere consideration of expanding research efforts, encompassing disputes about the specific nature of such research. Within the scientific community, perspectives on this issue vary widely, ranging from strong resistance to conducting field experiments to approval of small-scale field experiments (Frumhoff & Stephens, 2018). The rationale behind advocating for field research is grounded in the acknowledgment of the limitations of policy-relevant information derived solely from observational studies of volcanic eruptions and climate model simulations (Frumhoff & Stephens, 2018; Shrag, 2017). Presently, the predominant of solar geoengineering research relies on modelling. While modelling studies are considered valuable by some, it is argued that models alone are insufficient to provide reliable information about the overall risks, consequences, and benefits of solar geoengineering (National Research Council, 2015). To address this, some propose small-scale field experiments involving the release of aerosols into the atmosphere, aiming to mitigate climate model uncertainties related to deployment while minimizing environmental risks (National Research Council, 2015; Parson et al., 2017). Others raise concerns regarding model-based solar geoengineering research and field experiments. Some contend that models, while having some merit, influence societal and political expectations around technologies, incorporating assumptions from the prevailing social imaginary into modelling practices (McLaren, 2018). This could potentially result in creating misleading narratives of technological optimism regarding solar geoengineering. Such concerns

advocate for a cautious approach when considering the promises and potential benefits of solar geoengineering, especially when relying heavily on models. Concerning field experiments, opponents, beyond their broader objections to solar geoengineering as undesirable and ungovernable, frequently invoke the 'slippery slope' argument as previously outlined (Hulme, 2014; Szerszynski et al., 2013). They argue that even discussions of small-scale outdoor experiments with minimal direct environmental risks raise substantial ethical and geopolitical concerns. Furthermore, apprehensions related to 'moral hazard' are underscored, positing that engaging in field research, albeit on a small scale, could act as a distraction, undercutting the already insufficient national and global political will to adequately mitigate or adapt (Hulme, 2014). Furthermore, concerns are raised regarding the insights small-scale experimentation can provide. The absence of full-scale or global implementation leaves certain aspects of solar geoengineering unresolved, which cannot be adequately addressed through small-scale outdoor experiments (Robock et al., 2010).

Finally, linked to these perspectives on whether and how research should proceed is the way it should be governed. The consensus among most academics is that some form of governance is essential to ensure responsible research (McLaren & Corry, 2021). Proposals for governing research, span a spectrum from minimal self-regulation by scientists to existing measures, such as environmental impact assessments, to international frameworks designed to either restrict or facilitate research (McLaren & Corry, 2021; Owen, 2014; Parker, 2014). The debate extends to the scale of proposed projects. Some suggest taking into consideration the direct physical risks associated with research, and the societal implications when considering governance requirements (in McLaren & Corry, 2021). Several propositions have been put forth, outlining principles for 'responsible' research, or taking the shape of a code of conduct crafted by experts. For instance, the principles for research governance stemming from the 2010 Asilomar conference (Asilomar Scientific Organizing Committee, 2010), and the Oxford Principles (Rayner et al., 2013). Yet, some argue that these proposals for research governance often overlook the limitations of national or self-regulatory approaches, neglecting the significant international implications for solar geoengineering research, some of which are outlined above (McLaren & Corry, 2021).

5.5.2 Navigating the controversies of solar geoengineering as a climate policy option

Linked closely to the debates about whether and how solar geoengineering research should progress is the question of whether it should be considered as a potential supplementary climate policy option. Advocates support its consideration, emphasizing, among other reasons, the

urgent need to address climate change and the potential of solar geoengineering to deliver rapid cooling to limit global warming. Some argue that it could serve as an option if conventional mitigation efforts fall short, particularly when faced with the risk of surpassing critical climate tipping points and experiencing excessively high global warming levels (Keith, 2013; MacMartin et al., 2018). In this context, some highlight its perceived cost-effectiveness compared to climate mitigation and adaptation options. However, contrasting viewpoints exist, with various scholars arguing against the consideration of solar geoengineering as a viable climate policy option. They raise concerns, including the potential challenges of governing its deployment within democratic frameworks (Hulme, 2014; Szerszynski et al., 2013), the risk of 'moral hazard,' the possibility of technological lock-in, and potential violations of climate justice principles (Gardiner & McKinnon, 2020). Some key points of contention are discussed in the following.

One contested aspect related to whether solar geoengineering is viewed as a considerable climate policy option is related to concerns regarding the potential unilateral deployment of solar geoengineering. Unilateral deployment refers to a state or group of states deploying the technology without the consent or approval of the international community, and is according to some theoretically feasible (Corry, 2017; Keith, & Parker, 2015). As the atmosphere is indivisible, the potential deployment of solar geoengineering by a single state can bring about changes in the environment of other states, thereby potentially causing negative effects on other states' territory, economy, and security. Yet the likelihood of unilateral deployment of solar geoengineering is another point of contention. While some see a likelihood that vulnerable states in desperate situations might pose the most significant threat, others argue that only major global powers might be those who deploy solar geoengineering in their interests (Baskin, 2019). The concern about unilateral deployment is amplified by the relatively low costs associated with solar geoengineering and the speculative potential to rapidly reduce average global temperatures, which make unilateral deployment more likely (Weitzman, 2015). However, some counterargue this perceived cheapness, stating that all the steps necessary from research to development to deployment are only affordable by some states (Moriyama et al., 2017). Others emphasize that the focus on the risks of unilateral deployment might shift the discourse surrounding solar geoengineering risks by emphasizing the threat posed by unilateral deployment (Jacobson, 2018). This perspective supports the argument that legitimate research should be endorsed to prevent illegitimate actors from pursuing solar geoengineering. As Jacobson (2018) puts it: "This reorients the conception of risk in regard to geoengineering from what to who. Rather than the primary risk being deployment and its adverse consequences

(known and unknown), the risk is redefined from deployment itself to unilateral deployment" (p. 332).

Another disputed aspect related to the consideration of solar geoengineering as a climate policy option is associated with the *moral hazard* problem, also referred to as mitigation obstruction or mitigation deterrence. Extensively discussed in the literature, this issue relates to the potential disincentive for reducing greenhouse gas emissions due to the availability of solar geoengineering as a quick technological solution (McLaren, 2016). However, there is no consensus among scholars on the likelihood of this occurrence. Some scholars contend that moral hazard is of limited significance or, at the very least, an unsuitable term (Keith, 2013; Reynolds, 2014), whereas others continue to voice concerns (Gardiner, 2011; Lin, 2013).

Finally, various perspectives exist regarding the governance of solar geoengineering, particularly regarding the timing and necessity of international decision-making. Debates revolve around when and how to govern, whom to involve, and the purpose of governance – whether it should adopt restrictive measures or enabling frameworks (Gupta et al., 2020). Some advocate addressing scientific questions before initiating international governance discussions, proposing a framework prioritizing scientific research, and allowing state-based governance for potential future deployment to evolve as needed. In this context, the role of non-state actor governance, such as codes of conduct, is emphasized (Reynolds, 2019b). Others underscore the importance of initiating multilateral discussions across various United Nations institutions to address the whether and how questions. Proposed governance frameworks are characterized by political negotiation rather than expertise-led approaches (Gupta et al., 2020). Discussions typically centre on identifying the appropriate intergovernmental fora for decision-making and potential operational decision-making. Scholars suggest different institutions for governance, ranging from the UNFCCC (Burns & Nicholson, 2016; Zürn & Schäfer, 2013), CBD (Bodle et al., 2013), and UNEP to the establishment of new international institutions. Lastly, some scholars argue that the deployment of solar geoengineering cannot be "democratically nor effectively governed" within existing frameworks and intergovernmental institutions, proposing legally binding international moratoria and prohibitions on outdoor research and deployment (Asayama & Hulme, 2019; Hulme, 2014; Stephens & Surprise, 2020).

These preceding sections have elaborated upon some of the prevailing controversies. The subsequent sections delve into the analysis of the three cases as de facto sources of governance, providing insights into their intervention, potential de facto steering effects, and implications for *de jure* governance. This analysis is conducted within the broader context of the controversies previously outlined.

5.2 The Solar Geoengineering Non-Use Agreement Initiative

In January 2022, climate scientists and governance scholars worldwide initiated a global effort advocating for the establishment of an International Non-Use Agreement on Solar Geoengineering, particularly focusing on stratospheric aerosol injection (Solar Geoengineering Non-Use Agreement [SGNUA], 2021a). The initiative was launched based on an open letter written by 16 scholars affiliated with academic institutions from various countries worldwide (Biermann et al., 2022). The coordinating group of the initiative consists of 16 individuals all with an academic background (SGNUA, 2021c). Over 60 senior climate scientists and governance scholars supported the initiative at its launch and has since gained support from over 450 academics and numerous civil society organizations worldwide (SGNUA, 2021g-h). The initiative currently operates without external funding and relies solely on volunteers. It is emphasized that "all initiators and signatories have endorsed the open letter in their personal capacity, not on behalf of their institutions" (SGNUA, 2021g). Furthermore, it is stressed that the initiative is politically independent and not affiliated with any political party, organization, or ideology. Civil society organizations are invited to endorse the initiative but have not been involved in its development or management.

The primary activity of the initiative is increasing its network by engaging scholars, governments, civil society organizations, and citizens to support their call for a Solar Geoengineering International Non-use Agreement. The initiative provides the possibility to sign as an academic, endorse as a representative of a civil society organization, or sign the petition as a student or individual citizen (SGNUA, 2021i). Moreover, they share information on their website in the form of blog posts, briefing notes, and relevant publications. The initiative also maintains a presence on social media platforms such as Twitter and Instagram and is involved in external media outlets in terms of interview articles and events.

In the forthcoming sections, the nature of the initiative's attempted intervention, the potential de facto governance effects, and implications for future *de jure* governance are elaborated on. This analysis is based on their open letter and publicly available material and is juxtaposed with the controversies outlined above.

5.2.1 Intervention: A governance proposal for the Non-Use of Solar Geoengineering

The primary attempted *intervention* of the Solar Geoengineering Non-Use Agreement initiative, herein referred to as the non-use initiative, is to initiate and garner support for a concrete policy proposal on solar geoengineering. Specifically, they urge the United Nations, governments, and

other stakeholders to endorse their governance proposal. This ambition is reflected in the initiative's efforts, exemplified through their publication of an open letter and the dissemination of diverse publicly available materials (Biermann et al., 2022; SGNUA, 2021a-b). The core strategy employed by the initiative to garner support for its governance proposal involves seeking support from academics who can sign the open letter. Additionally, the initiative seeks endorsement from civil society organizations and signatures from students and individuals via a petition. To expand the reach of its intervention, the initiative deploys various outreach activities, encompassing engagement with the media and disseminating supplementary informational resources, thereby facilitating the distribution of its proposal. The subsequent section offers a concise overview of the five recommended core prohibitions and measures related to SRM within the governance proposal put forth by the initiative.

First, the initiative calls upon governments to commit to refraining from deploying solar geoengineering technologies, if developed by third parties (Biermann et al., 2022; SGNUA, 2021b). Second, governments are called upon to commit to prohibiting "their national funding agencies from supporting the development of technologies for solar geoengineering, domestically and through international institutions" (Biermann et al., 2022, p. 5). Third, governments are encouraged to commit to refraining from granting patent rights for solar geoengineering technologies, including supporting technologies like the retrofitting of airplanes for aerosol injections (Biermann et al., 2022). Concerning research, the initiative advocates for a commitment to prohibit outdoor experiments of solar geoengineering technologies within the jurisdictions of participating governments (Biermann et al., 2022). Lastly, participating governments are requested to commit to opposing the future institutionalization of "planetary solar geoengineering as a policy option in relevant international institutions, including assessments by the Intergovernmental Panel on Climate Change" (Biermann et al., 2022, p. 5). Related to the proposed measures related to research, they emphasize that the proposed International Non-Use Agreement on Solar Geoengineering does not seek to ban "atmospheric or climate research as such, and it would not place broad limitations on academic freedom" (Biermann et al., 2022, p. 5). Rather, the agreement is designed to concentrate exclusively on a defined set of measures aimed at limiting the development of solar geoengineering technologies within the jurisdictions of the potential participating parties.

Despite its primary design as an intergovernmental accord or treaty, the initiative states that the proposed Non-Use Agreement is receptive to the support and engagement of diverse stakeholders. For example, the initiative welcomes the participation of universities and scientific institutions. Additionally, philanthropic foundations are encouraged to publicly

commit to refraining from financing the development of solar geoengineering technologies. Furthermore, civil society organizations and local government authorities are invited to advocate for the adoption of a Non-Use Agreement. As argued, this collective effort would render such technologies less appealing for research groups to invest in, even in countries that may not endorse the call (Biermann et al., 2022).

5.2.2 Potential facto governance effects

After introducing the initiative's attempted intervention, a governance proposal, the subsequent sections explore the *potential* de facto governance effects that have been identified. It is crucial to acknowledge that assessing the initiative's de facto governance effects is premature due to its recent establishment. Although certain indicators of how the governance proposal of the non-use initiative may have functioned as a de facto steering mechanism are delineated below, the primary emphasis is on inferring prospective de facto governance effects. Here, it is illustrated how the initiative's intervention might de facto shape the future trajectory of this contentious field of inquiry within the broader context of existing controversies, assuming they succeed. Two key potential de facto governance effects were identified through this analysis, and are discussed below: i) to prevent further normalization of the consideration of solar geoengineering as a future climate policy option; and ii) to hinder the normalization of solar geoengineering research, specifically in its nature.

Forestall normalization of solar geoengineering as a future climate policy option

The first potential de facto governance effect identified involves the forestalling normalization of solar geoengineering as a future climate policy option. This objective is explicitly outlined in the initiative's governance proposal and associated core measures, which aim to "inhibit further normalization and development" of what they characterize as a "risky and poorly understood set of technologies" (Biermann et al., 2022, p. 6). All five core measures and prohibitions outlined above are viewed to "slow and most likely stop the creeping normalization of this speculative technology in climate debates" (Biermann et al, p. 5). Notably, the rationale behind forestalling the normalization of solar geoengineering as a future climate policy option is rooted in the perception that it is deemed "not necessary" (SGNUA, 2021b, p. 2; Vetter, 2022). The assertion that solar geoengineering is unnecessary is founded on the assertion that the "decarbonization of our economies is feasible if the right steps are taken" (Biermann et al., 2022, p. 6). In this context, the increasing integration and legitimization of solar geoengineering technologies in discussions about global climate governance is viewed as a risky development

(SGNUA, 2022m). The initiative posits that solar geoengineering is not just undesirable but also unethical and politically ungovernable, stances that support their advocacy for preventing its normalization as a future climate policy option. These perspectives are rooted in various concerns surrounding solar geoengineering, some of which are elaborated upon in the following sections.

