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Blue carbon as just transition? A structured literature review

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Review Article

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Abstract

Non-technical summary. Substantive carbon is sequestered in mangrove, saltmarsh, seagrass, and other marine ecosystems. Blue carbon is considered to offer potential for enhanced carbon sequestration. Bringing blue carbon to market, however, presents risks to local people and communities with livelihood and other connections to these environments. While efforts are forged to establish payments for ecosystem services, blue carbon presents critical challenges to social and environmental justice. In this paper, we synthesize insights from relevant literature and provide direction for future research on the social and cultural dimensions of blue carbon.

Technical summary. Blue carbon has been proposed as a nature-based solution to mitigate climate change and is the focus of concerted scientific and policy attention. The rush to operationalize blue carbon however, presents significant risks for social and environmental justice where it intersects with inequality and marginalization. To date, the reasonable and just consequences of the social transformation that will accompany blue carbon are under-examined. We undertake a structured literature review of research published over the past decade that addresses the social and cultural dimensions of blue carbon, and chart four themes: (1) conceptual issues, (2) governance issues; (3) emergent lessons (from practice); and (4) future research directions that address: social acceptability; processes to address social justice including engagement, participation, and benefit sharing; information and data deficits; and institutional governance reform. If the stated opportunities are to be fully realized, we argue the social and cultural dimensions of blue carbon, and its intersections with social justice, must be attended to explicitly and clarified.

Social media summary. Just transitions to climate change mean attending to people, culture, and livelihoods as blue carbon is operationalized.

1. Introduction

The term 'Blue carbon' ('BC') describes both the carbon sequestered in the biomass and soils of vegetated coastal ecosystems including mangroves, saltmarsh, seagrass, and the management approaches employed to ensure the storage of this carbon (Lovelock & Duarte, 2019, p. 1). Blue carbon ecosystems are significant natural carbon sinks due to their ability to trap sediments and accrete vertically (McLeod et al., 2011), and provide a host of valuable co-benefits including water quality improvements, fish habitat, and coastal protection (Barbier et al., 2011). While the meaning of blue carbon in some scientific fields is straightforward enough (Contreras & Thomas, 2019), emerging attempts to govern and promote blue carbon are of interest to environmental and critical scholars. This is because targeted interventions aiming to conserve, protect, and restore these systems for carbon sequestration may impinge on anthropogenic land-use, especially in the tropics, where most of the world's population lives (Sasmito et al., 2019; Zeng et al., 2021). Operationalizing blue carbon for climate mitigation therefore requires bringing together diverse disciplines and spheres of social action (Macreadie et al., 2022). Accordingly, initiatives – activities aimed at protecting and/or restoring blue carbon ecosystems – are not only complex and challenging to implement, they require critical attention with regard to how and with what effect people and communities are affected when specific environments are delineated for climate mitigation.

Substantial efforts by physical scientists to understand and quantify blue carbon thus far outweigh the depauperate state of knowledge about the social and cultural context in which it may be located. This knowledge gap is significant since the concentration of blue carbon at the coast collocates it with human populations and activity, including some of the most densely populated and economically marginalized regions on the planet (He & Silliman, 2019), and because payments for blue carbon actions require changes to existing land-use and livelihoods. Recent progress in bringing blue carbon to market (Lovelock et al., 2023; Sapkota & White, 2020) signals a shift in policy, opening the door for on-ground work, but with little acknowledgement of the people and communities who may be affected.

Furthermore, despite scientific progress, legal and policy changes to support blue carbon ecosystem protection and/or restoration, projects have been slow to emerge due to key knowledge gaps about social license and uncertainties around benefit sharing (Macreadie et al., 2022). In effect, operational issues reflect neglect of questions about blue carbon as a nature-based climate solution, and its intersections with environmental and social justice.

