Chapter 6

Solar Geoengineering and Obligations to the Global Poor

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One of the very few things that nearly all participants in the climate change debate agree on is that the effects of climate change will disproportionately affect the poor, for the simple reason that poorer people will have fewer resources available to them to manage climate risks and adapt to unavoidable changes compared to their wealthier neighbours. This simple fact applies both to disadvantaged people in every country and more broadly to the developing world in relation to rich, industrialized nations. Some concrete examples help illustrate this particularly tragic aspect of climate change.

More frequent and more intense heat waves will harm the poor more than the rich both because the rich are more protected by technology such as air conditioning and because the regions most prone to future extreme heat events are generally less wealthy. The poor have less reliable access to water, which will only be exacerbated by the growth in the number and severity of droughts. Climate change will reduce yields of many staple crops, with disproportionate impacts on the global poor whose economies rely more on agriculture and whose existence is more marginal to begin with. The disadvantaged are more likely to depend on local ecosystems for their subsistence and livelihoods, so that climate-induced ecosystem stresses will prove particularly harmful to the least well off. The loss of coral reefs, for example, will be especially damaging for poor coastal communities who rely on reefs for food and income as well as protection from increasingly destructive storm surges. Rising sea levels are also likely to affect the poor most of all, since they can least afford to relocate.

From a moral perspective, this asymmetry of impacts is particularly troubling since the emissions that give rise to climate change come from energy use that disproportionately benefits the rich. The rich have got richer doing things that will hurt the poor most of all.

Distributive concerns arise at two separate levels of analysis. First, *within* countries, climate change entails rich people making gains at the expense of poor people, who must bear the brunt of its consequences. This is as true within developing countries as it is within developed countries, since the disadvantaged in each will be relatively less capable of dealing effectively with climate stresses. Second, *among* countries, climate change entails rich nations making gains at the expense of poor nations, who similarly must bear the brunt of global warming. Individuals and collectives are distinct moral entities, each operating in recognizable ethical spheres that, while interconnected, are characterized by separate assumptions, expectations and internal logics (Cohen and Sabel 2006). In what follows, we proceed from an international, global perspective, although many of our arguments and conclusions may be equally applicable to individuals within societies.

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 develop and defend in this chapter the central thesis that taking principles of global distributive justice seriously entails a moral obligation to conduct research on solar geoengineering. In the first section, we make a case grounded in temporal considerations that justice requires a thorough investigation of solar geoengineering, also known as solar radiation management (SRM), as a potential tool of climate policy to complement mitigation and adaptation. SRM is a set of technologies that would reflect a small fraction of incoming sunlight back to space, thereby cooling the planet. The most commonly discussed type of SRM would involve scattering reflective aerosols in the upper atmosphere to reduce warming on a global scale. Following this we consider and critique two justice-based arguments against research into SRM: (1) that solar geoengineering would hurt the global poor disproportionately and (2) that solar geoengineering would represent an abdication of historical responsibility on the part of the global North. We conclude by situating these arguments in the context of the broader debate about geoengineering, contending that opposition to research on SRM threatens to violate principles of justice by effectively condemning developing countries to suffer the consequences of activities of which they have not been the primary beneficiaries.

DIFFERENT CLIMATE CHANGE POLICIES, DIFFERENT DISTRIBUTIONS OF BENEFITS AND HARMS

The ethical concerns arising from solar geoengineering are best understood in the context of the range of responses to growing climate risks. We consider four kinds of responses to limit climate risks: *mitigation* entails reducing emissions of carbon dioxide and other greenhouse gases (GHGs); *carbon removal* technologies remove carbon dioxide from the atmosphere; *adaptation* involves implementing social and technological changes that reduce the damage from a given amount of climate change; and finally, *solar geoengineering* would partially and temporarily offset some of the climate changes caused by a given level of accumulated GHGs.

The ethical implications of these responses turn on the particular distribution of benefits and harms associated with each. We focus on two dimensions over which benefits and harms are unequally distributed: time and wealth. For simplicity, we consider two time periods, the *near term*, or roughly the next half-century, and the *long term*, more than half a century out. Climate change is a slow-motion problem. In what follows, we also assume that our world is one of limited resources, so that money spent on one policy today entails the opportunity cost of what investing in another policy might have paid tomorrow.

