Localized governance of carbon dioxide removal in Small Island Developing States

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Highlights

- Small Island Developing States are particularly at risk from climate change impacts
- Participatory frameworks are key for societal appraisal of carbon dioxide removal
- Localized governance may positively influence public perception acceptability
- Social research can provide insights into public understandings of climate change

Abstract

Meeting global emissions targets is highly likely to require the removal of previously emitted greenhouse gasses from the atmosphere, and increasing attention is being paid to novel innovations for carbon dioxide removal (CDR). Small Island Developing States (SIDS) are particularly at risk from climate change impacts and are therefore important to consider for CDR efforts, both in terms of CDR potential and risks. Grassroots, inclusive frameworks are valuable to advancing our understanding of the social implications of CDR, including valid concerns around efficacy and scalability, and should constitute crucial foundations in establishing the public support to develop, trial and transition novel proposals. This position paper presents a simple model for integrating local ownership, inclusion, and participatory governance of CDR through a case study of a forthcoming coastal enhanced weathering project in the Dominican Republic. This paper argues that the inclusion of actors from the Global South into CDR innovation will strengthen both ethical and governance considerations. Critical discourse around whether researching CDR in a SIDS context raises novel, locally embedded and pertinent questions about the relationship between CDR and climate change adaptation. Conducting social science research to gauge understandings of climate change and public perceptions, while opening pathways for participation in project development, provides insight into and potentially addresses these emergent inquiries. Participatory, deliberative, and localized governance approaches may influence public perception in communities subject to climate change vulnerability, and evidence of its implementation would help to inform strategies to develop more ethical CDR solutions aligned with climate justice principles.

Keywords: Carbon Dioxide Removal; climate justice; Negative Emissions Technologies; Ocean Alkalinity Enhancement; Responsible innovation; enhanced weathering

The emergence of climate justice discourse

Small Island Developing States (SIDS) are particularly at risk from climate change effects such as sea level rise, hurricanes, and changing rainfall patterns (Nurse et al., 2014). These climate characteristics, combined with their socioeconomic circumstances, make SIDS among the most vulnerable countries in the world to climate change (Scandurra et al., 2018), and they will likely continue to experience a lack of environmental security because of their position at the forefront of climate change effects caused primarily by industrialized countries. Importantly, SIDS have not only represented the most vulnerable in the climate crisis – they have also been instrumental in calling for stronger action on a global scale and were among the first to call for putting climate change on the agenda of the UN Security Council (Mead, 2021).

One of the clearest injustices of the climate crisis is that those who contribute the least to the greenhouse gas problem often suffer the most severe impacts. Concomitantly, the development of research and implementation of solutions do not affect all citizens in the same way, as embedded inequities from climate change risk are reinforced by climate change mitigation and remediation (Healey et al., 2021). As such, notions of justice must play a strong role in any action to reduce the causes or impacts of climate change, including in the development of new technologies and interventions (Batres et al., 2021). The climate justice movement grew out of environmental justice action concerned with inequitable exposure to environmental risks (particularly pollution); the pursuit of 'just sustainability' involves managing the distribution of benefits and harms, not only between countries but also between different communities and generations (Healey et al., 2021). Against the backdrop of growing calls toward justice in adaptation to climate change (Adger et al., 2006; Popke et al., 2016), substantial research is focusing on decoloniality and advancing ethical and inclusive approaches to scientific endeavor (Mutua & Swadener, 2004; Trisos et al., 2021). The Intergovernmental Panel on Climate Change (IPCC) concludes that *"Inclusive governance that prioritizes equity and justice in adaptation planning and implementation leads to more effective and sustainable adaptation outcomes."*

According to Adams et al., (2009), the climate justice agenda should increase attention in four key areas: development disparities, vulnerable groups, governance, and resources. The climate crisis is a crisis of justice as much as it is a crisis related to the geophysical environment, and as such, calls for a reframing of climate, and broader environmental justice debates (Sultana, 2021). As a form of environmental justice, climate justice has three components: equitably distributed environmental risk, recognition for people's diverse needs and experiences and participation in the political processes that create and manage environmental policy (Schlosberg, 2007). Thus, the theory and practice of environmental justice includes not only distributive conceptions of justice, but also notions of justice based on recognition, capabilities, and participation (Schlosberg, 2007).

