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Ethics, Policy & Environment

ISSN: 2155-0085 (Print) 2155-0093 (Online) Journal homepage: www.tandfonline.com/journals/cepe21

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To cite this article: Daniele Fulvi & Kian Mintz-Woo (30 Sep 2025): Assessing Carbon Dioxide Removal Technologies Through Transitional Justice: Challenging the Moral Hazard Argument, Ethics, Policy & Environment, DOI: 10.1080/21550085.2025.2567824

To link to this article: https://doi.org/10.1080/21550085.2025.2567824

Published online: 30 Sep 2025.

ETHICS, POLICY & ENVIRONMENT
https://doi.org/10.1080/21550085.2025.2567824

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Assessing Carbon Dioxide Removal Technologies Through Transitional Justice: Challenging the Moral Hazard Argument

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ABSTRACT

We analyze the moral aspects of Carbon Dioxide Removal technologies (CDRs) through what we call 'transitional justice.' Experts currently consider CDRs to be essential for mitigating climate change. This raises the question: are CDRs compatible with a just transition? We argue that there is a strong case for adopting CDRs within a just transition, despite some potentially unjust facets of these technologies. We also show that framing CDRs as a moral hazard to climate change mitigation is not conducive to a just transition, and that instead a notional opposition to CDRs constitutes an actual moral hazard to sufficient mitigation.

ARTICLE HISTORY
Received 27 November 2024
Accepted 3 August 2025

KEYWORDS
Carbon dioxide removal technologies; climate justice; climate overshoot; just transition; moral hazard; transitional justice

1. Introduction

As recently highlighted by the Intergovernmental Panel on Climate Change (IPCC) in its special report on global warming of 1.5°C, current pledges to reach net-zero emissions are inadequate to achieve the goals of the Paris Agreement. In fact, climate overshoot – namely exceeding the temperature threshold of 1.5°C above pre-industrial levels – is now considered to be inevitable (IPCC, 2018, p. 159). In light of such inevitability, the IPCC *Sixth Assessment Report* labels Carbon Dioxide Removal technologies (CDRs) 'unavoidable' in drawing down greenhouse gasses (GHGs) – even when combined with more ambitious emissions reductions targets (IPCC, 2022, p. 36). These GHGs could then be stored in 'carbon sinks,' namely geographical features (soil, forests, etc.) that can absorb more atmospheric carbon than they release.

CDRs include geoengineering techniques such as Direct Air Carbon Capture and Storage, Direct Ocean Carbon Capture and Storage, Bioenergy with Carbon Capture and Storage (BECCS), as well as natural removals such as reforestation and soil carbon sequestration (Smith et al., 2023). More recently, bioengineering has also gained significant legitimacy in the research around carbon removal and sequestration technologies, due to its capacity to increase the mitigation potential of trees, plants, algae, yeasts,

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bacteria and/or microbes (DeLisi, 2019; DeLisi et al., 2020; Fulvi & Wodak, 2024a; Jatain et al., 2021; Symons et al., 2024).

These technologies have the potential to store enormous amounts of atmospheric carbon dioxide, hence theoretically bringing global temperatures down to sustainable levels for at least a few decades. In line with the IPCC reports, the Climate Overshoot Commission (2023, p. 10) has declared that reducing existing levels of GHGs emissions, although essential, is no longer sufficient, and that CDRs are absolutely integral in order to effectively mitigate global warming.

In our view, these conclusions require recognition and reframing with respect to discussions in climate ethics, while simultaneously opening up new considerations of justice. Although CDRs are becoming increasingly credible to several stakeholders in governments and academia (Buylova et al., 2021; Honegger et al., 2021; Schenuit et al., 2021, 2023), there is an open debate on their moral implications, and in particular on whether they constitute an unjust response to global warming. Such a debate is particularly relevant in the context of a just transition, which promotes a fair and equitable mitigation of the climate crisis, ensuring that the benefits and burdens of this transition are shared equitably while ensuring that various aspects of justice – such as distributional, recognitional, and procedural – are met (Galanis et al., 2025; Heffron & McCauley, 2018). This raises a crucial question: are CDRs compatible with a just transition, given the highly non-ideal circumstances in which such a transition is to be achieved?

The ethical dimensions of CDRs and other geoengineering techniques represent an important focus in recent scholarship (Pamplany et al., 2020; Schübel, 2024). In this context, current ethical debates reflect a twofold risk aversion toward these technologies. Firstly, concerns have been expressed around the efficacy of CDRs, as well as around the risks of unintended negative consequences. Some of these discussions are framed around conventional understandings of recognitional and procedural justice that raise moral concerns about at least some aspects of CDRs (Hourdequin, 2018, also cf. Section 2.2 in this paper; Preston & Carr, 2018; Whyte, 2018). Secondly, some scholars suggest that CDRs constitute a moral hazard to climate change mitigation, as these technologies may undermine alternative mitigation efforts, such as decarbonization and emissions reductions (cf. Wagner, 2021; Wagner & Zizzamia, 2022, for helpful histories of this concern) – an issue that scholars sometimes call 'mitigation deterrence' (Markusson et al., 2018; McLaren, 2020; Shue, 2017). Nevertheless, the urgency of an effective mitigation strategy, together with the catastrophic risks that failing to mitigate global warming entails, should play a non-negligible role in the moral assessment of CDRs. These considerations, we believe, could help inform and reframe current climate justice and environmental ethics debates. In short, we are concerned with narratives that rule out or straightforwardly justify CDRs; we believe their moral complexity needs to be admitted and grappled with.