Now let us consider how the four responses vary in their impacts across time and wealth. Because of inertia in the climate system and in the world's energy infrastructure, the benefits of any mitigation policy—say a commitment to a vastly faster transition to low-carbon energy—are necessarily slow. Cutting emissions does surprisingly little to reduce climate risks in the near term.

Suppose emissions are cut to zero in 50 years—an extraordinarily rapid energy system transition. Taking global surface temperatures as a proxy for climate risks, such a transition would reduce the growth of risks, but risks would still grow. And rapid emission cuts would impose significant economic costs that may, for example, appear as increased energy prices. While there would also be side benefits in the form of reduced air pollution, there is broad consensus that emission cuts impose costs, and, all else being equal, these costs will be felt more by the poor for whom energy is a larger fraction of expenses. So in the near term, mitigation has significant costs compared to only modest benefits, and a disproportionate share of the costs may fall on the poor.

Mitigation looks very different in the long term. From a more distant perspective, the benefits appear larger since it is mainly after the next half-century when climate risks that otherwise would have become manifest will be avoided due to emission cuts in the present. Furthermore, future benefits from present mitigation will accrue to rich and poor alike. At the same time, since most of the costs of mitigation are borne in the near term, future costs would be small. Thus, while the net short-term effects of mitigation would be harmful and may be concentrated on the poor, the long-term effects would generally be beneficial and universal.

The distribution of benefits and harms associated with carbon removal is very similar to that which characterizes mitigation (Keith 2009). Indeed, until net emissions are near zero, the distinction between mitigation and carbon removal is moot: both have local costs and reduce net emissions. The one exception relates to the ability of carbon removal technologies to generate 'negative emissions'—in the long term, carbon removal methods would enable society to draw down legacy emissions and thereby further reduce climate risk and/or reduce the amount of any solar geoengineering deployed. However, mitigation and carbon removal are sufficiently similar that, for purposes of the present discussion, we will not address carbon removal further.

Unlike mitigation, adaptation will provide substantial benefits in the short term. These benefits, however, are local in nature in that they reduce damages from climate impacts in a way that is spatially restricted. For example, a seawall protects only those located behind it from the encroaching sea. One consequence of the local scale of adaptation benefits is that the strongest incentives for action apply to local actors. All things being equal, the poor will therefore have fewer resources to devote to those adaptation measures that would benefit them. This situation is further aggravated by the costly nature of many adaptation measures. Because the benefits of adaptation are both local and expensive, the only way that all the world's poor will share in them equally is if global redistribution of wealth is perfect so that everyone can equally afford to adopt this response. This is theoretically possible, and for many it is the morally preferred outcome, but the persistence of inequality over millennia argues that it is unlikely to obtain.

If there is a trade-off between funds spent on adaptation and mitigation today, as might be the case if there were a de facto fixed amount of resources available for all climate response measures, then the opportunity cost of investing in adaptation would be the benefits of emission cuts that would have improved the welfare of future generations. Compared to mitigation, then, adaptation directly benefits the present at some expense to the future, but its theoretical potential to help the poor most of all is undermined by the practical consequences of its costly, local character.

Similar to adaptation, solar geoengineering might also provide benefits in the short term, but these benefits would differ from those provided by adaptation in two fundamental ways. First, the advantages conferred by solar geoengineering would be global in scale by virtue of SRM's inherently global

nature, in contrast to the local-scale benefits typical of adaptation. This means that local actors pursuing local interests through the use of SRM might, if the intervention was properly designed, benefit the rest of the world (especially the global poor) as a virtual by-product of their otherwise self-interested use of solar geoengineering. Second, assuming for the moment that adaptation provides the same reduction in climate risk as SRM, the cost of providing a given level of climate protection would likely be much lower for SRM than for adaptation, since SRM implementation is estimated to be relatively inexpensive (at least in direct cost terms) (McClellan, Keith, and Apt 2012). Since a given unit of climate protection would benefit the poor disproportionately, the cost differential between adaptation and SRM imparts a comparatively greater redistributive potential to the latter response option.

