Department of Geosciences
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The Ethics of Carbon Dioxide Removal
Differentiating Agents and Responsibilities to Remove Carbon Dioxide

THESIS

Presented to the Faculty of Science and Medicine of the University of Fribourg (Switzerland), in consideration for the award of the academic grade of

Doctor of Philosophy in Environmental Humanities

by
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Thesis No. 5329
Uniprint
2024

https://doi.org/10.51363/unifr.sth.2024.008

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Fribourg, 26.3.2024

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For Bastian, Emma, Jonathan, Oscar, Leopold, and Lucia.

Summary

The removal of carbon dioxide from the atmosphere is, next to emission reductions, a way to mitigate climate change. Carbon dioxide removal (CDR) technologies include a variety of activities that remove carbon dioxide from the atmosphere and store it. According to the Intergovernmental Panel on Climate Change, the deployment of CDR technologies is ‘unavoidable’ to achieve net zero carbon dioxide emissions (IPCC, 2022: 36). However, the governance of CDR technologies faces various challenges. These range from sustainability and feasibility challenges to ethical challenges such as defining the scale to which CDR technologies should be implemented. Finally, the pressing challenge arises of distributing responsibility between agents to remove carbon dioxide. A comprehensive account has not yet been provided of how to differentiate agents and their moral responsibilities to remove carbon dioxide. This thesis contributes to closing this gap by exploring the moral responsibilities of individuals, states, and corporations to remove carbon dioxide. It thereby advances discussion on the governance of CDR technologies and their ethical implications.

In this thesis, I argue that responsibilities to remove carbon dioxide must be differentiated between agents and present arguments for the responsibilities different agents bear to remove carbon dioxide. I develop four conclusions: (I) If CDR technologies are available to them, individuals hold both direct responsibilities to reduce their carbon footprints to zero. They also hold shared political responsibilities to ensure that carbon dioxide is removed and that the ethical costs of CDR technologies are minimized. (II) To reach net-zero targets, states can permissibly use CDR technologies for their hard-to-abate emissions. Their use of CDR technologies is conditionally permissible for removing the emissions that individuals need for full membership in society, but impermissible for removing luxury emissions. (III) There is a dilemma in rewarding corporations from the oil and gas industry for removing carbon. This arises from the historical responsibilities of these corporations and their position to benefit from a future market in carbon removals. (IV) If the current generation is responsible for carbon dioxide removal, this includes responsibility for the just governance of CDR technologies.

Zusammenfassung

Die Entfernung von Kohlendioxid aus der Atmosphäre ist neben der Emissionsreduzierung eine Möglichkeit, den Klimawandel abzumildern. Es sind verschiedene Technologien verfügbar, mit denen Kohlendioxid aus der Atmosphäre entfernt und gespeichert werden kann. Sie werden unter dem Begriff carbon dioxide removal (CDR) zusammengefasst. Dem Zwischenstaatlichen Ausschuss für Klimaänderungen (engl. IPCC) zufolge ist der Einsatz von CDR-Technologien unvermeidlich, um Netto-Null-Emissionen zu erreichen (IPCC, 2022: 36). CDR-Technologien bringen verschiedene Herausforderungen mit sich. Diese betreffen die Nachhaltigkeit und Machbarkeit der Technologien. Darüber hinaus bestehen ethische Herausforderungen in Bezug auf die Frage, in welchem Umfang CDR-Technologien eingesetzt werden sollten. Ebenso stellt sich die Frage, wie die Verantwortung für die Entfernung von Kohlendioxid auf verschiedene Akteure verteilt werden sollte. Bisher wurde noch nicht umfassend dargelegt, wie sich die Verantwortung für die Entfernung von Kohlendioxid zwischen verschiedenen Akteuren differenziert. Die vorliegende Arbeit trägt dazu bei, diese Lücke zu schließen, indem sie die moralische Verantwortung von Einzelpersonen, Staaten und Unternehmen für die Entfernung von Kohlendioxid untersucht. Dadurch wird die Diskussion über die Governance von CDR-Technologien und ihre ethischen Implikationen vorangetrieben.

Mein Hauptargument ist, dass die Verantwortung für die Entfernung von Kohlendioxid zwischen den Akteuren differenziert werden muss. Ich präsentiere Argumente für die Verantwortung, die verschiedene Akteure tragen. Ich gelange zu vier Schlussfolgerungen: (I) Wenn CDR-Technologien zur Verfügung stehen, tragen Einzelpersonen eine direkte Verantwortung, ihren Kohlendioxid-Fußabdruck auf null zu reduzieren. Sie tragen auch eine politische Verantwortung, gemeinsam mit anderen dafür zu sorgen, dass das Kohlendioxid entfernt wird und dass die ethischen Kosten von CDR-Technologien minimiert werden. (II) Um Netto-Null-Ziele zu erreichen, dürfen Staaten CDR-Technologien für Emissionen einsetzen, die schwer vermeidbar sind. Der staatliche Einsatz von CDR-Technologien ist bedingt zulässig für die Entfernung von Emissionen, die Einzelne für ihre volle Mitgliedschaft in der Gesellschaft benötigen. Er ist unzulässig, wenn es um die Entfernung von Luxusemissionen geht. (III) Es besteht ein Dilemma für die Belohnung von Großkonzernen der Öl- und Gasindustrie für die Entfernung von Kohlenstoff. Es resultiert aus der historischen Verantwortung dieser Konzerne und ihrer Position, von einem zukünftigen CDR-Markt profitieren könnten. (IV) Wenn die gegenwärtige Generation für die Entfernung von Kohlendioxid verantwortlich ist, so beinhaltet dies eine Verantwortung für die gerechte Steuerung von CDR-Technologien.

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Abbreviations

Abbreviation	*Explanation*
APP	Ability-to-pay principle
AR	Assessment Report of the IPCC (e.g., AR4, AR5, AR6)
BECCS	Bioenergy with Carbon Capture and Storage
BPP	Beneficiary-pays principle
CDR	Carbon Dioxide Removal
CCS	Carbon Capture and Storage
DACCS	Direct Air Capture with Carbon Storage
EpC	Equal-per-capita principle
FOEN	Swiss Federal Office for the Environment
IPCC	Intergovernmental Panel on Climate Change
NETs	Negative Emission Technologies
PPP	Polluter-pays principle
SAI	Sulphate Aerosol Injection
SRM	Solar Radiation Management
TRL	Technology Readiness Level
UNEP	United Nations Environment Programme

Overview of the papers

* Main paper of the thesis

Table 1 Overview of the papers

	Title	*Type*	*Authorship*	*Status*
1*	**Individual Responsibilities to Remove Carbon**	Peer-reviewed Journal article, published open access.	Single	Published 2023. In *Critical Review of International Social and Political Philosophy*, pp. 1-21. https://doi.org/10.1080/13698230.2023.2260241 Open access.
2*	**Setting a Permissible Target for Carbon Dioxide Removal**	Peer-reviewed Journal article.	Schübel & Wallimann-Helmer. Schübel was in charge of the writing, both authors contributed equally to the development of the argument.	Accepted for publication in *Environmental Ethics*, March 2024.
3	Food security and the moral differences between climate mitigation and geoengineering - the conflict between Biofuels and BECCS	Peer-reviewed conference proceedings.	Schübel & Wallimann-Helmer. Both authors contributed equally to the writing and development of the argument.	Published 2021. In *Justice and Food Security in a Changing Climate*, edited by Hanna Schübel and Ivo Wallimann-Helmer, pp. 71-79. Wageningen Academic Publishers. https://doi.org/10.3920/978-90-8686-915-2 Open access.

4*	**Justice in Benefitting from Carbon Removal**	Peer-reviewed Journal article	Lenzi, Schübel, Wallimann-Helmer. All authors contributed equally to the writing and development of the argument.	Published 2023. In *Global Sustainability*. https://doi.org/10.1017/sus.2023.22. Open access.
5	Who should get to take credit? Investigating the role of corporations in carbon removal developments	Peer-reviewed conference proceedings, open access.	Single	Published 2022. In *Transforming Food Systems: Ethics, Innovation and Responsibility*, edited by Donald Bruce and Ann Bruce, pp. 192-97. Wageningen Academic Publishers. https://doi.org/10.3920/978-90-8686-939-8_28 Open access.
6	Being Pivotal for Carbon Removal	Invited commentary.	Single	Forthcoming. In *Philosophy & Public Issues*; Special issue ‘Climate transition and the moral responsibility of the pivotal generation’; a symposium on Henry Shue *The Pivotal Generation: Why We Have a Moral Responsibility to Slow Climate Change Right Now* (2021). Revised January 2024.

And, boom, they've 'solved' climate change.
But if it sounds too good to be true, that's probably because it is.
Elizabeth Cripps, 2022

Introduction

Global temperatures are rising. Anthropogenic activities, such as the burning of fossil fuels and gases, are increasing the concentration of greenhouse gases (GHG), such as carbon dioxide (CO_2), in the atmosphere. This causes temperatures to rise and sets in motion several causal chains that lead to changes in weather events, such as precipitation, and, overall, anthropogenic climate change. Climate change threatens human well-being, ecosystems, biodiversity, and many other aspects of life on Earth. If climate change is not mitigated, the harm will be immense.

Given the urgency of mitigating climate change, carbon dioxide removal (CDR) technologies have become a topic of increasing interest. CDR technologies include 'anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products' (IPCC, 2023: 121). More than 120 national governments have committed to net zero emission targets and thereby implicitly committed to removing CO_2 from the atmosphere. Yet already today a gap can be observed between the commitments to implement CDR technologies and the amount of CDR technologies assumed in scenarios that reach the climate targets of the Paris Agreement (Smith et al., 2023).

There are many challenges to determining how CDR technologies should be governed. They include the knowledge gaps about the technologies as well as accounting for the carbon removed. The IPCC notes sustainability and feasibility concerns with implementing CDR technologies at large scales (IPCC, 2022: 36). These governance questions include moral questions, such as whether carbon should be removed, and if so, how much. These ethical challenges involve defining the 'unavoidability' of using CDR technologies; judging the risk of a moral hazard that CDR technologies could create for efforts to reduce emissions; minimizing the ethical costs introduced by CDR technologies; and deciding the scale and purpose to which CDR technologies may permissibly be implemented. Furthermore, challenges of both distributive and procedural justice arise about how CDR technologies should be implemented. Finally, responsibilities to remove carbon have in many cases not yet been distributed. Hence, an important question for the governance of CDR technologies is who should remove carbon?

Various agents and their responsibilities to mitigate climate change are discussed within climate ethics. However, the treatment of CDR within the climate ethics literature has focussed on broad categories without providing a specific account of carbon removal and the question of the moral responsibilities of agents to remove carbon dioxide has not yet been investigated systematically. At the same time, the challenges to CDR technologies obscure the issue of moral agents' permissible use and potential obligations regarding CDR technologies. An account that differentiates responsibilities between agents can help to address the challenges presented by CDR technologies, for example the risk of agents relying on the possibility of removing carbon dioxide in the future, but not undertaking the necessary action towards CDR technologies becoming available. If the responsibilities of moral agents to remove carbon are defined, governance schemes can take them as starting points.

In this thesis, I offer such an account. I argue that to arrive at policy relevant conclusions, differentiating the responsibilities of different agents is necessary. Based on this, I investigate the question *What are the moral responsibilities of individuals, states, and corporations to remove carbon dioxide?* and thereby provide an account of how agents' moral responsibilities to remove carbon dioxide can be defined. In doing so, I advance the literature on the ethics of governing CDR technologies to provide guidance to policymakers.

This introductory chapter has four sections. In the first, I highlight the role of CDR technologies in climate policy and the challenges that arise for governance. In the second, I draw a specific focus on the ethical challenges of CDR technologies. These, as I argue, show a need for theorizing responsibilities to remove carbon. In the third section, I outline how CDR technologies have been considered in climate ethics and show the shortcomings of this debate: its lack of adequate consideration and an account of the responsibilities of different moral agents to remove carbon. This is the gap in the literature that this thesis aims to fill. In the fourth section of this introduction, I present my project of differentiating agents and responsibilities to remove carbon to address this research gap.

The main body of this cumulative thesis is structured in four parts. Part I is on individuals' responsibilities to remove carbon. Part II investigates how states should balance emission reduction and carbon removal. Part III addresses the responsibilities of corporations and the concomitant question of benefits from CDR technologies. Part IV criticizes assigning responsibility by generation and synthesizes the arguments made in favour of differentiating agents' responsibilities. Overall, this thesis includes six stand-alone research articles. Parts I, II, and III contain the three main research articles. These are supplemented by three shorter articles I wrote on the topic during my PhD.[1] The main body of the thesis is followed by a general discussion and conclusion section.

[1] For an overview over the papers, see table 1 'Overview of the papers'.

1. CDR Technologies in Climate Change Politics

Climate politics aims to address the challenge of anthropogenic climate change. The different areas of climate policy can be linked to the causal chain of climate change, as illustrated in Figure 1. First, the release of greenhouse gases, in particular CO_2, can be avoided, which are resulting from human activities and are the main driver of climate change. Next, the increased concentration of CO_2 in the atmosphere can be addressed by removing CO_2 from the atmosphere with carbon dioxide removal (CDR) technologies.[2] Ideally, the greenhouse effect is reduced, and climate change is mitigated. This is the policy area of 'climate change mitigation'. Climate change may also be interfered with by increasing the reflection of the planet using solar radiation modification (SRM). These measures, together with CDR technologies, have been referred to as 'geoengineering'. Once global warming begins to affect the environment and humans, another response option is to adapt to climate change ('adaptation'). Finally, in cases where adaptation is not possible, the policy area 'Loss & Damage' aims to account for and compensate for the loss and damage caused by climate change.[3]

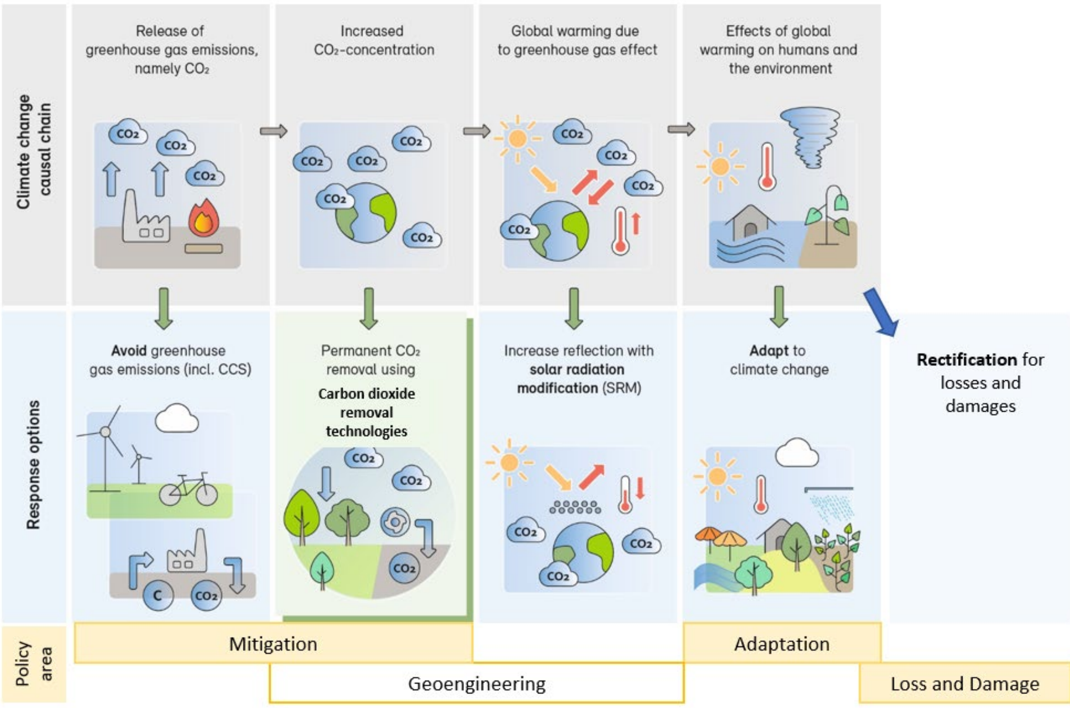


Figure 1 Climate change causal chain and responses.
Source: FOEN (2020), based on Minx et al., (2018). Own expansion, drawing on Heyward (2013).

[2] I refer to 'CDR technologies' to emphasize the range of technologies grouped under 'CDR'. I use the term 'technologies' and not 'methods' as the IPCC does. This is not to evoke the distinction between natural solutions and technical solutions, a distinction that is rarely used in the scientific literature. Instead, all carbon removal methods can be referred to as technological if they are 'standardized, engineered, machine-like, enclosed systems' Markusson (2022: 1). I did not alter quotations that refer to 'CDR'.

[3] The policy areas do overlap. For example, Loss & Damage policies include adaptation measures.

CDR technologies have been discussed within two policy areas: mitigation and geoengineering. CDR technologies are also sometimes discussed with adaptation policies (Buck et al., 2020). However, this is much less prominent.

The sixth IPCC Assessment Report (AR6) defines climate change mitigation as ‘a human intervention to reduce emissions or enhance the sinks of greenhouse gases’ (IPCC, 2023: 126). Climate change mitigation refers both to activities that reduce the flows of CO_2 and other GHGs into the atmosphere and to the increase of carbon sinks. In contrast, carbon dioxide removal refers only to activities that increase sinks. Hence, CDR technologies are a ‘subset of mitigation’ (Heyward, 2013: 25).

In climate change mitigation policies, many pledges have been formulated in recent years, such as to reach net zero emissions by 2050. Sustaining net zero emissions is projected to ‘result in a gradual decline in global surface temperatures’ (IPCC, 2023: 19). ‘Net zero carbon dioxide emissions’ are ‘achieved when anthropogenic CO_2 emissions are balanced globally by anthropogenic CO_2 removals over a specified period’ (IPCC, 2018b: 24). Hence, CDR technologies are key to achieving net zero targets. If more CO_2 is removed from the atmosphere than emitted to it, a situation of net negative emissions occurs. Because of this link, CDR technologies have been referred to as ‘negative emission technologies’ (NETs). The idea of the term is that as carbon is removed, this creates a negative in an emission balance.[4] A technology creates negative emissions if the whole process it entails removes more CO_2 than it releases.[5]

This first section of the introduction is structured as follows. To explain how CDR technologies are included in climate politics, I first present the various measures that fall into the category of CDR technologies (Section 1.1). Second, I explain the role that CDR technologies play in climate modelling pathways (Section 1.2). Third, I describe the various pledges to net zero and the extent to which they involve CDR technologies (Section 1.3). Fourth, I outline the current state of development of CDR technologies, which presents a CDR gap, and I explain four challenges that are identified for CDR and linked to this gap (Section 1.4). Then I draw a first conclusion (Section 1.5).

[4] I often refer to ‘carbon dioxide’ as ‘carbon’ for simplicity and space.

[5] I use the term CDR technologies, because it emphasizes the removal of carbon dioxide from the atmosphere and does not refer to an emission balance. Much of the discussion I draw on uses the term NETs and, in many cases, the labels ‘CDR’ and ‘NETs’ can be used interchangeably. While the term ‘NETs’ was predominantly used for some time, ‘CDR’ is the prevailing label today. See Renforth et al. (2023).

1.1 What are CDR technologies?

CDR technologies aim at mitigating climate change by reducing the concentration of carbon in the atmosphere. The second Assessment Report (AR2) of the IPCC noted that 'possible actions include mitigation of climate change through reductions of emissions of greenhouse gases and enhancement of their removal by sinks' (IPCC, 1995: 17). More recently, the IPCC defined CDR as follows in the AR6:

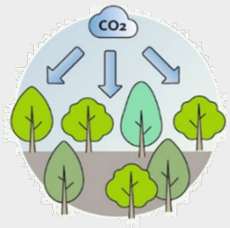
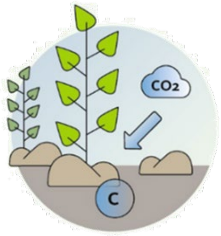
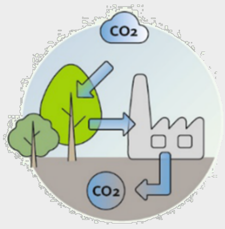
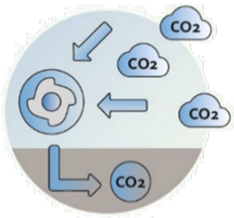
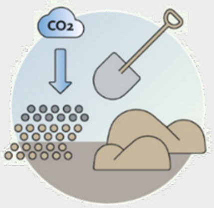
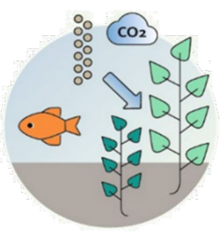
> Anthropogenic activities removing carbon dioxide (CO_2) from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 sinks and direct air carbon dioxide capture and storage (DACCS) but excludes natural CO_2 uptake not directly caused by human activities. (IPCC, 2023: 121)

While emphasizing the contrast between anthropogenic activities and natural CO_2 uptake, the definition subsumes a range of technologies. The main approaches referred to in the IPCC are explained in Table 1.

CDR technologies cover a wide spectrum of activities. CDR technologies 'vary in terms of their maturity, removal process, the time scale of carbon storage, storage medium, mitigation potential, costs, co-benefits, impacts and risks, and government requirements' (IPCC, 2023: 87). For example, time scales vary 'from decades to centuries for methods that store carbon in vegetation and through soil carbon management, to 10,000 years or more for methods that store carbon in geological formations' (IPCC, 2023: 87). Costs range from estimated USD45–100 per tCO_2 from soil carbon sequestration to USD100–300 per tCO_2 for DACCS. Finally, the IPCC notes as high confidence finding that '[t]he impacts, risks and co-benefits of CDR deployment for ecosystems, biodiversity and people will be highly variable depending on the method, site-specific context, implementation and scale' (IPCC, 2022: 36).[6]

[6] 'The robustness of a finding is based on the type, amount, quality and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgement) and on the degree of agreement across multiple lines of evidence. In this report, confidence is expressed qualitatively' (IPCC 2022: 1799, Glossary entry on "confidence").

Table 2 CDR Technologies
Based on definitions from the glossary of the IPCC (2022) report and Fuss et al. (2018). Illustrations Source: FOEN 2020 Factsheet 'Negative emissions: the main approaches'

Carbon Dioxide Removal Technologies	
	**Afforestation** refers to the conversion to forest of land that historically has not contained forest. **Reforestation** means the conversion to forest of land that previously contained forests but that has been converted to some other use. The growth of additional biomass sequesters CO_2 from the atmosphere.
	**Soil carbon sequestration** refers to land management changes that increase the soil's organic carbon content, resulting in a net removal of CO_2 from the atmosphere. Practices that increase carbon inputs in the soil (e.g., from litter, residues, roots, manure) or reduce carbon losses (mostly through respiration, increased by soil disturbance) can promote soil carbon sequestration.
	**Bioenergy with carbon dioxide capture and storage (BECCS)** means that carbon dioxide capture and storage (CCS) technology is applied to a bioenergy facility. Biomass is processed for bioenergy and CO_2 released during the combustion or other energy conversion process is captured. This CO_2 can then be stored (e.g. in geological formations) via CCS technology.
	**Direct air carbon capture and storage (DACCS)** refers to the capture of CO_2 directly from the air and its storage in products and geological reservoirs. It comprises several technologies to remove dilute CO_2 from the surrounding atmosphere (e.g., via filters). Energy is needed for releasing CO_2 from the sorbent, regenerating the sorbent, for fans, pumping, and pressurizing the CO_2 for transportation.
	**Enhanced weathering** increases the natural rate of removal of CO_2 from the atmosphere by using silicate and carbonate rocks. The active surface area of these minerals is increased by grinding before they are actively added to soil, beaches, or the open ocean.
	**Ocean alkalinization** involves the deposition of alkaline minerals or their dissociation products at the ocean surface. This increases surface total alkalinity and may thus increase ocean CO2 uptake and ameliorate surface ocean acidification. **Ocean fertilization** relies on the deliberate increase of nutrient supply to the near-surface ocean with the aim of sequestering additional CO2 from the atmosphere through biological production. Methods include direct addition of micro-nutrients or macro-nutrients. To be successful, the additional carbon needs to reach the deep ocean where it has the potential to be sequestered on climatically relevant time scales.

The differences between CDR technologies raise the question of to what extent they can be grouped as a single type of technology. There have been different approaches to circumvent this difficulty. One approach is to focus on one specific CDR technology only. BECCS has been treated as emblematic of the concerns surrounding CDR technologies and their implementation (Anderson and Peters, 2016; Shue, 2017a, 2021), and many models have focused on BECCS and afforestation (IPCC 2018, 2022, 2023). A second approach is to cluster CDR technologies: Smith et al. differentiate between conventional CDR on land, including afforestation, reforestation, soil carbon, peatland, and wetland restoration, and 'novel CDR', which includes all methods of 'storing captured carbon in the lithosphere (geological formations), oceans and products' (Smith et al., 2023: 17). Examples include BECCS, DACCS, biochar, and ocean alkalinization, which are currently deployed at smaller scales and are less developed than conventional CDR technologies. A third approach is to treat CDR technologies as one group, focussing on their key distinguishing feature: their 'ability to remove CO_2 from the atmosphere' (Smith et al., 2015: 43). This feature sets CDRs apart from other responses to climate change: efforts that avoid emissions cannot address emissions made in the past; and solar radiation management only sets in at a later point of the climatic chain, not addressing the increased concentration of CO_2 in the atmosphere. By removing emissions, CDR technologies allow first for corrections of the problem in hindsight, which is something that cannot be achieved neither by emission cuts nor by SRM. Second, CDR technologies expand what is possible in terms of reducing the concentration of CO_2 in the atmosphere.

The arguments presented in this thesis follow the first and third approach: BECCS is at several points used as an example to illustrate the challenges CDR technologies cause. BECCS is chosen because this technology is well included in the literature and raises challenges that also arise for other CDR technologies (e.g., afforestation and DACCS). At the same time, the arguments in this thesis are not sensitive to the CDR technology in question, because they focus on the shared characteristics of CDR technologies: removing carbon from the atmosphere and storing it durably. This characteristic has ethically relevant implications, as will be explained in more detail in section 2.

1.2 CDR technologies in climate pathways

How CDR technologies are included in climate pathways (IPCC, 2022: 25) varies widely. Here I highlight three ways in which they vary. The first is the extent to which climate pathways assume the use of CDR technologies. The climate target set in the Paris Agreement aims to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels (UNFCCC, 2023). Some scenarios for the 2°C target envision rapid reductions of emissions, and do not rely on CDR technologies. But CDR technologies have been included in all climate pathways that limit global warming to 1.5°C above pre-industrial levels with limited or no overshoot and in the majority of pathways that limit global warming to 2°C (IPCC, 2018a, 2022). Importantly, 'the deployment of carbon dioxide removal to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO_2 or GHG emissions are to be achieved' (IPCC, 2022: 36). Moreover, 'further delay of action or the tighter 1.5°C climate goal renders NETs indispensable in the currently available scenarios' (Fuss et al., 2018: 3). CDR technologies are modelled in these pathways to remove between 20 $GtCO_2$ and 660 $GtCO_2$. Modelled pathways that limit warming to 2°C envisage CDR technologies removing around 40 $GtCO_2$ per year (IPCC, 2022: 25).

Second, there is a variety in which CDR technologies may be used (see Figure 2). Although climate models have mainly included BECCS, this is starting to change, and for example, DACCS is gaining attention (Fuhrman et al., 2021). In 'modelled pathways that report CDR and that limit warming to 1.5°C (>50%) with no or limited overshoot, global cumulative CDR during 2020–2100 from BECCS and DACCS is 30–780 $GtCO_2$ and 0–310 $GtCO_2$, respectively.' (IPCC, 2023: 25). Depending on the pathway, for example, DACCS in 2050 could account for no emission removal or the largest share of carbon removal (see Figure 2). Climate pathways not only involve different CDR technologies at different scales but also make different assumptions about costs, availability, and constraints (IPCC, 2023: 25).

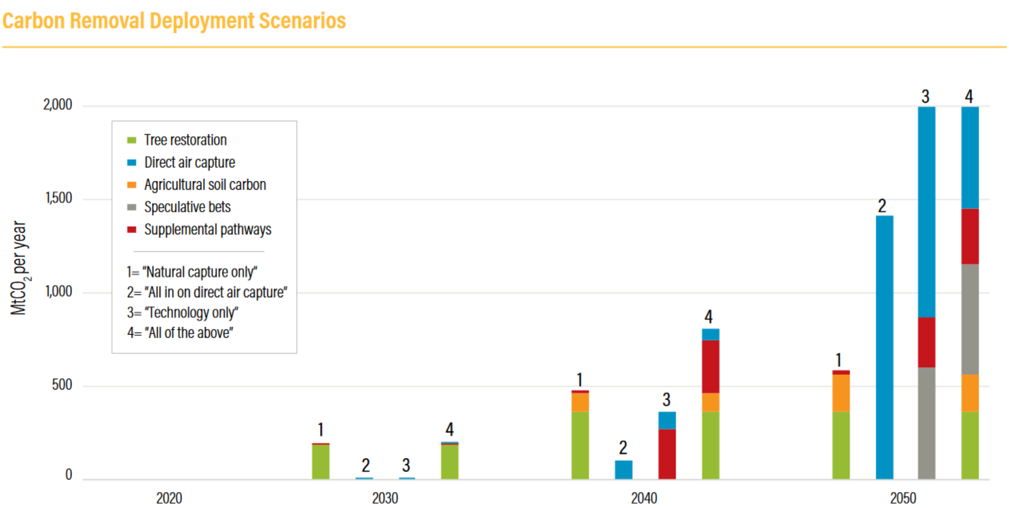


Figure 2 Carbon removal deployment scenarios
Figure from Mulligan et al., 2022: 10

Third, CDR technologies have been modelled to serve different purposes. The contrast between the two purposes is illustrated in Figure 3 (Fuss et al., 2020: 146). Whereas the 1.5°C target is reached in both scenarios depicted, CDR technologies are used to differing extents to achieve this (87 $GtCO_2$ in Scenario 1 and 500 $GtCO_2$ in Scenario 2). In the first scenario, CDR technologies are used solely to remove residual or hard-to-abate emissions. These are emissions from 'difficult-to-mitigate sources of CO_2, such as the transportation sector, as well as non-CO_2 GHGs' (Smith et al., 2015: 43). Removing this CO_2 is termed 'residual CDR'. The purpose of these removals would be to achieve net zero emissions rather soon. In the second scenario, CDR technologies are used 'to bring temperatures down after an overshoot of the target' (Fuss et al., 2020: 145), if concentrations of carbon dioxide in the atmosphere increased beyond the amount targeted to keep temperatures to a certain target. Hence, the idea of 'overshoot CDR' is that it removes carbon that led to an overshoot of the temperature target. The larger the overshoot in emissions, the larger the scale at which CDR technologies are needed to produce net negative CO_2 emissions. The faster net zero CO_2 emissions are reached, the less need there is for removing carbon with CDR technologies. Implementing less CDR technologies would reduce 'feasibility and sustainability concerns, and social and environmental risks associated with CDR deployment at large scales. (high confidence)' (IPCC, 2023: 25).

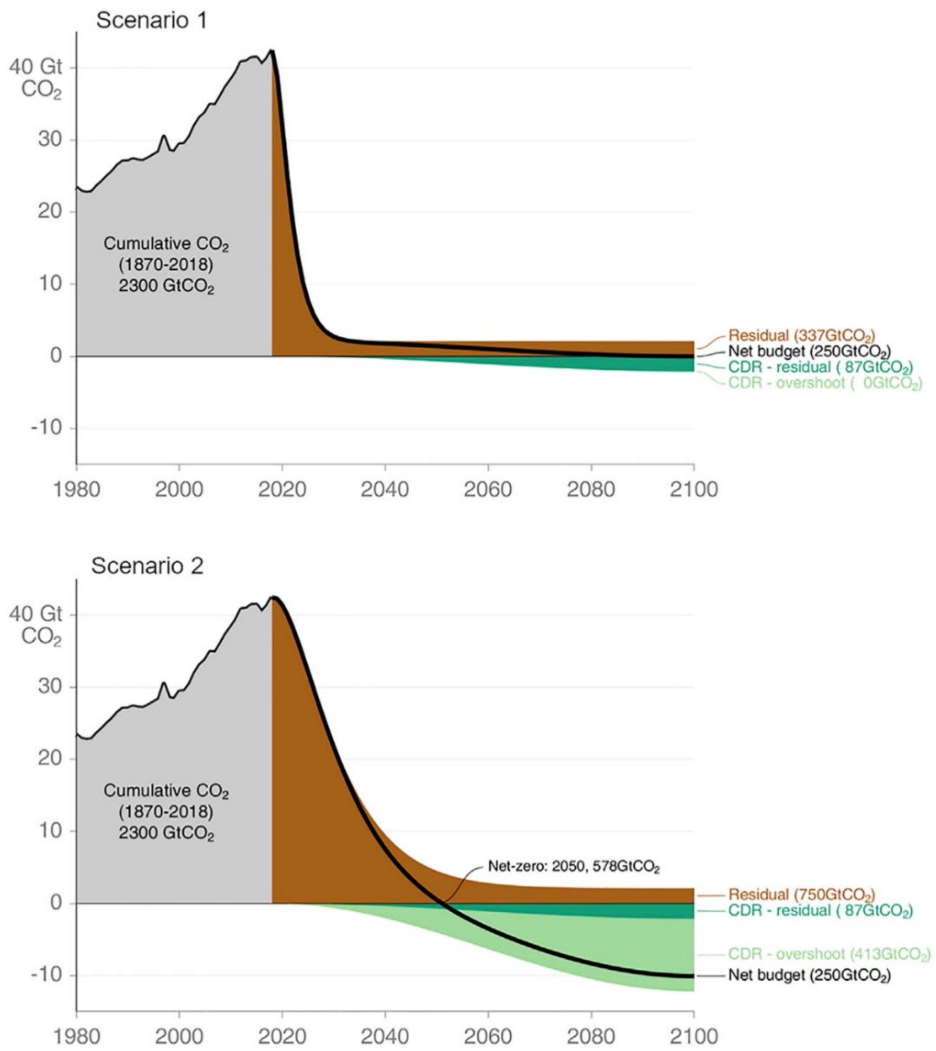


Figure 3 Historical emissions and stylized pathways
Historical emissions and stylized pathways that emit less than 250 Gt CO_2 between 2019 and 2100 to limit the temperature increase to 1.5°C in 2100. Scenario 1: negative emissions offset residual (positive) emissions, resulting in little CDR and drastic and immediate emission reductions. Scenario 2: greater positive emissions result in larger CDR and higher overshoot before the temperature increase declines to 1.3°C–1.4°C in 2100, still with drastic CO_2 emission reductions in the next two decades. Both scenarios reach 1.3°C–1.4°C in 2100, but temperature diverges beforehand. Data sources: historical emissions from the Global Carbon Project; scenarios based on stylized functions with cumulative emissions consistent with scenarios from the IPCC SR1.5 scenario database. (Fuss et al., 2020: 146)

1.3 Net zero targets and the 'CDR gap'

Over three-quarters of the world's global greenhouse gas emissions were covered by a net zero law, policy, or political pledge by September 2022 (UNEP, 2022: 13). Over 120 national governments have set net zero emission targets that involve CDR technologies, but 'only a few explicitly integrate CDR into their climate policies' (Smith et al., 2023: 11). For example, Australia, the USA, and Switzerland have set the target of reaching net zero emissions by 2050. The Australian long-term climate strategy (2021) refers to 'offset' and the establishment of an offsetting scheme. The White House aims to 'enhance carbon sinks through a range of programs and measures including nature-based solutions for ecosystems' (White House Factsheet 2021).

In contrast, Switzerland's long-term climate strategy explicitly refers to CCS and CDR as key technologies to reaching its target, because the technologies 'will be necessary to render difficult-to-avoid emissions at that time harmless to the climate' (FOEN, 2021: 3). The plan foresees that twelve million tonnes of CO_2 will be stored annually by 2050, seven of them from CDR technologies, and of these, a 'large proportion . . . will stem from direct air carbon capture and storage (DACCS) facilities located abroad' (FOEN, 2021: 4).[7] Several global corporations have also pledged to reach net zero emissions: Apple by 2030, by restoring mangrove trees in its partnership with the nongovernmental organization Conservation International; Amazon by 2040, using reforestation, and Shell by 2050, using afforestation and reforestation (Vivid Economics, 2020). Microsoft has pledged to become carbon-negative by using BECCS, DACCS, soil carbon sequestration, afforestation, and reforestation (Smith, 2020).

Despite these vague commitments to implement CDR technologies, a 'CDR gap' is emerging. This is the gap between the amount of CDR required to meet the goal of the Paris Agreement and 'how much CDR countries are planning' (Smith et al., 2023: 8). It is illustrated in Figure 4. This gap is wide, especially for CDR technologies that are not yet widely used. For example, although many models assume the use of BECCS, the extent to which states are planning to implement BECCS and scale up the technology is very limited.

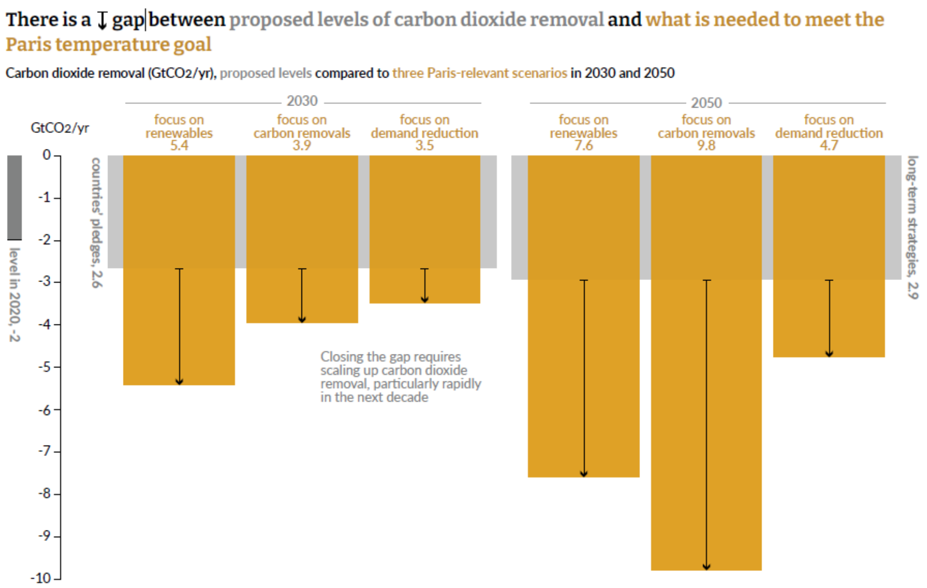


Figure 4 A CDR gap
Source: Smith et al., 2023: 9

[7] The European Union aims to be 'climate neutral' by 2050, which implies that by then, greenhouse gas emissions and removals regulated in the EU must be balanced Meyer-Ohlendorf (2021). The CDR technologies foreseen in the EU Carbon Removal Certification framework are 'nature-based solutions (restoring forests, soils, and innovative farming practices); technology, (bioenergy with carbon capture and storage, or direct air carbon capture and storage); long-lasting products and materials, such as wood-based construction' European Commission (2023).

1.4 Challenges in the governance of CDR technologies

The previous section highlights the CDR gap arising between commitments to use CDR technologies and the amount of CDR technologies included in pathways that model reaching the Paris Agreement goal. This brings us to the question of how to govern CDR technologies.

A body of literature on the governance of CDR technologies has grown in recent years. Contributions range from the policy literature from specific contexts such as the UK (Lezaun et al., 2021) to the governance of specific CDR technologies (Torvanger, 2019) and at different scales (Mace et al., 2021). Increasingly, philosophical literature has contributed (Honegger et al., 2022; Rabitz et al., 2022). I address the ethical challenges of CDR technologies in Section 2. Here, I focus on those identified in the climate politics literature. I consider challenges arising from considerations of (i) the knowledge gaps around CDR technologies, (ii) accounting for carbon removal, and (iii) the sustainability and (iv) the feasibility of CDR technologies.

i. Knowledge gaps

Many of the chemical and physical processes for capturing carbon from the air and storing it are well known. Trees and other plants capture carbon dioxide from the air and store it in their fibres. Oceans and soil store carbon that has been taken up by plants and other biochemical processes. Marshlands store large quantities of carbon.

What is unknown is the quantity of carbon that can be removed by CDR technologies and at potentially large scales. For example, while pledging to store 12 million tons of CO_2 annually by 2050, a large proportion of this by DACCS, Switzerland's climate strategy notes that the 'approaches are largely known but are not yet being actively deployed on a climate-relevant scale' (FOEN, 2021: 3). Here, several knowledge gaps have been identified about carbon removal (Fuss et al., 2016). The knowledge gaps vary between CDR technologies. For example, for enhanced weathering, they 'may relate more to being able to detect experiments and attribute impacts' but for DACCS, they are more about upscaling and side-effects. For biochar and BECCS, knowledge gaps are about soil quality and fertilizer use, and for afforestation, about land use practices (Sovacool et al., 2023: 69). These gaps 'extend far beyond mere "modelling gaps" to include gaps in empirical data, inconsistent data, and a lack of comprehensive field studies' (Sovacool et al., 2023: 69). Instead, these gaps refer to lack of knowledge regarding the side-effects and scalability of CDR technologies.

The knowledge gap in the scalability of CDR technologies is reflected in the 'technology readiness levels' of the technologies (see Table 2). Again, there are large differences between CDR technologies (Armstrong and McLaren, 2022; Michaelowa et al., 2023). While some CDR technologies such as afforestation and reforestation, soil carbon sequestration and peatland restoration are well-advanced, others, such as enhanced weathering and ocean fertilization, lag behind. Different levels of readiness are observed for BECCS and DACCS depending on whether capture or storage is considered.

Further, the cost estimates differ widely between CDR technologies, and some CDR technologies present a wider range of potential costs than others (see Table 2). This also influences the potential for their upscaling. It is not clear how prices will develop as CDR technologies are scaled up. The economics of scale suggest that prices will drop at larger scales, but there are natural limits to how much CDR technologies can be undertaken, which may counter this effect and even make CDR technologies more expensive at some point. For further discussion on this topic, see Chapter 5.

Table 3 Technology readiness levels (TRL) of CDR technologies
These range from TRL 1 (basic principles observed) to TRL 9 (actual system proven in operational environment).
Source: Michaelowa et al., 2023: 3

Removal method	**Average marginal abatement cost estimates in 2050 (USD/tCO$_2$)**	**Technology readiness level**
Accelerated mineralization	20–130	4–7
Afforestation/Reforestation	0–240	8–9
Bioenergy with carbon capture and storage (BECCS)	15–400	5–8 for carbon capture 5–9 for carbon storage
Biochar	10–345	6–7
Direct air capture and geological storage (DACCS)	100–300	5–6 for carbon capture 5–9 for carbon storage
Enhanced weathering	50–200	3–4
Ocean fertilization	5–500	1–2
Soil carbon sequestration	-45–100	8–9
Wetland / peatland restoration	Uncertain due to insufficient data	8–9

ii. Accounting

Besides knowledge gaps about CDR technologies, several accounting challenges may undermine carbon removal's effectiveness in mitigating climate change. These difficulties arise because certain parameters are hard to estimate. Brander et al. list five of them (2021: 699). First, it is hard to estimate the effects of carbon removal on the overall climate system. Second, accounting for carbon removal is complicated given the impermanence of some CDR technologies, such as afforestation if planted trees burn down and carbon is re-released into the atmosphere. Third, it is difficult to estimate and compare the effects of two different purposes that CDR technologies may serve. CDR technologies may be implemented to prevent an overshoot of the global carbon budget and to remove carbon after such an overshoot. These are not likely to have the same effects. Fourth, it is unclear what effect incentives for CDR technologies have on accounting practices. Fifth, it is hard to account for the temporal distribution of carbon emissions and their removals.[8]

These accounting challenges vary between CDR technologies. For example, while the challenge of impermanence is pressing for afforestation, it is less of an issue for CDR technologies that involve geological sequestration of carbon such as BECCS and DACCS. Hence, difficulties also arise from the 'non-equivalences' of CDR technologies (Sovacool et al., 2023: 74). Finally, the question remains at what point a technology overall removes more carbon than it releases (Tanzer and Ramírez, 2019).

iii. Sustainability

The IPCC notes as a high-confidence finding that 'upscaling the deployment of CDR depends on developing effective approaches to address feasibility and sustainability constraints, especially at large scales' (IPCC, 2022: 36). Let us begin with the sustainability constraints here, which involve creating negative side-effects and risks.

The case of BECCS is emblematic of the concerns related to large-scale CDR technologies (Smith et al. 2015, Fuss et al. 2018, Shue 2021). Models usually envision the biomass for BECCS grown in monocultures (Smith et al., 2015: 43). Furthermore, the 'production of biomass crops [for BECCS] can have adverse socio-economic and environmental impacts, including on biodiversity, food and water security, local livelihoods and the rights of Indigenous Peoples, especially if implemented at large scales and where land tenure is insecure' (IPCC, 2023: 21). Because large-scale BECCS 'inevitably requires enormous land-use changes, [it] will most likely infringe upon the right to food, the right to water, and the right to a healthy environment' (Günther and Ekardt, 2022: 1). Similar concerns are raised for afforestation projects at large scales (IPCC, 2023). Further risks are linked to the storage of carbon dioxide by CCS technology, which could cause seismic disturbances and leakages into groundwater (Bui et al., 2018). In addition, implementing BECCS and DACCS facilities requires many resources to set up their infrastructure. DACCS could also infringe on the human right to energy (Günther and Ekardt, 2022: 1).

[8] Sovacool et al. list similar concerns (2023: 74).

The introduction of negative side-effects and risks is especially relevant for the ethical justification of CDR technologies and the normative question of how to distribute the benefits and burdens of these technologies. They are discussed further below in Section 2.

iv. Feasibility

In September 2021, the first large-scale DACCS plant, Orca, was launched. The plant removes 4000 tonnes of CO_2 annually (Climeworks, 2023). This is equivalent to the annual emissions of about 790 cars (Skydsgaard, 2021). This is far from the scale at which CDR technologies are assumed in climate scenarios and policies.

The up-scaling of CDR technologies raises the question of the feasibility constraints mentioned by the IPCC (2022: 36). Some feasibility constraints arise from the knowledge gaps outlined above. Another feasibility constraint on the large-scale use of CDR technologies is that most CDR technologies are not yet available at large scale and 'most carbon-removal technology analyses are limited to the early stages of innovation (e.g., R&D) and have yet to seriously assess "demand pull" – market opportunities, policies, and niche markets that would stimulate their investment, improvement, and adoption' (Sovacool et al., 2023: 69). Because many CDR technologies do not bring about revenues, 'they will require substantial amounts of funding, either from public or private sources' (Honegger et al., 2022: 12).

However, it is hard to distinguish between the technological obstacles and natural limits to the large-scale implementation of CDR technologies and emission reduction and issues of political and economic feasibility. What is economically feasible is linked to the question of how much money is available to advance research and development in CDR technologies. What can be noted is that interest is growing in funding research and development in CDR technologies. For example, in April 2022, the carbon-removal fund Frontier was established by major technology firms such as Meta (Facebook), Shopify, and McKinsey Sustainability. Frontier attempts to act as a 'start-up accelerator' so that 'companies invited into Frontier's portfolio have access to advanced capital to develop and scale selected carbon-removal technologies' (Sovacool et al., 2023: 73). The fund has been announced as amounting to $925 million. However, this is not yet within the range of investment needed to close the CDR gap discussed earlier (Smith et al., 2023).

The question of funding illustrates the difficulty of setting feasibility constraints aside from societal discussions. Instead, 'what counts as economically, socially, or politically feasible is not fixed but shaped by social conditions' (Schuppert, 2021: 158). For example, a limiting factor to the large-scale implementation of BECCS is 'socio-institutional barriers, such as public acceptance of new technologies and the related deployment policies' (Fuss et al., 2014: 851). Yet, acceptance may depend on how the technologies are framed in the public discussion. And although the technical feasibility of CDR technologies undoubtedly presents obstacles, technical feasibility concerns cannot reliably be distinguished from a lack of political will (Heyward and Roser, 2016: 7). It has been argued that many feasibility claims are unjustifiable because they are 'intricately linked with existing power imbalances, structural injustices, and unwarranted privilege' (Schuppert, 2021: 159).

The question of feasibility and its meaning is increasingly discussed (cf. Katz and Kenehan, 2021; Kenehan and Katz, 2021) A full review of the literature on feasibility is beyond the scope of my discussion here. However, this growing normative literature on CDR technologies can contribute to the general discussion on feasibility (Lenzi and Kowarsch, 2021).

1.5 Conclusion on CDR technologies in climate politics

In this first section of the introduction, I provided an overview of the state of the art of CDR technologies in climate politics. I began by defining various CDR technologies and argued that despite their differences, we may still discuss them under the umbrella term CDR technologies. Second, I outlined how CDR technologies have been included in climate pathways. Third, I presented examples of how CDR technologies are included in net zero targets and introduced the concept of the CDR gap. In the fourth and final section, I turned to challenges to the governance of CDR technologies. Here, I discussed four practical challenges linked to the employment and up-scaling of CDR technologies. These are the challenges of knowledge gaps, accounting, sustainability, and feasibility. The discussion on feasibility indicates the need to expand our discussion to normative aspects of governing CDR technologies.

2. Ethical Challenges of Governing CDR Technologies

Several studies have examined the challenges and justice implications of net zero emission targets and the role of CDR technologies in them (Armstrong and McLaren, 2022; Fuss et al., 2020; Honegger et al., 2021b; Honegger and Reiner, 2018; Lenzi et al., 2021; Rabitz et al., 2022). However, there is a risk that these questions and normative literature are not considered sufficiently in the assessment of these technologies. For example, in the IPCC special report, 'no normative research was considered in the examination of the equity implications of CDR' (Lenzi and Kowarsch, 2021: 18).

Climate models that include CDR technologies and the pledges of states and corporations to use CDR technologies. In these circumstances, the main question seems to be not whether CDR technologies should be used to mitigate climate change but how this will be undertaken (Shue, 2021). But simply assuming CDR technologies will be implemented sets aside normative considerations and questions of ethics. For governing CDR technologies, many questions remain: How much carbon should be removed? How should CDR technologies be implemented? And who should remove carbon? Governance regimes that engage with CDR technologies will have to decide on policies that address these essentially ethical challenges (Heyward, 2014a).

This section focuses on these ethical challenges of governing CDR technologies. Section 1.4 outlined four challenges, such as knowledge gaps, accounting for carbon removal, sustainability, and feasibility. These challenges are connected to normative considerations in this section. This section outlines eight ethical challenges of governing CDR technologies.[9] First, I present five challenges linked to the question of whether carbon should be removed, and if so, how much (Section 2.1). Second, I present two challenges linked to the question of how CDR technologies should be implemented (Section 2.2). Third, I present the challenge of agency arising from the question of who should remove carbon (Section 2.3).

2.1 Should carbon dioxide be removed, and if so, how much?

Deciding whether we should remove carbon requires us to determine whether carbon removal is morally permissible. Here, I outline five challenges faced by any argument to remove or not remove carbon dioxide with CDR technologies. These are challenges to defining how

[9] As I highlighted in the previous section, many different CDR technologies are being developed. Although some ethical issues might be common to all of them, they do not all have the same set of ethical problems. Here, I focus on general governance challenges of CDR technologies.

unavoidable CDR technologies are, how the risk of moral hazard can be addressed, how ethical costs can be addressed, to what scale CDR technologies should be implemented, and to what purpose.

i. Unavoidable CDR

The IPCC states that the ‘deployment of CDR to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO_2 or GHG emissions are to be achieved’ (IPCC, 2022: 36). If net zero targets are to be reached by mid-century, which is essential to mitigate climate change, implementing CDR technologies seems unavoidable. The question of whether we should remove carbon seems quickly answered: Yes, we should, if this is the only way to prevent temperatures rising beyond 1.5° above pre-industrial levels.

However, what must be done, or is unavoidable, to achieve a certain goal depends on the alternative options as well as whether this action is permissible. If no other option is available, doing *x* is unavoidable to bring about *y*. If all other options are impermissible, the only available option may become permissible if it is not itself ruled out by any major moral concern (Stelzer and Schuppert, 2016). To judge whether the use of CDR technologies is unavoidable, knowledge must be acquired about the alternative scenarios, their feasibility, their ethical costs, and their benefits. Judging the permissibility of CDR technologies therefore not only involves judging the scenarios in which CDR technologies are implemented but also alternative scenarios in which CDR technologies are absent or implemented to a lesser degree.