In this paper we briefly outline the key relevant discourses surrounding climate justice related to removing anthropogenically emitted CO_2 from the atmosphere, collectively known as Carbon Dioxide Removal (CDR), addressing the paucity of studies about social and ethical considerations. Presenting an example case from one of the SIDS in the Caribbean, the Dominican Republic, we argue for the value of a localized governance approach to CDR development, which explicitly addresses the key underlying principles of climate justice and the related adaptation measures required to conciliate the social and ethical concerns surrounding CDR.

Climate justice and coastal carbon dioxide removal

As one means of addressing climate change, increasing attention is being paid to proposals for CDR, also known as Negative Emissions Technologies (NETs). The IPCC states unequivocally 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*.' (2022: 47). Indeed, debates are shifting away from *whether* CDR is required, to questions around how, where, why, and by whom (Bellamy & Geden, 2019) – questions which are similarly crucial to environmental justice movements (Batres et al., 2021). A recent commentary by Morrow et al. (2020:152) highlights that '*Not all carbon removal is created equal in terms of social, economic, and environmental impacts, and nuanced positions are needed to distinguish better technologies, practices, projects, and policies from worse ones*.' Our aim is to build upon known justice-based approaches and consider how this inherent inequality of impacts may be mitigated when exploring novel proposals for coastal CDR.

A diverse portfolio of CDR techniques may help to hedge against climate risk, for instance in the case of techniques proving unexpectedly unviable or unscalable (Cox et al., 2021). As part of this portfolio, proposals involving the ocean have been gathering increasing attention, and growing networks of actors and investment are increasingly promoting the so-called 'blue economy' (Boettcher et al., 2021). Ocean-based CDR is seen as attractive due to its potential to avoid the land availability issues associated with terrestrial CDR, as well as offering potentially long sequestration timescales due to the slow turnover of ocean waters (National Academies of Sciences, Engineering, and Medicine, 2022). Some proposed techniques also have the potential to slow or reverse anthropogenic ocean acidification (GESAMP, 2019). SIDS may play an important role in deployment of coastal CDR, because of their high ratio of coastal to inland areas, as well as the potential for synergies with adaptation imperatives such as coastal protection or alkalinization (Rosa & Lohmann, 2015). The understanding of the social and ethical implications of coastal CDR is at an extremely early stage, despite the fact that 'public acceptability' appears as a standard feature in lists of potential constraints and limitations on the upscaling of CDR (Bertram & Merk, 2020).

The literature identifies several social and ethical considerations which need to be considered for upscaling CDR. Key issues include the risk that CDR merely treats the symptoms of rising emissions rather than addressing the cause, thus failing to deliver broader social and environmental sustainability (Cox et al., 2018). CDR also may divert attention away from emissions reductions via 'mitigation deterrence' (Markusson et al., 2018). Such concerns may be particularly relevant to SIDS for which delays in global climate change mitigation could have particularly catastrophic consequences. Work on public attitudes towards CDR in the Global North finds that these issues are a major concern for lay publics, in addition to concerns about 'messing with nature' and the potential unintended consequences of intervening in complex, open ecosystems such as the ocean (Corner et al., 2013; Cox et al., 2021).

Least-cost modeling approaches often conclude that the Global South will play host to an outsized share of CDR, due to relative land availability and costs of land, energy, and labour (Fyson et al., 2020; Low & Honegger, 2020). Yet to date, the vast majority of social science research on CDR has been limited to the Global North (Sugiyama et al., 2020; Winickoff et al., 2015). One exception is a study on communities with high climate change vulnerability in Alaska, Sub-Saharan Africa, and South Pacific, which found a greater willingness to *reluctantly* consider climate engineering as a response (Carr & Yung, 2018). Importantly though, a key condition was that climate interventions should be responsive to local needs rather than the benefit of distant elites. We do not yet know whether these sentiments will be consistent in other communities vulnerable to climate change such as the Caribbean, and more research is needed which pays attention to differences in cross-cultural and geographical contexts for public perceptions of CDR.