First and foremost, the initiative asserts that the deployment of solar geoengineering is deemed "impossible to govern fairly and effectively in the current political system, under assumptions of effective global participation, inclusiveness, and justice" (Biermann et al., 2022, p. 3). Several arguments underline this perspective. First, the authors contend that implementing solar geoengineering at a planetary scale necessitates complex global decisions. The complexity of the deployment, coupled with the different impacts on various countries, makes democratic decision-making at a global scale crucial but challenging to safeguard in a fair and just manner. They emphasize that "fair and just governance would require *effective control* over the deployment of such technologies *by all countries*" (Biermann et al., 2022, p. 3, emphasis added). Here, they view enforceable and effective control over these technologies as particularly vital for the poorest and most vulnerable nations (SGNUA, 2022m). However, the authors note a lack of evidence suggesting that technologically advanced countries, able to develop these technologies, would willingly transfer control to the Global South, or would be willing to bear the responsibility and compensate for potential unintended catastrophic consequences that may disproportionately impact developing countries (SGNUA, 2022m). To ensure globally inclusive and effective governance, the initiative argues that powerful countries developing solar geoengineering technologies should place them under the control of effective multilateral institutions, "with guarantees of collective veto rights for the most vulnerable nations" (Biermann et al., 2022, p. 3). However, the authors express skepticism about the feasibility of reaching such agreements within the current world order, citing the inadequacy of existing international bodies, such as the United Nations General Assembly (UNGA), UNEP, and UNFCCC to enforce just, equitable, and effective multilateral control.

Furthermore, the authors argue that any global decisions on the deployment of solar geoengineering are unlikely to find consensus and require clear decision-making procedures to solve disagreement. Here, they highlight the absence of precedents for enforcing global decisions in the face of disagreements, citing the example of the United Nations Security Council, which lacks global legitimacy due to the veto power of its five members. In short, they argue that "the deployment of solar geoengineering at planetary scale would require entirely new international organizations with convincing means of democratic control and

unprecedented enforcement powers. Such organizations do not exist" (Biermann et al., 2022, p. 4; SGNUA, 2023q). Finally, it is stated that similar concerns emerge in the context of informal governance structures, such as stakeholder dialogues or voluntary codes of conduct. Where these informal arrangements are viewed to pose challenges for less powerful actors to participate. Consequently, this is viewed as potentially leading to the premature legitimization of speculative technologies such as solar geoengineering.

The initiative highlights a second concern regarding the perceived challenge of establishing effective global and democratic controls for solar geoengineering deployment, emphasizing the complex and alarming geopolitical dynamics surrounding potential unilateral actions (Biermann et al., 2022; Hanbury, 2022; SGNUA, 2023q). For instance, in a blog post, the initiative states that "geoengineering is likely to lead to dangerous geopolitical conflicts, with nations fiercely fighting over control of the global thermostat" (SGNUA, 2023q). Although the initiative does not explicitly address the inevitability of this scenario, it expresses apprehension concerning the potential consequences of unilateral deployment, particularly in light of the anticipated low costs associated with certain solar geoengineering technologies.

Finally, the initiative seems to view a possible likelihood of a deterrent effect on mitigation (Bisson, 2022; Biermann et al., 2022; Milman, 2022; SGNUA, 2023q; SGNUA, 2023r; Straver, 2022). For instance, they state that "speculative hopes about the future availability of solar geoengineering technologies *could* threaten commitments to mitigation and reduce incentives for governments, businesses, and societies to do their utmost to achieve decarbonization or carbon neutrality as soon as possible" (Biermann et al., 2022, p. 4, emphasis added). They exemplify this by referring to "powerful industry interests," particularly from the energy sector "have long invested in delaying stringent climate policies," or even denying climate change altogether (Biermann et al., 2022, p. 4). Furthermore, they argue that this risk is particularly high now "with a surge of countries announcing their intention to reach net-zero emissions by 2050 or earlier" (Biermann et al., 2022, p. 4).

Forestall further normalization of solar geoengineering research and its specific nature

The second potential de facto governance effect of the initiative's governance proposal and related efforts is the forestalling of continued normalization of solar geoengineering research and its specific nature. As previously noted, scholarly literature highlights the controversy surrounding the expansion of research in solar geoengineering, with differing viewpoints on its legitimacy among scholars. The initiative's stance on solar geoengineering research seems

somewhat ambiguous. However, several indications imply, at the very least, a call to halt further normalization of research, if not to limit its expansion.

A first instance, is the initiative advocating for specific research-related measures, including the prohibition of outdoor experiments and a commitment to oppose "assessments by the Intergovernmental Panel on Climate Change" (SGNUA, 2021b, p. 2, emphasis added). It is crucial to emphasize that the initiative explicitly outlines that its objective is to "focus solely on a specific set of *measures targeted purely at restricting the development* of solar geoengineering technologies under the jurisdiction of the parties to the agreement *without restricting legitimate climate research*" (SGNUA, 2021b, p. 2, emphasis added). This suggests that some research not aimed at development may be considered acceptable. However, additional insights into the initiative's stance on research are provided in the article presenting the extended argument of the open letter.

Here, the authors propose that philanthropic foundations, universities, science associations, civil society organizations, parliaments, and various entities openly declare their refusal to fund the development of solar geoengineering technologies. The intended outcome would be a collective effort to "make such technologies increasingly unattractive for *any serious research group to invest in*, including in countries that might not immediately sign the international non-use agreement" (Biermann et al., 2022, p. 6, emphasis added). This implies a preference for no investment from "any serious research groups," essentially suggesting a scenario where no or limited (expanded) research is undertaken. For some who see the potential benefits of solar geoengineering and a strong humanitarian case for acquiring knowledge, criticism has been directed at these research-related measures, particularly for their perceived impact on potentially stifling research endeavours (Buck, 2022). They argue that the initiatives' proposals generate "intense social pressure," creating an environment where serious research groups may be hesitant to engage in solar geoengineering research due to fear of criticism (Buck, 2022). However, there is scepticism regarding those who interpret or frame these research-related measures as seeking an outright prohibition on all research on solar geoengineering (SGNUA, 2023s). Some supporters of the initiative have argued that advocates of geoengineering research might exploit this perception, claiming censorship or stifling of their work, or that the non-use proposal disadvantages prospective geoengineering researchers from the Global South (SGNUA, 2023s). The interpretation of these measures as restrictions on research, and the specific conditions under which research could be considered legitimate, remains ambiguous. However, this proposed research related measure demonstrates, at the very

least, an effort to hinder the further normalization of research, whether it entails an outright prohibition or not.

In addition, and linked to these specific measures, the initiative highlights potential risks associated with solar geoengineering research, where it is asserted that "research is not innocent" (SGNUA, 2023q). First, the initiative expresses concerns about the "proliferating calls for solar geoengineering research and development," at present and the apprehension that such technologies could become normalized as a future policy option (Biermann et al., 2022, p. 2). Second, it is emphasized that current research often depends on idealized modelling, which presumes cooperative political conditions perceived as unrealistic in today's divisive global environment (Biermann et al., 2022). This suggests the initiative's recognition that models can shape expectations around technologies, potentially leading to the creation of narratives of technological optimism regarding solar geoengineering. A third concern, outlined in a briefing note by some of the non-use initiative's supporters, revolves around the risk of a "slippery slope" leading to full-scale deployment. They argue that historical experience and research indicate a pattern where investment in technological development increases the likelihood of eventual deployment. The briefing note suggests that "any investment in research and development tends to create a network of professionals and institutions interested in deploying that technology, and the risk of deployment increases as more people and institutions engage in research and development" (SGNUA, 2023j, p. 6). They conclude that "more research does increase the likelihood of deployment" (SGNUA, 2023j, p. 6).

As highlighted earlier, the debate on solar geoengineering research involves varying interpretations of uncertainty. Advocates often present uncertainty as a manageable risk through intensified research efforts, whereas critics argue that this perspective might overlook the potential unknowability of specific impacts. The initiative's position on uncertainty related to solar geoengineering is apparent in both their open letter and other available materials on their website. They explicitly acknowledge the potential unknowability of certain impacts associated with solar geoengineering, viewing uncertainty not as a manageable risk but as an inherent to these technologies (e.g., Biermann et al., 2022; Mukunth, 2022; SGNUA, 2021b). This acknowledgment is evident in their open letter, stating, "the risks of solar geoengineering are poorly understood and can never be fully known" (SGNUA, 2021b, p. 1). Another instance in their extended article emphasizes, "[e]ven with more research, there is deep-seated disagreement about whether the risks and effectiveness of solar geoengineering could ever be fully understood before deployment, and whether specific effects could be attributed" (Biermann et al., 2022, p. 2).

Furthermore, in a briefing note by some of the initiative's supporters, it is argued that additional research cannot address or resolve the social and political risks associated with geoengineering (SGNUA, 2023j). For instance, they assert that conducting more research is deemed insufficient for reducing the risk of, among other things, delaying urgently needed transformative policies, unilateral deployment without global consent, preventing uneven global impacts, or addressing the challenges of governing its potential future deployment fairly and equitably (SGNUA, 2023j, p. 4). The assumption that additional research would conclusively determine whether the benefits of solar geoengineering outweigh the risks is also challenged. It contends that due to the varied values, geographical contexts, concerned communities, and vested interests that support solar geoengineering, additional research is prone to display a positive bias. Consequently, this could lead to normalizing solar geoengineering and downplaying broader concerns and risks, particularly for the poor and vulnerable. This is further demonstrated by affirming that science networks presently are dominated by few industrialized nations, thereby giving less powerful countries limited or no direct impact. The note concludes that, instead of reducing risks, additional research on solar geoengineering might potentially amplify the risks associated with this speculative technology (SGNUA, 2023j, p. 5).

Finally, the initiative is explicit in its effort to prevent the further normalization of specific research types, specifically outdoor experiments, as found in one of their central proposed measures: "to prohibit outdoor experiments of solar geoengineering technologies" (SGNUA, 2021b, p. 2). They acknowledge that proponents of increased research argue that small-scale outdoor experiments are crucial for understanding the workings of solar geoengineering in climate system dynamics. However, the initiative contends that the results of such experiments cannot demonstrate how solar geoengineering interventions would function on a global scale and the potential adverse effects (SGNUA, 2023r). In their words: "any research that stops short of planetary-scale experimentation will not truly reveal the nature and distribution of global risks for humankind" (SGNUA, 2023j, p. 4).

5.2.3 Preliminary indications de facto steering effect

Several early signs suggest that the non-use initiative has already acted as a form of de facto steering. A first indicator relates to a decision made during the nineteenth session of the African Ministerial Conference on the Environment in August 2023. The decision expresses concern about the promotion of technologies, "particularly solar radiation management, and to call for a global governance mechanism for *non-use* of solar radiation management" (AMCEN, 2023,

p. 32, emphasis added). Although there is no explicit reference to the initiative, the language implies the influence of the non-use initiative. Similarly, another indicator is found in a resolution passed by the European Parliament in November 2023 concerning the UN Climate Change Conference 2023. The European Parliament, regarding SRM, "calls on the Commission and the Member States to initiate a *non-use agreement* at international level, in accordance with the precautionary principle and in the absence of evidence of its safety and a full global consensus on its acceptability" (European Parliament, 2023, emphasis added). Another indicator is found in the Bratislava Joint Regional Statement from Major Groups and Stakeholders in the European Region, in preparation for UNEA-6. In their statement, they explicitly state: "We therefore call to fully support the call for *a non-use agreement on solar geoengineering* already supported by hundreds of experts and academics who call on countries to forbid any public investments in the development of these technologies, not to hand out any patents and for no support for SRM in international institutions" (Major Groups and Stakeholders, 2023, p. 9, emphasis added).

Another notable example is its reference in a report from the United Nations Human Rights Council titled "Impact of New Technologies Intended for Climate Protection on the Enjoyment of Human Rights: Report of the Human Rights Council Advisory Committee," released in August 2023. The report recommends the adoption of "restrictive regulations, including potentially a moratorium," particularly when significant negative impacts are foreseeable. These regulations should persist until claims about the risks and negative impact of each technology are disproven (UNHRC, 2023, p. 18). This call for restrictive regulations cites the submission of the network of academics for an international non-use agreement on solar geoengineering in a footnote (Wewerinke-Singh et al., 2022).

A final indicator is its uptake and various endorsements by various civil society organizations. A notable endorsement of the initiative comes from the Climate Action Network, a global alliance of over 1900 civil society organizations in more than 130 countries, working collectively for action to address the climate crisis and achieve social justice (SGNUA, 2021h). Furthermore, during the 18th Conference of the Parties to the UNFCCC, a press release issued by the environmental non-governmental organization constituency "Demand Climate Justice" explicitly referenced the non-use initiative, advocating for a treaty to halt geoengineering and contemplating a non-use agreement specifically for solar geoengineering (UNFCCC, 2023).

These instances indicate, at the very least, the uptake of non-use and its objectives into various national, subnational, and international political and civil society spheres.

5.2.4 Potential implications *de jure* governance

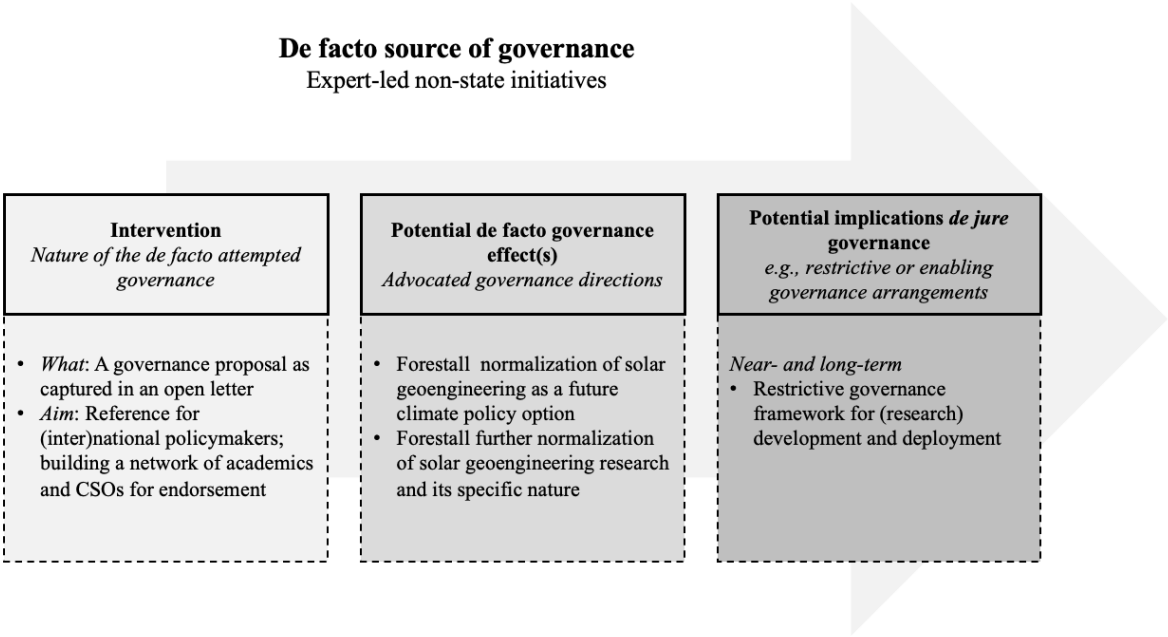
In this section, the potential implications for *de jure* governance—formal, state-led, and legally binding governance—resulting from the governance proposal of the non-use initiative are explored, presuming they succeed in de facto steering the field. Specifically, the implications for the near- and long-term formal governance of solar geoengineering research, development, and deployment are elaborated on.

