Does Global Justice Demand Solar Geoengineering?

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Abstract

This paper critically examines the Global Justice Argument for researching solar geoengineering, which posits that global justice concerns support an obligation to research such technologies. The argument relies on two key assumptions: that anthropogenic climate change constitutes an injustice against the climate-disadvantaged and that solar geoengineering deployment is best suited to reduce climate harms befalling the climate-disadvantaged. We argue that even if the latter, empirical claim is true, the argument fails because it lacks a necessary *consent requirement*. Since solar geoengineering cannot rectify the injustices by restoring pre-injustice conditions, it can, at best, serve as compensation. Drawing on the concepts of ends-displacing compensation and duties of justice, we demonstrate that a consent requirement is necessary for the global justice argument to succeed. Given evidence of explicit dissent from some climate-disadvantaged groups, we conclude that global justice does not currently demand solar geoengineering.

Keywords: compensation, consent, geoengineering, global justice.

1. Introduction

'Geoengineering' refers to intentionally altering Earth's environment to abate anthropogenic climate change. Our focus is on *solar* geoengineering to limit the amount of solar energy entering Earth's climate system by, for instance, injecting sulphur aerosols into the stratosphere to reflect some sun rays back into space (Royal Society, 2009). Specifically, we are interested in a recent argument that global justice demands solar geoengineering.

One fundamental assumption underlying this argument is that anthropogenic climate change constitutes a significant injustice, as those most susceptible to its impacts typically bear the least responsibility for its causes. Many agree that, because of this, there is a weighty moral reason—even an obligation—for those 'climate-advantaged' who have benefited from global warming-inducing activities to rectify the injustices suffered by those 'climate-disadvantaged' who, despite lack of contributions, are bearing the brunt of global warming. We discuss this NORMATIVE ASSUMPTION further in §2.

But what should we do to fulfil that imperative? Climate policies are often divided into four categories: mitigation, adaptation, carbon dioxide removal, and solar geoengineering.[1] According to some influential climate scholars,[2] solar geoengineering deployment is the best available policy to reduce climate risks and harms to the current climate-disadvantaged. We discuss this EMPIRICAL ASSUMPTION further in §3.

Given these assumptions, one might be tempted to conclude that there is a strong moral reason—again, even an obligation—to research and potentially deploy solar geoengineering. Indeed, the aforementioned influential climate scholars have drawn that conclusion. As we explain in §4, however, these assumptions are insufficient to render what we call the 'global justice argument' valid.

That said, the global justice argument is easily rendered valid by connecting the alleged benefits of deploying solar geoengineering to the purported obligation to research it. But the argument is not as easily rendered sound, even assuming the truth of the (controversial) EMPIRICAL ASSUMPTION. After dismissing some previous criticism against the argument in §5, §6 argues that for the global justice argument to support its conclusion, it must assume that the climate-disadvantaged (at least hypothetically) *consent* to researching and deploying solar geoengineering. More specifically, it must assume that the climate-disadvantaged accept (or would, under ideal conditions, accept) that researching and deploying solar geoengineering is adequate compensation for the injustice they have suffered.

The argument is thus undermined by the fact that some climate-disadvantaged explicitly do not consent to researching and deploying solar geoengineering (examples of which are discussed in §6). Hence, contrary to what proponents of the global justice argument claim, the NORMATIVE ASSUMPTION and, more importantly, the EMPIRICAL ASSUMPTION are insufficient to establish that global justice demands solar geoengineering.

In §7, we consider an alternative, forward-looking version of the global justice argument that focuses on reducing future harm rather than rectifying past injustice, in case some readers consider it closer to the argument proposed in the literature. We show that this version of the argument fares no better than the backward-looking version. §8 concludes by briefly discussing what the climate-advantaged ought to do instead of solar geoengineering.

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[1] As mentioned in §3, the boundaries between these policy alternatives are not always clear. However, we follow the literature to which we contribute by dividing the options this way.

[2] One example is David Keith (see, e.g., Horton & Keith, 2016; Keith, 2013), who led the Solar Geoengineering Research Program at Harvard University until 2023, when he left to found the Climate Systems Engineering Initiative at The University of Chicago.

Two clarificatory remarks are due before discussing the details of the global justice argument. First, we merely argue that the NORMATIVE ASSUMPTION and the EMPIRICAL ASSUMPTION are insufficient to establish an obligation for the climate-advantaged to research solar geoengineering. In fact, we contend that the global justice argument cannot even establish that such research is permissible. However, we do not claim that solar geoengineering research *is* impermissible. Nor do we claim that solar geoengineering *deployment* will never be permissible. We merely claim that the global justice argument—which is just one amongst many arguments for researching solar geoengineering—fails.

Second, it should be emphasised that although the global justice argument is explicitly about *researching* solar geoengineering, our interest in it stems from an interest in the ethics of *deploying* solar geoengineering. Again, there are several plausible arguments for the permissibility or obligatoriness of researching solar geoengineering that we do not consider in this article. Perhaps most obviously, we think that researchers should—with very few exceptions—be free to pursue whatever basic research that interests them. However, the global justice argument differs from many of these other arguments in that it seems plausible that if it succeeds, then there are possible circumstances where it is also obligatory to *deploy* solar geoengineering. After all, the EMPIRICAL ASSUMPTION is a hypothesis about the benefits of deploying solar geoengineering. If further research confirms that hypothesis, then the global justice argument may have as a corollary that we have an obligation towards the climate-disadvantaged to deploy solar geoengineering.

2. The Normative Assumption

It should be apparent to everyone that the effects of anthropogenic climate change are unjustly distributed (if not, see, e.g., Broome, 2012; Emmerling et al., 2024). Although storms, floods, and heat waves in the United States and Europe remind us that no one is safe from the greenhouse effect, such events are not (yet) threatening to make life impossible for most of those living in affluent parts of the world. By contrast, poorer regions are becoming uninhabitable, and the ways of life of comparatively disadvantaged people within more affluent parts of the world are becoming unsustainable.