For this reason, we deploy a novel form of justice for just transitions that we call 'transitional justice.' Transitional justice can be used to assess conflicting justice concerns, for instance, when unjust practices are permissible to lead to more overall just outcomes. We show that: (1) conceptually, introducing transitional justice is important to draw attention to and consider trade-offs between different justice theories in a just transition; (2) more practically, transitional justice helps reframe the vexed debate around CDRs and climate change mitigation; and (3) prescriptively, there is a strong case, given current scientific assessments, for adopting CDRs as part of a just transition, even granting

potentially unjust facets of these technologies. Again, it is important to clarify that we do not contend that CDRs are morally good or acceptable *simpliciter*; rather, we defend the subtle but important position that these technologies require balanced consideration in the debate on how to achieve a just transition.

Specifically, in this article we argue that, in light of the gravity of the climate crisis, potentially unjust practices – such as using CDRs to contribute to climate change mitigation – may be necessary to facilitate a just outcome – namely one where global warming is sufficiently abated. In doing so, we emphasize the centrality of intergenerational and distributional justice concerns, highlighting that a just transition aims at securing our shared future, even while the means of doing so may be morally objectionable. Following the latest scientific assessments by the IPCC and the Climate Overshoot Commission, CDRs appear to be key to securing such a shared future – which in turn suggests that including CDRs in our mitigation efforts is more just than not doing so. Thus, while acknowledging the validity of concerns related to procedural and recognitional justice, we suggest that these concerns should be weighed against the urgent and paramount need for an effective mitigation. We also challenge the predominant framing of CDRs as a moral hazard to climate change mitigation. Through an analysis of current moral hazard arguments, we conclude that notionally opposing CDRs would itself entail a greater moral hazard by hindering a necessary mitigation practice. We then conclude that a just transition requires adopting CDRs as part of a diversified mitigation strategy.

2. Defining Transitional Justice

First introduced by Zimm et al. (2024), transitional justice focuses on 'dynamic questions about approaching ideally just (or "end-state") goals,' such as 'how unjust policies [or actions] might be effective ways to promote overall just outcomes' (Zimm et al., 2024, p. 24).[1] This transitional form of justice is particularly salient for the debate on CDRs and climate change mitigation, since *prima facie* unjust aspects of these technologies seem to be incompatible with a just transition. For instance, some argue that relying on CDRs to successfully mitigate global warming is likely to increase the already profound effects of climate injustice and disproportionately affect those who are most vulnerable to the crisis (Armstrong & McLaren, 2022; Sovacool et al., 2022). Similarly, Hickel and Slameršak (2022, p. e630) highlight that 'most of the additional energy that can be consumed in high-negative emissions scenarios is not allocated to the Global South, but rather to the Global North, thus maintaining or further widening global energy inequalities.' Moreover, Smolker (2019) contends that implementing CDRs and negative emissions at a large scale would have extremely negative impacts on land use, biodiversity, and human rights.

By using transitional justice, however, it becomes possible to weigh or at least explicate the dynamics of injustice, whether involving the same forms of justice or even different forms of justice. For instance, a transitional justice question involving (only) distributional injustice might consider 'how quickly a trajectory gets to a (distributively) just outcome or whether [it is justifiable] that [the] trajectory goes through unjust states to ultimately arrive at a (distributively) just outcome' (Zimm et al., 2024, p. 24) – whereby 'distributively' refers here to a just allocation of costs and (more importantly) benefits of climate change mitigation through CDRs. Furthermore, transitional justice also entails a significant intergenerational justice component: its ideally just or 'end-state' goal is necessarily a future-

directed goal, where global warming is sufficiently mitigated and the burdens of such mitigation are distributed fairly.

Arguably, if CDRs are successful in contributing to mitigating the crisis, such mitigation would take us closer to an ideally just outcome where the effects of climate change are partly (or mostly) reduced. Therefore, from a transitional justice standpoint, it may be worth using these potentially unjust and undesirable technologies to get closer to such an ideally just (or at least less unjust and more desirable) outcome. In contrast, a failure of mitigation using CDRs could conceivably not lead to a less just outcome than before, given the abovementioned possibility of climate overshoot and its arguably catastrophic consequences – such as the risk of societal collapse (Steel et al., 2024) or of a human-induced Sixth Mass Extinction event (Cowie et al., 2022; Rull, 2022). For that reason, we begin with two versions of an intergenerational justice argument for CDRs (Section 2.1) before moving on to various justice considerations that tell against CDRs (Section 2.2) and concluding with a transitional justice analysis (Section 2.3).