If the governance proposal of the non-use initiative materializes, it would primarily lead to the establishment of an international governance framework, both near and long term, aimed at restricting the development and deployment of solar geoengineering technologies: an International Non-Use Agreement on Solar Geoengineering (Biermann et al., 2020, p. 5). The initiative draws parallels with existing international restrictions and moratoria on activities and technologies deemed dangerous or high risk. Examples cited by the initiative include, among others, the moratorium on mining in Antarctica, the ban on emitting ozone-depleting substances, and prohibitions on various nuclear activities, waste dumping at sea, certain uses of outer space, and the production of harmful chemicals (Bierman et al., 2020). Recognizing the potential time required for the establishment of such an international regime, the initiative puts forth an additional proposal for near-term governance in the context of development and future deployment. This approach involves forming a coalition of "like-minded governments" committed to the proposed prohibitions and measures (Bierman et al., 2020, p. 5). The agreement would be binding only on the countries that sign it. Importantly, the initiative emphasizes that its effectiveness does not hinge on universal support since such a broad coalition of governments is seen as sending "a strong message about the undesirability of solar geoengineering to the global research, technology and climate communities" (Biermann et al., 2020, p. 5). Additionally, it would involve establishing a near- and long-term, international or sub-national, governance framework to restrict or at the very least discourage SRM research. This is evidenced by the initiative's specific proposed measures and prohibitions such as banning outdoor experiments, and measures to hinder the further normalization of research and development, as outlined above.

The preceding sections outlined how the non-use initiative intervenes, its potential de facto steering effects, and potential implications for *de jure* governance. Figure 5 below offers a summary of the analysis provided above.

Figure 5

De facto governance by the Solar Geoengineering Non-Use Agreement initiative



5.3 The Climate Overshoot Commission

The Global Commission on Governing Risks from Climate Overshoot, commonly referred to as the 'Climate Overshoot Commission,' was established in May 2022 with the primary objective of formulating a comprehensive strategy to address climate risks, as outlined in their 'Reducing the Risks of Climate Overshoot' 2023 report (Climate Overshoot Commission [COC], 2023a). The Commission comprises twelve individuals from diverse backgrounds, including former presidents and prime ministers, national ministers, and senior international officers (COC, 2023b). To further strengthen its capabilities, the Commission is supported by a Secretariat, consisting of academic experts and professional diplomats, which, in turn, receives advisory and support services (COC, 2023c-e). Some of these academics involved have been labelled by others as either 'knowledge-brokers' or as part of a 'geo-clique,' shaping the dialogue on solar geoengineering and acknowledged for their advocacy in considering solar geoengineering (Baskin, 2019; CIEL, 2023; ETC Group, 2023; Farand, 2023). The hosting organization for the Secretariat is the Paris Peace Forum, an international non-profit organization engaged in global governance. The initiative is financially supported by various philanthropic organizations, including The Bill and Melinda Gates Foundation, Open

Philanthropy, Cohler Charitable Fund, LAD Climate Fund, 300 PPM, The Ginko Fund, the Astera Fund, and the Rockefeller Foundation (COC, 2023c).

The primary objective of the Commission is to "propose a strategy for mitigating risks in the event of surpassing global warming targets" (COC, 2023a). Their focus is on evaluating the risks associated with surpassing the 1.5 °C temperature threshold and exploring diverse response options. This involves a comprehensive consideration of potential benefits, costs, risks, and governance challenges associated with adaptation, carbon dioxide removal, and sunlight reflection methods (COC, 2023a). The Commission states it conducted transparent consultations with stakeholders to gather insights on climate risks and policy integration (COC, 2023a). Furthermore, the Commission asserts that its work builds upon rigorous scientific assessments from authoritative sources, including the IPCC, suggesting a high degree of credibility to its findings.

The Commission released its report in September 2023, timed ahead of the 2023 UN Climate Change Conference, with the explicit goal of positioning its recommendations as a reference for global discussions on comprehensive climate risk mitigation measures (COC, 2023a). Beyond the comprehensive 126-page report, the initiative shares information through videos, op-ed pieces, news articles, and interviews, all accessible on its website. Moreover, they maintain an active online presence on social media platforms such as X, formerly Twitter, and LinkedIn. Moreover, the initiative actively participates in and hosts a spectrum of events, such as a side event at COP27, panels, and round tables at the Paris Peace Forum and the Geneva Science and Diplomacy Accelerator Summit, as well as private events. Members of the commission contribute to the distribution of their findings through guest lectures, podcasts, TEDx talks, the Solar Geoengineering Conference, and forums at institutions such as the Harvard Kennedy School, among others (COC, 2023f-h).

In the following sections, the nature of the Commission's intervention, potential de facto governance effects, and implications for future *de jure* governance are elaborated on. This analysis is based on their report and publicly available material and is juxtaposed with the controversies outlined above.

5.3.1 Intervention: A governance proposal for solar geoengineering

The primary attempted intervention of the Overshoot Commission is initiating a governance proposal for, among others, solar geoengineering—by the Commission referred to as SRM—as reflected in the production and publication of a report. Their report outlines five SRM-related recommendations for "strengthened SRM governance, strengthened SRM research, and the

interactions between them" (COC, 2023d, p. 92). As outlined above, the findings were released in September 2023, before the 2023 UN Climate Change Conference, aiming to establish their recommendations as a reference in global discussions on comprehensive climate risk mitigation measures (COC, 2023a). The commission further amplifies its attempted intervention through various outreach activities, including participation in events and media engagement, to distribute its recommendations (COC, 2023h). The subsequent section offers a concise overview of the five recommendations related to SRM within the governance proposal developed by the initiative.

The Commission's first recommendation is to impose a moratorium on SRM deployment and large-scale outdoor experiments. This moratorium would apply to interventions posing transboundary harm risks, regardless of their location, executor, form, or purpose (COC, 2023d, p. 92). Second, the Commission calls for an expanded governance framework for SRM research, emphasizing that outdoor experiments should be limited to jurisdictions with effective environmental regulations. In addition, they highlight that transparency is necessary, with the Commission recommending that SRM research data, methods, and findings should be accessible to international audiences (COC, 2023d, p. 93). Moreover, they stress that SRM research should not be led by for-profit entities or funded by those with interests in maintaining greenhouse gas emissions, such as fossil fuel interests (COC, 2023d, p. 94).

As a third recommendation, the Commission calls for strengthening SRM research and ensuring its co-development with SRM governance. They propose expanding research, including joint North-South projects and research led by Southern scientists, to increase the participation and capacity-building of researchers from developing countries (COC, 2023d, p. 93). In addition, they highlight that research funding should be transparent, particularly given the necessity for SRM research to be perceived as unbiased and trustworthy (COC, 2023d, p. 93). Furthermore, they recommend significantly strengthening international coordination of SRM research based on shared priorities shaped by policymakers, ensuring equitable North-South representation (COC, 2023d, p. 93). Fourth, they recommend that an international, independent scientific review of SRM research should occur periodically. Lastly, due to the various concerns raised by SRM, including novel governance challenges, the Commission recommends that broad (international) consultations and dialogues on these issues are essential. The following section delves into the identified potential de facto governance effect of the Commission's governance proposal outlined above.

5.3.2 Potential facto governance effects

After introducing the Climate Overshoot Commission's intervention, comprising various governance recommendations, the subsequent sections explore potential de facto governance effects. Assessing the initiative's success in steering the field is premature, given its recent establishment and report release. Thus, this examination infers potential effects based on the proposed SRM recommendations in the report and available material. Here, the goal is to illustrate how the Commission's advocated governance directions might shape the future trajectory of this contentious field of inquiry within the broader context of existing controversies, assuming they succeed. Three main potential de facto governance effects were identified, and are discussed below: i) continued normalization of (expanded) solar geoengineering research efforts; ii) the normalization of the specific nature of such research; and iii) the normalization of (the consideration of) solar geoengineering as a future climate policy option. These are elaborated on in the following.

Normalization of (expanded) solar geoengineering research efforts

The first potential de facto governance effect identified in the Commission's report and additional efforts is the ongoing normalization and legitimization of expanded solar geoengineering research. As mentioned above, the scholarly literature reflects the controversy surrounding the expansion of solar geoengineering research and its legitimacy as a research topic. The Commission contends that, given the perceived high likelihood of risks associated with climate overshoot, coupled with preliminary indications suggesting that specific forms of SRM could substantially mitigate these risks, there is a justified need that "*more research on SRM should be conducted*" (COC, 2023d, p. 93, emphasis added). This stance is embedded in their CARE Agenda, where 'E' signifies the 'exploration' of SRM as an integral part of addressing climate overshoot alongside conventional options such as mitigation and adaptation (COC, 2023d, p. 110).

Additional instances of normalizing expanded research efforts are evident in the specific recommendations provided by the Commission. For example, recommendation four proposes periodic international scientific reviews to assess SRM research, suggesting bodies such as the IPCC, WMO, and UNEP as potential candidates. However, it is recommendation three, particularly emphasizing the imperative to strengthen SRM research (COC, 2023d, p. 93). In this context, the Commission advocates for the expansion of research through collaborative North-South projects and initiatives led by scientists from the global South, aiming to enhance participation and capacity building for researchers in developing countries (COC, 2023d, p. 93).

This commitment aligns with the Commission's identified research gaps before the publication of their report, emphasizing the need for increased research conducted by the Global South and enhanced international collaboration in SRM research (COC, 2023i). While acknowledging the inadequate representation of developing countries in SRM debates and research, the Commission underscores that "they *must* be fully involved in research activities and political dialogues going forward" (COC, 2023d, p. 88, emphasis added).

However, a distinct perspective emerges in certain academic discussions, highlighting that efforts to diversify solar geoengineering research often hinge on funding from philanthropies that predominantly support Global North research (Stephens & Surprise, 2019). These initiatives may (unintentionally) shape the dialogue within the confines of existing science and established methods, based on a Northern model (McLaren & Corry, 2021). The broader endeavour to expand global researcher inclusion may inadvertently overlook inherent structural power imbalances in advancing the field (Stephens & Surprise, 2019; Möller & Biermann, 2019; The Hindu, 2023). As emphasized by Stephens and Surprise (2019), "[i]t is well recognized that creating mechanisms for the inclusive 'participation' of Global South organizations in transnational policy networks has often been used as a vehicle to generate consent for policy prescriptions that flow from the Global North" (p. 3). In this regard, the Commission falls short in acknowledging and addressing the more inherent structural power imbalances, particularly in its call for a "truly equitable global deliberation" deemed necessary for SRM (COC, 2023d, p. 88). Consequently, this leaves a notable gap in its consideration of the broader dynamics within the global landscape in relation to its call for expanded solar geoengineering research.

As previously emphasized, the discourse surrounding solar geoengineering research delves into the interpretation of uncertainty. Proponents of research often depict uncertainty as a manageable risk through intensified research endeavours, while critics argue that this perspective might overlook the potential unknowability of specific impacts (e.g., Stilgoe, 2015; Baskin, 2019). Notably, in its call for expanded research, the Commission appears to sidestep the inherently irreducible uncertainties associated with the social, political, and physical dimensions of solar geoengineering, which may not be substantially clarified through additional research efforts. For instance, the Commission identified the "need to improve understanding and reduce uncertainties" as one of the "gaps in SRM research" before its publication (COC, 2023i). Additionally, one Commissioner stated that "further research and evidence are required to develop a clearer understanding of SRM's potential efficacy and risks" (Lan, 2023). Another significant instance is the Commission's proposed moratorium, which suggests that it should

continue "until advancements in scientific research have established a knowledge base robust enough to support informed decision-making on SRM" (COC, 2023d, p. 92). This indicates an expectation of reduced uncertainty through scientific endeavours, along with the assurance of enabling well-informed decision-making. Nevertheless, this portrayal of uncertainty as a concept to be 'mitigated' through additional scientific research has faced criticism for implying a false sense of clarity and resolution regarding the optimal course of action (Cairns, 2017). Notably, the extent to which such uncertainties can be reduced through scientific endeavours remains unspecified by the Commission.

Furthermore, the Commission's advocacy for expanded research fails to mention, acknowledge, or address potential risks associated with such endeavours. For instance, the report overlooks or fails to mention any of the potential risks related to research, such as mitigation deterrence or 'moral hazard' in the context of (expanded) SRM research. One instance has been found, where a science advisor to the commission states that "the opportunity to gain key insights from the research outweighs the risk of mitigation deterrence being unavoidable" (Levitan, 2023). This indicates that, while this perspective may not be universally held within the Commission, the value of acquiring insights from the research outweighs the potential adverse effects of mitigation deterrence. Nevertheless, the lack of discussion on the potential risks of increased research efforts in their report may imply that these are either deemed insignificant or considered negligible.

The normalization of the specific nature of solar geoengineering research and its governance

The second potential de facto governance effect identified is the normalization of the specific nature of solar geoengineering research and its governance. As previously discussed, the academic debate extends to disagreements about the specific characteristics of such research. Where perspectives vary, ranging from strong resistance to conducting field experiments to (cautious) approval of small-scale field experiments under certain conditions (Frumhoff & Stephens, 2018). The Commission seems to align with the latter perspective by advocating for small-scale field experiments, albeit under specific governance conditions.

As just one illustrative example, prior to their report, the Commission identified as a critical SRM research gap the "[n]eed to improve understanding and reduce uncertainties […] *through* observation, laboratory experiments, and *small-scale outdoor experiments*" (COC, 2023i, emphasis added). Despite the recommended moratorium on "any intervention with the risk of significant transboundary harm," the Commission appears to endorse outdoor experiments that do not qualify as posing such a risk (COC, 2023d, p. 92). The report leaves

room for ambiguity about what constitutes significant transboundary harm and who determines this. In this context, the Commission seems to overlook or avoid the qualifiers for small-scale outdoor experiments outlined in the CBD Decision X/33, such as a controlled setting, and the justification based on the need for specific data—as outlined in Chapter 4. By exclusively referring to the well-established and broader no-harm rule, particularly in the context of allowing any form of testing that, as some suggest, could erode the commitment to banning large-scale deployment (CIEL, 2023; Klönne et al., 2023).

The Commission's advocacy for outdoor experiments is accompanied by a proposal for research governance, centred on two key criteria determined by the scale of the experiment. The first criterion states that "[a]ny outdoor SRM experiments should occur solely in jurisdictions with an effective environmental regulatory regime" (COC, 2023d, p. 92). The Commission contends that the bulk of proposed research can be effectively regulated at the national level through existing regulatory frameworks, drawing upon examples from various sectors of climate and environmental science where field experiments involving minor material introductions into the air or water are subject to established regulations and protocols. It views these governance mechanisms as potentially adequate for monitoring SRM experiments comparable to or smaller than these, without necessitating additional SRM-specific oversight measures. However, this advocated approach seems to primarily focus on addressing physical impacts, neglecting to fully consider the potential social, ethical, or political implications of such small-scale outdoor experiments.