We will distinguish between two groups: the ‘climate-advantaged’ and the ‘climate-disadvantaged.’ Roughly, we take the climate-advantaged to be relatively *affluent*, which generally enables them to adapt to a changing climate; relatively *responsible* for

anthropogenic climate change,[3] which at least partially explains their affluence; and relatively *invulnerable* to the physical effects of climate change (for instance, by not being too dependent on climate-sensitive agriculture). The climate-*dis*advantaged are in the opposite positions: they are less affluent, making it harder for them to adapt; they are less responsible, partially explaining their lack of affluence; and they are more vulnerable to the physical effects of climate change.[4]

One paradigmatic case of a climate-disadvantaged group is the people of Tuvalu, a Pacific island country with 11,000 inhabitants that NASA projects will be largely submerged by mid-century. That includes much of its critical infrastructure, making life on the isles challenging, if not impossible. As John Broome (2012, p. 49) points out, the plight of the Tuvaluans illustrates the injustice of anthropogenic climate change:

> The Tuvaluans have contributed virtually nothing to climate change. They live very simple lives and use little energy. The threat of homelessness has been visited on them by profligate nations far away.

To take another example, about a million people in southern Madagascar suffered famine in 2021-2022 due to a drought most likely caused by anthropogenic climate change. In an interview with the BBC, Shelley Thakral (in Harding, 2021) from the United Nations World Food Programme said the following about the situation:

> These people have done nothing to contribute to climate change. They don't burn fossil fuels … yet they are bearing the brunt of climate change.

Finally, climate injustices are not only international but also intranational. Some people in otherwise advantaged regions are also climate-disadvantaged, such as the Indigenous people of the Arctic. Once again, despite having contributed very little to anthropogenic climate change, these people are "amongst the first to suffer badly from its consequences" (Broome, 2012, p. 3; see also Sámiráđđi, 2023).

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[3] It need not be true that every *member* of this group is responsible for (fixing) anthropogenic climate change; only that the *collective* has contributed significantly more to the problem than its counterpart.

[4] These are imperfect definitions. For example, the people of Amsterdam are relatively affluent and responsible but also relatively vulnerable (given that the city lies six feet under sea level). It is unclear, then, whether they are advantaged or disadvantaged. Still, this terminology is more precise and better suited to our purposes than the more common 'global poor' and 'developing world.' Both these terms fail to highlight the climate-specific ways in which these people are disadvantaged and fail to acknowledge that there are groups belonging to 'rich' and 'developed' parts of the world that are climate-disadvantaged, such as many Indigenous populations.

In sum, those least responsible for anthropogenic climate change suffer the most because of it. Most, if not all, serious writers on climate ethics agree that this feature of climate change makes it particularly unjust. That includes geoengineering researchers Joshua Horton and David Keith (2016, p. 80), who take this injustice to ground an obligation:

> Intuition tells us that the requirements of justice are violated when an activity benefits wealthy countries at the expense of poorer ones … In such cases, there would seem to be an obligation to, at a minimum, take steps to reduce harms falling on the most vulnerable nations. Additional obligations may exist as well, such as halting the activity in question or compensating states that have suffered harms.

We take it that the most plausible interpretation of the above observations—by philosophers like Broome, civil servants like Thakral, physicists like Keith, political scientists like Horton, and many others—is that they support the following claim:

> NORMATIVE ASSUMPTION. The climate-advantaged have an obligation to take steps to *rectify* the injustices due to the climate risks and harms that the current[5] climate-disadvantaged suffer.[6]

The astute reader will have noticed a crucial change of wording; Horton and Keith explicitly say that climate injustices result in an obligation to *reduce harms*, whereas our formulation of the NORMATIVE ASSUMPTION instead talks of *rectifying injustices*. This may suggest that the global justice argument, as found in the literature, is more forward-looking than we present it to be. But, whilst we will briefly discuss and dismiss such a forward-looking argument in §7, we will mostly focus on the backwards-looking alternative for the simple reason that we deem it more plausible. When someone is unjustly harmed, that injustice is not resolved simply by discontinuing the harm.

Moreover, despite our primary interest not being to understand precisely what Horton and Keith mean, it is worth noting that some of their claims suggest that they also take a partially backwards-looking perspective on justice. For example, their argument for

[5] This should not be taken to deny that the climate-advantaged *also* have an obligation towards future climate-disadvantaged people. However, the authors whose arguments we are inspired by (in particular, Horton and Keith) are primarily concerned with obligations towards current generations. To fairly portray and assess the global justice argument, we shall focus on current generations, too.

[6] We are not committed to any particular view about distributing this obligation. On the contrary, as we explain in §5, we believe that treating the climate-advantaged as a single agent or a homogenous set of agents with identical obligations is a mistake. Perhaps not all individuals and collectives among the climate-advantaged have this obligation, and perhaps different individuals and collectives can satisfy it in different ways.

researching solar geoengineering is grounded in "historical obligations to the global south" (Horton & Keith, 2016, p. 89) that stem from the fact that the climate-disadvantaged, because of climate change, suffer "the consequences of activities of which they have not been the primary beneficiaries" (p. 80).

3. The Empirical Assumption

Recall that climate policies are often divided into four categories, partly for convenience: mitigation, adaptation, carbon dioxide removal, and solar geoengineering (see Horton & Keith, 2016; Heyward, 2013).[7] Based on this typology, Horton and Keith (2016) argue that solar geoengineering is the superior policy alternative for reducing harm befalling the climate-disadvantaged. This section first relays Horton and Keith's cases against the other climate policies and then introduces the case for the EMPIRICAL ASSUMPTION, which we will, despite its controversy, take for granted for the sake of argument.

Mitigation, or the reduction of greenhouse gas emissions,[8] is usually viewed as the most just way for the climate-advantaged to reduce the risks and harms they impose on the climate-disadvantaged. However, Horton and Keith (2016) argue that mitigation primarily benefits *future* generations. Because of climate inertia, risks of climate harms would continue to grow for decades—and the climate-disadvantaged would continue to suffer the most—even if emissions were rapidly cut to zero. Moreover, such a rapid energy transition would be costly, and the costs "would be felt more by the poor for whom energy is a larger fraction of expenses" (Horton & Keith, 2016, p. 80). Hence, mitigation has no significant potential to reduce risks and harms for *current* generations, but would be very costly for the current poor.