Morrow and Svoboda have argued that the permissibility of certain technologies can be assessed by applying two criteria. First, the ‘proportionality criterion’, which compares the prima facie wrongs that implementing this technology inflicts with the injustice that it alleviates (2016: 86). Second, ‘the ‘comparative criterion’, which compares a proposed policy with other politically feasible alternatives (2016: 86). However, it is a ‘fundamental difficulty for accounts of non-ideal permissibility . . . that we simply do not know what sort of climate future we ought to consider relevant’ (Lenzi, 2021: 10). Because we do not know which alternatives are feasible and thus can be considered, we cannot claim CDR technologies to be unavoidable. Yet, the outlook is grim: ‘A few scenarios do meet the Paris temperature goal without novel CDR [BECCS; DACCS; etc.], but these require even more aggressive emission reductions, which we are not on track to achieve’ (Smith et al., 2023: 11). Because the judgement of the permissibility of CDR technologies also depends on what reductions of emissions are feasible within a certain timeframe, this brings us back to the discussion on feasibility.

ii. A moral hazard

The concern about CDR technologies most frequently discussed is that their existence or claims about their future development may undermine other efforts to mitigate or adapt to climate change. CDR technologies could give rise to a ‘moral hazard’ (Gardiner, 2011: 166). This term originally comes from economics and the discussion of insurance, where it describes the behaviour of people taking less care when they know they will be able to rely on their insurance company. It is feared that this behaviour will occur for climate change mitigation if CDR technologies offer a way to address emissions that we fail to reduce. This moral hazard may exist regardless of the capacities of CDR technologies. However, the moral hazard is especially threatening if the extent to which agents may rely on CDR technologies to balance out their emissions is not defined.

Several ethical problems arise if people forgo efforts to reduce emissions because they count on CO_2 being removed later (Fuss et al., 2014; Lenzi, 2018; Shue, 2017a). First, forgoing mitigation opportunities is morally problematic because it makes reaching climate targets such as the Paris Agreement less likely. Second, forgoing opportunities to reduce emissions increases the pressure to scale up CDR technologies. Given the uncertainties surrounding CDR technologies, this increases the overall risks. Emission abatement rather than CDR technologies is more closely in line with the Paris Agreement’s emphasis on equity and risk aversion (Anderson and Peters, 2016; Honegger et al., 2021a). Third, given the ‘risk that they will be unable to deliver on the scale of their promise’, relying on CDR technologies, is an ‘unjust and high-stakes gamble’ (Anderson and Peters, 2016: 183).

It is the challenges outlined in 1.4 that make relying on CDR technologies morally objectionable. For example, the knowledge gap about whether CDR technologies can remove the amounts of carbon needed makes relying on CDR technologies a ‘bet’ (Fuss et al., 2014). Taking the gamble implies that mitigation efforts are not undertaken and hence, overall, climate change is not mitigated. Yet, this is an important feature of moral hazard. It highlights that ‘less aggressive mitigation now, not the dreamed-of remedial CDR later, is the fundamental mistake, although much depends on when, where, how much of, and what kind of remedial CDR is hoped for—and actually accomplished’ (Shue, 2021: 97). Similarly, Lenzi notes that ‘deferred mitigation is the true problem’ (2021: 5). This is not simply because such deferral increases the dependence on CDR technologies. Instead, ‘substantially deferred mitigation amplifies the risk of a dangerous bet on negative emissions emerging, in which the prospect of extreme reliance on NETs incentivizes less mitigation now’ (Lenzi, 2021: 5). Instead of concluding that CDR technologies are a policy option that should not be discussed, we should theorize about what the interplay should be between CDR technologies and policies that abate emissions.

iii. Ethical costs

The negative side-effects and risks of CDR technologies have been referred to as moral or ethical costs (Lenzi, 2021; Shue, 2017a). This concept includes the risks the technologies introduce, which are linked to the moral hazard, and negative side-effects and risks for sustainability that the implementation of CDR technologies may entail. Hence, the ethical costs of carbon include the risk that CDR technologies may not be able to remove the quantities of carbon dioxide needed, either because the technologies cannot be upscaled fast enough or because they are ineffective. Thereby, the technologies may pose risks to those who must rely on them. But according to Shue, BECCS also has the moral costs 'that we might in fact undermine food security or sustainable development by causing absolute shortages or maldistributions of food as a result of appropriating land or water for BECCS' (Shue, 2017a: 208). The moral costs then include the risk that CDR technologies may undermine food security and sustainable development and further expose future generations and the people most vulnerable to these risks.

Besides the practical challenge of how to minimize the ethical costs of CDR technologies, there is the conceptual challenge of assessing the ethical costs of CDR technologies. To assess the ethical costs of CDR technologies, 'we require many more specific assumptions about the extent of deferred mitigation, the sort of development envisioned, lifestyle and behavioural change, the state of geopolitics and international cooperation, and so on' (Lenzi, 2021: 5). For example, CDR technologies may have positive or negative effects on the global poor depending on the accompanying policies.

iv. Scale

Most of the concerns linked to carbon removal are about the scale of CDR technologies. If CDR technologies are implemented at a large scale and draw on water, land, nutrients, and energy resources, they push the planetary boundaries for these resources (Günther and Ekardt, 2022; Heck et al., 2018; IPCC, 2018b). The IPCC notes 'feasibility and sustainability concerns, and social and environmental risks associated with CDR deployment at large scale' (IPCC, 2023: 23). Hence, many of the challenges of CDR technologies are explicitly linked to the large-scale employment of those technologies, such as sustainability, feasibility, moral hazard, and ethical costs. Yet, this does not mean that introducing them at small scales does not imply any of these challenges. Challenges may occur proportionately or even disproportionately to the scale of CDR technologies, but they only start to merit attention once the threshold to large-scale deployment of CDR technologies is passed.

To avoid these challenges of scale, arguments have appealed to a mix of CDR technologies and their combination with emission mitigation efforts (Cox et al., 2018; Fuhrman et al., 2023; Minx et al., 2018). Yet, estimating the harm and risk arising from various implementations of CDR technologies and mitigation measures will depend not only on the extent to which both are employed but also on what policies surround them. If, for example, the growth of biomass comes primarily at the expense of food security in developing countries, the harm will be severe. If the growth of biomass is accompanied by governance mechanisms that follow a more sustainable approach, these harms may be minimized.

Although there is disagreement about how mature CDR technologies are, fully scaled-up CDR technologies 'are indeed a less secure proposition than conventional mitigation' (Lenzi, 2021: 3). Yet, some large-scale mitigation efforts will have similar effects to some large-scale CDR technologies. Whether biomass is planted to produce biofuels or BECCS is not a difference in that respect (for more on this see Chapter 3). Indeed, some have argued that the main criterion for deciding between the implementation of CDR technologies or emission abatement measures should be the negative side-effects of their large-scale deployment (Cox et al., 2018).

v. Purpose

As discussed earlier, CDR technologies may serve different purposes: both balancing out residual or hard-to-abate emissions, residual CDR, and removing CO_2 after an overshoot in emission targets, overshoot CDR (see Section 1.2). This purpose may justify undertaking CDR technologies. Especially when risks are imposed, what is important is the justification provided (Barry and Cullity, 2022: 356).

Residual CDR could be implemented already today, but overshoot CDR would be implemented only after an overshoot of the emission budget. Given this delay, we should be more sceptical about overshoot CDR and promote CDR technologies to enhance ongoing efforts of emission reduction.[10] We may argue that CDR technologies should primarily be used to enhance mitigation efforts (Shue, 2021: 94–103) and reduce the risks of unmitigated climate change. Yet, there are also good reasons to pursue CDR technologies to address an overshoot in emissions: 'even if we were to get to zero tomorrow, there would still be future damage to

[10] This delay also adds to the accounting challenge discussed in Section 1.4.

compensate for, from the greenhouse gas load already emitted' (Habib and Jankunis, 2016: 72). The risk of unmitigated climate change would outweigh the ethical costs of CDR technologies. Failing to stabilize the global climate would lead to extreme harm, which makes the implementation of CDR technologies permissible under at least some circumstances (Lenzi, 2021: 10). Further, the scenarios that include CDR technologies reach net zero at lower costs than those that exclude it (Fuss et al., 2014: 851).

Shue adds a third 'radically different purpose' of CDR technologies, namely that of 'rescuing fossil-fuel companies' stranded assets' (Shue, 2021: 95). According to Shue, introducing CDR technologies for this purpose is 'in the interest of no one except those whose wealth is tied up in reserves of, and infrastructure for, coal, oil, and natural gas' (Shue, 2021: 95). I discuss the issue of using CDR technologies to rescue fossil-fuel companies' stranded assets in Chapter 6.

2.2 How should CDR technologies be implemented?

This section continues to outline the ethical challenges of CDR technologies. Because even if we have decided to remove carbon, how should these technologies be implemented? Like Simon Caney, I believe we should not consider the challenge of climate change in isolation from other global issues such as poverty and development (2012). Hence, I focus here on two dimensions of justice, distributive and procedural justice, and the challenges posed by implementing CDR technologies without violating them. The points raised here underlie the other problems and deeply influence the challenges already outlined.

Asking how CDR technologies should be implemented does not mean that we simply neglect the questions of CDR technologies being permissible and at what scales. These remain important questions. Probably, whatever solution would be determined, CDR technologies would entail implications for justice. For example, CDR technologies may create a moral hazard and slow emission abatement policies, thereby imposing more risks on future generations. Yet, even if CDR technologies entailed such unjust implications, we may still be able to identify some solutions as morally more desirable than others. As Dominic Roser argues, 'while unjust options can be more or less unjust, just options cannot be more or less just. They can, however, score better or worse according to other—moral and non-moral—criteria' (2016: 87).

vi. Distributive justice

The core ethical issue of climate justice 'concerns how to allocate the costs and benefits of greenhouse gas emissions and abatement' (Gardiner, 2010b: 14). As described above, CDR technologies introduce ethical costs in the form of negative side-effects and risks. In addition, CDR technologies introduce monetary costs, but also both monetary and nonmonetary benefits. We must consider how these costs and benefits of CDR technologies should be distributed globally and across generations. The discussion on the challenge of introducing ethical costs indicated several problems arising for global justice and intergenerational justice. Because CDR technologies are linked to future scenarios, they connect both these justice domains.

The climate regime, including the Paris Agreement, identifies equity as a guiding rule of conduct. It rests upon three pillars of equity: 'protecting the most vulnerable, guaranteeing sustainable development, and encouraging greater ambition by states which greater capability' (Dooley et al., 2021: 300–301). Because of this, has been argued that 'CDR policies should fulfil principles of inter- and intragenerational equity' (Honegger et al., 2022: 8).

The implementation of CDR technologies is going to be unequally distributed across the globe and as a result, it is likely that the negative side-effects of CDR technologies will also be unequally distributed. The implementation of CDR technologies such as reforestation, improved forest management, soil carbon sequestration, peatland restoration, and coastal management can have positive side-effects for local populations because they 'can enhance biodiversity and ecosystem functions, employment, and local livelihoods' (IPCC, 2023: 21). However, depending on the CDR technology and the scale of its implementation, large negative side-effects may also arise for both the natural environment and people affected. Large-scale BECCS and afforestation may undermine freshwater supply and food security. DACCS may infringe on the human right to energy (Günther and Ekardt, 2022). CDR technologies may be implemented disproportionately in developing countries, especially if CDR policies follow a cost-optimization approach (Lenzi et al., 2021: 7).[11]

The distribution of the burdens of CDR technologies is problematic not only globally but also intergenerationally. The risk that CDR technologies may fail to mitigate climate change falls on those who have emitted little and who do not have the financial resources to protect themselves. There are various uncertainties about the scalability and effectiveness (Lenzi, 2018), which may make an estimate of these effects difficult. This creates a risk for future generations and especially for those individuals financially vulnerable:

> the distribution of this risk is highly inequitable. If negative emission technologies fail to deliver at the scale enshrined in many IAMs [integrated assessment models], their failure will be felt most by low-emitting communities

[11] This has already been observed for credit schemes for forestry (REDD+).

> that are geographically and financially vulnerable to a rapidly changing climate (Anderson and Peters, 2016: 183).

Hence, it has been argued to be morally objectionable to expose others to the insecurities of scaling up CDR technologies by shifting the burden of action on uncertain technological developments to the future. Relying on CDR technologies in climate politics has been pointed out to be a 'gamble' or a 'bet' rather than a solid policy choice (Anderson and Peters, 2016; Lenzi, 2018; Shue, 2018).

However, implementing CDR technologies could contribute to reaching the target of the Paris Agreement and thereby benefitting many people of current and future generations. 'CDR has the potential to either achieve or undermine equitable net zero outcomes' (Lenzi et al., 2021: 6). If developed countries undertake CDR technologies, they can remove their historical emissions and fulfil the polluter-pays principle (Lenzi et al., 2021: 7), a central principle in climate justice. This would improve the situation of both poorer world regions and future generations. Depending on the conditions of their implementation and the degree of deferred mitigation, CDR technologies 'could be part of a minimally just and effective climate response, albeit one still involving a gamble on both their mitigation potential and on our ability to justly distribute the ethical costs' (Lenzi, 2021: 8).

Hence, the question arises whether technologies that introduce negative side-effects can be justified if they are to the advantage of the global poor, for example, if developing countries can continue to emit as other nations remove CO_2 from the atmosphere (Morrow and Svoboda, 2016). On the flipside, we may also deem forgoing the possibility of removing carbon and allowing temperatures to increase to be morally problematic.

Further, CDR technologies can create benefits because they allow agents to continue activities that create emissions. It can allow these agents to continue to make profits. CDR technologies also create benefits for those who offer carbon removal services. However, the monetary benefits of employing CDR technologies are likely to be accumulated by states and corporations that have the technological know-how and financial capacities to make these investments. Both usually co-occur with higher past emissions and hence raise questions of justice in accounting for historical emissions (Moss, 2020) The distribution of these benefits will depend on governance decisions, policies, and regulations.

Finally, CDR technologies create socio-technical lock-in (McLaren et al., 2019). As we have seen, the distribution of negative side-effects is likely to reflect existing global and intergenerational injustices as CDR technologies are implemented in countries of the Global South and scaled up. Hence, a challenge for distributive justice is that CDR technologies may exacerbate existing injustices. The extent to which climate justice should consider concerns of global justice and existing inequalities and injustices has long been discussed (Caney, 2021).

vii. Procedural justice

Although inequality in the distribution of these negative side-effects and risks is not necessarily an injustice, injustice does arise if these risks and negative side-effects are shifted towards more disadvantaged and vulnerable groups, especially on global scales, without these groups having an adequate say in these decisions or receiving adequate compensation for the burdens they will bear (Wallimann-Helmer 2018). Claims for procedural justice arise when trying to decide how costs and benefits should be distributed. They are especially present when CDR technologies create new risks or negative side-effects for local populations.

The lack of procedural justice links with global and intergenerational justice in the case of CDR technologies. These interlinkages are illustrated in Shue's example of playing a morally unacceptable gamble (2017a). Not only are those who decide to take the gamble of relying on technologies currently not available the ones who would gain, but those who will suffer have no say in it. Future generations and vulnerable communities in the current generation are the ones who will suffer the most climate change-related harm if emissions are not reduced and CDR technologies cannot be scaled up.

Drawing on the literature on climate governance, Honegger et al. argue that 'policies should be procedurally just' and that 'the policy design process should involve public participation and stakeholder involvement' (2022: 8). However, concerns about procedural justice have rarely been discussed regarding CDR technologies. So far, studies on the social acceptance of CDR technologies have focussed on a few industrialized countries. Countries such as the UK, the USA, and Germany are over-represented in research, but 'only seven countries from the Global South have been examined, with China the only one to be considered twice. No country in Latin America has yet been the focus of research' (Sovacool et al., 2023: 65). Here, the discussion on CDR technologies follows the same trend as that on climate engineering. While developing countries from the Global South have higher stakes at risk, 'the discussion about whether and how to engage with these technologies is shaped by experts from just a small set of countries in the Global North' (Biermann and Möller, 2019: 151). However, the discussion about the acceptability of CDR technologies is key to the up-scaling of CDR technologies (Fuss et al., 2020), and public engagement seems necessary for 'mobilizing political will and enabling careful policy design' (Lenzi et al., 2021: 7)

2.3 Who should remove carbon?

Having ascertained that CDR technologies may have to be used and their employment carefully governed, the question arises, who is responsible for doing so? Given the challenge of defining the permissible use of CDR technologies, the question arises as to who may permissibly use them. Because questions of governance involve moral questions, this is not just a matter of finding the political mechanism that could distribute these responsibilities. The moral question must be settled. Hence, who *should* remove carbon?

viii. Distributing responsibilities

When a state or the international community of states agrees on a net zero target, it is not clear what the responsibilities of various agents are to reduce emissions or to remove carbon. Setting a net zero target does not involve a commitment to 'any specific distribution of mitigation efforts between different actors' (Armstrong and McLaren, 2022: 521). We may hold the state responsible for reaching the net zero target to which it committed, but it is unclear how this translates into the target setting of local authorities or subgovernmental structures. A net zero target also does not indicate how responsibilities to remove carbon are distributed between the public and the private sector. Who should invest in carbon removal technologies? Here, 'the incentive structures for CDR deployment and the distributive effects of envisaged CDR upscaling (e.g. who bears responsibility for delivering and paying for removals)' (Smith et al., 2023: 58) are of particular importance. After all, lack of investment is a feasibility constraint for scaling up CDR technologies. Unfortunately, the question of who should act is left open in discussions about feasibility. Instead, 'appeals to feasibility are often vague about the agents about whom they are predicated, sometimes intentionally so' (Lenzi and Kowarsch, 2021: 19).

There is a risk that undertaking mitigation measures 'might not be so plausible to many individual and present-day actors or lobbies or may simply be overlooked' (Baatz, 2016: 31), even though it seems plausible from the perspective of the global community or 'humanity'. The moral hazard discussed earlier may occur. Hence, to reduce the risk that agents forgo mitigation opportunities, it is important to define the responsibilities of different agents to mitigate climate change – including carbon removal.

Further, the absence of a distribution of responsibilities may well be one of the reasons why we can today observe the CDR gap between the amount of carbon removal required to meet the temperature target of the Paris Agreement and the commitments of states to remove carbon. Determining the responsibilities of states and corporations for CDR technologies may help to close the CDR gap by aligning assumptions with research and development.

2.4 Conclusion on the ethical challenges

The eight ethical challenges outlined in this section have indicated the task of identifying what removing carbon permissibly implies. Such identification enables ethical governance of CDR technologies to advance. Because 'there is significant room for disagreements driven by both greater uncertainties, differing perceptions of feasibility, and the increased prominence of values in thinking about desirable mitigation future scenarios' (Lenzi, 2021: 4), we should both discuss these values and to involve normative arguments as to how uncertainties and feasibility constraints should be judged. Further, these challenges to CDR technologies obscure the issue of agents' permissible use and potential obligations regarding CDR technologies. This makes distributing responsibilities for carbon removal an ethical challenge. Settling these essentially ethical components provides a starting point to inform governance suggestions for CDR technologies. This is why I turn to the debate on CDR technologies in climate ethics in the next section.

3. CDR Technologies and Agency in Climate Ethics

So far, this introduction has provided an overview of how CDR technologies are included in climate change politics and of the challenges of governing CDR technologies, especially ethical ones. I closed the preceding section by arguing that the question of who should remove carbon dioxide needs to be investigated further. There are several pressing reasons for determining who is responsible for carbon removal. The question cannot be answered by looking at regulations or institutional mechanisms. The question of who bears responsibility for mitigating climate change, which may include implementing CDR technologies, is an essentially moral question. In trying to answer this question, we can draw on the philosophical literature that has been developed on questions of climate ethics.

In this third section of the introduction, I first outline the discussion on agents and responsibility in climate ethics (Section 3.1). Second, I show that CDR technologies have not been addressed sufficiently within climate ethics. Instead, CDR technologies have entered the discussion under the umbrella terms of geoengineering, offsetting, and climate change mitigation (Section 3.2). Third, I review how agency has been featured in the discussion of CDR technologies (Section 3.3). My conclusion is that the discussion in climate ethics cannot yet address the ethical challenge for the governance of CDR technologies, the distribution of responsibility (Section 3.4). This motivates my research project, that is presented in Section 4.

3.1 Agents and responsibility in climate ethics

Much of the climate ethics literature has addressed questions of justice and developed arguments for various principles by which to distribute climate change responsibilities. This raises the question of who the agents are who bear responsibilities. According to Gardiner, climate change presents a situation of fragmented agency, because ‘climate change is not caused by a single agent but by a vast number of individuals and institutions not unified by a comprehensive structure of agency’ (Gardiner, 2010a: 88). Hence, there are several answers to the question what kinds of agents can carry moral responsibilities to address climate change. The most frequently discussed are individuals and states, but the list can be expanded to include households, social movements, subnational governments, multinational corporations, religious organizations, nongovernmental organizations, ‘the planet’s (or rich countries’) most wealthy ten per cent, or meat eaters’ (McKinnon, 2022: 108; Umbers and Moss, 2020). Here, I highlight the discussions about the moral responsibilities of individuals, states, and corporations. Then I address the idea of a generation bearing responsibility to mitigate climate change.

Individuals

Individuals are commonly theorized as bearing moral responsibilities related to climate change. After all, 'we are at ease with the idea of individuals as duty-bearers; individuals can acquire duties through exercising their agency (e.g., by making a promise) or they can have duties that are independent of any particular act they have undertaken' (McKinnon, 2022: 110). Several accounts have been advanced that discuss the responsibilities of individuals related to climate change (Baatz, 2014; Broome, 2018; Burri, 2020; Cripps, 2013, 2021; Cullity, 2019; Nefsky, 2021; Schwenkenbecher, 2014; Sinnott-Armstrong, 2005). An important challenge when assigning climate-change related responsibilities to individuals is the question of whether individuals' contribution to climate change and climate change mitigation makes a difference. I engage with this literature in Chapter 1 and present my argument for two concepts of responsibility for individuals.

There is an important difference in assigning individuals or collectives responsibilities for climate change. While individuals are moral agents, this may not be the case for groups. For example, various candidates could be the 'we' who should take climate change mitigation action: 'the whole global population across time, all those now alive, the high-emitting subset of the world's current population, all the high emitters who will ever live' (Cullity, 2015: 148). Not all these groups are collective agents that can bear moral responsibility. Answering the question of what kind of group membership implies duties for individuals involves deep discussions about what it means to be a member of a group or a collective (Cripps, 2013). In our case, however, the question is narrower, namely whether states and corporations can have agency. If states and corporations have agency 'in ways similar to human agents, then perhaps some of them can also be duty-bearers, and be subject to the ethical requirements of climate justice' (McKinnon, 2022: 114).

States

There are different understandings as to why states can be considered 'subjects of responsibility' and how states can assume moral responsibilities (Wallimann-Helmer, 2019a). There exists 'a growing philosophical consensus that states are corporate moral agents, able to bear duties as entities conceptually distinct from—though supervenient upon and constituted by—their members' (Collins, 2016: 344).[12] For example, some argue that states can be

[12] An outlier is the approach to assign responsibility for state action to individuals. In this understanding, states are 'the most basic mechanisms for the accountability of political power to persons' Christiano (2015: 17).

considered as non-natural persons and subjects of responsibility because states can form intentions, generate knowledge, and make decisions within the framework of their governance institutions (Pasternak 2013; French 1984). We can evaluate the actions of states in moral terms, because 'nations perform actions which are capable of responsiveness to reasons' and it is 'intelligible to ask whether those actions take adequate account of the other-regarding reasons that bear upon them – whether they are morally right or wrong' (Cullity, 2015: 163). A different perspective assumes that states are not agents like natural persons, but that the status of agency is assigned either externally or through their members. This happens if the international community assigns states responsibilities or when citizens view their states as being responsible for realizing certain goals (Wallimann-Helmer, 2019a). According to these views, states that have signed the Paris Agreement can be considered responsible for implementing the policies necessary to achieve the goals set out in the agreement. If states are moral agents, these states have a moral obligation to reach the Paris Agreement.

Corporations

So far, the role of corporations in climate ethics has been underdeveloped but their importance is increasingly emphasized (Collins, 2020). Just as in the case of states, the question arises whether the group, such as a corporation, can be a duty bearer. There are, broadly speaking, three positions on this topic (McKinnon, 2022: 114). The first is that the moral agency and obligations of a corporation or organisation cannot be subsumed by addressing the obligations of its members. Instead, 'if an organisation can be shown to have moral agency, then it can have moral obligations qua organisation' (Schwenkenbecher, 2018: 56). The second is that corporations are moral agents because corporations have members who do bring in their goals and 'as long as members are not forbidden from bringing moral considerations to bear on the corporation's decision-making and as long as the corporation has the basic material and structural resources to make decisions on the basis of those considerations, the corporation is a moral agent' (Collins, 2020: 89). The third position is 'that groups cannot be duty-bearers but certain individuals within groups have moral responsibilities for what the group does' (for a discussion see McKinnon, 2022: 114–115). Hence, there is disagreement about how responsibilities are bestowed on groups, but all three arguments suggest that it is possible.

It has been argued that corporations in the oil and gas industry are moral agents because they 'have purposes, form reliable representations of their environment and act reliably to

If states are 'reasonably democratic', individuals participate in the decision making and in the process of how the state determines its position in international negotiations. Hence, it is them who bear responsibility for state action.

satisfy those purposes in light of the representations that they produce' (Moss, 2020: 46). Investor-owned carbon majors have distinctive responsibilities arising from the actions they 'took and could have taken to act upon the scientific evidence of climate change' (Frumhoff et al., 2015: 157). Others have been broader in their argument and include partly state-owned corporations when concluding that 'carbon majors are the most obvious case of companies who are likely to be liable for climate harms and there is also a great deal of empirical research on the kinds of contribution that they make' (Moss, 2020: 46). These corporations have been argued to bear responsibilities for mitigating climate change, funding adaptation, and participating in compensating for loss and damage. These responsibilities derive from the moral principles that society applies, such as, 'clean up your mess', and from which carbon producers are not exempt (Shue, 2017b: 594).

Generations

Finally, the question of what responsibilities one generation has towards future generations has strongly shaped the debate on climate justice. Intergenerational justice is a key component of the moral challenge of solving the climate crisis (Gardiner, 2010a), given the impact climate policies have on future generations.

There are different approaches to the question whether responsibilities or duties towards future generations are better understood as a set of individual duties (to contribute to a joint goal) or as duties held collectively. Some argue that 'duties towards future generations are situated on the collective level and that they should be understood in terms of collective responsibility for structural injustice' (Keij and van Meurs, 2023: 1). Elizabeth Cripps argues that '"the Young" (younger generations, globally) have a weakly collective duty to mitigate climate change' (2013: 3) and notes that this may expand to the members of future generations (2013: 27). The Young form a weak collective because they 'have a fundamental interest in climate change mitigation because climate change will expose their central human functionings to significant risk and so render their capabilities insecure' (Cripps, 2013: 27).

However, many accounts in the climate justice debate simply refer to 'us' as the 'current generation', not addressing the question of collective agency. For example, Darrel Moellendorf argues that 'our generation, comprising a small subset of all polluters historically, is morally responsible to mitigate climate change' (2014: 153). Henry Shue theorizes the role of the current generation as 'pivotal': 'We are not only the first to be able to understand what to do, but—most importantly—we may also be the last to be in a position to act before we exacerbate some major threats' (Shue, 2021: 6).

The appeal to the moral responsibilities of a generation leaves open the question of who should act. Hence, it is unlikely to address our challenge of distributing responsibilities to, for example, close the CDR gap. I comment on Shue's argument in Chapter 6.

3.2 CDR technology in climate ethics

Arguments have been put forward to assign individuals, states, corporations, or generations responsibility related to climate change. The question is whether and how this involves CDR technologies. To approach this question, I here give an overview of how CDR technologies have been included in three different debates in climate ethics: geoengineering, offsetting, and climate change mitigation. Section 3.3 outlines the agents assumed in these debates.

Geoengineering

Carbon dioxide removal has been featured in the discussion of geoengineering alongside solar radiation management (SRM). The Royal Society Report defined geoengineering as 'deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change' (2009: 1). The IPCC AR5 reflects this discussion on geoengineering and included in 2014, for the first and only time in an assessment report, a definition of geoengineering:

> Geoengineering refers to a broad set of methods and technologies that aim to deliberately alter the climate system in order to alleviate the impacts of climate change. . . Two key characteristics of geoengineering methods of particular concern are that they use or affect the climate system (e.g., atmosphere, land or ocean) globally or regionally and/or could have substantive unintended effects that cross-national boundaries. (IPCC, 2014: 123)

The discussion on geoengineering overall dates back some decades (for example, Jamieson, 1996), but these ideas were widely dismissed from modern science until the Nobel Prize winner Paul Crutzen reframed geoengineering in 2006 (Blackstock and Low, 2019). Crutzen urged that SRM, specifically the technique of sulphate aerosol injection (SAI) into the atmosphere, should be discussed, even though 'starting the discussion appeared to create a risk of distracting attention from the critical work of greenhouse gas mitigation' (Preston, 2016b: vii). He argued it was hopeless to wish for a steep decline in emissions and hope that geoengineering technologies would not be 'needed' to solve the climate crisis (Preston, 2016b: vii). This raised the question of a moral obligation to investigate geoengineering to prevent harm to vulnerable people and future generations (Betz, 2012; Gardiner, 2010c; Morrow and Svoboda, 2016).

Several challenges in the governance of geoengineering technologies have been discussed, especially following the publication of the Oxford Principles on geoengineering governance (Rayner et al., 2013). In the debate, special attention was drawn to a potential moral hazard: the argument that the existence of geoengineering methods could disincentivize agents from reducing their emissions (examples are Baatz, 2016; Gardiner, 2011; Hale, 2012; Lin, 2013; Morrow, 2014). This is probably the most pressing argument advanced against geoengineering.

Further, there are concerns that geoengineering technologies may become locked in (discussed in Preston, 2013: 28). It is due to the 'tendency of large research endeavours to create institutions that lead added support to deployment' (Gardiner, 2011: 167). This is further complicated by the danger of a termination shock, which might occur if the technology were no longer used. Hence, the challenge is how to end the activity once it has started (Preston, 2016a). Further, geoengineering technologies propose a technological fix to the climate crisis. Scott formulates the moral intuition behind this criticism as follows:

> In using technological fixes, we are avoiding important engagements in the world that ought to be required to solve a problem. Technological fixes can unburden us of efforts and interactions in the world that are morally significant, whether by developing virtues or promoting justice (Scott, 2019: 21).

Finally, Hale (2012) presents the hubris objection to geoengineering among 16 objections he formulates, basically as encouraging those engineering the climate to think of themselves as gods. It is important to note that most of these arguments focus on the example of the SRM technology SAI and exclude CDR technologies (Baatz, 2016; Blackstock and Low, 2019; Gardiner, 2010c, 2020). CDR technologies are perceived as less problematic in the cessation of the activity (Preston, 2016a) and for intergenerational equity (Burns, 2011).[13]

Overall, SRM and CDR technologies are very differently framed within the debate (McLaren, 2016). When discussed, CDR technologies are considered less morally problematic than SRM (Preston, 2013: 24). The technologies differ in some relevant respects, for example, their overall aim.[14] Given these differences and the lack of similarities that SRM and CDR technologies have with each other and not with other climate policies, the practice of treating SRM and CDR technologies within one climate policy category was criticized (Heyward,

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[13] However, a socio-technical lock-in may also occur for CDR technologies. See McLaren et al. (2019).

[14] CDR technologies aim to reduce GHG concentrations in the atmosphere. SRM aims to 'prevent climate change (or at least one key part of it) by keeping global temperatures stable, despite the increased GHG concentration' Heyward (2013: 26).

2013). In 2018, the IPCC noted that SRM and CDR technologies require separate treatment (2018a: 550). This calls for an investigation into the ethics of CDR technologies as such.

Despite these differences with SRM, the question remains whether CDR technologies are geoengineering. Defining CDR technologies as geoengineering assumes their implementation at a large scale. Small afforestation projects, for example, cannot be claimed to be 'large-scale manipulation of the planetary environment' (The Royal Society, 2009: 1) and correspond to the definition of 'mitigation' (Honegger et al., 2021a: 5) This turns the question of whether CDR technologies are geoengineering into a question of scale.[15] However, the term geoengineering no longer appears in the AR6 (cf. IPCC, 2023). Instead, the AR6 includes the definitions of CDR technologies cited in Section 1.1.

Offsetting

Besides occurring in the discussion of geoengineering, some CDR technologies like afforestation and 'blue carbon'[16] have been discussed under the label of carbon offsetting. The IPCC (2014: 1268) defines offsetting as the activity whereby 'a unit of CO_2-equivalent emissions is reduced, avoided, or sequestered to compensate for emissions occurring elsewhere'. At an individual level, 'offsetting your emissions means ensuring that, for every unit of greenhouse gas you cause to be added to the atmosphere, you also cause a unit to be subtracted from it. If you offset, on balance you add nothing' (Broome, 2012: 85). Here, I outline the debate on the ethics of carbon offsetting and argue that CDR technologies should be discussed on their terms.

Within the philosophical debate, some have presented offsetting as a duty of justice (Broome, 2012), but others have been extremely critical of this approach (Cripps, 2016). A range of moral arguments have questioned the permissibility of offsetting one's harmful acts for instance due to the challenges of introducing new risks by offsetting (Barry and Cullity, 2022), of whether simply removing a harmful situation is enough to make good a harm (Habib and Jankunis, 2016), and of what remedying a past wrong implies (Heyward, 2014a). Several moral objections to offsetting have been formulated, such as comparing offsetting to the practice of buying indulgences 'from the medieval church to absolve one's sins' (Goodin, 2010) or throwing a beer can into the Grand Canyon in return for a fee (Sandel, 2005). This seems morally objectionable as it contradicts moral values such as the protection of the natural environment. However, one thing that is often unclear in accounts of offsetting is what is being offset:

[15] In this, I disagree with Cox et al. (2018) that the main distinction between mitigation, SRM, and CDR technologies is in their scales, but rather in the aim they pursue. For further arguments, see Heyward (2013).

[16] 'Blue carbon' refers to the management of coastal wetlands that increases the biological storage of carbon dioxide in these regions. Smith et al. (2023).

CO_2 or harm. For some philosophers, the offsetting of emissions translates directly into the offsetting of harm, because they assume a more or less linear relation between the two (Broome, 2012). Others have more been interested in offsetting the harm caused by emissions more generally (Cullity, 2019). If this is the case, offsetting one's contribution to climate change may not only involve reducing emissions or removing carbon but also making payments to fund adaptation to climate change (Cripps, 2016).

Many services that provide carbon removal offsets offer credits from afforestation projects alongside credits from projects that avoid emissions, for example by providing people with more efficient stoves (Atmosfair, 2023). For example, afforestation has been framed as an offsetting of emissions as well as a CDR technology. The same is the case for reforestation projects and preserving forests. As a result of this broad conceptualization, much of the literature on offsetting has addressed the two forms of offsetting at once (for example, see Hyams and Fawcett, 2013). However, there are good reasons to theorize 'offsetting by forestalling', and 'offsetting sequestering' separately (Barry and Cullity, 2022: 354). In the latter case, carbon is removed from the atmosphere and stored by CDR technologies. Offsetting by forestalling and reducing or avoiding emissions is also called 'preventative offsetting', as carbon dioxide that would have been emitted is retained (Broome, 2012: 87). Essentially, offsetting by forestalling is emission abatement and hence different to emission removal.

There are good reasons to investigate the two kinds of offsetting in separation from each other. One complication of offsetting by forestalling is that even when all parties are well-intentioned and sincere, 'offsetting is only successful if it brings about an . . . reduction in GHG concentrations that would not have happened anyway' (Duus-Otterström, 2022: 10). Establishing this 'additionality' is notoriously difficult, so it is often unclear whether offsetting leads to genuine reductions as opposed to paying to avoid events that would not have happened either way (Hyams and Fawcett, 2013). This kind of offsetting only leads to additional emission reductions if people reduce their emissions beyond what they should have reduced anyway to meet their climate change mitigation duties. Basically, 'one could not discharge one's share by paying others to do what they should not have done anyway: one could only do so by paying others to go beyond the call of duty.' (Hyams and Fawcett, 2013: 95). Yet, even if additionality is established, another pressing moral concern is that offsetting results in a 'redistribution of harm'. Problematically, 'those [people] who ingest the molecules I discharge might not be the same people who would have ingested the molecules I extracted' (Barry and Cullity, 2022: 361). This is highly problematic in moral terms because 'an individual cannot generally justify harming person A by benefiting person B' (Cripps, 2016: 116).

CDR technologies in the discussion of offsetting raises old philosophical questions in a new way. Do actions to prevent harm have the same moral implications as actions to remedy harm? Should the first be preferred over the second? If so, why? These questions are important when evaluating the purposes for which CDR technologies can be undertaken. Recall that Fuss et al. (2020) suggested distinguishing residual CDR, which balances out residual emissions, from overshoot CDR, which balances out emissions that will have overshot the carbon budget.[17] The discussion of offsetting highlights that the terms in which carbon removal is discussed need to be addressed. One practical reason is that preventative offsetting is limited, and emissions reductions are insufficient to reach the goals of the Paris Agreement. To meet this challenge, the Oxford Offsetting Principles, on the governance of offsetting, call for a 'shift to carbon removal offsets' (Allen et al., 2022: 1).

Finally, carbon credits can be sold, bought, and thereby finance emission reductions elsewhere. Hence, they fall under the discussion of offsetting. It is hard to make the case that carbon trading, as required for offsetting, is always wrong for fairness reasons (Gosseries, 2015). However, offset markets and the international system of carbon credits as established by the Clean Development Mechanism in the Kyoto Protocol 'produce some questionable or even corrupt practices' (Duus-Otterström, 2022: 10). Voluntary offsets raise the question of compliance. For example, it can be questioned whether agents would buy offsets if they were more expensive (Spiekermann, 2014). I can only point here to discussions on the ethics of emission trading and carbon pricing (Caney and Hepburn, 2011; Espinosa-Flor, 2022; Page, 2013; Sayegh, 2019; Tank, 2022). The upshot is that there is disagreement about the ethics of both.

Climate change mitigation

Besides the discussion on geoengineering and offsetting, CDR technologies have been discussed in the climate ethics literature under the term of climate change mitigation (for example, Baatz and Ott, 2016: 93). Carbon removal has been seen in such close relation to the reduction of emissions that in some cases it has not been treated separately (Horton and Keith, 2016: 82). This section serves as a brief introduction to the vast literature in climate ethics on climate change mitigation. I only point to cornerstones of the discussion in the climate ethics literature on how the responsibilities to mitigate climate change should be distributed: three main principles and the fair share argument. I then argue that emission reduction and carbon removal should be treated separately from each other.

[17] Shue (2021) uses the terms 'enhancement CDR' and 'remedial CDR' respectively for these.

Distributing the costs and benefits of climate change mitigation raises concerns of justice, as does distributing responsibilities to undertake action. A key principle in the discussion on the burdens of climate change mitigation, be they to undertake action or to bear the costs of actions, is the polluter-pays principle (PPP). Those who had high emissions in the past should reduce their emissions now. They carry higher responsibilities to mitigate climate change due to their past and ongoing contribution to climate change than those who emit less and have emitted less. Approaches differ in how far historical emissions are taken into consideration. Often, the base year considered is 1990, as this is the year in which the scientific evidence on climate change was undoubtedly established with the publication of the first IPCC report. The PPP principle is especially important for carbon removal because the possibility of removing CO_2 emitted in the past opens new ways of holding emitters accountable, as I show below.

A second key principle is the ability-to-pay principle (APP), which establishes that responsibilities to ameliorate a harmful situation, such as climate change, fall to agents in proportion to their ability (Caney, 2005; Page, 2008; Shue, 1999). Hence, agents that have abilities such as resources and knowledge should contribute more to climate change mitigation. For example, 'economically powerful agents have duties to mitigate the harm done by the emissions activity for which they are responsible' (Cullity, 2020: 26). For carbon removal, this may imply that these parties have a responsibility to remove carbon or, at the current scale, advance research, and development to scale up carbon removal.

The third is the beneficiary-pays principle (BPP), which attributes higher responsibilities to those who have benefitted from emissions in the past and present, even though they may not have caused these emissions themselves (Baatz, 2013; Heyward, 2021; Page, 2012).

Fourth and finally, fair-share arguments feature in discussions of the fair distribution of the remaining carbon budget (Baatz and Voget-Kleschin, 2019). This also ties in with the discussion on equal-per-capita emission entitlements (Caney, 2009).

When distributing responsibilities to mitigate climate change, the question arises whether CDR technologies can substitute emission reductions and hence 'set aside or diminish the primary obligations for mitigation' (Baatz and Ott, 2016: 99). This is an important question, and I will address it further in the main parts of this dissertation. For now, we can note three important aspects of CDR technologies. First, CDR technologies could only substitute emission reductions if they can be considered 'as an almost perfect substitute' but this does not seem to be the case (Baatz and Ott, 2016: 100). There are at least two drawbacks. The first are sustainability concerns and feasibility constraints. As a result, CDR technologies bear certain risks, linked to the status of their development and their implementation. A second drawback is that

CDR technologies remove carbon after it has been in the atmosphere and contributed to rising temperatures. If this has caused harm, removing carbon does not repair this harm or the damage, it only prevents further harm. In this respect, CDR technologies are no substitute for reducing emissions. The second aspect that set CDR technologies apart from emission reduction efforts and that is specific for these technologies is that these technologies allow the carbon budget to be expanded as emissions are removed from the atmosphere. Thereby, CDR technologies change the discussion on the distribution of the remaining carbon budget. 'CDR technologies, if successful, enable retrospective action on levels of GHG concentrations' (Heyward, 2013: 25). Agents could take responsibility for their past emissions by accepting higher cuts of emissions and could remove their historical emissions by CDR. Third, with the help of CDR technologies, emission balances can become 'net negative'. This cannot be said for emission reductions, because once emissions are at zero, 'there is no further good that sort of action can do' (Habib and Jankunis, 2016: 72). This is morally relevant if the concentration of emissions in the atmosphere is already harmful. CDR technologies could be used to end this overshoot. Hence, what is important is that 'the key distinguishing feature of NETs [CDR technologies] is their ability to remove CO_2 from the atmosphere.' (Smith et al., 2015: 43). This marks a difference between CDR and efforts that avoid emissions. Although CDR technologies mitigate climate change, they should still be treated separately from policies that abate emissions.

In conclusion, CDR technologies have implications that cannot be fully addressed if it is subsumed within a broader category and alongside other measures. They seem to be the 'B-side', with the specific features being overlooked.

3.3 Agents and CDR technologies so far

Let's look at how agents have so far been included in three debates in which CDR technologies have featured: geoengineering, offsetting, and climate change mitigation.

Within the literature on geoengineering, there is often a reference to 'we'. Gardiner writes that 'we might end up facing a choice between allowing catastrophic impacts to occur, or engaging in geoengineering' (2010c: 1). Like many other authors contributing to the discussion on geoengineering, he uses 'we' to refer to the agents who could undertake actions or to whom the responsibility to geoengineer would apply. Similarly, Preston writes that 'either we never allow climate engineering to start in the first place, or we abandon the idea of climate engineering having a cessation requirement' (2016a: 103). Further examples of a generic 'we' facing choices about geoengineering can be found in Hale (2012), Jamieson (1996), Schneider

(1996), and Shue (2010). There is little tendency to specify the moral agents involved. Yet, 'the real question is not so much whether 'humanity' has reasons to do less mitigation but rather how SRM research will impact today's decision-makers: companies, governments, etc.' (Baatz, 2016: 31). The same is true of CDR technologies: the question is not whether humanity or 'we' as a generation do less mitigation but how the possibility of CDR technologies will impact the decision makers and especially those who have committed to a net zero target.

In contrast to the discussion on geoengineering, the discussion on offsetting has primarily focussed on individuals (Broome, 2012; Duus-Otterström, 2022; Spiekermann, 2014). The discussion on the ethics of offsetting considers what the permissible moral behaviour of individuals would be. States and corporations are rarely discussed, though states include measures for offsetting by forestalling in their climate strategies,[18] and corporations advertise their carbon neutrality. These actions need to be considered from an ethical perspective. Hence, the discussion on offsetting must be expanded beyond considerations of individuals as moral agents.

Finally, most of the literature on climate change mitigation focussed on 'the nature and basis of states' duties to reduce their emissions to mitigate climate change' (Umbers and Moss, 2020: 3). States 'policies on climate change are also substantially responsible for the contribution that their (and other) citizens make to the problem of climate change' (Moss, 2020: 45). This raises the question of justice how to fairly distribute the responsibilities for emission reductions or carbon removal between a state and individuals. Other agents, such as corporations, have not been much discussed (Umbers and Moss, 2020).

3.4 Conclusion on CDR technologies and agency in climate ethics

This section discussed the question of agency and the embedding of CDR technologies within the climate ethics literature. I first introduced ideas of assigning responsibility to individuals, states, corporations, and a generation. I then turned to the discussion of CDR technologies in the climate ethics literature. I have argued that there is a need to treat CDR technologies distinctively, as they are insufficiently treated when subsumed under the categories of geoengineering, offsetting, or climate change mitigation. As I have shown in the final part of this section, the discussions on CDR technologies consider various moral agents depending on the umbrella term under which they are discussed. Thus, an account of agents' responsibilities regarding CDR technologies is missing.

[18] For example, Switzerland is financing the electrification of busses in Thailand to reach its emission reduction objective. swissinfo.ch (2022).

4. Project: Differentiating Agents and Responsibilities to Remove Carbon

In this final section of the introductory chapter, I present my research project on the responsibilities of various agents to remove carbon. This section has four parts: First, I present the research gap and my research question (Section 4.1). Second, I give an overview of the main argument (Section 4.2). Third, I provide some insights into the theoretical background of this thesis (Section 4.3). Fourth, I outline the scope and assumptions of the thesis (Section 4.4).

4.1 Research gap and research question

Given the harms of climate change, it may be morally required to remove carbon from the atmosphere with CDR technologies. For this, as for other actions of climate change mitigation, we can ask, 'suppose that action on climate change is morally required. Whose responsibility is it?' (Gardiner, 2010b: 14). This question has yet to be answered for carbon dioxide removal. As I showed in Section 2.3, the current literature on the governance of CDR technologies does not provide much motivation to distribute responsibilities between different agents. A net zero target does not involve a commitment to 'any specific distribution of mitigation efforts between different actors' (Armstrong and McLaren, 2022: 521).

To distribute such responsibility to remove carbon under a specific target, it is necessary to know what moral responsibilities different agents have to remove carbon. The literature on climate ethics, as I showed in Section 3, does not provide a comprehensive treatment of CDR technologies. While research is growing on the climate change mitigation responsibilities of states, individuals, and corporations, none of these is yet clearly defined for CDR technologies. The literature on the ethics of CDR that exists so far is primarily concerned with role of states (examples include Fyson et al., 2020; McMullin et al., 2020). Yet, calls are rising to also consider the responsibilities of other agents, such as corporations, especially those who commit to net zero targets. As shown in Section 3.3, a comprehensive account of the responsibilities of individuals, states, corporations, and generations to remove carbon has yet to be offered. This thesis addresses this gap in the literature.

CDR technologies may influence the responsibilities to mitigate climate change of individuals, states, and corporations. However, the ethical challenges of CDR technologies outlined in Section 2 obscure moral agents' permissible use and potential obligations regarding CDR technologies from consideration and precise definition. How the challenges of CDR technologies play out differently for various agents has yet to be investigated systematically. Hence, this thesis aims to answer the research question: *What are the moral responsibilities of individuals, states, and corporations, to remove carbon dioxide?*

This thesis is part of a growing effort to theorize climate responsibilities beyond state agency and to theorize the responsibilities of individuals, subnational governments, nongovernmental organizations, and corporations (Moss and Umbers, 2020). Because of the urgency of climate change and the inaction of many states to undertake climate policies, the question arises what the responsibilities of these other agents are. Many non-state actors contribute significantly to climate change and have means to influence climate change policies (Moss and Umbers, 2020: 3). An important step in designing policies that build on the capacity of these agents to mitigate climate change is to conceptualise the responsibilities arising from these activities.

Some may object to the claim that responsibilities may differ according to the type of agent under consideration. In the following, I consider three objections and argue that when theorizing about responsibilities for carbon dioxide removal there are good reasons to distinguish between different agents and their respective responsibilities.

A first objection to the project of differentiating the responsibilities of moral agents is that we may derive the obligations of countries from the rights and responsibilities of their populations (Baer, 2010: 247). For example, we may argue that individuals are liable for contributing to climate change and hence, should undertake climate change mitigation action. The state's responsibility to act derives from these obligations. Hence, it is sufficient to theorize the responsibilities of individuals. My response is that we cannot read off the responsibilities of collective agents from the responsibilities of individuals. Instead, a state has responsibilities that do not arise for its populations.[19] These responsibilities may, for example, be linked to the capacities that states have but individuals do not.

A second objection is that the arguments made about one kind of agent, such as states, could be extended to apply to another kind of moral agent, such as individuals (Horton and Keith, 2016: 80). Hence, we do not need to theorize them separately. This objection can be addressed by appealing to the fact that the capacities that individuals and states have to remove carbon are very different, and these differences are relevant to assigning them responsibility.

A third objection foregrounds the capacities of moral agents and argues that agents are attributed responsibility by their ability to address the problem: 'all it takes to possess a climate duty is either economic power, or political responsibility, or the capacity for joint action' (Cullity, 2020: 26). If so, there is no need to theorize the climate change responsibilities of different

[19] For an explanation, see Section 3.1 on agents and responsibility in climate ethics.

kinds of agents; we could stay at the level of abstraction at which we assign them responsibilities by their capacities. I am sympathetic to this argument, but it also implies overlooking relevant differences in the contexts in which agents act. Assigning agents responsibility solely based on their capacities blends out differences in the normative basis on which responsibilities are assigned and agents are held accountable for not fulfilling their responsibilities. For example, the responsibility of states towards their citizens is different than the responsibilities of corporations to their shareholders or customers. Capacities are not the only relevant aspect in determining their responsibilities. These need to be considered if our conclusions and arguments aim at being action-guiding for policymakers.[20]

Hence, we have good reasons to investigate what the responsibilities of different moral agents here. Differentiating the responsibilities that agents hold to remove carbon is a step that foregrounds other considerations of how burdens should be distributed between these agents. This also considers the specific institutional set-up in which agents find themselves: individuals hold political responsibilities, states need to consider the well-being of their citizens while being committed to net zero targets, corporations may want to meet net zero targets but may have to be incentivized to scale up CDR technologies.

4.2 Overview of the main argument

This thesis contributes to the fast-changing research environment on CDR technologies (Minx et al., 2017). It is important to remember that CDR technologies are numerous and diverse, and whilst some ethical issues might be common to all of them, they do not all bring the same set of ethical problems. However, my overall argument is about CDR technologies and their governance, focussing on their key distinguishing feature of removing carbon from the atmosphere and storing it. I argue that states, individuals, and corporations all have a responsibility to remove carbon. In addition, they have responsibilities to ensure certain conditions of carbon removal, which may differ, according to the type of agent under consideration. These responsibilities to remove carbon interact with the responsibility to reduce emissions and I argue for how they should be balanced.

In the following, I summarize the argument of each chapter, thereby relating the different publications and submitted pieces which together comprise this dissertation. The overall argument made is that as we proceed from one agent to another, the responsibilities identified

[20] The capacities of different kinds of agents also interrelate with each other. For example, states can change the capacities of individuals to reduce emissions (see Chapter 2). Some corporations have know-how to up-scale CDR technologies, thereby expanding the capacities of all agents to remove carbon (see Chapter 4).

change. The second variable that changes over the course of the chapters are the assumptions about the feasibility of large-scale implementation of CDR technologies.