Like other nature-based climate solutions, blue carbon requires the transformation of social and cultural relationships – between private and public actors, local and global finance, scientific and other knowledges – and 'reflect[s] the evolving character of global environmental governance in response to climate change' (Contreras & Thomas, 2019, p. 227). Widespread uptake of blue carbon will be accompanied by redistributions of wealth and decision-making power, and thus requires substantial and ongoing consideration as to its just effects. Environmental social scientists are already attuned to these broader questions of climate mitigation, for example; how particular governmentalities may obscure the real causes of environmental loss and damage (Jackson et al., 2023); how technologies promoted to aid environments can mediate and/or promulgate damaging relations (Gabrys et al., 2022; Turnbull et al., 2023); and how deep connections to place intersect with where mitigation activities are located (Praskievicz, 2022). Broad frameworks are emerging for implementing just climate transitions (Malloy & Ashcraft, 2020). However, blue carbon as climate mitigation raises additional and unique challenges for people and communities; the location of blue carbon ecosystems in the intertidal zone is generally the point where different land tenures intersect, requiring wider systems of governance to be re-evaluated (Bell-James et al., 2023); blue carbon ecosystems underpin the fisheries resource and therefore will impact at a global scale as a key source of protein for billions of people, and income for many millions (Teh & Sumaila, 2013); and activities that will be encouraged in a blue carbon market, such as the flooding of coastal wetlands for restoration, will impact existing agriculture (Lovelock et al., 2023) at a time of increasing global food insecurity. The global blue carbon market is relatively new and mostly dominated by voluntary payment schemes for private equity investment, which are purported to offer 'niche' social and environmental benefits despite the absence to date of 'non-standard' performance measures (Vanderklift et al., 2019).

With these concerns in mind, this paper reviews recent research that addresses the social and cultural dimensions of blue carbon. In doing so, we aim to synthesize emergent lessons, identify key gaps, and bring the social and cultural dimensions of blue carbon more urgently into dialogue with other blue carbon research. In a systematic review of literature almost a decade ago, Thomas (2014) identified 46 articles focused predominantly on the biophysical science and economic dimensions in existence at the time. As Thomas (2014, p. 36) noted, 'little specific research had so far been conducted into the social aspects of blue carbon, particularly around community-level experiences and motivations; that is, the viewpoint of potential sellers of BC'. Since 2014, there has been some attention given to these aspects, although this literature has not been examined in any thematic way. Given the growing interest in blue carbon, including applications from The World Bank (Valero et al., 2021) and the US agency NOAA (Brodeur et al., 2022), calls for codes of conduct (BNA, 2020; CI, 2022), and the burgeoning nature of blue carbon research in financial markets (Friess et al., 2022) and governance (Bell-James, 2016), we undertook a structured literature review ('SLR') to track progress and outline where future research efforts are best placed to support just transitions.

We commence with a method and scope of data. Our review traces four themes in recent literature on the social and cultural dimensions of blue carbon: conceptual issues; governance issues; emergent lessons from practice; and fourth, future directions for research focused on: social acceptability; resolving processes impacting social justice and sustainability; addressing information deficits; and addressing governance reform. We argue that consideration of these aspects is key to advancing blue carbon in just and sustainable terms.

2. Review method and data

We undertook a SLR, an approach that has been deemed appropriate for 'under-investigated' fields and for identifying critical insights and future directions (Massaro et al., 2016, p. 767; Secundo et al., 2020, p. 2). Whilst different methods exist for undertaking SLRs (Armitage & Keeble-Allen, 2008; Massaro et al., 2016; Rocco et al., 2023), and methods are not formulaic, SLRs generally involve four key distinguishing elements which we used in our review; emphasis on qualitative content review; focus on addressing questions, including the use of conceptual frameworks and formulation of implications; articulation of a process which could be replicated and verified; and inclusion of data extraction and analysis (Rocco et al., 2023).