Environmental and climate justice are emerging as increasingly central issues to CDR efforts (Batres et al., 2021; Pozo et al., 2020; Schlosberg & Collins, 2014), but there is a distinct lack of empirical research into the types of social and ethical dynamics which deployment of CDR in developing countries might entail (Cox et al., 2021). This partly stems from a lack of capacity, particularly in terms of available research funding (Delina, 2021). However, it may also stem from the way in which CDR has been predominantly framed as a top-down, global technique, aligned with its history as 'geoengineering' (Honegger et al., 2021; Lezaun, 2021). It has been divorced from older debates and lessons about the risks of effort sharing of carbon sinks (Carton et al., 2020). Indeed, work on marine CDR as a climate technique sits almost entirely separately from understandings of more locally situated techniques such as blue carbon and ecosystem restoration (Bertram & Merk, 2020; Lezaun, 2021). For example, research on mangroves illustrates the complex interactions between people's dependence on an ecosystem and their attitudes toward interventions in these ecosystems (Srivastava & Mehta, 2017). Various challenges remain in the politics of scaling up CDR techniques and decarbonization in rural and coastal communities, and Buck (2018) identifies three summary principles for the governance of CDR which are relevant to our case study: 1) entrenched interests can play a role in shaping how particular CDR techniques compete; (2) environmental justice concerns around CDR should be viewed as more than 'not-in-my-backyard-ism'; and (3) incentives must be tailored to local contexts.

Increasingly, social scientists are arguing for the inclusion of a diverse range of actors in the development and deployment of novel CDR techniques, starting at an early stage and continuing throughout the innovation and upscaling process. Such so-called 'responsible innovation' should seek to anticipate potential risks and impacts, be reflexive regarding the purposes of research, be inclusive in its processes and outcomes and respond to public concerns (Stilgoe et al., 2013). Such an approach also entails opening up the innovation process to include non-experts, both in terms of directly affected local communities and broader publics. Work on the ethics of social impact assessment emphasizes the importance of procedural fairness and adequate reflexivity, as well as consideration of the distribution of impacts and benefits and the adaptability and resilience of communities to change (Parsons & Luke, 2021). One of the key goals of this paper is to develop a framework whereby approaches to responsible CDR might be put into practice in a particular context, using a case study of a forthcoming coastal enhanced weathering project in the Dominican Republic.

Dominican Republic – climate change action in a Small Island Developing State

Since the first *Global Conference on Sustainable Development of SIDS* adopted the Barbados Programme of Action (United Nations, 1994), SIDS now comprise 52 small countries and territories in the tropics and low-latitude sub-tropics. While there is much diversity in SIDS' physical and human geographies, the United Nations (2005) describe how all display some level of similarity in terms of sustainable development. Even though SIDS typically contribute less than 1% of total emissions, they are disproportionately affected by climate change (Kelman & West, 2009). The Wider Caribbean Region, comprising of 23 SIDS, with around 50% of the population living within 1.5 kilometers of the coast, was hit by a record-breaking 30 tropical storms in 2021 including six major hurricanes. The Dominican Republic is a developing country in the Caribbean, classified as upper-middle income. It is ranked as one of the 10 most vulnerable and exposed areas in the world in relation to climate change effects, particularly extreme temperatures, changes in precipitation patterns, ocean acidification, projected sea level rise, and increases in tropical storm activity

(USAid, 2013). As of 2020, the Dominican Republic has an estimated population of 10.8 million, with approximately 83% in urban areas and cities (CIA, 2022).