"[T]he distinction between mitigation and carbon dioxide removal is moot," Horton and Keith (2016, p. 82) say, since the climate effects of the two policies are roughly equivalent (both resulting in reduced carbon dioxide concentration in the atmosphere) until emissions are close to zero. So, even disregarding worries about the potential inefficiency of carbon dioxide removal technologies (see Jacobsson, 2019; Chiquier et al., 2022), it is unlikely that these could significantly benefit current generations.

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[7] Clare Heyward (2013) adds rectification (e.g., financial compensation) to this typology. Our paper does not concern such policies but rather explores the treatment of solar geoengineering *as* rectification.

[8] The Intergovernmental Panel on Climate Change defines mitigation as reducing greenhouse gas *concentrations*, in which case carbon dioxide removal is a form of mitigation (see Heyward, 2013). However, much of the literature on climate policies, including the literature we are engaging with, uses mitigation to refer to reducing greenhouse gas *emissions*, and we will follow that tradition in this paper.

In contrast to both mitigation and carbon dioxide removal, adaptation would have immediate effects. But those effects would be costly and local, which is why Horton and Keith (2016) suggest that the climate-disadvantaged living today are unlikely to benefit from adaptation. They are unlikely to implement adaptation measures themselves (because of the cost), unlikely to benefit from the climate-advantaged's implementation of them (since the effects are local), and the climate-advantaged are unlikely to implement them on the climate-disadvantaged's behalf.

Solar geoengineering can potentially combine the best parts of these other policy options. To see why, it is worth looking into a specific form of solar geoengineering: Stratospheric Sulphur Aerosol Injections (SSAI). SSAI is often explained by analogy to volcanic eruptions, which have been documented to decrease average surface temperatures due to their release of sulphur dioxide. That enhances Earth's 'albedo,' or reflectivity, thereby scattering solar energy back into space, reducing the amount reaching Earth's surface. For instance, the eruption of Mount Pinatubo in 1991 resulted in a 0.5ºC reduction in average surface temperatures over the subsequent year. SSAI could be even more effective than this natural phenomenon, as it would allow for the direct injection of sulphur aerosols into the stratosphere, increasing the particles' longevity and consequently decreasing the amount required to achieve a desired surface temperature reduction (see Crutzen, 2006).[9]

Discussing the benefits of SSAI, Jesse Reynolds (2021, p. 2) says that it "has substantial potential to reduce climate change … in ways that other responses could not: it appears to be relatively inexpensive, rapid, and possible without broad international cooperation." Horton and Keith (2016, p. 83) expand on the latter point, claiming that solar geoengineering allows for local actors, such as nations, to "benefit the rest of the world (especially the [climate-disadvantaged]) as a virtual by-product of their otherwise self-interested use of [solar geoengineering]." In sum, solar geoengineering could avoid the problems of inertia and inefficiency affecting mitigation and carbon dioxide removal, as well as the issues of cost and locality affecting adaptation. Or, more directly:

> EMPIRICAL ASSUMPTION. The existing evidence suggests that the most effective and most feasible option to reduce climate risks and harms to the current climate-disadvantaged's well-being is to deploy solar geoengineering.

[9] Other solar geoengineering proposals include putting 'space reflectors' into orbit (see Angel, 2006) and increasing the albedo of stratocumulus clouds (see Latham et al., 2012).

That is a controversial assumption, both because of its negative claims about other climate policies and because of its positive claims about solar geoengineering.

First, Horton and Keith's negative claims can be criticised on numerous grounds. Most notably from a global justice perspective, their central point regarding adaptation is that "the only way that all the world's poor will share in [adaptation measures] equally is if global redistribution of wealth is perfect so that everyone can equally afford to adopt this response" (Horton & Keith, 2016, p. 82). That misses an important point. As we explain in the next section, the global justice argument for solar geoengineering posits that the climate-advantaged have an obligation to research the technologies *for the sake of* the climate-disadvantaged. But given Horton and Keith's description of the limits of adaptation, why is it not instead the case that the climate-advantaged have an obligation to provide adaptation measures for the sake of the climate-disadvantaged? It seems that the main reason against this alternative conclusion is that adaptation is more expensive than solar geoengineering. But that cannot be a sufficient reason for dismissing adaptation, given that the climate-advantage owe the climate-disadvantaged compensation. If paying for adaptation turns out to be the most just way for the advantaged to compensate the disadvantaged, then it is worth paying some additional cost for that (Hourdequin, 2018 makes a similar point). We return to this issue in the concluding section.

Second, evidence for the positive part of the EMPIRICAL ASSUMPTION can be criticised for relying on models whose empirical results are tainted by questionable assumptions.[10] For example, one study (Moreno-Cruz et al., 2012) fails to highlight the implication of its findings that optimising the level of SSAI for powerful and climate-advantaged regions like the United States would "make things relatively worse for some of the poorest countries in the world" (McLaren, 2018, p. 214). That sheds doubt on Horton and Keith's claim that solar geoengineering could 'benefit the rest of the world as a by-product of self-interested deployment.' Other models ignore or diminish parameters that are more important for the climate-disadvantaged,[11] such as the importance of ocean temperatures and currents for fishing societies (see Hourdequin, 2019).

In light of these doubts, it is important to note that the EMPIRICAL ASSUMPTION does not assert *knowledge* that solar geoengineering would benefit the climate-disadvantaged. If

[10] Including three models cited by Svoboda and colleagues (2018), who, as we explain in §4, support the global justice argument.

[11] Which is perhaps a consequence of research being made primarily by researchers working in the 'climate-advantaged' part of the world (see Morrow, 2019; Möller, 2023).

that were the case, then the global justice argument would conclude in *deployment*—not research—of solar geoengineering. So, although influential climate scholars take the current evidence to support the EMPIRICAL ASSUMPTION, they do not consider it conclusive. This is expressed by what we in the next section call the UNCERTAINTY ASSUMPTION.

Moreover, whilst we agree that the global justice argument can be legitimately criticised on empirical grounds, we also believe it can be criticised purely on normative grounds. That is precisely what we aim to show. *Even* if the EMPIRICAL ASSUMPTION is true, the global justice argument fails.