Part I: Responsibilities of Individuals to Remove Carbon focusses on individuals. In Chapter 1, I argue that individuals have a moral obligation to remove the CO_2 they emitted if it is possible for them to use CDR technologies under just conditions. This is based on the idea of liability for individual emissions and the no-harm principle. In addition to this direct responsibility for their emissions, individuals have a shared, political responsibility to ensure that carbon is removed that cannot be attributed to individuals. Their shared, political responsibility includes ensuring that CDR technologies are implemented at minimal ethical costs. This first chapter departs from the assumption that CDR technologies are available to individuals, hence avoiding an ought-implies-can objection the individual responsibility to remove carbon may face otherwise. It suggests that it is also the shared, political responsibility of individuals to bring about carbon removal at low ethical costs – and potentially to demand an up-scaling of CDR technologies. This raises two questions: First, how are responsibilities to scale up CDR distributed between the state and its citizens? And second, how can problems related to the potential up-scaling of CDR technologies be avoided? Especially the challenge of CDR technologies potentially undermining efforts of emission reduction needs to be addressed. This can be done by fixing the amount of permissible CDR and by carefully balancing the effects of large-scale CDR against the effects of emission abatement at large scales. These considerations motivate the arguments in Part II.

Part II: States and the Permissibility of CDR technologies examines the responsibility of states to remove carbon, and in particular the challenge of balancing emission reduction with carbon removal. Chapter 2 investigates the extent to which states can use CDR technologies to reach net zero targets. To meet net zero targets, policymakers assume the use of CDR technologies. This is an ethical challenge as the danger exists that states will forgo emission reductions and rely instead on CDR technologies later, the challenge of moral hazard. Hence, the chapter argues for a framework to determine a permissible target for CDR technologies. It argues that, first, CDR is impermissible for the current high emissions, which exceeds the emissions that individuals need for full membership in society. In many states, these emissions can be said to be mere luxuries and can be abated at costs that are not morally significant. For such emissions, the ethical costs of CDR cannot be justified. Second, CDR is only conditionally permissible for removing the emissions that individuals need for full membership in society. Wherever possible, emissions in this category must be lowered by structural emission reduction efforts. Third, it is permissible for states to use CDR technologies to address hard-to-abate emissions, and given their commitment to net zero, they have a moral obligation to do so.

The question remains how to balance the various measures, especially if emission reduction and CDR are both implemented at large scale. Chapter 3 focusses on this question. The chapter develops an argument about how to weigh large-scale mitigation against large-scale CDR technologies using the example of food security being endangered both by growing biomass for biofuels, a form of emission mitigation, and BECCS.

Hence, Part II addresses challenges surrounding the permissibility of implementing CDR technologies at potentially large scales. However, the feasibility of such implementation can be called into question. Implementing CDR technologies requires the engagement of corporations which will have to be incentivized and governed. Part III identifies various challenges that may arise and presents arguments on how to address them.

Part III: Corporations and Benefits from Carbon Removal discusses both the responsibilities of corporations to remove carbon and the conditions under which CDR technologies are permissible. Chapter 4 investigates a specific and important case in this context: For CDR technologies to include long-term carbon sequestration and storage (CCS), investment must be made in these technologies. This raises the dilemma of benefitting carbon majors by providing incentives for CCS. Here, the challenge is addressed that carbon majors will not comply with the moral requirement of reducing or removing CO_2 unless they are incentivized to do so, yet doing so raises concerns of justice about the unaddressed historical responsibilities of these corporations. The argument is that corporations can only permissibly obtain just benefits from CDR technologies if they account for their historical responsibilities of climate change.

Chapter 5 extends this argument to the use of CDR technologies for corporations overall and investigates the extent to which corporations may permissibly buy carbon removal credits to reach net zero targets. It focusses on corporations using BECCS to lower their carbon footprint. The key concern here is the cost of carbon removal, which is likely to be high if CDR technologies are implemented at large and unsustainable scales. The chapter discusses how to govern a market for carbon removal, given the sustainability limitations of implementing BECCS.

Having addressed the responsibilities of different agents while taking up the challenges that CDR technologies may raise, I turn in the last part to the proposal of dissolving the responsibilities of different agents into the responsibility of one generation. This investigation allows to discuss a more pessimistic view on the development of CDR technologies: the risk that they will not be implemented at all.

Part IV: A Generation's Responsibility to Remove Carbon? addresses the question of summarizing these agents within one generation and hence discusses the responsibility of the current generation for carbon removal. In Chapter 6, I comment on Henry Shue's book *The Pivotal Generation*. First, in agreement with Shue, I highlight that our generation overall is pivotal for how CDR technologies are brought about, which is also an entailment of the argument made in this thesis. Second, I highlight that in addition to Shue's presentation, our generation is also pivotal for CDR technologies being implemented at all. Third, I argue that we need an ethical discussion about the motive for CDR technologies, undertaking CDR technologies to save assets, which Shue dismisses. My final claim in this chapter is a synthesis of the previous arguments made in this thesis: to determine the responsibilities regarding removal, we require an approach that differentiates agents and their responsibilities.

The four parts are followed by a general discussion, where I draw my major conclusions, summarize my results, synthesize them, suggest directions for further research, and conclude.

4.3 Theoretical background

This thesis is a thesis in political philosophy, and more specifically within applied ethics. My focus here is on 'applied ethics, which attempts to determine moral responses to particular situations' (Cripps, 2013: 208). It is less about normative ethics, which 'investigates methods of determining whether an action or course of behaviour is moral (good or bad, right or wrong)' (Cripps, 2013: 208). I am interested in how carbon removal can be included in existing theories on responsibilities for climate change mitigation, theories that already indicate what agents should be doing about climate change. After all, 'climate change poses a unique challenge to our commonsense moral notions' (Jamieson, 2014: 161). The considerations in climate ethics go beyond questions of justice: 'When confronting the challenges of climate change … justice clearly plays a large role, but many would argue for the relevance of other kinds of moral consideration, including a recognition of the intrinsic value of the natural world. Climate ethics, one might say, includes more than justice' (Caney, 2021).

My account falls into what is called 'non-ideal theory'. John Rawls, who provided the first definition of the term non-ideal theory, described an ideal theorizing for distributive justice to be meeting the conditions of individuals and states acting in full compliance with the principles of justice; and favourable circumstances, such as the absence of feasibility constraints (Rawls, 1971). Non-ideal theory can investigate 'what an agent must do or is entitled to do in situations of partial, rather than full compliance, or when any (or all) of the favourable circumstances do not obtain' (Heyward and Roser, 2016: 6). In climate justice, there is a need to accommodate aspects such as noncompliance (Caney, 2016) and theorize about the least unjust options instead of merely about just options (Roser, 2015).

According to Valentini (2012: 654), Rawls' distinction between 'full-compliance theory' and 'partial compliance theory' is one of three distinctions we can draw in the debate on non-ideal theory. The second is between 'utopian or idealistic theory' and 'realistic' theory and discusses the question of whether and what sorts of feasibility constraints should constrain normative political theorizing. The third is between 'end-state' or 'transitional' theory, basically disagreeing on 'whether a normative political theory should aim at identifying an ideal of societal perfection, or whether it should focus on transitional improvements without necessarily determining what the 'optimum' is' (Valentini, 2012: 654).

All these three aspects are relevant to our theorizing on CDR technologies. First, one leading question is what obligations agents have in situations where there is only partial compliance with demands of justice. My theorizing on CDR technologies considers the failure of agents to abate emissions. Considerations of how to limit the danger of a moral hazard and agents forgoing their responsibilities to abate emissions, drive my arguments. We even may say that the ethical debate about CDR technologies overall arises because of the failure to abate emissions and a failure to comply with the moral duty of agents to not harm others through emitting excessively.

Second, the use of CDR technologies is entangled with numerous feasibility concerns: it is unclear to what extent the technologies can be scaled up, and whether they can effectively deliver the emission removals needed to reach climate targets. At the same time, there are feasibility constraints to the overall aim of mitigating climate change and efforts to abate emissions. In light of these, it is important to consider that '[i]t is not only the demandingness of duties that might change when shifting from an ideal to a non-ideal world but also the content of these duties.' (Heyward and Roser, 2016: 6). If the abatement of emissions is subject to feasibility constraints, this may not only increase the demandingness of duties to abate emissions today but may also change the content of these duties and include carbon removal. Hence, I do argue that feasibility constraints do matter for our normative political theorizing and discuss what sorts of feasibility constraints should matter.

Third, my account is non-ideal in the sense that I do focus on transitional improvements of the climate situation via CDR technologies, without arguing what the 'ideal' would be. The injustices arising from CDR technologies suggest that CDR technologies may only be justified in a transitional theory – not a desirable component in long-term climate policies.

There is a fourth point in which my theory is non-ideal: The aim of it is to provide the basis for policy-relevant arguments by advancing our conceptual understanding of CDR technologies. While the findings themselves may not yet directly be applicable to policy making, they contribute to a first understanding of the moral responsibilities of different agents.

It is because of this focus on the applicability of the arguments (or their role in establishing a first step in finding such answers) that I do focus on the responsibilities of different agents. For example, the question to what extent states should pursue climate change policies is being investigated intensively. Instead of aiming to arrive at a statement about how much CDR states should do, in chapter 2 we take the commitment of states to a net zero target as our starting point. This starting point of our ethical investigation makes it possible to link it to the policy setting that focusses on CO_2 and net zero targets. However, by assuming such a starting point, our investigation and proposal cannot claim to be more than non-ideal theory.

My underlying theoretical approach is pragmatist. Environmental pragmatism focusses on the methodology of inquiry, motivated to offer practical suggestions to environmental policymaking, and proposing 'a pluralistic moral stance capable of integrating the entire environmental community to engage a diversity of actors and disciplines in discussions of public environmental problems that demand ethical scrutiny' (Voisard and Wallimann-Helmer, 2023: 9). In my arguments, I emphasise the factors relevant to our ethical decision-making in each context. This also means to blend out other factors. This explains for example how I conceptualize the different agents in this thesis: I take individuals, states, and corporations to have moral responsibilities. I am aware that agency is constituted differently for these agents. Individuals are moral agents, and we can judge their behaviour morally right or wrong. Corporations are different, and they are not moral agents in the same sense as individuals. I take the position that we can assign responsibility to corporations as is done in every day and legal contexts. We may not investigate the morality of their intentions but can nevertheless be concerned with justice implications of them receiving benefits (as Part III then investigates). However, besides this focus on non-ideal theory, the method of reflective equilibrium plays a role, which aims at establishing a theory of justice. This method of analytic political philosophy introduced by John Rawls (1971) tries to establish a coherence between theories in the background and moral principles and considered judgements about specific cases. In general terms, a reflective equilibrium is 'the end-point of a deliberative process in which we reflect on and revise our beliefs about an area of inquiry, moral or non-moral' (Daniels, 2020). Because of this pragmatic focus and aim of being policy-relevant in a non-ideal setting, I am hesitant to commit to one specific normative background theory. I use the method of wide reflective equilibrium when I argue that current theories of climate change mitigation responsibilities of individuals include a responsibility to remove carbon, to satisfy the no-harm principle, a 'cornerstone' of common-sense morality (Cripps, 2022: 18). I do not aim here to present a full theory of justice. Rather, I present a theory regarding the responsibilities of diverse moral agents for carbon removal. I aim to provide arguments that can inform decisions on how CDR technologies are governed.[21]

4.4 Scope and assumptions

This thesis sets out to investigate the moral responsibilities of different agents to remove carbon dioxide from the atmosphere. Providing these accounts has multiple benefits. However, before pointing out what these are, I must note seven points on the scope and assumptions of this thesis. Other limitations on my arguments are introduced at the beginning, mentioned in the discussions of the various parts, or taken up in the overall discussion.

First, although there are practical implications to be drawn from this thesis, it is primarily intended to advance our conceptual understanding. I do not provide empirical insights into the discussion of CDR technologies in different countries, the weighing of different CDR technologies against one another in one specific context, or guidelines for policy in accounting for carbon removals. Instead, this thesis contributes to the conceptual and moral debate on climate politics, with the aim of advancing these discussions by making policy relevant contributions.

Second, given the fast-developing landscape on CDR technologies, I decided to vary my assumptions on the status of CDR technologies. For example, in Chapter 1, I assume that CDR technologies can be made available to the individual. In contrast, in Part III and IV, I address the challenge of scaling up the technology to the extent that is needed to mitigate climate change. Making different assumptions about the status of the development of CDR technologies also helps in investigating the most pressing moral challenges for the agents.

Third, overall, I assume that CDR technologies can, if applied well, be an effective way of mitigating climate change. This means that I do not question the technological details of the various measures that are subsumed under the term here. Some of my findings rely on the current development of CDR technologies. Technological developments affecting the costs of emission reduction and removal, dependence on fossil energy, and social standards all change over time. However, the underlying theoretical, moral, and philosophical argument I present applies to different developments.

[21] Chapter 3 stands out, as it is the only chapter that explicitly uses one ethical approach, namely principlism. I am not committed to the principlist approach. In the context of this thesis, it illustrates one way of trying to answer a policy relevant question: how to balance emission reductions and removals.

Fourth, as highlighted already, CDR technologies subsume many kinds of technologies, and whilst some ethical issues might be common to all of them, they do not all raise exactly the same set of ethical problems or raise exactly the same governance challenges. This thesis is limited in its scope of addressing these in depth. However, some elements of the thesis focus on specific CDR technologies: Chapter 3 and Chapter 5 focus on BECCS, and the discussion on carbon majors and the geological storage of CO_2 in Chapter 4 is most relevant for CDR technologies such as BECCS and DACCS that rely on the geological storage of carbon dioxide. The choice of BECCS is a practical one: not only is it the technology most often included in climate models, but it also combines most of the concerns we also encounter for other CDR technologies: for example, challenges linked to the use of land and freshwater are similar to afforestation; and the dependence on storage infrastructure the same for DACCS. Other parts treat CDR technologies as a monolith, for example, Chapter 2 and to some extent Chapter 6. This is done deliberately to contrast carbon removals with emission reductions and to analyse implications of their specific feature of removing carbon from the atmosphere.

Fifth, my use of the term 'mitigation' is not consistent across all publications. I use 'mitigation' to refer to only emission abatement, not to removing carbon in Chapter 3. In newer elements of the thesis, I refer to 'emission abatement' or 'emission reduction' instead. Climate change mitigation subsumes emission reductions and carbon removal.

Sixth, I discuss the capturing and storage of carbon (CCS) in relation to CDR technologies but not as a technology by itself. This is because CCS not a CDR technology, but emission abatement. Whether the CO_2 had been released into the atmosphere does not matter for CCS.

Seventh, though the thesis is on moral agents generally, I focus on individuals from affluent societies; on industrialized states, though not necessarily democratic; and on carbon majors. I note in other chapters how dropping this focus might influence the findings we have, for example in Chapter 3 on countries where food security may be undermined due to climate change mitigation efforts. In Chapter 5, I discuss the role of corporations overall.

Finally, many arguments have pointed to a 'duty' of individuals to mitigate climate change, including to mitigate their carbon footprint arising from a duty not to harm others (e.g., Collins, 2017, 2020; Cripps, 2013, 2021). Others refer to a 'responsibility' to mitigate climate change (examples are Burri, 2020; Keij and van Meurs, 2023) or a 'responsibility' for climate harms (Cullity, 2019). Agents may be duty-bearers in the sense that they should not harm others with their emissions. For climate justice, we can identify duty-bearers, such as individuals, who have a duty to fulfil their responsibilities (Caney, 2014). I argue here for a responsibility to remove CO_2 from the atmosphere that originates from such a duty.

Part I: Responsibilities of Individuals to Remove Carbon Dioxide

Introduction

The individual is the first agent to consider when we are investigating moral responsibilities for carbon removal. This is because individuals are moral agents and can bear moral responsibilities. However, individuals are constrained in their actions in several ways. Given the challenges of developing and up-scaling CDR technologies, individuals may simply not be able to remove carbon. The question arises what responsibility individuals have for removing carbon. If individuals cannot remove carbon, they cannot be responsible for doing so. To avoid this 'ought implies can' objection, I begin Chapter 1 with the assumption that CDR technologies will become available to individuals, as they are scaled up by states. If we assume that the large-scale removal of carbon is possible and hence, in theory, all individuals could remove carbon, the question is what this implies for the climate change mitigation responsibilities of individuals. Throughout the chapter, I weaken this assumption and discuss the implications of doing so. I argue that individuals hold not only direct responsibilities to remove carbon but also have shared political responsibilities to remove carbon and for the circumstances of how CDR technologies are implemented. This then raises the question what responsibilities individuals hold to contribute to the net-zero target of the state they live in. I do address this question in Part II.

The paper 'Individuals' Responsibilities to Remove Carbon' on which Chapter 1 is based was published on 21 September 2023 in *Critical Review of International Social and Political Philosophy (CRISPP)*. It was authored solely by me.

Status: Published in Critical Review of International Social and Political Philosophy, *September 2023, pp. 1-21.*
DOI: 10.1080/13698230.2023.2260241

Chapter 1: Individuals’ Responsibilities to Remove Carbon

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Abstract

The potential upscaling of carbon dioxide removal (CDR) technologies to meet states’ net-zero targets may enable individuals to remove emissions by purchasing carbon removal certificates. In this paper, I argue for two concepts of individual responsibility to capture the moral responsibility of individuals to remove carbon dioxide from the atmosphere through CDR technologies. The first is that of liability, a direct responsibility to remove carbon in order to minimize one’s carbon footprint. The second is a shared political responsibility to remove carbon that individuals have by virtue of being part of weak collectives responsible for mitigating climate change or by virtue of participating in structures that contribute to climate change. I argue that the concept of shared political responsibility can be used to determine how CDR technologies should or should not be implemented. Finally, I discuss how these two responsibilities are related.

Keywords: individual responsibility, carbon footprint, Iris Marion Young, Elizabeth Cripps, carbon dioxide removal.

1. Introduction

In September 2021, the ‘world’s largest climate-positive direct air capture plant’, designed and built by the Swiss company Climeworks, entered service in Iceland (The Economist, 2021). The company engages in carbon dioxide removal (CDR) with a technology known as direct air carbon capture and storage (DACCS), whereby carbon dioxide is removed from the air and stored permanently in geological formations. Individuals can purchase carbon dioxide removal certificates on the company’s website and thus remove carbon dioxide from the air (Climeworks, 2021)[1] Using services like this, individuals could minimize their carbon footprint not only by reducing their emissions but also by removing carbon once emitted. For example, they can already reduce their emissions by taking the train rather than the plane from London

[1] In this paper, I use the term ‘carbon’ as short for ‘carbon dioxide’; I use the term ‘emissions’ as short for “carbon dioxide emissions”; and when I write that individuals should remove their emissions, I mean that they should remove the same amount of carbon dioxide as they emitted, not the same molecules of carbon dioxide.

to Edinburgh. The train ride will create far fewer emissions than the flight. But it will nevertheless create some. Then, by buying carbon removal certificates from a company that removes carbon from the atmosphere, the traveller could reduce the total carbon dioxide emitted by their journey to zero or even beyond.[2] Reducing emissions is argued to be part of the responsibility that individuals bear to mitigate climate change. But given the current limited capacities for removing carbon, we may argue that today it is not an individual's responsibility to remove carbon. After all, individual responsibilities are relative both to the control that individuals have and to the current state of technology (Seager et al., 2011). Although CDR services are offered today, they cannot account for all the carbon individuals currently emit.

But the net-zero targets of various states will very likely lead to the expansion of market-based mechanisms for removing carbon by CDR technologies (Sayegh, 2019). The various commitments of countries and companies to reach net-zero emissions by 2050 rest not only on assumptions of rapid and deep decarbonization but also on the development and upscaling of CDR technologies and industry to make large-scale carbon removal available by mid-century (McLaren et al., 2019; Peters and Geden, 2017; Schreyer et al., 2020). CDR includes 'activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, and oceanic reservoirs and in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage' (IPCC, 2018a: 24). These include growing biomass by, for instance, afforestation, reforestation, plankton growth, and planting mangroves. The category of CDR includes measures such as planting biomass for bioenergy and storing the CO_2 subsequently captured in geological reservoirs, termed bioenergy with carbon capture and storage (BECCS), and the capture of CO_2 directly from the air and its storage in products and geological reservoirs, termed direct air capture and carbon storage (DACCS). All of these raise ethical questions, but the extent to which they imply ethical challenges depends on the precise technology and context of implementation under question.[3]

The feasibility of scaling up CDR technologies is a main concern raised about climate policies that rely on CDR (Lenzi, 2021; Shue, 2021). Yet, if CDR technologies are implemented at a large scale by mid-century and purchasing carbon removal certificates becomes widely accessible to individuals, this will have implications for individuals' responsibility for climate

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[2] If more emissions were removed than emitted, the emissions from this trip would be net negative. This possibility of doing good by removing more carbon than one has emitted could be theorized further from a moral perspective. But because avoiding harm usually takes precedence over doing good, I will focus here on avoiding harm and achieving net-zero emissions.

3 I focus on afforestation, BECCS and DACCS. These three technologies are the ones most widely researched and argued to have the greatest potential Sovacool et al. (2023).

change mitigation. In this paper, I investigate whether individuals have a responsibility not only to reduce their emissions but also to remove carbon by purchasing certificates from CDR technologies. I argue for two responsibilities of individuals to remove carbon: the direct responsibilities of individuals to remove carbon, which is part of their duty to minimize their carbon footprint, and the shared political responsibility that individuals have for ensuring that this removal is done at low 'ethical costs' (Lenzi, 2021).

I begin by investigating how the possibility of CDR technologies changes individuals' responsibility for the carbon they emit (Section 2). I show how arguments for a duty to minimize individuals' carbon footprints include a direct responsibility for individuals to remove carbon. Secondly, I turn to two challenges that require the extension of individuals' responsibilities beyond their carbon footprints: to ensure that carbon is removed for which no individual carries a direct responsibility, and to ensure that the ethical costs of carbon removal are minimized. To address these challenges, I draw on an account of shared political responsibilities by Elizabeth Cripps and another by Iris Marion Young (Section 3). Thirdly, I explain how the two responsibilities to remove carbon are related (Section 4). Then I conclude (Section 5).

2. Individuals' direct responsibility to remove carbon

In this section, I argue for a direct responsibility of individuals to remove carbon. With the current high concentration of carbon dioxide in the atmosphere, we can consider emissions caused by individuals to be a waste product that potentially creates severe harm. The basic claim for an individual's responsibility to reduce their carbon footprint to zero rests on the argument that individuals cause emissions, that these emissions cause harm by contributing to climatic change, and that individuals can be blamed for this harm. When we consider a specific action, such as taking a flight, and determine how much carbon must be removed to avoid contributing to climate change, we apply the concept of 'responsibility as liability'. This model of responsibility assumes liability for the harm caused by individuals and implies that individuals can be causally related to the harm their actions cause and blamed for that harm (Young, 2011: 97).[4] The underlying moral principle is that it is wrong to do serious, foreseeable, avoidable harm to others (Cripps, 2022: 18).

John Broome has made the case for offsetting, which includes removing carbon, arguing that the duty to not harm others with your emissions requires individuals to avoid any net

[4] For Young, both the standard frameworks of both moral and legal responsibility are based on the 'liability model', relying on causal contribution and blame. In the following, 'liability' is used as a term of art referring to moral liability, not legal liability Young (2011: 97–98).

emissions of greenhouse gas at all: 'You cannot live your life without causing any emissions, but you can easily cancel the emissions you do cause by offsetting them' (2012: 14). This is a 'direct duty' because fulfilling it means mitigating harm directly (Cripps, 2013: 140) by reducing or removing emissions. Hence, individuals are directly responsible for reducing and removing their emissions, and thus, overall, for reducing their carbon footprints to zero.[5] Under the term 'offsetting', we can distinguish between offsetting that removes carbon from the atmosphere, the purpose of CDR technologies, and 'preventative offsetting', which prevents carbon that would have been emitted from being emitted (Broome, 2012: 87).[6] Broome argues for offsetting overall, but there are morally relevant differences between paying others to emit less and removing carbon. For example, it is difficult to justify how paid emission reductions go beyond what agents should have done anyway (Hyams and Fawcett, 2013: 95). Further, arguments for a responsibility for preventative offsetting are limited to cases in which agents are able and willing to emit less if they are paid to do so. Once emissions have been reduced to this level, carbon removal is needed to account for surplus emissions. Finally, the carbon already accumulated in the atmosphere cannot be addressed by emission reductions. The latter two arguments are especially relevant for carbon removal on the collective level. For these reasons, I focus in my argument on removing carbon.

With this focus on carbon removal, I take Broome's account as a starting point for my argument for a direct responsibility to remove carbon. I begin with the discussion of his account and a direct responsibility of individuals to minimize their carbon footprint. Then, I turn to two objections to the claim that individuals should reduce their carbon footprint to zero. Finally, I discuss whether carbon removal can remedy past harm and compensate for the failure to reduce emissions.

The first objection to Broome's account and a direct responsibility of individuals is that it singles out individuals for having caused harm with their emissions. Sinnott-Armstrong (2005) famously argued that individuals are under no moral responsibility to reduce their emissions as each can claim that global warming 'is not *my* fault': Harm from climate change is not something for which we can hold any individual morally responsible when their emissions alone have no significant effect and climate change would also have occurred in the absence of their contribution to it. One may submit to the 'no-effect view', which suggests that the

[5] Various concerns and challenges exist regarding the accounting for carbon removal Brander et al. (2021). For the purpose of my argument here, I assume we can account for carbon emissions and their removal.
[6] Alternatively, Barry & Cullity distinguish 'offsetting by sequestering' and 'offsetting by forestalling' (2022: 354). I focus here on 'offsetting by sequestering'.

reduction of one's carbon footprint has 'no effect or an effect so vanishingly small that is it not of moral significance', and as a result one has no duty to change one's behaviour (Schwenkenbecher, 2014: 176). But a direct duty to reduce or remove emissions motivated by the no-harm principle requires that fulfilling this duty is effective in counteracting this harm. If the removal of emissions has no effect, there is no duty to remove them. As a result, individual duties are solely political: 'It is better to enjoy your Sunday driving while working to change the law so as to make it illegal for you to enjoy your Sunday driving' (Sinnott-Armstrong, 2005: 312).

Broome objected to this, arguing that every increase in emissions can be linked to an increase in climate change harm (Broome, 2012; Nolt, 2011). Unfortunately, this argument relies on a more or less linear relationship between emissions and climate change harm. This has been criticized by pointing, for example, to tipping points in the climatic system. At such tipping points, a small increase in temperature caused by a small amount of additional emissions accelerates climate harm much more than any previous amount of emissions. Rather than relating to climate change harm directly, emissions contribute to climate change and increase the expected harm (Burri, 2020; Cripps, 2021).[7] This argument provides grounds for a direct responsibility of individuals to minimize their carbon footprint.

Another way of dealing with the no-effect view is by arguing that difference-making is not the relevant criterion for establishing a moral relationship between individuals and the harms they cause (Nefsky, 2015) and that 'an act can play a non-superfluous part in changing the outcome, even if it is not itself sufficient to make a difference (Nefsky, 2019: 3). Alternatively, one may argue for a duty to reduce emissions because one should do one's fair share to mitigate climate change (Baatz, 2014). Overall, several responses to Sinnott-Armstrong's account have argued for a duty to minimize carbon footprints (Broome, 2018; Burri, 2020; Cripps, 2013, 2021; Cullity, 2019; Schwenkenbecher, 2014).

I take these arguments to provide firm foundations for the direct responsibility of individuals to minimize their carbon footprint. However, even among those who accept a duty of individuals to minimize their carbon footprints, the standard view is that nobody is required to reduce it to zero. Two objections have been made to the claim that individuals should reduce their carbon footprint to zero: the entitlement objection and the demandingness objection. In the following, I show that if carbon removal is added to the mix of possible actions to minimize the carbon footprint, both objections lose force.

[7] Broome (2018) revised his arguments, moving away from this linear presentation, but still argues that individual contributions make a difference to climate-change-related harm.

The entitlement objection to a duty to reduce carbon footprints to zero is that individuals are entitled to a certain amount of emissions. Such an entitlement could be a fair share of a carbon budget or an entitlement to a threshold of well-being that is connected to some emissions, such as subsistence emissions (Caney, 2012; Shue, 2019). Yet, the entitlement objection does not hold for carbon removal because 'people can and often do have a duty to make up for emitting even though emitting was morally permissible' (Duus-Otterström, 2022: 6). In the case of subsistence emissions, people may be permitted to produce them, but this does not necessarily exempt them from responsibilities for carbon removal, because 'it does not follow conceptually from the fact that an act was morally permitted that it could not lead to corrective duties' (Duus-Otterström, 2022: 7). If carbon can be removed, the necessity of emitting carbon is decoupled from an entitlement to cause harm. For instance, an individual may be entitled to perform activities that produce waste, but we still blame them for not disposing of their waste correctly. To ensure that their emissions do no harm, the individual can not only avoid producing them but also ensure that they are removed from the atmosphere.

The demandingness objection is that the severe cuts in emissions necessary to achieve this would likely be overly demanding for the individual (Baatz, 2014; Cripps, 2021). This objection to the reduction of individuals' carbon footprints argues that 'we cannot be required to make such a substantial effort, because we can have moral duties to act in certain ways only if we do not have to sacrifice something of comparable moral importance in order to comply with that duty' (Schwenkenbecher, 2014: 180). If reducing their carbon footprints to zero is too demanding, individuals cannot be blamed for the harm their emissions cause. The demandingness objection must be carefully reassessed given the feasibility of carbon removal. If carbon removal is possible, individuals do not have to reduce their emissions to zero. Instead, individuals can make payments and remove carbon to balance out any emissions that cannot be avoided. They still need to change habits that are fossil-fuel driven, because of limited capacities of CDR technologies and their negative side-effects, which I discuss below. But they do not need to give up basic standards of well-being to eliminate their carbon footprints. Hence, reducing their carbon footprint to zero is much less demanding.

Thus, if carbon removal is possible, both the entitlement and demandingness objections weaken. We can argue that individuals should reduce their carbon footprint to zero, which includes a direct responsibility to remove carbon. This direct responsibility to remove carbon, like the responsibility to reduce emissions, is motivated by the no-harm principle.

The direct responsibility to remove carbon also can be motivated by the responsibility to remedy a harm that was created by emissions one failed to reduce – something emission reductions cannot achieve. We may demand that people remove carbon they emitted in the past because they failed to fulfil their duty to reduce their emissions. Individuals can be morally required to assist in remedying harms even at great cost to them if they have previously failed to discharge duties (Cordelli, 2018). In many cases, the harm through these emissions could not have been avoided by individuals, nor did individuals know that their actions created harm. But individuals can have reasons and even duties to rectify a situation even when they were not responsible for creating it. This applies to emission removal (Duus-Otterström, 2022) and is closely congruent with the idea of being liable for the harm caused by one's actions. This responsibility to 'clean up your mess' falls on those who have failed to fulfil their responsibility of not causing any unnecessary harm (Shue, 2017b: 593). Carbon removal is a way of cleaning up the mess of harmful high concentrations of carbon in the atmosphere. One important drawback to the idea of offsetting harm by carbon removal is the timing of offsetting (Duus-Otterström, 2022: 10): Carbon emissions are balanced out after they have already been made, meaning that while carbon is removed, the harm it contributed to in the meantime is not remedied. Hence, the claim that carbon removal can remedy past harm is somewhat compromised. However, this does not mean we should abandon the idea of removing carbon altogether: Harm is reduced if carbon is removed that would otherwise remain in the atmosphere for hundreds or even thousand years, continuously contributing to climate change.

This direct responsibility to remove carbon may meet a concern of overdemandingness. Surely, if carbon removal is expensive, some individuals may be exempt from fulfilling this responsibility because they have to fulfil other morally important needs. Like emission reductions, a responsibility to remove emissions cannot go beyond of 'what can reasonably be demanded' of individuals (Baatz, 2014: 10). But if carbon removal is cheap, individuals are morally required to remove emissions, as they are morally required to minimize the negative effects of their actions if they can do so at low costs (Burri, 2020). Importantly, it is not clear whether carbon removal will be expensive or cheap in a scenario in which CDR technologies are available to individuals. Estimates for the costs of CDR technologies differ widely (Fuss et al., 2018). As CDR technologies are scaled up, prices may fall, but once the scarcity of CDR technologies due to the limited availability of land and water becomes apparent, prices may increase again. Given these uncertainties, we can conclude that if individuals can remove carbon, they should do so unless it exceeds what can reasonably be demanded of them.[8]

[8] I rely here on the argument Cripps (2021) provides for the demandingness of emission reductions for individual.

Importantly, a responsibility to remove carbon does not compromise a responsibility to reduce carbon emissions. Even though emission reduction and carbon removal both reduce carbon footprints, one is not simply a replacement for the other. Emission reduction and carbon removal have different motivations: reducing emissions means avoiding exacerbating the problem of climate change, whereas carbon removal aims to remedy the situation by removing carbon from the atmosphere so that it stops contributing to climate change (Heyward, 2013: 25). Because individuals are liable for their emissions, they have moral reasons to do both. Further, there are pragmatic grounds for favouring emission reductions over carbon removals, as in most cases it is much easier and cheaper to avoid emissions than to remove carbon, and emission reductions providing co-benefits which many CDR technologies do not provide (Fyson et al., 2020). CDR technologies entail ethical costs that must be weighed against the ethical costs of reducing emissions, as I discuss in Section 3.

Thus, I have argued that if CDR technologies are available, individuals are directly responsible for removing carbon because individuals ought to reduce their carbon footprint to zero to avoid causing harm through their emissions. This account of direct responsibility rests on the claim that individuals are liable for their emissions. Hence, the availability of CDR technologies can strengthen the responsibilities of individuals for the carbon they produce: the responsibility to remove carbon is added to the responsibility of individuals to reduce their emissions.

3. Shared political responsibility and carbon removal

So far, I have argued for a direct responsibility of individuals to remove carbon based on liability for their emissions. In this section, I argue that individuals' responsibilities for carbon removal go further because focus on liability has two important drawbacks. The first drawback is that there are large amounts of emissions that no individual is liable for and hence no individual has any direct responsibility to remove them. However, the carbon resulting from these emissions may well have to be removed, and the question is what responsibilities individuals have to do this. The second drawback is that a direct responsibility to minimize the carbon footprint cannot account for the implications of implementing CDR technologies. Some CDR technologies, especially if implemented at a large scale, will have ethical costs, such as introducing negative side-effects, endangering sustainability, and distributing these side-effects unjustly (IPCC, 2018a; Lenzi, 2021; Shue, 2017a). The concept of direct responsibility to remove carbon does not provide an answer to how individuals should consider aspects of the distribution of harm introduced by side-effects. In addition to arguments for reducing harm, we also need to include considerations of fairness and justice about how the ethical costs should be distributed.

These drawbacks lead me to argue for a shared political responsibility to remove carbon in this section. I do so by building on the approaches of Elizabeth Cripps and Iris Marion Young, who argue for such a shared political responsibility. Their views differ about how individuals acquire such a responsibility and what the exact nature of such a responsibility is. Yet, both ascribe a shared political responsibility to individuals to act with others: Cripps argues that individuals have 'cooperative promotional duty' to 'act together with motivated others, so far as possible at reasonable cost to oneself, to promote fair, efficient, effective global-level progress on climate change mitigation and adaptation' (Cripps, 2020: 102). Young argues that individuals are under an obligation to 'join with others … to transform the structural processes to make their outcomes less unjust' (Young, 2006: 96).

I begin by addressing the challenge of removing carbon that no individual is directly responsible for removing by proposing the idea of shared responsibility. Secondly, I use these approaches to shared political responsibility to determine how different CDR technologies should or should not be implemented.

3.a Sharing responsibility to remove carbon

The idea of direct responsibility cannot extend the responsibility for carbon removal to carbon that cannot be attributed to the activities of an individual in a way that finds the individual liable. Take the example of emissions from the public transport system in the city where I live, which I use sporadically. The emissions from the transport system could be attributed to me and my carbon footprint calculated to include the number of rides I take and how many emissions each of these creates. However, there are emissions that the overall system creates, such as the night buses that drive almost empty. They are an essential element of public transport provision. We could divide the amount of carbon emitted in proportion to the number and length of rides individuals take. But such a division would not correspond to the idea that I am liable for these emissions in the sense that I caused them and can be blamed for them causing harm. My emitting activities are mediated and constrained through structures, such as the public transport system. Rather, to account for these emissions and assign the responsibility to remove carbon, we need an account of shared responsibility. This 'shared responsibility is a personal responsibility for outcomes, or the risks of harmful outcomes, produced by a group of persons'

(Young, 2006: 122). This responsibility falls on the individuals themselves and is shared with others in the group or collective.

In the case of the public transport system, the city's inhabitants can be held collectively responsible for removing carbon. But this is not the case with climate change, for which the collectives that could act are only weakly defined. Here, the responsibility is shared between the individuals that make up such weak collectives. In the case of climate change, potential collectives are the polluters, the able, and the young (Cripps, 2013: 59). Cripps argues that individuals who are part of these weak collectives have 'duties to attempt to bring about the necessary collective action' (2013: 140). This includes 'organiz[ing] as necessary to act on mitigation, adaptation and compensation' (2013: 197).

We can also argue that individuals acquire a shared responsibility to reduce emissions and, in addition, to remove them because of their participation in structures that contribute to climate change. In Iris Marion Young's model of responsibility, individuals who participate in structures that produce unjust outcomes have a shared political responsibility to change these structures to make their outcomes less unjust (2006, 2011). The concept includes both material structures such as highways and formal and informal rules-based structures that shape how individuals interact, such as social norms. Structures include transnational processes such as financialized capitalism that have both national and global effects on individuals. All these structures exist because people act and interact, producing and reproducing these structures unintentionally (Young, 2011: 53–55). Responsibility for the structural injustice that occurs is shared between individuals. Young's approach to responsibility for contributing to structural injustice has been applied to climate change in multiple ways, and arguments for climate change mitigation have appealed to Young's concept of social connection to assign a shared political responsibility to transform unjust structures (Godoy, 2017; Larrère, 2018; Sardo, 2020). Here, climate change is conceptualized as a structural injustice to which individuals contribute through their emissions. Based on this, individuals should 'join with others … to transform the structural processes to make their outcomes less unjust' (Young, 2006: 96).

What does this idea of shared responsibility imply for carbon removal? We can use Young's approach to justify why we hold individuals responsible for removing carbon emitted by structures: Individuals can be ascribed a responsibility to remove carbon because it is the product of the structures in which the individuals participate. The outcome of these structures is unjust because carbon contributes to climate change. The responsibility to remove carbon is shared between the individuals who participate in these structures. Importantly, Young's appeal for the transformation of processes that produce unjust outcomes does not depend on a backward-looking idea of having to account for the carbon emitted. It is a forward-looking responsibility that requires collective action targeting the structures that produce unjust outcomes. I share the responsibility to remove the carbon emitted by the transport system in which I participate with all other passengers. The removal requires collective action, because no individual alone can bring about the scaling-up of CDR technologies needed.

Using Cripps's approach, it could be argued that individuals have a shared responsibility to remove carbon based on their belonging to one or several of the weak collectives relevant for climate mitigation. The responsibility to remove carbon could be justified differently for the three weak collectives: The polluters may have a responsibility to remove the carbon they emitted because they are 'required to act together . . . in compliance with a collectivized no-harm principle' (Cripps, 2013: 197) or to clean up their mess (Shue, 2017b: 593). The able 'have a duty to organize to act collectively on mitigation and adaptation, defended by appeal to a moderate version of the collectivized principle of beneficence' (Cripps, 2013: 197). Having the possibility to remove carbon that cannot be attributed to individuals, the able may be responsible for doing so. Finally, the young may also have a self-interested responsibility to remove carbon to complement other efforts to mitigate climate change.

Thus, both approaches can provide arguments why individuals have a shared responsibility to remove the carbon for which no individual is directly responsible. Individuals have a shared political responsibility due to their membership in weak collectives that carry responsibilities for climate change mitigation or because they participate in structures that contribute to climate change. This may justify individuals undertaking collective efforts to remove carbon.[9] Yet, whichever of these approaches is applied to carbon removal, several challenges must be considered in the implementation of various CDR technologies, as I show in the next section.

3.b Political responsibility for carbon removal

I have shown how Cripps's and Young's arguments can both be used to account for carbon in the atmosphere for which no individual is directly responsible and for which a shared responsibility arises to undertake collective action. In this section, I turn to how their accounts can be used to argue about how carbon should be removed. Unfortunately, some CDR technologies and scales of their implementation will come at an 'ethical cost' (Lenzi, 2021) by

[9] One may object that carbon removal does not require collective action. If I am very rich, I may simply pay a lot of money and remove a lot of emissions, which does not require any collective action. However, collective efforts are needed to scale up CDR technologies. This cannot be achieved by individuals alone. In the introduction, I have related the scale up of CDR to the action of states that set net-zero targets, but if we drop this assumption, it may be up to individuals to push their governments to take the steps needed to reach these targets.

introducing negative side-effects and by distributing these side-effects unjustly.[10] We may hold individuals directly responsible for the harm caused by the negative side-effects of implementing CDR technologies. In addition, arguments are needed for how the risks, negative side-effects, and benefits of CDR technologies should be distributed. I show in this section that Young's and Cripps's accounts provide guidance for answering this question.

I first outline three challenges that the implementation of different CDR technologies may raise. I then turn to the question of how CDR technologies can be part of a fair, effective, and efficient climate policy in Cripps's understanding (2021) or a transformation of structural processes towards less unjust ones in Young's understanding (2011). As both Young and Cripps argue, bringing about such policies is a shared political responsibility of individuals.

The first challenge is posed by the negative side-effects and risks that CDR technologies may introduce. Importantly, these vary between the CDR technologies and how they are implemented, and increase with the scale at which CDR technologies are implemented. For example, for afforestation, side-effects such as water use and impact on biodiversity depend on the region and tree species planted (Doelman et al., 2020; Fuss et al., 2018). Overall, large-scale afforestation projects and the mass plantation of biomass for BECCS pose risks to food security because arable land is no longer available for food production (Doelman et al., 2020; IPCC, 2018a; Kortetmäki and Oksanen, 2023). In contrast, DACCS requires not land but energy (Fuhrman et al., 2021). The large-scale deployment of BECCS could infringe on human rights to food, water, and a healthy environment. Similarly, DACCS could entail significant risks for the human right to energy (Günther and Ekardt, 2022). Further, both BECCS and DACCS entail storing the captured carbon in geological storage spaces underground for long-term sequestration. However, the discussion on carbon capture and storage (CCS) shows that there are long-term risks with geological sequestration: underground injection of CO_2 can increase local seismicity and contaminate groundwater and needs long-term containment to be secure (Bui et al., 2018).

Second, the fairness of implementing some CDR technologies at large scales may be challenged, given the side-effects and risks potentially introduced. For example, vulnerable people may be forced off their land so that biomass for BECCS can be grown (Blomfield, 2021), as is already occurring in cases of afforestation (Michaelowa et al., 2019). Threatening food security in certain regions through large-scale BECCS or afforestation projects raises food justice concerns (Kortetmäki and Oksanen, 2023). If large-scale BECCS and DACCS put human rights at risk (Günther and Ekardt, 2022), they may cause injustices as forms of oppression and

[10] Assessing which CDR technology is less ethically costly than another is beyond the scope of this paper.

domination that constrain a large group of people's opportunities for self-development and self-determination (Young, 1990). The side-effects and new risks introduced remain problematic and are potentially unjust, as the parties suffering them have not agreed to bear these costs (Shue, 2021; Wallimann-Helmer, 2021). Further, the distribution of these risks and negative side-effects is unjust, for example if implementing afforestation and BECCS at large scales would put countries of the Global South at a risk disproportionate to their contribution to climate change (Morrow et al., 2020). Other concerns echo injustices related to climate change, such as shifting the burden of reducing emissions and the overall risks of implementing large-scale CDR technologies to future generations (Heyward, 2014a; Shue, 2017a), even if these generations will have benefitted from these measures (Shue, 2021: 48).[11]

Third, other fairness challenges arise in relation to access to and distribution of benefits from BECCS and DACCS, which involve the geological sequestration of carbon. Large fossil fuel companies are very likely to benefit from being able to store captured carbon because the infrastructure and knowledge required for this activity are similar to those needed for the extraction of carbon (Hastings and Smith, 2020; Shue, 2021). As carbon majors carry historical responsibilities, this creates a moral dilemma about the extent to which they can permissibly benefit from removing carbon (Lenzi et al., 2023). Further, concerns have been raised that CDR technologies are being used to save assets rather than to mitigate climate change (Shue, 2021: 95). If these technologies perpetuate the current fossil energy system, they are not an effective policy for mitigating climate change.

Given these challenges, one may argue that neither Young's nor Cripps's account of shared political responsibility includes carbon removal. If CDR technologies could only be implemented in unfair, ineffective, and inefficient climate change policy, individuals would not have a political responsibility to promote them, on Cripps's account. The question is what kind of policies individuals have a responsibility to support. Importantly, the ethical costs vary depending on which and how CDR technologies are implemented, the accompanying measures, and the quantities of carbon to be removed. Policies for implementing CDR technologies could address injustice by providing co-benefits such as energy from BECCS, increased soil fertility from biochar, and protection of coastal ecosystems from mangroves (Fuss et al., 2018). Policies could also be targeted to support poorer regions, for example by funding the exploration of their potential for geological carbon storage for DACCS and BECCS (Mintz-Woo and Lane, 2021).

[11] The focus here is on risks created through the implementation of CDR. This is different from the risk of reduced efforts to mitigate emissions due to the assumption that emissions can be removed with CDR Lenzi (2018); Shue (2017a).

One way of acting against carbon majors profiting from BECCS and DACCS unjustly is to tax the gains these corporations make from trading in carbon removal at higher rates (Lenzi et al., 2023).

The use of CDR technologies may feature in several policy responses that pursue a ‘minimal’ account of justice (Lenzi, 2021: 6). By removing emissions until they can be mitigated, CDR technologies may play an important part in the energy transition, especially BECCS (Azevedo et al., 2021: 3; Sovacool et al., 2023). In theory, carbon removal could ameliorate intergenerational justice by reducing the burden of emissions of past and present generations on future generations. By placing responsibility on those who have emitted excessively in the past, carbon removal could reduce the injustices between countries that have high past emissions and those that do not but are impacted by climate change. Hence, carbon removal could contribute to policies that promote fairness and structural change.

Importantly, the ethical costs of CDR technologies also depend on ‘the extent of deferred mitigation’ (Lenzi, 2021: 5). The later emissions are reduced, the greater the pressure to scale up CDR technologies and the larger the scale required. Hence, policies that reduce emissions should precede or at least accompany implementing CDR technologies. However, measures to reduce emissions may also have important ethical costs, especially if implemented at large scale (Cox et al., 2018). They also pose the risk that negative side-effects are distributed in ways that reflect unjust social structures (Eckersley, 2016; Sardo, 2020). Hence, though individuals have responsibilities to both reduce emissions and remove carbon (as argued in Section 2), the ethical cost of reducing emissions must be weighed against the ethical costs of implementing CDR technologies (Schübel and Wallimann-Helmer, 2021). Overall, ethical costs may be reduced by relying on a portfolio of different emission reduction measures and various CDR technologies, as this minimizes the risks associated with various technologies (Cox et al., 2018; Fuhrman et al., 2023; Minx et al., 2018).

In conclusion, individuals have a shared political responsibility to remove carbon and to ensure that, if carbon is removed, the ethical costs are minimized. Though various CDR technologies present different challenges, a shared political responsibility to promote fair, effective, and efficient climate policies and to transform structural processes to less unjust ones could include removing carbon. To this end, the implementation of CDR technologies will need to be accompanied by specific policies tailored to the challenges posed by the different technologies pose. Bringing these policies about requires political action by individuals.

4. The two responsibilities to remove carbon

I have argued for two responsibilities to remove carbon: a direct one and a shared political one. In this section, I address the relationship between the two responsibilities. First, I show how shared political responsibility is a condition for direct responsibility. Second, I argue that direct responsibility cannot be subsumed under shared political responsibility. Third, I reject the concern that the two responsibilities together are overdemanding.

First, imagine that the shared political responsibility to remove carbon is not fulfilled and ethical costs of carbon removal are high. The ethical costs of carbon removal can weaken the responsibility of individuals to remove emissions: If it is possible to remove emissions at ethical costs that are lower than the harm created by these emissions, individuals have a direct responsibility to do so. Conversely, if the ethical costs of carbon removal are higher than the harm remedied by emissions removed, individuals have no direct responsibility to remove them. Hence, a condition for individuals having a direct responsibility to remove carbon is that they fulfil their shared political responsibility to minimize the ethical costs of implementing CDR technologies. The question arises at what point the ethical costs of carbon removal outweigh individuals' direct responsibilities to remove carbon. Here, we enter the realm of non-ideal theory in trying to weigh the ethical costs of carbon removal against the ethical costs not doing so. A full answer to the question is beyond the scope of the paper. However, it is possible to remove carbon from the atmosphere by enhancing natural carbon sinks, for example through afforestation. Though large-scale afforestation also has an ethical cost, as mentioned above, it is bold to claim that removing carbon from the atmosphere always has higher ethical costs than not removing it.[12]

Second, the question arises whether, if individuals fulfil their shared political responsibility to remove carbon, purchasing carbon removal certificates is still among the responsibilities of individuals. Fulfilling the shared political responsibility may result in the political decision that the state will remove all emissions, including those for which individuals are directly responsible. However, this is not the case at present, and in addition, 'the promotional role of individual contributory cuts must be considered' (Cripps, 2021: 12). Demanding emission removals at the collective level but not being willing to cut one's own emissions may be criticized as a sign of hypocrisy and could potentially undermine efforts to promote collective action (Hourdequin, 2010; Schwenkenbecher, 2014). We may doubt that removing carbon 'can

[12] I speak here about the removal of emissions could not be avoided. It is not about balancing the removal of emissions with the possibility of making efforts to reduce emissions.

promote emissions cuts by others' in the same way as emission cuts (Cripps, 2021: 9). Carbon removal may have fewer impacts on others because it is not an activity visible in public life, such as taking the bike instead of the car, ordering vegetarian food, and buying vegan products in the supermarket. But take the example Al Gore flying around the world to promote climate change mitigation policies, including policies for just implementation of CDR technologies. If the conditions for implementing CDR technologies at minimal ethical cost are ensured, individuals have a direct responsibility to remove the emissions for which they are liable. Hence, if Al Gore really cannot avoid the flight, he should remove his emissions and try to do so at the lowest ethical costs possible. Thus, the direct responsibility for carbon removal is not subsumed under the shared political responsibility.

Finally, some may fear that assigning individuals a responsibility to reduce their emissions will foster a focus on individual emissions and a loss of support for more structural changes; others may argue that demanding simultaneously that individuals minimize their carbon footprint and promote collective change could be exceeding 'the limits of reasonable demandingness' (Cripps, 2021: 8). These concerns cannot all be addressed here. But at a practical level, are funds and attention ineffectively directed if both responsibilities are assigned? I do not think this is necessarily the case, as each draws on different resources. Put simply, carbon can be removed by paying money, whereas political engagement may predominantly require time and effort. In the case of carbon removal, both responsibilities fall on the individual.

5. Conclusion

Overall, I have argued for two responsibilities for carbon removal. First, I argued that individuals have a responsibility to reduce their carbon footprint to zero by removing emissions through CDR technologies. Second, individuals have a shared political responsibility to ensure that carbon is removed for which no individual holds any direct responsibility. Thus, both direct responsibility and shared political responsibility justify why individuals should remove carbon: either because they are liable for the harm caused by their emissions or because they share with others the responsibility for removing harmful carbon. Third, the shared political responsibility also relates to how carbon should be removed. Individuals have a shared political responsibility to minimize the ethical costs of implementing various CDR technologies. This requires political action.

Climate change policy has to acknowledge that its justice implications go beyond its effects on the climate and extend to current global injustices. The case of CDR technologies highlights both this need and the need to include the responsibility of individuals. We need to theorize how the implementation of different CDR technologies is linked to unjust structures, which means going beyond the simple view of carbon removal as contributing to justice by mitigating climate change. Although my arguments here are specific to the use of CDR technologies, they may have wider implications for conceptualizing individuals' climate change responsibilities.

Acknowledgments

I received many helpful comments on this paper and its earlier drafts. I thank Joseph Conrad, Elizabeth Cripps, Grace Garland, Clare Heyward, Tristan Katz, Dominic Lenzi, Simon Milligan, Rebecca Richards, Henry Shue, Lukas Sparenborg, Kathrin von Allmen, Ivo Wallimann-Helmer, and two anonymous reviewers for engaging with it. I thank the participants of the Political Theory Research Group at the University of Edinburgh, the Environmental Humanities Colloquium at the University of Fribourg, the MANCEPT 2022 Workshop, the ESDiT Conference in Leiden, and the Work-In-Progress Workshop at the philosophy department of the Arctic University of Norway for their questions and comments.

