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Geoengineering and the Climatic Sword of Damocles

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1. Introduction

In her 2021 non-fiction book "Under a White Sky",[1] Elizabeth Kolbert tells stories of different teams of scientists working to limit humanity's impact on the natural environment. The second-last chapter reveals the origin of the novel's title – whiter skies are one of the predicted side effects of stratospheric aerosol injections. Such particle releases are one of the forms of environmental manipulation suggested to remedy climate change, collectively called geoengineering. However, changing the composition of the atmosphere to limit warming, as stratospheric aerosol injections would aim to do, presents a plethora of other complex and long-lasting implications.

The risk of termination shock is one of those implications. Once stratospheric aerosol injections start, they cannot be suddenly stopped. A sudden halt, as Kolbert writes, "would be like opening a globe-sized oven door",[2] with greenhouse gases, previously masked by geoengineering, suddenly leading to a hyper-accelerated temperature increase, a termination shock. The necessity to continue releasing reflective particles into the stratosphere for centuries to come becomes thus a climatic equivalent to the Sword of Damocles, hanging above the planet's biosphere. Because of this, the

[1] Elizabeth Kolbert, *Under a White Sky: The Nature of the Future* (Paperback edition, Crown 2022).
[2] ibid 180.

decision to carry out solar geoengineering cannot be limited to a single generation; it also imposes an obligation on future generations to carry on.

The discourse on future generations is now firmly present in international law, including a mention in the United Nations Framework Convention on Climate Change (UNFCCC) and the recent Pact for the Future and Declaration on Future Generations. It thus becomes relevant not only to assess solar geoengineering as a way of pursuing obligations toward future generations but also from the perspective of obligations that geoengineering creates for future generations.

To that end, the following paragraphs introduce the scientific basis for solar geoengineering and bring Stephen Humphrey's discourse on future generations into the discussion.[3] The purpose of this piece is to apply some of the future generations' discourse to solar geoengineering and, in that context, to note the assumptions made in the present and the obligations imposed on the future by invoking the moral(s) from the tale of Damocles. What concludes is a substantiated response on whether the implications of geoengineering are reconcilable with obligations toward future generations.

2. Geoengineering and Termination Shock – The Science

Geoengineering has been defined as the "deliberate manipulation of the planetary environment".[4] When following this broader approach, every human action, from the reduction in forest cover in the Bronze Age to a 50% increase in global atmospheric CO_2 as compared to the amount before the Industrial Revolution, is geoengineering.[5] This piece therefore follows David Keith's approach and understands geoengineering as an intentional, large-scale environmental manipulation to mitigate human-caused climate change.

Even with this narrower view, geoengineering can take many forms with direct carbon capture, ocean fertilization, and atmospheric scatterers among many others. Solar Radiation Management (solar geoengineering, SRM) via stratospheric aerosol injections entails the release of reflective particles in the stratosphere to increase the planet's reflectivity and thereby reduce solar energy.[6] SRM does not remove CO_2 from the atmosphere but rather obscures the impact that atmospheric CO_2 has on the global climate. As solar geoengineering responds to the warming globe by going around greenhouse gas emissions, the root cause of the problem remains.

Upon implementation of SRM, a sudden stop in atmospheric injections can very quickly return the planet to its warming self. This *termination shock* exists because the

[3] Stephen Humphreys, 'Against Future Generations' (2022) 33 European Journal of International Law 1061.
[4] David W Keith, 'Geoengineering the Climate: History and Prospect' (2000) 25 Annual Review of Energy and the Environment 245.
[5] Gustav Strandberg and others, 'Did the Bronze Age Deforestation of Europe Affect Its Climate? A Regional Climate Model Study Using Pollen-Based Land Cover Reconstructions' (2023) 19 Climate of the Past 1507.
[6] Andy Parker and Peter J Irvine, 'The Risk of Termination Shock From Solar Geoengineering' (2018) 6 Earth's Future 456.

reflective particles do not stay in the atmosphere but fall to the surface within a few years of being released. Other than simply rapid warming, the termination shock presents a handful of other related challenges for both the human and the more-than-human. Indeed, the speed at which the climate changes directly influences the capacity of ecosystems to adapt, with a higher rate of change (estimated to be up to 20 times higher in termination shock than the current rates),[7] corresponding to lower adaptation capacity in both terrestrial and aquatic ecosystems.[8]

Such a rapid change, next to going against the UNFCCC objective of allowing ecosystems to adapt naturally to climate change, could have a devastating effect on biodiversity and ecosystem productivity and services, including carbon storage. Additionally, rapid warming also compromises the ability of humans, especially in the most vulnerable regions, to adapt in time. This, in turn, goes against the objective of the Paris Agreement, which aims to give ample opportunity for States to pursue their adaptation efforts. Finally, there are known unknowns. With the current understanding of the global climate, termination shock may significantly disrupt global weather patterns and, as a result of ecosystem degradation, may bring the climate beyond various tipping points.