4. The Global Justice Argument

Based on thoughts we have tried to capture in the NORMATIVE ASSUMPTION and EMPIRICAL ASSUMPTION, Horton and Keith (2016, p. 84) conclude that there is a "*prima facie* obligation … to investigate the potential of [solar geoengineering] to help the [climate-disadvantaged]." Indeed, they claim that "opposition to research [on solar geoengineering] threatens to violate principles of justice by effectively condemning [the climate-disadvantaged] to suffer the consequences of activities of which they have not been the primary beneficiaries" (Horton & Keith, 2016, p. 80). Similarly, in a study of multiple SSAI models, Toby Svoboda and colleagues (2018, p. 362) conclude that researching solar geoengineering is "warranted" because "there is a strong *prima facie* case that SSAI could be used in ways that substantially reduce emissions-driven injustices."[12]

The above conclusions do not, however, follow from the two assumptions. After all, *researching* solar geoengineering does not itself reduce the risk of harm to the climate-disadvantaged. So, the global justice argument contains a gap: it moves from an empirical claim about deployment to a normative claim about research. Moreover, Horton and Keith (2016, p. 84) are keen to emphasise that theirs is only an argument for research, pointing out that "An obligation to investigate is not the same as an obligation to use."

That is, of course, true, and many arguments for researching solar geoengineering can maintain a sharp distinction between reasons for research and reasons for deployment. For

[12] The *prima facie*-clauses of the above statements should be discussed. Svoboda and colleagues use this clause to say that existing evidence of SSAI's effects on global climate is uncertain. But then there *is* a case for researching SSAI because that could remove such uncertainty. However, Horton and Keith's use of the clause is different. They seemingly use it to emphasise that the obligation to research solar geoengineering is subject to exogenous overriding considerations. One way to conceive of our upcoming critique against the global justice argument is that we identify *endogenic* overriding considerations. That is, we identify overriding considerations within the sphere of global justice. Hence, we shall formulate the conclusion of the global justice argument as an 'actual' obligation to research solar geoengineering, and we shall say that we have shown that the global justice argument does not even support a *prima facie* obligation to do so.

example, some suggest that solar geoengineering should be researched to avoid or prepare for rogue unilateral deployment (e.g., Stefánsson, 2023). In that case, research is motivated because deployment could be *harmful*. The global justice argument is different since it relies on the explicit premise that deployment seems *beneficial*. Hence, a connection must be established between these alleged benefits and the argument's conclusion.

The following is our suggestion for how to render the global justice argument valid:

> NORMATIVE ASSUMPTION. The climate-advantaged have an obligation to take steps to rectify the injustices due to the climate risks and harms that the current climate-disadvantaged suffer.
> EMPIRICAL ASSUMPTION. The existing evidence suggests that the most effective and most feasible option to reduce climate risks and harms to the current climate-disadvantaged's well-being is to deploy solar geoengineering.
> UNCERTAINTY ASSUMPTION. The existing evidence on solar geoengineering is uncertain and inconclusive.
> CONDITIONAL OBLIGATION. If the climate-advantaged have an obligation to take steps to rectify the injustices due to the climate risks and harms that the current climate-disadvantaged suffer, and solar geoengineering is the most effective and most feasible way to reduce climate risks and harms to the current climate-disadvantaged's well-being, then the climate-advantaged have an obligation to take the necessary steps towards morally defensible solar geoengineering deployment.
> RESEARCH ASSUMPTION. Due to the UNCERTAINTY ASSUMPTION, further research on solar geoengineering is the next necessary step towards morally defensible solar geoengineering deployment.
> CONCLUSION. The climate-advantaged have an obligation to conduct further research on solar geoengineering.

That is not the only valid argument for the above CONCLUSION that incorporates the NORMATIVE ASSUMPTION and EMPIRICAL ASSUMPTION. But we do suspect that it is the strongest version of the argument proposed by Horton and Keith and, to a lesser extent, Svoboda and colleagues.[13] (The closest contender is the forward-looking version mentioned in §2 and discussed in detail in §7.) If that is correct, then the strongest version of the global

[13] Svoboda and colleagues (2018, p. 354) only claim that solar geoengineering (SSAI) research is "warranted," as opposed to Horton and Keith's claim that it is (*prima facie*) obligatory.

justice argument is *weak*, because the CONDITIONAL OBLIGATION is false: the antecedent is insufficient to establish an obligation to take steps towards solar geoengineering deployment. Therefore, the global justice argument fails to establish that the climate-advantaged have an obligation to conduct further research on solar geoengineering. We are not the first to note this. In the next section, we respond to an earlier critique of the global justice argument. In the section after that, we present our own critique of the argument.

5. Earlier Criticism of the Global Justice Argument

Geoengineering generally, and solar geoengineering specifically, engenders several ethical problems that we set aside. For instance, we overlook worries that regulating global temperature is intrinsically wrong and, as Stephen Gardiner (2011, p. 390) puts it, that "pursuing geoengineering manifests arrogance and recklessness." Perhaps more importantly, given our focus, we set aside the worry that deployment of solar geoengineering may itself cause climate injustices through, for example, changes in precipitation patterns (see Ricke et al., 2023). Finally, we overlook the worry that by disincentivising mitigation that has the potential to benefit future generations, solar geoengineering research could contribute to intergenerational injustice (see Gardiner, 2011; Horton & Keith, 2016).

In this section, we instead respond to a very tempting—but, we think, ultimately mistaken—response to the global justice argument. This response starts from the thought that the only way for emitters to take proper responsibility for the harm they have caused, and continue to cause, due to anthropogenic climate change, is to stop emitting—despite the considerable economic cost to themselves. By proposing geoengineering instead, proponents of the global justice argument are effectively suggesting a way for the climate-advantaged to "shirk responsibility" (Horton & Keith, 2016, p. 87) for their unjust and harmful emissions.