With one of the fastest-growing economies in the Latin America and the Caribbean region, and as an active player in the international climate regime, the government of the Dominican Republic ratified the Paris Agreement in September 2017, and committed, within its Nationally Determined Contribution (NDC), to reducing its greenhouse gas emissions by 25% by 2030 compared to 2010 levels (Gobierno de la República Dominicana, 2020). The NDC also stipulates a commitment to a participatory and inclusive process, although specific details and mechanisms are not defined (WWF, 2020). Aligning with the NDC, the Dominican Republic has been working on a Gender and Climate Change Action Plan to increase climate change resilience and address issues of gender inequity. The aim is to empower local representatives through knowledge and capacity building, to integrate sustainable, gender-responsive actions into policy frameworks and foster climate change resilience. Aligning with the country's involvement in the Initiative for Climate Action Transparency to strengthen understanding and inclusivity in climate action, the Climate Action Enhancement Package works with over 50 other national governments in the Global South providing training of public servants on climate policies, climate assessment and climate reporting and by supporting their dialogue with national governments. Such initiatives respond to global calls for greater transparency, citizen participation and localized governance on climate action, an emergent approach which we describe below.

Pilot Weathering Study in the Dominican Republic

The focus of this approach is on a pilot study that aims to enhance the weathering of the silicate mineral olivine, through the spreading of olivine grains in a coastal zone. Silicate minerals like olivine have been slowly weathering on the Earth's surface for billions of years, gradually sequestering and storing CO_2 in the process, as part of the global carbon cycle (Hartmann et al., 2013). The principle behind 'enhanced' weathering is to accelerate the dissolution of silicate minerals by grinding them into smaller grain sizes to increase the surface area and spreading them in terrestrial or coastal environments. This process may increase the rate of atmospheric CO_2 sequestration through the generation of alkalinity, with the additional benefit of potentially counteracting ocean acidification (Meysman & Montserrat, 2017; Schuiling & Krijgsman, 2006). The experiments are being carried out by Project Vesta, a Public Benefit Corporation[1] based in San Francisco which first started researching coastal enhanced weathering as a nonprofit in 2019, and which currently has over 30 employees composed of scientists, engineers, and various operators. The organization is engaged in numerous collaborations with researchers at domestic and international universities, conducting studies on ecotoxicology, ecology, biogeochemistry, olivine dissolution, geomorphology, and social sciences.

The development of this pilot study by Project Vesta provides a unique opportunity to explore the social and ethical issues surrounding coastal CDR in SIDS, including interrogating whether and how research can support local adaptation and development through inclusive methods of implementation (Lezaun, 2021; Morrow et al., 2020). Investment and support of these technologies could potentially support national efforts for climate change adaptation and resilience in the Dominican Republic and other SIDS (Kelman &

[1] A Public Benefit Corporation is a for-profit corporate entity which pursues positive impacts to society, workers, the community, and the environment, as part of its legally defined goals.

West, 2009). Much of the adaptive benefit of CDR emerges from strengthening response capacity and addressing the drivers of vulnerability through developing new economic opportunities, knowledge networks and data sources (Buck et al., 2020a). The potential for CDR to increase adaptive capacity is not inherent in the technology itself and relies on effective and inclusive implementation, with sufficient uptake to scale impact. The exact mechanisms of actualizing and distributing the social, environmental, and economic benefits of climate change adaptation remain unclear, and one should be cognizant that as well as increasing adaptive capacity, new vulnerabilities may also be introduced, depending on policy and project design (Buck et al., 2020a).

The nature of these projects requires multi-year monitoring as olivine minerals continue to dissolve over time, which, in turn, necessitates a robust program with local, regional, and national communities to ensure ecological safety and efficacy of the research and any eventual scale-up. Including citizens within a process of participatory governance could potentially contribute toward the responsible innovation of coastal enhanced weathering. The history of climate interventions in the Global South clearly identifies issues with capacity-building, and a serious need to learn from the mistakes of the past by implementing genuine co-production processes with local communities and stakeholders. Such processes are especially important when there are still knowledge gaps, risks, and cost/benefit calculations to be made. In addition, documenting and providing a platform for the public to share their opinions on this novel CDR technique may assist in developing political mandates and action on much-needed CDR regulations. It may also help researchers and practitioners to understand the extent to which social and ethical concerns around CDR identified in the Global North, such as mitigation deterrence, are salient in the context of SIDS such as the Dominican Republic.