At the same time, differences in the nature of the radiative forcings produced by greenhouse warming compared to solar geoengineering mean that SRM cannot perfectly compensate for the effects of elevated GHG levels; in other words, solar geoengineering is incapable of wholly undoing climate change. Solar geoengineering would also entail potentially negative side effects such as uneven regional changes in temperature and precipitation (although such effects could probably be minimized or possibly even negated through optimization—see below). Moreover, as with adaptation, the opportunity cost of mitigation foregone in favour of SRM would be greater climate risk in the long term. Overall, therefore, compared to mitigation, SRM would likely provide net benefits in the near term that would help the poor most of all, at the cost of emission cuts today that would otherwise benefit everyone in the future. Unlike adaptation, however, the functionally redistributive benefits of SRM would be relatively cheap to provide and could in principle be supplied globally by agents acting primarily in their own interest.

We assumed above that adaptation and SRM are perfect local substitutes, but in reality they are not. Limits exist to the ability of adaptation measures to reduce climate risks. Coastal defences may be adequate to protect against storm surges, and people may be relocated away from areas vulnerable to sea-level rise, but other climate harms, such as those related to unavoidable temperature increases, will not be amenable to adaptation measures. Some staple crops such as maize, rice and wheat, for example, are subject to temperature thresholds above which yields fall dramatically. Similarly, coral bleaching above fixed thresholds will be irreversible on human timescales, depriving coastal communities of critical natural resources.

By contrast, if SRM were proven effective in reducing the global mean temperature, as the available evidence strongly suggests it would be, both the direct effects of increased temperature such as threats to public health and the indirect effects such as agricultural losses and more destructive storms could be at least partially offset by use of the technology.[1] And SRM appears capable of reducing some major present-day risks that cannot be addressed nearly as effectively by adaptation. For instance, there is new evidence that increased temperatures have direct impacts on human physical and intellectual productivity as well as on mortality and that even in wealthy countries which have technology to lessen these effects (such as air conditioning), the economic value of these impacts can be roughly as large as all other climate impacts combined (Park 2016). Given that these impacts are regressive in that they harm the poor more than the rich, and given that the one thing SRM is best able to achieve appears to be an approximately globally uniform reduction in temperatures, there is now an additional reason to expect that SRM would benefit the poor even more than the rich.

Based on these arguments demonstrating both that adaptation and solar geoengineering are capable of benefitting today's poor in ways that mitigation cannot and that the benefits from SRM compared to adaptation are cheaper, more global in scale and effect, and more reliant on the realistic assumption of self-interested behaviour, we conclude that a prima facie moral obligation exists to investigate the potential of SRM to help the developing world. An obligation to investigate is not the same as an obligation to use. SRM technology is subject to a range of significant uncertainties, and if research into SRM were to demonstrate a potential for harmful side effects or unresolvable uncertainties with serious risks for people or the natural environment, SRM should at the least be critically reassessed and may ultimately warrant abandonment. Yet such research has yet to be performed, and without an adequate evidence base, the *a priori* dismissal of SRM as one potential tool of climate policy is at best imprudent, and at worst immoral.

ARGUMENTS AGAINST RESEARCH

From this perspective, the fact that many critics of SRM research base their opposition on self-described concerns about global distributive justice is paradoxical. There are at least two types of argument against research into SRM formulated in terms of global distributive justice.