After establishing a review protocol (Petticrew & Roberts, 2008), we defined the research questions, as directed by Massaro et al. (2016). Our review sought to answer: (1) how blue carbon discourse is developing with respect to social and cultural dimensions; what emergent issues are apparent (or assumed) in relation to the incorporation of these dimensions into (2) governance frameworks and (3) individual projects (emergent lessons); and (4) what are the implications of these findings for the development of effective, feasible, and just governance of blue carbon initiatives? We selected the Scopus database of peer-reviewed journals (Mishra et al., 2017; Secundo et al., 2020), including in the environmental and social sciences (Blythe et al., 2020; Frohlich et al., 2018; Moore et al., 2014). We also conducted pilot searches of Web of Science, Lexis Advance, and Westlaw; however, these did not return new or relevant results. The keywords selected were '"*blue carbon*" *AND soci* OR cultur* AND governance OR policy OR regulation OR management*'. These terms sought to capture literature from a variety of disciplines including geography, law, and social policy, and interdisciplinary fields of conservation, biodiversity, and environmental management. We restricted inclusion to peer-reviewed publications, including empirical and review, and excluded conference papers.

Selected articles were examined, and excluded if they did not specifically address social and cultural dimensions. We suspected the Scopus search did not capture non-indexed scholarship and therefore supplemented with 10 articles, drawn from pre-existing knowledge. These additions were made subsequent to initial coding but were coded the same way. From a replicability perspective, this is a limitation, but necessary to ensure the totality of relevant literature. A second limitation is the restriction of scope to articles published in English, excluding scholarly contributions from diverse languages and cultural backgrounds.

Our review sample includes 35 articles published between 2014 and 2022 (Table 1). We note a steady increase over time in the number of publications related to the social and cultural dimensions of blue carbon (Figure 1). Geographic coverage is broad; just under 30% of articles do not specify a geographic

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Table 1. Selected studies of social and cultural dimensions of blue carbon included in structured review

Key themes	Study	Study area	Methodology	Codes
Conceptual	Quevedo et al. (2020a)	Southeast Asia (Philippines)	Stakeholder interviews	*alternative perspectives*
Conceptual	Quevedo et al. (2021a)	Southeast Asia (Philippines)	Stakeholder interviews	*drivers of community perceptions*
Conceptual	Song et al. (2021)	Southeast Asia (Philippines)	Literature and policy review	*alternative perspectives*
Conceptual; methodological	Cisneros-Montemayor et al. (2019)	Unspecified	Literature review	*alternative perspectives; actual benefits; availability of information*
Conceptual; methodological	Reiter et al. (2021)	Unspecified	Theoretical analysis (response to Paris Agreement)	*alternative perspectives; identify drivers of community perceptions; actual benefit; tradeoffs, displacement*
Conceptual; methodological	Merk et al. (2022)	Unspecified (local-commons contexts)	Literature review	*ideological barriers; effective engagement*
Conceptual; policy/ practice	Cormier-Salem (2017)	Africa (including Madagascar)	Surveys (stakeholders, longitudinal)	*alternative perspectives; unethical outcomes; governance structures; tradeoffs, displacement; tenure*
Conceptual; policy/ practice	Contreras and Thomas (2019)	Indo-Pacific	Case studies, literature review	*alternative perspectives; neoliberalism; governance structures*
Conceptual; policy/ practice	Neimark et al. (2020)	Africa (Kenya); South-East Asia (Philippines & Cambodia)	Theoretical analysis; case studies.	*Neoliberalism/unfair labour practices; practical implementation*
Conceptual; methodological; policy/ practice	Espinoza-Tenorio et al. (2019)	North America (Mexico)	Empirical analysis	*alternative perspectives; drivers of community perceptions; actual benefits; availability of information knowledge; tradeoffs, displacement; land tenure*
Conceptual; methodological; policy/ practice	Herr et al. (2019)	South-East Asia (India, Indonesia); Africa (Kenya, Madagascar)	Case study analysis	*alternative perspectives; actual benefits; availability of information; governance structures; tradeoffs, displacement; land tenure; impact of external factors.*
Conceptual; methodological; policy/ practice	Bennett et al. (2021)	Unspecified	Literature review	*alternative perspectives; drivers of community perspectives; unethical outcomes; actual benefit; tradeoffs, displacement*
Conceptual; methodological; policy/ practice	Dencer-Brown et al. (2022)	Unspecified	Surveys (of experts in blue carbon)	*reinforcing inequality; alternative framings; effective engagement; actual benefits; complex/fragmented governance; trade-offs; displacement*
Methodological	Wylie et al. (2016)	Africa (Kenya, Madagascar); South-East Asia (India, Vietnam)	Empirical analysis (case studies)	*actual benefit*
Methodological	Quevedo et al. (2020b)	Southeast Asia (Philippines)	Stakeholder interviews	*definition / understanding of effective engagement*
Methodological	Quevedo et al. (2021b)	Southeast Asia (Philippines)	Stakeholder interviews	*definition / understanding of effective engagement*
Methodological	Mateos-Molina et al. (2021)	Middle East (UAE)	Empirical analysis (spatial habitat mapping)	*availability of information/knowledge*
Methodological	Quevedo et al. (2021c)	Southeast Asia (Philippines)	Stakeholder interviews	*definition / understanding of effective engagement*
Methodological; policy/ practice	Thompson et al. (2017)	Southeast Asia (Philippines)	Multi-methodological including policy review, stakeholder interviews	*actual benefit; governance structures; tradeoffs; land tenure*
Methodological; policy/ practice	Vierros (2017)	Unspecified	Literature review	*understanding of effective engagement; actual benefit; governance structures*
		Unspecified	Literature review	