2.1. A Strong and a Weak Argument for Intergenerational Justice and Carbon Dioxide Removal

Given the relevance of intergenerational and distributional justice concerns within the notion of transitional justice, we should focus on these concerns first. As Sanklecha highlights, the full magnitude of the climate crisis emerges only when we consider our duties and responsibilities toward future generations – namely when we question whether humanity should continue to exist in the future, since 'most of the likely consequences of climate change will occur into the future, and well after currently living people have stopped existing' (Sanklecha, 2017, p. 3). Herein, we suggest that there is a stronger and a weaker form of an intergenerational climate injustice argument. On the stronger form, we outline precautionary reasons for avoiding things that could trigger catastrophic climate change. On the weaker form, we emphasize that there are significant intergenerational and distributional climate benefits for actions that reduce the risk of climate harms. We think either of these arguments can be used to support our conclusion, but discuss both in turn.

The first, stronger, way of understanding this intergenerational consideration consists in the idea that intergenerational justice may require insurance or precautionary measures against remote but extremely dangerous outcomes, like catastrophic climate change (McKinnon, 2011, pp. 47ff.). This type of argument is suggested by Sanklecha, recalling the motto of the Holy Roman Emperor Ferdinand I 'let justice be done, and the world perish' (*Fiat justitia, et pereat mundus*). However, Sanklecha (2017, p. 8) also points out that, when it comes to climate change mitigation, 'the choice really would be between doing justice and letting the world perish.' Therefore, instead of adopting Kant's radically deontological appraisal, according to which one should abide to Ferdinand I's maxim 'let justice reign even if all the rogues in the world perish' (Kant, 1996, p. 345), we are more sympathetic to Hegel's contention (Hegel, 2008, p. 126) that '*fiat justitia* should not be followed by *pereat mundus*,' but rather that justice should be done *so that* the world does not perish (i.e. *fiat justitia ne pereat mundus*).

In short, a just transition is not achieved when an ideal of justice is blindly upheld regardless of its practical consequences – and of the material conditions

where it is applied. In the context of the current climate crisis, the strong precautionary reading of intergenerational justice means that a just transition requires the survival of 'the world,' including future generations of both human and countless more-than-human beings. We think that versions of standard precautionary criteria apply here: the costs of mitigation (including CDRs) are real but not catastrophic, while the likelihood of serious collapse is non-trivial (Steel et al., 2024), and serious societal climate collapse would be irreversible and catastrophic. Such outcomes threaten to undermine the circumstances of justice (Mittiga, 2022, 2024, pp. 18–46). In other words, with the near-inevitability of climate overshoot and the potentially catastrophic consequences of insufficiently abated climate change, there can be no just transition if the survival of 'the world' is not prioritized. So, if 'the world' perishes, there is simply no justice.

However, besides this strong precautionary form of intergenerational injustice, we can also consider a weaker form, which just points to the distributional and intergenerational aspects of justice associated with significant mitigation (or even marginal improvements in mitigation). Such a weaker version of the argument does not rely on the absence or impossibility of justice given catastrophic outcomes; instead, it points out that reducing the impacts of climate change can be expected to intertemporally or intergenerationally improve global distributional justice.

We acknowledge that gaps in adaptation and resilience are disproportionately focused in the Global South, where there are generally both fewer resources and more exposure to climate-driven impacts like extreme weather events. In contrast, in the Global North there are both more material resources and human capital, allowing for greater (albeit insufficient) adaptation measures, along with less exposure.[2] As Mishra et al. (2023, p. 883) explain, '[t]he Global South, which hosts the majority of the world's population, is unequivocally more vulnerable to climate change than the Global North, owing to widespread poverty, income inequality and its heavy dependence on climate-sensitive sectors.' In other words, increasing climate change would disproportionately harm the Global South, i.e. it would harm most of the globe (most, but not necessarily all), but a greater proportion of harms would congregate in the Global South.

The corollary of these claims is straightforward: there is a greater than proportional benefit to the Global South for avoiding climate change (even marginal or non-catastrophic climate change). This has an equally straightforward distributional justice implication: global distributional justice is promoted by decreasing climate effects since that helps contrast global inequalities – or at least lessen the rate of their growth. This distributional justice issue is partially intertemporal or intergenerational since we can expect that the disproportionate benefits of reduced climate change to eventuate over roughly decadal timescales.

Nevertheless, we recognize that it is crucial to acknowledge the multifaceted nature of justice concerns in the context of CDRs. For this reason, in the next sub-section we briefly discuss additional dimensions of justice – namely procedural and recognitional – that play an important role in existing scholarship and that warrant careful consideration in the debate on achieving a just transition.