'Solar Geoengineering Would Hurt the Global Poor'

The first argument contends that, just as impacts from climate change will disproportionately affect developing countries, so too the harms likely to result from solar geoengineering would affect the global South most of all. Christopher Preston refers to this exacerbated global gap as a 'moral deficit' (Preston 2012: 79). Arguably, this view derives in large measure from a widely publicized 2008 article by Alan Robock and colleagues, who reported that solar geoengineering could potentially disrupt Asian and African summer monsoons (Robock 2008). Martin Bunzl, for example, raises the possibility that 'SRM itself may do harm by making some *worse off than they would be with global warming alone*. In support of this inference, Robock et al. have a model that suggests that sub-Saharan Africa would have less cloud cover after geoengineering and thus be hotter and drier than it would be with climate change alone' (italics in original) (Bunzl 2011: 71). Building on this, Toby Svoboda and colleagues catalogue possible reductions in precipitation caused by sulphate aerosol geoengineering (SAG) in Africa, South America and Southeast Asia, leading them to conclude that solar geoengineering 'has the potential to increase benefits for some by increasing harms for others. For this reason, ... SAG faces an obstacle in meeting the requirements of ... theories of distributive justice' (Svoboda et al. 2011: 165). We might call this the Hurts the Global Poor argument.

A substantial part of this argument rests on an empirical claim either that solar geoengineering will be inherently harmful to parts of the world where poverty is greatest or that a specific implementation of solar geoengineering would be harmful. We first address the strongest empirical claim before discussing the implications arising from the range of ways in which solar geoengineering might be implemented.

Scientific analysis of SRM remains at a very early stage. Yet preliminary work already indicates that use of SRM could reduce the most important aspects of climate change, including changes in temperature, precipitation and extreme events. Specifically, research shows that if relatively small SRM interventions were conducted, *all* regions of the world, encompassing global North *and* South, would be better off in the sense that the most salient climate risks would be reduced (Moreno-Cruz et al. 2011, Ricke et al. 2013). Ben Kravitz et al., for instance, show that when a moderate amount of SRM is used, and both temperature and precipitation values are taken into account, all regions are brought closer to preindustrial conditions than they would be without SRM (Kravitz et al. 2014). Under this admittedly idealized scenario, using SRM in effect shifts the Pareto curve outward, so that no region is harmed in absolute terms. Since in relative terms developing countries stand to gain more from reductions in climate change than developed countries, the world's poorest and most vulnerable people would likely benefit disproportionately under this scenario. This study is the only multi-model study that examines all regions systematically, and, at a minimum, it casts substantial doubt on the types of claims we cite above which tend to focus on a single model, variable or region. The assertion that SRM hurts the poor requires demonstrating that those regions where damages from SRM are largest correlate with poverty. We are unaware of any such study for even a single experimental model run of SRM, let alone for a representative ensemble of SRM methods and models.

Note that to the extent that specific harms such as reduced rainfall did fall on developing countries as a result of solar geoengineering, it is possible that these would be offset by the gains attributable to other avoided damages from climate change. Quantifying the costs and benefits of SRM is undoubtedly a problematic proposition, and practical efforts to do so would certainly fall short of the ideal (Davies 2010). In addition, any utilitarian assessment would need to ensure robust procedural and substantive protections so as not to violate fundamental principles of justice (Rawls 1999). But given these not inconsiderable caveats, the available evidence indicates that developing countries could enjoy absolute gains in welfare over the short term as a result of SRM, while also making relative welfare gains compared to industrialized countries.

Now let us turn to the question of how specific implementations of SRM might harm the poor. While it is true that SRM may *hurt* the developing world disproportionately, it is equally true that SRM may *help* the developing world disproportionately, at least in the near term. Indeed, a multitude of global distributive outcomes might result from the use of SRM. Which outcome obtains in practice, that is which particular distribution of harms and benefits materializes, would depend entirely on *how* SRM is used. In other words, the short-term distributive impact of solar geoengineering is ultimately a question of optimization.

Implementing SRM in the real world would necessarily entail selecting values for a number of control parameters, so that system operators could 'turn the knobs' to preferred settings. These parameters include how much reflectant to use, where to disperse it (latitude, longitude, altitude), how often to disperse it, how long to use it and so on. These are hardly trivial questions, as the specific details of any actual deployment would have significant consequences in terms of regional effects. The regional distribution of harms, benefits and risks resulting from SRM, in other words, would not be fixed, but rather would vary depending on the particular choices made by decision-makers. In technical terms, 'Introducing multiple spatial and temporal degrees of freedom has the potential to improve how well SRM can compensate for CO_2-induced climate change, and thus reduce concerns over the resulting regional inequalities' (MacMartin et al. 2013: 365). Yet while this claim may be physically realistic, any serious discussion of how solar geoengineering might be fine-tuned to achieve an optimal geographic distribution of harms and benefits (however defined) is clearly premature.