The second criterion proposed by the Commission states that "[e]xperiments of a larger scale, even below the 'significant transboundary harm' threshold of the recommended moratorium, will require additional governance mechanisms" (COC, 2023d, p. 92). While indirectly endorsing larger-scale experiments, the Commission acknowledges some of the social, ethical, or political impacts associated with such endeavours. Specifically, it identifies concerns about potential indirect socio-political effects, such as "undermining emission cuts or lock-in" (COC, 2023d, p. 91). To mitigate these concerns, the Commission emphasizes that "[a]dditional risk assessment, transparency, and public engagement mechanisms *may* be necessary" (COC, 2023d, p. 91, emphasis added). Furthermore, it suggests that if experiments entail specific or "novel environmental risks," an independent group of scientific experts should be tasked with formulating guidelines and best practices for such activities (COC, 2023d, p. 92). These proposals align closely with the self-regulatory approaches mentioned earlier. While only briefly touching on the potential for mitigation deterrence or 'undermining emission cuts,' as well as the 'lock-in' concern in the context of larger field experiments, the Commission

regards voluntary self-regulatory approaches by scientific experts and additional risk assessment, transparency, and public engagement mechanisms as sufficient for addressing these concerns. Notably, in the Commission's endorsement of outdoor experiments, their report fails to mention or address the possibility that such endeavours might lead to the development of technologies that could be utilized by actors beyond the control of the researchers, regardless of their initial intentions.

Finally, the Commission's endorsement of small-scale experiments lacks mentioning the potential insights these field trials could offer and whether they can adequately address crucial questions about the climate's response to large-scale deployment, leaving questions about the knowledge they could provide unanswered. As previously mentioned, some argue that the untestable nature of such experiments is tied to the need for extensive large-scale deployment over a prolonged period to understand their full climate impact. Consequently, some perceive the initiative's endorsement of small-scale experiments as a pretext for advancing larger-scale trials aimed at facilitating future deployment rather than fostering a comprehensive understanding of their climate implications (ETC, 2023). In summary, the Commission delves into a contentious aspect of solar geoengineering research and governance by weighing in on the criteria for acceptable SRM research practices while overlooking the question of the desirability of such research.

Normalization of solar geoengineering as a future climate policy option

A third potential de facto governance effect identified in the Commission's recommendations is the normalization of considering solar geoengineering as a potential future climate policy option. Motivated by the perceived urgency to address the consequences of global warming and the imperative to minimize associated harm, the Commission seems to advocate for considering solar geoengineering to mitigate climate impacts. Despite calling for a near-term moratorium on deployment, their call for expanded research is grounded in the belief that SRM may become necessary "should other actions fail to achieve desired results," thereby leaving the possibility open for future consideration (COC, 2023d, p. 87-88). At least three significant observations emerge that support the Commission's stance on considering solar geoengineering as a potential future climate policy option.

First, the Commission's report prominently emphasizes solar geoengineering in the context of 'Reducing the Risks of Climate Overshoot.' Despite the Commission stating the intention to exercise caution and refrain from suggesting that SRM could serve as an alternative to other climate action measures (COC, 2023d; Lan, 2023), it appears to fall short of achieving

this objective. For instance, SRM is featured in their list of core responses to climate overshoot, alongside emission reduction, adaptation, carbon dioxide removal, and climate finance (COC, 2023d, p. 50-51). Here, it is presented on equal footing with other key areas of the Commission's CARE agenda. While the Commission proposes a moratorium on deployment or any intervention with the risk of significant transboundary harm, a closer examination within the context of other recommendations suggests that this moratorium primarily aims to prevent premature or unilateral deployment, leaving the door open for future consideration and potential use (COC, 2023d, p. 87).

Second, the report consistently expresses optimism regarding the potential effectiveness of SRM as "a *potentially powerful tool* to reduce risk and lower suffering," cautioning against prematurely rejecting these ideas as risky (COC, 2023d, p. 88). For instance, it is argued that "the Commission believes it would be imprudent not to investigate or discuss SRM because present evidence suggests the possibility that it could complement other approaches to reducing climate harms in ways these others alone cannot, especially in terms of speed" (COC, 2023d, p. 89-90). The cited evidence is drawn from the recently published UNEP report, where the Commission highlights that "[m]odeling studies consistently show that climate change impacts, both in terms of temperature and hydrological metrics, are significantly reduced with a carefully designed SRM deployment compared to a scenario without such intervention" (COC, 2023d, p. 90). Here, the Commission fails to acknowledge the fundamental nature of solar geoengineering, which would involve "masking" climate change impacts—in addition to introducing new risks—rather than significantly reducing the impacts of climate change. Moreover, as previously emphasized, while models have their merits, they also have the potential to shape societal and political expectations, potentially fostering narratives of technological optimism. By presenting SRM as a potentially powerful tool to mitigate climate change impacts, based solely on modelling studies and a lack of recognition of the limitations of modelling evidence, the Commission appears to be contributing to the development of a narrative that promotes technological optimism regarding SRM, that could contribute to the normalization of its consideration.

Third, both before and after the report's release, various sources, including statements from Commissioners and its supporting members, underscore the perceived importance of giving substantial attention to solar geoengineering as a potential solution to the challenges posed by a rapidly warming world (Farand, 2023; Fortson, 2023; Lan, 2023). Notably, a member of the secretariat conveyed in an interview that the Commission's report represents "the first major political intervention that would *put geo-engineering on the table as*

mainstream policy... My hope is that this report creates space and a level of acceptance for discussing it seriously" (Fortson, 2023, emphasis added). Additionally, the Chair of the Commission stressed the need for a comprehensive review of options that might not have been seriously or adequately considered before, asserting that "in these conditions, we should not leave any stone unturned," and insisting that all available options must be kept on the table (GESDA Global, 2022). Moreover, an academic advising the secretariat on an ad hoc basis suggested that initiatives like the establishment of the Overshoot Commission mark a significant shift in taking solar geoengineering seriously (Borenstein, 2022).

It is worth noting that not all commissioners share the perspective that considering solar geoengineering as a viable climate policy option is necessary. Some commissioners have resigned or expressed criticism over the Commission's perceived role in promoting solar geoengineering (Civillini, 2023; Sheik, 2023). For instance, one commissioner has expressed being "extremely worried from the get-go" about the inclusion and emphasis on solar geoengineering, expressing the hope that the report will instead motivate the global community to intensify efforts in mitigation (Farand, 2023). Another departed member of the Commission argues that "[d]iscussing SRM is the wrong priority; we know what we have to do [to address climate change], so let's focus on that" (Farand, 2023). As reported by Climate Change News, this commissioner left due to feeling uneasy about the focus on SRM in briefing documents and sensing discussions were leaning towards 'how do we take this on' (Farand, 2023). Additionally, some academics suggest that the Commission, supported by geoengineering researchers, was established with the specific goal "to put SRM as an option on the table" and "build its global legitimacy" (Farand, 2023). Furthermore, despite concerns voiced by some Commissioners, merely considering solar geoengineering as an option in their report has been recognized by some as diverting attention from the imperative to reduce emissions, potentially having a detrimental effect on climate action (Civillini, 2023).

5.3.3 Potential implications *de jure* governance

As previously stated, it remains premature to assess the initiative's impact on de facto steering the field of inquiry toward specific trajectories or the realization of their efforts. This uncertainty also extends to the potential impact of the Commission on shaping *de jure* governance, meaning formal, state-led, and legally binding governance. Nonetheless, this section outlines some of the potential implications for formal governance arrangements of the Overshoot Commission's attempted intervention and potential steering effects, assuming they

succeed. Specifically, by drawing inferences in terms of near- and long-term restricting or enabling governance for research, development, and deployment of solar geoengineering.

Should the Overshoot Commission's governance proposal materialize, it would involve establishing a near-term, state-based restrictive framework for the deployment of solar geoengineering. By urging countries to adopt a moratorium on interventions with the risk of significant transboundary harm, the Commission appears to advocate for near-term restrictive (anticipatory) governance of solar geoengineering regarding its deployment. The *coordination* of countries adopting this moratorium is envisioned through "applicable multilateral institutions such as UNEA" (COC, 2023d, p. 92). However, an international governance framework for SRM decision-making and/or deployment would be absent in the near term. Given the perceived challenges and uncertainties tied to negotiating a formal, legally binding treaty, the Commission calls upon individual states to adopt the moratorium (COC, 2023d; Harvey, 2023). Despite recognizing the role of near-term intergovernmental consultation and dialogue, which could occur in various settings, such as the UN General Assembly or UNEA, as well as informal and multi-party settings, the Commission emphasizes that these consultations should not initially pursue formal legal or policy action (COC, 2023d, p. 94).

Simultaneously, if the governance proposal put forth by the Overshoot Commission were to materialize, it would entail establishing a near-term governance framework that facilitates SRM research, albeit with some additional oversight measures. This is evidenced by the Commission's view that research should be intensified, and most research currently envisioned, including small-scale outdoor experiments, "can be adequately regulated at the national level using existing regulatory frameworks" (COC, 2023d, p. 92). Similar to the conduct of field experiments in climate and environmental science areas that are governed by existing regulations and protocols without requiring additional SRM-specific governance. Some additional proposed research governance would include that "data, methods, and findings of SRM research should be transparent" and accessible "through mechanisms including disclosure of funding and open access to publications and data" (COC, 2023d, p. 93). In the case experiments entail specific or novel environmental risks, "then a group of independent scientific experts should write guidelines and best practices for the activities" (COC, 2023d, p. 92). These proposals explicitly foster an enabling research environment where existing state-based regulation and additional self-regulation by scientific experts are considered sufficient and desirable, and additional governance arrangements may evolve alongside the expanding scale and scope of field tests over time.

Despite the proposed near-term moratorium on deployment, the simultaneous emphasis on scientific advancement implies the establishment of a long-term governance structure that could facilitate future deployment if deemed necessary. However, while the Commission has provided some indications of what this governance framework might entail, they remain ambiguous. For instance, the Commission states that one condition for lifting the moratorium is the existence of an "adequate governance framework" (COC, 2023d, p. 92). However, the specifications of what constitutes such an "adequate governance framework," whether it enables or restricts deployment, remain unspecified. What is evident is that any such framework should evolve based on emerging needs and be rooted in "robust science" (COC, 2023d, p. 92). For instance, the Commission emphasizes that when "issues have ripened enough that intergovernmental decisions about SRM governance are judged appropriate or necessary, these should be based on robust science and assessment" (COC, 2023d, p. 92). However, the criteria for when these issues are "ripe enough" for intergovernmental decisions or what "robust science and assessment" would entail, remain undefined. It suggests and expects a future context where research has sufficiently developed to inform decision-making on SRM. In the Commission's words: "a knowledge base strong enough to support informed decision-making on SRM" (COC, 2023d, p. 92). However, again, the specific criteria for a strong knowledge base are not provided.

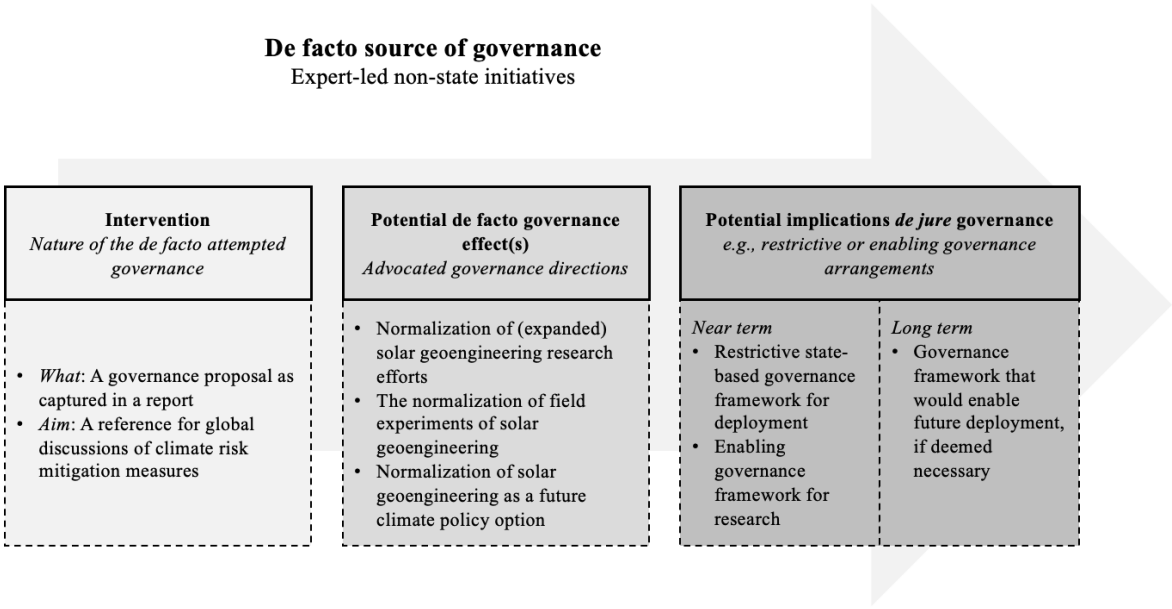
Furthermore, apart from an envisioned long-term governance framework grounded in "robust science," the report highlights the necessity for such a framework to be built upon "broadly shared views about acceptable risk tradeoffs, precaution, and just and legitimate global decision-making" (COC, 2023d, p. 92). Yet again, the details of such "just and legitimate global decision-making", and what this would entail, are not provided. The Commission does recognize the myriad challenges tied to potential SRM deployment and what such a governance framework should adhere to, such as the need for international consensus on deployment; preventing SRM from undermining emissions reduction efforts; establishing effective multilateral or cooperative mechanisms to prevent unilateral deployment; constructing reliable management frameworks capable of enduring decades or even centuries under unpredictable geopolitical conditions to mitigate termination shock risks; compensating affected countries; and ensuring meaningful community participation in decision-making (COC, 2023d, p. 90-91). Despite emphasizing the necessity of global governance and rules for addressing these challenges, the Commission fails to provide a concrete global governance framework capable of addressing or accounting for these challenges. Some analogies are made to existing governance arrangements for other high-stakes technologies, such as nuclear, biological, and

chemical weapons. Despite stating that these are imperfect analogies, the Commission argues that it suggests "that governance of SRM is possible, at least in principle" (COC, 2023d, p. 90). Yet notably, these examples primarily focus on preventing the deployment of such technologies rather than governing their potential use.

The preceding section outlined how the Climate Overshoot Commission intervenes, its potential de facto steering effects, and potential implications for *de jure* governance. Figure 6 below offers a summary of the analysis provided above.

Figure 6

De facto governance by the Climate Overshoot Commission



5.4 Call for Balance

In February 2023, an open letter was published "calling for balance in research and assessment of solar radiation modification" (Call for Balance [CB], 2023a). The letter was authored by a collective of seven scholars spanning three countries: the Netherlands, Switzerland, and two the United States. Currently, the letter has been signed by approximately 150 signatories, its signatories predominantly consist of academics, while also encompassing students and individuals from diverse professional backgrounds. It is noted that the open letter is "an initiative of individual researchers who express their shared view on SRM research in their individual capacity" (CB, 2023a). Moreover, it is stated that the signatories have signed the

letter not as representatives of their respective organizations but in their individual capacities. Furthermore, it is emphasized that the initiative does not have affiliations with political, academic, commercial, or ideological entities.

The initiative is currently self-funded and explicitly states its commitment to operate without seeking financial gain from its activities (CB, 2023a). The primary activity of the initiative is increasing its network by engaging scholars to support their open letter, a 'Call for Balance' (CB, 2023c). The initiative provides the possibility to sign as an academic, while also providing space for students and individuals from diverse professional backgrounds to sign. Furthermore, the initiative shares some supplementary information encompassing media coverage, including newspaper articles, interviews, and podcasts (CB, 2023c). Additionally, the platform shares related literature such as books, reports, and research articles. The initiative does not maintain a presence on social media platforms.