2.2. Considerations of Recognitional and Procedural Justice

Recognitional and procedural justice are also important within the ethical assessment of CDRs. Considering these forms of justice facilitates acknowledging the trade-offs between different justice concerns that are central to our notion of transitional justice. While different scholars use the terms 'recognitional' or 'procedural justice' in diverse ways, CDRs (like other forms of geoengineering) may well involve failures of these forms of justice. For instance, Preston and Carr (2018, pp. 309–311) contend that a distributional approach fails to achieve justice as it does not recognize the specificity of individuals or groups affected by alleged benefits and harms of proposed mitigation strategies, and because it overlooks the diverse and specific social dynamics and cultural values of those impacted by environmental issues (also cf. Whyte, 2011). Simply put, not recognizing these aspects is a form of injustice. Moreover, Preston and Carr are somewhat skeptical about the expectation that the kind of purely distributional approach, as discussed in the previous sub-section, would actually benefit those who are most vulnerable to the effects of climate change.

Similarly, Hourdequin (2018, pp. 271ff.) contends that the lack of universal consensus around fair and equitable distributive principles makes distributional justice blind to a genuine form of procedural and participatory justice. That is to say, pure distributional justice is seemingly unable to involve all parties into a fair, equitable, and transparent decision-making process (or at the very least it does not *guarantee* such a process). Accordingly, it would be preferable to respond to the crisis with an approach based on care and on emphasizing '*relationships*, *context*, *dependence*, *power/vulnerability*, *affect*, and *narrative*' (Preston & Carr, 2018, p. 313, emphases in original), as opposed to an allegedly oversimplified distributional approach. In other words, '[a] multidimensional approach to justice, grounded in recognition and participatory parity' (Hourdequin, 2018, p. 282) is preferable to a one-dimensional distributional approach, and necessary to achieve actual justice – whereby distributional justice complements recognitional and procedural justice, and fully accounts for potential impacts on future generations.

We agree that CDRs may be subject to the kind of concerns that Hourdequin, Preston, and Carr raise (along with other scholars who make similar points, such as Whyte, 2018). Additionally, we believe that other justice concerns, including multispecies justice – namely a form of justice that encompasses not only the interests of humans but also those of more-than-human beings – should be considered under the rubric of transitional justice.[3] Transitional justice, then, becomes highly relevant because it makes the justice trade-offs explicit when we are in the kind of clearly non-ideal contexts where justice concerns collide. This explication allows us to consider these conflicting justice concerns in a more nuanced manner, as we clarify in the next sub-section.

2.3. Transitional Justice and Carbon Dioxide Removal: Weighing Competing Concerns

Transitional justice acts as a kind of meta-justice, or a site where various forms of justice dynamically interact and can be evaluated. In this context, there is strong scientific evidence that mitigation in the absence of CDRs would be insufficient; thus, CDRs

might be highly beneficial in terms of global distributional justice and intergenerational justice. However, there are good reasons to think that CDRs, whether in development or deployment, might exacerbate or instantiate procedural or recognitional injustices. Given these different considerations of justice are in tension with each other, should CDRs be part of a just transition – and if yes, how?

It is important to note upfront that transitional justice is a new concept and certainly is not yet advanced enough to give algorithmic methods for comparing different forms of justice (and it may never be). So we start from a premise that we believe everyone can agree on: the efficacious implementation of CDRs is bundled with a high level of risk and uncertainty. Nevertheless, such a risk requires balanced and context-sensitive consideration in ethical debates around climate change mitigation (Fulvi & Wodak, 2024b).

If we adopt the strong precautionary intergenerational argument, then there is priority in guaranteeing effective climate change mitigation. Furthermore, there should also be very little doubt that the catastrophic consequences of unabated climate change would be far more deleterious to future generations than any potentially negative impacts of risky mitigation strategies involving CDRs. Hence, while it is crucial to ensure that recognitional and procedural justice concerns are addressed in the development and implementation of any form of CDRs, it is absolutely essential that all existing justice concerns are subordinated to the undeniable necessity of integrating CDRs into mitigation pathways – in order to keep the planet habitable for future humans and countless more-than-human lifeforms. Accordingly, we think that the strong precautionary intergenerational argument supports development of CDRs, even in light of these (important) justice concerns. Similarly, in line with multispecies justice concerns, developing CDRs arguably contributes to limiting harm to more-than-human species and ecosystems, as opposed to the much greater harm that would ensue from unabated global warming.

With respect to the weaker intergenerational account, there is more ambivalence. On the one hand, lack of recognitional and procedural justice can exacerbate existing tensions and injustices (Preston & Carr, 2018). On the other hand, the effects of overshoot can be expected to affect a very large number of people over a very long period. Also, the effects of climate change are not themselves limited to the physical effects. Climate change acts as a force multiplier for regional and resource conflicts, potentially contributing to other kinds of tensions (Bartrem et al., 2022; Onuoha et al., 2023). Furthermore, climate change undermines people's social and mental health as well (Clayton, 2021), particularly for disadvantaged groups (Tiatia-Seath et al., 2020). In this case, due to the sheer variety and scope of distributional and intergenerational injustice that overshoot could demonstrate, we believe that a reasonable transitional justice evaluation could allow for CDRs contributions to mitigation.