Part II: States and the Permissibility of CDR technologies

Introduction

The previous chapter has indicated that individuals have shared, political responsibilities towards CDR technologies. These responsibilities can be directed to the state of which these individuals are citizens. The question is what implication the availability of CDR technology may have for the moral responsibility of states to mitigate climate change. Most of the literature on climate justice is focused on 'the nature and basis of states' duties to reduce their emissions to mitigate climate change' (Umbers and Moss, 2020: 3). But while many states have committed to reach net zero emissions, their commitment to use CDR technologies remains vague – leading to the carbon gap, discussed in Section 1.3.

In Chapter 2, Ivo Wallimann-Helmer and I take the commitments of states to the Paris Agreement and to reach net zero emissions as starting points. We investigate the relationship between states and citizens and argue that for different emissions, citizens or states carry the responsibility to address them with emission reduction measures or CDR technologies. To do so, we propose a framework for defining the permissible contribution of CDR to the net zero targets of individual states. The framework establishes three categories of emissions for which the permissibility of CDR varies depending on the ethical costs of both emission abatement and CDR. We argue that (i) luxury emissions should be reduced without using CDR; (ii) emissions for full membership in society should be abated by structural efforts, although using CDR is permissible, given certain conditions; and (iii) CDR is permissible for residual emissions because otherwise net zero targets cannot be reached.

Hence, Chapter 2 addresses the challenge of weighing emission abatement and removal efforts against each other, based on their ethical costs. The question is how such a weighting could be done. In Chapter 3, Ivo Wallimann-Helmer and I apply a principlist framework to two kinds of measures: the reduction of emissions with biofuels and the removal of emissions via BECCS. We use a principlist approach to identify relevant moral differences between these technologies using four principles from the climate justice debate: the polluter-pays principle, the ability-to-pay principle, the equal-per-capita principle, and the procedural involvement principle. This consideration is most relevant for states, as they are the agents who are making the decision on implementing large-scale policies and how to balance emission reductions and carbon removals within their net zero targets. However, the argument could also be applied to the decisions of individuals and corporations on how to balance emission reductions and carbon removals. In the context of this thesis, Chapter 3 stands out as it commits to a specific methodology, principlism. Yet, this methodology is compatible with the aim of the thesis to provide arguments that can advance policy decisions, though the other parts of the thesis do not commit to this approach.

The paper 'Setting a Permissible Target for Carbon Dioxide Removal' on which Chapter 2 is based has been accepted for publication in *Environmental Ethics* on 26 March 2024. Ivo Wallimann-Helmer and I worked equally on the argument presented. I was in charge of the writing.

The article 'Food security and the moral differences between climate mitigation and geoengineering: The conflict between biofuels and BECCS', on which Chapter 3 is based, has been published in the *Conference Proceedings of the European Society on Agriculture Food and Ethics*, 2021. Ivo Wallimann-Helmer and I were equally involved in developing the argument of the paper. I was in charge of the writing. Please note that in the paper, we refer to CDR technologies as geoengineering because we discuss the implementation of BECCS at large scales and use the term 'mitigation' to refer to emission reductions. This does not exactly match the terminology used in the rest of the thesis, because my conceptual understanding has advanced since writing this piece.

Status: Accepted for publication in Environmental Ethics*, March 2024.*

Chapter 2: Setting a Permissible Target for Carbon Dioxide Removal

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Abstract

Meeting the net zero emission targets set by many states after the Paris Agreement to help keep global warming well below 2°C above pre-industrial levels will require carbon dioxide removal technologies (CDRs). Several moral concerns arise if the contribution of CDRs to achieving net zero is not specified, but such concerns can be met by defining a permissible target for CDRs. We propose a framework for defining the permissible contribution of CDRs to the net zero targets of individual states. The framework identifies three categories of emissions for which the permissibility of CDRs varies depending on the ethical costs of both emission abatement and CDRs. We argue that (i) luxury emissions should be reduced without using CDRs; (ii) emissions for full membership in society should be abated by structural efforts, although using CDRs is permissible, given certain conditions; and (iii) CDRs are permissible for residual emissions because otherwise net zero targets cannot be reached.

Keywords: climate ethics, climate justice, geoengineering, carbon budget.

1. Introduction

Following the climate target formulated in the Paris Agreement to limit global warming to well below 2°C above pre-industrial levels, various states have committed to reaching net zero emissions by 2050. Limiting global warming to acceptable levels entails a limit on cumulative CO_2 emissions and implies that global emissions have to become net zero at some point in the future (Rogelj et al., 2015: 1). Net zero emissions are reached if "anthropogenic emissions of greenhouse gasses to the atmosphere are balanced by anthropogenic removals" (IPCC, 2018b: 555). To reach net zero targets, emissions must be abated to a significant extent.[1] However, in addition to efforts to reduce emissions, carbon dioxide must be actively removed from the atmosphere and stored permanently in geological, terrestrial, and oceanic reservoirs (Fyson et al., 2020: 836). Otherwise, net zero targets and thus the target of the Paris Agreement are impossible to reach.

[1] Abating emissions is also referred to as mitigating emissions. The policy area of mitigating climate change includes emission removal and emission abatement. To avoid this confusion, we speak about abating emissions, not about mitigating them.

The question we address here is whether it is permissible for states to address their current high emissions by removing them from the atmosphere with carbon dioxide removal technologies (CDRs) instead of avoiding them in the first place. CDRs include a variety of activities that remove carbon dioxide from the atmosphere and store it durably in geological, terrestrial or ocean reservoirs (IPCC 2023: 121). CDRs are afforestation and reforestation, enhanced weathering, biochar, and technological methods for removing emissions from the atmosphere and storing them permanently underground or in the deep sea, such as direct air capture with carbon capture and storage (DACCS) and bioenergy with carbon capture and storage (BECCS). Importantly, the longer that states wait to reduce their emissions, the greater will become the demand for the development and implementation of such CDR technologies.

Moral concerns arise when the quantity of CDRs is not specified in net zero targets. One concern is that of ignoring the risks and negative side-effects of CDRs (IPCC, 2018b: 17; Minx et al., 2018: 21). A second concern that has been salient in the discussion on CDRs is that the assumed or future availability of CDRs may disincentivize efforts to reduce emissions (Fuss et al., 2014; Lenzi, 2018; Shue, 2017a). Meeting these concerns requires a specific target to be defined for CDRs. The normative implications of net-zero targets have gained attention in the past years, highlighting a need to converge emissions to net zero and to consider of equity implications of both CDRs and rapid mitigation efforts (Armstrong & McLarren 2022; Lenzi et al 2021). In this paper, we advance this discussion by arguing for a way to define a permissible target for CDRs. We do this by introducing the category of emissions of full membership in a society, which carves out the space between the standing categories of luxury and subsistence emissions. By comparing the ethical costs of CDRs with the ethical costs of emission abatement efforts for different categories of emissions, we suggest how a target for CDRs should be set.

We begin our investigation by specifying the moral concerns arising from net zero targets and the arguments for distinguishing two distinct targets, one for emission removal by CDRs and one for emission abatement (section II). We argue that to set a permissible target for CDRs, three morally relevant categories of emissions need to be distinguished. For each category, we provide an argument for whether the use of CDRs is morally permissible or even obligatory, impermissible, or only permissible under certain conditions (section III). We start with the category of the luxury emissions of the citizens of many states. Our second category is the emissions that an individual requires to be able to maintain the minimal cultural and social standards required for being a full member of their society. In our framework, these emissions constitute the morally relevant threshold of well-being that individuals should not fall below as emissions are removed or reduced. The third category of residual emissions is those emissions remaining despite a state having undertaken the largest cuts in emissions possible. We then draw our conclusion (section IV).

Although we are aware that reaching net zero targets requires a range of technologies for simplicity's sake, we do not treat the differences between the various CDR technologies that certainly exist. The technologies differ in the dangers and injustices they create, as well as the 'ethical costs' they entail, as we discuss below. Because BECCS is the technology most prominently featured in climate scenarios and pledges to reach net zero emissions (Fuss et al., 2020) and connects several of the concerns of other technologies, it is the technology we chiefly consider as the paradigmatic example in our arguments.

2. The ambiguity of net zero emission targets

Net zero targets emerge from the fact that a finite carbon budget can be spent until climate change exceeds a certain level of warming, as has been acknowledged in the Paris Agreement. Net zero targets are said to be ambiguous for several reasons (Armstrong and McLaren, 2022: 507–508). They do not specify when or by how much emissions should be reduced. Moreover, net zero targets do not define the quantity of emissions to be avoided or the quantity of emissions to be removed by CDRs. Instead, some "net zero emission" scenarios include higher cumulative emissions than others and assume correspondingly higher degrees of carbon removal. What often is overlooked in the current policy debates are the 'ethical costs' of CDRs: the potential damages that the implementation of CDR technologies cause; and the injustice of taking the gable of relying on CDRs (Shue, 2017a: 208). These ethical costs are likely to increase in the absence of a specific target for CDRs (Lenzi 2021). As a result, net zero targets do not give priority to emission abatement efforts over the implementation of CDRs at large scales, as seems to be necessary from an ethical perspective. We now discuss these concerns in turn and highlight the need to define a permissible target for CDRs. We then suggest how to set such a target to avoid ambiguity.

Theoretically, a state could reach net zero emissions while still emitting large quantities of carbon if these were balanced by removing carbon from the atmosphere through large-scale CDRs. This possibility is problematic given the potential damages that CDRs bring along. For example, if implemented at large scales, BECCS requires fast-growing biomass to be planted extensively (Pacala, 2018: 3). This may pose dangers to freshwater supply, biodiversity, and food security because the arable land where it will be planted will no longer be available for food production (Creutzig et al., 2015: 931; Heck et al., 2018: 151; Kortetmäki and Oksanen, 2023; Schübel and Wallimann-Helmer, 2021: 72). Furthermore, sites for liquefied carbon imply risks to potable water and leakages, nullifying the benefits achieved by BECCS. Finally, the implementation of large-scale BECCS may face sustainability challenges (IPCC, 2018b), and the extent to which BECCS can be implemented sustainably is much lower than actual commitments to removing emissions via BECCS (Fuss et al., 2018: 11; Reid et al., 2020: 278). These potential damages are ethical costs to CDRs.

Importantly, there is a second way of how CDRs can create ethical costs. In the absence of a specific target for CDRs, a gamble on CDRs could arise (Lenzi, 2018; Shue, 2018): States may assume that CDRs at large scales will be available to create negative emissions and thus may forgo necessary, radical emission abatement (Lenzi, 2021: 2; Minx et al., 2018: 19). Taking this gamble has ethical costs for two reasons. First, forgoing emission abatement is problematic because current climate scenarios indicate that without these emission abatement efforts, the target of the Paris Agreement cannot be achieved. Second, forgoing emission abatement efforts will increase the pressure to scale up CDRs. This is problematic due to the risk that CDRs will not be available to the extent that is assumed in most climate models (Lenzi, 2018: 3). Although CDRs are assumed at large scales in many climate pathways to net zero emissions, its upscaling faces serious challenges, such as physical constraints, the need for financial support (Honegger et al., 2021a: 7), and socio-institutional barriers (Fuss et al., 2014: 851; Wallimann-Helmer, 2021: 195). Vast investments in infrastructure will be needed for transport and safe storage, and public acceptance has yet to be established (Aminu et al., 2017: 1390). Additionally, the net effectiveness of many CDRs remains to be determined: for instance, the effectiveness of BECCS varies greatly depending on the emissions caused by land use change as biomass is planted (Humpenöder et al., 2018: 2).

There are moral arguments in favor of prioritizing emission abatement and against implementing CDRs at large scales. A basic moral principle is that it is wrong to do serious, foreseeable, avoidable harm to another human being, and if one can avoid unnecessary harm, one should do so (Cripps 2021). If emission abatement implies avoiding the harm done by large-scale CDRs, emissions should be avoided. We can appeal to the basic idea that it is better to avoid harm than to create harm and remedy it because such a strategy always entails the risk that we may fail to remedy the harm created. This seems to be the case with CDRs because implementing CDRs at large scales implies many insecurities.[2]

Overall, climate scenarios with greater emission abatement now and fewer or no CDRs carry lower risks than those that delay emission abatement and assume large-scale CDRs (Lenzi, 2021: 4). Hence, accepting this gamble means introducing unjustified ethical costs: those of exposing others to new potential harm. According to Shue (2017) taking this gamble is unjust especially because the consequences of losing the gamble will harm those most vulnerable, and not those who decide to take the gamble in the first place.

Both of these aspects of ethical costs, the potential damages, and the injustice of taking this gamble need to be considered.[3] Setting distinct targets for emission abatement and CDRs each limits the risk that states will use CDRs to obscure their emission abatement failures (Honegger et al., 2022: 7; Jeffery et al., 2020: ii; McLaren et al., 2019: 4). But how should the target for CDRs be set? Which proportion of emissions may a state permissibly remove, and which should it abate?

To set the permissible target for CDRs, we compare the ethical costs of CDRs with those of emission abatement. Only if the ethical costs of emission abatement are higher than the ethical costs of CDRs, CDRs are permissible and even obligatory to meet net zero targets.[4] In contrast, if emissions can be abated at ethical costs lower than those of CDRs, their removal by CDRs is impermissible. This helps define the extent to which states may permissibly rely on CDRs to reach their net zero targets.

It seems that for some emissions, abatement has lower ethical costs than implementing CDRs. At the current high levels of emissions in some states, some emissions can simply be avoided without introducing any morally significant burdens, for example when avoiding those emissions produced for luxury purposes. But this is not the case for all emissions. Social, economic, and technological circumstances limit the feasibility and increase the ethical costs of reducing emissions. Some emissions can more easily be reduced and with lower ethical costs. Other emissions are more fundamental and avoiding them would have high ethical costs. Our

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[2] Further, in the current policy setting, time plays a crucial role. There is currently not enough implementation of CDRs to claim that carbon is removed directly. Hence, it will remain in the atmosphere for a certain time and contribute to climate change.

[3] Afforestation has high potential damages (e.g., undermining fresh-water supply and sustainable development) and is an unjust gamble because these trees grow slowly and may burn down, thereby re-releasing the carbon dioxide back into the atmosphere. DACCS may have fewer potential damages (though, there is the risk that it will undermine energy security) but is more of an unjust gable to take due to the infrastructure that will have to be implemented. BECCS does share some of the potential damages with afforestation, and the injustice of the gamble may be more like those introduced by DACCS.

[4] We assume that if an option is not excluded by any major moral concern and no other option exists, this option is morally permissible Stelzer and Schuppert (2016: 15).

framework, introduced in the next section, helps to distinguish different categories of emissions and the ethical costs of their abatement and hence the permissibility of CDRs.

Although there may be further reasons to justify the permissibility of CDRs than relying on the weight of the ethical costs of CDRs and emission abatement only, we agree with the majority of the ethical debate that weighing up their ethical costs is the key ethical trade-off (Armstrong and McLaren, 2022; Lenzi, 2018, 2021). In the following, for developing our framework to define a permissible target for CDRs we will focus on this trade-off.

3. A framework for defining a permissible target for CDR

Here, we introduce our framework for defining the permissible target of CDRs within net zero targets of individual states as parties to the Paris Agreement. This framework explains how a target for CDRs should be set by arguing which emissions may permissibly be addressed by CDRs. We show how introducing three morally relevant categories of emissions helps to determine whether CDRs are permissible, impermissible, or only permissible under certain conditions. We show that the ethical costs of CDRs differ relative to the ethical costs of emission abatement depending on the category of emissions at stake. CDRs are only permissible if the ethical costs of emission abatement are higher than the ethical costs linked to CDRs. Hence, defining a permissible target for carbon removal by CDRs also implies defining the acceptability of the ethical costs of CDRs, such as their risks and negative side-effects.

We define the three morally relevant categories of emissions by states as luxury emissions, emissions necessary for individuals to be full members of their societies, and residual emissions. For each of these three categories, we show whether emissions can permissibly be removed by CDRs or whether emissions must be reduced. The novelty of our approach lies in introducing an additional morally relevant category of emissions lower than “luxury emissions” and higher than “subsistence emissions,” which are well-referenced emission categories in the climate ethics literature (Shue, 1993: 56, 2019: 251–254).[5] By introducing this additional category, we highlight important changes in responsibility between the state and citizens in efforts to reach net zero targets. Full membership in society constitutes a morally relevant threshold for individuals. Securing this threshold becomes a key responsibility of the state, which has a political responsibility to address these emissions. As emissions become harder for citizens to

[5] For example, Armstrong and McLaren (2022) rely on this distinction in their argument for net zero targets which involve little emissions and little CDR: residual emissions should be ‘linked to subsistence-related (rather than luxury) projects’ (517) and emission pathways avoiding risks to sufficiency emissions should be prioritized.

avoid, the state's responsibility to address these emissions increases. And as emissions become harder to avoid without morally significant implications for citizens' well-being, the permissibility of CDRs increases.

Each of the following sub-sections has three steps: first, we introduce the category of emissions; then we discuss the ethical costs of abating the respective category of emissions; then we apply the criterion of weighing the ethical costs of CDRs against those of abating emissions in this category. Based on this third step we then decide on the permissibility of CDRs for these emissions.[6]

1. Luxury emissions

In the following, we argue that the ethical costs of reducing luxury emissions are lower than the ethical costs of removing them by CDRs. To start, consider the example of emissions caused by a family flying on a beach holiday. As pleasant as such holidays might be, the emissions they cause can easily be avoided by enjoying holidays without flying. Reducing new emissions means that trips such as this one are not made, and instead the family enjoys a more local trip or travels by train.[7] The emissions generated by an activity are luxurious if the action "either (a) has no moral weight or (b) an alternative course of action (that can be considered an adequate substitute) causing less emissions exists" (Baatz, 2014: 15). At the current high level of emissions, many citizens of industrialized states engage in activities that fulfill both criteria and hence, many emissions by members of industrialized states are simply for the sake of luxury.

Ethical costs of abating luxury emissions: Various arguments have been advanced to explain why individuals have a duty to avoid current high "luxury emissions" (Baatz, 2014: 15; Burri, 2020: 120; Cripps, 2011: 172; Shue, 1993: 56). Avoiding such luxury emissions would neither affect emissions for ensuring subsistence living conditions nor imply anyone falling below a morally relevant threshold. Hence, demanding that individual citizens avoid luxury emissions seems morally acceptable.

However, policies avoiding luxury emissions may restrict individual freedoms and hence involve moral costs. Although this might be the case it is improbable that such restrictions push people below a morally relevant threshold of well-being, given what is being regulated

[6] To be clear: Our claim is not that the specific molecules emitted by these activities should be removed. Rather, the claim is that the volume of emissions that is made within a certain category should be removed.

[7] Here are two examples: A return trip from Geneva to Barcelona with the high-speed train creates 3kg of CO_2 emissions per traveller, the plane 332kg of CO_2. A return flight from New York to Florida emits 568kg CO_2, the train ride 4kg CO_2. Calculated by https://ecotree.green/en/calculate-flight-co2, 22.12.2023.

are luxury emissions. Further, it is the emissions that are released by such an action, and not the action itself that would be regulated. It would not be per se forbidden to go on vacation but instead forbidden to create a lot of emissions while flying on vacation.

Weighing the ethical costs: Removing emissions by CDRs might enable a trip such as a beach holiday to be made with net zero emissions if the emissions of the flight were balanced by removing and permanently storing an equivalent quantity of carbon. Understanding whether it is permissible to balance emissions from activities such as flying to a beach for holidays requires considering the difference between abating emissions and removing carbon. Using CDRs to counterbalance emissions has ethical costs such as potentially imposing additional harm on the people who suffer potential risks and negative side-effects from its implementation (Shue, 2017a: 208). Such harm is not introduced if emissions are not produced in the first place. Importantly, it is impermissible to introduce such harm if avoiding it does not undermine any morally relevant entitlements. In our example, enjoying holidays locally instead of flying to a beach does not undermine any morally relevant entitlements, and hence introducing harm to remove these luxury emissions with CDRs is impermissible. Overall, introducing the ethical costs that CDRs create is impermissible for emissions that can be removed at no ethical costs, and hence CDRs are impermissible.

One may argue that additional risks and negative side effects are introduced not only by CDRs but also by some emission abatement strategies. Relying on biofuel, for example, might have similar negative impacts on food security as BECCS (Schübel and Wallimann-Helmer, 2021), and the creation of energy parks such as hydraulic dams may have negative impacts on local biodiversity (Wallimann-Helmer, 2022). Although we agree that in some cases additional risks and negative side-effects of emission abatement may be similar, this is not a main concern in the current category of luxury emissions. These emissions can be avoided by simply refraining from action that results in emissions without creating any morally significant costs for those avoiding them. Thus, to reduce the luxury emissions in many states, using CDRs is morally impermissible, and hence a permissible target for CDRs does not cover these emissions. These emissions must be abated if a state pursues net zero targets.

We can construct examples where not being allowed to fly to the beach would undermine morally relevant entitlements of citizens. However, if this were the case, the emissions from flying to the beach would not be classified as luxury emissions, but as emissions belonging to the next category in our framework: emissions required for full membership in society.

2. *Emissions for full membership in society*

We have argued that the category of luxury emissions in many states demands emission abatement instead of removing emissions by CDRs if such states want to reach net zero emissions. However, we cannot claim that all the current high emissions of states are luxury emissions. Individuals produce some emissions simply by being full members of society. In this section, we again show first why this category of emissions is relevant. Second, we elaborate on the conditions under which emissions of this category can be assumed to be reducible. Third, we suggest that the use of CDRs is permissible for this category of emissions if reductions cannot be realized without some member of society falling below the morally relevant threshold of full membership in society.

Climate ethics research has long been familiar with the demand for a minimum level of emissions to guarantee basic standards of living (Rao and Baer, 2012: 656). Most prominently, Henry Shue suggested a division between luxury emissions and subsistence emissions. In his understanding, subsistence emissions ensure a "rise out of poverty" for developing nations and guarantee their inhabitants a minimally decent life (Shue, 1993: 43). The idea of subsistence emissions can be criticized in at least two ways. First, any definition of minimally necessary emissions to ensure acceptable living conditions is problematic because it implies that these entitlements in sum create a right to contribute to dangerous climate change (Duus-Otterström, 2014: 28). Second, various approaches have stressed that the standard of subsistence living conditions is too low and needs to be raised for guaranteeing either further human rights or human life in dignity (Caney, 2009: 132–133; Nussbaum, 2000: 440).

A counterargument to the first claim is that it is not emission levels that must be maintained but levels of well-being, access to energy, and human rights (Caney, 2012: 285–291; Hayward, 2007: 440–443).[8] What is relevant is not a specific amount of emissions but granting specific living conditions for all members of society. A counterargument to the second claim is that many emissions above such subsistence emissions stem from morally relevant activities that depend on existing social structures and technological development, and hence cannot simply be described as subsistence conditions for human beings independently of the societies they live in (Baatz, 2014: 10). Theorizing the responsibilities for emission reduction requires consideration of these dependencies on social structures and technological development. These considerations lead us to a morally relevant category of emissions that is higher than subsistence emissions and sensitive to the social and technological structures of different societies.

[8] Shue agreed to this view in his later work (2013: 392), having been convinced by Haywards argument (2007).

We suggest that individuals should not only be entitled to subsistence emissions but also to full membership in their societies. These conditions are necessary for granting basic social conditions for self-respect, equality in societal relations, and opportunities for realizing a life of one's own (Kymlicka, 1990: 3–4). Such a standard includes individuals having the capability to appear in public without shame and to participate as full members in the lives of their communities (Anderson, 1999: 289; Peacock, 2019: 2). The argument for the moral relevance of this category of emissions is rooted in the ideal that all members of a society have a right to be full members and are entitled to the means that enable them to be perceived as such (Sen, 1992; Young, 1990). Since being a full member of one's society is a basic need of human beings and must thus be protected as a fundamental right, this category of emissions defines a morally relevant threshold.

In our framework, being a full member of society is the morally relevant threshold that defines minimally acceptable conditions of well-being for all members of any particular society. Because maintaining this social standard depends on the social conditions and technological development of a society, it also defines a distinct category of emissions. It is very likely that the emissions currently needed for individuals in industrialized states to be full members of society are incompatible with the target of the Paris Agreement. However, simply reducing these emissions risks undermining basic thresholds for many, particularly poor members of society (Sovacool et al., 2019: 591). For example, if high emissions from driving cars are reduced by higher gasoline prices, this may exclude some members of society in rural areas from fully participating in social life (Baatz, 2014: 10; Heyward, 2014b: 151). If full membership in society is a morally relevant threshold, this is a morally relevant criterion to be considered when reducing emissions to meet net zero targets.

Exactly what activities and circumstances are needed for full membership in society may vary with the social norms of different societies (Anderson, 1999: 316-318). To return to our example of flying, we may consider the case of a citizen who travels by plane from a remote area to the capital city to reach the ballot box. If the state does not allow citizens the possibility to vote online and does not provide public transport from remote areas, not allowing them to fly would undermine their status as full members of a democratic society. Whether emissions are necessary for minimum cultural and social standards depends very much on the social conditions of societies and on how their members perceive them.

Consider Ann and Ben, members of two different societies complying with the social norms of their respective societies. Ann lives in a society that primarily consumes fossil fuels and hence has high overall emissions. Ann depends on her car in her everyday life. In contrast, Ben lives in a low-emitting society that chiefly uses natural sources of renewable energy. Ben does not depend on a car for his everyday life because he can use the existing public transport system. As a result, Ann produces far more emissions than Ben to be a full member of her society. Emissions that are luxury for Ben define a morally relevant threshold for Ann. However, in both cases, these are minimally acceptable conditions that all members of a society should be able to uphold. They do not reflect the personal preferences of Ann and Ben or their more specific positions within their societies. It is the structural conditions of their societies that define whether car driving is required to be a full member.

Ethical costs of abating emissions of full membership in society: The threshold of full membership in society may be interpreted as quite high by some societies and, as a result, justify less ambitious emission reduction efforts by its members (Heyward, 2014b: 161–162). The responsibilities of individuals are specific to the society of which they are members: Ann may produce high emissions as a full member of her society but bear fewer responsibilities to avoid emissions than Ben, who overall produces fewer emissions than Ann. However, if Ben enjoys going for a drive on Sundays in his gas-guzzling car, which is considered a luxury in his society, then he produces more emissions than needed for full membership in his society.[9]

However, even if conditions of full membership in society entail high emissions, these do not justify a state's overall higher emissions. These emissions only indicate what standard of well-being needs to be secured to grant all members of a state full membership. Such emissions only indicate a morally relevant threshold to be considered when emissions are reduced because, in current conditions, they are necessary to remain a full member of society. A state committed to net zero targets must address these emissions. Their reduction can be considered possible because social standards are not directly dependent on emissions but on social, economic, and technological circumstances for securing such standards. If the social structures and institutions of societies can be altered without undermining basic social thresholds, emissions of this category can be reduced.

We term such emission abatement action structural emission abatement. It implies that regulations fostering lower emissions are accompanied by changes to infrastructure by finding less emission-intensive alternatives in, for instance, energy production, transport, construction, housing, nutrition, and agriculture. It also concerns changes to cultural and social norms for lifestyles and mobility (Creutzig et al., 2016: 175–176; Gössling et al., 2019: 2–3). These changes to norms are not enforced by the state but occur through public discourse. For example,

[9] For a discussion on whether or not Ben should refrain from driving his car, see Sinnott-Armstrong (2005).

the Fridays for Future Movement in Europe made the climate crisis a broader societal concern and thus changed how certain activities and lifestyles are perceived (Huggel et al., 2022: 5–6). Public discourse is key to determining the nature of these changes. How structural emission abatement proceeds is linked to the public perception of what full membership in society entails. Because states must secure the means and energy for full membership for all members of society, higher emissions for full membership in society involve greater structural emission abatement duties.

Weighting the ethical costs: These considerations about emission abatement for this emission category influence the permissibility of CDRs. The Paris Agreement asks parties to prioritize rapid emission reductions while addressing CDRs in the long term (Honegger et al., 2021a: 1). However rapid reductions of emissions without changing societal structures may come at the morally relevant cost of individuals falling below the critical threshold of full membership in society. While the overall need to reduce emissions is pressing, structural emission abatement through changes to infrastructure and societal norms takes time (IPCC, 2022: 49). If emissions are not reduced, the concentration of atmospheric carbon will continue to rise, and implementing CDRs at large scales becomes even more urgent. This dilemma may justify the implementation of CDRs.[10] The condition for this is, however, that structural emission abatement has higher ethical costs than those introduced by CDRs.

Deciding how much CDRs should be implemented to address emissions for full membership in society is challenging, as the ethical costs of both may depend on societal processes and technological progress. However, in most societies and under most circumstances, it is very likely to be possible to reduce the emissions that individuals need for full membership in society through structural emission abatement. Take again the example of a citizen taking a plane to reach the ballot box. Emissions of this citizen voting can be reduced by introducing postal or online voting, which could be implemented fairly quickly. But take the case of car driving in a society in which local public transport is purely developed. Until these emissions are reduced, they must be removed. Consequently, the ethical costs imposed by CDRs for removing emissions for full membership in society are unjustifiable if they can be avoided by structural emission abatement, and hence CDRs are not permissible. CDRs are permissible for this category of emissions only on condition that structural emission abatement cannot be fully implemented

[10] Lenzi reaches a similar conclusion: Because failing to stabilize the global climate would lead to extreme harms, it is permissible to remove emissions at large scales (2021, 10).

at ethical costs lower than those introduced by CDRs.[11] Given that a state is morally committed to the net zero target, there is hence an obligation to invest in CDRs under these conditions. The argument of there being an obligation to remove CO_2 is fleshed out in the next section regarding the category of residual emissions.

3. *Residual emissions*

We have argued that structural emission abatement is needed to address the emissions that individuals need to be full members of society. Structural emission abatement includes changes to both infrastructure and social norms. However, even such emission mitigation may not eradicate all the emissions that a society produces. In this section, we consider the emissions that may remain even after substantial emission reduction efforts: residual emissions.

No IPCC scenario assumes that carbon dioxide emissions will ever be zero, because practically all human activity, including food production, mobility, and the use of land, produces emissions (Rogelj et al., 2015: 2). Most climate models showing the target of the Paris Agreement to be possible assume that net carbon emissions of states reach zero instead of assuming that they no longer produce any emissions: despite the drastic need for states to reduce emissions, emissions will still occur in some sectors even after the strongest emission abatement efforts. It seems that some emissions are necessary for the functioning of states and societies. However, what counts as residual emissions is being disputed (Buck et al., 2023).

Abating residual emissions: The costs of avoiding residual emissions would be disproportionately high. For example, relocating funding to emission abatement in a way that undermines basic social services, education, or public health would entail morally unacceptable high costs. This is especially pertinent because it is the responsibility of states to guarantee to all their citizens the standard needed for full membership in society. This very probably involves the production of at least some emissions. Hence, there may be a limit to the emission abatement duties of states.

Weighing the ethical costs: At the same time, given the climate responsibilities of states, there are strong moral arguments for committing to the Paris Agreement. Using CDRs to remove residual emissions is obligatory because not removing these emissions would expose others to avoidable, foreseeable harm. In consequence, the use of CDRs becomes an unavoidable

[11] One objection to our conclusion that CDRs are permissible under certain conditions seems to be the recurring risk of a gamble on CDRs because we argue that the permissibility of CDRs depends to some extent on the availability of structural emission abatement. However, this seems unavoidable at this point. We can only stress that if measures to reduce structural emissions can be taken at reasonable costs, the use of CDRs is not permissible.

part of net zero targets to compensate for residual emissions (IPCC, 2018b: 17). For example, Switzerland's long-term climate strategy foresees the annual removal of 7 million tons of CO_2 by 2050 (Swiss Federal Council, 2021: 49–50). Although the concerns of negative side-effects and the risks of implementing CDRs still exist, for residual emissions, they are outweighed by the negative impacts of dangerous climate change. Hence, if a state is committed to realizing net zero emission targets, the implementation of CDRs becomes not merely permissible but obligatory.[12]

This claim concludes our framework. Overall, our framework restricts the permissible and unconditional implementation of CDRs to residual emissions and hence limits the spectrum of options for avoiding dangerous climate change without reducing emissions. Given that the concentration of carbon in the atmosphere is rising, one may object that we have a moral responsibility to do as much as we can to reduce this concentration, be it by reducing emissions or by CDRs. It may seem problematic to declare measures for avoiding such harm morally impermissible when all possible action is urgently needed. This is a strong point. However, as we argued in Section II, the permissible target for CDRs needs to be defined to minimize the risk of a gamble on CDRs. If future technical improvements change the risks and negative side-effects, we associate with CDRs today, our argument and conclusions will change accordingly. But even then, the risk of a gamble on CDRs will remain. Hence, setting a limit to CDRs stresses the ethical argument that to reach net zero emissions, CDRs need to be implemented alongside emission abatement efforts.

4. Conclusion

CDRs will be necessary to achieve the net zero targets many states have committed to following the Paris Agreement. Setting a target for CDRs and hence defining which quantities of emissions are to be abated and which permissibly removed by CDRs can limit the concern that CDRs will disincentivize states from undertaking much-needed emission abatement efforts and overlook the ethical costs of large-scale implementation of CDRs. Defining a permissible target for carbon removal by CDRs entails defining the acceptability of the risks and negative side-effects of implementing CDRs and the acceptability of relying on an immature technology.

[12] Another way of justifying why emissions do not have to be reduced to zero is an entitlement by all states to a fair share of the remaining carbon budget defined by the Paris Agreement. However, many states, probably including all industrialized states, have already exceeded their fair share of this global emission budget. They possess what can be framed as a "carbon debt," which could be compensated by removing more carbon from the atmosphere than a state currently produces. Because there is no possibility to mitigate these historical emissions, the use of CDRs becomes an unavoidable prerequisite for meeting responsibilities for this carbon debt. However, full discussion of this claim demands another paper.

This, we argue, depends on the category of emissions. We have developed a framework that defines three categories of emissions at which CDRs are either permissible or not:

(1) *Luxury emissions:* CDRs are impermissible for the current high emissions, which exceed the emissions that individuals need for full membership in society. In many states, these emissions can be said to be mere luxuries and can be abated at costs that are not morally significant. For such emissions, the ethical costs of CDRs cannot be justified.

(2) *Emissions for full membership in society:* CDRs are only conditionally permissible for removing the emissions that individuals need for full membership in society. Wherever possible, emissions in this category must be lowered by structural emission reduction efforts. Because reaching the overall aim of net zero emissions is pressing, CDRs are permissible and obligatory on condition that structural emission abatement cannot be fully implemented without risking individuals falling below the morally relevant threshold required for full membership in society.

(3) *Residual emissions:* CDRs are permissible for emissions that cannot be avoided despite all other efforts. Removing residual emissions with CDRs to meet net zero targets even becomes a duty of states.

In our view, the exact definition of these categories of emissions must remain open to both empirical research and political discourse at national and global governance levels. What full membership in a society means and what quantities of emissions this may require is, crucially, a socially defined decision. Hence, although we do not provide a precise means of calculating a state's permissible target for CDRs, the identification of morally relevant categories of emissions and the permissibility of CDRs helps to identify what numerical targets are morally legitimate for emission abatement and CDRs in more concrete terms.

Status: Published in Justice and Food Security in a Changing Climate*, June 2021, edited by Hanna Schübel and Ivo Wallimann-Helmer, 71–76. The Netherlands: Wageningen Academic Publishers.*
https://doi.org/10.3920/978-90-8686-915-2

Chapter 3: Food Security and the Moral Differences Between Climate Mitigation and Geoengineering: The Case of Biofuels and BECCS

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Abstract[1]

Both biofuels and BECCS serve the purpose of reducing the concentration of carbon in the atmosphere, biofuels by reducing the quantity of CO_2 newly added and BECCS by removing the CO_2 already emitted. Both rely on the large-scale growth of biomass and hence compete with food production for arable land. Consequently, the implementation of both at large scale potentially endangers food security. Given this conflict and the need for climate action, this paper discusses whether there are differences between the ethical implications of mitigation by biofuels and geoengineering with BECCS. We apply a principlist approach, specifying and weighting four key principles of climate ethics: the polluter-pays principle, the ability-to-pay principle, the equal-per-capita principle, and the procedural involvement principle. Because the ethical and practical implications of BECCS and biofuels have many parallels, applying these four principles identifies relevant moral differences to decide between these technologies.

Keywords: biofuels, BECCS, principlism, polluter-pays principle, procedural justice

1. Introduction

To achieve the goal of the Paris Agreement to keep global mean temperature well below 2°C above pre-industrial levels, most climate models assume that we need to vastly reduce emissions, for example through the use of biofuels. At the same time, most modelling scenarios for keeping the global mean temperature increase to 1.5°C above pre-industrial levels assume the large-scale availability of geoengineering technologies to remove carbon from the atmosphere (Fuss et al., 2018). Most frequently, the use of bioenergy with carbon capture and storage (BECCS) is assumed (IPCC, 2018a; Minx et al., 2017): This technology removes carbon from the air and stores it permanently underground. Carbon is removed with the large-scale plantation of biomass on arable land. Such large-scale planting of biomass is also necessary when

[1] Please note that the terminology used here is not coherent with the rest of the thesis, where CDR technologies are not conceptualized as geoengineering. For an explanation, see Section 3.2 of the introduction for a discussion of the term. Further, in other parts of the thesis I refer to ‘emission abatement’ and not ‘mitigation’.

scaling up the production and use of biofuels to reduce emissions. If industrialized countries grow this biomass themselves, they tend to increase their imports of grain, rice, and other staple foods, which can increase global food prices. In consequence, implementing these technologies at large scale may well endanger food security in the poorest regions of the world (Kortetmäki and Oksanen, 2016; Renzaho et al., 2017).

In this paper, we compare the ethical implications of biofuels and BECCS in light of the risk they pose to food security. To assess their ethical implications, we apply a principlist approach by specifying and weighting four key principles of climate ethics (Wallimann-Helmer, 2019b): the polluter-pays principle (PPP), the ability-to-pay principle (APP), the equal-per-capita principle (EpC), and the procedural-involvement principle (PIP), also sometimes called the demands of procedural justice. Because the ethical and practical implications of biofuels and BECCS have many parallels, the application of these four principles will indicate moral parallels and differences between the two strategies. We argue that the main difference between the two lies in the specification of the PPP, because biofuels can bring the burdens of climate action closer to the polluting parties, whilst deploying BECCS allows historical emissions to be taken into account. However, which of these specifications of the PPP should be prioritized must be decided by involving all those concerned most directly and hence means relying on the PIP.

2. A disturbing conflict of goals

The starting point of our investigation is the challenge that the target of the Paris Agreement to reduce the negative impacts of climate change for the poorest regions of the world may demand measures that threaten the livelihoods of these very same regions. In the following, we first explain why climate protection is important to ensure food security in poor regions of the world and then explain in more detail the similarities and differences between biofuels and BECCS relevant for ethical analysis.

In the poorest regions of the world, many people depend directly on agricultural food production for their livelihood. For the agricultural sector, avoiding dangerous climate change means avoiding significant changes in the distribution of rainfall, long droughts, and extreme events such as flooding and heavy rainfall. Hence, climate protection becomes a key factor to foster food security in these regions (Myers et al., 2017). Even though some adaptation to changing climatic conditions is possible in the agricultural sector, at some point, the transformation of traditional ways of livelihood may become necessary. If these transformations mean leaving ancestral lands, such transformational adaptation increase the risk of poverty and hunger. Hence, keeping the current climate as stable as possible contributes significantly to food security in these regions of the world. Both biofuels and BECCS can support this goal.

Biofuels such as biodiesel or bioethanol have a considerable potential to save carbon over their entire life cycle. Because reaching the Paris target requires steep reductions in carbon emissions while ensuring enough energy for economic development, biofuels become an important part of the menu of renewable energy transitions (Fulton et al., 2015). However, the saving potential of biofuels depends on the weight that the land use changes it requires are given in the balance sheets. A critical aspect of the use of biofuels is that it requires the large-scale cultivation of biomass. Studies show that one consequence of this will be a massive increase in grain prices on the global market, to the disadvantage of poorer regions of the world (Brinkman et al., 2020; Hasegawa et al., 2018).

In parallel, many climate models show that employing BECCS to remove carbon emissions from the atmosphere is necessary to achieve the Paris target (Anderson and Peters, 2016; Minx et al., 2017). Hence, aiming for this goal implies that all over the world plantations of fast-growing biomass will be developed to bind carbon and used as an energy source. In BECCS, parts of this energy will be used to liquefy carbon to store it in terrestrial aquifers or deep under sea. Thus, beyond vast areas of arable land, BECCS also involves facilities for producing energy, liquefying carbon, transporting the liquefied carbon, and storing it. Biofuels also demand energy for their production, and they must be transported and stored until they are used.

Therefore, BECCS and biofuels are very similar in their negative impacts. The main difference is that BECCS requires the storage of removed carbon whereas biofuels do not. But because both require the growth of vast quantities of biomass, both tend to threaten food security in poor regions of the world. Thus, it is necessary to balance food security with implementing biofuels and BECCS at large scale, both of which are necessary to avoiding dangerous climate change. However, to do so is challenging. Both technologies are quite similar in their negative impacts and are not easily differentiated in an ethical evaluation. In the next two sections, we apply a principlist approach to analyse the ethical conflicts presented.

3. Specifying principles to understand the conflict of goals

The methodology suggested to analyse the conflict of goals identified in the last section is principlism, well known from medical practice. Principlism assumes that for a given practice there exists a core set of principles that need to be specified and weighted differently depending on the moral issue at stake. Whereas the core principles are well established in medical ethics, such core principles have not yet been defined for environmental issues. While in climate ethics the polluter-pays principle (PPP), the ability-to-pay principle (APP), the equal-per-capita principle (EpC), and the procedural-involvement principle (PIP) are most commonly used to differentiate responsibilities and entitlements in climate action, it is of key importance to specify their meaning with regard to the conflict of the goals under scrutiny. In the following, we specify each principle for the given case before proposing a weighting of them and offering concluding remarks.

Specifying the polluter-pays principle

The PPP is usually understood as assigning responsibilities for climate action in proportion to contributions to anthropogenic climate change. Parties emitting more greenhouse gases should shoulder heavier burdens in avoiding dangerous climate change. In a variant, this principle also concerns those who benefit proportionally more from the emissions of others. Historical emissions are relevant here because current welfare most probably depends on emissions made in the past. Both biofuels and BECCS can make proportional contributions to climate change because they serve as means to reduce emissions. The more someone contributes or has contributed to anthropogenic climate change, the more they should reduce their production of emissions or remove emissions from the air.

However, the PPP identifies two crucial differences between these technologies. First, BECCS demand centralized facilities for producing energy and liquefying carbon from the biomass grown nearby. Storing liquefied carbon requires a transportation infrastructure (e.g. pipelines) and appropriate geological sites (Bui et al., 2018). Although biofuels must be produced and stored in centralized facilities as well, their negative impacts will most probably be more decentralized. To lower transportation costs, biofuels will be produced geographically closer to those who emit and hence bring negative impacts closer to those contributing more to climate change. This is not the case for BECCS, whose scale effects may favour large facilities, especially for storage. Second, biofuels only possess the potential to reduce currently produced carbon because the carbon they capture will be released again once they are burnt for energy production. By contrast, BECCS capture whatever quantity of carbon from the atmosphere that is processed by facilities. This also enables the capture and storage of historical emissions.

The PPP clearly assesses the potential negative impacts of both biofuels and BECCS on food security as an injustice. The poorest regions of the world did not contribute most to climate change. Consequently, the PPP requires that the implementation of both biofuels and BECCS is realized in a way that minimizes their negative impacts on the poorest regions of the world. Beyond this, the PPP remains rather neutral regarding a choice between biofuels or BECCS. However, we argue that there is a slight tendency to favour biofuels over BECCS because they allow negative impacts to be more closely aligned with individual pollution. By contrast, BECCS has the advantage of accounting for all emissions, both those currently produced and those in the past.

Specifying the ability-to-pay principle

Most commonly, the APP does not assign responsibilities for climate action in proportion to current and past contributions to climate change but relies on agents' capacities. Those more capable of remedying environmental threats are ascribed heavier burdens for acting. Parties commanding more financial resources or better expertise are seen as having a duty to take the lead and assist those less well equipped. The APP entails a crucial further implication: Demanding action from those not able to act is considered illegitimate. Only those capable of acting can be ascribed responsibilities.

In our context this means that those parties financially and technologically able to foster research on biofuels and BECCS and to implement these technologies must take the lead. They are responsible for providing the finance, technology, and managerial skills for their implementation where needed and possible. Hence, the APP differentiates between parties with financial capacities and those with the skills necessary to implement these two technologies. These skills might further differentiate responsibilities because they might not be equally distributed between the technologies. Because biomass must be planted where it can grow and liquefied carbon must be stored in appropriate sites, the APP may also be interpreted as defining where biomass should be grown and BECCS should be realized.

However, the APP has an important limitation when applied to both BECCS and biofuels. With the APP, tropical regions might have a duty to make land available to grow biomass if this is more efficient than growing it in colder climates. But arguments like these do not reflect any differences in the economic and social conditions of those affected by the implementation of these technologies. This is problematic if the negative impacts of their implementation worsen conditions that are already poor. However, realizing such facilities might also be of advantage for these regions because these technologies may also mean economic gain for those involved. If economic gain can outweigh the negative impacts on food security, implementing plantations and facilities might be justifiable.

Specifying the equal-per-capita principle

In its classical interpretation, the EpC assigns rights to equal quantities of emissions to all human beings. This quantity is usually calculated from an emissions budget defined by a climate target such as that of the Paris Agreement. An entitlement to an equal quantity of emissions is usually justified by two arguments. First, no morally relevant differences exist between human beings regarding emission entitlements. Second, if no morally relevant differences exist, then the only pattern of distribution that requires no justification is an equal distribution. However, if there are legitimate reasons to distribute unequally, such as the need to heat or the limited availability of low-carbon technology, then unequal distributions of emission entitlements might be justified.

The promise of biofuels is to produce similar amounts of energy while releasing less carbon. It is this entitlement to an equal amount of energy that we think is relevant when specifying the EpC to decide between the two technologies. Whereas biofuels reduce emissions released in energy production, BECCS removes fossil emissions from the atmosphere after they have been burnt to produce energy. Deciding which technology is more closely in line with the EpC depends strongly on technological details and on the degree to which emissions of energy production can be balanced. The more energy that can be produced with a technology, the more favourable this technology becomes. In consequence, the decision depends on the degree to which each technology can help reduce emissions while at the same time ensure a high level of equal amounts of energy for all.

The EpC sheds some critical light on the consequences of biofuels and BECCS for food security. As a principle that defines rights to equal entitlements, the EpC demands food security for all to an equal degree. In whatever way such equality of food security is defined, deviation from it would have to be justified. Because human beings do not seem to differ in their need for food security, such inequalities can hardly be justified. Thus, unequal distribution of the negative impacts of biofuels and BECCS on food security need to be avoided unless they can be justified. Many egalitarians argue that an important exception to equal distribution is voluntary choice. This would be the case, for example, if regions accepted biomass plantations in exchange for economic advantages.

Specifying the procedural-involvement principle

The procedural involvement on fair terms of all affected demands that environmental policy decisions are taken in a collective endeavour. This principle, more common in empirical environmental justice literatures, demands collective decision-making because not all environmental questions are strictly speaking questions of fair distribution. Important examples include the evaluation of risks and compensatory measures for climate loss and damage. In both cases, it can be argued that assessment is only legitimate if it is achieved by involving those who have morally relevant interests at stake (Page and Heyward, 2017; Wallimann-Helmer, 2015).

Biofuels and BECCS both involve negative impacts that might require compensation for unfair disadvantages. This is the case if the unequal distribution of their negative impacts cannot be justified. In such cases, those facing negative impacts have to be involved in decision-making under fair conditions to decide what compensation is appropriate for the unfairness faced. Because biofuels and BECCS might also have economic advantages for those living near these facilities, such processes might also legitimize unfairly heavier burdening. However, one of the most serious challenges is to ensure appropriate recognition of indigenous peoples, ethnic minorities, and other marginalized social groups in such decisions.

Special emphasis must be given to the food security of indigenous peoples and more generally to poor communities and regions of the world. Not only is their livelihood endangered due to climate change; there is also a high risk that their voices will not be heard when it comes to the threats to their food security. Hence, to ensure food security for the poor, it will be of key importance to involve these peoples and communities in decision-making about the implementation of biofuels and BECCS and to ensure appropriate recognition.

4. Weighting principles to decide the conflict of goals and concluding remarks

According to the principlist approach, once principles are specified, they need to be weighted. Principlism assumes that the principles building the core set of ethical principles in a given context have no predefined hierarchy. The hierarchy of principles might differ by case and context. However, once a hierarchy of principles has been established, it justifies a decision. The principle or the principles that are at the top of this hierarchy decide the ethical conflict at scrutiny. What action these principles demand in a given context is the morally right thing to do.

Following our analysis, in the current situation we deem the PIP to be the most important principle in this context. The reason for this is that the specifics of the efficiency and negative side-effects of biofuels and BECCS are both still to be determined, which makes it difficult to identify exactly which technology the other three principles would propose. Under such conditions, we believe that it is most important to involve those who are most directly affected by the large-scale implementation of biofuel and BECCS facilities in deciding how to prioritize them.

We take the PPP to be the second most important principle because it most clearly identifies the injustices at stake in food security. Those who have contributed the least to climate change will suffer the greatest threats to their food security. However, what the PPP recommends depends on how much weight is given to bringing the additional burdens of new technologies closer to those emitting, as is possible with biofuels, or to accounting for historical emissions, as BECCS allows.

We argue that both the APP and the EpC could serve as safeguards. The APP ensures that those disadvantaged are not carrying heavy burdens due to the implementation of both technologies, especially if their food security is endangered. Further context is needed to fully specify the EpC because its demands depend strongly on the technology used and its efficiency. However, the EpC demands equal energy be ensured and thus that no one is left behind when implementing new technology for climate protection.

Part III: Corporations and Benefits from Carbon Removal

Introduction

Having addressed the responsibilities of individuals and states under rather favourable assumptions for the development of CDR technologies, the question remains how CDR technologies can be scaled-up and how the ethical challenges linked to such a development can be addressed. To answer this question, corporations must be considered. Corporations influence both the development and upscaling of CDR technologies and are active participants on both the supply side of carbon removal services and the demand side for purchasing such removals (Hyams and Fawcett, 2013). There may be even more reason to ascribe obligations to reduce emissions to corporations than to ascribe such obligations to individuals (Schwenkenbecher, 2018: 56). Especially for CDR technologies and 'in the context where states are not doing nearly enough to address climate change, attention is increasingly turning to the contribution that corporations make to climate change' (Moss, 2020: 45). By removing emissions, corporations may not only contribute to climate change but also to its mitigation. However, corporations may have different motivations than climate change mitigation and need to be incentivised to remove emissions (alongside, in some cases, their commitments to net-zero targets). The benefits that corporations can potentially derive from carbon removal raise important questions of justice. Hence, as part of providing an argument on the ethics of carbon removal, this part of the thesis addresses the responsibilities of corporations to remove carbon dioxide within the non-ideal setting where the benefits are likely to be distributed unjustly.

In Chapter 4, we consider the responsibilities of carbon majors. 'Justice in benefitting from carbon removal' addresses the question of to what extent carbon majors may profit from CDR technologies. The prospect of a carbon removal market dominated by carbon majors raises questions about the fairness of benefits drawn from CDR technologies. This situation has the structure of a moral dilemma, because choosing either option seems to mean choosing to do injustice: either allowing carbon majors to benefit unfairly from extending CDR technologies as far as is feasible or preventing such benefits yet undermining climate stabilization. To clarify this situation, the paper defines the conditions under which incentives for contributing to climate stabilization are morally justified. It categorises three unjust benefits from climate change and the carbon removal market. In the second part, the paper explores a non-ideal argument for permitting the injustice of providing economic incentives for carbon majors to undertake CDR technologies. The paper was accepted for publication at *Global Sustainability* on 28 September 2023. Dominic Lenzi, Ivo Wallimann-Helmer, and I all contributed equally to the development of the argument and the writing of the resulting article.