In the forthcoming sections, the nature of the initiative's attempted intervention, the potential de facto governance effects, and implications for future *de jure* governance are elaborated on. This analysis is based on their open letter and publicly available material and is juxtaposed with the controversies outlined above.

5.4.1 Intervention: A governance proposal for solar geoengineering research

The attempted intervention of the Call for Balance initiative revolves around advocating and mobilizing support for a governance proposal primarily centred on research in the context of solar geoengineering—by the initiative referred to as SRM. In the open letter, seven broad principles are outlined (Call for Balance [CB], 2023a). As previously outlined, the initiative strategically seeks support primarily from scholars who sign the open letter. To broaden its impact, the initiative employs additional although limited outreach activities, including engagement with the media. Their open letter proposes seven SRM-related "broad principles" for what seems to be suggested as a "moral framework for SRM" research, also touching upon governance principles for potential deployment (Wieners et al., 2023). The forthcoming section offers a concise overview of the seven governance principles.

As a first principle, the initiative asserts that the primary focus of any climate policy should prioritize mitigation, which also includes both removal efforts and adaptation. Solar geoengineering, according to the initiative, should, at most, "complement the reduction of greenhouse gas concentrations" (Wieners et al., 2023, p. 2). Second, the initiative asserts that SRM research efforts should aim "to create a comprehensive body of knowledge covering environmental, technical, political, societal and ethical sciences and properly linking and

combining these domains" (Wieners et al., 2023, p. 2). In addition, the proposed research should prioritize transparency, reflexivity, and collaboration, extending to the international level. It should also provide opportunities for course correction, particularly if certain findings suggest adverse outcomes stemming from the deployment of SRM (Wieners et al., 2023).

As a fourth principle, before seriously contemplating implementation, the initiative calls for the establishment of a "solid governance framework" for SRM (Wieners et al., 2023, p. 2). This entails, as outlined by the authors, "engaging in research and consultations on governance concurrently with the examination of the environmental and technological aspects of SRM" (Wieners et al., 2023, p. 2-3). Furthermore, the initiative underscores the significance of adhering to legitimate governance processes, highlighting the pivotal role of societal values, particularly justice and equality, when evaluating the potential contribution of SRM research in mitigating the risks associated with climate change. The proposed governance framework for SRM deployment should align with at least two key principles. First, the initiative proposes overseeing the implementation and knowledge of SRM in the public interest, organized through a globally legitimized entity rather than being driven by private interests. Second, the initiative recommends that deployment decisions should involve public participation, with specific attention given to underrepresented and vulnerable communities, including those in the Global South and Indigenous Peoples.

5.4.2 Potential facto governance effects

After introducing the attempted intervention, a governance proposal, the subsequent sections outline the identified *potential* de facto governance effects. Assessing the initiative's success in de facto steering the governance field is premature, given its recent establishment and the release of its open letter. Consequently, this examination infers *potential* de facto governance effects as captured in their open letter and other publicly available material. Here, the goal is to illustrate how the initiative's advocated governance directions might shape the future trajectory of this contentious field of inquiry within the broader context of existing controversies, assuming they succeed. Three main potential de facto governance effects were identified, and are discussed below: i) continued normalization of expanded solar geoengineering research and the legitimization of a 'balanced' scientific assessment; ii) reorienting and reframing the risks associated with solar geoengineering; and iii) the normalization of (the consideration of) solar geoengineering as a future climate policy option. These are elaborated on in the following.

Normalization of expanded solar geoengineering research efforts and 'balanced' assessment

The first identified potential de facto governance effect is the continued normalization of expanded solar geoengineering research and the legitimization of a 'balanced' scientific assessment. As previously noted, the academic literature illustrates the ongoing debate regarding the advancement of solar geoengineering research and its legitimacy as a research topic. In the open letter, the authors argue that concerns about climate mitigation "call for investigating SRM" (Wieners et al., 2023, p. 1). The assertion that expanded solar geoengineering research is viewed as imperative relates to concerns that the climate may react more intensely to greenhouse gases than anticipated, removing carbon dioxide from the atmosphere may not be achievable at the required scale and speed, and that limiting global warming to 1.5 degrees may not suffice to prevent severe damage (Climate Now, 2023; Wieners et al., 2023). They emphasize the significant probability of all three concerns and underscore that "the world must be prepared," if one or more of these concerns materialize, justifying the exploration of SRM (Wieners et al., 2023, p. 1). Here, SRM is regarded and labelled as a "last resort option," to be considered if other measures fail (Kraan, 2023; Wismans, 2023). This concern is also echoed by a prominent scholar who endorsed the open letter, emphasizing that "today we are in a more desperate situation than we were a decade ago" and highlighting the accelerated pace of climate change compared to previous predictions (Singer, 2023). Moreover, this justification for exploring solar geoengineering is grounded in the belief that "society has a moral obligation to engage in SRM research" (Wieners et al., 2023, p. 3). They assert that the critical state of the climate system, "which in itself is the result of large-scale, albeit unintentional, human intervention, is so dire that it justifies considering SRM" (CB, 2023b).

Their advocacy for, and justification of, increased research efforts rests also on the premise that "humanity is inadequately prepared to make informed decisions on SRM," given the persisting "grave knowledge gaps" (CB, 2023b). These knowledge gaps are identified "SRM's technical implementation, effectiveness, climate and environmental effects, best implementation scenarios, and governance" (Wieners et al., 2023, p.2). According to the initiative, these knowledge gaps can and should be addressed through "responsible and critical SRM research," to acquire "the knowledge needed for sound decision-making" (Wieners et al., 2023, p. 2). This suggests that with the 'right' scientific endeavors, uncertainty or what the initiative terms 'knowledge gaps' can be reduced to the point of clarity about the best way forward. Significantly, the initiative appears to sidestep, or even outright avoid, acknowledging the inherent uncertainties associated with specific impacts of solar geoengineering that may remain unclarified despite additional research endeavors. Furthermore, even if 'grave

knowledge gaps' were resolved, the initiative seems to assume rational decision-making, informed by these scientific insights, by all affected countries worldwide.

These advocated expanded research endeavours are viewed as necessary for facilitating or enabling what they term a "balanced assessment of SRM" (Wieners et al., 2023, p. 3). This 'balanced assessment,' according to the initiative, involves weighing the risks associated with researching, developing, and potentially implementing SRM against the climate risks it aims to mitigate (Wieners et al., 2023, p. 1). In other words, they propose that assessing the risks and benefits of SRM should be a relative endeavour that can be enabled through comprehensive research efforts. Consequently, this assessment is presumed and advocated as a means to, and essential to, informed decision-making (Wieners et al., 2023). However, this may raise the (false) expectation that clarity about the best way forward will be provided through comprehensive research efforts, giving conclusive answers regarding the rejection or pursuit of SRM. Furthermore, it presupposes the existence of a global political actor who employs rigorous scientific methods to determine whether to reject or pursue solar SRM. Despite also advocating for public participation, the initiative presents this 'balanced' risk assessment as primarily an epistemic matter, implying that science holds the primary authority in guiding considerations of SRM. Some scholars have argued that such an emphasis on science can marginalize governance issues, impacting who holds power in shaping the debate (Flegal & Gupta, 2018). In this regard, the initiative seems to ignore that decisions regarding the types of evidence considered authoritative and the selection of suitable methodologies in risk assessment processes are frequently recognized as being as much influenced by political considerations as technical ones.

Another instance that indicates the potential for further normalization of research relates to the initiative's call for diversifying solar geoengineering research. Specifically, they argue that "outreach and capacity building, especially in vulnerable developing countries, can empower citizens and underrepresented regions to take part in the debate and pre-empt rogue actors from monopolizing SRM knowledge" (Wieners et al., 2023, p. 2). However, similar to the Overshoot Commission, their call for expanding research appears to overlook the fact that efforts to diversify solar geoengineering research often rely on funding from philanthropies that predominantly support research in the Global North (Stephens & Surprise, 2019). These capacity-building and outreach initiatives may unintentionally shape the dialogue within the confines of existing science and established methods, predominantly based on a Northern model (McLaren & Corry, 2021). The broader effort to expand global researcher inclusion may inadvertently disregard inherent structural power imbalances in advancing the field (Stephens

& Surprise, 2019; Möller & Biermann, 2019). In this respect, the initiative fails to acknowledge and address the more entrenched structural power imbalances, particularly in its call for "ethical SRM research" (Wieners et al., 2023, p. 3). Consequently, this overlooks a significant aspect of the broader dynamics within the global landscape in its advocacy for expanded solar geoengineering research.

Reorienting and reframing the risks associated with solar geoengineering

The second potential governance effect identified involves the reorientating and reframing of the risks associated with solar geoengineering, thereby reinforcing the justification for its scientific exploration. Specifically, the initiative redirects attention from the risks linked to deploying solar geoengineering to the perils of premature rejection and "inappropriate implementation," as evident in both their open letter and additional material (Wieners et al., 2023, p. 2).

As indicated by the open letter's title, "Solar radiation modification is risky, but so is rejecting it," the argument is made that "ignoring either type of risk would distort judgment" (CB, 2023b). This implies a perceived necessity to balance the risks of SRM, both deployment and research, against those of rejecting it. The risks of rejecting SRM are identified as depriving "humanity of a potential auxiliary tool against climate change impacts" (Wieners et al., 2023, p. 2). Regarding the risks that research would pose, the initiative outlines three common concerns against research and deployment: the risk of delayed decarbonization ('moral hazard' concern), the risk that researching and discussing SRM may inevitably lead to its development and implementation ('slippery slope' argument), and the risk potential undemocratic decision-making and governance with powerful actors imposing decisions on SRM globally. Despite recognizing these as important, the initiative seems to perceive them as not necessarily inevitable. For instance, regarding a slippery slope and lock-in dynamics, they note that many emerging technologies never progress to the implementation stage, emphasizing that research does not automatically lead to implementation (CB, 2023b; Climate Now, 2023; Wieners et al., 2023; Wismans, 2023). Also, rejecting SRM research, according to the authors, will not prevent future non-inclusive decision-making or unwarranted reliance on technological solutions. Therefore, they conclude that these identified risks "do not justify ignoring the potential of SRM" (Wieners et al., 2023, p. 2). This indicates that the initiative perceives the risks associated with rejecting SRM—depriving humanity of a potential supplementary tool against the impacts of climate change—as more significant than the risks linked to research, justifying their call for, at the very least, exploring SRM through expanded research efforts.

Furthermore, the initiative underscores a significant probability that, as concerns about climate mitigation become more pressing, "a decision on the use of SRM *has to be made* in the future" (Wieners et al., 2023, p. 3). Particularly if perceived pressure from climate impacts prompts action, or if a powerful government opts to deploy it unilaterally (Climate Now, 2023; Kraan, 2023; Wieners et al., 2023). They argue that in such scenarios, "ignorance" heightens the risk of misguided decisions, potentially undermining the legitimacy of the decision-making process. According to the initiative, this ignorance "jeopardizes rational, balanced, justifiable decision-making" (CB, 2023b). This emphasis on the risks associated with what the initiative terms "ignorance" appears to divert attention from the risks of solar geoengineering deployment and research, instead highlighting the danger of "ignorance" itself, particularly in their justification for scientific exploration. Rather than presenting the primary risk as the deployment of SRM and its potential adverse consequences, the focus is shifted from the "risks of deployment" to the risk of "ignorance" and its consequences.

Normalization of solar geoengineering as a potential future climate policy option

A third potential de facto governance effect identified in the initiative's recommendations is the normalization of considering solar geoengineering as a potential future climate policy option. The advocacy for expanded research is linked to the justification that solar geoengineering is an option that needs to be considered, may other conventional measures fail. Despite explicitly stating that the authors "do not promote the eventual use of SRM," this assertion is grounded in the rationale that there is currently insufficient evidence to confirm or refute its absolute usefulness or desirability (CB, 2023e; Wieners et al., 2023). This implies a willingness to leave the door open for its future inclusion in the climate response portfolio, depending on scientific advances. Moreover, the authors express optimism about the potential effectiveness of solar geoengineering as a "potential auxiliary tool against climate change impacts," based on modeling studies available, that "suggest that SRM could deliver rapid cooling to help limit peak global warming to 1.5ºC" (Wieners et al., 2023, p. 1).

5.4.3 Potential implications *de jure* governance

This section explores the potential implications for *de jure* governance—referring to formal, state-led, and legally binding governance structures—arising from the initiative's de facto intervention and potential steering effects, assuming their success. Specifically, the implications

for the near- and long-term formal governance of solar geoengineering research, development, and deployment are elaborated on.

If the Call for Balance governance proposal were to come to materialize, it would entail the establishment of a near-term enabling framework for research, centered on self-governance and codes of conduct within the scientific community. In other words, state-led or legally binding governance would be absent. It is considered enabling, as evidenced by the initiative's stance on the necessity for expanded research. In terms of proposed governance, albeit not formal, there is a call for research to adhere to principles of thoroughness, impartiality, interdisciplinarity, and inclusion for internationally legitimatized assessments by bodies like the IPCC. Additionally, the initiative advocates for principles that safeguard transparency, reflectiveness, and cooperation internationally. However, the means by which these principles would be safeguarded or enforced are not specified. Notably, the initiative acknowledges the absence of a governance framework to ensure adherence to these principles, yet points to proposals by entities such as the US National Academies of Sciences, Engineering, and Medicine. Such proposals aim to promote solar geoengineering research through measures such as establishing "self-governance by the scientific community, for example, by establishing a code of conduct; transparency and commitment to open access; public engagement, outreach and inclusive international consultation; international collaboration and capacity building; regulating (large- scale) outdoor experiments; and non-commerciality" (Wieners et al., 203, p. 3). In summary, the implementation of the initiative's proposal would establish a short-term enabling framework for research, without additional state-led governance measures. Instead, it would rely on self-governance by the scientific community.