When conducting scientific research in a coastal SIDS community, the overriding imperative should be to avoid entrenching inequities and to challenge outmoded and unethical research paradigms (Healey et al., 2021; Mutua & Swadener, 2004). A cycle of inclusion, openness and receptivity must be maintained. Developed through a reflexive process building on codes of research conduct and adoption of standards for community engagement, Project Vesta ensures that CDR research only occurs with critical engagement with local communities following the justice principles outlined in this paper. The social research and engagement at Project Vesta are led by a local female leadership team made up of community experts and a senior regional manager, and includes the following key components:

Socio-demographic and attitudinal baseline surveys

Social science research takes a multidisciplinary, mixed methods approach. Baseline surveys represent the foundation of local social engagement and knowledge exchange and are conducted as soon as possible upon establishment in the area, prior to any placement of olivine sand. The first survey phase uses semi-structured interview questionnaires, where participants are qualitatively interviewed whilst interviewers fill out electronic or paper questionnaires, in order to assess the socio-demographic and situational profiles of local communities. This is in order to understand the current knowledge and attitudes toward the project and climate change. Further cross-sectional interviews are conducted after the CDR research has been implemented (olivine sand placement) to measure any influence of the implementation of the CDR research and community engagement, with datasets treated as a like for like comparative. They are initially drawn from a non-probability sample of the local population identified through a chain referral method. This involves selecting individuals as key informants referred to by local representatives and based upon criteria discussed with the community leaders (gatekeepers) representing the key target groups within the local community. These groups include a women's collective, fisherman's group, local government representatives

(Municipal District), educational and religious leaders, a handicraft group and the neighborhood council. While the initial focus of the data collection is to obtain an informative baseline from key individuals affected directly or indirectly by the CDR technology and community outreach, a probability sample of the entire population of neighboring communities to the project (Newing, 2010) alongside longitudinal data may also be compared over time to monitor any trends and changes, and to respond to potential sources of influence.

Community working groups

Local community members affected by the project must be listened to, understood, and involved in the decision-making process through regular and structured outreach and engagement activities. After the initial baseline surveys are conducted, the second research phase involves regular focus group sessions defined by key community stakeholder groups, involving community representatives identified in the first phase baseline research and facilitated by Project Vesta staff and community members. The participative focus group meetings discuss the project's development and encourage feedback on any insights or queries from the broader cross-sections of the communities. These meetings aim to understand the communal processing of notions and social constructs to generate meaning (Morgan & Morgan, 1997), and are regarded as a powerful method to provide rich understandings of certain social issues and socially constructed discourses (Agar & MacDonald, 2008). In this case the themes are determined by local representatives, emerging from responses to the baseline survey interviews, although there is also a research commitment to explore important notions of climate change, socio-cultural significance of the coastal habitat, and perceptions of (and engagement with) the project. By creating platforms whereby multiple members of the community participate in open discourse on key topics, a deeper understanding of collective meaning in relation to the research objectives is gained, as well as a pertinent opportunity to record and relay the knowledge, concerns and needs of the local communities.

Qualitative interviews

Also in the second phase, immediately following each focus group session, qualitative ethnographic interviews are held with a chain referral sample of representatives from each of the local targeted community groups. These help to reveal a further layer of depth to explore the research objectives, revealing the stories and personal perspectives that underpin the responses provided within the baseline questionnaires and the collective notions brought up in the focus group sessions. The interviews are almost exclusively participant led and include only a few guiding questions. They continue until no new or significantly relevant data or patterns emerge, or the category becomes well developed and validated (Strauss & Corbin, 1998). This method enables in-depth, free, and unstructured inquiry into the key thematic areas and provides a 'deeper' understanding of social phenomena than would be obtained from purely quantitative methods, such as questionnaires alone (Gill et al., 2008).