(*Continued*)

Table 1. (*Continued.*)

Key themes	Study	Study area	Methodology	Codes
Methodological; policy/ practice	Cisneros-Montemayor et al. (2022)			*effective engagement; actual distribution of benefits; governance; displacement; tenure*
Methodological; policy/ practice	Macreadie et al. (2022)	Unspecified	Review (opinion)	*effective engagement; distribution; information deficit; land tenure*
Methodological; policy/ practice	Warner et al. (2016)	Southeast Asia (Vietnam)	Literature review and empirical analysis (fieldwork data)	*definition / understanding of effective engagement*; *governance structures; land tenure*
Methodological; policy/ practice	Thomas (2014)	Unspecified	Literature review (incl. gray literature)	*availability of information / knowledge; governance structures*
Methodological; policy/ practice	Hejnowicz et al. (2015)	Unspecified (draws on multi-nation examples)	Literature and policy review	*actual benefits; availability of information / knowledge*; *governance structures; tradeoffs, displacement; land tenure*
Methodological; policy/ practice	Vanderklift et al. (2019)	Unspecified	Literature review	*private & public investment; regulatory conditions; stakeholder engagement; benefits*
Methodological; policy/ practice	Ruiz-Frau et al. (2017)	Global	Literature review; ecosystem services analysis	*ecosystem services; policy development*
Methodological; policy/ practice	Sangha et al. (2019)	Australia (Northern Territory)	Review and analysis	*ecosystem services; cultural values; payment mechanisms*
Methodological	Raw et al. (2021)	South Africa	Scientific modelling	*availability of information*
Policy/practice	Aziz et al. (2016)	South-East Asia (Malaysia)	Stakeholder interviews and analysis	*governance structures; trade-offs, displacement; tenure*
Policy/practice	Thomas (2016)	South East Asia (Malaysia)	Theoretical analysis (systems-based political ecology)	*governance structures; trade-offs; tenure*
Policy/practice	Howard et al. (2017)	Unspecified; Case studies (Indonesia, Australia, USA)	Empirical analysis (framework)	*tenure*
Policy/practice	Schröter et al. (2018)	Central America (Costa Rica)	Social network mapping	*governance structures*
Policy/practice	Bryan et al. (2020)	West Africa (multi-national)	Review and ecosystem service analysis	*tenure*
Policy/practice	Friess et al. (2020)	Unspecified	Literature review	*governance structures; ecosystem services & disservices*