Both Gardiner (2011, 2013a) and Hourdequin (2018, p. 278) have put forth powerful versions of this argument, the latter by using the following allegory:

> I take actions that benefit me and (incidentally) harm you. I benefit a lot from these actions, which vastly increases my power and wealth … I continue to act in the ways that benefit me in the short term while harming you and others, and I determine that it is too expensive for me to stop doing so … Harms to you continue to accumulate, and your situation is becoming increasingly dire. I could provide resources to you that would enable you to better cope with your situation, but doing so would be expensive … So, I argue that I should investigate a technology that I believe would benefit us

> both, alleviating some of the harm to you in the near term—though it might leave our grandchildren worse off.

The problem with this and similar responses to the global justice argument is that they treat the climate-advantaged as a single agent or a homogenous set of agents. That is a convenient way of writing (and we have indeed partly done so ourselves!), but it misses an important feature of the argument. The allegory suggests a situation where *I* harm you, *I* could stop the activity causing the harm, *I* could provide you with resources to adapt, but instead *I* argue that *I* ought to investigate a technological fix potentially benefitting us both, but at the expense of future generations. That would be very problematic, but it mischaracterises the argument.

By contrast, it would not necessarily be problematic if *I* proposed to investigate a technology to limit the harm you suffer because *they*—to my frustration!—continue to act in ways that harm you. That might very well be the *right* thing to do, in particular if I am sceptical that I will be able to convince them to stop the activities that harm you.[14]

Those proposing the global justice argument are, we contend, in this latter situation, not the one suggested by Hourdequin's allegory. True, the climate-advantaged have, as a collective, harmed the climate-disadvantaged through their emissions of greenhouse gases, and they could stop doing so. But the scholars proposing solar geoengineering research cannot themselves do much to stop the activities causing the imposition of risk and harm. (The latter is in fact true of most governments too.)

Nor can the scholars themselves 'provide resources to the climate-disadvantaged that would enable them to better cope with their situation,' and they may be sceptical of the likelihood of convincing their government to pay for adaptation measures for others. In contrast, they may reasonably believe that they could convince their government to fund solar geoengineering research and potential deployment for self-interested reasons, which could, as a by-product, benefit the climate-disadvantaged (recall Horton & Keith, 2016, p. 83).

In sum, once we isolate those making the global justice argument, distinguish them from the *collective* 'the climate-advantaged,' and in particular appreciate that they cannot themselves do much to directly stop the harm that is caused by greenhouse gas emissions by the collective, we see that the argument is not quite as suspect as Hourdequin allegory suggests. Is it, therefore, sound? No. In the next section, we argue that the argument fails to account for the requirement of *consent*.

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[14] It might even be right to ask that *they* pay for my investigation of said technology, for instance, if I believed that that would be the only way in which harm for you could be significantly reduced.

6. The Global Justice Argument and Consent

Recall that the global justice argument includes the NORMATIVE ASSUMPTION that the climate-advantaged have an obligation to rectify the injustices due to anthropogenic climate change suffered by the climate-disadvantaged. In other words, a group of people have been harmed by another group of people, which requires a response from the latter group. Again, most, if not all, climate ethicists would agree. But the question at issue is: What response is called for? That is, what would satisfy the climate-advantaged's obligation? We argue that solar geoengineering is not the answer. In particular, we argue that solar geoengineering is not the answer because it does not meet an important consent requirement. Our argument can be cashed out by utilising two concepts: Robert Goodin's (1989) *ends-displacing compensation* and John Broome's (2012) *duties of justice*. We shall discuss each in turn, but first, we shall say something about how one ideally rectifies injustices.

When someone has been unjustly harmed, *restoring* the situation that prevailed before the injustice would be the best way to rectify it. For example, if I have stolen your bike, the ideal way to deal with the injustice would be to return it to you.[15] But restoration is not always possible. In fact, restoration is rarely an available option for injustices caused by climate change. Consider again the Indigenous people of the Arctic, whose ways of life are threatened by anthropogenic climate change. It is unlikely that, at least in the near term, any policy could restore the climate around which these people have built their lives.

Moreover, most solar geoengineering proposals aim to maintain the status quo of average temperatures, slow the increase in average temperatures caused by greenhouse gas emissions, or, at best, slightly decrease average temperatures (see, e.g., Irvine et al., 2019). Certainly, deploying solar geoengineering to restore a pre-industrial or 'pre-injustice' climate is not feasible. Hence, it is unlikely that solar geoengineering can restore, for example, the loss of biodiversity in reindeer calving grounds (van Rooij et al., 2022) or precipitation patterns and local weather conditions (Ricke et al., 2023). All of which are important for the reindeer-herding practices of the Saami population (see Sámiráđđi, 2023), an example of Indigenous Arctic people.

When restoration is not possible, *compensation* is instead required. And, as the following two subsections show, that implies a further requirement of (hypothetical) *consent*;

[15] I may also have to provide you with some compensation for the inconvenience of not having a bike for however long it took to return it to you, but that is beside the present point.

more specifically, that the victims of the injustice accept (or at least would, under ideal conditions, accept) the proposed compensation *as compensation*.

Our main concern with the global justice argument is thus related to Hourdequin's (2018) charge that the argument is *paternalistic*. In §6.3, however, we explain why we think that paternalism is *not* the argument's main weakness.

6.1. Solar Geoengineering as Ends-Displacing Compensation

For much the same reasons that solar geoengineering cannot restore the pre-injustice climate, solar geoengineering cannot provide what Robert Goodin (1989) calls *means-replacing compensation*. That is, it cannot provide compensation that enables the climate-disadvantaged to pursue the *same* ends as before the climate injustices started, albeit with different means. Instead, we take it that solar geoengineering can, at best, compensate the climate-disadvantaged "not by helping them pursue the same ends in some other ways, but rather by helping them pursue some other ends in a way that leaves them subjectively as well off overall as they would have been had they not suffered the [injustice]" (Goodin, 1989, p. 60). In other words, solar geoengineering can, if anything, likely only provide *ends-displacing compensation*, forcing the climate-disadvantaged to alter their ways of life. The Saami people would have to rely less on reindeer herding, the Inuit might not be able to continue the fishing and hunting practices around which much of their culture has traditionally revolved, and similar.