In the larger context of choices between different climate response instruments, it is true that the use of SRM today might come at the opportunity cost of future mitigation benefits that would otherwise accrue to the entire global population. Hence, even a justly designed SRM deployment scheme may harm the poor in the long term if resources are diverted from mitigation in the present. Yet this possibility makes the issue of harm to the most vulnerable a complicated trade across time, not a simple trade between rich and poor. To assert that solar geoengineering would harm developing countries most of all, as the Hurts the Global Poor argument would have it, both obscures this inherently complex temporal trade-off and misunderstands the existing evidence base by attributing an essential regressive quality to SRM technology where none appears to exist.

'SOLAR GEOENGINEERING WOULD SHIRK RESPONSIBILITY'

The other, more nuanced, global distributive justice argument against SRM claims that conducting research on SRM, and possibly deploying the technology, represents a means for the rich world to avoid meeting its historical climate justice commitments to the poor. In other words, principles of justice require that the global North, which is primarily responsible for climate change, take primary responsibility for mitigating the problem, which as noted above disproportionately affects the global South. The fullest, and most morally correct, way to accomplish this is for the global North to take on the (costly) burden of emissions reduction. SRM is an imperfect substitute for emissions mitigation but appears to be less expensive, by orders of magnitude. The temptation for industrialized countries to 'take the easy way out' by pursuing SRM rather than a substantive programme of decarbonization is obvious. The justice implications of opting for the 'quick fix' of SRM over more demanding but ethically satisfactory mitigation efforts, however, make solar geoengineering morally dubious. As Stephen Gardiner argues (albeit from a virtue ethics perspective), 'One way in which our lives might be tarnished would be if the commitment to geoengineering becomes a vehicle through which we (e.g. our nation and/or our generation) try to disguise our exploitation of other nations, generations, and species' (Gardiner 2011: 392).[2] Clive Hamilton puts it in more direct distributive justice terms: 'Installing a solar filter would cement the failure of the North in its obligations to the global South' (Hamilton 2013: 163).

The argument that SRM would represent the unjust avoidance of a moral obligation to cut emissions, which we might call Shirks Responsibility, has two significant flaws. The first relates to the so-called 'moral hazard'—or 'risk compensation' effect (Reynolds 2015)—of solar geoengineering, that is the possibility that the availability of SRM might lead individuals to reduce their efforts at emissions abatement, since SRM appears to be much less costly and easier to implement than mitigation while providing benefits that are approximate to emissions reductions. The moral hazard argument differs from the simpler opportunity cost argument presented above in that the latter pertains to the practical consequences of options foregone, whereas the former pertains to the likelihood of foregoing those options. From a theoretical perspective, there is reason to believe that an economically rational agent would indeed shift some resources away from mitigation and towards solar geoengineering if the latter were an available policy option.[3]

Interestingly, there is little empirical evidence that people would behave this way in practice. Christine Merk, Gert Pönitzsch and Katrin Rehdanz, in the first rigorous empirical analysis of the question, declare, 'We find no evidence for risk compensation at an individual level as a reaction to information on SAI [stratospheric aerosol injection]' (Merk et al. 2015: 6). Existing studies have been conducted at the level of individuals, yet critics generally make no distinction between moral hazard for individuals and for states, and to our knowledge have not presented any evidence that governments would be more susceptible than people.

However, given the limited empirical work conducted to date, generally supportive results from theoretical modelling exercises and common-sense expectations that rational actors would compensate for risk in the short term by switching effort from mitigation to solar geoengineering, we accept that 'moral hazard' in some form would be likely to occur. If so, what would be the impacts for distributive justice? In the short term, the poor would be better off in that there would be less-severe climate impacts due to the action of solar geoengineering. In the long term, the entire global population, rich and poor alike, would be worse off as a consequence of the added risk caused by lessened efforts on mitigation. The crux of the matter is the rights of the poor in the coming decades compared to the poor in the distant future.