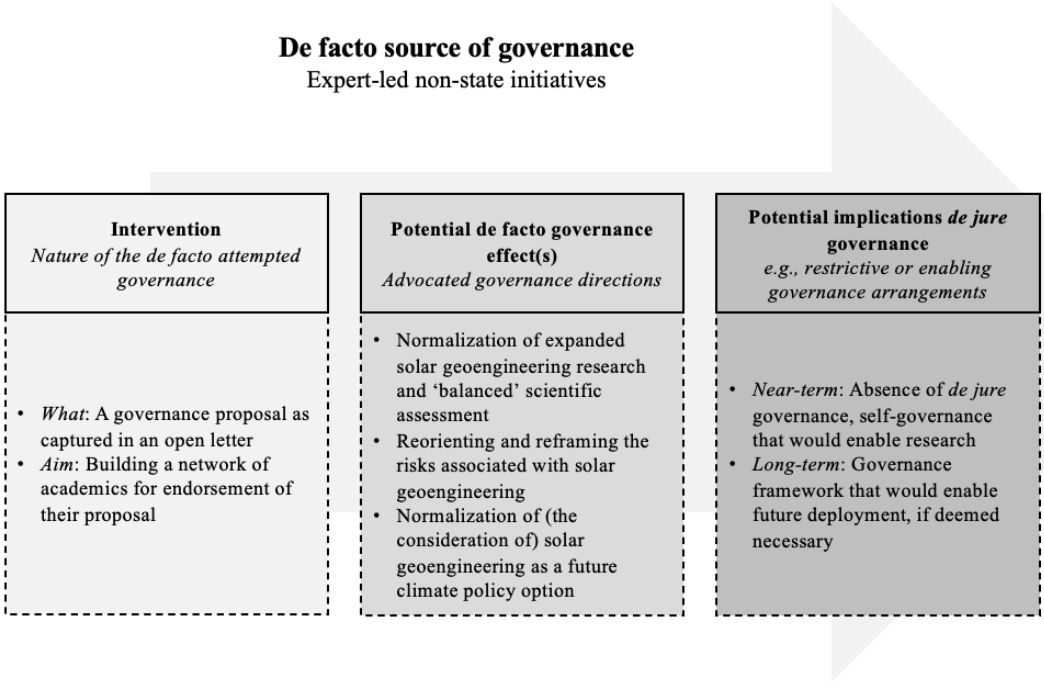
Despite the initiative's statement that the authors do not endorse the eventual use of SRM, the simultaneous emphasis on scientific advancement of their proposed principles implies the establishment of a long-term governance framework to enable potential future deployment, if deemed necessary. This is evident in the emphasis on mitigation and adaptation as primary focuses of climate policy, with SRM considered as a supplementary measure at most, depending on research findings. While there are some indications found regarding the potential structure of this governance framework envisioned by the initiative, they remain ambiguous. For instance, the initiative suggests that "a solid framework for the governance of SRM should be in place before implementation is seriously considered" (Wieners et al., 2023, p. 2) Such a framework, it is stated, should involve research and consultations on governance concurrent with the study of the environmental and technological aspects of SRM, suggesting that this "solid framework" should evolve based on emerging needs rooted in scientific findings.

Furthermore, it is emphasized that research and transparent assessment are needed to lay the groundwork for future decision-making, but specific criteria for determining when research has sufficiently informed such decisions are not provided. Additionally, the initiative underscores the importance of broad public participation in decision-making, with a special focus on underrepresented and vulnerable communities such as those in the Global South and Indigenous Peoples. However, the initiative fails to provide a concrete global governance framework capable of addressing or accounting for these challenges.

The preceding section outlined how the Call for Balance initiative intervenes, its potential de facto steering effects, and potential implications for *de jure* governance. Figure 7 below offers a summary of the analysis provided above.

Figure 7

De facto governance by the Call for Balance initiative



5.5 Chapter conclusion

This chapter addressed the sub-research questions (SRQ4-6) regarding expert-led initiatives as de facto sources of governance within the context of emerging solar geoengineering governance. The examined initiatives included the International Non-Use Agreement on Solar

Geoengineering initiative, the Climate Overshoot Commission, and the Call for Balance initiative. It focused on understanding how these initiatives intervene, their potential de facto governance effects, and potential implications for (future) *de jure* governance. Throughout the chapter, it has been demonstrated how these initiatives aim to intervene in the solar geoengineering governance landscape by presenting different governance proposals, in terms of measures, recommendations, and principles. They utilize diverse methods, including open letters, reports, and outreach activities, to gain support within academic networks and political spheres. Both the Call for Balance and non-use initiatives are led by academics, suggesting legitimacy stemming from the expertise of the individuals involved. In contrast, the Overshoot Commission relies on the political expertise of its members.

These initiatives share certain commonalities, insofar as they all oppose the near-term deployment of solar geoengineering technologies. Moreover, they agree on the severity of the climate crisis and the necessity for drastic emission cuts, emphasizing the prioritization of mitigation efforts. However, they diverge in terms of their potential de facto steering effects, in terms of the advocated governance directions in this highly contested field. While the Overshoot Commission and the Call for Balance initiative, to some extent implicitly, contribute to the normalization of the consideration of solar geoengineering as a viable climate policy option, the non-use initiative aims to prevent such consideration altogether. Additionally, both the Overshoot Commission and the Call for Balance governance proposals potentially contribute to normalizing expanded research and its specific nature, while the non-use initiative governance proposal seeks to prevent this. These variations in advocated governance directions are rooted in their varying stances on various contested aspects related to solar geoengineering.

First, differing assertions exist regarding the implications or risks associated with research. The non-use initiative views research into solar geoengineering as carrying and potentially exacerbating risks. Conversely, both the Overshoot Commission and the Call for Balance initiative view research as a means to mitigate risks, asserting that the insights gained outweigh the potential risks of research itself. Additionally, the initiatives hold varying interpretations of uncertainty and the role of research in addressing these. The non-use initiative acknowledges the inherent limitations in understanding certain impacts associated with solar geoengineering, recognizing that additional research may not fully address or resolve the physical, social, and political uncertainties and associated risks inherent to solar geoengineering. Conversely, the Overshoot Commission and the Call for Balance initiative suggest that scientific endeavours will reduce uncertainty and risks. They both suggest that clarity about the best path forward will emerge through rigorous scientific inquiry. Regarding

the role of field experiments, the non-use initiative argues that such experiments cannot adequately demonstrate how solar geoengineering interventions would function on a global scale and may lead to a slippery slope toward full-scale deployment. In contrast, the Overshoot Commission advocates for outdoor experiments to further scientific understanding of solar geoengineering. However, they do not explicitly address the specific insights that field experiments could offer, leaving questions about the knowledge they could provide unanswered and failing to address the potential contribution to a slippery slope toward full-scale deployment.

Second, diverse perspectives exist regarding the necessity, effectiveness, and governability of solar geoengineering, influencing differing views on its consideration and potential incorporation into climate policy. The non-use initiative contends that decarbonization is achievable with appropriate measures, thus deeming solar geoengineering "unnecessary". Conversely, the Overshoot Commission and the Call for Balance initiative, while recognizing the need for caution, advocate for exploring solar geoengineering as a "last resort option" to be considered if alternative measures are deemed inadequate, a scenario they perceive as highly probable. In this context, both initiatives express optimism regarding the effectiveness of SRM as a potentially powerful tool to reduce risks, a stance based on existing modelling studies.

A final significant point of contention concerns the potential governability of solar geoengineering deployment as viewed by the initiatives. The non-use initiative perceives the governance of SRM deployment as politically ungovernable in a just and fair manner. Conversely, the Overshoot Commission and the Call for Balance initiative assert that governance of SRM deployment is, at least in principle, possible. They advocate for ongoing research to enhance unspecified "informed decision-making" processes and ensure responsible deployment.

Depending on the success of initiatives in de facto shaping the solar geoengineering field, there would be varying implications for formal (*de jure*) governance. If the non-use initiative governance proposal were to prevail, it would entail the establishment of national or international regulations restricting research, development, and deployment of solar geoengineering technologies in both the short and long term. Notably, some early indications are suggesting that the objectives of the non-use initiative have already acted as a form of de facto steering. Conversely, if the Overshoot Commission and the Call for Balance were to succeed, it would entail a predominantly self-regulatory framework led by the scientific community for research in the short term, fostering an enabling environment for solar geoengineering exploration. Over the long term, this would lead to the establishment of a

governance framework enabling potential future deployment, if deemed necessary and if scientific advances show its feasibility.

6. DISCUSSION AND CONCLUSIONS

This concluding chapter builds upon the empirical chapters by outlining their key findings and the interpreting them within framework of existing literature. It addresses the central research question of the study, elaborating on the evolving landscape of global governance for solar geoengineering, encompassing both de jure and de facto dimensions. Subsequently, it explores some key insights into the challenges inherent in anticipatory governance within this domain. The chapter concludes with some reflections on the conceptual and methodological aspects of this study, along with suggestions for future research directions.

6.1 Key findings and interpretation

This study sought to analyse and comprehend the emerging anticipatory governance of solar geoengineering, focusing on its nature and implications. Guided by the overarching research question, "How is solar geoengineering being governed globally at this juncture in time, and with what implications?" To answer this overarching research question, *de jure* and de facto sources of governance were analysed, using various descriptive cases. The following sections synthesize the key findings and provide interpretations in the context of existing literature. Subsequently, the overarching research question is addressed.

6.1.1 *De jure* governance of solar geoengineering: Limited or vanguard advocacy?

The analysis in Chapter 4 delved into two significant *de jure* governance attempts existing to date: Decision X/33 by the CBD in 2010 and the draft resolution on geoengineering and its governance proposed during the fourth session of UNEA in 2019. The examination revealed that Decision X/33 distinguishes itself through its precautionary and restrictive stance on solar geoengineering. The decision explicitly states that no climate-related geoengineering activities, including "any technologies that deliberately reduce solar insolation," that may affect biodiversity take place, albeit with some qualifiers (CBD, 2010c). In contrast, the attempt at *de jure* governance at UNEA-4 stands out for failing to achieve consensus among states on a resolution to assess (solar) geoengineering and its governance. Furthermore, the chapter demonstrated that the meaning and significance of both these attempts are contested in scholarly literature. Therefore, the first key finding in this section of the study highlights the perceived limited nature of both analyzed governance attempts within the scholarly literature.

This perception of limitation stems from several key factors, notably, the perceived 'failure' of UNEA to establish consensus, and the disputed status of the CBD's decision in the literature despite achieving party consensus. To put it differently, had the CBD decision not been perceived as limited consensus in the literature would have likely been found, even if regarded as a 'de facto' moratorium rather than a legally binding one. Such perceived limitations and the related contested nature of these attempts may not be surprising within the broader context of emerging anticipatory governance, given the challenge of establishing formal governance frameworks under conditions marked by extreme scientific uncertainty and normative conflicts regarding environmental and technological risks and harms. This aligns with existing literature, reflecting the challenging task of designing formal and legally binding governance arrangements for emergent anticipatory governance challenges (Foley et al., 2018; Jinnah, 2018; Oldham, 2014; Rip, 2018). Furthermore, the perceived limitations of these attempts align with the often-invoked framing of 'governance gaps' frequently used in the context of solar geoengineering governance (e.g., Brent et al., 2015; Flegal et al., 2019).

However, as discussed in the conceptual chapter, such disputed assertions can be regarded as political interventions, inherent to the construction of anticipatory governance and anticipation practices (Jasanoff & Kim, 2015; Muiderman et al., 2020). This prompts consideration of the overarching perspective represented by these claims in scholarly literature regarding these governance attempts. In other words, it raises the question: How should these conflicting claims be interpreted? A first notable observation emerges from the extensive body of literature emphasizing the (in)significance and non-binding nature of one specific CBD decision. This prompts consideration as to whether a similar emphasis exists for other CBD decisions related to other topics. This observation underscored the expectation of a collective of academics, conceptualized as '*sociotechnical vanguards*,' that formulate and act (intentionally) to advance specific visions, governance rationales, and, related to this, particular put forth assertions regarding existing *de jure* governance attempts. A second notable observation is that conflicting claims regarding these governance attempts were identified among both groups of vanguards—those advocating for enabling/oversight and those advocating for restrictive/vigilant governance rationales. This finding suggests, in alignment with prior research, the coexistence of competing visions and associated claims that often run in parallel and rarely go uncontested (Hilgartner, 2015; Mager & Katzenbach, 2021; Sovacool et al., 2020). This prompts consideration of whose visions, governance rationales, and claims regarding these governance attempts in scholarly literature prevail, if any, and the implications thereof.

This study found that a considerable portion of the literature discussing the meaning and significance of the CBD decision primarily originates from scholars advocating the enable/oversight governance rationale. It is worth noting that this group comprises a small number of scholars who have published a diverse array of papers. As this study reveals, the prevailing perspective of this group is that the CBD decision lacks legal force, is non-binding, and has limited practical impact. Moreover, they express criticisms regarding the vagueness, weakness, or poor wording of the decision text. These claims may find their explanation in the discrepancy between the content of the CBD decision and the desired governance framework envisioned by this group. The CBD decision is characterized by a restrictive and precautionary stance on both deployment and research, rather than one that promotes scientific research advancement or would allow for flexible large-scale governance of potential future deployment as envisioned as desirable by this vanguard group. Despite the noted challenges in defining "act intentionally" within the framework of sociotechnical vanguards, the substantial volume of literature from proponents of this perspective suggests an attempt to shape scholarly discourse and influence the realization of a particular vision, which involves downplaying the decision's significance by challenging various aspects.

Given this, it may not be surprising that there is a relatively limited body of literature discussing the significance and implications of the CBD decision among scholars who advance the restrict/vigilant governance rationale. This group generally refers to the CBD decision as a de facto moratorium, underscoring its perceived significance. They emphasize its importance as a reflection of global consensus and the emergence of an international norm against such activities. The relatively limited literature from this vanguard group may be attributed to the alignment between the CBD decision and their envisioned desired governance framework. Additionally, the decision takes a cautious stance on both research and deployment, reflecting broad international participation, which is viewed as desirable by this vanguard group. In other words, these findings suggest that those who share a similar restrictive governance stance may perceive the CBD's message as desirable, regardless of the decision being strictly legally binding, thus not prompting further questioning of its significance or scholarly publication on the matter.

Another notable observation is that the literature discussing the attempted resolution at the UNEA offers a more balanced representation, with publications from scholars advancing both governance rationales. This balance may be explained by the absence of a concrete resolution and proposed assessment, which leaves the nature of the attempt neither strictly restrictive nor enabling, thus negating the need to downplay its significance. Nonetheless, as

anticipated, scholars aligned with diverse governance rationales offer differing perspectives and assertions on the significance of the attempt, each reinforcing their envisioned governance frameworks.

Building upon the preceding insights, a second key finding comes to light. Scholarly collectives, referred to here as vanguards, not only formulate distinct visions but also, as suggested with caution, act intentionally to advance specific notions of desirable governance and corresponding assertions regarding formal governance efforts within the academic discourse. Considering that the initial key finding of this study highlighted the perceived limitation of these governance efforts, one might question the true extent of these limitations in light of the second key finding. In the instance of CBD Decision X/33, one could question whether it is strictly limited or insignificant given its non-legally bindingness, as would be the case for all non-legally binding decisions by the CBD. Moreover, as this study has demonstrated, the CBD decision has been effectively utilized by both governmental bodies, such as the Mexican government, and civil society actors to impose restrictions on solar geoengineering activities. This implies that claims regarding the decision's insignificance in the literature could be open to challenge.

With various political and research-related developments currently unfolding, such as new authoritative reports and the forthcoming draft resolution on solar geoengineering during UNEA-6, the implications of scholarly claims on governance become a crucial area of inquiry. These developments raise the political stakes in understanding the diverse perspectives surrounding the anticipatory governance of solar geoengineering. Such claims regarding existing efforts may hold crucial implications for both present and future policy decisions, shaping the discourse surrounding solar geoengineering (Flegal & Gupta, 2018; Gupta et al., 2020). A critical question arises regarding the persuasiveness of these academic visions, including their conception of desirable governance for managing emerging technology, and their influence on decision-makers. In this context, it is essential to highlight that the authors of the scholarly literature analysed are not directly involved in the negotiation process as state delegates. However, as argued here, scholars may act (intentionally) to shape the discourse around decisions and policies after they are made, or in anticipation of future decisions. Even when scholars claim first-hand witness to events, their accounts may not conclusively evidence the decision-making process. For instance, it remains uncertain whether delegates deliberately avoided or rejected specific terms like 'moratorium' during negotiations or lacked adequate knowledge of certain aspects. Nonetheless, such assertions may influence upcoming decisions regarding solar geoengineering and the categorization of solar geoengineering in scholarly

literature, particularly concerning the CBD decision, as either a to some extent governed or ungoverned domain.