In Chapter 5, I investigate the responsibilities of corporations more generally. I explore how some corporations may be more or less entitled to benefit from carbon removal. This raises the question of how the responsibilities and entitlements of different corporations can be weighed against each other. Once more, I focus on the emblematic case of BECCS and the sustainability challenges it raises if implemented at large scales, especially to food security. Through both funding the development and up-scaling of BECCS and providing these services, corporations are important players. Given that the sustainability of BECCS is likely to be limited, the question arises under which conditions corporations can permissibly offer BECCS and benefit from offering these services. Further, the question arises which corporations may purchase carbon removals certificates, given their limited availability, and thereby offset their emissions. I argue that justice and sustainability criteria should guide how much land can be used for BECCS, and that further criteria are needed to define which corporations are most or least entitled to use BECCS. The paper on which Chapter 5 is based is 'Who should get to take credit? Investigating the role of corporations in carbon removal developments', which was published in *Transforming Food Systems: Ethics, Innovation and Responsibility*, the conference proceedings of the European Society of Agriculture Food and Ethics, held September 2022 in Edinburgh. It was authored solely by me.

Status: Published at Global Sustainability *in September 2023. DOI:10.1017/sus.2023.22.*

Chapter 4: Justice in Benefitting from Carbon Removal

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Non-Technical Summary

Climate stabilisation requires scaling up technologies to capture and store carbon. Carbon removal could be very profitable, and some of the agents best placed to benefit are ‘carbon majors’, i.e., fossil fuel companies. We argue that in ordinary circumstances only agents without significant historical climate responsibilities would be entitled to the full benefits from carbon removal. Under non-ideal conditions, carbon majors might be entitled to benefit, provided that no other agent could remove similar quantities of carbon at similar costs. This burden of proof is only likely to be met in countries with poor governance capacities.

Technical Summary

Climate stabilisation requires scaling up technologies to capture and store carbon. Some of the agents best placed to profit from carbon removal are ‘carbon majors’, especially fossil fuel companies. Yet incentivising carbon majors to undertake carbon removal poses an ethical dilemma: carbon majors have made significant historical contributions to climate change, and have significantly benefitted from such contributions without being made to compensate for resulting climate harms. This is why it seems unfair to reward them with additional economic benefits. However, carbon majors possess the technological skills and infrastructure to upscale carbon removal efficiently. We argue that in ordinary circumstances, only agents without significant climate responsibilities would be morally entitled to fully benefit from carbon removal. Yet under non-ideal conditions, it might be permissible to reward carbon majors if no other agent were capable of removing as much carbon at similar costs and on similar timeframes. We believe this argument faces an imposing burden of proof that is only likely to be met in countries with poor governance capacities. In more favourable circumstances, including those of most OECD countries, rewarding carbon majors without having them pay for their historical climate responsibilities remains impermissible.

Social Media Summary

Rewarding carbon majors to undertake carbon dioxide removal is unjust due to their historical climate responsibilities. Where possible, governments should empower other agents to remove CO_2.

1. Introduction

In May 2021 in the case Milieudefensie (the Dutch branch of Friends of the Earth) *vs* Royal Dutch Shell, the District Court of the Hague found that the multinational corporation must reduce its CO_2 emissions by net 45% by 2030 (relative to its 2019 emissions) (Nollkaemper, 2021). Royal Dutch Shell is a ‘carbon major’, with emissions and complicity in producing emissions exceeding those of most countries. The term ‘carbon major’ refers to major producers of hydrocarbons, including coal, oil, and gas. A 2017 report by the Climate Accountability Institute (Griffin, 2017) found that 100 extant carbon majors have been linked to 71% of global GHG emissions since 1988. Stating that Shell’s current policy and climate targets were violating a ‘due standard of care’, the court further noted that the corporation has significant historical responsibility for climate change (Giabardo, 2021). While this may signal greater legal accountability for carbon majors, the urgency of decarbonisation also raises the uncomfortable prospect of rewarding carbon majors for removing atmospheric carbon if these agents are best placed to do so.

Given decades of climate policy failure, limiting warming to ‘well below’ 2 C° above pre-industrial levels in line with the Paris Agreement is likely to require large-scale use of carbon dioxide removal (CDR) technologies (IPCC, 2022). Energy analysts have begun to speculate about a future market in captured and stored carbon to rival existing energy markets (Vivid Economics, 2020). We refer to this as the *carbon removal market*. Some of this speculation concerns revenues that might be drawn from using carbon capture and sequestration (CCS) technology, which is a component of several CDR methods, such as direct air capture (DACCS) and bioenergy with CCS (BECCS). Such a market would likely be backed by public financing and favourable regulatory conditions. And at present, carbon majors look set to be leading beneficiaries. Shell is involved in one of the European Union’s major carbon storage projects (the Northern Lights Project) (European Commission, 2021) while ExxonMobil is asking the US Congress for subsidies to kick-start its carbon removal business (Lefebvre, 2021). In May 2021, Shell and ExxonMobil were granted $2.4 billion in subsidies by the Dutch government for carbon sequestration and storage projects (Meijer, 2021).

In this paper, we analyse the ethical implications of a carbon removal market in CDR, from which carbon majors stand to be leading beneficiaries. We first introduce the dilemma of benefitting carbon majors by providing insights into the kind and scale of benefits that can be earned. Section 3 focuses on the first horn of the dilemma, arguing that benefitting from carbon removal is unjust under conditions applicable to carbon majors. Section 4 argues that the second horn of the dilemma may be resisted, since it requires showing that it is necessary to allow carbon majors to benefit from CDR in order to secure a stable climate. As we show, this claim only appears plausible in circumstances that do not apply to most OECD countries. We conclude by suggesting ways to balance the need to incentivise carbon removal without cancelling out historical climate responsibilities.

2. The dilemma of benefitting carbon majors

While the possibility of benefitting from emission reductions has long existed, the promise of benefitting from carbon dioxide removal has only emerged in the last few years. Carbon removal is increasingly prominent in national and private sector commitments to net zero emissions (Honegger et al., 2017; Lenzi et al., 2021). In most cases, carbon dioxide removal will be very costly (Fuss et al., 2018). For example, bioenergy with carbon capture and storage (BECCS) is estimated to cost $100-200 per ton of CO_2, while direct air capture with carbon capture and storage (DACCS) is estimated at $600-1000 per ton for early plants, with costs potentially falling to $100-300 as more facilities are built (Fuss et al., 2018, all figures quoted in US dollars).

A carbon removal market could provide significant new revenues if appropriate state incentives and regulation were made available. A study by Vivid Economics (2020) estimated that such a market could present a trillion dollar investment opportunity that may eventually rival the current oil and gas sector. This study estimates that 'nature-based' CDR, primarily afforestation and reforestation, could provide $190 billion annually by 2050, while 'avoided deforestation' could provide as much as $610 billion annually by 2050. BECCS and DACCS could provide as much as $625 billion annually by 2050. In the US context, tax credits for biofuel generation may turn BECCS into a profit-generating opportunity (Ryan, 2018), whereas a regime to pay farmers to sequester carbon in soil is currently being considered (Colman et al., 2021).

Some of the world's largest corporations are already investing in CDR, and into CCS as a component of CDR strategies. For instance, Microsoft has announced a $1 billion climate innovation fund to develop CDR and CCS technologies, aiming to become 'carbon negative' by 2030, and to remove all carbon directly or indirectly emitted since its foundation in 1975 (Smith, 2020). Large oil and gas companies are also investing in carbon dioxide removal to reduce their carbon footprints. ExxonMobil has invested $3 billion in CCS projects over the next five years, estimating that the market for carbon capture will be roughly $2 trillion by 2040

(Eberhart, 2021). From these considerations it appears that CDR is becoming an attractive investment for carbon majors.

Carbon majors already possess CCS infrastructure, which is necessary for prominent forms of CDR. At present, the technical capacities and the knowledge to do CCS, and thus CCS-dependent forms of CDR in future, are largely limited to companies which produce fossil energy, i.e. carbon majors. This is due to large similarities in technology and infrastructure between oil extraction and carbon sequestration and storage (Hastings and Smith, 2020). As such, these companies seem to be key for the development and scaling up of prominent CDR techniques such as BECCS and DACCS. The EU 'Northern Lights' CCS project is a partnership with fossil fuel companies Equinor, Shell and Total (Global CCS Institute, 2020). Likewise, the UK's 'Acorn' CCS project is being carried out by Pale Blue Dot Energy, in partnership with Harbour Energy and Shell, and with funding from the EU and the UK (Pale Blue Dot Energy, 2021). We note that other authors (e.g. Moss, 2020) include cement producers under this category because they also contribute a large amount of yearly carbon emissions. However, the dilemma we discuss applies only to fossil fuel companies, because they already possess CCS infrastructure.

If CDR is to be incentivised through market mechanisms, as many analysts suppose, the prospect of economic gains appear necessary. Since many CDR facilities, especially DACCS, are in early stages of commercialisation and face high costs (Fasihi et al., 2019), a major concern is whether the gains received from a future carbon removal market will be sufficient to incentivise investments. However, it seems morally problematic that those who are best placed to profit from an emerging carbon removal market have profited significantly from the sale of vast quantities of fossil fuels, the key driver of anthropogenic climate change. While carbon majors do not bear the sole responsibility for the harm created by climate change, their supply of a primary driver of climate change, and their profits from doing so, appear to be morally relevant when considering future economic rewards from doing CDR.

Despite these facts about carbon majors and the distribution of capacities, not engaging in CDR likely leads to dangerous climate change given the reliance upon these technologies in most temperature stabilisation pathways (IPCC, 2018a, 2022). Since carbon majors already possess the necessary technology for future CDR implementation, it is likely that they could render these technologies viable within shorter timeframes and at larger scales than other agents. If so, carbon majors could be key to avoiding morally unacceptable climate harms, and could contribute significantly to the global public good of a stable climate system in line with the Paris Agreement.

These considerations lead to what we call the 'dilemma of benefitting carbon majors'. The first horn of this dilemma concerns the unfairness of allowing carbon majors to benefit from the carbon removal market. This seems compelling for two reasons: first carbon majors should be made to pay for their contribution to climate change and second, they should also be made to pay for any unjust benefits they have gained and continue to gain from such contributions. Thus, it appears fair that some or all of the revenue that carbon majors draw from carbon dioxide removal should be withheld. As we show in Section 3, this argument follows from formulations of the polluter pays principle that are interlinked with the beneficiary pays principle (Heyward, 2021).

However, this leads us to the second horn of the dilemma, which concerns the moral permissibility of providing economic incentives to achieve a desirable public good. Most plausible moral views hold that there is a moral imperative to limit climate change to 'well below' 2°C, in line with the Paris Agreement. Given the necessity of not only reducing emissions but removing atmospheric CO_2, decreasing incentives to undertake CDR may reduce the likelihood of stabilising the global climate. Yet carbon majors appear to be uniquely well-placed to undertake CDR if economic incentives were available. Because failing to stabilise the global climate would create very serious injustices, it seems permissible to reward the agents able to scale up CDR as rapidly as possible.

The prospect of a carbon removal market dominated by carbon majors thus raises questions about the fairness of benefits drawn from CDR. This situation appears to have the structure of a moral dilemma, because choosing either option seems to mean choosing to do injustice: either allowing carbon majors to unfairly benefit to do as much CDR as is feasible, or preventing such benefits yet undermining climate stabilisation. To clarify this situation, we need to understand the conditions under which incentives for contributing to climate stabilisation are morally justified. In the next section we categorise the three unjust benefits from climate change and the carbon removal market, and then turn to the challenges of morally justifying incentives to undertake CDR.

3. Benefitting from climate change and from a carbon removal market

This section deals with the first horn of the dilemma of benefitting carbon majors. It argues that benefitting from CDR is unjust under certain conditions, and that such conditions apply to carbon majors.

First, a note about how we understand benefits. Benefits from the carbon removal market can be obtained by providing knowledge (e.g. of how carbon can be captured and stored) and infrastructure (e.g. for transport and storage of carbon). Benefits may be gained through the development and selling of CDR technology to remove, liquefy and transport carbon; by providing infrastructure and technologies for capturing and transporting carbon; and by providing storage locations (Hastings and Smith, 2020). Most importantly, benefits will be gained through the removal and storage of carbon on behalf of enterprises or states, e.g., through the purchase of carbon credits because they either voluntarily decided to reduce their carbon footprint or were legally obliged to do so.

While the climate ethics literature has primarily focused on the negative impacts from climate change and the fair sharing of burdens for their minimisation, prevention, and compensation (cf. Gardiner et al., 2010; Hayward, 2012; Page, 2008; Wallimann-Helmer, 2019b), potential benefits from contributing to emissions reduction have been comparatively neglected. Normative literature on benefitting and climate change focuses on the Beneficiary Pays Principle (BPP), which holds that those who benefit from climate change have proportionally greater responsibilities for climate action (Heyward, 2014a; Page, 2012). The BPP is most often understood not to be independent from historical contributions and therefore draws some of its normative force from the Polluter Pays Principle (PPP) (García-Portela, 2023; Heyward, 2014a).

Nonetheless, previous discussions of the BPP only capture some of the concerns raised by the benefitting carbon majors dilemma. On the basis of an expanded understanding of the BPP, we argue that it would be just for agents without large historical climate responsibilities to benefit from removed and stored carbon. On the basis of the PPP, we argue that it would be unjust for agents with large historical responsibilities to benefit.

To justify these claims, we outline three categories for assessing benefits in the context of climate change (see Table 3): (a) benefits gained by contributing to climate change; (b) benefits gained due to favourable changes in climatic conditions; and (c) benefits gained from climate change mitigation policies. We include CDR under the broader category of climate change mitigation policies, following the IPCC's recent reclassification of it as a form of mitigation (Babiker et al., 2022). CDR had previously been classified as 'geoengineering' (Edenhofer et al., 2014: 60). Our discussion concerns benefit (c), although we focus on benefits derived from CDR. For each category, we suggest conditions under which benefitting would be unjust.

Table 4 Benefits, the benefit-generating action, and the criterion to assess injustice

	Category	**Benefit**	**Action generating benefit**	**Criterion for assessing injustice**
a	Benefitting from contributing to climate change	Economic gains from producing or using fossil energy	Selling or utilising a key source of anthropogenic climate change	Proportional contribution to negative climate impacts, or benefit from supplying others' contributions
b	Benefitting from favourable changes in climatic conditions	Economic gains from favourable market conditions due to changing climatic conditions	Conducting business under favourable climatic conditions	Proportional benefits attributable to changes in climatic conditions
c	Benefitting from climate change mitigation policies (limited to the carbon removal market)	Economic gains from employing CDR	Implementation of CDR; providing technical knowledge or infrastructure for CDR	If reason for access to CDR technologies is benefit (a)

a) Unjustly benefitting from contributing to climate change:

Benefits obtained from contributing to climate change can be deemed unjust because these actions contribute to morally serious forms of harm (Butt, 2009; Goodin, 2013; Heyward, 2014a). According to the PPP, there is a duty to support climate action in proportion to one's current or historical emissions (Caney, 2005; Meyer and Roser, 2010; Neumayer, 2000; Shue, 1999). Similarly, the BPP places greater responsibility upon those who have benefitted more from actions that contributed to climate change, even if they did not directly cause the emissions (Page, 2012). Under both the PPP and the BPP, carbon majors carry unaddressed historical responsibilities deemed unjust and both principles identify duties to correct for this situation (García-Portela, 2023; Heyward, 2021; Wallimann-Helmer, 2019b). Most importantly, investing in CDR may allow carbon majors to become 'carbon neutral' while continuing to contribute to climate change or to benefit from actions contributing to it. Benefit (a) is highly relevant in the assessment of carbon majors, since as we will see shortly, it is the reason they stand to benefit from CDR.

b) Unjustly benefitting from favourable market conditions:

Some benefits are not gained directly from activities contributing to climate change, but from adapting to new climatic conditions. Examples include growing wine in areas where it could not previously be grown or selling more air conditioners. Such actions fall under benefitting from injustice because they only become possible due to unjust climate harms (Butt, 2009;

Goodin, 2013; Heyward, 2014a). Although these conditions were not intentionally brought about, they happen as a consequence of changing climatic conditions jointly produced by all emitting parties. Voluntarily benefitting from these injustices can be argued to be a reason for carrying responsibilities towards those treated unjustly (Pasternak, 2014). Under the BPP, actions may generate the obligation to compensate even if the actions are not consensual or voluntary (Atkins, 2018). Where 'losers' of climate change are compensated by polluters, the entitlement of the 'winners' to benefits from climate change may depend on whether they resulted from a course of action or maintaining one's economic activities (Mintz-Woo and Leroux, 2021). Nonetheless, culpability is necessary for benefits to be unjust. Heyward (2014a) distinguishes culpable from non-culpable beneficiaries on the basis of being partly or fully responsible for the injustice or having no role in its occurrence. Agents who share culpability are under strict duties of remedial justice to surrender any benefits. The culpability condition of benefit (b) is also highly relevant for carbon majors, since these agents have voluntarily contributed to climate change through the extraction and sale of fossil fuels, through ongoing lobbying for weaker climate change mitigation policies, and even through the dissemination of misinformation (Oreskes and Conway, 2010).

c) Unjustly benefitting from climate change mitigation policies:

Some benefits are not gained as the result of climate change, but specifically due to climate change mitigation policies. Such policies involve CDR which, in contrast to most economic activities, do not produce additional emissions. Instead, carbon removal is their product, and their wider aim is to reduce the concentration of CO_2 in the atmosphere. These are benefits made from climate change mitigation policies that set up, regulate, and incentivise investments in the carbon removal market. This market is based on governments creating conditions to bring about the public good of a stable global climate. Because the benefits from the carbon removal market are largely drawn from public funds and are aimed at a public good, it is difficult to maintain that their distribution is not a matter of justice. Further, not all agents benefit from this market for the same reasons. While the primary good traded is captured carbon, we saw that benefits can be obtained by making available storage space, infrastructure, knowledge, and technology in exchange for payment.

As such, the reasons for access to CDR become a principal criterion for determining whether a benefit counts as an injustice. Some CDR businesses possess these capacities independently of past contributions to climate change, such as the Swiss company Climeworks (founded in 2009) (Climeworks, 2022). It could be argued that such agents are entitled to their gains since they lack historical responsibility, and since these agents are directly contributing to climate change mitigation (Mintz-Woo and Leroux, 2021). Carbon majors, by contrast, possess these capacities precisely because of their past contributions to climate change (see benefit (a)). They gained the capacities to profit from the carbon removal market by extracting, transporting, and selling fossil fuels, and because CDR infrastructure turns out to be similar to the infrastructure needed to extract fossil fuels. Pipelines built for transporting fossil fuel and gas will be essential for reducing the costs of transporting liquified carbon. By extracting fossil fuels, carbon majors have also gained empty reservoirs that can serve as storage sites for liquefied carbon (Bui et al., 2018).

Therefore, it would be unjust for carbon majors to be allowed to benefit from a carbon removal market in CDR due to their unaddressed historical climate responsibilities, as well as their continuous contributions to climate change. Since this carbon removal market only becomes profitable given the existence of climate change, it is a benefit built atop the prior injustice of benefitting from and contributing to climate change. Thus, the first horn of our dilemma remains compelling: carbon majors ought not to be permitted to benefit from CDR.

Yet this result runs into the second horn of the dilemma: preventing carbon majors from revenues gained from the carbon removal market implies that less CDR will be done. Given this concern, the next section explores a non-ideal argument for permitting what we have argued to be a clear injustice, namely providing economic incentives for carbon majors to undertake CDR.

4. Justice and incentivising carbon removal

Discussions of benefitting from climate change have seldom considered the importance of incentives, yet incentives can matter greatly for achieving climate justice (Mintz-Woo and Leroux, 2021). Ignoring economic incentives to invest in carbon removal may undermine the economic case for some agents to invest in this business (Ko et al., 2021). Nonetheless, ignoring the history of carbon majors when designing incentives would undermine any attempt at fairly distributing responsibilities for climate action, and could even be self-defeating.

We argue that under non-ideal conditions, economic incentives for carbon majors to undertake CDR would be morally permissible *if and only if* no other agents were capable of removing as much carbon at roughly similar costs, and on roughly similar timeframes, and in accordance with existing demands of justice. Even given this condition, carbon majors may only benefit from the carbon removal market if they address their existing historical climate responsibilities. We will shortly explain what these conditions require.

There are different views about the morality of incentives to comply with justice. As Mintz-Woo and Leroux note (2021), consequentialists generally regard incentives to maximise the good as morally legitimate, if not compulsory. They favour incentives to decarbonise the global economy, internalising all harmful impacts of climate change. By contrast, Rawls' 'difference principle', which holds that inequalities are permitted so long as this benefits the worst off , allows for the incentivisation of those capable of producing more – but only to the extent that this benefits the worst off (Rawls, 1971). A Rawlsian view would mean that carbon majors would be entitled to incentives from the carbon removal market only if these benefitted the worst off, i.e. those most vulnerable to the negative impacts of climate change. It is safe to assume that a stabilised climate would benefit the worst off. However, in his prominent critique of the Rawlsian position, Cohen (2008) objected that the talented are not justified in working less hard unless they are paid more. This appears somewhat analogous to the case of carbon majors, who like Cohen's talented rich, would be unjustly demanding an incentive if they invested less in CDR unless they received public subsidies.

Nonetheless, this critique comes from ideal theory, and thus appears to be inapplicable to the dilemma of carbon majors. This dilemma is more plausibly viewed under the lens of non-ideal justice. A situation falls under non-ideal justice when two conditions of ideal justice are absent, namely full compliance with principles of political morality and favourable external conditions (Rawls, 2001). Climate ethics generally seems to be especially apt for non-ideal analysis because there remains little compliance with demands of climate justice, and because climate policy is fraught by unfavourable political and economic circumstances (Heyward and Roser, 2016).

Non-ideal justice allows consideration of actions that would be impermissible under ideal justice, in the interests of making a just future situation more likely (Stemplowska and Swift, 2012). From a non-ideal view, one might make the following argument: carbon dioxide removal has become essential for avoiding dangerous climate change. The urgency of avoiding dangerous climate change is such that as much carbon removal should be done as is possible without severe adverse side-effects. Carbon majors are also among the agents most capable of speedily scaling up carbon removal. Thus, carbon majors should be allowed economic gains from doing so, despite this being unjust (see Section 3). As a result, the incentivisation of carbon majors is morally permitted if it could be reasonably shown that such incentives were necessary to avoid dangerous climate change. This would be so even if such incentives involve sufficient injustice to render them impermissible under ideal justice. If so, it seems morally permissible for carbon majors to benefit from CDR to the extent that this is actually required to avoid dangerous climate change.

However, this argument is unlikely to succeed in most contexts where CDR is being contemplated. It requires demonstrating that no other agents are capable of doing as much CDR as carbon majors, as rapidly, and at similar costs. There are serious challenges facing any attempt to bear out this claim. These stem from the conditions of non-ideal justice of most relevance to climate change, namely epistemic uncertainty, moral uncertainty, and technological constraints (Heyward and Roser, 2016). First, there is epistemic uncertainty about whether the involvement of carbon majors would in fact allow for more rapid upscaling of CDR, and whether large-scale implementation of CDR is feasible at all. There is moral uncertainty about the conditions under which implementing CDR would be permissible (Lenzi, 2021). There is also technical uncertainty about the viability of redeploying existing fossil fuel infrastructure for carbon removal and about the technical viability of CDR techniques. Further, there is epistemic and moral uncertainty about the likely costs, side-effects and threats to justice posed by CDR (Lenzi, 2018; Schübel and Wallimann-Helmer, 2021; Wallimann-Helmer, 2021). Due to such uncertainties, it is difficult to demonstrate that carbon majors are indeed the agents who could undertake CDR most efficiently, or that they could do so without causing further injustice.

Whether alternative courses of action are available is also likely to depend upon the governance capacities of individual countries. One approach for assessing governance capacity is the World Bank's worldwide governance indicators, which include indicators for voice and accountability, political stability and the absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption (World Bank, 2022). Among these indicators, regulatory quality, rule of law, and control of corruption appear most directly relevant to the implementation and monitoring of carbon removal infrastructure. Countries that score poorly on regulatory quality, rule of law, and controlling corruption may face severe challenges in incentivising carbon removal using state capacities, such as expropriating private capital infrastructure under public domain, establishing publicly owned corporations to undertake carbon removal, or supporting private corporations without historical climate responsibilities to undertake carbon removal. It appears easier to justify incentivising carbon majors to undertake carbon removal under conditions where these alternatives are unlikely to succeed.

Yet according to these World Bank indicators, few if any OECD countries could reasonably claim that they lack the governance capacities to undertake CDR themselves, or to incentivise carbon removal from actors without significant historical responsibilities. Appealing to the urgency of climate stabilisation does not justify rewarding carbon majors so long as there are alternative agents who might do this effectively in due time, and certainly does not permit carbon majors to unilaterally dictate the economic gains they are entitled to as the condition for scaling up carbon removal.

The difficulties with showing the necessity of incentivising carbon majors also turn on epistemically dubious and potentially unverifiable judgements of political feasibility. The ambiguity surrounding feasibility judgements exacerbates the challenge of showing why incentivising carbon majors is genuinely necessary. Extra caution is required since claims about what is economically or politically infeasible can be disguised statements of willingness, knowledge, or even strategic attempts to secure advantage (Schuppert and Seidel, 2017; Schuppert and Wallimann-Helmer, 2014; Wallimann-Helmer, 2022). For example, carbon majors may exclude smaller players from entering in the market, which could lead to path dependencies for them to undertake CDR. There is also the danger of carbon majors pursuing emitting activities in some countries while benefitting from incentives and state subsidies to undertake CDR in other countries. To make feasibility assessments more credible in the future, it is essential to create opportunities for democratic participation in determinations of feasible and fair policy proposals to decarbonise (Honegger et al., 2017; Lenzi and Kowarsch, 2021; Wallimann-Helmer, 2018, 2021).

Thus, the non-ideal argument may justify incentivising carbon majors to undertake CDR in certain circumstances. Yet the burden of proof is very demanding and fraught with technical, epistemic, and moral uncertainties, including questions of feasibility. We have suggested that this burden of proof is likely to be met only in countries with poor regulatory and governance capacities. However, in most contexts where CDR is being contemplated, such as OECD nations, it remains impermissible to incentivise carbon majors to undertake CDR, at least until they address their historical climate responsibilities.

5. Managing the dilemma of benefitting carbon majors

We have argued that even where rewarding carbon majors turns out to be morally permissible, this does not cancel their historical climate responsibilities. For this reason, governments are justified in imposing additional burdens upon carbon majors, irrespective of whether they claim benefits from a market in carbon removal. In principle, any economic gains from the carbon removal market can be treated separately from obligations to redress historical responsibilities for emissions, since the fact of benefitting is insufficient to show that an injustice has occurred – at least when this benefit occurs as a result of climate change mitigation. However, if, as in case of carbon majors, agents stand to benefit from CDR due to their past and current contributions to and benefits from climate change, then any benefits from these technologies remain unjust, at least until such historical responsibilities are met. These benefits are only possible due to the existence of climate change, which is a very serious injustice.

This indirect connection between climate harms and benefits from the carbon removal market shows why any future beneficiaries must account for the fact that they are also benefitting from an injustice. In practice, this can be achieved via well-known means of climate policy. One possibility would be lowering revenues through taxes, which would be redistributed to the victims of climate change. Compensation could also be paid by providing technology and know-how for climate adaptation, or by developing CDR infrastructure and technology for other agents to profit from the carbon removal market. However, most actors capable of developing CDR technologies also benefit from past emissions indirectly. Their technological innovation would not have been possible if past generations had not enjoyed the benefits of carbon emissions. This especially holds true for businesses of industrialised countries that have contributed proportionally more to climate change.

Historical contributions to climate change are especially morally relevant in the case of carbon majors. While it may seem expedient to incentivise them to invest in CDR, their historical responsibilities cannot be ignored. Taxing away gains from trading in carbon removal in higher proportion might be one way to account for their historical responsibilities. Because this poses the risk of rendering carbon removal less attractive for carbon majors, it might be justifiable to allow carbon majors similar revenues from carbon removal to other market actors, but only where no other agents are available and where governance capacities are poor. Conversely, carbon majors could be obliged to make available part of their infrastructure or storage space free of charge. Where there is already a legal requirement to become carbon neutral, as in the case of Shell, removing more carbon than is currently produced or providing infrastructure and storage space for other parties without revenue might be a way of paying court-imposed fines.

Such policy measures demand caution. If carbon majors do not foresee sufficient profits from investing in CDR, they may abandon this business model. Yet it remains to be seen whether this would be ruinous for the project of climate stabilisation, or simply hard luck for carbon majors. One additional challenge for policy makers is that carbon majors are (partly) state owned in many cases. This is one of the reasons why our solution to the dilemma may be problematic or challenging for policy makers: they would have to move away from (partly) state-owned carbon majors towards smaller corporations to carry out CDR. Investigating different layers of institutional capacity and feasibility is also likely to resolve what otherwise appears to be a serious dilemma of choosing between two kinds of injustice.

6. Conclusion

The dilemma of rewarding carbon majors is based on the historical responsibilities of carbon majors, on account of which they now stand to benefit from a future market in CDR. Historical responsibilities make it unjust to permit carbon majors to benefit unconditionally from climate change mitigation policies, such as policies incentivising carbon dioxide removal. However, there may be circumstances under which carbon majors can indeed be incentivised to undertake CDR. We have argued that such circumstances are unlikely to be found in OECD nations, because they require that no other agent could achieve carbon removal at approximately the same rate as carbon majors. This is very difficult to demonstrate, and any legitimate attempt to do so must be transparent about its assumptions of feasibility.

Acknowledgements

The authors wish to thank participants at the *Climate Engineering in Context 2021* Conference in Berlin, the *World Forum on Climate Justice* 2021 in Glasgow, the Philosophy Colloquium of the Arctic University of Norway, and the *ESDiT Conference 2022* in Leiden. We also wish to thank Clare Heyward and two anonymous reviewers for helpful comments on an earlier draft. Publication of this paper was made possible with the financial support from the University of Fribourg Environmental Sciences and Humanities Institute.

Author Contributions

All authors contributed equally to the development of the argument and the writing of the resulting article.

Status: Published in Transforming Food Systems: Ethics, Innovation and Responsibility*, September 2022, edited by Donald Bruce and Ann Bruce, 192–97. The Netherlands: Wageningen Academic Publishers.* *https://doi.org/10.3920/978-90-8686-939-8_28*

Chapter 5: Who Should Get to Take Credit? Investigating the Role of Corporations in Carbon Removal Developments

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Abstract

Planting biomass on agricultural land to feed bioenergy with carbon capture and storage (BECCS) technology is often included in countries and corporations' strategies for reaching their net zero targets. The limited availability of land and the need for food production impose important practical and moral constraints on using agricultural land for growing biomass for BECCS. Corporations are key players in scaling up BECCS technologies, both through funding their development and through developing and providing these services. In light of the constraint of available land, two questions arise: Under which conditions can corporations permissibly offer BECCS and benefit from offering these services? And under which conditions can corporations permissibly use BECCS to offset their emissions? This paper investigates these questions by addressing both the supply and demand side of the newly emerging market in carbon removal, capture, and storage and its link with land. I argue that strong governance is needed for how land is used to supply BECCS, based on justice as well as environmental sustainability criteria. Further, criteria are needed to define which corporations are most or least entitled to use BECCS, given the limited supply of BECCS.

Keywords: land use, bioenergy with carbon capture and storage (BECCS), corporate responsibility, offsetting, sustainability.

1. Introduction

Bioenergy with carbon capture and storage (BECCS) is the technology that the IPCC assumes will be most commonly used in climate stabilization pathways (Fuss et al., 2018). In BECCS, biomass is planted, harvested, and processed in special facilities to create bioenergy. The carbon captured in the biomass is sequestered and stored (CCS), for example in geological reservoirs. As carbon is removed from the atmosphere, employing BECCS at large scales could grant more time for societies, economies, and ecosystems to adapt to changing climatic conditions. The production of bioenergy offers additional mitigation potential and could help economies to decarbonize.

Corporations are key players in scaling up BECCS, both through developing and providing these services and through funding the development by using CDR. BECCS is the carbon dioxide removal (CDR) method most widely adopted in corporations' investment plants on carbon removal, because it allows gains in energy generation and carbon dioxide sequestration (Vivid Economics, 2020). These increasing widespread commitments of corporations to reach net zero targets create high demand for carbon removal services via BECCS to offset their emissions. For example, Microsoft has announced a $1 billion climate innovation fund to develop CDR and CCS technologies, including BECCS; the company intends to become 'carbon negative' by 2030 and to remove all carbon directly or indirectly emitted since its foundation in 1975 (Smith, 2020).

Most importantly, the supply of BECCS is limited by the availability of land, and especially land where biomass can conveniently be planted and harvested. Producing the large quantities of biomass that are needed for BECCS 'is likely to push the world to its planetary boundaries in terms of water and land availability' (Vivid Economics, 2020: 3) and compete with other land usage. Large-scale BECCS could create problems for sustainable land use, including soil degradation and losses of biodiversity. As a result, the quantity of carbon that can sustainably be removed by BECCS is limited (Fuss et al., 2018).

The extent to which BECCS can be used sustainably is by far exceeded by the commitments of corporations to remove carbon with this method (Reid et al., 2020). This creates a tension between demand and sustainable supply of BECCS raises questions about how such a market should be governed. The revenues to be gained from employing BECCS and buying certificates for BECCS, as well as the major role of corporations on either side of the market, motivate the investigation in this paper of two questions: Under which conditions can corporations permissibly offer BECCS and benefit from offering these services? Under which conditions can corporations permissibly use BECCS to balance out their emissions?

In the following, I present my argument how to answer these questions, drawing attention to the fact that sustainable carbon removal via BECCS is a scarce resource. This restriction needs to be included in the governance of this newly emerging market. I show that inadequate consideration risks not only unsustainable use of land but also increasing injustices on both the demand and supply sides of the market. I first consider the supply side of the carbon market and identify potential injustices that may require the definition of sustainability to be supplemented, as these concerns of justice shape how corporations can permissibly offer BECCS. Second, for the demand side, I present a range of suggestions for criteria that could define which corporations can permissibly use BECCS to offset their emissions.

2. The challenge of limited sustainable supply

The involvement of the private sector is crucial in upscaling BECCS, and the potential revenues associated with BECCS may be an important driver for its supply. This section investigates the conditions under which corporations can permissibly offer BECCS and benefit from offering these services. I start by outlining the arguments for efficiency and ecological sustainability and argue these, if we accept them, need to be supplemented by justice concerns.

First, efficiency been presented as important criteria for the permissible implementation of BECCS. Because land is scarce and bioenergy can provide an important contribution to reducing emissions, Reid et al. claim that we should use land 'as efficiently as possible' (2020: 276). The efficient usage of BECCS is limited, among other factors, by the storage capacity of the land in its current state. If ecosystems that store large amounts of carbon are destroyed because the land is converted to plant biomass for BECCS, this creates net positive emissions (Harper et al., 2018) and be inefficient in removing carbon from the atmosphere. Moreover, Megan Blomfield has argued that there are important moral objections against viewing land as a common resource for sequestering emissions that can be distributed efficiently, such as serious implication for land justice like land-grabbing, forced displacement, and unfairness in land-based climate mitigation (2021). These suggest that we need additional justice criteria.

Second, Fuss et al. (2018) estimates that the carbon dioxide removal potential of sustainable BECCS could range from 0.5 $GtCO_2$/year to 5 $GtCO_2$/year in 2050, depending on the definitions of sustainability used in the model. This is due to the negative impacts of BECCS on biodiversity, soil degradation, and water use. Due to these detrimental effects, it seems plausible that corporations can only permissibly benefit from BECCS if they implement the technology in an environmentally sustainable way – and BECCS is restricted to this estimated amount. But notably, Fuss et al. (2018) bases their judgement on a notion of ecological sustainability, primarily based on environmental factors like soil erosion, soil degradation or water availability. It does not directly include social aspects, which are hard to include to the modelling processes their work is based on. But the implementation of BECCS will always have implications for local societies that go beyond securing water and food availability. To decide whether the implementation of BECCS is permissible, both burdens and benefits for the local population and the corporation need to be considered. These are considerations of justice.

Hence, efficiency and ecological sustainability criteria need to be supplemented by justice concerns for determining the permissible use of BECCS by corporations. In the following, I identify three implications of justice that arise when BECCS is implemented.

A first implication of justice is the distribution of burden that arise when BECCS is implemented on an area of land. One burden is to give up the benefits of other alternative uses of the land and water, like agriculture for food and habitation. Most notably, some groups in society are more prone to suffer from food shortages and more likely to have their land grabbed and experience forced displacement (Blomfield, 2021). It poses challenges to food justice if BECCS competes with food production and thereby disadvantage small stakeholders (Kortetmäki and Oksanen, 2016). On a global scale, implementing large-scale BECCS puts the risks of removing carbon on countries of the Global South, disproportionally to their contribution to climate change (Morrow et al., 2020). Hence, like other climate mitigation measures, the burdens of BECCS may be distributed in ways that perpetuate unjust social structures.

A second implication of justice relevant concerns the benefits of employing the technology and how they are distributed. Because BECCS will provide bioenergy and deliver carbon that then can be stored, there are potentially large revenues to be gained (Vivid Economics, 2020) and benefits provided to the sites of implementation. Hence, BECCS can be an important investment in developing countries to support their economies. Unfortunately, investments in the carbon market have been observed to follow the structures of past colonialism (Michaelowa et al., 2019) and mirror the same problematics as other foreign direct investments, such as weak mechanisms for regulating the behaviour of foreign corporations. Forestry projects for carbon credits have already been criticized for a lack of transparency regarding the benefits provided to the local community and stewards of the land (Michaelowa et al., 2019). For BECCS, the situation may be even more difficult: in the case of forestry projects, local communities could make claims to the ‘carbon credits’ their land was storing, but this claim cannot be made if biomass is planted for BECCS and the carbon is not stored on the land. It may be contested that BECCS would have to provide any benefits to the local communities where the facilities are installed and the biomass planted. However, if the land that BECCS is used on was ‘grabbed’ and the community displaced, the is no legitimate claim to the land and we can contest that the corporation using BECCS on this land is entitled to these benefits.

A third justice dimension concerns the suitability of corporations to permissibly offer BECCS, and particularly the storage of the carbon that is captured in BECCS. Corporations from the oil and gas industry (‘carbon majors’) are leading the expansion of carbon sequestration and storage in this emerging market, raising questions of justice (Moss, 2020). The fact that they bear heavy historical responsibilities for their emissions and contribution to climate change makes it morally problematic for them to benefit from carbon removal activities (Lenzi et al., 2023).

These considerations of justice as the distribution of burden and benefit need to be considered in addition to the sustainable implementation of BECCS. They limit the permissibility of corporations to implement and benefit from BECCS. For corporations to permissibly offer BECCS and benefit from offering these services, these challenges have to be given adequate consideration, for example, by hindering the access of corporations to regions where food security is already at stake or by reforming land tenures to ensure that local populations are not driven off their land. The case of carbon majors shows that we could consider excluding some corporations from benefitting from BECCS due to their past actions. These considerations may further restrict the use of BECCS if they are translated into criteria that determine whether corporations can permissibly offer and benefit from BECCS in certain regions.

Is this account too restrictive, and will this disincentivize efforts in BECCS? Importantly, current commitments to remove emissions by far exceed the extent to which BECCS can sustainably be provided, even without considering justice as I have done above: The estimate of sustainable usage provided by Fuss et al (2018) is much lower than most models and scenarios predict for the use of BECCS (Reid et al., 2020). This indicates that careful governance is needed when upscaling this technology to avoid major problems of sustainability and justice given the limited supply of land.

3. The challenge of high demand for BECCS

The transition towards the targets of the Paris Agreement and general climate-stable pathways requires the involvement of global players. Therefore, the multitude of pledges from corporations to be carbon neutral by 2030 (Apple) or 2050 (Volkswagen, Hitachi), or net zero by 2030 (Unilever), 2040 (Walmart, Amazon, Vodafone), and 2050 (Nestle) are a positive development, albeit that varying degrees of integrity have been observed in achieving these targets (Day et al., 2022). While most of these commitments do not include clear strategies of how emissions are offset, BECCS is the CDR method most included in investment plans (Vivid Economics, 2020) BECCS provides benefits in multiple ways for those who fund its use: Corporations that can improve their public image by showing that they fund bioenergy the removal and storage of carbon emissions. But primarily, they can continue to benefit from activities that create emissions, while reducing their net emissions by purchasing certificates.

Given the limited potential of sustainable BECCS, the question is under which conditions can corporations permissibly use BECCS to offset their emissions. Various criteria have been raised in the debate to define whether a corporation permissibly uses BECCS, or more generally offsets, in their climate strategy and I present four central ones below. However, my concern here is that applying these criteria to corporations may not be sufficient, given the limited extent to which BECCS can sustainably be used. Therefore, I then discuss three ways of deciding which corporations are most or least entitled to use BECCS.

Current discussions on net zero targets already indicate that stricter governance is needed to define, assess, and overall regulate the extent to which corporations rely on offsetting in their climate strategies (Black et al., 2021). The following four criteria have been suggested to assess the climate strategies of corporations and help to decide whether a corporation can permissibly use BECCS.

Fixing concrete steps.

Reports have criticized the lack of concrete steps taken by corporations to meet their climate commitments (Day et al., 2022). One apparent condition to be met would be a transparent communication of the steps the corporation is undertaking, including timelines and intermediate targets of how to reach the target they committed to, and reporting on this progress (Black et al., 2021). Given uncertainties and risks regarding the use and scale-up of BECCS and other CDR, relying on these technologies and forgoing emission efforts has been pointed out to be morally problematic (Lenzi, 2018).

Setting separate targets.

The commitments of corporations have to state more precisely the degree of carbon removal they envision. Keeping the pledges of emission reductions and removal distinct from each other instead of summing them up in net zero targets (McLaren et al., 2019) is a vital step in assessing the extent to which a corporation is relying on removal and forgo opportunities to cut their emissions if emission removal is cheaper.

Commitment to sustainable BECCS.

The conditions under which BECCS is implemented play a crucial role whether a corporation can permissibly rely on it. When considering the duties of corporations in reducing or removing their emissions, Jeremy Moss argues for applying the ‘principle of unjust restitution’. This principle states that ‘it is impermissible for an agent to inflict new harms on third parties to rectify past harms.’ (Moss, 2020: 51) Hence, it would be impermissible for corporations to use carbon removal credits if these impose harms. This would be a moral argument for corporations using solely ‘sustainable’ BECCS, including justice aspects, as discussed in the previous section.

Prioritizing emission reductions.

If the extent to which BECCS can be carried out sustainably is limited, and similar findings limit the use of other CDR methods, corporations must limit it to the extent to which they use these methods. To reach their climate targets, especially commitments to net zero emissions, they need to prioritize reducing their emissions over offsetting them. Not prioritizing emission reductions creates a high risk that the use of CDR technologies and bioenergy will lead to unsustainable lock-in effects instead of a transition to a low-carbon and energy-efficient economy (Reid et al., 2020). Further, the principle of unjust restitution can give corporations a ‘pro tanto’ duty which prioritizes the cessation of emitting activities a stronger over discharging liabilities in many practical instances, such as employing BECCS (Moss, 2020).

Given the large commitments to net zero and hence the high demand for using BECCS, it may be the case that the extent to which corporations fulfil these four criteria would still exceed the extent to which BECCS can sustainably be implemented. Given this imbalance, how should we decide which corporations are most or least entitled to use BECCS?

Taking the market prize.

It may be argued that as long as we ensure that the only credits on the market originate from sustainable implementation of BECCS, we could leave the market to determine who purchases removals. Given the needs of corporations to offset their emissions, this would probably lead to raising the prices for BECCS. This would allow corporations with substantial capital to purchase credits and reach their net zero targets. By buying carbon removal certificates, they could reach net zero targets at higher emission levels than corporations that cannot afford buying offsets at high prices. As there is a strong link between the capital held by corporations and their past emissions, it would probably lead to corporations with histories of high emissions to continue to profit from emitting because they could also pay for the removal of these emissions. Hence, this could allow precisely those who have contributed the most to climate change to continue to benefit from creating emissions.

Using emissions as indicator.

Another is proposal to take the current level of emissions as an indicator of how many emissions can permissibly be removed by BECCS. Corporations creating high emissions already face high costs in reducing their emissions. Hence, corporations that face strong restraints in reducing their emissions should, it could be argued, be entitled to benefit more from carbon removal. However, it is not clear how to attribute such an entitlement to corporations and may be objected on the same reasons as the market price.

Revenues from emissions as indicator.

Instead, we could decide the extent to which a corporation may remove emissions by the profits the corporation makes by emitting. Corporations have been criticized for using net zero pledges to continue benefitting from their emitting activities. Hence, the higher the profits the corporation makes, the higher the price they should have to pay for carbon removals. This could promote stronger efforts to reduce emissions and reduce the incentives to buy carbon credits from BECCS.

4. Conclusion

Where does this leave us regarding the question of the role of corporations in the market for BECCS? Because corporations have a central role in financing the upscaling of BECCS, the challenge is to keep their commitments to remove emissions via BECCS at the limit of sustainable use without undermining investments in this technology. I have argued that strong guidelines should govern for how land is used by corporations to remove emissions via BECCS, and these should include justice as well as environmental sustainability criteria. As the quantity of BECCS that will be available under these criteria is restricted, strong guidelines should govern how much corporations are allowed to use BECCS to balance out their emissions. The most important guideline is a clear commitment to reducing emissions. If using carbon credits from BECCS is restricted, the criteria proposed to define permissible use of credits should be sensitive to the revenues made from emitting, because profiting from emissions is the main reason for the need for using BECCS.

Part IV: A Generation's Responsibility to Remove Carbon?

Introduction

According to Henry Shue, everyone alive today is part of the 'pivotal generation', which carries special responsibilities for climate change mitigation. Climate change mitigation includes carbon removal. Shue's conceptual understanding has shaped the discussion on CDR technologies unlike any other scholars. His book 'The Pivotal Generation: Why We Have a Moral Responsibility to Slow Climate Change Right Now' synthesizes many of the arguments he has made elsewhere about CDR technologies.

My commentary on Shue's book synthesizes several arguments from the preceding chapters of this thesis, as well as the overall point argued for in this thesis. I discuss the question for which purpose CDR technologies may be employed, an issue that has occurred several times. I elaborate on the importance including justice considerations when suggesting how CDR technologies should be implemented. But importantly, I critique Shue's idea of dissolving the responsibilities of separate agents into the responsibility of one generation. I argue that, instead, we should differentiate responsibilities to remove carbon. Finally, this commentary continues the discussion on the responsibility of corporations of part III. I stress the importance of investigating CDR that is undertaken by agents to save their assets from a moral perspective. This stands in close relation to the argument made in Chapter 4 about the impermissibility of carbon majors to benefit from CDR. There, I pre-supposed that carbon majors could be incentivized to undertake CCS, and that the necessary institutional settings exist to do so.

In this chapter, I take a less optimistic outlook on agents' commitments to their responsibilities and the institutional setup. Unlike in the preceding chapters, I do not assume that CDR will be scaled up because states or corporations aim to fulfil their net zero targets. Instead, I am concerned with the idea of moral agents failing to do what they ought to do or have committed themselves to do. I argue that moral agents today are is not only pivotal to deciding whether to implement carbon dioxide removal but to ensuring just conditions of its implementation.

The paper 'Being pivotal for carbon removal' will be part of the special issue 'Climate Transition and the Moral Responsibility of the Pivotal Generation' in *Philosophy & Public Issues*. This contains a book symposium on Henry Shue's 'The Pivotal Generation: Why We Have a Moral Responsibility to Slow Climate Change Right Now' (2021), to which I was invited to contribute at Henry Shue's suggestion.

Status: forthcoming.
Contribution to the special issue 'Climate Transition and the Moral Responsibility of the Pivotal Generation', in Philosophy & Public Issues, *edited by Fausto Corvino, Alberto Eugenio Ermenegildo Pirni and Gianfranco Pellegrino. It is part of a symposium on Henry Shue's book* 'The Pivotal Generation: Why We Have a Moral Responsibility to Slow Climate Change Right Now' *(2021).*

Chapter 6: Being Pivotal for Carbon Dioxide Removal

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1. Introduction

Why do we have a moral responsibility to slow climate change right now? In his latest book, *The Pivotal Generation: Why We Have a Moral Responsibility to Slow Climate Change Right Now* (2021), Henry Shue provides appealing reasoning based on a synthesis of empirical facts and moral arguments to answer this question. In the climate ethics debate, the question of our moral responsibilities has been in the spotlight. However, at least two aspects of this question are new.

First, we speak about slowing climate change. This is different from stopping or preventing climate change. But how do we slow climate change? One of the answers, though by no means an alternative to reducing emissions, is the removal of emissions from the atmosphere with carbon dioxide removal (CDR) technologies. CDR includes a range of technologies from afforestation and reforestation programs to the construction of facilities that capture CO_2 from the ambient air and allow the captured carbon to be sequestered and stored (carbon capture and storage, CCS). The use of CDR technologies will be necessary if the targets defined in the Paris Agreement are to be reached (Shue, 2021: 92).[1] For Shue, CDR is a central element of climate change policies, and one that should be more extensively discussed because its implementation is necessary and because of its moral implications. [2]

Second, slowing climate change right now emphasizes the urgency of acting *right now*. The responsibility arises from a particular temporal position: we are the pivotal generation, as Shue argues.[3] It is this situation that makes our generation pivotal: previous generations have

[1] In the following, citations with page numbers only refer to Henry Shue *The Pivotal Generation: Why We Have a Moral Responsibility to Slow Climate Change Right Now*, Princeton University Press, 2021.
[2] The term 'CDR technologies' would be more accurate than 'CDR' and emphasize that this is an approach that combines several technologies. However, to avoid confusion, I will use Shue's terminology of 'CDR' as an approach to climate change mitigation.
[3] 'We can be the "greatest generation" for the climate struggle or the miserably self-preoccupied and easily manipulated ones who failed to rise to the occasion and whom future generations will recall, if at all, with contempt. . . So those of us alive now are the pivotal generation in human history for the fate of our planet's liveability' (p.2).

implemented an infrastructure that causes climate change, but we now know how climate change is created and what we have to do to influence it for the better, and we 'may also be the last to be in a position to act before we exacerbate some major threats' (p.6). Given the knowledge we have and the moment of time in which we find ourselves, there is still room to act before the window closes: 'we still have the opportunity to act just in time' (p.2).

While there is much to be said for the numerous contributions of the book, in the following I focus on the claims and assumptions Shue makes in his discussion of CDR. I primarily discuss chapter four. In what follows, I present what I understand to be Shue's main claim about CDR (section 2). I then lay out my argument of what it could mean for our generation to be pivotal for carbon removal (section 3). Contrary to Shue, I argue that 'asset-rescue CDR' needs to be included in our ethical discussion of CDR (section 4). This then requires a more nuanced understanding of the moral responsibility of corporations that links with the idea of a pivotal generation (section 5). Then, I draw my conclusions (section 6).

2. A second chance on climate change

In chapter four of *The pivotal generation*, Shue considers whether CDR offers a second chance to mitigate climate change. How CDR is treated in the climate ethics literature has shifted over the past few years. Originally, concerns about CDR were discussed together with solar radiation management (SRM) under the umbrella of geoengineering (Gardiner, 2010c; Heyward, 2014a; Preston, 2013). However, accompanied by changes in the terminology of the IPCC, CDR is now discussed within the context of climate change mitigation and net zero emission targets (Armstrong and McLaren, 2022; Lenzi, 2021; McLaren et al., 2019). Shue was one of the first to explore the topic of CDR and the moral challenges it poses (Shue, 2014, 2015, 2017a, 2017b, 2018, 2019) and he has repeatedly pointed to the danger that CDR technologies could be used as an excuse to slow efforts of emission reductions. This, Shue argues, leads to a problematic distribution of the risks of climate change because it overburdens future generations and overall increases the risk of dangerous climate change.

Shue seeks to identify the 'proper role' for CDR technologies in policy on climate change (p.100). He proposes classifying CDR technologies according to their purpose: '(1) enhancing current mitigation [enhancement CDR], (2) remedying insufficient past mitigation [remedial CDR], and (3) rescuing fossil-fuel companies' stranded assets [asset-rescue CDR]' (p.95). He notes that asset-rescue CDR 'is in the interest of no one except those whose wealth is tied up in reserves of, and infrastructure for, coal, oil, and natural gas' (p.95) and that he will not discuss this matter further (I will comment on this in section 4). Instead, the chapter criticizes the idea that removing CO_2 from the atmosphere could be viewed as a 'second chance' to slow climate change. Shue points out what is wrong with the idea that emissions that are not mitigated today can be removed by CDR later. He provides three arguments to make the case 'against complacency now, grounded in hoped-for remedial CDR later' (p.98).