Note that these are not meant to be easy or welcome conclusions. They at best follow from the highly non-ideal circumstances in which a just transition is to be achieved. Gardiner draws a related distinction between ideal and transitional ethical theories. Specifically, he contends that 'projects in *ideal* ethical theorizing aim to work out the best way in which to deal with some domain or issue in an otherwise neutral (or even moderately encouraging) practical setting' (Gardiner, 2011, p. 399, emphasis in original). This means that an ideal theory tends to disregard important constraints to its feasibility, such as 'the existence of background injustice, maladapted institutions, or deeply hostile agents' (Gardiner, 2011, p. 399). Alternatively, 'projects in the

ethics of the transition articulate how we might proceed ethically starting from existing, and sometimes deeply constrained or ethically compromised, social realities in the direction of better solutions and general circumstances' (Gardiner, 2011, p. 400, emphasis in original). This transitional approach 'aims to identify how policies should be targeted and assessed given our actual constrained starting position' (Gardiner, 2011, p. 400). What we are calling 'transitional justice' aligns well with Gardiner's 'ethics of the transition.' Accordingly, we concur with the transitional ethics approach that Gardiner suggests.

To clarify, based on the abovementioned definition of transitional justice, we contend that intergenerational justice concerns are more weighty than other concerns, due to the long timeframe of climate harms resulting from inability to keep temperatures down, as well as the severity and magnitude of those harms. Furthermore, these harms are likely to underscore other kinds of impacts, and we can expect that the cumulative effect would be very high. Hence, we conclude that intergenerational justice outweighs the (legitimate and important) other forms of justice at play. That is, if it is of overriding importance to robustly tackle climate change for intergenerational and distributional justice reasons, then one might be willing to accept CDRs in a just transition even granting other justice concerns apply to CDRs, including recognitional or procedural justice.

One way of respecting these potential injustices is emphasizing that transitional justice applies during the transition, ideally limiting the injustices to a determined finite period. As an example of such temporary justice trade-offs, consider the need to mitigate global warming in an effort to keep the planet habitable for future human and more-than-human beings (Radchuk et al., 2019). In order to meet the various legitimate concerns emerging from procedural, recognitional, and multispecies justice (San Martín & Wood, 2022), it is essential that the climate crisis is first mitigated at a level sufficient to allow such concerns to be subsequently addressed on a habitable planet. However, we might consider transitional justice as no longer applying once GHGs levels have been reduced to a sustainable level and the threat of a Sixth Mass Extinction has been sufficiently limited.

In short, despite their potentially unjust and undesirable facets, this transitional justice approach allows us to consider CDRs under a more realistic light in the existing debates on climate justice and environmental ethics. However, we still need to address some further problematic aspects of these technologies: namely, a non-negligible number of leading scholars contend that CDRs are undesirable not only because they are potentially risky and unjust, but also because they constitute a moral hazard to climate change mitigation. In the next section we discuss this contention more in detail, showing how framing CDRs as a moral hazard to climate change mitigation is not conducive to a just transition, and that it is a notional opposition to CDRs that constitutes an actual moral hazard to climate change mitigation.

3. Carbon Dioxide Removal Technologies: Moral Hazard or Lesser Evil?

Although the notion of moral hazard has been used in various and even conflicting ways in the literature (Tsipiras & Grant, 2022), it plays a central role in public debates around CDRs and geoengineering (Burns et al., 2016). As shown by Carton et al. (2023), CDR scenarios are often seen as constituting a moral hazard to climate change mitigation. In this context, 'moral hazard' is generally understood as the idea that relying on CDRs

entails the risk that these technologies will reduce or delay alternative near-term mitigation efforts, such as decarbonization. In other words, there is a broad agreement in extant scholarship around the fact that proposed mitigation pathways that include CDRs – in combination with other negative emissions technologies (NETs) – present a significant moral hazard. Indeed, while including CDRs in proposed mitigation efforts 'may increase overall mitigation ambitions, it is unequivocal that it also substitutes for reductions, and does so on very large scales' (Carton et al., 2023, p. 7).

Anderson and Peters (2016) have influentially criticized the integrated assessment models used to inform current climate change mitigation assessments, models which rely almost entirely on the timely and large-scale development of CDRs to mitigate global warming. Specifically, Anderson and Peters contend that '[i]f we rely on these [technologies] and they are not deployed or are unsuccessful at removing CO_2 from the atmosphere at the levels assumed, society will be locked into a high-temperature pathway' (2016, p. 182). They identify non-negligible risk and a clear moral hazard emerging from such a scenario. If CDRs are successful, they suggest, 'any reduction in near-term mitigation caused by the appeal of negative emissions will likely lead to only a small and temporary overshoot of the Paris temperature goals,' whereas their failure will lead to 'rapid temperature rises reminiscent of the 4°C "business as usual" pathway feared before the Paris Agreement' (Anderson & Peters, 2016, p. 183).