Considering these impacts, to maintain a stable climate and avoid a termination shock, SRM must be conducted regularly and be phased out gradually. This by itself raises substantial governance and coordination challenges.[9] In response to these issues, carbon capture and storage while under a solar geoengineering regime has been proposed as a potential solution to adjust the planet and eventually phase out SRM. This method removes the CO_2 from the atmosphere, preventing damage to marine environments via ocean acidification. However, with or without solar geoengineering, carbon capture efforts are inherently long-term, and therefore SRM has been proposed as a fix-climate-quick scheme, in large part by oil companies hoping to maintain the status quo.

3. Future Generations, Present Obligations

3.1. Assumptions and Critique

The discourse of obligations toward future generations has found its way into international environmental and climate agreements. Principle 1 of the Stockholm Declaration states that humans have "… a solemn responsibility to protect and improve the environment for present and future generations". Regarding explicitly climate agreements, the UNFCCC states that "[t]he Parties should protect the climate system for the benefit of present and future generations of humankind …", while the Paris

[7] H Damon Matthews and Ken Caldeira, 'Transient Climate–Carbon Simulations of Planetary Geoengineering' (2007) 104 Proceedings of the National Academy of Sciences 9949.
[8] Andrew Ross and H Damon Matthews, 'Climate Engineering and the Risk of Rapid Climate Change' (2009) 4 Environmental Research Letters 045103.
[9] Florian Rabitz, 'Governing the Termination Problem in Solar Radiation Management' (2019) 28 Environmental Politics 502.

Agreement mentions "… intergenerational equity" in its preamble. Upon first glance, the general idea presented by this obligation is that we, as the global populace today, bear responsibility towards the global populace in the future.

In "Against Future Generations", Stephen Humphreys criticizes this discourse. He points out that such framing carries with it the implications that disregard inequality and uneven impacts of climate change. It is the wealthy States and individuals who emit the most today, yet the majority of the impacts in the future will be borne by less prosperous States and individuals, meaning those who contributed the least to the crisis. In general, the discourse around future generations creates a framing of "all of us" owing a responsibility to "all of them", but, as argued by Slavoj Žižek, such calls for universality are an "empty signifier" as they always exclude some people or groups. While not basing on Žižek's critique of ideology, Humphreys raises a similar point in the context of claims of universality in the discourse around future generations. Considering the uneven contributions to, and impacts of, climate change, the claims of "all of us" and "all of them" are far from the truth.

Humphreys argues that incorporating this framing into decision-making is elusive regarding the concrete actions that are to be taken, but also shifts away the focus from the clear-cut steps that ought to be taken in the present, often related to assisting those who face the biggest impacts and have the least resources to adapt, and instead makes them responsible for the future too. This rhetoric extends into the idea of discounting, where the ethereal future generations are assumed to be better adapted to negating the effects of climate change. This approach, due to focusing on the future, may argue for more fossil-fueled development in the name of better equipping future generations to deal with the climate costs of creating it. However, discount rates differ across the world, and while it may be an alluring gamble for those who will face the least consequences, the prosperous in the present, this approach becomes unthinkable to those who will actually bear these costs, the not prosperous in the future.

3.2. Positive and Negative Obligations

The discourse introduced in "Against Future Generations" reveals assumptions and a lack of consideration by those invoking the framing of future generations. Due attention should be given to what actions we do and do not consider when talking about our responsibility towards the future. Borrowing from the human rights frameworks, indispensable when talking about the impacts of climate change on humanity,[10] it is possible to deconstruct this responsibility into positive and negative obligations.

Positive obligations thus include acting to ensure a less climate-changed future, while negative obligations entail refraining from actions that actively disadvantage the generations to come, for example allowing further greenhouse gas emissions. From this standpoint, contemporary climate governance operates somewhere in between.

[10] Stephen Humphreys, 'Competing Claims: Human Rights and Climate Harms' in Stephen Humphreys (ed), *Human Rights and Climate Change* (1st edn, Cambridge University Press 2009) 37.

Depending on specific actions, steps taken in the name of climate mitigation can be considered as falling under either a positive obligation, such as carbon capture, or a negative obligation, such as allowing the energy transition to continue. Approaches like future discounting, however, ignore negative obligations with the hope of better dealing with positive ones in the future. While Humphreys critiques the framing as such, the distinction between the kinds of obligations serves to qualify his argument.

When applying this separation, it is revealed that only the positive obligations are subject to this critique. Such obligations call for action to protect the future while shifting the focus away from inequality in the present. Additionally, as Humphreys notes, the future generations framing creates an uncertainty about what concrete actions are to be taken. In the light of positive obligations, this is because we do not know which positive actions will lead to the "best" future; it is the future after all. In contrast, negative obligations do not rely on ambiguity and thus remain indifferent to future scenarios. They also do not shift focus away from present inequalities as they require restraint, not action. In essence, it remains difficult to say which specific steps will lead to a better future, but it is clear which actions will lead to a worse one.