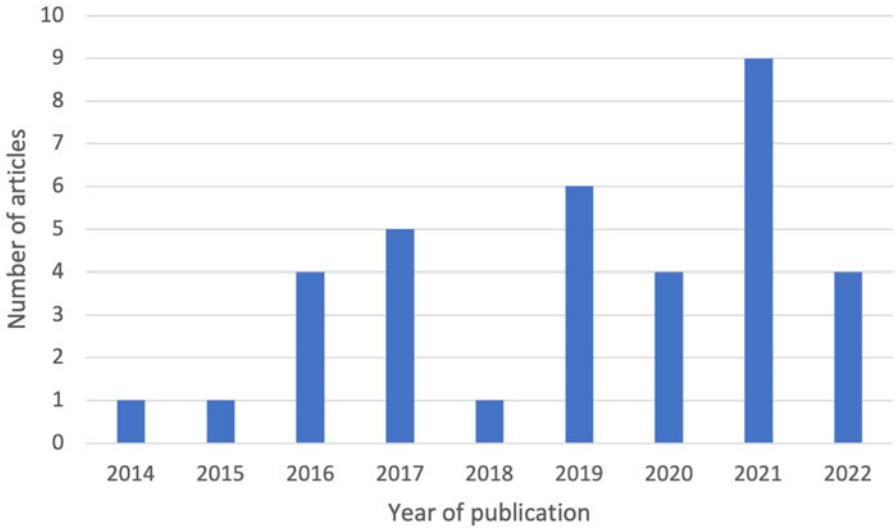

Figure 1. Selected articles by year of publication, demonstrating the overall increase in publications addressing the social and cultural dimensions of blue carbon over time.

scope, particularly reviews. Works from South America are absent (Table 1). We also identified each article's methodology, which ranged from empirical studies (which particularly focused on understanding stakeholder perspectives – see e.g. Aziz et al., 2016; Quevedo et al., 2020a), to case studies (e.g. Contreras & Thomas, 2019), and reviews (e.g. Vanderklift et al., 2019) (Table 1). Where relevant, we sought to extract empirical examples from the literature, however, the early stage of this field means that there are limited (peer review reported) examples to draw from to date.

Our analysis was guided by four pre-identified themes (aligned to the SLR question model): (1) conceptual issues (addressed by 13 articles); (2) governance issues (addressed by 23 articles); and (3) emerging lessons (from practice) (addressed by 23 articles) (Table 1). While reviewing the articles, qualitative codes were inductively generated by one researcher, following discussion and development of the research protocol (Cope, 2010). The codes themselves were subsequently checked and queried by other team members, until a final set emerged. These codes eventually informed the content of discussion under each of the four themes. After the set of codes were generated, code validity was established by selecting codes and classifying adjacent context. For example, the code 'land tenure', initially attributed to the 'governance' theme, was tested for strength and impact by assessing whether it was absent, present without definition, or well developed in each article. Each code was therefore reviewed by at least two co-authors, ensuring the insights generated were accurate (Rocco et al., 2023). Our final theme (4) charts future directions and scope for further research.

3. Results

3.1 Conceptual issues: how is blue carbon discourse developing with respect to the social and cultural dimensions?

The topic of blue carbon draws in concepts from across the social sciences that have been discussed at length. Significant amongst those is that the terms deployed within mitigation agendas are far from shorthand descriptor or objective codifier. Rather, terms such as blue carbon become apparent in science, policy, and practice, serving to shift vested political, social, and economic interests, marking their social construction (Castree, 2013) in discourse. In short, the social construction of climate mitigation phenomena enables an understanding of blue carbon not only as material phenomena, but also as becoming part of social, political, and social systems (Bridge, 2011) that work in tandem with efforts to materially sequester physical carbon. Within the discourse on blue carbon, as interests and efforts evolve, ideas and concepts take on new meaning and significance. In our review, we identified three key concepts apparent *within* contemporary blue carbon scholarship on social and cultural dimensions – resilience, care, and ethics – noting how each is shaping the direction of current efforts. As we outline here, these three concepts are contributing to the early social construction of blue carbon initiatives as something inherently good.