As Goodin notes, means-replacing compensation is morally preferable to ends-displacing compensation. That is because the latter cannot rectify *intrapersonal redistributions*. Even if ends-displacing compensation leaves the victim of an injustice (in some sense) as *well* off as prior to the injustice, it inevitably leaves them "*differently* off" (Goodin, 1989, p. 60) by virtue of changing the ends that make up their lives. If compensatory policies aim to remove distributional objections, ends-displacing compensation can only do "half that job" (Goodin, 1989, p. 68).

The fact that solar geoengineering can at best provide ends-displacing compensation is not a problem unique to this policy; mitigation, adaptation, and carbon dioxide removal are also unlikely to, in the near term, restore calving ground biodiversity, precipitation patterns, local weather conditions, and so on. There are simply no perfect or close substitutes to what the climate-disadvantaged have lost as a result of anthropogenic climate change. However,

noting that solar geoengineering would, if anything, provide ends-displacing compensation highlights the need for *consent* from the climate-disadvantaged to solar geoengineering.[16]

Consent is required to legitimise ends-displacing compensation because such compensation may otherwise leave objectionable intrapersonal redistributions uncorrected when the compensated are forced to re-prioritise amongst their ends. For example, when the Roskill Commission found that eight per cent of the homeowners who would be displaced by the building of a third London airport saw no price at which they would be willing to sell their property, it would be wrong to say that this was because they were "so silly as to deny that with £5 million in compensation they would, in some sense, be better off moving out of their £5,000 house and living elsewhere" (Goodin, 1989, p. 74). More reasonably, these people judged that there was no compensation for the fact that by moving out, they would be forced to re-prioritise amongst some of their most important ends.

Similarly, it would not be 'silly' for the Indigenous people of the Arctic to say that even if solar geoengineering in some sense leaves them as well off as (or better off than) alternative policies, it is nonetheless an inadequate response to the injustices they have suffered because it forces them to re-prioritise among their ends. On this analysis, then, solar geoengineering would be a legitimate response only if the climate-advantaged consented to it, in particular, found acceptable the way in which it would force them to re-prioritise amongst their ends. At the very least, we would need reason to believe that the climate-advantaged *would* find it acceptable if they were properly informed about the relevant facts and made no reasoning errors. However, as we will see in §6.4, some climate-disadvantaged actually do *not* consent to solar geoengineering. But first, let us consider another reason why consent is required in this case.

6.2. Solar Geoengineering as a Duty of Justice

Duties to rectify climate injustices are what Broome (2012) calls *duties of justice*. Those are duties owed *to someone*. In particular, the NORMATIVE ASSUMPTION expresses a duty owed by the climate-advantaged to the climate-disadvantaged.

[16] It might, therefore, be the case that all alternative climate policies are subject to a consent requirement, if none of those policies can provide means-replacing compensation. That seems correct. Also if we are arguing for a certain adaptation measure to be implemented *for the sake of* the climate-disadvantaged, it makes sense to give significant weight to what the climate-disadvantaged think of that adaptation measure. Importantly, then, the present argument is not affected by the assumption that solar geoengineering is *better* for the climate-disadvantaged than its alternatives. Even if it is, it likely cannot provide means-replacing compensation, and is therefore subject to a consent requirement.

The fact that it is a duty owed to someone limits the set of options that the perpetrators of the injustice (i.e., the climate-advantaged) can use to legitimately rectify the injustice suffered by the victims (i.e., the climate-disadvantaged). In particular, it places tighter constraints on the set of legitimate options than do *duties of beneficence*. Those living in affluent parts of the world arguably have a duty to 'make the world better' and, in particular, to improve the situation of the badly off. However, there is considerable freedom in how to satisfy this latter duty. After all, no particular group of badly-off people is owed—due to this general duty of beneficence—to be helped in any particular way by some particular private person (Broome, 2012). Therefore, it would be hard to morally criticise someone who, say, donates ten per cent of their income to the cause they judge—based on relevant empirical evidence and appropriate reasoning—to most effectively 'do good.'

Things are different when it comes to rectification owed *to someone*. In such cases, the fact that some option is deemed *by someone other than the victim* as being best suited or most likely to improve the victim's well-being does not suffice for that option to belong to the set of legitimate ones. The option must also fit with the values of the victim. More generally, it must be acceptable to the victim. More specifically, it must be true that the victim would consent to the option as acceptable rectification if she had the relevant evidence and reasoned appropriately in light of both this evidence and her values.

The implication for the global justice argument is, again, that for solar geoengineering research (and deployment) to be part of the set of options that the climate-advantaged can use to rectify the injustices suffered by the climate-disadvantaged, it must be that the latter would find this to be an acceptable policy. The climate-disadvantaged must (at least hypothetically, in ideal circumstances) *consent*.

6.3. Paternalism

We are not the first to note that (what we are calling) the global justice argument is unconvincing if the climate-disadvantaged do not consent to geoengineering research and potential deployment. For instance, Hourdequin (2018) points out that, without such consent, the argument is problematically *paternalistic*. Below we use the distinction between duties of justice and duties of beneficence to illustrate why we think that the argument's main weakness is not paternalism.

Imagine that an affluent person wants to satisfy the duty of beneficence by helping people at their local homeless shelter. Suppose that the people served by the shelter would most prefer to receive cash, and the person in question knows this. Worried that they will

spend the money unwisely, he instead decides to visit the shelter regularly with substantial food donations. Although it might be possible to criticise him for being paternalistic, few would deny that donating food weekly to a homeless shelter is a perfectly acceptable way for him to satisfy his duty of beneficence, even though the people who benefit from the donation would prefer cash.

Now compare the above to a situation where a person has unjustly caused someone to be homeless. In that case, the perpetrator of the injustice owes compensation to the victim. Suppose that the victim of the injustice thinks that the only acceptable way for the preparator to compensate for the injustice is to help them acquire a home. The perpetrator does not do so, however, but instead donates enough food to the homeless shelter in which the victim is staying for everyone there to be well fed. Finally, suppose again that the perpetrator knows that all those who benefit from the donation would prefer cash to food.