The first reason is that CDR may not be up to the challenge: for now, too little has been invested in CDR and the associated infrastructure, and after this weak start, it is not clear that CDR can be scaled up to the extent it would have to be (p.98). According to Shue, '[i]t is misguided simply to dream that however lackadaisical and underfunded our efforts at controlling climate change continue to be, future generations can simply repair everything later with CDR' (p.103). Importantly, delaying mitigation efforts increases the challenge for future people to address climate change (p.103).

The second reason is the implications of CDR, especially remedial CDR, for the distribution of risks between generations. It may interfere with decisions on how much mitigation is undertaken. Shue argues that 'current half-hearted and half-baked mitigation' (p.103) is deeply objectionable. His two main theses are

> (1) that, in general, all decisions in the past about the degree of ambition for emissions mitigation are unavoidably also decisions about how to distribute risk across generations; and (2) that, more specifically, the less ambitious the mitigation is, the more inherently objectionable the resulting intergenerational risk distribution is (p.103).

The third reason why remedial CDR and overshooting targets on the promise of CDR is morally unacceptable is, according to Shue, because these changes may well be irreversible, and even if changes are only temporary, they may have permanent effects (p. 111).

It follows from Shue's argument that CDR should be undertaken to enhance our mitigation efforts, not remedy the problem later. Hence, CDR does not provide us with a second chance to solve the climate crisis.[4]

However, more needs to be done to define the 'proper role' of CDR. Investigating why CDR is undertaken is surely relevant for the normative assessment of CDR and policies promoting CDR. But I am not convinced that the moral implications of the three purposes of CDR that Shue conceptualizes are as 'radically different' as he claims (p.95). What makes both enhancement CDR and remedial CDR problematic or permissible are the policies that accompany

[4] The problems of framing of CDR and solar radiation management as a 'Plan B' are also investigated by Gardiner and Fragnière (2016).

them. Remedial CDR is not morally problematic in itself, and as Shue admits, we do not want to object to remedial CDR as such because it is 'a good thing at some scale' (p.97). Remedial CDR is needed once emissions are strongly mitigated and carbon needs to be removed from the atmosphere to stabilize or lower global temperatures. Whether and for what purposes we deem pursuing CDR permissible or not may depend on how far from an ideal scenario we set our assumptions about global emissions decreasing in the next decades.

3. Being pivotal for carbon dioxide removal

If Shue is right and we have a moral responsibility to slow climate change right now, and our generation is pivotal for doing so, what does this entail for CDR? What does it mean for our generation to be pivotal for CDR? Being pivotal means changing fundamental social structures and physical processes that 'shape which possibilities are and are not open, at least initially, to the people who follow us in multiple future generations' (p. 115). This includes not only infrastructure and technology but also the concentration of carbon in the atmosphere. Given current and past levels of emissions, there is by now necessary to start CDR in order to meet climate targets (p. 92). Hence, being pivotal for carbon removal has two aspects: to shape how CDR is implemented and to ensure that it is undertaken in the first place.

3.a Pivotal for how CDR is undertaken

The moral permissibility of CDR depends in part on how technologies are implemented. Citing the IPCC, Shue notes 'substantial concerns about adverse side-effects on environmental and social sustainability' (p.99). Several elements could make the implementation of CDR unjust, and not only in comparison to the scenario in which CDR would not have been necessary. Implementing CDR may create new structural injustices and contribute to existing ones.

Take the example of the CDR technology known as bioenergy with carbon capture and storage (BECCS). BECCS is the CDR technology most widely assumed in climate modelling and climate mitigation policies. However, the vast quantities of land it requires make it impossible to scale up (p.101). Besides these restrictions on feasibility, the burdens of BECCS may be distributed unjustly: burdens are over proportionally imposed in countries of the Global South, regardless of low historical emissions in these countries; and where BECCS is implemented, some social groups are more prone to be dispossessed and to suffering food insecurity. Not only are the burdens of BECCS are likely to be distributed unjustly but also its benefits. Conditions of land acquisition play an important role in whether corporations can permissibly offer BECCS (Blomfield, 2021). If the land that is used for BECCS was 'grabbed' and the community displaced, we can contest whether the corporation using BECCS on this land is entitled to these benefits. Further, BECCS depends on the availability of CCS, where carbon is stored in geological formations. There are large similarities in technology and infrastructure between oil extraction and carbon sequestration and storage (Hastings and Smith, 2020). Many corporations potentially benefitting from CDR carry high historical responsibilities, especially companies from the oil and gas industry situated in countries of the Global North (Lenzi et al. 2023).

Importantly, '[w]hether this environmental colonialism happens depends on which future path of political economy is now chosen by societies' (Shue, 2019: 259). We are pivotal in the sense that we know the malfunctioning of our market mechanisms and the limits of policy-making. The choices we make will influence what happens in the future, particularly in terms of how CDR is implemented and justice in the CDR market. This points to the importance of setting up and scaling up CDR in a way that does not foster existing unjust structures, as well as our responsibility to do so. Structural injustices can be perpetuated over a long time in a pattern that needs to be avoided (Ackerly, 2018) and need to be considered in policy aiming for climate justice (Sardo, 2020). We should not encourage more lock-in effects and structural injustices as we scale up a technology that will operate within old structures.

Governing CDR can be key not only to addressing climate change but also to making climate action more just. To achieve this, there is a need to transform the structures in which CDR takes place. This includes both the economic context, including regulation, price regulation, and incentives, and the implementation context: ecological footprint of facilities, legal protection of people on the land, working conditions, and so forth.

The injustices that may be perpetrated when implementing CDR are among the reasons for Shue's appeal to mitigation measures over CDR. Hence, being pivotal for CDR implies responsibility for determining the conditions under which CDR is implemented and scaled up.

3.b Pivotal for CDR being undertaken

Besides being pivotal for how CDR is to be undertaken, our generation seems to be key in ensuring that CDR is undertaken, if we take the claim seriously that CDR is required to reach climate targets such as the ones set in the Paris Agreement. Yet, Shue details arguments why we should prioritize enhancement CDR over remedial CDR. He seems more concerned with the danger of CDR undermining emission reduction efforts (the danger of a 'moral hazard') than with the urgency of implementing CDR.

This focus on the danger of a moral hazard can be criticized. First, the moral hazard phrasing assumes that CDR and emission reductions can be treated as substitutes (Heyward, 2019). Yet, as Shue outlines in his discussion, this is not actually the case – we cannot and should not try to treat CDR as being identical to emission reductions. Second, there is little evidence that CDR actually weakens efforts to reduce emissions (Heyward, 2019). Given the availability and advantages of renewable energies and the shortcomings of the fossil energy system, it seems hard to believe that it is the promise of CDR that keeps global emissions rising. So far, global emissions are still rising for several reasons. It would be presumptuous to assume that the promise of CDR is the major reason behind this. As Shue notes, we consider how to govern CDR under the premise that 'decades of failure to control emissions have made overshoot of most reasonable carbon budgets impossible to prevent at this late date' (p.100). Given the current lack of policies for enhancement CDR, we may have to discuss cases where neither emission reduction nor enhancement CDR is undertaken and the implications this may have for CDR overall. It seems unjust to future generations not to scale up CDR because one deemed the danger of undermining emission reduction too high.

Although Shue indicates that CDR is needed, I think the need for our generation to start removing CO_2 is not being treated with the urgency it deserves. If our generation is pivotal in mitigating climate change, this must include investment and policies for more CDR. The fact that this has been overlooked by policy makers has been noted by both modellers and ethicists. If we are indeed the pivotal generation to mitigate climate change, we should compare efforts to mitigate climate change including emission reductions and all kinds of CDR with an absence of such efforts. Instead, what is compared most often are emission reductions and carbon removal. Even if investments into enhancement CDR are used to justify weak emission reduction efforts, the lack of these efforts in the past still requires that we undertake CDR. Hence, we may have to encourage CDR even if some of its implications are morally objectionable.

This resembles Gardiner's 'arm the future' argument (2010c): we should pursue ways of geoengineering as they are a lesser evil than unmitigated climate change. But much about CDR differs from the technologies Gardiner considers, especially because CDR technologies have been assumed in all climate pathways that might reach the 1.5°C target and that have informed climate policy in recent years. In this light, undertaking CDR more seems like fulfilling a promise rather than a cheap way out of the dilemma. Of course, emissions have to be reduced. This is not to be questioned by anyone serious about climate change mitigation. But being the pivotal generation, we may also have the responsibility to remove carbon and make carbon removal possible for future generations.

A key aspect of our discussion is the noncompliance with moral imperatives, such as those Shue has been proclaiming for thirty years. If agents had met their climate responsibilities and reduced emissions, there would be no (or only very little) need for CDR. In that sense, CDR is always remedial. Considering these aspects acknowledges that answering the question of how CDR should be governed requires nonideal theorizing. What shapes the starting point of our discussion is the partial compliance of agents in the past and present, feasibility constraints, and the aim of the theory's aim to be transitional (Valentini, 2012). We need to theorize noncompliance with the moral responsibility to reduce emissions and thus may make remedial CDR a moral requirement. We need to theorize feasibility constraints in scaling up CDR in addition to problems of non-compliance of major players of the oil and gas industry, which means including asset-rescue CDR in the ethical discussion. Finally, we should work out to what extent CDR is a transitional solution or part of the final solution to climate change. To what extent CDR is supportive of a transformation towards renewable energies or lower energy consumption overall is far from clear.

Shue points to these challenges, but I think we can take the analysis further. Importantly, Shue excludes asset-rescue CDR from his discussion (p.95) and notes that self-interested motivations are not interesting for our philosophical discussion (p.7). I think that to determine how our generation should handle the challenge of being pivotal in a morally justified manner, we must know how to theorize self-interest and potential noncompliance with the promises of CDR. In the following, I expand on the need to discuss asset-rescue CDR (section 4). This then leads me to discuss the moral responsibility of corporations within the pivotal generation (section 5).

4. Asset-rescue CDR

The sharp contrast Shue suggests between the various purposes of CDR and the fact that he explicitly excludes asset-rescue CDR from his discussions motivate my critique of Shue's account. When speaking about the third purpose of CDR, Shue quickly dismisses the discussion on undertaking CDR with the purpose of rescuing fossil-fuel companies' assets, which would otherwise be stranded. He argues that

> Asset-rescue CDR is in the interest of no one except those whose wealth is tied up in reserves of, and infrastructure for, coal, oil, and natural gas, which at present still includes, besides the companies themselves, socially important players like large pension fund that persist in clinging to stock in the companies. Pension funds ought to divest these holdings rapidly for reasons of both self-interest since fossil-fuel corporations are headed into decline, and

> morality, rather than expecting anyone other than the executives and owners of the companies to support asset-rescue CDR, which I will discuss no further. (p.95)

Asset-rescue CDR and the interplay of self-interest and morality requires more philosophical investigation than Shue accredits it because implementing CDR for the purpose of rescuing sinking assets may be the main driver of CDR developments, with consequent deep entanglements of the morality of CDR with further justice implications for the market for carbon removal. Consistency with the idea that our generation is pivotal to slowing climate change requires that we consider asset-rescue CDR.

Trying to rescue assets currently motivates many corporations to identify net zero targets and invest in CDR, especially if the assumption is that fossil fuel corporations will be declining (p.95). A corporation may benefit from investing in CDR because this will allow it to reach net zero CO_2 emissions while still pursuing some emitting activities. Many corporations have already committed themselves to reaching net zero emissions and thereby more or less explicitly committed themselves to removing carbon (Day et al., 2022).

There seem to be clear moral reasons why CDR should not be undertaken merely to save assets. The most pressing reason may be ineffectiveness: if agents are no longer able to conduct their businesses because they create too many emissions, they may invest in CDR to continue these emitting activities and, hence, rescue their assets. In this case, CDR is used to justify forgoing the efforts of emission reductions. Importantly, the commitments to using CDR go beyond the estimates about how much carbon can be removed in a sustainable manner (Reid et al., 2020). The limited extent to which CDR measures such as BECCS can be sustainable creates a tension between demand and the sustainable supply of BECCS, raising the challenges of governing BECCS (Honegger et al., 2022) and organizing such a market (Schübel, 2022).

The implications of asset-rescue CDR are probably most relevant to corporations in the oil and gas industry. This is clearly problematic when such corporations seek to save their 'natural assets', the oil and gas that is still in the ground and that could still be extracted and sold. Shue warns of the danger of a 'final harvest' that fossil-fuel companies are gathering today, moving as many fossils as possible to make money while they still can (p.125). Using CDR to justify this is clearly impermissible.

However, our perspective on asset-rescue CDR may shift if we consider the role these assets can play for scaling up CDR technologies. Again, this is most relevant to corporations in the oil and gas industry. These corporations have the knowledge and capital to undertake CCS at large scale. This is due to similarities in the technology and the locations owned by these corporations (Hastings and Smith, 2020). The fact that corporations from the oil and gas industry are leading the expansion of CCS in this emerging market raise questions of justice (Moss, 2020). The fact that they bear heavy historical responsibilities for their emissions and contribution to climate change makes it morally problematic for them to benefit from carbon removal activities. If they are the only agents able to undertake the measures needed to prevent dangerous climate change, this poses a moral dilemma (Lenzi et al., 2023): these corporations are in this position because they have created the dangerous situation in which we find ourselves. It would be morally impermissible to let them benefit from the injustice they have created.

The idea of giving incentives for carbon removal to firms in the fossil fuel and gas industry stands in contrast to the idea of adopting political measures before shaping economic incentive structures, which Shue adopts from Matto Mildenberger (p.130). Against solar radiation management (SRM) as a response to climate change, the concern has been raised that big projects like this may in the end will be pursued to not have to face sunk costs and institutions that promote this setting (Gardiner, 2010c: 6). A similar concern is surely justified for large-scale CDR that relies heavily on infrastructure owned by a few powerful corporations.

Yet, if we are the pivotal generation for global climate change, there may be good moral reasons to overlook these justice implications of CDR and instead incentivize carbon majors to invest in and implement CDR technologies. One may argue that whether CDR is implemented to enhance mitigation efforts or to rescue assets of fossil fuel corporations is subordinate to the main aim of mitigating climate change. The 'bleak outlook for a policy of mitigation only and the potentially catastrophic risks of relying too heavily or asking too much of NETs [CDR]' (Callies and Moellendorf, 2021: 144) may even justify SRM in future climate policy. If that is the case, the current lack of ambitious emission reduction policies surely justifies CDR, even if it is undertaken to rescue assets.

Implementing CDR to rescue assets is essentially a self-interested reason. When discussing reasons for slowing climate change, Shue notes that 'the philosophically uninteresting reasons are self-interested, and there are tons of those' (p.7). I do not disagree that other reasons seem more philosophically interesting to discuss than pure self-interest. However, if we aim to describe our moral responsibilities in the current, clearly nonideal setting of climate policy, we cannot dismiss such self-interested reasons. Nor, in the case of CDR, should we exclude this motivation from our moral theorizing about CDR and its governance. Following this idea, we need to take a closer look at the climate responsibilities of corporations.

5. Corporations and the pivotal generation

As I argued in section 3, our current generation is pivotal for CDR being implemented and the conditions how this is done. In section 4, I argued that asset-rescue CDR needs to be included in the ethical discussion on CDR. This leaves open the important question of the role of corporations in the pivotal generation. How are we to deal with corporations and their moral agency as part of the pivotal generation?

Shue's conception of 'us' against 'them', them being leading corporations of the fossil fuel and gas industry and other global players, contrasts with his conception of 'our' moral responsibility as the pivotal generation. Throughout the book, the 'us' changes between contexts: in a discussion of intergenerational justice, Shue focuses on 'us' as one pivotal generation. Everyone alive today is part of this generation (p.2). But turning to the question of intragenerational justice, 'we' have to stand up against 'them': banks and corporations of the fossil fuel and gas industry are our 'powerful enemies'. This leads me to critique Shue's idea of the pivotal generation in two ways.

First, splitting our generation between 'the active many' and 'the ruthless few' (p.130) while tempting, is difficult maintain. Shue demonstrates the problematic behaviour of oil and gas companies (p.124-128) and argues that 'the fundamental strategy of the fossil-fuel interests always involves deceiving the general public' (p.124). At the same time, he stresses the importance of the decisions they take. We may go ahead and hold these corporations morally responsible for their contribution to climate change. Shue has famously argued that moral agents may have a responsibility to 'clean up [their] mess' (Shue, 2017b: 593). This idea is appealing in the case of carbon removal. We could pin down the historical emissions of corporations and ask them to do the respective amount of CDR. This may define their moral responsibilities for CDR and even indicate the extent to which corporations may benefit from CDR (Lenzi et al., 2023).

Yet, there is an important link between states and oil corporations: many of the corporations in the oil and gas industry are state-owned. In '2018, nearly 60% of production of oil and 50% of production of gas came from state-controlled oil companies (Shue, p.122). If corporations are state-owned, we may be more willing to agree to the statement 'the enemy is us' (p.135). It also means that the enemy's activities may be part of a more widely shared interest. For example, it is in the interest of a state that its corporations deliver revenue and supply energy. It is not only fossil fuel companies and corporations generally whose assets are stranded as mitigation policies are implemented: the investors involved include states, communities, companies, families, individuals, societies, and industries, because basically everyone is involved in the fossil-fuel system. As Shue admits, 'this crucial fact about state-ownership is often overlooked by climate activists' (p.122). This calls for defining the role of corporations within the pivotal generation more clearly. And it questions the split Shue makes himself between 'the active many' and 'the ruthless few'.

My second critique of Shue's concept of the pivotal generation is that using 'we' to refer to 'everyone who lives today' overlooks the power dynamics between agents. In the face of wealth accumulating and being preserved in infrastructure, the connections between powerful agents in the past, present, and future seem the most tangible. For example, it is important not to overlook the power dynamics that individuals possess as a result of their societal positions. Doing so means failing in two ways: First, one may fail to attribute stronger responsibilities to those agents who are in a pivotal position. What climate responsibilities fall on corporations, given their potential of being decisive in the energy transition or for scaling up CDR? Do individuals not bear responsibilities by their involvement in corporations from the fossil fuel and gas industry, especially if we acknowledge the huge power these corporations hold over climate change mitigation? After all, the individuals who steer these corporations also belong to the 'we' of 'the pivotal generation'. The responsibility to slow climate change falls on these individuals as well. Second, one may fail by holding agents responsible who are not in fact responsible. Individuals who do not have power are not pivotal, and it seems to be morally problematic to hold them accountable for choices they did not make. Instead, they most likely will carry the burdens of whatever decisions the truly pivotal make. This begs the question of whether 'the pivotal generation' with regards to climate policies as conceptualized by Shue is first and foremost comprised of individuals in western industrialized states, and first and foremost those who have a right to vote.

6. Conclusion

In *The Pivotal Generation,* Henry Shue argues that being the pivotal generation, our tasks are to slow climate change and to do so right now. He puts CDR technologies at the centre of the discussion on climate policymaking, stressing that the various purposes for undertaking CDR may influence our ethical judgement of them.

I have argued that when we theorize about the ethics of CDR and our decision making about undertaking CDR, we should include the factors that constitute the non-ideal situation in which we find ourselves. If we are interested in the philosophical underpinnings of climate policy on CDR, the questions surrounding the inclusion of feasibility constraints, self-interest, and non-compliance in normative theories need to be answered. Being the pivotal generation for CDR requires us to establish a system that does not create more injustices than it seeks to eradicate. Including asset-rescue CDR and an account of moral responsibility for corporations seems to be key to arriving at an understanding of what 'our' current role is in CDR developments. This goes beyond discussing differences in the moral implications of enhancement CDR and remedial CDR, and instead theorize on asset rescue CDR.

If we implement CDR without thinking about the right way to do it, we will be contributing to the suffering and injustices that is the main motivation for tackling climate change. At the same time, failing to undertake CDR in the face of these challenges would mean waiving our chance of being pivotal for mitigating climate change. Shue uses the image that humanity has set the house on fire, but there is still time to ensure it does not all go up in flames. He uses the image of horses galloping out of the barn where we have left the door open, but there is still time to close the door and save the few that are still inside. This is the point of CDR: it is to ameliorate a situation that is not ideal.

Acknowledgements

I thank Lukas Sparenborg, Simon Milligan, Alexander Schulan, and Darrel Moellendorf for helpful comments and discussions.

General Discussion and Conclusion

I began this thesis by arguing that the responsibility to remove carbon needs to be differentiated between agents. In the preceding chapters, I presented my account of the responsibilities of individuals, states, and corporations to remove carbon. In this final section, I discuss various elements of the thesis and conclude. I begin by stating my major conclusions from this thesis (Section 1). Second, I summarize my results chapter by chapter (Section 2). Third, I synthesize my findings (Section 3). Fourth, I discuss remaining questions and outline three directions for further research (Section 4). Finally, I make a concluding remark (Section 5).

1. Major Conclusions

Overall, this thesis contributes to the growing literature on the ethics of carbon dioxide removal in the field of climate justice, as well as to the normative literature for governing CDR technologies. It does so by differentiating responsibilities to remove carbon between agents.

The first major conclusion is that individuals hold a direct responsibility to reduce their carbon footprints to zero if CDR technologies are available to them. They also hold shared political responsibilities to ensure that carbon is removed for which no individual is liable and that the ethical costs of CDR technologies are minimized. Thus, the possibility of removing carbon increases the responsibility of individuals for the carbon they emit. This was argued in Chapter 1.

The second major conclusion of this thesis is that states can use CDR technologies permissibly for their hard-to-abate emissions and should do so to reach their net zero targets. Using CDR technologies is only conditionally permissible for states to remove the emissions that individuals need for full membership in society; they are impermissible for removing luxury emissions. These emissions should be abated. This was argued in Chapter 2.

The third major conclusion is that there is a dilemma in rewarding carbon majors for removing carbon. This dilemma stems from the historical responsibilities of carbon majors, on account of which they now stand to benefit from a future carbon removal market. Only if no other agent could achieve carbon removal at approximately the same rate as carbon majors, carbon majors should be incentivised to undertake CDR technologies. This is the upshot of Chapter 4.

My fourth major conclusion is that instead of holding one generation responsible, responsibilities should be differentiated between individuals, states, and corporations. This was argued for in the introduction and applied to Shue's argument in Chapter 6. If we do find the current generation pivotal and responsible for carbon removal, it not only bears a responsibility to remove carbon but to do so in a way that does not perpetrate injustices. But assigning responsibility to one generation overlooks differences between agents, which are relevant for their responsibilities to remove carbon. It is therefore necessary to define the responsibilities of agents, in particular companies, rather than placing the responsibility on one generation. This was argued in Chapter 6.

Although my conclusions are not enough to suggest a clear way to govern CDR technologies or to capture all the normatively relevant aspects of CDR technologies, they do provide some guidance on how CDR technologies should be governed and how the ethical approach should be conceptualized. Hence, this thesis contributes to the state of the art on climate change mitigation responsibilities by including CDR technologies in this discussion. It especially contributes to the growing literature on the climate change mitigation responsibilities of corporations by advancing the discussion on carbon majors and their historical responsibilities and by suggesting how benefits from CDR technologies may be distributed among corporations. Although the arguments here are made about carbon dioxide removal policies, some of them may also be applied to other areas of climate policymaking.

Finally, avoiding unmitigated climate change is the overall aim. As Chapter 6 discussed, the setting in which we find ourselves is far from ideal and hence may call for accepting some injustices to mitigate climate change by removing carbon. However, the motivation of my discussion is not only to avoid high ethical costs of CDR technologies but also to avoid agents delaying emission reduction by relying on CDR technologies.

2. Summary of Results

I now summarize the findings of each chapter and highlight how they contribute to the ongoing debate on the ethics of CDR technologies.

The introduction presented the current literature on CDR technologies and argued for my research project to differentiate responsibilities to remove carbon between agents.

Chapter 1 on the individual's responsibilities to remove carbon argues for two concepts of responsibility. First, if CDR technologies are available to them, individuals have a direct responsibility for the carbon they emit and should remove carbon they failed to reduce, as much as needed to reduce their carbon footprint to zero. The responsibility to remove carbon does not compromise their responsibility to reduce their emissions. Second, individuals have shared political responsibilities to remove the carbon for which no individual is directly responsible. This shared political responsibility includes ensuring that the ethical costs of carbon removal are minimized. These two responsibilities are interrelated and not supplementary to each other. With these findings, the chapter advances the literature on individual climate change mitigation responsibilities by referring explicitly to carbon dioxide removal. The argument focuses on individuals in industrialized countries who intend to employ CDR technologies in the future. The extent to which the argument proceeds beyond this is open to discussion.

Chapter 2 takes the commitment of states to net zero targets as a starting point. It argues for a framework to differentiate the emissions of states into luxury emissions, emissions for full membership in society, and residual emissions. The framework provides a moral argument for which purpose the use of CDR technologies is permissible or, in the case of residual emissions, even obligatory. The chapter discusses how carbon removal and emission reductions are linked and makes tentative suggestions about how they should be balanced to reach net zero targets. The conclusion is that states are allowed to remove carbon to the extent of their hard-to-abate emissions and may transitionally remove more carbon to ensure that their individual members do not fall below a morally relevant threshold. They should distribute the benefits and burdens of CDR technologies in a way that minimizes ethical costs.

Chapter 3 suggests for a way to weigh CDR technologies and emission abatement against each other by applying four key principles from the environmental ethics debate. The upshot is that the procedural involvement of those affected is very relevant, given the gaps in knowledge and insecurities surrounding the deployment of both biofuels and BECCS at large scales. These proposals contribute to the discussion on net-zero targets and the policies permissibly chosen to reach these targets.

Chapters 4 and 5 of the thesis contribute to the growing field of research on the responsibilities of corporations to mitigate climate change. Chapter 4 focusses on carbon majors and the profits they could from CDR technologies that involve the geological sequestration and storage of carbon dioxide, like BECCS and DACCS. Here, a dilemma arises, because it seems impermissible for carbon majors to profit until they have repaid the benefits, they gained from selling fuel and gas. However, they seem best placed to scale up CDR technologies, given their capital and know-how. The urgency to mitigate climate change may justify providing them the needed incentives to invest in CDR technologies. We argue that there may be circumstances under which carbon majors can indeed be incentivized to implement CDR technologies. Yet, such circumstances are unlikely to be found in OECD nations, because they require that no other agent could achieve carbon removal at approximately the same rate as carbon majors. This is very difficult to demonstrate, and any legitimate attempt to do so must be transparent about its assumptions of feasibility. The conclusion is that where possible, governments should empower other agents to remove carbon.

Chapter 5 investigates the challenge of the limited sustainable supply of BECCS and, at the same time, the high demand by corporations for credits from BECCS. It elaborates on balancing investment in BECCS between what is necessary to mitigate climate change and within the limits of sustainable use. I argue that not only BECCS but also the corporations that aim to buy credits arising from BECCS should be subject to strong regulation and suggest different ways of how such a market could be governed.

Finally, Chapter 6 argued that if the current generation is pivotal for carbon removal, this implies a responsibility to ensure that the implementation of CDR technologies does not foster existing injustices but instead promotes climate justice. Further, I argued against combining the responsibilities to implement CDR technologies for one generation. Instead, the responsibilities need to be differentiated, and the responsibilities of corporations in particular need to be investigated. For example, there is a need for normative theorizing on the motivation for implementing CDR to save the assets of fossil fuel and gas companies. This commentary on Henry Shue's book *The Pivotal Generation: Why We Have a Moral Responsibility to Slow Climate Change Right Now* (2021) contributes to the ongoing discussion in climate ethics about how CDR technologies should be discussed and judged from a moral perspective.

3. Synthesis of Results

The following section synthesizes the findings of the chapters of this thesis. There are five aspects to highlight.

First, agents can have moral responsibilities to remove carbon. These can be justified by their liability for the harm their emissions cause or by their commitment to reach the Paris Agreement or a net zero target. If the responsibility to remove carbon stems from liability for emissions, how emissions are attributed to different agents remains to be theorized. I suggested such an account for individuals and, to some extent, for the distribution of responsibilities between states and individuals. More can be discussed for the distribution between states and corporations and between individuals and corporations. However, it is not the case that the use of CDR technologies is a moral responsibility per se. Instead, it arises out of the context in which agents are embedded, which may imply that climate change mitigation responsibilities cannot solely be fulfilled by emission reductions. For example, states will have to remove their hard-to-abate emissions.

The second aspect is that as agents remove carbon, the ethical costs of CDR technologies should be minimized. Ethical costs include the negative side-effects and risks of CDR technologies, as well as the risk of CDR technologies overall failing to deliver what is assumed about them, namely, to remove large quantities of carbon from the atmosphere. I have provided normative arguments on why different moral agents should minimize these ethical costs and how. The scale of carbon removal should be restricted due to the injustices it could contribute to and the ethical costs it would entail at large scales. However, none of the arguments I and my co-authors made in this thesis are linked solely to scale because such a statement would be extremely hard to make given the dynamically changing environment in which CDR technologies are implemented.

This responsibility to minimize the ethical costs of CDR technologies implies my third point. The point is that priority should be given to efforts that focus on emission reductions unless they have higher ethical costs than implementing CDR technologies. The importance of prioritizing emission reductions has been noted widely. My arguments contribute to the question of how to relate this to a responsibility for carbon removal. For example, I argued that it is important to understand the responsibility for carbon removal as additional to the responsibility to reduce emissions.

Fourth, participatory values play an important role in the ethics of CDR technologies. In addition to technological knowledge gaps, there are many uncertainties about CDR technologies and their role in structural transformation. Judgements about the permissibility of CDR technologies are linked to the ultimate goal, priorities, and strategies of structural transformation to address climate change – and there is disagreement about these. To address this, societal, democratic discussion is important. I argued in chapter 1 that individuals have shared, political responsibilities to minimize the ethical costs of CDR technologies and ensure that the emissions that result from structures such as the public transport system are removed. These responsibilities have to be discharged by political action, such as campaigning, voting, and running for candidacy. In Chapter 2, we argued that how much emissions are required to support an equal membership in society must be determined by public deliberation and is essentially the decision between citizens. This sets a priority in the transition to a net zero target, as conditions to participate in public deliberation should not be undermined. These conditions define an intermediate target to which CDR technologies may be permissible beyond residual emissions.

Finally, we argued in chapter 3 that procedural involvement is the principle to be considered as most important when comparing the large-scale implementation of emission abatement and carbon removal technologies. The imposition of ethical costs is one of the reasons why the decisions on CDR technologies must be made democratically. Overall, my findings echo the claim that democratic decision-making and democratic values are key in governing CDR technologies: 'Given the incendiary nature of the whole idea of climate engineering … the discussion ahead needs to be deeply contextualized, richly detailed, and thoroughly democratic.' (Preston, 2016b: xxi).

Finally, assumptions about feasibility shape agents' responsibilities. Different parts of the thesis assume different states of development of CDR technologies. The chapters rest on a spectrum of assumptions about the feasibility and necessity of CDR technologies. Chapter 1 investigates the responsibilities of individuals to remove carbon in the hypothetical case that carbon removal is already available before then challenging this claim and arguing for a shared political responsibility to ensure that carbon is removed. Chapter 2 investigates the responsibilities of states under the assumption that states will aim to reach the commitment they made in the Paris Agreement. Chapter 4 assumes a rather dim outlook on the willingness of corporations and especially carbon majors to participate in carbon removal unless revenues are provided to do so. Chapter 6 discusses the problem of the current generation not only failing to reduce emissions but also failing to remove carbon. The feasibility of various CDR technologies and of CDR technology overall is rapidly changing, and statements about it change too. Hence, although these differences in assumptions about the feasibility of carbon removal may convey a lack of coherence in my arguments, they have the important advantage of presenting frameworks and arguments apply to different scenarios with different assumptions about the feasibility of scaling up CDR technologies. They illustrate how a decision can be made for CDR technologies. Changes to the details, and especially changes to judgments of the feasibility of CDR technologies, may affect some aspects of the thesis. The main moral arguments analysed in this thesis and the underlying ethical concerns raise old questions in a new way.

4. Ideas for Future Research

4.1 Relating different types of agents

The chapters in this thesis explore to differing degrees the responsibilities of individuals, the responsibilities states have towards their citizens, and how responsibility is shared between corporations and the states in which they reside or by which they are partly owned. More theorizing is needed regarding the links between the responsibilities of different agents. Chapter 1 has already suggested that responsibilities can be linked to emissions and responsibilities shared to implement carbon removal with other agents. The chapter addressed the question of how responsibilities for carbon removal are generated, for example, by emitting activities. I argued from the idea of liability for the harm arising from these emissions that individuals have a direct responsibility to remove carbon. Yet, the question arises how to account for emissions and how emissions are allocated to states, individuals, and corporations. For example, are the emissions of the state merely the accumulation of the emissions of individuals? If all individuals in the state minimize their carbon footprint to zero, would the state have net zero emissions at this point? Answering these questions requires a more elaborate framework to relate the emissions and responsibilities of individuals and their states. This also is a challenge for corporations. If all emissions that are linked to products are assigned to the individual, is there no responsibility for corporations to remove carbon? My argument in Chapter 1 presupposed that individuals have a shared political responsibility to ask their state to scale up CDR technologies and to ensure that this is done with minimal ethical costs. If states do not remove carbon, this responsibility falls on the individual. Is the same the case for corporations? Answering these questions requires further arguments addressing how in general, responsibilities are distributed between states, individuals, and corporations. Although such arguments exist within political philosophy, they still have to be applied to the non-ideal setting of climate change and its mitigation.

4.2 Towards national or global net-zero emissions?

The Swiss Long-Term Climate strategy (Swiss Federal Council, 2021: 50) states that a share of the carbon removed in Switzerland will be stored elsewhere. This is because it is uncertain whether the domestic potential for carbon storage will be sufficient to fully meet the requirement for negative emissions. This directs us towards an important clash in the literature on CDR technologies and the idea of a net zero balance: whereas net zero targets are determined on a national level and overall, these levels have to result in net zero emissions, other models approach the issue from a more global perspective. The question of whether the goal of net-zero emissions is to be established globally or nationally raises interesting questions about the distribution of responsibilities between different states. Yet to my knowledge, a normative approach to this topic is lacking.

This is not to say that no arguments have been advanced about which states should get involved in developing and up-scaling CDR technologies. Removing carbon dioxide from the atmosphere with CDR technologies could be a way for states to address their responsibilities to mitigate climate change by removing the carbon they emit and hence to 'clean up the mess' they have caused (Shue, 1999, 2021). By removing carbon from the atmosphere, agents can balance out their past emissions that have exceeded their fair share of the global emission budget (McMullin et al., 2020). Arguments have been advanced about how the possibility of removing carbon may increase the climate change mitigation responsibilities of major emitters (Fyson et al., 2020). The historical emissions of some agents impose a responsibility on them to enlarge the carbon budget by removing more carbon than they emit and to have a net negative emission balance. For example, industrialized countries may be urged to become net negative instead of net zero in their emissions by mid-century, thereby allowing developing countries to reach these targets later (Mohan et al., 2021). Removing carbon may be a way for states to fulfil their compensatory duties to one another (Mintz-Woo, 2023) or to 'pick up the slack' for others who undertake no efforts to mitigate climate change (Caney, 2016). Because 'principles and expectations regarding fairness and equity of mitigation efforts include CDR efforts', we can argue that 'industrialized countries are expected to take the lead on CDR—including particularly those at an early technological development stage—and to support developing nations where appropriate in their eventual pursuit of CDR.' (Honegger et al., 2021a: 9).

Building on these arguments, this research project would critically examine whether carbon removal can be a way of fulfilling the responsibilities of one state towards another. This may inform how challenges in international corporation can be addressed, such as where the carbon is to be captured, where it is to be stored, and who will benefit from this action.

4.3 The role of CDR technologies for transition and beyond

One open question in the debate on CDR technologies is what role CDR technologies will play in the transition to a net zero society and beyond. CDR technologies may well be part of a long-term strategy to address climate change. However, the role of CDR technologies within net zero targets and beyond is little theorized. Some publications have raised the question of 'net-negative emissions' in the long run. It is often set aside that the 'deployment of CDR will likely not just be a one-time effort to allow the world to reach net zero, but a durable part of the global landscape for the foreseeable future' (Iyer et al., 2021: 3).

It is at this point that the governance challenges discussed in this thesis may become even more pressing. Some findings of this thesis lead us to doubt that CDR technologies should be part of the long-term strategy to mitigate climate change. Carbon majors can benefit from CDR technologies because of the prevailing market structures and institutional structures. CDR technologies such as BECCS and DACCS that rely on CCS may contribute less to a structural change that empowers dominated groups of society. This seems more to be the case for terrestrial carbon storage such as afforestation, soil sequestration, and biochar that may have co-benefits for societies (Fyson et al., 2020). Some have argued that these CDR technologies should be included in the discussion on climate change adaptation (Buck et al., 2020). The question remains whether CDR technologies are part of the structural change to a low-emitting society.

In Chapter 2, we discussed the extent to which CDR technologies are permissible in reaching net zero targets. We argued that states should undertake structural changes to reduce the emissions that individuals need to be full members of their societies. We highlighted that CDR technologies can also play a transitional role in removing carbon until emissions can be reduced. CDR technologies allow agents to continue emitting as long as the ethical costs of carbon removal are lower than those of abating emissions. The framework proposed can be used to argue about the permissible long-term use of CDR technologies: CDR technologies are only permissible to the extent that there are residual emissions. This directs us to the challenge of defining what residual emissions are and how this may change over time. The findings in this thesis could be used to research the permissibility of long-term targets for carbon removal.

5. Concluding Remark

With these thoughts for future research, I close this thesis. I started my discussion by presenting the possibility of removing carbon dioxide from the atmosphere. I outlined challenges to the governance of the technologies that do so. These challenges go beyond practical questions about whether and how carbon dioxide can be removed. They include the question whether carbon should be removed, and if so, how much. They raise justice challenges. To meet these challenges and establish an account of the ethics of carbon removal, this thesis investigated the moral responsibilities to remove carbon of three kinds of agents: individuals, states, and corporations. This thesis provides an account that differentiates agents and their responsibilities to remove carbon dioxide from the atmosphere and thus contributes to an overall account of climate justice.

Acknowledgements

Writing this dissertation was an undertaking that I could not have accomplished alone.

I wrote this dissertation during my time as a research assistant at the University of Fribourg Environmental Sciences and Humanities Institute, starting in August 2019. I thank Ivo Wallimann-Helmer for his supervision, support, and enthusiasm in these years. I learned a lot about writing, teaching, organizing, and even a bit of Aikido.

Many thanks go to Clare Heyward and Dominic Lenzi for their helpful comments on my work and advice. I thank them and Olivier Graefe for having been my accompanying PhD jury, providing advice and steering my ideas. I also thank Christian Baatz for agreeing to join them in evaluating this thesis.

I received thoughtful comments on my work by Kathrin von Allmen, Elizabeth Cripps, Joseph Conrad, Samuel Eberenz, Laura García-Portela, Grace Garland, Antonia Holland-Cunz, Tristan Katz, Teea Kortetmäki, Simon Kräuchi, Darrel Moellendorf, Rebecca Richards, Dominic Roser, Felix Schrade, Alexander Schulan, Henry Shue, Lukas Sparenborg, Lukas Tank, and Ilias Voiron. Thank you, a lot! A special thanks goes to Joseph, Lukas, and Rebecca for many insightful reading-group discussions on structural injustice, climate justice, and beyond. Many thanks also go to Grace Garland and Simon Milligan for their corrections, edits, and suggestions. Of course, any errors in this thesis are my own and my dyslexia's.

I thank Elizabeth Cripps for welcoming me to Edinburgh University in autumn 2021, and Darrel Moellendorf for hosting me in Frankfurt at Normative Orders in January 2023. Both were very inspiring times for me. I thank Amélie Pochon and Astrid Kaiser for their kind help on all administrative journeys.

The thoughts in this thesis also developed by discussing with many others. I thank my students at the University of Fribourg for our discussions on climate ethics, CDR and beyond. I thank my colleagues in the geography department at Fribourg University for their welcoming attitude and the many interdisciplinary lunch-break discussions. Thanks for taking me in, though I had no idea about snow layers, rock glaciers, or water systems in Central Asia. I am very thankful for the many moments of thinking aloud with Anouchka, Estelle, Flo, Felix, Francois, Simeon, Susanne, Dominik, Isabel, and other old and new friends.

I'd like to thank the wonderful people in the shared flats I lived in or stayed to write my thesis, especially in La Planafino. Thanks for being there with me, enduring my stress levels and providing the needed distractions. The times of the covid-pandemic and the months of home office would have been very hard without your support. *Ein ganz großes Danke geht an meine Alltagsheldin der letzten vier Jahre, Estelle.*

Moreover, being in the mountains and going climbing has been a crucial part of getting the energy for continuing this project. I especially thank Nicole for sharing her expertise and encouraging me to go on new adventures. Many thanks go to all those who were part of them. *C'était très chouette de partager ces aventures avec vous !*

Finally, I am grateful for the support from my family, especially my mum Barbara and my siblings Julia, Jakob, Niki, Regina, Leo and Lenni, and their partners. I feel very fortunate to have such an amazing and loving family. *Ihr Lieben, ich dank euch von Herzen für eure Unterstützung auf so vielen Wegen, euer Mitfiebern, eure offenen Ohren, eure Ratschläge, und die nötigen Ablenkungen und Ermutigungen! Ich hab euch sehr lieb!*

2050 is the year most featured in climate scenarios and in targets that imply carbon removal. In 2050, my niece Lucia will be at the age I am now. I dedicate this thesis to my nieces and nephews. They are my reminder that the future is not far away, and that climate action is needed today.

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Schübel H and Wallimann-Helmer I (2021) Food security and the moral differences between climate mitigation and geoengineering: the case of biofuels and BECCS. In: *Justice and food security in a changing climate: (*eds H Schübel and I Wallimann-Helmer), Fribourg, Switzerland, 24-26 June, 2021, pp. 71–76. The Netherlands: Wageningen Academic Publishers.

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Appendix A: Curriculum Vitae

1. Personal Information

Hanna Mirjam Schübel

University of Fribourg	hanna.schuebel@unifr.ch
Environmental Sciences and Humanities	hanna.schuebel@gmail.com
Chemin du Musée 4	ORCID 0000-0002-0548-6340
CH-1700 Fribourg	

Born 20.09.1992 in Schwäbisch Hall (D).

2. Education

Since 2019/08	PhD in *Environmental Humanities* at the Environmental Sciences and Humanities Institute, University of Fribourg (CH)
2023/01 – 2023/02	Research stay at Goethe Universität Frankfurt (D), Research Cluster Normative Orders, supervised by Darrel Moellendorf
2021/10 – 2021/12	Research stay at University of Edinburgh (UK), School of Political and Social Sciences, supervised by Elizabeth Cripps
2016/10 – 2019/04	M.Sc. *Politics, Economics and Philosophy* at University of Hamburg (D), overall grade: excellent
2012/10 – 2016/04	B.A. *Philosophy & Economics* at University of Bayreuth (D).
July 2012	Abitur, Gymnasium Möckmühl (D)

3. Employment

2019/08 – 2024/03	Diploma Assistant at the Environmental Sciences and Humanities Institute, University of Fribourg.
2017/10 – 2019/02	Tutor for the courses 'Ethics' and 'Epistemology', University of Hamburg.
2017/04 – 2017/09	Student Assistant at the Chair for Sociology, Prof. Dr. Jürgen Beyer, University of Hamburg.
2015/10 – 2016/02	Tutor for the course 'Fundamentals of Decision Theory' at University of Bayreuth.

4. Professional Development

04/2021 – 03/2024	Diploma of Advanced Studies in Higher Education Didactics (30 ECTS) at University of Fribourg (CH)

5. Institutional Responsibilities

UniFR_ESH Institute supporting grant applications, website management, PR, teaching, organization of the institute's colloquium.

6. Approved Research Projects

2022/06 Funding for the Workshop 'Ethical Challenges of Carbon Dioxide Removal' by the City of Zürich; with Samuel Eberenz (Stiftung Risikodialog), Ivo Wallimann-Helmer (UniFR); CHF 20'000

2021/03 Funding for the EurSafe2021 Conference 'Justice and Food Security in a Changing Climate' by the Swiss National Science Foundation, with Ivo Wallimann-Helmer; CHF 14'500

2020/10 Funding for the EurSafe2021 Conference 'Justice and Food Security in a Changing Climate' by the Forschungsfond of University of Fribourg, with Ivo Wallimann-Helmer; CHF 5'000.

2020/01 Funding for the project 'Ethical Conflicts between Carbon Dioxide Removal and Food Security' by the Forschungspool of University of Fribourg, with Ivo Wallimann-Helmer; CHF 30'000

2018/10 Funding for M.Sc. Thesis 'Trade-offs between Efficiency and Fairness in Consumer Boycotts: An Experimental Approach' by the Department of Economics, Hamburg University; EUR 1'200

7. Teaching activities

Spring Term '23	Seminar 'Ethik und Umweltpraxis' at University of Fribourg (UniFR)
Autumn Term '22	Reading seminar accompanying the lecture 'Principles of Environmental Ethics' at UniFR
Spring Term '22	Seminar 'Ethik und Umweltpraxis' at UniFR (co-teaching)
Autumn Term '20	Reading seminar accompanying the lecture 'Principles of Environmental Ethics' at UniFR
Spring Term '20	Seminar 'Ethik und Umweltpraxis' at UniFR (co-teaching)
Autumn Term '19	Seminar 'Fokus Umweltethik' at UniFR (co-teaching)
2017/10 – 2019/02	Tutorials 'Ethics' and 'Epistemology' at University of Hamburg.
Autumn Term '15	Tutorial 'Fundamentals of Decision Theory' at University of Bayreuth.

8. Memberships in working groups and boards

Institute council of the UniFR_ESH Institute (2020/02-2023/08)
Member of the EurSafe Newsletter committee
Working Group "Policy" of the Carbon Removal Platform Switzerland

9. Reviewing Activities

Journals Ethics, Politics & Environment

Publishers Wageningen Academic Publishers

Conferences ISEE Annual Meeting
MANCEPT Workshop
European Society of Agriculture, Food and Ethics

10. Organization of conferences and workshops

2023/11 Workshop '2nd Swiss Animal-Environmental Ethics Network Meeting' at UniFR, with S. Kräuchi, K. von Allmen, A. Deplazes-Zemp, M. Eggel, A. Martin, I. Wallimann-Helmer, M. Wild. Fribourg (CH).

2022/11 Workshop '1st Swiss Animal-Environmental Ethics Network Meeting' at UniFR, with I. Wallimann-Helmer, A. Martin, M. Eggel. Fribourg (CH).

2022/09 Panel 'Structural Injustice, Responsibility, and the Passage of Time' at MANCEPT Workshops in Political Theory 2022; with J. Conrad, É. Litalien, R. Richards, J. Salomone-Sher, L. Sparenborg. Manchester (UK).

2022/06 Workshop 'Ethical Challenges of Carbon Dioxide Removal' with S. Eberenz, I. Wallimann-Helmer, J. von Rothkirch. Zürich (CH).

2021/11 Workshop 'Science Sustainability Dialogues' with Swiss Academy of Sciences with I. Wallimann-Helmer, M. Eggel, G. Wülser, A. Bretzle. Fribourg (CH).

2021/10 Session 'The Ethics of CDR Technologies' at the Climate Engineering in Context 2021 conference, with I. Wallimann-Helmer, C. Baatz. Potsdam (D) / online.

2021/06 Conference 'EurSafe 2021: Justice and Food Security in a Changing Climate', Congress of the European Society of Agriculture, Food and Ethics (EurSafe), lead organization, with I. Wallimann-Helmer, A. Pochon. Fribourg (CH) / online.

2020/11 Workshop 'Ethical Challenges in Carbon Dioxide Removal' at Fribourg University, with I. Wallimann-Helmer. Fribourg (CH) / online.

2019/05 Workshop 'Encouraged Ignorance' at University of Hamburg, with G. Perkins, A. Donders, C. Schmitz. Hamburg (D).

11. Skills

Languages

German	native
English	fluent
French	proficient

Programmes

MODX	Website tool, proficient use
MS Office	proficient for Word and PowerPoint

12. Research Output List

i. Publications

Schübel, H.; Wallimann-Helmer, I. (forthcoming): Setting a Permissible Target for Carbon Dioxide Removal. In *Environmental Ethics*.

Schübel, H. (forthcoming): Being Pivotal for Carbon Dioxide Removal. In *Philosophy & Public Issues*. Contribution to the special issue Climate Transition and the Moral Responsibility of the Pivotal Generation, edited by F. Corvino, A. E. E. Pirni and G. Pellegrino.

Wallimann-Helmer, I.; **Schübel, H.** (2024): Ein Modell zur Zuschreibung individueller Klimaschutzverantwortung. In C. Heite, V. Magyar-Haas, C. Schär, G. Wagner (Eds.): Responsibilisierung. Wiesbaden: Springer VS. DOI: 10.1007/978-3-658-42456-5_10

Lenzi, D.; **Schübel, H.** & Wallimann-Helmer, I. (2023). Justice in benefitting from carbon removal. In *Global Sustainability*, p. 1-8. DOI: 10.1017/sus.2023.22

Schübel, H. (2023): Individuals' responsibilities to remove carbon. In *Critical Review of International Social and Political Philosophy*, pp. 1–21. DOI: 10.1080/13698230.2023.2260241

Brazzola, N.; Eberenz, S.; Honegger, M.; Becattini, V.; Betz, R.; Bischof, S.; Brunner, C.; Florin, M-V.; Hüppi, R.; Koch, K.; Reymond, A.; Rothkirch, J. von; **Schübel, H.**; Sievert, K. (2023): Carbon Dioxide Removal Policies for a Net Zero Switzerland and Beyond. Policy Pathways and Visions. CDR Swiss White Paper. Risk Dialogue Foundation. Zürich, Switzerland. https://www.carbon-removal.ch/wp-content/uploads/2023/09/CDR_Policy_WhitePaper_2023-6.pdf

Schübel, H. (2022): Who should get to take credit? Investigating the role of corporations in carbon removal developments. In D. Bruce, A. Bruce (Eds.): *Transforming food systems: ethics, innovation and responsibility*. EurSafe 2022. The Netherlands: Wageningen Academic Publishers, pp. 192–197. DOI: 10.3920/978-90-8686-939-8_28.

Schübel, H.; Wallimann-Helmer, I. (2021): Food security and the moral differences between climate mitigation and geoengineering: the case of biofuels and BECCS. In H. Schübel, I. Wallimann-Helmer (Eds.): *Justice and food security in a changing climate.* EurSafe 2021. The Netherlands: Wageningen Academic Publishers, pp. 71–76. DOI: 10.3920/978-90-8686-915-2.

Wallimann-Helmer, I.; **Schübel, H.** (2021): Introduction: Justice and Food Security in a Changing Climate. In H. Schübel, I. Wallimann-Helmer (Eds.): *Justice and food security in a changing climate.* EurSafe 2021. The Netherlands: Wageningen Academic Publishers, pp. 17–22. DOI: 10.3920/978-90-8686-915-2_0.

Wallimann-Helmer, I.; Terán, L.; Portmann, E.; **Schübel, H.**; Pincay, J.; Akhundova, J. (2021): An integrated framework for ethical and sustainable digitalisation. In L. Terán, C. Vaca, D. Riofrio (Eds.): 2021 Eigth International Conference on eDemocracy & eGovernment (ICEDEG), 156-162. DOI: 10.1109/ICEDEG52154.2021.9530972

Schübel, H. (2016): The Covariance between Explanation and Prediction in Economic Models. In *Rerum Causae* 8 (2).

ii. Edited Publications

Special Issue 'The Ethics of Carbon Dioxide Removal Technologies' with C. Heyward, D. Lenzi and I. Wallimann-Helmer; in Global Sustainability (ongoing)

Topical Collection 'Just Food Production in a Changing Climate' (2023). With I. Wallimann-Helmer and Mattias Eggel, Journal of Agricultural and Environmental Ethics, Springer. https://link.springer.com/collections/iifhddbjbb

Schübel, Hanna; Wallimann-Helmer, Ivo (Eds.) (2021): *Justice and food security in a changing climate*. EurSafe 2021. Fribourg, Switzerland, 24-26 June 2021. The Netherlands: Wageningen Academic Publishers. https://doi.org/10.3920/978-90-8686-915-2

iii. Oral contributions to conferences & workshops

*Invited talk or contribution.