First, the concept of resilience is widely, and yet mostly uncritically, deployed as a way of promoting the potential of blue carbon ecosystem protection (also restoration) for livelihood sustainability; that is, that addressing ecosystem conservation will *benefit* livelihood resilience. The significance and function of blue carbon ecosystems for promoting physical resilience along coasts have been noted by natural scientists for some time (Van Slobbe et al., 2013). In this context, blue carbon ecosystems are also sometimes referred to as 'green infrastructure', and are increasingly promoted as part of contemporary adaptation measures to the emerging impacts of climate change such as a sea-level rise (Macreadie et al., 2021), including in developing country contexts (Zeng et al., 2021). The use of the term 'resilience' in the natural sciences often relies on an understanding of ecological resilience, being traits that promote ecosystem recovery and thereby resistance to stress and disturbance (De Battisti, 2021). The potential of blue carbon ecosystems for building livelihood resilience is often foreshadowed in science and policy scholarship as a way of addressing existing social vulnerability (Quiros et al., 2021), diversifying livelihoods away from damaging income strategies (Bunting et al., 2017), and as remedy to disaster resilience (Lee et al., 2022). On the face of it, these would seem to be valuable objectives.

However, as has been discussed by social scientists at length outside the blue carbon context, livelihood resilience has long been difficult to define, observe, and measure (Adger, 2000; Weichselgartner & Kelman, 2015). Within the research we

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reviewed, resilience has received some limited scholarly attention, approached and measured as part of socio-ecological systems, as social capacity for learning and adaptation to change (Espinoza-Tenorio et al., 2019). And others have been cautious about claims regarding the potential of blue carbon efforts to promote livelihood resilience (Espinoza-Tenorio et al., 2019; Herr et al., 2019). Restraint from these scholars may reflect an understanding of social complexity, built on empirical analysis and diverse geographical case studies (see Table 1), that acknowledges that while some people and communities benefit from conservation actions, others do not. For example, benefits derived from projects that aid livelihoods can be distributed, long-term and difficult to attribute to mitigation activities undertaken (Espinoza-Tenorio et al., 2019; Herr et al., 2019). Critical scholars have argued that asserting such outcomes will flow from blue carbon initiatives, risks trivializing and disadvantaging those communities projects seek to address (Song et al., 2021). Testing assumptions about blue carbon and livelihood resilience is therefore essential, as is a more robust approach to its conceptual deployment within research.

Second, the concept of care has been used to highlight the value of blue carbon in climate mitigation. For example, in non-government circles (e.g. RTW 2024), and private development initiatives (e.g. BHP 2024), care is being mobilized to raise public awareness and generate social license. Care is a strongly normative concept and has received extensive attention in environmental fields (Conradson, 2011; Milligan & Wiles, 2010) owing to its widespread and diverse use in framing socially desirable human relationships with the environment and other aspects of social life. Normative environmental reproductions of care are derived from dominant, often scientific, approaches to environmental governance rooted in a modernist ontology (DePuy et al., 2022). These commonly assume a public good model of goal setting, treating individuals, communities, and organizations in flattened ahistorical hierarchies with perspectives, attitudes, and behaviors to be managed or addressed, often as lacking in relation to care (Bennett & Satterfield, 2018). Such constructions of care can make it difficult to identify what constitutes care, or that some forms of care are valued or more desirable over others (DePuy et al., 2022). For example, as some have claimed in the literature we reviewed, there is a risk that blue carbon projects, often driven from 'elsewhere' (often developed world contexts) promote blue carbon initiatives in aid of protecting the environment, but repeat damaging colonial histories and paternalistic approaches when they assume either that people don't already care for local places, or when they don't recognize how local people practice environmental protection (Bennett et al., 2021; Cormier-Salem, 2017).