Along these lines, Shue (2017) claims that CDRs are simply morally unacceptable, both because they constitute a moral hazard to climate change mitigation and because their risks outweigh their alleged benefits. Focusing specifically on BECCS, Shue argues that, while it is highly uncertain whether these technologies will work at a scale that is sufficient to mitigate global warming in a significant way, relying on BECCS (as well as other CDRs) 'unjustly transfers risk to vulnerable people of the future who are at our mercy' (Shue, 2017, p. 214). Relying on these technologies, then, delays immediate climate action, leaving the long-term effects of global warming untouched. Shue's contention also resonates with Robock's et al. (2008) earlier admonition that relying on geoengineering is imprudent, given the inadequacy of climate models and the ineliminable uncertainty surrounding the potentially negative effects of this kind of technology. Along these lines, Grant et al. (2021, p. 11) contend that '[n]ear-term emission reductions should not be substituted for uncertain future contributions to decarbonization [through CDRs]. Low-carbon scenarios must not dilute the pressure for systemic change or lead decision makers to underestimate the potential for action now,' including transitioning away from fossil fuels.

The notion of moral hazard is also quite relevant when it comes to public perceptions of the climate crisis (Burns et al., 2016). For instance, there is evidence that framing CDRs or other NETs as a moral hazard to climate change mitigation often depends on existing individual views or belief systems. In this regard, Corner and Pidgeon (2014) emphasize that climate skeptics are likely to remain unconvinced by the moral hazard framing, since 'the "risk" of others reducing their motivation to mitigate climate change may in fact not be [seen as] a "risk" at all, but a step in an appropriate direction' (Corner & Pidgeon, 2014, p. 12). Instead, those more concerned about the state of the climate crisis and its broader consequences are 'more likely to perceive *other people* and politicians to be susceptible to the moral hazard trap (although not themselves)' (Corner & Pidgeon, 2014, p. 12, emphasis in original).

Another relevant question is whether there is evidence suggesting that moral hazard is an issue in the empirical data. It is possible that moral hazard is conceptually or theoretically an issue – but in practice it does not seem to occur. Regarding this question, recent data shows that the way information about CDRs and the effects of climate change is presented to the public affects the public's perceptions of these technologies and of the moral hazard argument. Specifically, Hart et al. (2022, p. 9) have found that 'absent explicit information about climate change impacts, CDR is likely to either have a null effect, or a very small risk compensation effect [i.e. less support for climate change mitigation].' Therefore, they conclude that 'it is unlikely that CDR information will cause a substantial risk compensation effect and is more likely to have no effect on the perceived threat of climate change' (Hart et al., 2022, p. 9). However, their data also indicate that 'both climate change impact information on its own [. . .] *and* climate change impact information combined with CDR information increased perceptions of the threat of climate change – thus indirectly increasing support for climate change policies' (Hart et al., 2022, p. 9, emphasis in original).

Furthermore, Andrews et al.'s (2022) study has found very little evidence to support the claim that proposed CDRs and geoengineering are perceived as moral hazards to climate change mitigation. Instead, their findings tellingly suggest that it is not moral hazard as such, but 'the *anticipation* of moral hazard by policymaker players, and their reluctance to use geoengineering due to their anticipation,' to deter potentially effective mitigation strategies (Andrews et al., 2022, p. 7, emphasis in original).[4]

Most recently, Schoenegger and Mintz-Woo (2024) conducted a large-scale moral hazard experiment with both stated preference (e.g. hypothetical support for climate policies) and behavioral measures (e.g. clicking on links to petitions). They employed empirical best practices, such as controlling for salience and content: in order to hide the topic of interest, they gave participants some non-climate questions and, in order to provide a variety of climate options, they discussed alternatives to geoengineering. They found no statistically significant moral hazard effect.[5] More importantly, they used statistically sophisticated methods ('Two One-Sided Tests') to conclude that there was likely no effect to detect.[6] While data from this and the other studies cannot be said to be conclusive, it can be said to be indicative that moral hazard is more of a theoretical concern than a demonstrated or detectable one (Burns et al., 2016).

These empirical data also resonate with various philosophical and sociological critiques of the moral hazard argument. For instance, Reynolds (2015) highlights that the moral hazard framing around CDRs and climate engineering is not only questionable, but bears the potential risk of a reverse effect. That is, he contends that an excessive pessimism and risk aversion around CDRs could effectively hinder the development of such technologies and increase the potential harms of unabated climate change. Similarly, Morrow (2014) points out that even if there is a moral hazard effect, that is not sufficient to demonstrate a problem: the mitigation deterrence could be outweighed by the intervention's climate benefits.[7]

Finally, Jebari et al. (2021) suggest that the moral hazard framing is unhelpful and counterproductive, as it implicitly relies on the false assumption that CDRs operate as a total substitute for other mitigation efforts, such as emissions reductions and decarbonization. Accordingly, 'the moral hazard framing ultimately directs attention away from the options we need to be considering and towards options that are not actually

available' (Jebari et al., 2021, p. 3). Alternatively, they propose a 'risk-response feedback' framework, which focuses on specific policy packages and not on the sole outcomes of singular policy interventions such as CDRs. Hence, Jebari et al. (2021, p. 3) argue that 'since this framework doesn't restrict the set of available options to a forced choice between adaptation interventions and geoengineering interventions,' it is still possible to implement a diverse mitigation strategy that include both CDRs and alternative mitigation practices such as decarbonization and emissions reductions.