In conclusion, this section of the study showed that global *de jure* governance of solar geoengineering primarily relies on the CBD decision, which, although non-legally binding, holds considerable weight. This is particularly evident in the absence of a UNEA resolution. However, it remains uncertain whether and how the decision will be upheld in practice and its implications for future decision-making on solar geoengineering, as well as the extent to which prevailing academic discourses will shape these outcomes.

6.1.2 De facto governance of solar geoengineering: Whose will shape the field?

In addition to the *de jure* governance explored in this study, Chapter 5 delved into three prominent non-state, expert-led initiatives as de facto sources of governance: The Solar Geoengineering Non-Use Agreement, the Climate Overshoot Commission, and the Call for Balance initiative. This examination revealed how these initiatives aim to intervene in the solar geoengineering governance landscape by presenting concrete governance proposals. The initiatives seek to garner support within academic and political spheres by employing diverse strategies such as issuing open letters or publishing a report, and various outreach activities.

A key finding from this empirical part of the study is that each of these initiatives seeks to shape and influence the trajectory of the contentious field of solar geoengineering in distinctive ways, related to their respective positions on specific controversies. These attempts may lead to a de facto steering effect, including normalizing and legitimizing specific governance directions or countering such processes. Given the contentious nature of the solar geoengineering field and in line with existing literature, it was expected that there would be variations in the attempts to shape the field and advocate for specific governance directions through these initiatives. However, understanding the implications of such steering is crucial, according to Gupta and Möller (2019), as particular acts of de facto governance can empower certain actors while marginalizing others. This raises the question: How should these findings be interpreted? And why does it matter that the potential de facto governance acts of these initiatives might contribute to or hinder the normalization and legitimization of solar geoengineering research and its consideration as a policy option?

Understanding the driving forces behind particular trajectories in the solar geoengineering governance landscape is crucial as it sheds light on who advocates for specific courses of action and identifies those who may establish the boundaries and thresholds of governance (Owen, 2014). As emphasized in the introduction, proponents of this speculative

technology primarily consist of a select group of academics affiliated with institutions, mainly situated in the Global North (Bierman & Möller, 2019; Jinnah et al., 2018; Stephens & Surprise, 2020). Despite efforts to depict the Overshoot Commission as a product of independent global leadership, it is apparent that the advocated directions may have been influenced by the involvement of long-standing advocates of solar geoengineering research. The governance recommendations regarding solar geoengineering could thus reflect the influence of researchers deeply entrenched in the field, potentially explaining the bias towards the normalization of expansive research endeavours. Similarly, the Call for Balance initiative, predominantly authored by scientists originating from the Global North, may echo their perspectives and priorities. In contrast, the non-use initiative, spearheaded by governance scholars with a more diverse global composition, offers alternative perspectives and directions for governance.

Related to this, it is imperative to understand how these initiatives may contribute to empowering specific forms of knowledge and actors within the solar geoengineering governance landscape. The governance proposals put forward by these initiatives and their potential de facto steering effects could have significant implications for what is considered relevant knowledge in the solar geoengineering governance debate, and which actors are regarded as significant. Both the Overshoot Commission and the Call for Balance initiative operate under the assumption that decision-makers may soon consider solar geoengineering as a response to climate change impacts. Within this framework, they stress the need to address 'knowledge gaps' through scientific endeavours before making any decisions. However, in advocacy for more comprehensive knowledge, both initiatives seem to prioritize technical knowledge and expertise over broader social, political, and ethical considerations—considerations that are prominently highlighted by the non-use initiative. This emphasis on technical knowledge requirements and the promotion of expanded 'responsible' solar geoengineering research, including outdoor experimentation, might inadvertently prioritize scientific inquiries above broader social, political, and ethical dimensions. This prioritization could explain their advocated directions, potentially leading to the normalization of solar geoengineering research and its integration into policy considerations. In contrast, the non-use initiative aims to foreground political, social, and ethical considerations in the governance debate. It contends that precisely because of the potential social, political, and ethical implications involved, efforts should be made to prevent the normalization and legitimization of solar geoengineering research and policy considerations.

The question requiring further scrutiny pertains to which governance proposal will ultimately prevail, if any. In other words, the extent of the de facto governance effect of each

initiative, and the implications for *de jure* governance, remain uncertain. Will an international solar geoengineering research program, potentially incorporating outdoor experimentation, emerge, drawing legitimacy and purpose directly from the existence and recommendations of these initiatives? Alternatively, could an International Non-Use Agreement on Solar Geoengineering gain momentum, supported by a widespread global network of academics, governments, or civil society organizations advocating for its adoption? The perceived legitimacy of these sources of de facto governance is expected to exert significant influence over the trajectory of future governance endeavours. This may carry particular significance for the Overshoot Commission, given its involvement of a select group of longstanding research advocates. Conversely, the non-use and Call for Balance initiatives may draw their credibility from a wider academic network of backing. In the case of the non-use initiative, the support of civil society may also influence the perceived legitimacy and scope of support of their proposition.

6.1.3 Current state of global solar geoengineering governance

Returning to the central research question of this study, "*How is solar geoengineering being governed globally at this juncture in time, and with what implications?"* As demonstrated in this study, both *de jure* and de facto forms of governance currently play a role in shaping the governance landscape of solar geoengineering. Some may argue that there is currently a 'governance gap' due to the lack of a legally binding global framework specifically addressing solar geoengineering. However, it is important to note that even soft-law mechanisms, like the non-binding restrictive and precautionary CBD decision, could effectively deter research, development, and potential deployment of solar geoengineering. Decisions of this nature may not only signal to states and other actors supportive of a (de facto) moratorium that backing for solar geoengineering is unlikely, but they can also be used by states to enforce binding national regulations or by civil society organizations to oppose advancements in the field. Nevertheless, as demonstrated in this study, deliberate efforts to undermine such mechanisms may diminish their significance. Powerful actors, or those with interests in exploring solar geoengineering, may attempt to downplay the significance of such formal governance efforts to push their agenda. Moreover, in light of recent announcements for expanded research and research programs by the US, Canada, and the UK (Government of Canada, 2024; The White House, 2023; UK Research and Innovation, 2024), it is ever more important for international deliberation on the advancement of solar geoengineering either within the CBD to uphold or build on its 2010 and subsequent decisions, or within other relevant fora such as UNEA.

Moreover, the perceived limited nature of formal governance may allow for greater influence from de facto sources in shaping the ongoing governance discourse. These sources may leverage legitimacy from their expert context and advocate for specific governance directions through their efforts. Whether and to what extent these de facto sources will impact the debate, research developments, and governance directions in the field will likely depend on the perceived legitimacy of these sources. Consequently, the success of their efforts in shaping the trajectory of solar geoengineering, and their influence in shaping the context for formal governance remains uncertain.

6.2 Challenges of emerging anticipatory governance

Navigating governance in a field without universal agreement on its defining aspects presents a significant challenge. In this study, anticipatory governance, subject to diverse interpretations and applications within academic communities, was conceptualized as an attempt to govern in the present, amid inherent uncertainties and unknowns regarding the very existence and nature of future environmental and technological risk (Muiderman et al., 2020). Rather than proposing a normative or best practice, this study aimed to delineate and analyse the features of emerging anticipatory governance in the context of solar geoengineering. By exploring both formal (*de jure*) and emerging informal (de facto) sources of governance within the realm of solar geoengineering, some valuable insights into the key challenges of constructing anticipatory governance for emerging technologies can be drawn.

One of the primary challenges in establishing anticipatory governance for emerging technologies, such as solar geoengineering, is the creation of formal regulatory frameworks to guide their trajectory. Previous studies have emphasized the difficulty of proactively implementing such frameworks in anticipation of potential issues arising from emerging technologies (Jinnah, 2018; Rip, 2018). As this study has shown, in the case of solar geoengineering as an emerging technology, the CBD Decision X/33 in 2010 stands out as significant in this regard. It is notable that, relatively early on, state delegates reached a consensus on a decision regarding (solar) geoengineering, despite the United States not having ratified the treaty. While not legally binding, the fact that the topic was brought into international forums is noteworthy. This diverges from the usual reactive approach seen in international formal governance processes on other issues. However, ongoing disputes about the decision's significance, and the failure of states to reach a consensus during subsequent

developments, such as the UNEA-4 resolution, underscore the challenges associated with establishing formal governance structures for anticipatory governance challenges.

A second challenge in establishing anticipatory governance relates to acknowledging radical uncertainty and its implications within anticipatory governance practices. As outlined in the conceptual framework, anticipatory governance involves a process that ideally moves beyond the conventional "knowledge first" approach, acknowledging the limitations of understanding the situation before taking action, especially in the face of radical uncertainty (Foley et al., 2018). However, the findings of this study highlight a significant challenge: the tendency of key actors in the solar geoengineering governance space to disregard or downplay radical uncertainty, mistakenly treating uncertainties as resolvable—a finding echoed in previous research (Baskin, 2019; Cairns, 2017; Stilgoe, 2015). Such portrayals carry significant implications. A strong emphasis on the imperative to reduce uncertainties or the insistence on addressing 'scientific inquiries' or reducing 'knowledge gaps' before engaging in governance discussions or as a prerequisite for 'informed' decision-making, as advocated by certain vanguards and within two expert-led initiatives, may shift the focus away from pivotal social, political, and, ethical, considerations. Similarly, some vanguards argue that forums like the UNEA are not suitable for these discussions, advocating instead for the IPCC, as they consider the questions ripe for scientific knowledge. This may steer discussions towards more technocratic or logistical inquiries, such as the measurement and assessment of specific climate and earth system parameters (Gupta & Möller, 2019). This narrow focus on technical aspects and scientific inquiry may not only limit the scope of governance discussions but also side-line critical discussions on the broader societal, ethical, and political implications of emerging technologies like solar geoengineering. Neglecting these aspects and prioritizing technical inquiries could lead to a depoliticization of the governance debate, shifting the focus away from essential first-order considerations regarding the desirability and governability of these technologies (Gupta & Möller, 2019).

6.3 Conceptual and methodological reflections

The results of this study have to be seen in the context of its limitations. This section reflects on some of the limitations of the study, including those related to conceptualization, research design and methodology employed, and the data analysis process.

6.3.1 Conceptual reflections

In the conceptualization and operationalization of vanguard visions, any researcher or academic who addresses solar geoengineering governance in academic literature was initially regarded as part of this vanguard group. However, it is crucial to acknowledge that not all academics may fit this classification. Some scholars may not act intentionally to realize particular visions or contribute to shaping the discourse or governance landscape of solar geoengineering, perhaps by having limited publications on the topic. Additionally, the majority of scholars could not be assigned to either the enable/oversight or restrict/vigilant vanguard groups, as there may be a lack of clear statements indicating membership in either group. Thus, while academics collectively were seen as vanguards in the context of solar geoengineering governance, individual scholars may vary in their level of influence and involvement in shaping governance discourse.

Moreover, for the assessment of academic assertions on *de jure* governance, it is worth noting that both scholarly contributions and the scholars themselves may have also been conceptualized as de facto sources of governance. Rather than seeking to legitimize SRM research as a subject of governance, as shown by Owen (2014), academics, as shown in this study, may strive to advocate for specific visions within scholarly literature regarding desirable governance, especially concerning formal governance attempts. This active engagement may be considered a de facto source of governance once academics have effectively influenced the governance landscape by challenging or contesting these governance efforts through their scholarly work.

The operationalization of the de facto governance lens was pivotal in aligning with the objectives for analyzing the initiatives. However, it is essential to acknowledge that the lens introduced in the conceptual chapter was developed by the researcher of this study, allowing for alternative approaches. Despite intentionally broadening the lens to accommodate potential differences among the initiatives, it effectively fulfilled its purpose. A notable limitation arises from the requirement that de facto sources of governance can only be recognized when they have generated or exercised governance effects (Möller & Gupta, 2019). In this study, a different approach was adopted, assuming that these sources may generate a de facto governance effect and thus warrant scrutiny beforehand, deviating from prior research focusing specifically on the realized steering effects of de facto sources (Oldham et al., 2014; Owen, 2014). Given the recent establishment of all initiatives, this posed a significant constraint. However, such a lens was deemed valuable, especially in the early stages, as it allowed for a preemptive study to identify and critically examine these potential effects before they become

entrenched. Furthermore, it is important to acknowledge that these initiatives' potential steering effects, goals and objectives are stated more openly compared to other de facto sources, for example, authoritative assessments scrutinized by Gupta and Möller (2019). However, as these initiatives operate under the guise of impartiality or may be perceived as authoritative due to their expert context, they may inadvertently disguise the underlying steering effects from the public or other stakeholders who rely on their governance proposal. Understanding this aspect is crucial for grasping the gradual, potentially undesirable normalization of solar geoengineering research and its potential consideration as a policy option.

6.3.2 Limitations research design and methodology

The appropriateness of the research design in achieving the overarching research aim should be considered, with particular attention to highlighting its limitations concerning the scope of this study. This research aimed to capture the emerging anticipatory governance of solar geoengineering through a multiple descriptive case study design for both the *de jure* and de approach. A case study design has proven suitable as it enabled a comprehensive and in-depth understanding of the phenomena under investigation, allowing for a thorough exploration of various aspects of emerging anticipatory governance. However, it is important to acknowledge the limitations of these cases in capturing all facets of emerging anticipatory governance.

Regarding the sub-research questions concerning the *de jure* governance of solar geoengineering at a global level, certain limitations have been identified. For instance, the analysis could have encompassed additional instances of relevant formal state-led international governance, such as the amendment LP.4(8) addressing marine geoengineering activities, including marine solar geoengineering techniques. Furthermore, other international agreements, frameworks, and organizations indirectly addressing potential impact dimensions of solar geoengineering could have been examined to assess their relevance in governing solar geoengineering if ever considered for deployment. Examples include the Montreal Protocol on Substances that Deplete the Ozone Layer and its associated framework convention, the Vienna Convention for the Protection of the Ozone Layer, the World Meteorological Organization, the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, and the United Nations Framework Convention on Climate Change. Despite not directly addressing solar geoengineering, these international agreements and organizations, along with their mandates, *may hold significance for (future) international governance of solar geoengineering*. Furthermore, the analysis could have included relevant governance mechanisms at the national level. Despite the limitations inherent in the selection

of these two cases to fully encompass all facets of (potential) *de jure* governance of solar geoengineering, this study provides valuable insights within the constraints of time and resources. These selected cases were deemed the most relevant for *de jure* governance as they directly engage with solar geoengineering and have been extensively deliberated in academic and civil society spheres, remaining relevant in the ongoing governance debate.

Regarding the sub-research questions concerning de facto sources of governance of solar geoengineering, certain limitations regarding the scope have been identified. First, additional cases representing non-state expert-led initiatives could have been included to enhance the comprehensiveness of the analysis. Moreover, while this study focuses exclusively on expert-led non-state initiatives as a primary source of de facto governance, it is crucial to acknowledge the presence of other de facto sources influencing the solar geoengineering governance landscape. Despite these limitations, this study offers valuable insights within the constraints of time and resources. The selected cases were chosen for their relevance to ongoing governance debates and are widely discussed in both media and academic circles, offering diverse perspectives that have not been extensively examined elsewhere.