In the scholarly literature we examined, care is infrequently mentioned and it is asserted as being required (e.g. in design) but not often defined or contextualized (Dencer-Brown et al., 2022; Vierros, 2017). Critical scholars of blue carbon warn normative framings of care can fail to account for the deep and 'complex' character of human–nature relationships (Song et al., 2021) that manifest diverse understandings, histories, and practices. Thus, notions of what constitutes good or appropriate care for blue carbon environments may not be shared and don't always align with how care in understood or practiced in local contexts. Conceptual clarity with regard to care is not esoteric to operationalizing blue carbon; as mooted in the literature, projects may meet resistance where for example, commodification of nature, which is key to how a blue carbon market will work, is understood to be in conflict with social and cultural traditions of caring for nature (Reiter et al., 2021), and interrupting cultural connections may undermine Indigenous and local maintenance or care practices, disrupting 'social relations and cohesion' (Bennett et al., 2021, p. 4). Some go further, arguing we need to rethink the paternalism of western governance, and assert it might be reframed in relation to local stewardship, for example, through the 'logic of care' in order to 'valorize' and 'mainstream' decarbonization (Contreras & Thomas, 2019; see also Jackson et al., 2017, p. 867). Ongoing scholarly attention to the deployment and normative assumptions of this concept and its relationship to blue carbon is warranted.

Third, and surprisingly, given widespread concerns about the 'proximity' of modern, mostly western and global north, conservation efforts to profit making ideologies and enterprises (Shoreman-Ouimet & Kopnina, 2015), the meaning of ethics and justice remain underdeveloped in blue carbon literature. This is not to say that ethics and justice are not discussed, but that in work we reviewed, the focus of concern has mostly been confined to aspects of implementation, rather than with systematic and integrated attention to how environmental justice is defined and practiced in systems of governance (Schlosberg, 2007). For example, as the literature we reviewed indicates, there are already legitimate fears that blue carbon initiatives may promote unethical outcomes where they perpetuate unfair practices by characterizing labor as participation and not properly compensating people for their work (Neimark et al., 2020, p. 499). Likewise, there are specific fears about intrusion into local or Indigenous places and in local common contexts (Merk et al., 2022). Institutions, in which a monetary carbon payment would function, are thought to pose risks to local communities through appropriation of knowledge (Dencer-Brown et al., 2022) and by assuming and replicating power asymmetries about whose knowledge counts (Contreras & Thomas, 2019). Authors also note, across countries in Africa, that projects may threaten dispossession (Cormier-Salem, 2017). Recent review contributions in blue carbon argue, 'social equity and human well-being should not be viewed as a means to an end but as the overarching goal' (Cisneros-Montemayor et al., 2019, p. 3). Others indicate there are significant tensions with regard to the urgency of climate mitigation agendas and justice, for example, as work is 'scaled-up' to meet national or global impact agendas (Dencer-Brown et al., 2022).

Design and implementation issues are significant for ethics and justice (more on these below), but the blue carbon literature to date reflects a lack of attention to the conceptual complexity of these terms. For example, recent work outside blue carbon highlights the need for robust conceptualization, and integrated and intersectional approaches to climate transitions and justice (Amorim-Maia et al., 2022; Sultana, 2022) in order for initiatives to address multiple and coinciding forms of injustice. Additionally, in conservation settings (outside blue carbon), the perpetuation of nature culture or nature society binaries – pitting humans against nature, or social against ecological justice, is argued to be 'theoretically inadequate' (Shoreman-Ouimet & Kopnina 2015, p. 320) leading to perceptions that efforts focused on human justice come at the expense of nonhuman nature. Such ontological arguments are considered relevant in ocean and coastal contexts; Bercht et al. (2021) argue the histories and narratives of environmental, climate, and marine justice are all intertwined and relevant for understanding conflicts. However, in the blue carbon literature, there was little, if any, direct acknowledgement or attention to ontologies of justice, and we noted the

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absence of multi-species justice in recent synthesis for 'blue growth and blue justice' (Bennett et al., 2021).