2024/03	'The Ethics of Carbon Dioxide Removal: Differentiating Agents and Responsibilities to Remove Carbon Dioxide'. Public Defense of PhD. University of Fribourg. Fribourg (CH).
2024/02	'Differentiating Agents and Responsibilities to Remove Carbon Dioxide' at ETH sus.lab working group. Zürich (CH).*
2023/06	'Normative Challenges for Governing CDR'. Workshop. University of Twente, Enschede (NL).*
2023/01	Commentary on Chris Armstrong 'Conservation and Global Justice: Responding Fairly to the Biodiversity Crisis'. Workshop. Goethe University, Frankfurt (D).*
2023/01	'Being Pivotal for Carbon Dioxide Removal – A Comment on Henry Shue's 'The Pivotal Generation'. Presentation at Working group Climate Ethics, Sustainability and Global Justice University of Kiel (D).*
2022/10	'The Emission Connection Model' at Ethics of Socially Disruptive Technologies 2022 International Conference. Leiden (NL).
2022/09	'The individual responsibility to remove emissions'. Tagung für Praktische Philosophie. Salzburg (AT).
2022/09	'Die individuelle Verantwortung Emissionen zu entfernen' at Kongress of the Gesellschaft für analytische Philosophie (GAP). Berlin (D).
2022/09	'Who should get to take credit? Investigating the role fo corporations in carbon removal developments' EurSafe 2022 Conference. Edinburgh (UK).
2022/09	'The Emission Connection Model' at MANCEPT Workshops in Political Theory, Panel 'Structural Injustice, Responsibility, and the Passage of Time'. Manchester (UK).
2022/08	'Justice in Benefitting from Carbon Removal' (with Dominic Lenzi and Ivo Wallimann-Helmer). Philosophy Colloquium of the Arctic University of Norway. Tromsø (N).*

2022/06 ‘Ethical Challenges of Carbon Dioxide Removal: A Conceptual Map’ at Workshop ‘Ethical Challenges of Carbon Dioxide Removal’. Zürich (CH).

2022/06 Commentary on Elizabeth Cripps ‘What Climate Justice Means – And Why We Should Care’. Book Symposium on Climate Justice. Goethe University, Frankfurt (D).*

2022/04 ‘The Emission Connection Model: Defining the Moral Permissibility of Carbon Removal’ at Environmental Humanities Colloquium, University of Fribourg (CH).

2022/03 Commentary on ‘Climate Change as a Structural Harm?’ by Megan Bloomfield at Workshop ‘Principles of Ethical Decision Making in Environmental Practice’, University of Fribourg (CH).*

2021/12 ‘The Emission Connection Model’ at Political Theory Research Group Colloquium, School of Political and Social Sciences, University of Edinburgh (UK)/online.

2021/10 ‘Going Net Zero: Defining the Moral Permissibility of Carbon Dioxide Removal’ at Climate Engineering in Context 2021 Conference, session ‘The Ethics of CDR Technologies’, Potsdam(D)/online.

2021/09 ‘Justice in benefitting from carbon removal’ at the 2nd World Forum for Climate Justice, Glasgow (UK)/online.

2021/09 ‘The Emission Connection Model‘ at DGPhil (Deutsche Gesellschaft für Philosophie e.V.) Conference, Erlangen (D)/online.

2021/06 ‘Food security and the moral differences between climate mitigation and geoengineering’, EurSafe2021 Conference ‘Justice and Food Security in a Changing Climate’, Fribourg (CH)/ online.

2021/05 ‘Going Net Zero: Defining the Moral Permissibility for Carbon Dioxide Removal’ at the Sixth Annual Conference of the Centre for the Study of Global Ethics, Birmingham (UK)/ online.

2021/03 ‘Moral Obligations for Carbon Dioxide Removal’ in Environmental Humanities Colloquium, University of Fribourg/online.

2021/03 ‘Going Net Zero: Defining the Moral Permissibility of Carbon Dioxide Removal’, Geocolloquium, University of Fribourg(CH)/online.

2020/12 ‘Ethics in Governing Negative Emission Technologies’ at Workshop Ethical Challenges in Carbon Dioxide Removal at University of Fribourg/online.

2020/03 ‘Ethics in Governing Negative Emission Technologies’, Geocolloquium, University of Fribourg(CH)/online.

iv. Poster presentation at conferences

2019/08 Swiss Climate Summer School ‘Getting out of the Carbon Crunch’ organized by ETH Zürich (CH).

v. Other publications

Doninelli, Christian (2024). "Emissions Carbone: La Fin Justifie-t-Elle Les Moyens?" Interview avec Dominic Lenzi, **Hanna Schübel** et Ivo Wallimann-Helmer. Alma & Georges, January. https://www.unifr.ch/alma-georges/articles/2024/emissions-carbone-la-fin-justifie-t-elle-les-moyens.

Schübel, Hanna (2022): Book Review of Elizabeth Cripps 'What climate justice means and why we should care'. In EurSafe Newsletter, September 2022. Available at https://www.eursafe.org/images/Eursafe_Newsletter_September_2022.pdf

Newsletter EurSafe September 2022, edited by Hanna Schübel, available at https://www.eursafe.org/images/Eursafe_Newsletter_September_2022.pdf.

Michaud, Patricia (2021) "Lutter contre le changement climatique, mais pas n'importe comment!" – Interview avec **Hanna Schübel**. In Alma & Georges, online at https://www.unifr.ch/alma-georges/articles/2021/lutter-contre-le-changement-climatique-mais-pas-nimporte-comment.

vi. Non-academic presentations

2024/01	Climate Lunch - Objectivs climatiques cantonaux, comment y pavenir ? / Wie können die kantonalen Klimaziele erreicht werden? Roundtable Discussion. Fribourg
2022/11	Negative Emissionen unter der Lupe. TecDay. Gymnasium Lerbermatt Bern-Köniz. Lebermatt (CH).
2022/06	Ethical Challenges of Carbon Dioxide Removal. Workshop 'Ethical Challenges of Carbon Dioxide Removal'. Zürich (CH).
2022/05	Individual Responsibility and Climate Change. Workshop. Philexpo 2022, Fribourg (CH).
2022/03	Negative Emissionen Unter der Lupe. University of Fribourg Sustainability Week. Centre Fries. Fribourg (CH).
2022/03	Gerechtigkeit im Klimaschutz. TecDay. Alte Kanti Aarau. Aarau (CH).
2021/06	'The Future of the Earth: Preenacting Climate Scenarios'. Interactive theatre performance with invited experts. Organized by Gusset, Patrick. Züricher Hochschule der Künste. Klima Kontor Basel. Basel (CH).
2021/04	Gerechtigkeit im Klimaschutz – die Erzeugung von „negativen" Emissionen unter der Lupe. Jugend-Umwelt-Plattform Österreich. Jugend-Umwelt-Plattform. Vienna (AT) / online.
2020/02	Gerechtigkeit im Klimaschutz. Klimatag. Kantonsschule Stadelhofen. Zürich (CH).

Appendix B: Published Papers

- Individuals' responsibilities to remove carbon (Chapter 1)
- Food security and the moral differences between climate mitigation and geoengineering: The case of Biofuels and BECCS (Chapter 3)
- Justice in Benefitting from Carbon Removal (Chapter 4)
- Who should get to take credit? Investigating the role of corporations in carbon removal developments (Chapter 5)

Critical Review of International Social and Political Philosophy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/fcri20

Individuals' responsibilities to remove carbon

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To cite this article: Hanna Schübel (21 Sep 2023): Individuals' responsibilities to remove carbon, Critical Review of International Social and Political Philosophy, DOI: 10.1080/13698230.2023.2260241

To link to this article: https://doi.org/10.1080/13698230.2023.2260241

Published online: 21 Sep 2023.

CRITICAL REVIEW OF INTERNATIONAL SOCIAL AND POLITICAL PHILOSOPHY
https://doi.org/10.1080/13698230.2023.2260241

Routledge
Taylor & Francis Group

Individuals' responsibilities to remove carbon

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ABSTRACT

The potential upscaling of carbon dioxide removal (CDR) technologies to meet states' net-zero targets may enable individuals to remove emissions by purchasing carbon removal certificates. In this paper, I argue for two concepts of individual responsibility to capture the moral responsibility of individuals to remove carbon dioxide from the atmosphere through CDR technologies. The first is that of liability, a direct responsibility to remove carbon in order to minimize one's carbon footprint. The second is a shared political responsibility to remove carbon that individuals have by virtue of being part of weak collectives responsible for mitigating climate change or by virtue of participating in structures that contribute to climate change. I argue that the concept of shared political responsibility can be used to determine how CDR technologies should or should not be implemented. Finally, I discuss how these two responsibilities are related.

KEYWORDS Elizabeth Cripps; individual responsibility; carbon footprint; Iris Marion Young; carbon dioxide removal

Introduction

In September 2021, the 'world's largest climate-positive direct air capture plant', designed and built by the Swiss company Climeworks, entered service in Iceland (The Economist, 2021). The company engages in carbon dioxide removal (CDR) with a technology known as direct air carbon capture and storage (DACCS), whereby carbon dioxide is removed from the air and stored permanently in geological formations. Individuals can purchase carbon dioxide removal certificates on the company's website and thus remove carbon dioxide from the air (Climeworks, 2021).[1] Using services like this, individuals could minimize their carbon footprint not only by reducing their emissions but also by removing carbon once emitted. For example, they can already reduce their emissions by taking the train rather than the plane from London to Edinburgh. The train ride will create far fewer emissions than the flight. But it will nevertheless create some. Then, by buying carbon removal certificates

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from a company that removes carbon from the atmosphere, the traveller could reduce the total carbon dioxide emitted by their journey to zero or even beyond.[2] Reducing emissions is argued to be part of the responsibility that individuals bear to mitigate climate change. But given the current limited capacities for removing carbon, we may argue that today it is not an individual's responsibility to remove carbon. After all, individual responsibilities are relative both to the control that individuals have and to the current state of technology (Seager et al., 2011). Although CDR services are offered today, they cannot account for all the carbon individuals currently emit.

But the net-zero targets of various states will very likely lead to the expansion of market-based mechanisms for removing carbon by CDR technologies (Sayegh, 2019). The various commitments of countries and companies to reach net-zero emissions by 2050 rest not only on assumptions of rapid and deep decarbonization but also on the development and upscaling of CDR technologies and industry to make large-scale carbon removal available by mid-century (McLaren et al., 2019; Peters & Geden, 2017; Schreyer et al., 2020). CDR includes activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, and oceanic reservoirs and in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage (IPCC, 2018, p. 24). These include growing biomass by, for instance, afforestation, reforestation, plankton growth, and planting mangroves. The category of CDR includes measures such as planting biomass for bioenergy and storing the CO_2 subsequently captured in geological reservoirs, termed bioenergy with carbon capture and storage (BECCS), and the capture of CO_2 directly from the air and its storage in products and geological reservoirs, termed direct air capture and carbon storage (DACCS). All of these raise ethical questions, but the extent to which they imply ethical challenges depends on the precise technology and context of implementation under question.[3]

The feasibility of scaling up CDR technologies is a main concern raised about climate policies that rely on CDR (Lenzi, 2021; Shue, 2021). Yet, if CDR technologies are implemented at a large scale by mid-century and purchasing carbon removal certificates becomes widely accessible to individuals, this will have implications for individuals' responsibility for climate change mitigation. In this paper, I investigate whether individuals have a responsibility not only to reduce their emissions but also to remove carbon by purchasing certificates from CDR technologies. I argue for two responsibilities of individuals to remove carbon: the direct responsibilities of individuals to remove carbon, which is part of their duty to minimize their carbon footprint, and the shared political responsibility that individuals have for ensuring that this removal is done at low 'ethical costs' (Lenzi, 2021).

I begin by investigating how the possibility of CDR technologies changes individuals' responsibility for the carbon they emit (Section 2). I show how arguments for a duty to minimize individuals' carbon footprints include a direct responsibility for individuals to remove carbon. Secondly, I turn to two challenges that require the extension of individuals' responsibilities beyond their carbon footprints: to ensure that carbon is removed for which no individual carries a direct responsibility, and to ensure that the ethical costs of carbon removal are minimized. To address these challenges, I draw on an account of shared political responsibilities by Elizabeth Cripps and another by Iris Marion Young (Section 3). Thirdly, I explain how the two responsibilities to remove carbon are related (Section 4). Then I conclude (Section 5).

Individuals' direct responsibility to remove carbon

In this section, I argue for a direct responsibility of individuals to remove carbon. With the current high concentration of carbon dioxide in the atmosphere, we can consider emissions caused by individuals to be a waste product that potentially creates severe harm. The basic claim for an individual's responsibility to reduce their carbon footprint to zero rests on the argument that individuals cause emissions, that these emissions cause harm by contributing to climatic change, and that individuals can be blamed for this harm. When we consider a specific action, such as taking a flight, and determine how much carbon must be removed to avoid contributing to climate change, we apply the concept of 'responsibility as liability'. This model of responsibility assumes liability for the harm caused by individuals and implies that individuals can be causally related to the harm their actions cause and blamed for that harm (Young & Nussbaum, 2011, p. 97).[4] The underlying moral principle is that it is wrong to do serious, foreseeable, avoidable harm to others (Cripps, 2022, p. 18).

John Broome has made the case for offsetting, which includes removing carbon, arguing that the duty to not harm others with their emissions requires individuals to avoid any net emissions of greenhouse gas at all: 'You cannot live your life without causing any emissions, but you can easily cancel the emissions you do cause by offsetting them' (2012, p. 14). This is a 'direct duty' because fulfilling it means mitigating harm directly (Cripps, 2013, p. 140) by reducing or removing emissions. Hence, individuals are directly responsible for reducing and removing their emissions, and thus, overall, for reducing their carbon footprints to zero.[5] Under the term 'offsetting', we can distinguish between offsetting that removes carbon from the atmosphere, the purpose of CDR technologies, and 'preventative offsetting', which prevents carbon that would have been emitted from being emitted (Broome, 2012, p. 87).[6] Broome argues for offsetting overall, but there are morally relevant differences between removing carbon and paying others to emit less. For example, it is difficult to justify how paid emission reductions go beyond what agents should have done anyway (Hyams & Fawcett, 2013, p. 95). Further, arguments for a responsibility for preventative offsetting are limited to cases in which agents are able and willing to emit less if they are paid to do so. Once emissions have been reduced to this level, carbon removal is needed to account for surplus emissions. Finally, the carbon already accumulated in the atmosphere cannot be addressed by emission reductions. The latter two arguments are especially relevant for carbon removal on the collective level. For these reasons, I focus in my argument on removing carbon.

With this focus on carbon removal, I take Broome's account as a starting point for my argument for a direct responsibility to remove carbon. I begin with the discussion of his account and a direct responsibility of individuals to minimize their carbon footprint. Then, I turn to two objections to the claim that individuals should reduce their carbon footprint to zero. Finally, I discuss whether carbon removal can remedy past harm and compensate for the failure to reduce emissions.

The first objection to Broome's account and a direct responsibility of individuals is that it singles out individuals for having caused harm with their emissions. Sinnott-Armstrong (2005) famously argued that individuals are under no moral responsibility to reduce their emissions as each can claim that global warming 'is not *my* fault': Harm from climate change is not something for which we can hold any individual morally responsible when their emissions alone have no significant effect and climate change would also have occurred in the absence of their contribution to it. One may submit to the 'no-effect view', which suggests that the reduction of one's carbon footprint has 'no effect or an effect so vanishingly small that is it not of moral significance', and as a result one has no duty to change one's behaviour (Schwenkenbecher, 2014, p. 176). But a direct duty to reduce or remove emissions motivated by the no-harm principle requires that fulfilling this duty is effective in counteracting this harm. If the removal of emissions has no effect, there is no duty to remove them. As a result, individual duties are solely political: 'It is better to enjoy your Sunday driving while working to change the law so as to make it illegal for you to enjoy your Sunday driving' (Sinnott-Armstrong, 2005, p. 312).

Broome objected to this, arguing that every increase in emissions can be linked to an increase in climate change harm (Broome, 2012; Nolt, 2011). Unfortunately, this argument relies on a more or less linear relationship between emissions and climate change harm. This has been criticized by pointing, for example, to tipping points in the climatic system. At such tipping points, a small increase in temperature caused by a small amount of additional emissions accelerates climate harm much more than any previous amount of emissions. Rather than relating to climate change harm directly, emissions contribute to climate change and increase the expected harm

(Burri, 2020; Cripps, 2021).[7] This argument provides grounds for a direct responsibility of individuals to minimize their carbon footprint.

Another way of dealing with the no-effect view is by arguing that difference-making is not the relevant criterion for establishing a moral relationship between individuals and the harms they cause (Nefsky, 2015) and that 'an act can play a non-superfluous part in changing the outcome, even if it is not itself sufficient to make a difference (Nefsky, 2019, p. 3). Alternatively, one may argue for a duty to reduce emissions because one should do one's fair share to mitigate climate change (Baatz, 2014). Overall, several responses to Sinnott-Armstrong's account have argued for a duty to minimize carbon footprints (Broome, 2018; Burri, 2020; Cripps, 2013, 2021; Cullity, 2019; Schwenkenbecher, 2014).

I take these arguments to provide firm foundations for the direct responsibility of individuals to minimize their carbon footprint. However, even among those who accept a duty of individuals to minimize their carbon footprints, the standard view is that nobody is required to reduce it to zero. Two objections have been made to the claim that individuals should reduce their carbon footprint to zero: the entitlement objection and the demandingness objection. In the following, I show that if carbon removal is added to the mix of possible actions to minimize the carbon footprint, both objections lose force.

The entitlement objection to a duty to reduce carbon footprints to zero is that individuals are entitled to a certain amount of emissions. Such an entitlement could be a fair share of a carbon budget or an entitlement to a threshold of well-being that is connected to some emissions, such as subsistence emissions (Caney, 2012; Shue, 2019). Yet, the entitlement objection does not hold for carbon removal because 'people can and often do have a duty to make up for emitting even though emitting was morally permissible' (Duus-Otterström, 2022, p. 6). In the case of subsistence emissions, people may be permitted to produce them, but this does not necessarily exempt them from responsibilities for carbon removal, because 'it does not follow conceptually from the fact that an act was morally permitted that it could not lead to corrective duties' (Duus-Otterström, 2022, p. 7). If carbon can be removed, the necessity of emitting carbon is decoupled from an entitlement to cause harm. For instance, an individual may be entitled to perform activities that produce waste, but we still blame them for not disposing of their waste correctly. To ensure that their emissions do no harm, the individual can not only avoid producing them but also ensure that they are removed from the atmosphere.

The demandingness objection is that the severe cuts in emissions necessary to achieve this would likely be overly demanding for the individual (Baatz, 2014; Cripps, 2021). This objection to the minimization of individuals' carbon footprints argues that we cannot be required to make such a substantial effort, because we can have moral duties to act in certain ways only if we do not have to sacrifice something of comparable moral importance in order to comply with that duty (Schwenkenbecher, 2014, p. 180). If reducing their carbon footprints to zero is too demanding, individuals cannot be blamed for the harm their emissions cause. The demandingness objection must be carefully reassessed given the feasibility of carbon removal. If carbon removal is possible, individuals do not have to reduce their emissions to zero. Instead, individuals can make payments and remove carbon to balance out any emissions that cannot be avoided. They still need to change habits that are fossil-fuel driven, because of limited capacities of CDR technologies and their negative side-effects, which I discuss below. But they do not need to give up basic standards of well-being to eliminate their carbon footprints. Hence, reducing their carbon footprint to zero is much less demanding.

Thus, if carbon removal is possible, both the entitlement and demandingness objections weaken. We can argue that individuals should reduce their carbon footprint to zero, which includes a direct responsibility to remove carbon. This direct responsibility to remove carbon, like the responsibility to reduce emissions, is motivated by the no-harm principle.

The direct responsibility to remove carbon also can be motivated by the responsibility to remedy a harm that was created by emissions one failed to reduce – something emission reductions cannot achieve. We may demand that people remove carbon they emitted in the past because they failed to fulfil their duty to reduce their emissions. Individuals can be morally required to assist in remedying harms even at great cost to them if they have previously failed to discharge duties (Cordelli, 2018). In many cases, the harm through these emissions could not have been avoided by individuals, nor did individuals know that their actions created harm. But individuals can have reasons and even duties to rectify a situation even when they were not responsible for creating it. This applies to emission removal (Duus-Otterström, 2022) and is closely congruent with the idea of being liable for the harm caused by one's actions. This responsibility to 'clean up your mess' falls on those who have failed to fulfil their responsibility of not causing any unnecessary harm (Shue, 2017b, p. 593). Carbon removal is a way of cleaning up the mess of harmful high concentrations of carbon in the atmosphere. One important drawback to the idea of offsetting harm by carbon removal is the timing (Duus-Otterström, 2022, p. 10): Carbon emissions are balanced out after they have already been made, meaning that while carbon is removed, the harm it contributed to in the meantime is not remedied. Hence, the claim that carbon removal can remedy past harm is somewhat compromised. However, this does not mean we should abandon the idea altogether: Harm is reduced if carbon is removed that would otherwise remain in the atmosphere for hundreds or even thousand years, continuously contributing to climate change.

This direct responsibility to remove carbon may meet a concern of overdemandingness. Surely, if carbon removal is expensive, some individuals may be exempt from fulfilling this responsibility because they have to fulfil other morally important needs. Like emission reductions, a responsibility to remove emissions cannot go beyond of 'what can reasonably be demanded' of individuals (Baatz, 2014, p. 10). But if carbon removal is cheap, individuals are morally required to remove emissions, as they are morally required to minimize the negative effects of their actions if they can do so at low costs (Burri, 2020). Importantly, it is not clear whether carbon removal will be expensive or cheap in a scenario in which CDR technologies are available to individuals. Estimates for the costs of CDR technologies differ widely (Fuss et al., 2018). As CDR technologies are scaled up, prices may fall, but once the scarcity of CDR technologies due to the limited availability of land and water becomes apparent, prices may increase again. Given these uncertainties, we can conclude that if individuals can remove carbon, they should do so unless it exceeds what can reasonably be demanded of them.[8]

Importantly, a responsibility to remove carbon does not compromise a responsibility to reduce carbon emissions. Even though emission reduction and carbon removal both reduce carbon footprints, one is not simply a replacement for the other. Emission reduction and carbon removal have different motivations: reducing emissions means avoiding exacerbating the problem of climate change, whereas carbon removal aims to remedy the situation by removing carbon from the atmosphere so that it stops contributing to climate change (Heyward, 2013, p. 25). Because individuals are liable for their emissions, they have moral reasons to do both. Further, there are pragmatic grounds for favouring emission reductions over carbon removals, as in most cases it is much easier and cheaper to avoid emissions than to remove carbon, and emission reductions providing co-benefits which many CDR technologies do not provide (Fyson et al., 2020). CDR technologies entail ethical costs that must be weighed against the ethical costs of reducing emissions, as I discuss in the next section.

Thus, I have argued that if CDR technologies are available, individuals are directly responsible for removing carbon because individuals ought to reduce their carbon footprint to zero to avoid causing harm through their emissions. This account of direct responsibility rests on the claim that individuals are liable for their emissions. Hence, the availability of CDR technologies can strengthen the responsibilities of individuals for the carbon they produce: the responsibility to remove carbon is added to the responsibility of individuals to reduce their emissions.

Shared political responsibility and carbon removal

So far, I have argued for a direct responsibility of individuals to remove carbon based on liability for their emissions. In this section, I argue that individuals' responsibilities for carbon removal go further because the focus on liability has two important drawbacks. The first drawback is that there are large amounts of emissions that no individual is liable for and hence no individual has any direct responsibility to remove them. However, the carbon resulting from these emissions may well have to be removed, and the question is what responsibilities individuals have to do this. The second drawback is that a direct responsibility to minimize the carbon footprint cannot account for the implications of implementing CDR technologies. Some CDR technologies, especially if implemented at a large scale, will have ethical costs, such as introducing negative side-effects, endangering sustainability, and distributing these side-effects unjustly (IPCC, 2018; Lenzi, 2021; Shue, 2017a). The concept of direct responsibility to remove carbon does not provide an answer to how individuals should consider aspects of the distribution of harm introduced by side-effects. In addition to arguments for reducing harm, we also need to include considerations of fairness and justice about how the ethical costs should be distributed.

These drawbacks lead me to argue for a shared political responsibility to remove carbon in this section. I do so by building on the approaches of Elizabeth Cripps and Iris Marion Young, who argue for such a shared political responsibility. Their views differ about how individuals acquire such a responsibility and what the exact nature of such a responsibility is. Yet, both ascribe a shared political responsibility to individuals to act with others: Cripps argues that individuals have 'cooperative promotional duty' to 'act together with motivated others, so far as possible at reasonable cost to oneself, to promote fair, efficient, effective global-level progress on climate change mitigation and adaptation' (Cripps, 2020, p. 102). Young argues that individuals are under an obligation to 'join with others … to transform the structural processes to make their outcomes less unjust' (Young, 2006, p. 96).

I begin by addressing the challenge of removing carbon that no individual is directly responsible for removing by proposing the idea of shared responsibility. Secondly, I use these approaches to shared political responsibility to determine how different CDR technologies should or should not be implemented.

Sharing responsibility to remove carbon

The idea of direct responsibility cannot extend the responsibility for carbon removal to carbon that cannot be attributed to the activities of an individual in a way that finds the individual liable. Take the example of emissions from the public transport system in the city where I live, which I use sporadically. The emissions from the transport system could be attributed to me and my carbon footprint calculated to include the number of rides I take and how many emissions each of these creates. However, there are emissions that the overall system creates, such as the night buses that drive almost empty. They are an essential element of public transport provision. We could divide the amount of carbon emitted in proportion to the number and length of rides individuals take. But such a division would not correspond to the idea that I am liable for these emissions in the sense that I caused them and can be blamed for them causing harm. My emitting activities are mediated and constrained through structures, such as the public transport system. Rather, to account for these emissions and assign the responsibility to remove carbon, we need an account of shared responsibility. This 'shared responsibility is a personal responsibility for outcomes, or the risks of harmful outcomes, produced by a group of persons' (Young, 2006, p. 122). This responsibility falls on the individuals themselves and is shared with others in the group or collective.

In the case of the public transport system, the city's inhabitants can be held collectively responsible for removing carbon. But this is not the case with climate change, for which the collectives that could act are only weakly defined. Here, the responsibility is shared between the individuals that make up such weak collectives. In the case of climate change, potential collectives are the polluters, the able, and the young (Cripps, 2013, p. 59). Cripps argues that individuals who are part of these weak collectives have 'duties to attempt to bring about the necessary collective action' (2013, p. 140) This includes 'organiz[ing] as necessary to act on mitigation, adaptation and compensation' (2013, p. 197).

We can also argue that individuals acquire a shared responsibility to reduce emissions and, in addition, to remove them because of their participation in structures that contribute to climate change. In Iris Marion Young's model of responsibility, individuals who participate in structures that produce unjust outcomes have a shared political responsibility to change these structures to make their outcomes less unjust (2006, 2011). The concept includes both material structures such as highways and formal and informal rules-based structures that shape how individuals interact, such as social norms. Structures include transnational processes such as financialized capitalism that have both national and global effects on individuals. All these structures exist because people act and interact, producing and reproducing these structures unintentionally (Young & Nussbaum, 2011, pp. 53–55). Responsibility for the structural injustice that occurs is shared between individuals. Young's approach to responsibility for contributing to structural injustice has been applied to climate change in multiple ways, and arguments for climate change mitigation have appealed to Young's concept of social connection to assign a shared political responsibility to transform unjust structures (Godoy, 2017; Larrère, 2018; Sardo, 2020). Here, climate change is conceptualized as a structural injustice to which individuals contribute through their emissions. Based on this, individuals should 'join with others … to transform the structural processes to make their outcomes less unjust' (Young, 2006, p. 96).

What does this idea of shared responsibility imply for carbon removal? We can use Young's approach to justify why we hold individuals responsible for removing carbon emitted by structures: Individuals can be ascribed a responsibility to remove carbon because it is the product of the structures in which the individuals participate. The outcome of these structures is unjust because carbon contributes to climate change. The responsibility to remove carbon is shared between the individuals who participate in these structures. Importantly, Young's appeal for the transformation of processes that produce unjust outcomes does not depend on a backward-looking idea of having to account for the carbon emitted. It is a forward-looking responsibility that requires collective action targeting the structures that produce unjust outcomes. I share the responsibility to remove the carbon emitted by the transport system in which I participate with all other passengers. The removal requires collective action, because no individual alone can bring about the scaling-up of CDR technologies needed.

Using Cripps's approach, it could be argued that individuals have a shared responsibility to remove carbon based on their belonging to one or several of the weak collectives relevant for climate mitigation. The responsibility to remove carbon could be justified differently for the three weak collectives: The polluters may have a responsibility to remove the carbon they emitted because they are 'required to act together … in compliance with a collectivized no-harm principle' (Cripps, 2013, p. 197) or to clean up their mess (Shue, 2017b, p. 593). The able 'have a duty to organize to act collectively on mitigation and adaptation, defended by appeal to a moderate version of the collectivized principle of beneficence' (Cripps, 2013, p. 197). Having the possibility to remove carbon that cannot be attributed to individuals, the able may be responsible for doing so. Finally, the young may also have a self-interested responsibility to remove carbon to complement other efforts to mitigate climate change.

Thus, both approaches can provide arguments why individuals have a shared responsibility to remove the carbon for which no individual is directly responsible. Individuals have a shared political responsibility due to their membership in weak collectives that carry responsibilities for climate change mitigation or because they participate in structures that contribute to climate change. This may justify individuals undertaking collective efforts to remove carbon.[9] Yet, whichever of these approaches is applied to carbon removal, several challenges must be considered in the implementation of various CDR technologies, as I show in the next section.

Political responsibility for carbon removal

I have shown how Cripps's and Young's arguments can both be used to account for carbon in the atmosphere for which no individual is directly responsible and for which a shared responsibility arises to undertake collective action. In this section, I turn to how their accounts can be used to argue about how carbon should be removed. Unfortunately, some CDR technologies and scales of their implementation will come at an 'ethical cost' (Lenzi, 2021) by introducing negative side-effects and by distributing these side-effects unjustly.[10] We may hold individuals directly responsible for the harm caused by the negative side-effects of implementing CDR technologies. In addition, arguments are needed for how the risks, negative side-effects, and benefits of CDR technologies should be distributed. I show in this section that Young's and Cripps's accounts provide guidance for answering this question.

I first outline three challenges that the implementation of different CDR technologies may raise. I then turn to the question of how CDR technologies can be part of a fair, effective, and efficient climate policy in Cripps's understanding (2021) or a transformation of structural processes towards less unjust ones in Young's understanding (2011). As both Young and Cripps argue, bringing about such policies is a shared political responsibility of individuals.

The first challenge is posed by the negative side-effects and risks that CDR technologies may introduce. Importantly, these vary between the CDR technologies and how they are implemented, and increase with the scale at which CDR technologies are implemented. For example, for afforestation, side-effects such as water use and impact on biodiversity depend on the region and tree species planted (Doelman et al., 2020; Fuss et al., 2018). Overall, large-scale afforestation projects and the mass plantation of biomass for BECCS pose risks to food security because arable land is no longer available for food production (Doelman et al., 2020; IPCC, 2018; Kortetmäki & Oksanen, 2023). In contrast, DACCS requires not land but energy (Fuhrman et al., 2021). The large-scale deployment of BECCS could infringe on human rights to food, water, and a healthy environment. Similarly, DACCS could entail significant risks for the human right to energy (Günther & Ekardt, 2022). Further, both BECCS and DACCS entail storing the captured carbon in geological storage spaces underground for long-term sequestration. However, the discussion on carbon capture and storage (CCS) shows that there are long-term risks with geological sequestration: underground injection of CO_2 can increase local seismicity and contaminate groundwater and needs long-term containment to be secure (Bui et al., 2018).

Second, the fairness of implementing some CDR technologies at large scales may be challenged, given the side-effects and risks potentially introduced. For example, vulnerable people may be forced off their land so that biomass for BECCS can be grown (Blomfield, 2021), as is already occurring in cases of afforestation (Michaelowa et al., 2019). Threatening food security in certain regions through large-scale BECCS or afforestation projects raises food justice concerns (Kortetmäki & Oksanen, 2023). If large-scale BECCS and DACCS put human rights at risk (Günther & Ekardt, 2022), they may cause injustices as forms of oppression and domination that constrain a large group of people's opportunities for self-development and self-determination (Young, 1990). The side-effects and new risks introduced remain problematic and are potentially unjust, as the parties suffering them have not agreed to bear these costs (Shue, 2021; Wallimann-Helmer, 2021). Further, the distribution of these risks and negative side-effects is unjust, for example if implementing afforestation and BECCS at large scales would put countries of the Global South at a risk disproportionate to their contribution to climate change (Morrow et al., 2020). Other concerns echo injustices related to climate change, such as shifting the burden of reducing emissions and the overall risks of implementing large-scale CDR technologies to future generations (Heyward, 2014; Shue, 2017a), even if these generations will have benefitted from these measures (Shue, 2021, p. 48).[11]

Third, other fairness challenges arise in relation to access to and distribution of benefits from BECCS and DACCS, which involve the geological sequestration of carbon. Large fossil fuel companies are very likely to benefit from being able to store captured carbon because the infrastructure and knowledge required for this activity are similar to those needed for the extraction of carbon (Hastings & Smith, 2020; Shue, 2021). As carbon majors carry historical responsibilities, this creates a moral dilemma about the extent to which they can permissibly benefit from removing carbon (Lenzi et al., under review). Further, concerns have been raised that CDR technologies are being used to save assets rather than to mitigate climate change (Shue, 2021, p. 95). If these technologies perpetuate the current fossil energy system, they are not an effective policy for mitigating climate change.

Given these challenges, one may argue that neither Young's nor Cripps's account of shared political responsibility includes carbon removal. If CDR technologies could only be implemented in unfair, ineffective, and inefficient climate change policy, individuals would not have a political responsibility to promote them, on Cripps's account. The question is what kind of policies individuals have a responsibility to support. Importantly, the ethical costs vary depending on which and how CDR technologies are implemented, the accompanying measures, and the quantities of carbon to be removed. Policies for implementing CDR technologies could address injustice by providing co-benefits such as energy from BECCS, increased soil fertility from biochar, and protection of coastal ecosystems from mangroves (Fuss et al., 2018). Policies could also be targeted to support poorer regions, for example by funding the exploration of their potential for geological carbon storage for DACCS and BECCS (Mintz-Woo & Lane, 2021). One way of acting against carbon majors profiting from BECCS and DACCS unjustly is to tax the gains these corporations make from trading in carbon removal at higher rates (Lenzi et al., under review).

The use of CDR technologies may feature in several policy responses that pursue a 'minimal' account of justice (Lenzi, 2021, p. 6). By removing emissions until they can be mitigated, CDR technologies may play an important part in the energy transition, especially BECCS (Azevedo et al., 2021, p. 3; Sovacool et al., 2023). In theory, carbon removal could ameliorate intergenerational justice by reducing the burden of emissions of past and present generations on future generations. By placing responsibility on those who have emitted excessively in the past, carbon removal could reduce the injustices between countries that have high past emissions and those that do not but are impacted by climate change. Hence, carbon removal could contribute to policies that promote fairness and structural change.

Importantly, the ethical costs of CDR technologies also depend on 'the extent of deferred mitigation' (Lenzi, 2021, p. 5). The later emissions are reduced, the greater the pressure to scale up CDR technologies and the larger the scale required. Hence, policies that reduce emissions should precede or at least accompany implementing CDR technologies. However, measures to reduce emissions may also have important ethical costs, especially if implemented at large scale (Cox et al., 2018). They also pose the risk that negative side-effects are distributed in ways that reflect unjust social structures (Eckersley, 2016; Sardo, 2020). Hence, though individuals have responsibilities to both reduce emissions and remove carbon (as argued in section 2), the ethical cost of reducing emissions must be weighed against the ethical costs of implementing CDR technologies (AUTHOR b). Overall, ethical costs may be reduced by relying on a portfolio of different emission reduction measures and various CDR technologies, as this minimizes the risks associated with various technologies (Cox et al., 2018; Fuhrman et al., 2023; Minx et al., 2018).

In conclusion, individuals have a shared political responsibility to remove carbon and to ensure that, if carbon is removed, the ethical costs are minimized. Though various CDR technologies present different challenges, a shared political responsibility to promote fair, effective, and efficient climate policies and to transform structural processes to less unjust ones could include removing carbon. To this end, the implementation of CDR technologies will need to be accompanied by specific policies tailored to the challenges posed by the different technologies pose. Bringing these policies about requires political action by individuals.

The two responsibilities to remove carbon

I have argued for two responsibilities to remove carbon: a direct one and a shared political one. In this section, I address the relationship between the two responsibilities. First, I show how shared political responsibility is a condition for direct responsibility. Second, I argue that direct responsibility cannot be subsumed under shared political responsibility. Third, I reject the concern that the two responsibilities together are overdemanding.

First, imagine that the shared political responsibility to remove carbon is not fulfilled and ethical costs of carbon removal are high. The ethical costs of carbon removal can weaken the responsibility of individuals to remove emissions: If it is possible to remove emissions at ethical costs that are lower than the harm created by these emissions, individuals have a direct responsibility to do so. Conversely, if the ethical costs of carbon removal are higher than the harm remedied by emissions removed, individuals have no direct responsibility to remove them. Hence, a condition for individuals having a direct responsibility to remove carbon is that they fulfil their shared political responsibility to minimize the ethical costs of implementing CDR technologies. The question arises at what point the ethical costs of carbon removal outweigh individuals' direct responsibilities to remove carbon. Here, we enter the realm of non-ideal theory in trying to weigh the ethical costs of carbon removal against the ethical costs not doing so. A full answer to the question is beyond the scope of the paper. However, it is possible to remove carbon from the atmosphere by enhancing natural carbon sinks, for example through afforestation. Though large-scale afforestation also has an ethical cost, as mentioned above, it is bold to claim that removing carbon from the atmosphere always has higher ethical costs than not removing it.[12]

Second, the question arises whether, if individuals fulfil their shared political responsibility to remove carbon, purchasing carbon removal certificates is still among the responsibilities of individuals. Fulfilling the shared political responsibility may result in the political decision that the state will remove all emissions, including those for which individuals are directly responsible. However, this is not the case at present, and in addition, 'the promotional role of individual contributory cuts must be considered' (Cripps, 2021, p. 12). Demanding emission removals at the collective level but not being willing to cut one's own emissions may be criticized as a sign of hypocrisy and could potentially undermine efforts to promote collective action (Hourdequin, 2010; Schwenkenbecher, 2014). We may doubt that removing carbon 'can promote emissions cuts by others' in the same way as emission cuts (Cripps, 2021, p. 9). Carbon removal may have fewer impacts on others because it is not an activity visible in public life, such as taking the bike instead of the car, ordering vegetarian food, and buying vegan products in the supermarket. But take the example of Al Gore flying around the world to promote climate change mitigation policies, including policies for just implementation of CDR technologies. If the conditions for implementing CDR technologies at minimal ethical cost are ensured, individuals have a direct responsibility to remove the emissions for which they are liable. Hence, if Al Gore really cannot avoid the flight, he should remove his emissions and try to do so at the lowest ethical costs possible. Thus, the direct responsibility for carbon removal is not subsumed under the shared political responsibility.

Finally, some may fear that assigning individuals a responsibility to reduce their emissions will foster a focus on individual emissions and a loss of support for more structural changes; others may argue that demanding simultaneously that individuals minimize their carbon footprint and promote collective change could be exceeding 'the limits of reasonable demandingness' (Cripps, 2021, p. 8). These concerns cannot all be addressed here. But at a practical level, are funds and attention ineffectively directed if both responsibilities are assigned? I do not think this is necessarily the case, as each draws on different resources. Put simply, carbon can be removed by paying money, whereas political engagement may predominantly require time and effort. In the case of carbon removal, both responsibilities fall on the individual.

Conclusion

Overall, I have argued for two responsibilities for carbon removal. First, I argued that individuals have a responsibility to reduce their carbon footprint to zero by removing emissions through CDR technologies. Second, individuals have a shared political responsibility to ensure that carbon is removed for which no individual holds any direct responsibility. Thus, both direct responsibility and shared political responsibility justify why individuals should remove carbon: either because they are liable for the harm caused by their emissions or because they share with others the responsibility for removing harmful carbon. Third, the shared political responsibility also relates to how carbon should be removed. Individuals have a shared political responsibility to minimize the ethical costs of implementing various CDR technologies. This requires political action.

Climate change policy has to acknowledge that its justice implications go beyond its effects on the climate and extend to current global injustices. The case of CDR technologies highlights both this need and the need to include the responsibility of individuals. We need to theorize how the implementation of different CDR technologies is linked to unjust structures, which means going beyond the simple view of carbon removal as contributing to justice by mitigating climate change. Although my arguments here are specific to the use of CDR technologies, they may have wider implications for conceptualizing individuals' climate change responsibilities.

Acknowledgements

I received many helpful comments on this paper and its earlier drafts. I thank Joseph Conrad, Elizabeth Cripps, Grace Garland, Clare Heyward, Tristan Katz, Dominic Lenzi, Simon Milligan, Rebecca Richards, Henry Shue, Lukas Sparenborg, Kathrin von Allmen, Ivo Wallimann-Helmer, and two anonymous reviewers for engaging with it. I thank the participants of the Political Theory Research Group at the University of Edinburgh, the Environmental Humanities Colloquium at the University of Fribourg, the MANCEPT 2022 Workshop, the ESDiT Conference in Leiden, and the Work-In-Progress Workshop at the philosophy department of the Arctic University of Norway for their questions and comments.

Notes

1. In this paper, I use the term 'carbon' as short for 'carbon dioxide'; I use the term 'emissions' as short for 'carbon dioxide emissions'; and when I write that individuals should remove their emissions, I mean that they should remove the same amount of carbon dioxide as they emitted, not the same molecules of carbon dioxide.
2. If more emissions were removed than emitted, the emissions from this trip would be net negative. This possibility of doing good by removing more carbon than one has emitted could be theorized further from a moral perspective. But because avoiding harm usually takes precedence over doing good, I will focus here on avoiding harm and achieving net-zero emissions.
3. I focus on afforestation, BECCS and DACCS. These three technologies are the ones most widely researched and argued to have the greatest potential (Sovacool et al., 2023).
4. For Young, both the standard frameworks of both moral and legal responsibility are based on the 'liability model', relying on causal contribution and blame. In the following, 'liability' is used as a term of art referring to moral liability, not legal liability (Young & Nussbaum, 2011, pp. 97–98).
5. Various concerns and challenges exist regarding the accounting for carbon removal (Brander et al., 2021). For the purpose of my argument here, I assume we can account for carbon emissions and their removal.
6. Alternatively, Barry & Cullity distinguish 'offsetting by sequestering' and 'offsetting by forestalling' (Barry & Cullity, 2022, p. 354). I focus here on 'offsetting by sequestering'.
7. Broome (2018) revised his arguments, moving away from this linear presentation, but still argues that individual contributions make a difference to climate-change-related harm.
8. I rely here on the argument Cripps (2021) provides for the demandingness of emission reductions for individual.

9. One may object that carbon removal does not require collective action. If I am very rich, I may simply pay a lot of money and remove a lot of emissions, which does not require any collective action. However, collective efforts are needed to scale up CDR technologies. This cannot be achieved by individuals alone. In the introduction, I have related the scale up of CDR to the action of states that set net-zero targets, but if we drop this assumption it may be up to individuals to push their governments to take the steps needed to reach these targets.
10. Assessing which CDR technology is less ethically costly than another is beyond the scope of this paper.
11. The focus here is on risks created through the implementation of CDR. This is different from the risk of reduced efforts to mitigate emissions due to the assumption that emissions can be removed with CDR (Lenzi, 2018; Shue, 2017a).
12. I speak here about the removal of emissions could not be avoided. It is not about balancing the removal of emissions with the possibility of making efforts to reduce emissions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributor

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8. Food security and the moral differences between climate mitigation and geoengineering: the case of biofuels and BECCS

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Abstract

Both biofuels and BECCS serve the purpose of reducing the concentration of carbon in the atmosphere, biofuels by reducing the quantity of CO_2 newly added and BECCS by removing the CO_2 already emitted. Both rely on the large-scale growth of biomass and hence compete with food production for arable land. Consequently, the implementation of both at large scales potentially endangers food security. Given this conflict and the need for climate action, this paper discusses whether there are differences between the ethical implications of mitigation by biofuels and geoengineering with BECCS. We apply a principlist approach, specifying and weighting four key principles of climate ethics: the polluter-pays principle, the ability-to-pay principle, the equal-per-capita principle, and the procedural involvement principle. Because the ethical and practical implications of BECCS and biofuels have many parallels, applying these four principles identifies relevant moral differences to decide between these two technologies.

Keywords: biofuels, BECCS, principlism, polluter-pays principle, procedural justice

Introduction

Reaching the goal of the Paris Agreement to keep global mean temperature well below 2 °C above pre-industrial levels, requires steep reductions in carbon emissions while ensuring enough energy for economic development. Because of this, biofuels become an important part of the menu of renewable energy transitions (Fulton *et al.*, 2015). At the same time, most modelling scenarios for keeping the global mean temperature increase to 1.5 °C above pre-industrial levels assume the large-scale availability of geoengineering technologies to remove carbon from the atmosphere (Fuss *et al.,* 2018). To this goal, the use of bioenergy with carbon capture and storage (BECCS) is assumed most often (IPCC, 2018; Minx *et al.*, 2017). BECCS removes carbon from the air and stores it permanently underground. This is done by binding carbon in large plantations of biomass that is then combusted for energy production. The carbon produced in this process is captured and liquefied, and later stored by using parts of this energy (Bui *et al.*, 2018).

The large-scale planting of biomass is also necessary when scaling up the production and use of biofuels to reduce emissions in order to meet the 1.5 °C target from the Paris Agreement. However, if industrialized countries grow this biomass for BECCS and biofuels themselves, they tend to increase their imports of grain, rice, and other staple foods, which can increase global food prices. In consequence, implementing both these technologies at large scale may well endanger food security in the poorest regions of the world (Kortetmäki and Oksanen, 2016; Renzaho *et al.*, 2017).

In this paper, we compare the ethical implications of biofuels and BECCS in light of the risks they pose to food security. To assess their ethical implications, we apply a principlist approach by specifying and weighting four key principles of climate ethics we explain in more detail below (Gardiner *et al.*, 2010): the polluter-pays principle (PPP), the ability-to-pay principle (APP), the equal-per-capita

EurSafe 2021 – DOI 10.3920/978-90-8686-915-2_8, © Wageningen Academic Publishers 2021

principle (EpC), and the procedural-involvement principle (PIP), also sometimes called procedural justice. Because the ethical and practical implications of biofuels and BECCS have many parallels, the application of these four principles will indicate moral parallels and differences between the two strategies. We argue that the main difference between the two lies in the specification of the PPP, because biofuels can bring the burdens of climate action closer to the polluting parties, whilst deploying BECCS allows historical emissions to be taken into account. However, we argue that which of these specifications of the PPP should be prioritized must be decided by involving all those concerned most directly and hence means relying on the PIP.

A disturbing conflict of goals

The starting point of our investigation is the challenge that the target of the Paris Agreement to reduce the negative impacts of climate change for the poorest regions of the world may demand measures that threaten the livelihoods of these very same regions. In the following, we first explain why climate protection is important to ensure food security in poor regions of the world. We then investigate in more detail the similarities and differences between biofuels and BECCS that are relevant for our ethical analysis.

In the poorest regions of the world, many people directly depend on agricultural food production for their livelihood. For the agricultural sector, dangerous climate change results in significant changes in the distribution of rainfall, longer droughts, and extreme weather events such as flooding and heavy rainfall. Hence, climate protection becomes a key factor to foster food security in these regions (Myers *et al.*, 2017). Even though some adaptation to changing climatic conditions is possible in the agricultural sector, at some point, the transformation of traditional ways of livelihood may become necessary. If these transformations mean leaving ancestral lands, such transformational adaptation may increase the risk of poverty and hunger (Preston *et al.*, 2013). Hence, keeping the current climate as stable as possible significantly contributes to food security in these regions of the world. Both biofuels and BECCS can support this goal.

The way we will consider biofuels and BECCS here, both require the large-scale plantation of biomass. In the case of biofuels, such as biodiesel or bioethanol, this biomass is processed into energy. In the case of BECCS, biomass is also processed into energy but the carbon released in this process is captured, liquified (using some of the energy released in the process of burning it) and stored in geological formations (Bui *et al.*, 2018). The plantation of biomass is most efficient if agricultural land is used for this purpose, as transforming other areas into farmland results in emissions and loss of natural carbon sinks (Field *et al.*, 2020). In terms of infrastructure, BECCS and biofuels may be combined (Field *et al.*, 2020). Biofuels demand facilities and energy for their production, and they must be transported and stored until they are used (Fulton *et al.*, 2015). Likewise, BECCS involves facilities for producing energy to capture and liquefy carbon, but additionally also for transporting the liquefied carbon and storing it. This storage of carbon is the main difference between two the technologies: BECCS removes carbon from the atmosphere whereas biofuels do not. Instead, biofuels mitigate emissions by displacing fossil fuels (Field *et al.*, 2020).

Because both technologies require the growth of vast quantities of biomass, both tend to threaten food security in poor regions of the world. Studies indicate that an important consequence of planting of biomass at large scale will be a massive increase in grain, rice and staple food prices on the global market, to the disadvantage of poorer regions of the world (Brinkman *et al.*, 2020; Hasegawa *et al.*, 2018). Thus, it is necessary to balance food security with implementing biofuels and BECCS at the scale assumed in climate models for avoiding dangerous climate change. To do so is challenging and both technologies are not easily differentiated in an ethical evaluation. In the next two sections, we apply a principlist approach to analyse the ethical conflicts presented.

Specifying principles to understand the conflict of goals

The methodology suggested to analyse the conflict of goals identified in the last section is principlism, well known from medical practice and ethics. Principlism assumes that for a given practice there exists a core set of principles that need to be specified and weighted differently depending on the moral issue at stake (Beauchamp and Childress, 2009). Whereas the core principles are well established in medical ethics, such core principles have not yet been defined for environmental issues. For the purpose of this investigation, we assume that they are the core principles of climate ethics and the principle of procedural involvement as explained in Wallimann-Helmer (2019): the polluter-pays principle (PPP), the ability-to-pay principle (APP), the equal-per-capita principle (EpC), and the procedural-involvement principle (PIP). In the following, we specify each principle for the given case before proposing a weighting of them and offering concluding remarks.

Specifying the polluter-pays principle

The PPP is usually understood as assigning responsibilities for climate action in proportion to contributions to anthropogenic climate change. Parties emitting more greenhouse gases should shoulder heavier burdens in avoiding dangerous climate change. In a variant, this principle also concerns those who benefit proportionally more from the emissions of others. Historical emissions are relevant here because current welfare most probably depends on emissions made in the past. Both biofuels and BECCS can make proportional contributions to climate protection. The more someone contributes or has contributed to anthropogenic climate change, the more they should reduce their production of emissions or remove emissions from the air.

However, the PPP identifies two crucial differences between these technologies. First, BECCS demand centralized facilities for producing energy and liquefying carbon from the biomass grown nearby. Storing liquefied carbon requires a transportation infrastructure (e.g. pipelines) and appropriate geological sites (Bui *et al.*, 2018). Although biofuels must be produced and stored in centralized facilities as well, their negative impacts will most probably be more decentralized. To lower transportation costs, biofuels most probably will be produced geographically closer to those who emit and hence bring negative impacts closer to those contributing more to climate change. This is not the case for BECCS, whose scale effects may favour large facilities, especially for storage. Second, biofuels only possess the potential to reduce currently produced carbon because the carbon they capture will be released again once they are burnt for energy production. By contrast, BECCS capture whatever quantity of carbon from the atmosphere that is processed by facilities. This also enables the capture and storage of high emissions produced in the historical past.