In the second example, the perpetrator of the injustice may well, by their donation, be satisfying a duty of beneficence. The way in which they do that may be criticised for being paternalistic, but again few would deny that donating food to homeless people is an acceptable way to satisfy a duty of beneficence. By contrast, the person in question would *not* be satisfying the duty of justice owed to the victim of the injustice (even though the victim happens to be staying at the shelter in question). That is true even if the victim was so poor, before the injustice was inflicted on them and they lost their home, that they were on the brink of starvation. So, even if the victim would, in some sense, be better off in a homeless shelter where—thanks to the perpetrator of the injustice—everyone is well fed, compared to in their own home, that does not mean that the perpetrator has satisfied the duty that they owe to the victim. In other words, unlike in the first example, the problem in the second is not that the person satisfies a duty in a paternalistic way, but rather that they simply fail to satisfy their duty to provide acceptable compensation to the victim of their injustice.

The lesson for the global justice argument should be clear. Unless the climate-disadvantaged accept (or would, under idealised circumstances, accept) that solar geoengineering research is acceptable compensation for the injustice they have suffered, such research is not a way for the climate-advantaged to satisfy the duty they owe the climate-disadvantaged. So, the problem is not (merely) that solar geoengineering research would be a paternalistic way for the advantaged to satisfy this duty. The problem is that it would not satisfy the duty *at all*, unless the disadvantaged accept that solar geoengineering research and potential deployment is an acceptable way to satisfy the duty.

Unfortunately for proponents of the global justice argument, the next subsection provides strong evidence that many climate-disadvantaged would neither consent to solar geoengineering research nor deployment. But if they do not even *consent* to research or deployment, it seems evident they would not consider research or deployment acceptable compensation for the injustice they have suffered.

6.4. Dissent Against Solar Geoengineering

Perhaps the strongest evidence about what a group of climate-disadvantaged people think of solar geoengineering comes from a letter that the Saami council—representing the Indigenous Saami people of the Arctic regions of Sweden, Norway, Finland, and Russia—wrote in 2021 to protest the so-called SCoPEx solar geoengineering experiment planned in Kiruna, Sweden. The letter expressed a clear dissent of solar geoengineering (in particular, Stratospheric Sulphur Aerosol Injections) as an acceptable policy response to anthropogenic climate change, stating that "it is a technology that entails risks of catastrophic consequences" and that there are "no acceptable reasons for allowing the SCoPEx project to be conducted either in Sweden or elsewhere" (Sámiráđđi, 2021, p. 2). The protest was successful, and the experiment was abandoned.[17]

So, we know that one group among the climate-disadvantaged in fact do not consent to solar geoengineering research (or deployment), and we have seen no reason to think that the lack of consent was due to some reasoning error or because they lacked relevant information. What about other groups? The climate-disadvantaged are a large and heterogeneous group, and there is no reason to expect they will have a unified view on solar geoengineering. Further research is required. That said, recent research (e.g., Whyte, 2018, 2020; Carr & Preston, 2017) suggests that the Saami are far from alone in dissenting against solar geoengineering.

For example, Carr and Preston (2017) interviewed people from three climate-vulnerable areas—Solomon Islands, Alaska, and Kenya—and interviewees from all three areas expressed concern about geoengineering exacerbating global power imbalance by concentrating power even further in the more affluent parts of the world.[18] Moreover, and

[17] Granted, the Saami council's protest was explicitly aimed at SSAI *research*, not deployment. But given that the SCoPEx experiment would 'merely' test whether a high-altitude balloon could function at the altitude necessary to effectively release sulphur aerosols into the stratosphere (but not actually release such particles), it seems reasonable to conclude that the Saami council's protest was also aimed at use of the technology.

[18] Several philosophers have raised the same concern, including Jamieson (1996), Gardiner (2011), Preston (2012), and Hourdequin (2018).

more directly related to our argument in §6.1, people living on the Solomon Islands are sceptical of solar geoengineering because its potential effects on regional climate would imply a "huge, huge shift of how people live" (anonymous interviewee in Carr & Preston, 2017, p. 766). Another way to put this is that people would be forced to pursue different ends. In sum, the existing (admittedly limited) empirical evidence strongly suggests that solar geoengineering fails to meet the consent requirement, and we see no reason to think that these dissenters' reasoning is flawed or based on misinformation.

We are now in a position to properly explain why the global justice argument fails. Since solar geoengineering is unlikely to restore pre-injustice climate or provide means-replacing compensation, it can, at best, provide ends-displacing compensation. Since ends-displacing compensation requires consent and many climate-disadvantaged clearly dissent, the global justice argument fails. Equally, because the duty to compensate the victims of climate change is a duty of justice, it matters what the victims reasonably consider acceptable compensation. Since many climate-disadvantaged clearly do not consider solar geoengineering acceptable, the global justice argument fails.

Importantly, the global justice argument fails for the above reasons even if the EMPIRICAL ASSUMPTION is true. That assumption only asserts the effects of solar geoengineering on the climate-disadvantaged's *well-being*. But, as Goodin (1989, p. 70) notes, "When a new bundle of goods is simply foisted upon people … whether or not it is an equally good bundle is simply irrelevant."

But what if some climate-disadvantaged consent and others dissent? Given the global nature of solar geoengineering and how heterogeneous 'the climate-disadvantaged' are, such a situation is perhaps to be expected. Indeed, it would not be too surprising if, say, the Tuvaluans consented to solar geoengineering if they perceived it to be the only feasible alternative for protecting their territory, even though, say, the Indigenous people of the Arctic held an opposing view.

Such situations of competing interests would raise difficult questions about how to think about compensation that only some of the victims of an injustice accept as appropriate but that either all or none of the victims must get [any suggestions for reference here?]. That type of question lies outside the scope of our paper. Our point is quite modest. The fact that solar geoengineering is the option that most effectively, or most likely, reduces the unjust risks and setbacks to the climate-disadvantaged's well-being—that is, if the EMPIRICAL ASSUMPTION is true—does not suffice for solar geoengineering research (or deployment) to satisfy the obligation expressed in the NORMATIVE ASSUMPTION.

7. The Forward-Looking Global Justice Argument

The worries raised in the previous section concerned the possibility that solar geoengineering can *rectify* past and present injustices suffered by the climate-disadvantaged. In a nutshell, our point has been that it is impossible to restore the pre-injustice situation fully, that some sort of compensation is therefore needed, and that solar geoengineering research (and deployment) is, due to lack of consent, morally unacceptable as compensation.