4. Geoengineering and Future Generations

4.1. Assumptions in the Present

With the critique and its qualification in mind, this section applies the discourse of future generations to solar geoengineering. At first glance, it is difficult to definitively define what sort of obligation SRM would fall under. On the one hand, geoengineering will not happen by itself, and therefore implementing it would be considered as pursuing a positive obligation. On the other hand, the possibility of termination shock imposes substantial obligations on the future, and the decision to not conduct geoengineering should be treated as fulfilling a negative obligation. Considering that the risk of the termination shock is well-known, all calls for changing the composition of the atmosphere carry with them certain assumptions about the future.

One such assumption is that humanity will continue pursuing efforts to remove CO_2 from the atmosphere through various methods of carbon capture. As of now, such technologies do not work on a large scale,[11] and carry with them a further assumption that the process of energy transition will move in a way that allows for the energy and materials to be allocated to such activities.

Another assumption is that there will be no major global event that would lead to a sudden termination of geoengineering. Such events are, of course, difficult to anticipate, but large-scale wars, pandemics, and natural disasters all have the potential to decrease global capacity and render the continuation of SRM impossible. A possible governance solution would be to ensure multiple sites and backup systems, and

[11] Mark Zoback and Dirk Smit, 'Meeting the Challenges of Large-Scale Carbon Storage and Hydrogen Production' (2023) 120 Proceedings of the National Academy of Sciences 324.

although this would increase the resilience of the system, no option is entirely bulletproof.

The final assumption presented here is the belief that future generations will want solar geoengineering and will not take steps to end it abruptly. Even though the risks of the termination shock are known, its impact will not be equal, much in the same way as the effects of climate change are today. If current global dynamics are any indication, the States engaged in SRM would likely also be the States at the lowest risk of facing the adverse impacts of climate change. A possible shift in domestic attitudes and a low impact of termination could render such States vulnerable to unilaterally abandoning solar geoengineering. This issue could be addressed through global institutional arrangements, but with States being the ultimate actors in international law there is no guarantee that such arrangements will suffice.

4.2. Obligations Imposed on the Future

The tale of Damocles serves as a good illustration of the effect that these assumptions have on the future. As a courtier, Damocles constantly praised and complimented the tyrant he served. On one occasion, when Damocles spoke of Dionysus's happiness which he believed to be inherent to being a ruler, the tyrant offered to take Damocles to a banquet. During the feast, Dionysus seated Damocles on a throne with a sword suspended in the air directly above it. Upon realizing this, the courtier begged the tyrant to allow him to leave this precarious position. The moral of this story is that what looks like a great life is also, in fact, full of dangers and anxiety. However, the tale has also been misinterpreted as presenting the existence of great peril, implicitly requiring certain steps to avoid it.

Both the story's actual moral and its misinterpretation are relevant when talking about the impact of SRM on the future. When we assume that the generations to come will be more technologically and economically developed than us, we neglect the risk of termination shock that we would create if we committed to solar geoengineering. When looking at the misinterpretation of this story, by geoengineering we simultaneously create the risk of peril and dictate the steps needed to avoid it, and as outlined in the previous section, these steps are much more than just the need for regular stratospheric aerosol injections. Any act or event going against the assumptions that the present imposed on the future would risk breaking the single hair that holds the sword of Damocles above the throne.

The assumptions we have about the future under SRM all come with potential shortcomings or uncertainties. Therefore, approaching the commitment to not engage in solar geoengineering as a negative obligation toward future generations should be considered. By introducing a new risk, even if small, that doesn't even address the root cause of the problem, we do not "protect the climate system for the benefit of present

and future generations of humankind".[12] Instead, we gamble that no event that could abruptly stop SRM or carbon capture efforts will happen for as long as geoengineering takes place.

If considered as a negative obligation, the attention can be redirected to dealing with unequal impacts in the present, addressing root causes, and reducing the human and more-than-human impacts of the changing climate. This also allows for climate action in a manner that does not make predictions about future human societies, treating future generations as capable of making decisions on their own. This is not to say that all forms of geoengineering should be abandoned. Changing the global environment to return to its pre-industrial temperatures and reducing human impact on the climate is the end goal of climate action, but taking steps towards this goal should not involve taking up additional risks.

5. Conclusion

Solar geoengineering will continue to be a highly controversial topic, both in climate science and global governance circles. Considering the issues with evoking the framing of future generations in a vacuum, as outlined by Stephen Humphreys, it should be stated that engaging in SRM is not compatible with intergenerational equity as even though it may reduce the effects that greenhouse gases have on the climate, it makes assumptions about the future. Assumptions that future generations will have to treat as obligations at the cost of potentially greater damage than might be caused without SRM.

However, treating solar geoengineering as a techno-fix that specifically should not be followed, for the very reason of avoiding the risk of termination shock for generations to come, sits well with the idea of our responsibility towards the future. Inaction in this sphere redirects global attention to actions that assist those impacted the most in the present and thus ensures that future generations will include them as well. In the 21st century, we are paying, and will continue to pay, the price of emissions in the 20th century. If we hope to be remembered in a positive light by those who come after us, we should seek to protect those in the present and reduce our impact on the future, instead of making the people in the 22nd century pay the price for our unwillingness to do so.

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[12] United Nations Framework Convention on Climate Change 1992 (30822 UNTS) art 3.1.