According to our specification, the PPP clearly assesses the potential negative impacts of both biofuels and BECCS on food security as an injustice. The poorest regions of the world did not contribute the most to climate change but most probably have negative impacts on their food security. Consequently, the PPP requires that the implementation of both biofuels and BECCS is realized in a way that minimizes their negative impacts on the poorest regions of the world. Beyond this, the PPP remains rather neutral regarding a choice between biofuels or BECCS. Biofuels allow negative impacts to be more closely aligned with individual pollution. By contrast, BECCS has the advantage of accounting for all emissions, both those currently produced and those in the past. Hence, it is difficult to fully dismiss one of the two technologies from the perspective of the PPP.

Specifying the ability-to-pay principle

Most commonly, the APP does not assign responsibilities for climate action in proportion to current and past contributions to climate change but relies on agents' capacities. Those more capable of remedying environmental threats are ascribed heavier burdens for acting. Parties commanding more financial resources or better expertise are seen as having a duty to take the lead and assist those less well equipped. The APP entails a crucial further implication: Demanding action from those not able to act is considered illegitimate. Only those capable of acting can be ascribed responsibilities.

In our context this means that those parties financially and technologically able to foster research on biofuels and BECCS and to implement these technologies must take the lead. They are responsible for providing the finance, technology, and managerial skills for their implementation where needed and possible. Hence, the APP differentiates between those parties with financial capacities and those with the skills necessary to implement these two technologies. These skills might further differentiate responsibilities because they might not be equally distributed between the technologies. Because biomass must be planted where it can grow and liquefied carbon must be stored in appropriate sites, the APP may also be interpreted as defining where biomass should be grown and BECCS should be realized.

However, the APP has an important limitation when applied to both BECCS and biofuels: with the APP, tropical regions might have a duty to make land available to grow biomass if this is more efficient than growing it in colder climates. But arguments like these do not reflect any differences in the economic and social conditions of those affected by the implementation of these technologies. This is problematic if the negative impacts of their implementation worsen conditions that are already poor. However, realizing such facilities might also be of advantage for these regions because these technologies may also mean economic gain for those involved. If economic gain can outweigh the negative impacts on food security, implementing plantations and facilities might be justifiable.

Specifying the equal-per-capita principle

In its classical interpretation, the EpC assigns rights to equal quantities of emissions to all human beings. This quantity is usually calculated from an emissions budget like the one defined by the climate target of the Paris Agreement. An entitlement to an equal quantity of emissions is usually justified by two arguments. First, no morally relevant differences exist between human beings regarding emission entitlements. Second, if this is the case then the only pattern of distribution that requires no justification is an equal distribution. However, if there are legitimate reasons to distribute unequally, such as the need to heat or the limited availability of low-carbon technology, then unequal distributions of emission entitlements might be justified.

The promise of biofuels is to produce similar amounts of energy like fossil fuels while releasing less carbon. This entitlement to an equal amount of energy seems relevant when specifying the EpC to decide between the two technologies. While biofuels reduce emissions released in energy production, BECCS delivers less energy and removes fossil emissions from the atmosphere. Deciding which technology is more closely in line with the EpC depends strongly on technological details and on the degree to which emissions of energy production can be balanced. The more energy that can be produced with a technology, the more favourable this technology becomes. In consequence, the decision depends on the degree to which each technology can help reduce emissions while at the same time ensure a high level of equal amounts of energy for all.

The EpC sheds some critical light on the consequences of biofuels and BECCS for food security. As a principle that defines rights to equal entitlements, the EpC demands food security for all to an equal degree. In whatever way such equality of food security is defined, deviation from it would have to be justified. Because human beings do not seem to differ in their need for food security, such inequalities can hardly be justified. Thus, unequal distribution of the negative impacts of biofuels and BECCS on food security need to be avoided unless they can be justified. Many egalitarians argue that an important exception to equal distribution is voluntary choice. This would be the case, for example, if regions accepted biomass plantations in exchange for economic advantages.

Specifying the procedural-involvement principle

The procedural involvement on fair terms of all affected demands that environmental policy decisions are taken in a collective endeavour. This principle, more common in empirical environmental justice literatures, demands collective decision-making because not all environmental questions are strictly speaking questions of fair distribution. Important examples include the evaluation of risks and compensatory measures for climate loss and damage. In both cases, it can be argued that assessment is only legitimate if it is achieved by involving those who have morally relevant interests at stake (Wallimann-Helmer, 2015).

Biofuels and BECCS both involve negative impacts that might require compensation for unfair disadvantages. This is the case if the unequal distribution of their negative impacts cannot be justified. In such cases, those facing negative impacts have to be involved in decision-making under fair conditions to decide what compensation is appropriate for the unfairness faced. Because biofuels and BECCS might also have economic advantages for those living near these facilities, such processes might also legitimize unfairly heavier burdening. However, one of the most serious challenges is to ensure appropriate recognition of indigenous peoples, ethnic minorities, and other marginalized social groups in such decisions.

Special emphasis must be given to the food security of indigenous peoples and more generally to poor communities and regions of the world. Not only is their livelihood endangered due to climate change; there is also a high risk that their voices will not be heard when it comes to the threats to their food security. Hence, to ensure food security for the poor, it will be of key importance to involve these peoples and communities in decision-making about the implementation of biofuels and BECCS and to ensure appropriate recognition.

Weighting principles to decide the conflict of goals and concluding remarks

According to the principlist approach of Beauchamp and Childress, once principles are specified, they need to be weighted to decide the given case. Principlism assumes that the principles building the core set of ethical principles in a given practice have no predefined hierarchy. The hierarchy of principles might differ by case and context. However, once a hierarchy of principles has been established, it justifies a decision. The principle or the principles that are at the top of this hierarchy decide the ethical conflict at scrutiny. What action these principles demand in a given context is the morally right thing to do.

Following our analysis, we deem the PIP to be the most important principle when comparing biofuels and BECCS. The reason for this is that the specifics of the efficiency and negative side-effects of biofuels and BECCS are both still to be determined, which makes it difficult to identify exactly which technology the other three principles would propose. Under such conditions, we believe that it is most important to involve those who are most directly affected by the large-scale implementation of biofuel and BECCS facilities in deciding how to prioritize them.

We take the PPP to be the second most important principle because it most clearly identifies the injustices in food security at stake. Those who have contributed the least to climate change will suffer the greatest threats to their food security. However, what the PPP recommends depends on how much weight is given to bringing the additional burdens of new technologies closer to those emitting, as is possible with biofuels, or to accounting for historical emissions, as BECCS allows.

We argue that both the APP and the EpC could serve as safeguards. The APP ensures that those disadvantaged are not carrying heavy burdens due to the implementation of both technologies, especially if their food security is endangered. Further context is needed to fully specify the EpC because its demands depend strongly on the technology used and its efficiency. However, the EpC demands that equal energy be ensured for all and thus that no one is left behind when implementing new technology for climate protection.

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Global Sustainability

cambridge.org/sus

Research Article

Cite this article: Lenzi D, Schübel H, Wallimann-Helmer I (2023). Justice in benefitting from carbon removal. *Global Sustainability* **6**, e22, 1–8. https://doi.org/10.1017/sus.2023.22

Received: 7 March 2022
Revised: 21 April 2023
Accepted: 27 September 2023

Keywords:
adaptation and mitigation; policies; politics and governance

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Justice in benefitting from carbon removal

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Abstract

Non-Technical Summary. Climate stabilization requires scaling-up technologies to capture and store carbon. Carbon removal could be very profitable, and some of the agents best placed to benefit are 'carbon majors', i.e. fossil fuel companies. We argue that in ordinary circumstances only agents without significant historical climate responsibilities would be entitled to the full benefits from carbon removal. Under non-ideal conditions, carbon majors might be entitled to benefit, provided that no other agent could remove similar quantities of carbon at similar costs. This burden of proof is only likely to be met in countries with poor governance capacities.

Technical Summary. Climate stabilization requires scaling up technologies to capture and store carbon. Some of the agents best placed to profit from carbon removal are 'carbon majors', especially fossil fuel companies. Yet incentivizing carbon majors to undertake carbon removal poses an ethical dilemma: carbon majors have made significant historical contributions to climate change and have significantly benefitted from such contributions without being made to compensate for resulting climate harm. This is why it seems unfair to reward them with additional economic benefits. However, carbon majors possess the technological skills and infrastructure to upscale carbon removal efficiently. We argue that in ordinary circumstances, only agents without significant climate responsibilities would be morally entitled to fully benefit from carbon removal. Yet under non-ideal conditions, it might be permissible to reward carbon majors if no other agent were capable of removing as much carbon at similar costs and on similar timeframes. We believe this argument faces an imposing burden of proof that is only likely to be met in countries with poor governance capacities. In more favorable circumstances, including those of most OECD countries, rewarding carbon majors without having them pay for their historical climate responsibilities remains impermissible.

Social Media Summary. Rewarding carbon majors to undertake carbon dioxide removal is unjust due to their historical climate responsibilities. Where possible, governments should empower other agents to remove CO_2.

1. Introduction

In May 2021 in the case Milieudefensie (the Dutch branch of Friends of the Earth) *vs* Royal Dutch Shell, the District Court of the Hague found that the multinational corporation must reduce its CO_2 emissions by net 45% by 2030 (relative to its 2019 emissions) (Nollkaemper, 2021). Royal Dutch Shell is a 'carbon major', with emissions and complicity in producing emissions exceeding those of most countries. The term 'carbon major' refers to major producers of hydrocarbons, including coal, oil, and gas. A 2017 report by the Climate Accountability Institute (Griffin, 2017) found that 100 extant carbon majors have been linked to 71% of global GHG emissions since 1988. Stating that Shell's current policy and climate targets were violating a 'due standard of care', the court further noted that the corporation has significant historical responsibility for climate change (Giabardo, 2021). While this may signal greater legal accountability for carbon majors, the urgency of decarbonization also raises the uncomfortable prospect of rewarding carbon majors for removing atmospheric carbon if these agents are best placed to do so.

Given decades of climate policy failure, limiting warming to 'well below' 2 °C above pre-industrial levels in line with the Paris Agreement is likely to require large-scale use of carbon dioxide removal (CDR) technologies (IPCC 2022). Energy analysts have begun to speculate about a future market in captured and stored carbon to rival existing energy markets (Vivid Economics, 2020). We refer to this as the *carbon removal market*. Some of this speculation concerns revenues that might be drawn from using carbon capture and sequestration (CCS) technology, which is a component of several CDR methods, such as direct air capture (DACCS) and bioenergy with CCS (BECCS). Such a market would likely be backed by public financing and favorable regulatory conditions. And at present, carbon majors look set to be leading beneficiaries. Shell is involved in one of the European Union's major carbon storage projects (the Northern Lights Project) (European Commission, 2021) while ExxonMobil is

https://doi.org/10.1017/sus.2023.22 Published online by Cambridge University Press

asking the US Congress for subsidies to kick-start its carbon removal business (Lefebvre, 2021). In May 2021, Shell and ExxonMobile were granted $2.4 billion in subsidies by the Dutch government for carbon sequestration and storage projects (Meijer, 2021).

In this paper, we analyze the ethical implications of a carbon removal market in CDR, from which carbon majors stand to be leading beneficiaries. We will focus primarily on BECCS and DACCS, since these are the CDR techniques involving CCS that carbon majors possess the technical capabilities to undertake. We note that CCS can be used without achieving CDR, such as when it is fitted to existing fossil infrastructure to render it carbon neutral. However, we do not discuss CCS as a stand-alone technology nor the ethical implications of its use. We first introduce the dilemma of benefitting carbon majors by providing insights into the kind and scale of benefits that can be earned. Section 3 focuses on the first horn of the dilemma, arguing that benefitting from carbon removal is unjust under conditions applicable to carbon majors. Section 4 argues that the second horn of the dilemma may be resisted since it requires showing that it is necessary to allow carbon majors to benefit from CDR to secure a stable climate. As we show, this claim only appears plausible in circumstances that do not apply to most OECD countries. We conclude by suggesting ways to balance the need to incentivize carbon removal without canceling out historical climate responsibilities.

2. The dilemma of benefitting carbon majors

While the possibility of benefitting from emission reductions has long existed, the promise of benefitting from carbon dioxide removal has only emerged in the last few years. Carbon removal is increasingly prominent in national and private sector commitments to net zero emissions (Honegger et al., 2017; Lenzi et al., 2021). In most cases, carbon dioxide removal will be very costly (Fuss et al., 2018). For example, bioenergy with carbon capture and storage (BECCS) is estimated to cost $100–200 per ton of CO_2, while direct air capture with carbon capture and storage (DACCS) is estimated at $600–1000 per ton for early plants, with costs potentially falling to $100–300 as more facilities are built (Fuss et al., 2018, figures quoted in US dollars).

A carbon removal market could provide significant new revenues if appropriate state incentives and regulations were made available. A study by Vivid Economics (2020) estimated that such a market could present a trillion-dollar investment opportunity that may eventually rival the current oil and gas sector. This study estimates that 'nature-based' CDR, primarily afforestation and reforestation, could provide $190 billion annually by 2050, while 'avoided deforestation' could provide as much as $610 billion annually by 2050. BECCS and DACCS could provide as much as $625 billion annually by 2050. In the US context, tax credits for biofuel generation may turn BECCS into a profit-generating opportunity (Ryan, 2018), whereas a regime to pay farmers to sequester carbon in soil is currently being considered (Colman et al., 2021).

Some of the world's largest corporations are already investing in CDR, and in CCS as a component of CDR strategies. For instance, Microsoft has announced a $1 billion climate innovation fund to develop CDR and CCS technologies, aiming to become 'carbon negative' by 2030 and to remove all carbon directly or indirectly emitted since its foundation in 1975 (Smith, 2020). Large oil and gas companies are also investing in carbon dioxide removal to reduce their carbon footprints. ExxonMobile has invested $3 billion in CCS projects over the next five years, estimating that the market for carbon capture will be roughly $2 trillion by 2040 (Eberhart, 2021). From these considerations, it appears that CDR is becoming an attractive investment for carbon majors.

Carbon majors already possess CCS infrastructure, which is necessary for prominent forms of CDR. At present, the technical capacities and the knowledge to do CCS, and thus CCS-dependent forms of CDR in the future, are largely limited to companies which produce fossil energy, i.e. carbon majors. This is due to large similarities in technology and infrastructure between oil extraction and carbon sequestration and storage (Hastings & Smith, 2020). As such, these companies seem to be key for the development and scaling up of prominent CDR techniques such as BECCS and DACCS. The EU 'Northern Lights' CCS project is a partnership with fossil fuel companies Equinor, Shell, and Total (Global CCS Institute, 2020). Likewise, the UK's 'Acorn' CCS project is being carried out by Pale Blue Dot Energy, in partnership with Harbour Energy and Shell, and with funding from the EU and the UK (Pale Blue Dot Energy, 2021). We note that other authors (e.g. Moss, 2020) include cement producers under this category because they also contribute a large amount of yearly carbon emissions. However, the dilemma we discuss applies only to fossil fuel companies, because they already possess CCS infrastructure.

If CDR is to be incentivized through market mechanisms, as many analysts suppose, the prospect of economic gains appears necessary. Since many CDR facilities, especially DACCS, are in the early stages of commercialization and face high costs (Fasihi et al., 2019), a major concern is whether the gains received from a future carbon removal market will be sufficient to incentivize investments. However, it seems morally problematic that those who are best placed to profit from an emerging carbon removal market have profited significantly from the sale of vast quantities of fossil fuels, the key driver of anthropogenic climate change. While carbon majors do not bear the sole responsibility for the harm created by climate change, their supply of a primary driver of climate change, and their profits from doing so, appear to be morally relevant when considering future economic rewards from doing CDR.

Despite these facts about carbon majors and the distribution of capacities, not engaging in CDR likely leads to dangerous climate change given the reliance upon these technologies in most temperature stabilization pathways (IPCC, 2018, 2022). Since carbon majors already possess the necessary technology for future CDR implementation, it is likely that they could render these technologies viable within shorter timeframes and on larger scales than other agents. If so, carbon majors could be key to avoiding morally unacceptable climate harms and could contribute significantly to the global public good of a stable climate system in line with the Paris Agreement.

These considerations lead to what we call the 'dilemma of benefitting carbon majors'. The first horn of this dilemma concerns the unfairness of allowing carbon majors to benefit from the carbon removal market. This seems compelling for two reasons: first carbon majors should be made to pay for their contribution to climate change and second, they should also be made to pay for any unjust benefits they have gained and continue to gain from such contributions. Thus, it appears fair that some or all of the revenue that carbon majors draw from carbon dioxide removal should be withheld. As we show in Section 3, this

Table 1. Different benefits, their benefit-generating action, and the criterion to assess injustice

	Category	Benefit	Action generating benefit	Criterion for assessing injustice
a	Benefitting from contributing to climate change	Economic gains from producing or using fossil energy	Selling or utilizing a key source of anthropogenic climate change	Proportional contribution to negative climate impacts, or benefit from supplying others' contributions
b	Benefitting from favorable changes in climatic conditions	Economic gains from favorable market conditions due to changing climatic conditions	Conducting business under favorable climatic conditions	Proportional benefits attributable to changes in climatic conditions
c	Benefitting from climate change mitigation policies (limited to the carbon removal market)	Economic gains from employing CDR	Implementation of CDR; providing technical knowledge or infrastructure for CDR	If reason for access to CDR technologies is benefit (a)

argument follows from formulations of the polluter pays principle that are interlinked with the beneficiary pays principle (Heyward, 2021).

However, this leads us to the second horn of the dilemma, which concerns the moral permissibility of providing economic incentives to achieve a desirable public good. Most plausible moral views hold that there is a moral imperative to limit climate change to 'well below' 2 °C, in line with the Paris Agreement. Given the necessity of not only reducing emissions but also removing atmospheric CO_2, decreasing incentives to undertake CDR may reduce the likelihood of stabilizing the global climate. Yet carbon majors appear to be uniquely well-placed to undertake CDR if economic incentives were available. Because failing to stabilize the global climate would create very serious injustices, it seems permissible to reward the agents able to scale up CDR as rapidly as possible.

The prospect of a carbon removal market dominated by carbon majors thus raises questions about the fairness of benefits drawn from CDR. This situation appears to have the structure of a moral dilemma because choosing either option seems to mean choosing to do injustice: either allowing carbon majors to unfairly benefit to do as much CDR as is feasible or preventing such benefits yet undermining climate stabilization. To clarify this situation, we need to understand the conditions under which incentives for contributing to climate stabilization are morally justified. In the next section, we categorize the three unjust benefits of climate change and the carbon removal market and then turn to the challenges of morally justifying incentives to undertake CDR.

3. Benefitting from climate change and from a carbon removal market

This section deals with the first horn of the dilemma of benefitting carbon majors. It argues that benefitting from CDR is unjust under certain conditions and that such conditions apply to carbon majors.

First, a note about how we understand benefits. Benefits from the carbon removal market can be obtained by providing knowledge (e.g. of how carbon can be captured and stored) and infrastructure (e.g. for transport and storage of carbon). Benefits may be gained through the development and selling of CDR technology to remove, liquefy, and transport carbon; by providing infrastructure and technologies for capturing and transporting carbon; and by providing storage locations (Hastings & Smith, 2020). Most importantly, benefits will be gained through the removal and storage of carbon on behalf of enterprises or states, e.g., through the purchase of carbon credits because they either voluntarily decided to reduce their carbon footprint or were legally obliged to do so.

While the climate ethics literature has primarily focused on the negative impacts of climate change and the fair sharing of burdens for their minimization, prevention, and compensation (cf. Gardiner et al., 2010; Hayward, 2012; Page 2008; Wallimann-Helmer, 2019), potential benefits from contributing to emissions reduction have been comparatively neglected. Normative literature on benefitting and climate change focuses on the Beneficiary Pays Principle (BPP), which holds that those who benefit from climate change have proportionally greater responsibilities for climate action (Heyward, 2014; Page, 2012). The BPP is most often understood not to be independent from historical contributions and therefore draws some of its normative force from the Polluter Pays Principle (PPP) (García-Portela, 2023; Heyward, 2014).

Nonetheless, previous discussions of the BPP only capture some of the concerns raised by the benefitting carbon major's dilemma. On the basis of an expanded understanding of the BPP, we argue that it would be just for agents without large historical climate responsibilities to benefit from removed and stored carbon. On the basis of the PPP, we argue that it would be unjust for agents with large historical responsibilities to benefit.

To justify these claims, we outline three categories for assessing benefits in the context of climate change (see Table 1): (a) benefits gained by contributing to climate change; (b) benefits gained due to favorable changes in climatic conditions; and (c) benefits gained from climate change mitigation policies. We include CDR under the broader category of climate change mitigation policies, following the IPCC's recent reclassification of it as a form of mitigation (Babiker et al., 2022). CDR had previously been classified as 'geoengineering' (Edenhofer et al., 2014, 60) Our discussion concerns benefit (c), although we focus on benefits derived from CDR. For each category, we suggest conditions under which benefitting would be unjust.

(a) Unjustly benefitting from contributing to climate change: Benefits obtained from contributing to climate change can be deemed unjust because these actions contribute to morally serious forms of harm (Butt, 2009; Goodin, 2013; Heyward, 2014). According to the PPP, there is a duty to support climate action in proportion to one's current or historical emissions (Caney, 2005; Meyer & Roser, 2010; Neumayer, 2000; Shue, 1999). Similarly, the BPP places greater responsibility upon those

https://doi.org/10.1017/sus.2023.22 Published online by Cambridge University Press

who have benefitted more from actions that contributed to climate change, even if they did not directly cause the emissions (Page, 2012). Under both the PPP and the BPP, carbon majors carry unaddressed historical responsibilities deemed unjust and both principles identify duties to correct for this situation (García-Portela, 2023; Heyward, 2021; Wallimann-Helmer, 2019). Most importantly, investing in CDR may allow carbon majors to become 'carbon neutral' while continuing to contribute to climate change or to benefit from actions contributing to it. Benefit (a) is highly relevant in the assessment of carbon majors, since as we will see shortly, it is the reason they stand to benefit from CDR.

(b) *Unjustly benefitting from favorable market conditions:* some benefits are not gained directly from activities contributing to climate change, but from adapting to new climatic conditions. Examples include growing wine in areas where it could not previously be grown or selling more air conditioners. Such actions fall under benefitting from injustice because they only become possible due to unjust climate harms (Butt, 2009; Goodin, 2013; Heyward, 2014). Although these conditions were not intentionally brought about, they happen as a consequence of changing climatic conditions jointly produced by all emitting parties. Voluntarily benefitting from these injustices can be argued to be a reason for carrying responsibilities toward those treated unjustly (Pasternak, 2014). Under the BPP, actions may generate the obligation to compensate even if the actions are not consensual or voluntary (Atkins, 2018). Where 'losers' of climate change are compensated by polluters, the entitlement of the 'winners' to benefits from climate change may depend on whether they result from a course of action or maintaining one's economic activities (Mintz-Woo & Leroux, 2021). Nonetheless, culpability is necessary for these benefits to be unjust. Heyward (2014) distinguishes culpable from non-culpable beneficiaries on the basis of being partly or fully responsible for the injustice or having no role in its occurrence. Agents who share culpability are under strict duties of remedial justice to surrender any benefits. The culpability condition of benefit (b) is also highly relevant for carbon majors since these agents have voluntarily contributed to climate change through the extraction and sale of fossil fuels, through ongoing lobbying for weaker climate change mitigation policies, and even through the dissemination of misinformation (Oreskes & Conway, 2010).

(c) *Unjustly benefitting from climate change mitigation policies:* Some benefits are not gained as the result of climate change, but specifically due to climate change mitigation policies. Such policies involve CDR which, in contrast to most economic activities, do not produce additional emissions. Instead, carbon removal is their product, and their wider aim is to reduce the concentration of CO_2 in the atmosphere. These are benefits made from climate change mitigation policies that set up, regulate, and incentivize investments in the carbon removal market. This market is based on governments creating conditions to bring about the public good of a stable global climate. Because the benefits from the carbon removal market are largely drawn from public funds and are aimed at a public good, it is difficult to maintain that their distribution is not a matter of justice. Further, not all agents benefit from this market for the same reasons. While the primary good traded is captured carbon, we saw that benefits can be obtained by making available storage space, infrastructure, knowledge, and technology in exchange for payment.

As such, the reasons for access to CDR become a principal criterion for determining whether a benefit counts as an injustice. Some CDR businesses possess these capacities independently of past contributions to climate change, such as the Swiss company Climeworks (founded in 2009) (Climeworks, 2022). It could be argued that such agents are entitled to their gains since they lack historical responsibility and since these agents are directly contributing to climate change mitigation (Mintz-Woo & Leroux, 2021). Carbon majors, by contrast, possess these capacities precisely because of their past contributions to climate change (see benefit (a)). They gained the capacity to profit from the carbon removal market by extracting, transporting, and selling fossil fuels, and because CDR infrastructure turns out to be similar to the infrastructure needed to extract fossil fuels. Pipelines built for transporting fossil fuel and gas will be essential for reducing the costs of transporting liquified carbon. By extracting fossil fuels, carbon majors have also gained empty reservoirs that can serve as storage sites for liquefied carbon (Bui et al., 2018).

Therefore, it would be unjust for carbon majors to be allowed to benefit from a carbon removal market in CDR due to their unaddressed historical climate responsibilities, as well as their continuous contributions to climate change. Since this carbon removal market only becomes profitable given the existence of climate change, it is a benefit built atop the prior injustice of benefitting from and contributing to climate change. Thus, the first horn of our dilemma remains compelling: carbon majors ought not to be permitted to benefit from CDR.

Yet this result runs into the second horn of the dilemma: preventing carbon majors from revenues gained from the carbon removal market implies that less CDR will be done. Given this concern, the next section explores a non-ideal argument for permitting what we have argued to be a clear injustice, namely, providing economic incentives for carbon majors to undertake CDR.

4. Justice and incentivizing carbon removal

Discussions of benefitting from climate change have seldom considered the importance of incentives, yet incentives can matter greatly for achieving climate justice (Mintz-Woo & Leroux, 2021). Ignoring economic incentives to invest in carbon removal may undermine the economic case for some agents to invest in this business (Ko et al., 2021). Nonetheless, ignoring the history of carbon majors when designing incentives would undermine any attempt at fairly distributing responsibilities for climate action, and could even be self-defeating.

We argue that under non-ideal conditions, economic incentives for carbon majors to undertake CDR would be morally permissible *if and only if* no other agents were capable of removing as much carbon at roughly similar costs, and on roughly similar timeframes, and in accordance with existing demands of justice. Even given this condition, carbon majors may only benefit from the carbon removal market if they address their existing historical climate responsibilities. We will shortly explain what these conditions require.

There are different views about the morality of incentives to comply with justice. As Mintz-Woo and Leroux note (2021), consequentialists generally regard incentives to maximize the good as morally legitimate, if not compulsory. They favor incentives to decarbonize the global economy, internalizing all harmful impacts of climate change. By contrast, Rawls' 'difference principle', which holds that inequalities are permitted so long as this benefits the worst off, allows for the incentivization of those capable of

https://doi.org/10.1017/sus.2023.22 Published online by Cambridge University Press

producing more – but only to the extent that this benefits the worst off (Rawls, 1971). A Rawlsian view would mean that carbon majors would be entitled to incentives from the carbon removal market only if these benefitted the worst off, i.e. those most vulnerable to the negative impacts of climate change. It is safe to assume that a stabilized climate would benefit the worst off. However, in his prominent critique of the Rawlsian position, Cohen (2008) objected that those capable of producing more are not justified in working less hard unless they are paid more. This appears somewhat analogous to the case of carbon majors, who like Cohen's talented rich, would be unjustly demanding an incentive if they invested less in CDR unless they received public subsidies.

Nonetheless, this critique comes from ideal theory and thus appears to be inapplicable to the dilemma of carbon majors. This dilemma is more plausibly viewed under the lens of non-ideal justice. A situation falls under non-ideal justice when two conditions of ideal justice are absent, namely full compliance with principles of political morality and favorable external conditions (Rawls, 2001). Climate ethics generally seems to be especially apt for non-ideal analysis, because there remains little compliance with demands of climate justice, and because climate policy is fraught with unfavorable political and economic circumstances (Heyward & Roser, 2016).

Non-ideal justice allows consideration of actions that would be impermissible under ideal justice, in the interests of making a just future situation more likely (Stemplowska & Swift, 2012). From a non-ideal view, one might make the following argument: carbon dioxide removal has become essential for avoiding dangerous climate change. The urgency of avoiding dangerous climate change is such that as much carbon removal should be done as is possible without severe adverse side-effects. Carbon majors are also among the agents most capable of speedily scaling up carbon removal. Thus, carbon majors should be allowed economic gains from doing so, despite this being unjust (see Section 3). As a result, the incentivization of carbon majors is morally permitted if it could be reasonably shown that such incentives were necessary to avoid dangerous climate change. This would be so even if such incentives involve sufficient injustice to render them impermissible under ideal justice. If so, it seems morally permissible for carbon majors to benefit from CDR to the extent that this is actually required to avoid dangerous climate change.

However, this argument is unlikely to succeed in most contexts where CDR is being contemplated. It requires demonstrating that no other agents are capable of doing as much CDR as carbon majors, as rapidly, and at similar costs. There are serious challenges facing any attempt to bear out this claim. These stem from the conditions of non-ideal justice of most relevance to climate change, namely epistemic uncertainty, moral uncertainty, and technological constraints (Heyward & Roser, 2016). First, there is epistemic uncertainty about whether the involvement of carbon majors would, in fact, allow for more rapid upscaling of CDR, and whether large-scale implementation of CDR is feasible at all. There is moral uncertainty about the conditions under which implementing CDR would be permissible (Lenzi, 2021). There is also technical uncertainty about the viability of redeploying existing fossil fuel infrastructure for carbon removal and about the technical viability of CDR techniques. Further, there is epistemic and moral uncertainty about the likely costs, side effects, and threats to justice posed by CDR (Lenzi, 2018; Schübel & Wallimann-Helmer, 2021; Wallimann-Helmer, 2021). Due to such uncertainties, it is difficult to demonstrate that carbon majors are indeed the agents who could undertake CDR most efficiently, or that they could do so without causing further injustice.

Whether alternative courses of action are available is also likely to depend upon the governance capacities of individual countries. One approach for assessing governance capacity is the World Bank's worldwide governance indicators, which include indicators for voice and accountability, political stability and the absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption (World Bank, 2022). Among these indicators, regulatory quality, rule of law, and control of corruption appear most directly relevant to the implementation and monitoring of carbon removal infrastructure. Countries that score poorly on regulatory quality, rule of law, and controlling corruption may face severe challenges in incentivizing carbon removal using state capacities, such as expropriating private capital infrastructure under the public domain, establishing publicly owned corporations to undertake carbon removal, or supporting private corporations without historical climate responsibilities to undertake carbon removal. It appears easier to justify incentivizing carbon majors to undertake carbon removal under conditions where these alternatives are unlikely to succeed.

Yet according to these World Bank indicators, few if any OECD countries could reasonably claim that they lack the governance capacities to undertake CDR themselves, or to incentivize carbon removal from actors without significant historical responsibilities. Appealing to the urgency of climate stabilization does not justify rewarding carbon majors so long as there are alternative agents who might do this effectively in due time, and certainly does not permit carbon majors to unilaterally dictate the economic gains they are entitled to as the condition for scaling up carbon removal.

The difficulties with showing the necessity of incentivizing carbon majors also turn on epistemically dubious and potentially unverifiable judgments of political feasibility. The ambiguity surrounding feasibility judgments exacerbates the challenge of showing why incentivizing carbon majors is genuinely necessary. Extra caution is required since claims about what is economically or politically infeasible can be disguised statements of willingness, knowledge, or even strategic attempts to secure advantage (Schuppert & Seidel, 2017; Schuppert & Wallimann-Helmer, 2014; Wallimann-Helmer, 2022). For example, carbon majors may exclude smaller players from entering the market, which could lead to path dependencies for them to undertake CDR. There is also the danger of carbon majors pursuing emitting activities in some countries while benefitting from incentives and state subsidies to undertake CDR in other countries. To make feasibility assessments more credible in the future, it is essential to create opportunities for democratic participation in determinations of feasible and fair policy proposals to decarbonize (Honegger et al., 2017; Lenzi & Kowarsch, 2021; Wallimann-Helmer, 2018, 2021).

Thus, the non-ideal argument may justify incentivizing carbon majors to undertake CDR in certain circumstances. Yet the burden of proof is very demanding and fraught with technical, epistemic, and moral uncertainties, including questions of feasibility. We have suggested that this burden of proof is likely to be met only in countries with poor regulatory and governance capacities. However, in most contexts where CDR is being contemplated, such as OECD nations, it remains impermissible to incentivize carbon majors to undertake CDR, at least until they address their historical climate responsibilities.

5. Managing the dilemma of benefitting carbon majors

We have argued that even where rewarding carbon majors turns out to be morally permissible, this does not cancel their historical climate responsibilities. For this reason, governments are justified in imposing additional burdens upon carbon majors, irrespective of whether they claim benefits from a market in carbon removal. In principle, any economic gains from the carbon removal market can be treated separately from obligations to redress historical responsibilities for emissions, since the fact of benefitting is insufficient to show that an injustice has occurred – at least when this benefit occurs as a result of climate change mitigation. However, if, as in the case of carbon majors, agents stand to benefit from CDR due to their past and current contributions to and benefits from climate change, then any benefits from these technologies remain unjust, at least until such historical responsibilities are met. These benefits are only possible due to the existence of climate change, which is a very serious injustice.

This indirect connection between climate harms and benefits from the carbon removal market shows why any future beneficiaries must account for the fact that they are also benefitting from an injustice. In practice, this can be achieved via well-known means of climate policy. One possibility would be lowering revenues through taxes, which would be redistributed to the victims of climate change. Compensation could also be paid by providing technology and know-how for climate adaptation, or by developing CDR infrastructure and technology for other agents to profit from the carbon removal market. However, most actors capable of developing CDR technologies also benefit from past emissions indirectly. Their technological innovation would not have been possible if past generations had not enjoyed the benefits of carbon emissions. This especially holds true for businesses of industrialized countries that have contributed proportionally more to climate change.

Historical contributions to climate change are especially morally relevant in the case of carbon majors. While it may seem expedient to incentivize them to invest in CDR, their historical responsibilities cannot be ignored. Taxing away gains from trading in carbon removal in higher proportion might be one way to account for their historical responsibilities. Because this poses the risk of rendering carbon removal less attractive for carbon majors, it might be justifiable to allow carbon majors similar revenues from carbon removal to other market actors, but only where no other agents are available and where governance capacities are poor. Conversely, carbon majors could be obliged to make available part of their infrastructure or storage space free of charge. Where there is already a legal requirement to become carbon neutral, as in the case of Shell, removing more carbon than is currently produced or providing infrastructure and storage space for other parties without revenue might be a way of paying court-imposed fines.

Such policy measures demand caution. If carbon majors do not foresee sufficient profits from investing in CDR, they may abandon this business model. Yet it remains to be seen whether this would be ruinous for the project of climate stabilization, or simply hard luck for carbon majors. One additional challenge for policymakers is that carbon majors are (partly) state-owned in many cases. This is one of the reasons why our solution to the dilemma may be problematic or challenging for policymakers: they would have to move away from (partly) state-owned carbon majors toward smaller corporations to carry out CDR. Investigating different layers of institutional capacity and feasibility is also likely to resolve what otherwise appears to be a serious dilemma of choosing between two kinds of injustice.

6. Conclusion

The dilemma of rewarding carbon majors is based on the historical responsibilities of carbon majors, on account of which they now stand to benefit from a future market in CDR. Historical responsibilities make it unjust to permit carbon majors to benefit unconditionally from climate change mitigation policies, such as policies incentivizing carbon dioxide removal. However, there may be circumstances under which carbon majors can indeed be incentivized to undertake CDR. We have argued that such circumstances are unlikely to be found in OECD nations because they require that no other agent could achieve carbon removal at approximately the same rate as carbon majors. This is very difficult to demonstrate, and any legitimate attempt to do so must be transparent about its assumptions of feasibility.

Acknowledgments. The authors wish to thank participants at the *Climate Engineering in Context 2021* Conference in Berlin, the *World Forum on Climate Justice* 2021 in Glasgow, the Philosophy Colloquium of the Arctic University of Norway, and the *ESDiT Conference 2022* in Leiden. We also wish to thank Clare Heyward and two anonymous reviewers for their helpful comments on an earlier draft.

Author contributions. All authors contributed equally to the development of the argument and the writing of the resulting article.

Financial support. Dominic Lenzi's research on this piece was supported by the RIVET project (grant number: 2020-00202), funded by FORMAS Sweden; and by the research program Ethics of Socially Disruptive Technologies (ESDiT), funded through the Gravitation program of the Dutch Ministry of Education, Culture, and Science and the Netherlands Organization for Scientific Research (NWO grant number 024.004.031).

Competing interest. None.

Research transparency and reproducibility. This research does not produce any empirical results.

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28. Who should get to take credit? Investigating the role of corporations in carbon removal developments

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Abstract

Planting biomass on agricultural land to feed bioenergy with carbon capture and storage (BECCS) technology is often included in countries and corporations' strategies for reaching their net zero targets. The limited availability of land and the need for food production impose important practical and moral constraints on using agricultural land for growing biomass for BECCS. Corporations are key players in scaling up BECCS technologies, both through funding their development and through developing and providing these services. In light of the constraint of available land, two questions arise: Under which conditions can corporations permissibly offer BECCS and benefit from offering these services? And under which conditions can corporations permissibly use BECCS to offset their emissions? This paper investigates these questions by addressing both the supply and demand side of the newly emerging market in carbon removal, capture, and storage and its link with land. I argue that strong governance is needed for how land is used to supply BECCS, based on justice as well as environmental sustainability criteria. Further, criteria are needed to define which corporations are most or least entitled to use BECCS, given the limited supply of BECCS.

Keywords: land use, bioenergy with carbon capture and storage (BECCS), corporate responsibility, offsetting, sustainability

Introduction

Bioenergy with carbon capture and storage (BECCS) is the technology that the IPCC assumes will be most commonly used in climate stabilization pathways (Fuss *et al.,* 2018). In BECCS, biomass is planted, harvested, and processed in special facilities to create bioenergy. The carbon captured in the biomass is sequestered and stored (CCS), for example in geological reservoirs. As carbon is removed from the atmosphere, employing BECCS at large scales could grant more time for societies, economies, and ecosystems to adapt to changing climatic conditions. The production of bioenergy offers additional mitigation potential and could help economies to decarbonize.

Corporations are key players in scaling up BECCS, both through developing and providing these services and through funding the development by using CDR. BECCS is the carbon dioxide removal (CDR) method most widely adopted in corporations' investment plants on carbon removal, because it allows gains in energy generation and carbon dioxide sequestration (Vivid Economics, 2020). These increasing widespread commitments of corporations to reach net zero targets create high demand for carbon removal services via BECCS to offset their emissions. For example, Microsoft has announced a $1 billion climate innovation fund to develop CDR and CCS technologies, including BECCS; the company intends to become 'carbon negative' by 2030 and to remove all carbon directly or indirectly emitted since its foundation in 1975 (Smith, 2020).

Most importantly, the supply of BECCS is limited by the availability of land, and especially land where biomass can conveniently be planted and harvested. Producing the large quantities of biomass that are

Donald Bruce and Ann Bruce (eds.) ***Transforming food systems: Ethics, innovation and responsibility***
EurSafe 2022 – DOI 10.3920/978-90-8686-939-8_28, © Wageningen Academic Publishers 2022

needed for BECCS 'is likely to push the world to its planetary boundaries in terms of water and land availability' (Vivid Economics, 2020, p. 3) and compete with other land usage. Large-scale BECCS could create problems for sustainable land use, including soil degradation and losses of biodiversity. As a result, the quantity of carbon that can sustainably be removed by BECCS is limited (Fuss *et al.,* 2018).

The extent to which BECCS can be used sustainably is by far exceeded by the commitments of corporations to remove carbon with this method (Reid *et al.,* 2020). This creates a tension between demand and sustainable supply of BECCS raises questions about how such a market should be governed. The revenues to be gained from employing BECCS and buying certificates for BECCS, as well as the major role of corporations on either side of the market, motivate the investigation in this paper of two questions: Under which conditions can corporations permissibly offer BECCS and benefit from offering these services? Under which conditions can corporations permissibly use BECCS to balance out their emissions?

In the following, I present my argument how to answer these questions, drawing attention to the fact that sustainable carbon removal via BECCS is a scarce resource. This restriction needs to be included in the governance of this newly emerging market. I show that inadequate consideration risks not only unsustainable use of land but also increasing injustices on both the demand and supply sides of the market. I first consider the supply side of the carbon market and identify potential injustices that may require the definition of sustainability to be supplemented, as these concerns of justice shape how corporations can permissibly offer BECCS. Second, for the demand side, I present a range of suggestions for criteria that could define which corporations can permissibly use BECCS to offset their emissions.

The challenge of limited sustainable supply

The involvement of the private sector is crucial in upscaling BECCS, and the potential revenues associated with BECCS may be an important driver for its supply. This section investigates the conditions under which corporations can permissibly offer BECCS and benefit from offering these services. I start by outlining the arguments for efficiency and ecological sustainability and argue these, if we accept them, need to be supplemented by justice concerns.

First, efficiency been presented as important criteria for the permissible implementation of BECCS. Because land is scarce and bioenergy can provide an important contribution to reducing emissions, Reid *et al.* claim that we should use land 'as efficiently as possible' (2020, p. 276). The efficient usage of BECCS is limited, among other factors, by the storage capacity of the land in its current state. If ecosystems that store large amounts of carbon are destroyed because the land is converted to plant biomass for BECCS, this creates net positive emissions (Harper *et al.,* 2018) and be inefficient in removing carbon from the atmosphere. Moreover, Megan Blomfield has argued that there are important moral objections against viewing land as a common resource for sequestering emissions that can be distributed efficiently, such as serious implication for land justice like land-grabbing, forced displacement, and unfairness in land-based climate mitigation (2021). These suggest that we need additional justice criteria.

Second, Fuss *et al.* (2018) estimates that the carbon dioxide removal potential of sustainable BECCS could range from 0.5 $GtCO_2$/year to 5 $GtCO_2$/year in 2050, depending on the definitions of sustainability used in the model. This is due to the negative impacts of BECCS on biodiversity, soil degradation, and water use. Due to these detrimental effects, it seems plausible that corporations can only permissibly benefit from BECCS if they implement the technology in an environmentally sustainable way – and BECCS is restricted to this estimated amount. But notably, Fuss *et al.* (2018) bases their judgement on a notion of ecological sustainability, primarily based on environmental factors like soil erosion, soil degradation or water availability. It does not directly include social aspects, which are hard to include to the modelling processes their work is based on. But the implementation of BECCS will always have implications for local societies that go beyond securing water and food availability. To decide whether the implementation of BECCS is permissible, both burdens and benefits for the local population and the corporation need to be considered. These are considerations of justice.

Hence, efficiency and ecological sustainability criteria need to be supplemented by justice concerns for determining the permissible use of BECCS by corporations. In the following, I identify three implications of justice that arise when BECCS is implemented.

A first implication of justice is the distribution of burden that arise when BECCS is implemented on an area of land. One burden is to give up the benefits of other alternative uses of the land and water, like agriculture for food and habitation. Most notably, some groups in society are more prone to suffer from food shortages and more likely to have their land grabbed and experience forced displacement (Blomfield, 2021). It poses challenges to food justice if BECCS competes with food production and thereby disadvantage small stakeholders (Kortetmäki and Oksanen, 2016). On a global scale, implementing large-scale BECCS puts the risks of removing carbon on countries of the Global South, disproportionally to their contribution to climate change (Morrow *et al.*, 2020). Hence, like other climate mitigation measures, the burdens of BECCS may be distributed in ways that perpetuate unjust social structures.

A second implication of justice relevant concerns the benefits of employing the technology and how they are distributed. Because BECCS will provide bioenergy and deliver carbon that then can be stored, there are potentially large revenues to be gained (Vivid Economics, 2020) and benefits provided to the sites of implementation. Hence, BECCS can be an important investment in developing countries to support their economies. Unfortunately, investments in the carbon market have been observed to follow the structures of past colonialism (Michaelowa *et al.,* 2019) and mirror the same problematics as other foreign direct investments, such as weak mechanisms for regulating the behaviour of foreign corporations. Forestry projects for carbon credits have already been criticized for a lack of transparency regarding the benefits provided to the local community and stewards of the land (Michaelowa *et al.,* 2019). For BECCS, the situation may be even more difficult: in the case of forestry projects, local communities could make claims to the 'carbon credits' their land was storing, but this claim cannot be made if biomass is planted for BECCS and the carbon is not stored on the land. It may be contested that BECCS would have to provide any benefits to the local communities where the facilities are installed and the biomass planted. However, if the land that BECCS is used on was 'grabbed' and the community displaced, the is no legitimate claim to the land and we can contest that the corporation using BECCS on this land is entitled to these benefits.

A third justice dimension concerns the suitability of corporations to permissibly offer BECCS, and particularly the storage of the carbon that is captured in BECCS. Corporations from the oil and gas industry ('carbon majors') are leading the expansion of carbon sequestration and storage in this emerging market, raising questions of justice (Moss, 2020). The fact that they bear heavy historical responsibilities for their emissions and contribution to climate change makes it morally problematic for them to benefit from carbon removal activities (Lenzi *et al.,* under review).

These considerations of justice as the distribution of burden and benefit need to be considered in addition to the sustainable implementation of BECCS. They limit the permissibility of corporations to implement and benefit from BECCS. For corporations to permissibly offer BECCS and benefit from offering these services, these challenges have to be given adequate consideration, for example, by hindering the access of corporations to regions where food security is already at stake or by reforming land tenures to ensure that local populations are not driven off their land. The case of carbon majors shows that we could consider excluding some corporations from benefitting from BECCS due to their past actions. These considerations may further restrict the use of BECCS if they are translated into criteria that determine whether corporations can permissibly offer and benefit from BECCS in certain regions.

Is this account too restrictive, and will this disincentivize investments in BECCS? Importantly, current commitments to remove emissions by far exceed the extent to which BECCS can sustainably be provided, even without considering justice as I have done above: The estimate of sustainable usage provided by Fuss *et al.* (2018) is much lower than most models and scenarios predict for the use of BECCS (Reid *et al.,* 2020). This indicates that careful governance is needed when upscaling this technology to avoid major problems of sustainability and justice given the limited supply of land.

The challenge of high demand for BECCS

The transition towards the targets of the Paris Agreement and general climate-stable pathways requires the involvement of global players. Therefore, the multitude of pledges from corporations to be carbon neutral by 2030 (Apple) or 2050 (Volkswagen, Hitachi), or net zero by 2030 (Unilever), 2040 (Walmart, Amazon, Vodafone), and 2050 (Nestle) are a positive development, albeit that varying degrees of integrity have been observed in achieving these targets (Day *et al.,* 2022). While most of these commitments do not include clear strategies of how emissions are offset, BECCS is the CDR method most included in investment plans (Vivid Economics, 2020). BECCS provides benefits in multiple ways for those who fund its use: Corporations that can improve their public image by showing that they fund bioenergy the removal and storage of carbon emissions. But primarily, they can continue to benefit from activities that create emissions, while reducing their net emissions by purchasing certificates.

Given the limited potential of sustainable BECCS, the question is under which conditions can corporations permissibly use BECCS to offset their emissions. Various criteria have been raised in the debate to define whether a corporation permissibly uses BECCS, or more generally offsets, in their climate strategy and I present four central ones below. However, my concern here is that applying these criteria to corporations may not be sufficient, given the limited extent to which BECCS can sustainably be used. Therefore, I then discuss three ways of deciding which corporations are most or least entitled to use BECCS.

Current discussions on net zero targets already indicate that stricter governance is needed to define, assess and overall regulate the extent to which corporations rely on offsetting in their climate strategies (Black *et al.,* 2021). The following four criteria have been suggested to assess the climate strategies of corporations and help to decide whether a corporation can permissibly use BECCS.

- *Fixing concrete steps*. Reports have criticized the lack of concrete steps taken by corporations to meet their climate commitments (Day *et al.,* 2022). One apparent condition to be met would be a transparent communication of the steps the corporation is undertaking, including timelines and intermediate targets of how to reach the target they committed to, and reporting on this progress (Black *et al.,* 2021). Given uncertainties and risks regarding the use and scale-up of BECCS and other CDR, relying on these technologies and forgoing emission efforts has been pointed out to be morally problematic (Lenzi, 2018).
- *Setting separate targets.* The commitments of corporations have to state more precisely the degree of carbon removal they envision. Keeping the pledges of emission reductions and removal distinct from each other instead of summing them up in net zero targets (McLaren *et al.,* 2019) is a vital step in assessing the extent to which a corporation is relying on removal and forgo opportunities to cut their emissions if emission removal is cheaper.
- *Commitment to sustainable BECCS.* The conditions under which BECCS is implemented play a crucial role whether a corporation can permissibly rely on it. When considering the duties of

corporations in reducing or removing their emissions, Jeremy Moss argues for applying the 'principle of unjust restitution'. This principle states that 'it is impermissible for an agent to inflict new harms on third parties to rectify past harms.' (Moss, 2020, p. 51) Hence, it would be impermissible for corporations to use carbon removal credits if these impose harms. This would be a moral argument for corporations using solely 'sustainable' BECCS, including justice aspects, as discussed in the previous section.

- *Prioritizing emission reductions.* If the extent to which BECCS can be carried out sustainably is limited, and similar findings limit the use of other CDR methods, corporations must limit it to the extent to which they use these methods. To reach their climate targets, especially commitments to net zero emissions, they need to prioritize reducing their emissions over offsetting them. Not prioritizing emission reductions creates a high risk that the use of CDR technologies and bioenergy will lead to unsustainable lock-in effects instead of a transition to a low-carbon and energy-efficient economy (Reid *et al.,* 2020). Further, the principle of unjust restitution can give corporations a 'pro tanto' duty which prioritizes the cessation of emitting activities a stronger over discharging liabilities in many practical instances, such as employing BECCS (Moss, 2020).

Given the large commitments to net zero and hence the high demand for using BECCS, it may be the case that the extent to which corporations fulfil these four criteria would still exceed the extent to which BECCS can sustainably be implemented. Given this imbalance, how should we decide which corporations are most or least entitled to use BECCS?

- *Taking the market prize.* It may be argued that as long as we ensure that the only credits on the market originate from sustainable implementation of BECCS, we could leave the market to determine who purchases removals. Given the needs of corporations to offset their emissions, this would probably lead to raising the prices for BECCS. This would allow corporations with substantial capital to purchase credits and reach their net zero targets. By buying carbon removal certificates, they could reach net zero targets at higher emission levels than corporations that cannot afford buying offsets at high prices. As there is a strong link between the capital held by corporations and their past emissions, it would probably lead to corporations with histories of high emissions to continue to profit from emitting because they could also pay for the removal of these emissions. Hence, this could allow precisely those who have contributed the most to climate change to continue to benefit from creating emissions.
- *Using emissions as indicator.* Another is proposal to take the current level of emissions as an indicator of how many emissions can permissibly be removed by BECCS. Corporations creating high emissions already face high costs in reducing their emissions. Hence, corporations that face strong restraints in reducing their emissions should, it could be argued, be entitled to benefit more from carbon removal. However, it is not clear how to attribute such an entitlement to corporations and may be objected on the same reasons as the market price.
- *Revenues from emissions as indicator.* Instead, we could decide the extent to which a corporation may remove emissions by the profits the corporation makes by emitting. Corporations have been criticized for using net zero pledges to continue benefitting from their emitting activities. Hence, the higher the profits the corporation makes, the higher the price they should have to pay for carbon removals. This could promote stronger efforts to reduce emissions and reduce the incentives to buy carbon credits from BECCS.

Conclusions

Where does this leave us regarding the question of the role of corporations in the market for BECCS? Because corporations have a central role in financing the upscaling of BECCS, the challenge is to keep their commitments to remove emissions via BECCS at the limit of sustainable use without undermining investments in this technology. I have argued that strong guidelines should govern for how land is used by corporations to remove emissions via BECCS, and these should include justice as well as environmental sustainability criteria. As the quantity of BECCS that will be available under these criteria is restricted, strong guidelines should govern how much corporations are allowed to use BECCS to balance out their emissions. The most important guideline is a clear commitment to reducing emissions. If using carbon credits from BECCS is restricted, the criteria proposed to define permissible use of credits should be sensitive to the revenues made from emitting, because profiting from emissions is the main reason for the need for using BECCS.

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