One way out may be to assume that global economic growth will continue into the future, and therefore tomorrow's poor are likely to be better off than today's poor. With the future poor both less certain to lack resources, and more likely to be better situated than their contemporaries, it could be argued that the obligation to today's poor, and hence to use SRM, is stronger. This resolution, however, is speculative. In the end, whether or not SRM would be morally appropriate in this complex ethical landscape is a question that can be answered only by broad-based research on solar geoengineering. Indeed, to close off research into SRM is to shirk the Northern responsibility to address the full range of climate risks destined to affect the global South most of all. A more nuanced understanding of the temporal dimensions of climate risk thus has the effect of inverting the Shirks Responsibility argument and places the burden of proof on those who would seek to prevent investigation into solar geoengineering.

The second flaw in this argument, which is suggested by the language used in our critique up to now, is that its frame of reference is based on particular climate policy tools, rather than on reducing climate risk more generally.[4] By focusing on risk management tools rather than on risk management itself, critics of SRM have allowed preferences for certain policy instruments to dictate their views at the cost of addressing the complete spectrum of risks posed by climate change. Assuming that both mitigation and SRM, responsibly pursued, satisfy basic moral requirements (which we believe they do, though we acknowledge that this is contested), the refusal to countenance SRM based solely on hypothesized technical, organizational, political or other qualities necessarily comes at the expense of endeavouring to protect people in poor countries from extreme temperatures, violent storms, rising seas and other climate harms likely to manifest in the coming decades. By contrast, when managing climate risk is the framework for evaluation, ethical considerations demand that SRM be taken seriously (in addition to mitigation and adaptation). Historical obligations to the global South include mitigating harms not just in the long term, but in the near future as well; this duty cannot be fulfilled by emissions reductions alone.

CONCLUSION

Thus, a better appreciation of climate science, including the findings from initial research on SRM, as well as the adoption of a comprehensive climate risk management framework, come together to undercut both the Shirks Responsibility and Hurts the Global Poor arguments against solar geoengineering. To repeat, we contend that a prima facie moral obligation exists to research SRM in the interest of developing countries, because SRM appears to be the most effective and practicable option available to alleviate a range of near-term climate damages that are certain to hurt the global South most of all. It is incumbent on those who oppose research on solar geoengineering to either (1) propose an alternative to SRM that would be as capable of reducing climate risks over the next several decades as solar geoengineering appears to be, or, failing that, (2) demonstrate that SRM would violate principles of global distributive justice. Since we know of no other plausible response that would be as effective in scope and scale at reducing short-term climate risks as SRM appears to be, and we regard as false the technological essentialism that underlies arguments about the supposed inevitability of unfair distributive consequences, we believe that justice requires further research on solar geoengineering.

The moral hazard argument, which underlies what we have termed the Shirks Responsibility argument against SRM, is central to a wide range of critiques of solar geoengineering (Hale 2012). Generally speaking, these critiques both originate and target audiences in the global North (Belter and Siedel 2013). Hamilton, for instance, writes that 'research is virtually certain to reduce incentives to pursue emission reductions. ... Already a powerful predilection for finding excuses not to cut greenhouse gas emissions is obvious to all, so that any apparently plausible method of getting a party off the hook is likely to be seized upon' (Hamilton 2014: 167–68). The ETC Group, a civil society group critical of many emerging technologies, similarly warns against geoengineering as a 'perfect excuse', suggesting 'Geoengineering offers governments an option other than reducing emissions and protecting biodiversity. Geoengineering research is often seen as a way to "buy time," but it also gives governments justification to delay compensation for damage caused by climate change and to avoid taking action on emissions reduction' (ETC 2010: 33). Naomi Klein offers another example, declaring, 'the fact that geoengineering is being treated so seriously should underline the urgent need for a real plan A—one based on emission reduction, however economically radical it must be' (Klein 2014: 283). She continues: 'How about some other solutions … like taking far larger shares of the profits from the rogue corporations most responsible for waging war on the climate and using those resources to clean up their mess? Or reversing energy privatizations to regain control over our grids?' (ibid., 284).