However, in §2, we noted that one could perhaps interpret some proponents of the global justice argument as proposing a more forward-looking argument that replaces our rectification-focused NORMATIVE ASSUMPTION with the following alteration:

> NORMATIVE ASSUMPTION*. The climate-advantaged have an obligation to take steps to *reduce* the risks and harms that the current climate-disadvantaged suffer.

This version of the assumption does not state that the climate-advantaged have some responsibility to rectify past injustices. It only considers the distribution of climate risks and harms and obliges the advantaged to reduce those that the disadvantaged suffer.

To make a correspondingly forward-looking global justice argument valid, we would also need to tweak the conditional obligation:

> CONDITIONAL OBLIGATION*. If the climate-advantaged have an obligation to take steps to *reduce* the climate risks and harms that the current climate-disadvantaged suffer, and solar geoengineering is the most effective and most feasible alternative to reduce climate risks and harms to the current climate-disadvantaged's well-being, then the climate-advantaged have an obligation to take the necessary steps towards morally defensible solar geoengineering deployment.

Does a forward-looking global justice argument incorporating the NORMATIVE ASSUMPTION* and the CONDITIONAL OBLIGATION* fare better than the backwards-looking version we have considered? We think not. True, unlike the backwards-looking global justice argument, the observation that solar geoengineering does not *rectify* injustices suffered by the climate-disadvantaged does not undermine the forward-looking global justice argument. Nevertheless, if our worries expressed in §6 are well-founded, then a forward-looking argument is no less problematic.

To see this, let us for now suppose that the climate-disadvantaged dissent to solar geoengineering research (and deployment). The above discussion certainly suggests that this

is true for some climate-disadvantaged groups. The forward-looking argument then implies that the climate-advantaged have an obligation towards the climate-disadvantaged to research solar geoengineering both *for their sake* but nevertheless *against their will*. That seems problematically paternalistic. Moreover, it is unclear why (at last hypothetical) consent would be less important for the forward-looking version of the global justice argument than for the backward-looking one.[19] If the climate-disadvantaged dissent to solar geoengineering, after careful deliberation in light of the available facts, then it is hard to see how the advantaged could be obliged to pursue solar geoengineering *for the sake of* the disadvantaged.

Here is another way to see the problem with the forward-looking global justice argument. For the argument not to be undermined by the assumption that the climate-disadvantaged dissent to solar geoengineering research (and deployment), the obligation expressed in the NORMATIVE ASSUMPTION* would have to be an obligation grounded in some form of *teleological prioritarianism* (to paraphrase Kymlicka, 1990 and Rawls, 1971). According to such a view, we have an obligation to improve the well-being of the badly off not because we have an obligation towards those people but because we have an obligation towards the *state of affairs* in which those people are better off. If, in contrast, the obligation is held towards those badly off, then our previous worries re-emerge: such an obligation cannot be satisfied in a way that is unacceptable to those towards whom it is an obligation.

Now, as Kymlicka notes, such a teleological view is unmotivated. We have obligations towards people, not states of affairs. Consequently, the obligation expressed in the NORMATIVE ASSUMPTION(*) is not an obligation towards the state of affairs where the climate-disadvantaged are better off. It is an obligation towards the climate-disadvantaged. Therefore, dissent towards solar geoengineering amongst the climate-disadvantaged means that deploying or researching this technology does not satisfy the obligation in question. Hence, a forward-looking global justice argument does not escape our criticism.

8. Concluding Remarks

Influential climate scholars have suggested that solar geoengineering's allegedly positive welfare effects on the climate-disadvantaged result in a strong moral reason—even an obligation—to research the technologies. We have argued that even if it is correct that solar geoengineering has these benefits, the 'global justice argument' fails. The emphasis put

[19] In fact, according to the second principle of the Oxford Principles on geoengineering governance, geoengineering researchers should in general consult, and ideally obtain informed consent from, "those affected by the research activities" (https://www.oxfordmartin.ox.ac.uk/geoengineering).

on the EMPIRICAL ASSUMPTION by proponents of the global justice argument makes for an overly welfarist view and misses the necessary condition that there is (at least hypothetical) consent to solar geoengineering amongst the climate-disadvantaged.

The proponents of the global justice argument have provided no evidence for such consent. Perhaps such consent will, at some point, emerge. Further research on what the climate-disadvantaged think of solar geoengineering is certainly needed. But presently, the injustices that anthropogenic climate change imposes on the climate-disadvantaged, combined with the purported welfare benefits of solar geoengineering for the climate-disadvantaged, does not suffice to justify a "*prima facie* obligation … to investigate the potential of [solar geoengineering] to help the [climate-disadvantaged]" (Horton & Keith, 2016, p. 84).

So, what should the climate-advantaged do? If Horton and Keith's doubts regarding mitigation, adaptation, and carbon dioxide removal described in §3 are well-founded, is there *any* policy that fulfils the obligation expressed in the NORMATIVE ASSUMPTION? Certainly, it seems unlikely that any policy can restore the pre-injustice situation or provide perfect or close substitutes for the things the climate-advantaged have lost due to climate change.

Our tentative answer is that global justice favours a response where the climate-advantaged pay, at least in part, for acceptable adaptation measures for the sake of *current* climate-disadvantaged and use a combination of mitigation and carbon dioxide removal for the sake of *future* climate-disadvantaged (and, indeed, all future people). Such a policy is just as unlikely to *rectify* the injustices suffered by the climate-disadvantaged as solar geoengineering is. But, crucially, it does not face the problem of implementing a policy for the sake of a group who explicitly and reasonably dissent to that policy.

Moreover, as emphasised in the introduction, we do not claim that solar geoengineering research (nor deployment) is, all things considered, impermissible. Like other research, it may have intrinsic value. It may also have instrumental value by virtue of convincing otherwise rogue unilateral deployers not to deploy. Or, more importantly, solar geoengineering may prove to be our best option to avoid catastrophic climate impacts. It may be the 'lesser evil' (see Crutzen, 2006; cf. Gardiner, 2013b). But if it is, then solar geoengineering is motivated by *those* concerns. It would still be false that *global justice* demands solar geoengineering.

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