When discussing the limitations of the methods employed in this study, it is essential to address several key limitations concerning the document analysis and literature review employed. A primary concern regarding document analysis pertains to the accuracy and comprehensiveness of the data in addressing the research questions. Relying predominantly on documents as the primary data source in this study may have resulted in insufficient detail or an incomplete portrayal of the available evidence. For instance, when examining the context and negotiation process of the *de jure* governance attempts, documents may lack the necessary level of detail to fully address the research questions, given that the two cases under investigation occurred in the past, and the context and setting of these *de jure* governance attempts could only be inferred from documents. Insights into negotiation processes, for example, were drawn from sources such as the 'Earth Negotiation Bulletin,' a reporting service of UN environmental negotiations. However, it is worth noting that secondary sources like this may contain errors or inaccuracies, which were taken into consideration when interpreting the data by drawing from various sources. Additionally, it is important to acknowledge that the documents used were not created specifically for the purpose of this research, and thus may not encompass all relevant details.

While a literature review served as a valuable method for analysing scholarly assertions on the *de jure* governance attempts, it is not without limitations. A first limitation relates to restricted access to certain journals, databases, or publications that may have limited the

researcher's ability to include all relevant literature. As a result, the review may have overlooked valuable contributions that were not accessible, potentially limiting the comprehensiveness and depth of the analysis. Second, published studies may lack detailed contextual information, posing challenges in fully comprehending the nuances of the research being reviewed. Despite the potential for alternative methods like interviews to offer more nuanced insights, they were ultimately excluded for various reasons. Primarily, the decision to focus on examining academic interpretations within scholarly literature rather than conducting interviews allowed for a specific examination of how perspectives on *de jure* efforts by scholars or academics, who may intentionally shape narratives within scholarly contributions, are presented. This distinction in contrast to interviews is particularly relevant when considering scholarly works may be viewed as 'science-based' or authoritative given being part of recognized published work that may be influential in shaping current practices. This nuanced contextual factor, as captured in scholarly literature, could not have been comprehensively explored through interviews seeking scholars' interpretations of scrutinized governance attempts, which could have introduced a more subjective or opinion-based context. While interviews could have contributed to validating the findings from the literature review and enabled more comparative analysis, time constraints necessitated their exclusion.

6.3.3 Reflections on data analysis

In both empirical segments of this study, coding was utilized during the data analysis phase. However, it is crucial to acknowledge a primary limitation related to the inherent subjectivity in coding. The process of coding content involves subjectivity and can lead to differences among different coders. Furthermore, coding necessitates interpretation, and different researchers may apply different codes to the same material, introducing the potential for bias and impacting the reliability of the coding process (Syed & Nelson, 2015). The involvement of a second researcher could have mitigated this limitation, but logistical constraints prevented this option. Consequently, relying solely on a single coder or researcher may have compromised the reliability of the results.

Furthermore, concerning the data collection and analysis employed, particularly for the scholarly interpretations of *de jure* governance attempts, an alternative approach could have been considered. One viable method entails selectively including articles authored by scholars with clear alignment to a specific side of the governance spectrum. However, the central goal of this aspect of the study was to conduct a comprehensive examination of all existing literature on the attempts, to identify emerging themes related to the interpretation, significance, and

meaning. By encompassing all literature, rather than restricting it to a specific category of scholars, the study aimed to unveil themes that might have otherwise been missed. In this context, it is important to note that the categorization of scholars on the governance rationale spectrum has also been subject to interpretation, relying on the work of other scholars and publicly available statements of the scholars involved, even though these scholars may not categorize themselves as belonging to this particular category

6.4 Further research and final remarks

This study aimed to capture the emerging anticipatory governance of solar geoengineering, by analysing its nature and implications. However, seeking anticipatory governance of solar geoengineering is an ongoing challenge, that requires ongoing scrutiny. As a critical starting point toward advancing empirical analysis, it is thus imperative to maintain comprehensive research into unfolding political and research-related dynamics in the solar geoengineering field. Such endeavours could focus on identifying prevailing visions shaping developments, including research initiatives, authoritative reports, and decision-making processes, given their significant influence on solar geoengineering governance. As underscored in this study, the absence of a resolution at the UNEA has prompted the emergence of a non-state-mandated report sponsored by UNEP, which has faced criticism for its perceived bias toward long-standing research proponents. Continued scrutiny of such publications and international developments is imperative to reveal whose perspectives and agendas are represented, especially considering that stakeholders may leverage these developments to promote their respective viewpoints.

Another critical area for further scrutiny is the continuous examination of expert-led non-state initiatives as sources of de facto governance. While the de facto governance effects of these initiatives are yet to be fully understood, it remains essential to evaluate their potential influence on directing the solar geoengineering governance field toward specific paths, and consequently shaping the context for de jure governance, both nationally and internationally. Other emerging initiatives, such as the Alliance for Just Deliberation on Solar Geoengineering and the SRM Youth Watch, may also require scrutiny. Specifically, understanding who is driving such initiatives and how they shape the trajectory of the field, in terms of their efforts to facilitate or constrain specific governance objectives, remains crucial in the solar geoengineering domain. Furthermore, investigating the involvement of such expert-led initiatives in formal governance spaces, such as UN forums, where they may seek to influence

and contribute to the shaping of formal governance arrangements, remains another crucial field of inquiry. Such research could also explore the relationship between de facto and de jure sources of governance and how they may influence each other, providing insights into the dynamics of emerging anticipatory governance. In conclusion, further research in these areas is crucial to advance understanding of the emerging governance of solar geoengineering and to effectively address the challenges associated with anticipatory governance in this rapidly evolving, and still highly contested, field.

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APPENDIX A: OVERVIEW SEARCH STRINGS AND RESULTS

Keywords	Results	Date	Included
"CBD" AND "solar geoengineering"	512	1 December 2022	
"CBD" AND "solar radiation management"	514	1 December 2022	
"CBD" AND "stratospheric aerosol injection"	154	2 December 2022	
"CBD" "SRM"	1830	2 December 2022	
"Convention on Biological Diversity" AND "solar geoengineering"	265	8 December 2022	
"Convention on Biological Diversity" AND "solar radiation management"	701	9 December 2022	
"Convention on Biological Diversity" AND "stratospheric aerosol injection"	209	8 December 2022	
"Convention on Biological Diversity" AND "SRM"	819	9 December 2022	
Total	**5004**		**252**

Keywords	Results	Date Search	Included
"UNEA" AND "solar geoengineering"	33	5 December 2022	
"UNEA" AND "solar radiation management"	43	5 December 2022	
"UNEA" AND "stratospheric aerosol injection"	27	5 December 2022	
"UNEA" AND "SRM"	74	6 December 2022	
"United Nations Environment Assembly" AND "solar geoengineering"	35	6 December 2022	
"United Nations Environment Assembly" AND "solar radiation management"	40	6 December 2022	
"United Nations Environment Assembly" AND "stratospheric aerosol injection"	21	7 December 2022	
"United Nations Environment Assembly" AND "SRM"	42	7 December 2022	
Total	**315**		**61**

APPENDIX B: DE JURE – OVERVIEW LITERATURE REVIEW SOURCES

1. CBD

Code	Reference
1	Abelkop, A. D., & Carlson, J. C. (2012). Reining in Phaethon's chariot: principles for the governance of geoengineering. *Transnat'l L. & Contemp. Probs.*, *21*, 763.
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APPENDIX C: DE FACTO – OVERVIEW DOCUMENT ANALYSIS SOURCES

1. Solar Geoengineering Non-Use Agreement

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NPO Radio1	NPO Radio1. *Climate engineering onder de loep*. https://www.nporadio1.nl/podcasts/vroeg/85705/03-03-climate-engineering-onder-de-loep	March 3, 2023	Audio
Tebbens, 2023	Tebbens, M.D. (2023). De zon dimmen? Wetenschappers willen meer onderzoek klimaatinterventies. NOS. https://nos.nl/nieuwsuur/artikel/2465608-de-zon-dimmen-wetenschappers-willen-meer-onderzoek-klimaatinterventies	February 28, 2023	News article
Monahan, 2023	Monahan, K. (2023). Scientists push for more geoengineering testing as first "carbon cooling" credits emerge. Carbon Pulse. https://carbon-pulse.com/193618/	February 28, 2023	News article
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APPENDIX D: FULL TEXT RECOMMENDED SBSTTA DRAFT DECISION

UNEP/CBD/COP/10/1/Add.2/Rev.1*

DRAFT DECISIONS FOR THE TENTH MEETING OF THE CONFERENCE OF THE PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY

[…]

The Subsidiary Body on Scientific Technical and Technological Advice recommends that the Conference of the Parties at its tenth meeting adopt a decision along the following lines:

The Conference of the Parties

[(w) Ensure, in line and consistent with decision IX/16 C, on ocean fertilization and biodiversity and climate change, and in accordance with the precautionary approach, that no climate-related geo-engineering activities take place until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts]

Requests the Executive Secretary to:

[…]

(n) Compile and synthesize available scientific information on the possible impacts of geo-engineering techniques on biodiversity and make it available for consideration at a meeting of the Subsidiary Body on Scientific, Technical and Technological Advice prior to the eleventh meeting of the Conference of the Parties;

[…]

Invites Parties, other Governments and relevant organizations to submit information on synthetic biology and geo-engineering in accordance with the procedures set out in decision IX/29, for the consideration by the Subsidiary Body on Scientific, Technical and Technological Advice, while applying the precautionary approach to the field release of synthetic life, cell or genome into the environment;]

Retrieved from, https://www.cbd.int/doc/meetings/cop/cop-10/official/cop-10-01-add2-rev1-en.pdf

APPENDIX E: FULL TEXT CBD DECISION X/33

UNEP/CBD/COP/DEC/X/33

DECISION ADOPTED BY THE CONFERENCE OF THE PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY AT ITS TENTH MEETING
X/33. *Biodiversity and climate change*

The Conference of the Parties

8. *Invites* Parties and other Governments, according to national circumstances and priorities, as well as relevant organizations and processes, to consider the guidance below on ways to conserve, sustainably use and restore biodiversity and ecosystem services while contributing to climate-change mitigation and adaptation:

[…]

(w) Ensure, in line and consistent with decision IX/16 C, on ocean fertilization and biodiversity and climate change, in the absence of science based, global, transparent and effective control and regulatory mechanisms for geo-engineering, and in accordance with the precautionary approach and Article 14 of the Convention, that no climate-related geo-engineering activities[3] that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts, with the exception of small scale scientific research studies that would be conducted in a controlled setting in accordance with Article 3 of the Convention, and only if they are justified by the need to gather specific scientific data and are subject to a thorough prior assessment of the potential impacts on the environment.

Footnote (3): Without prejudice to future deliberations on the definition of geo-engineering activities, understanding that any technologies that deliberately reduce solar insolation or increase carbon sequestration from the atmosphere on a large scale that may affect biodiversity (excluding carbon capture and storage from fossil fuels when it captures carbon dioxide before it is released into the atmosphere) should be considered as forms of geo-engineering which are relevant to the Convention on Biological Diversity until a more precise definition can be developed. It is noted that solar insolation is defined as a measure of solar radiation energy received on a given surface area in a given hour and that carbon sequestration is defined as the process of increasing the carbon content of a reservoir/pool other than the atmosphere.

9. *Requests* the Executive Secretary to:

(l) Compile and synthesize available scientific information, and views and experiences of indigenous and local communities and other stakeholders, on the possible impacts of geo-engineering techniques on biodiversity and associated social, economic and cultural considerations, and options on definitions and understandings of climate-related geo-engineering relevant to the Convention on Biological Diversity and make it available for consideration at a meeting of the Subsidiary Body on Scientific, Technical and Technological Advice prior to the eleventh meeting of the Conference of the Parties;

(m) Taking into account the possible need for science based global, transparent and effective control and regulatory mechanisms, subject to the availability of financial resources, undertake a study on gaps in such existing mechanisms for climate-related geo-engineering relevant to the Convention on Biological Diversity, bearing in mind that such mechanisms may not be best placed under the Convention on Biological Diversity, for consideration by the Subsidiary Body on Scientific Technical and Technological Advice prior to a future meeting of the Conference of the Parties and to communicate the results to relevant organizations;

Retrieved from, https://www.cbd.int/doc/decisions/cop-10/cop-10-dec-33-en.pdf

APPENDIX F: VERSION UNEA-4 DRAFT RESOLUTION TEXT

Draft Resolution for consideration for the 4th United Nations Environment Assembly

Geoengineering and its governance

Submitted by *Switzerland*

Supported by

Burkina Faso, Federated States of Micronesia, Georgia, Liechtenstein, Mali, Mexico, Montenegro, Niger, Republic of Korea, and Senegal

PREAMBULAR PART

The United Nations Environment Assembly,

PP1. *Recognizing* that climate change is one of the greatest challenges of our time, which undermines the ability of all countries, especially those developing countries that are particularly vulnerable to the adverse effects of climate change, to achieve sustainable development and poverty eradication.

PP2. *Further recognizing* the urgent and prior need for further reduction of global greenhouse gas emissions and noting that geoengineering should not be seen as an alternative to mitigation efforts.

PP3. *Deeply concerned* about the potential global risks and adverse impacts of geoengineering on environment and sustainable development, and *noting* the lack of multilateral control and oversight.

PP4. *Mindful* of the varying definitions of geoengineering and the general distinction of technologies in solar radiation management and carbon dioxide removal, and *taking into account* their varying state of development with respect to science, their application, and potential risks.

PP5. *Welcoming* the considerations by United Nations specialized agencies and programs, multilateral agreements, and other multilateral fora, within their scope and mandates, in particular the Intergovernmental Panel on Climate Change, the Convention of Biological Diversity, the Montreal Protocol on Substances that Deplete the Ozone Layer, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and its Protocol, and *noting* the identified knowledge and information gaps.

PP6. *Recalling* General Assembly resolution 2997 (XXVII) states the main functions and responsibilities of UNEP that are to keep under review the world environmental situation in order to ensure that emerging environmental problems of wide international significance receive appropriate and adequate consideration by Governments, and *recalling* UN Environment Assembly Resolution 2/6 and the need to strengthen the United Nations Environment Program support for and contributions to global climate-change-related assessments.

[…]

OPERATIVE PART

Requests the Executive Director of the United Nations Environment Programme to

OP1. *Prepare* an assessment of the status of geoengineering technologies, in particular carbon dioxide removal technologies and solar radiation management, to include, inter alia:

a. criteria which define these technologies;
b. the current state of the science, including research gaps;
c. the actors and activities with regard to research and deployment;
d. current knowledge of potential impacts, including risks, benefits, and uncertainties with regard to each geoengineering technology;
e. current state, including challenges, of governance frameworks for research, potential deployment and control for each geoengineering technology;
f. conclusions on potential global governance frameworks for each geoengineering technology.

OP2. *Call* for proposals of and select participants for an Ad Hoc Independent Expert Group to advise the Executive Director on the development of the abovementioned assessment.

OP3. *Engage* the relevant entities of the United Nations, including treaty secretariats, in the above.

OP4. *Submit* the assessment, no later than by August 2020, for consideration at the fifth session of the United Nations Environmental Assembly.

Retrieved from, https://www.politico.eu/wp-content/uploads/2021/08/24/Draft-resolution-for-consideration-for-the-4th-UN-environment-assembly-%E2%80%94-Geoengineering-and-its-governance.pdf