Participatory governance and community outreach

Collectively, these multiple methods provide comprehensive and rich insights into the research objectives and help to gain a clear understanding of the cultural, communal, and local drivers of specific attitudes and behaviors relevant to climate change adaptation, and the key social considerations critical to engage in CDR initiatives. The nature of the methodology further helps to identify key local stakeholders, capture and respond to feedback, and initiate the enabling conditions for involvement where appropriate. Project Vesta works closely with local governments, universities, NGOs, and communities encouraging inclusion and collaboration at each step of the project's development. A long-term programme of community outreach and participatory activities is being established to support community development in the areas surrounding the CDR trial sites, informed by exploration of needs within the baseline surveys, focus groups and

qualitative interviews. Adoption of a possible model whereby carbon credit sales may be shared with local communities to support sustainable development (Blaufelder et al., 2021) is also central to the Project Vesta vision. Community members are actively encouraged to be spokespeople for climate change and coastal CDR in order to raise awareness within their offline and online social networks. Project Vesta also facilitates virtual platforms for dialogues about the work within and outside the community, including continuous updates about the scientific and community engagement aspects of the project. Regular feedback on the progress of the project is provided to a local steering committee comprising key stakeholders, including the National Environmental Ministry, science academy, National Authority for Maritime Affairs, Geological Society, and local NGOs. The committee routinely provides input and scrutiny into the scientific and public engagement approaches and has helped to inform the overall scientific strategy of the project.

Increasing awareness of the value of coastal resources that provide resilience to climate change can reduce vulnerabilities, in the same way that strengthening law enforcement can reduce unsustainable exploitation of resources (Rosa & Lohmann, 2015). Academic seminars and workshops with the Ministry of Environment are carried out alongside openings for student internships from a national Young Women in Science scholarship programme. Newsletters and participation in local media networks help to disseminate findings to both the broader scientific and lay public. To address the unique concerns of all representatives of the local communities, the working groups encourage members to review the information they are receiving, voice concerns, ask questions and make suggestions. Insights from the groups are communicated back to the management team in order to review recommendations and adapt approaches accordingly through a reflexive process. Responses are reviewed by the project team and responses are again relayed to the working groups at follow up- sessions, where appropriate inviting input from stakeholder representatives relevant to the query or concern raised.

The main objective of this approach is to ensure that every community member's opinion, concerns, or objections, are genuinely heard and addressed. Beyond simply attempting to avoid the mistakes of scientific research projects in the past, we also aim to develop new understandings of how a process of participatory governance might work in practice, with a commitment to reflexivity and an acceptance that mistakes will occur with ensuing adaptive measures. In doing so, the aim is to generate knowledge about participatory processes and CDR in the Dominican Republic, which may also be relevant to a wider range of contexts and interventions.

Toward localized governance and inclusion as standard practice in CDR development

In developing countries, achieving a meaningful role for CDR will need to be based on careful and sensitive programmes of stakeholder and public engagement (Healey et al., 2021). Responsible innovation can be seen as a way of embedding deliberation within the CDR development process. The framework proposed by Stilgoe et al. (2013) presents four dimensions of responsible innovation (anticipation, reflexivity, inclusion and responsiveness) stressing the importance of the input of diverse stakeholders and publics. Crucial to this process is second-order reflexivity (Schuurbiers, 2011), in which the value systems and theories that shape CDR governance are themselves scrutinized. Ultimately, defining and addressing issues which are specific to CDR approaches in each context will be critical to ensuring that it is done in a way that fairly distributes responsibilities and burdens, with communities at the core of decision-making (Batres et al., 2021). The US National Academy of Sciences argues that *"it is critical that research and development activities [on marine CDR] incorporate equity, diversity, and inclusion with a particular focus on coastal communities"* (2022:

59). While current discourses of CDR continue to be framed in planetary terms, attention should also be given to local and regional scales of assessment (Lezaun, 2021), and mechanisms must be designed that can mitigate the place-based conflicts that are bound to emerge in developing CDR at scale. Bellamy & Geden (2019) call for governance of CDR from the ground up, with reference to individual methods as they emerge in specific contexts. Localizing coastal CDR is crucial in characterizing its governance challenges, as it is necessary for identifying and involving the collectives and environments that will be most directly affected by their implementation.