Along these lines, Merk and Wagner (2024, p. 265) define the notion of moral hazard as 'a misnomer for many related concepts that fall under the guise of direct risk compensation or "risk-response feedback."' This criticism, discussed also by Merk et al. (2016), Wagner (2021), Merk and Wagner (2024), and Tsipiras and Grant (2022), aims at denying that the mere prospect of implementing CDRs and geoengineering practices is a deterrent to parallel mitigation efforts. Such a position, however, does not translate into a blind and uncritical acceptance of CDRs and geoengineering, but rather provides a reasonable argument for a fruitful trade-off between the implementation of CDRs and emissions reductions. Even McLaren (2016, p. 600) argues that the 'idea of an all-or-nothing moral hazard' is unhelpful, and that the notion of moral hazard should be examined in light of 'the extent of the likely negative impacts on climate policy and its goals, including that of climate justice' (McLaren, 2016, pp. 600–601). While McLaren (2020) affirms that CDRs may still delay or deter emissions reductions, he also maintains that that does not constitute sufficient reason to halt research into CDRs and other negative emissions pathways.[8]

While we do not intend to reduce the moral hazard paradigm to a sheer binary choice between adopting or not adopting CDRs, we maintain that it is critical to challenge such a paradigm in order to pursue a just transition. That is, we contend that the moral hazard argument relies on a form of risk-aversion toward CDRs that is fundamentally at odds with a just transition. Instead, CDRs can be conducive to a just transition, in light of the gravity of the climate crisis and of the subsequent non-ideal circumstances in which justice is to be achieved. Once sufficient climate change mitigation becomes contingent on the adoption of such technologies – alongside other mitigation practices – then framing those potentially efficacious means as a moral hazard hinders an ideally just (or less unjust) outcome, as discussed above.

Relevantly, Lenzi (2021, p. 132) suggests that, 'due to the extreme harms that would result from failing to stabilize the global climate, it is permissible to implement negative emissions at large scales.' Like us, Lenzi suggests that these technologies are permissible not because they are intrinsically a good or desirable solution, but rather because we find ourselves under highly non-ideal conditions for climate justice. These non-ideal conditions neither 'beg the question of permissibility by *lowering* ordinary ethical restrictions upon action,' nor imply that 'we are permitted to choose second-best options from among those *now* available' (Lenzi, 2021, p. 130, emphasis in original). Rather, a non-ideal approach to climate justice relies on the acknowledgment that

> we are constrained to choose among alternatives that are *temporally second-best*, that is second-best relative to those that were available to us earlier, but which have since been closed off by the failure of ambitious mitigation and the passage of time. (Lenzi, 2021, p. 130, emphasis in original)

We believe Lenzi's position strongly resonates not only with the gravity of the climate crisis, but also and more importantly with both the urgency of an effective mitigation and the suggested need for large-scale mitigation from CDRs.

Applying this approach to the debate around a just transition, it emerges quite clearly that framing CDRs as a moral hazard does not contribute to achieving a just transition. On the contrary, opposing CDRs because they are seen to constitute a moral hazard is what can actually delay or deter effective mitigation, hence threatening to bring about more unjust outcomes. Furthermore, under the strong intergenerational argument, given the non-ideal conditions under which a just transition is to be attempted, it is apparent that the fundamental precondition to pursue a just transition is to provide the conditions for human and more-than-human beings to still be able to live on Earth. Hence, it becomes vital to allow for a realistic trade-off between various justice concerns. As we have already argued above, discussing such trade-offs is made possible by considering transitional justice.

On these grounds, if the scientific assessments provided by the IPCC and by the Climate Overshoot Commission are to be taken seriously, it follows that opposing CDRs because they appear as a moral hazard to less risky and more desirable mitigation alternatives is at odds with a just transition. In fact, the main ethical challenge posed by a just transition is no longer that of finding the most ideal solution to an unjust crisis. Rather, the challenge to attempt a just transition is that of doing so within the non-ideal circumstances of the current climate crisis – which include the use of undesirable and potentially unjust technologies to ensure the success or survival of humans and countless more-than-human species.[9]

We believe that introducing transitional justice helps explicate the justice trade-offs involved in a just transition. We think that considering these trade-offs allows us to select the best possible way to address such an ethical challenge, whereby 'rather than a danger to be avoided, [climate change] is an opportunity to maintain and remake the world in ways that we think matter' (Sanklecha, 2017, p. 8). Accordingly, if climate justice is of the highest importance within this challenge, then attempting the best possible mitigation strategy is essential to pursue a just transition. But once again, the best possible mitigation strategy, within the current constraints of available mitigation pathways, seems to make the use of CDRs necessary as part of a diverse approach including a variety of mitigation practices (Schübel & Wallimann-Helmer, 2024). If the empirical results are accurate, and CDRs would not displace (via moral hazard) other mitigation measures, then this diversity would be more feasible and more effective.