At the risk of oversimplification, this line of argument essentially involves rich-country commentators criticizing solar geoengineering in an effort to shore up mitigation as their priority domestic climate policy, while ignoring the potentially huge distributional advantages SRM might confer on the world's poorest in the global South. Their deeper motives vary, from a sense of moral indignation over shirking (Hamilton) to neo-Luddism (ETC Group) to anti-corporate ideology (Klein) and beyond. Whatever the reasons, the resulting admonition not to research SRM for fear of its policy implications for industrialized countries, at the expense of possibly enormous welfare gains in developing countries, is ethically disturbing in a global moral context.

We agree with these critics that, since long-term climate risks can only be reduced through mitigation, the present generation has a duty to future generations to implement major reductions in carbon emissions, whatever the efficacy of solar geoengineering turns out to be. But we part ways with them in their neglect of the short term, during which millions of the world's most vulnerable people will suffer harms from climate change that simply cannot be mitigated by emissions cuts. Given the very strong evidence that SRM would significantly reduce global temperatures and thereby limit climate impacts, particularly in the developing world, we view research on SRM as a moral imperative.

Fundamental principles of justice require that, all things being equal, the disadvantaged should not suffer from the results of actions benefitting the better off. Opponents of research into the possible benefits (*and harms*) of solar geoengineering threaten to violate this requirement in at least two ways. First, failing to conduct research puts the global South at risk of paying the highest near-term price for rich-world industrialization and the historical emissions associated with it. And second, stopping research may advance some rich-world political agendas in which geoengineering is at most a tangential issue, but it would come at the cost of assured suffering by poor countries confronting immediate threats that are largely absent from such agendas. Supporting research on solar geoengineering offers the best way to avoid these unjust outcomes.

NOTES

1. For robust evidence of the efficacy of SRM in reducing global mean temperature, see Kravitz et al. (2014).
2. It is important to note that Gardiner is primarily concerned with the implications of geoengineering for individual character rather than its specific distributional consequences. While we disagree with Gardiner's proposition that researching and/or implementing geoengineering might ultimately be a reflection of "moral corruption," we do not consider his argument further here.
3. See, for example, Heutel et al. (2015).
4. For an articulation of the rationale for approaching climate change as an issue of risk management, see Schneider (2001).

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Chapter 7

Why Aggressive Mitigation Must Be Part of Any Pathway to Climate Justice

Christian Baatz and Konrad Ott

This contribution's aim is twofold: on the one hand, we argue that wealthy high-emitting countries are obligated to radically lower their greenhouse gas (GHG) emissions, and if undertaken properly, this will very likely not overburden their respective citizens (section "Mitigation duties and associated burdens"); on the other hand, we defend the primacy of mitigation duties arguing that possible obligations to adopt further supplementary strategies do not diminish these duties (section "Mitigation Duties and climate engineering options"). Please note that we do not claim that mitigation alone will be able to limit temperature increase to 'well below 2 degrees' as the Paris Agreement states, and we remain agnostic on which carbon dioxide removal (CDR) technologies should back up mitigation efforts (but think that some of them are necessary). We also do not comment on what might in future justify a high-risk climate engineering (CE) technology deployment. Finally, note that we use 'mitigation' as a shortcut for the reduction of anthropogenic GHG emissions, considering all forms of sink enhancement as CDR.

MITIGATION DUTIES AND ASSOCIATED BURDENS

It is widely agreed that global GHG emissions ought to be limited. From the moral point of view, every person is entitled to some part of the remaining emissions budget, and this can be referred to as a person's fair share (FS) of emissions entitlements (Caney 2012; Shue 2014: 311). In an ideal situation, no one exceeds her FS, and the total past, present and future emissions budget does not cause harmful climate change. By contrast, if a sufficient number of agents do exceed their FS, they collectively cause harm (Baatz 2014).