Traditionally, CDR has been seen as most closely connected with mitigation (Cox et al., 2018; Heyward, 2013). Importantly for areas vulnerable to climate change effects, research on CDR also tends to sit apart from conversations on climate change adaptation, which arguably have a longer and richer history of engaging with climate justice discourses (Berrang-Ford et al., 2021; Popke et al., 2016). A critical question for this research is therefore whether studying CDR in a SIDS context raises novel, locally embedded and pertinent questions about the relationship between CDR and climate change adaptation. For example, there may be synergistic opportunities to conduct coastal enhanced weathering in conjunction with beach nourishment efforts for adaptation to sea level rise; yet the relationship between CDR and adaptation could also generate new risks, including the risk that CDR efforts could divert funding and policy attention away from vital coastal adaptation and capacity-building programs. Again, this creates a unique learning opportunity, and several groups including Project Vesta are exploring partnerships with coastal nourishment projects; this will need to focus on areas where sand placement methods are well developed and have well established assessment frameworks. Future research may be able to explore the potential impact of CDR upscaling on the ability of SIDS like the Dominican Republic to adapt to climate change.

We have outlined a simple model for integrating local ownership, participation, and localized governance through a case study in the Dominican Republic. The insights from this study align with recommendations that the inclusion of actors from the Global South may strengthen both research and governance (Winickoff et al., 2015). Reflexive approaches as presented here require that scientists think critically about the boundary between their roles and wider, moral responsibilities and that they challenge prevailing conceptions about the moral division of labour within science and innovation (Stilgoe et al., 2013). Care should be taken with adopting community-based and localized governance approaches, acknowledging the need to avoid forcing participatory processes (Cooke et al., 2001) and to recognise that local knowledge may reveal inaccuracies in methodological or ethical approaches (Tibby et al., 2007). We argue that encouraging a sense of agency, ownership and deliberation could help to foster inclusion-based principles and propagate localized governance opportunities.

Conclusion

The Caribbean is one of the most susceptible regions in the world to climate change, and the Dominican Republic is one of the top 10 most vulnerable countries to climate change effects, despite contributing only a relatively small amount to global greenhouse gas emissions. Notions of climate justice must play a strong role in any climate intervention, including novel proposals for Carbon Dioxide Removal. We have outlined a simple model for integrating local ownership, participation and localized governance, through a case study within a research project on enhanced coastal weathering, being conducted by Project Vesta in the Dominican Republic.

We argue that it is necessary to take into consideration the adaptation needs of groups vulnerable to marginalization in rural and coastal communities that are likely to be disproportionately affected by climate change. The inclusionary, selectively framed and locally salient principles outlined here speak to the foundations of climate justice, which we and others have presented as crucial principles for establishing the social trust and support to develop, trial and transition CDR technologies. In addition, this project may help to further the understanding of social and ethical risks and benefits associated with CDR; in particular, we will identify knowledge gaps relating to the interaction between CDR and climate adaptation, and around public attitudes toward CDR (especially ocean-based CDR) in the Global South. The project presents a unique learning opportunity to explore the translation of theories of responsible and just innovation into a real-world deployment context, with all its associated complexities and uncertainties. The project is now proceeding with the social research and participatory frameworks outlined in this paper, with preliminary results from the empirical work expected in 2023. Our eventual goal is to encourage further research which investigates how participatory, democratic, localized governance and selective framing approaches may influence public attitudes toward CDR in more climate vulnerable communities, and to inform strategies to develop more inclusive and just CDR solutions.

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