If climate justice matters, and if a just transition is to be achieved, then one must come to terms with the fact that a just transition can be attempted only within the dire and non-ideal predicament of the climate crisis. Therefore, we maintain that adopting CDRs, notwithstanding their potentially unjust facets, is compatible with a just transition. Instead, opposing CDRs due to their unjust facets and their alleged moral hazard component not only is itself a moral hazard to a potentially effective mitigation, but is also inherently more unjust than attempting mitigation through a diversified strategy that includes CDRs.

4. Conclusion

In this paper, we have discussed the moral dimensions of using CDRs as part of a just transition. Using a form of justice that we call 'transitional justice,' we have shown that a thoughtful trade-off between different justice concerns (such as distributional, recognitional, and procedural justice) allows us to reconsider the vexed debate around CDRs in a nuanced manner. Indeed, we have shown that, given the latest scientific assessments provided by the IPCC and the Climate Overshoot Commission, there is a strong case for adopting CDRs as part of a just transition – together with more ambitious emissions reduction targets and additional mitigation practices.

In conclusion, we reiterate that the risks associated with CDRs should be weighed against the risks of opposing their use due to ethical concerns with scarce empirical support or contextual relevance. From our analysis, it emerges not only that a risk-averse approach to using CDRs for climate change mitigation is not commensurate with the current state of the climate crisis, but also that risk aversion toward CDRs is itself a moral hazard to climate change mitigation. We believe that the current evidence supports the claim that climate change mitigation cannot occur without including CDRs. Accordingly, opposing these technologies in the name of risk aversion or of idealized notions of justice – or regarding them as moral hazards – itself gives rise to a moral hazard to effective mitigation, as this opposition undermines our already limited chances of mitigating climate change effectively. Accordingly, a just transition can only occur if CDRs are given balanced and careful consideration, refraining from a notional opposition to these technologies that is not conducive to a higher justice.

Notes

1. Note that this meaning is independent of the use of the identical term 'transitional justice' for processes responding to massive social trauma, which may also be worth exploring for climate ethics, but is otherwise unconnected (Rodeiro, 2024).
2. Note that *less* exposure does not mean *no* exposure: Western Europe has suffered very severe heat waves in the past few years and North America, especially Canada, has had record-breaking wildfires. These are significant effects, but in wealthy countries there are more resources and social safety nets to help those affected, whereas the exposure tends to be greater and the protection tends to be lesser in the Global South.
3. Indeed, recognizing the urgency of effective and just mitigation may be central to multispecies justice (Tschakert et al., 2021).
4. Focusing on Stratospheric Aerosol Injection (SAI), Merk et al. (2016) found that informing people about SAI led them to increase, rather than decrease, their mitigation efforts, with no evidence supporting a moral hazard or risk compensation effect.
5. It is important to note that Schoenegger and Mintz-Woo were specifically targeting solar radiation management geoengineering, not CDRs, but it is at least plausible that moral hazard would apply (or not apply) similarly in both domains.
6. A similar study has been recently conducted by Merk and Wagner (2024), highlighting that information about CDR and Solar Radiation Management neither consistently triggered moral hazard nor altered their study population's support for a leading US environmental NGO.
7. A similar argument is outlined in Lin (2013).
8. This line of argument was originally presented by Crutzen (2006, p. 214), who was among the first scholars to contend that 'research on the feasibility and environmental consequences of

climate engineering [. . .] which might need to be deployed in future, should not be tabooed,' given the lack of adequate global mitigation policies.

9. Such a challenge requires us to decide between doing justice for both humans and more-than-human beings, or let the world perish as a consequence of unabated climate change. If we are willing to openly take on such a challenge, as Sanklecha (2017, p. 8) puts it, not only we have higher 'chances of finding solutions, whether theoretical or procedural,' but we can also 'potentially transform the way in which we understand the ethical dimension of climate change.

Acknowledgement

The authors would like to thank Hanna Schübel for her feedback on a previous draft of this paper. The authors would also like to thank Francesca Pongiglione, Jeremy Bendik-Keymer, Marjolein Oele and Hayden Kee for their feedback on this paper's original proposal.

Disclosure Statement

No potential conflict of interest was reported by the authors. Daniele Fulvi's research was funded by the Australian Research Council Centre of Excellence in Synthetic Biology (CE200100029). The views expressed herein are those of the authors and are not necessarily those of the Australian Government or the Australian Research Council.

Funding

Kian Mintz-Woo receives funding from the International Institute for Applied Systems Analysis and from Canada's Social Sciences and Humanities Research Council (SSHRC) under the SSHRC Insight Grant Program.

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