3.2 Governance issues: what emergent issues are apparent in relation to the design and incorporation of social and cultural dimensions into governance frameworks?

A second distinct theme in the scholarship we considered were the governance issues associated with designing blue carbon policies and projects. Blue carbon is governed by a complex array of fragmented and/or overlapping legal and policy frameworks, which operate in a part of the landscape where land tenure can be contentious. The themes of care and ethics (from above) can also be traced through this theme, with a number of scholars raising concerns about how Western market-based concepts can, perhaps inadvertently, lead to or exacerbate inequality. The literature also considers how blue carbon governance can incorporate bottom-up governance models, local knowledge, and ensure equitable outcomes.

First, the complex, fragmented, and sometimes overlapping nature of environmental governance frameworks has for some time been noted as a barrier to successful management of blue carbon ecosystems (Friess et al., 2016; also Rice, 2011). This situation is noted as partly due to definitional issues – that is, a lack of clarity and consistency in what a 'mangrove' is, and therefore how it is classified and governed (Thompson et al., 2017). It also relates to the multi-level governance structures commonly in place to manage coastal ecosystems, and which may or may not be well integrated (see e.g. in the Philippines, Thompson et al., 2017). Blue carbon implementation presents further complications. For example, Thomas (2016) referring to a case study in Malaysia notes that despite a substantial body of environmental laws and regulations in place, there are also overlaps and gaps in coverage which compound management difficulties alongside inadequate law enforcement, corruption, and racism. Likewise others note, also based on case work from Malaysia, the fragmented nature of governance structures can prevent equitable distribution of benefits (Aziz et al., 2016), indicating the import of addressing justice in both procedural and distributional terms.

Second, land tenure is also underscored as a widespread and ongoing governance issue (Aziz et al., 2016; Dencer-Brown et al., 2022; Thompson et al., 2017; Warner et al., 2016), with Bryan et al. (2020, p. 8) noting that it is 'perhaps the most ambiguous yet crucial potential impediment'. This impediment is attributed to patterns of ownership of land and resources, especially in developing countries, not always being clear, and being governed by a complicated patchwork of overlapping, formal, and informal (customary) tenure and rights-based arrangements (Dencer-Brown et al., 2022; Hejnowicz et al., 2015, p. 14 and see also Awono et al., 2014; Resosudarmo et al., 2014; Rights & Resources Initiative, 2014; Sunderlin et al., 2014). Scholars of blue carbon included in our review noted that contexts where these factors coincide can lead to conflict and increased degradation of mangroves (Espinoza-Tenorio et al., 2019). Relatedly, customary tenure regimes may not necessarily cohere with the type of legal arrangements commonly associated with PES (payment for ecosystem services) schemes. For example, Thomas (2016) observed that in Sabah, Malaysia, Indigenous people believe that land, culture, and community are deeply connected, underscoring the relevance of ontologies of care and ethics noted above. Further, in West Africa, where tenure is unclear, there is a potential for land grabbing and for traditional owners to be excluded from accessing their land (Bryan et al., 2020). Whilst some blue carbon scholars argue that land tenure issues should be considered and resolved early in a process, which may require input from government agencies and will therefore differ in geographic context (Howard et al., 2017), others highlight this process should always aim to avoid marginalization of communities, and reinforcement of social inequities and power imbalances (Hejnowicz et al., 2015).

However, as the literature makes clear, the solution to the issue of land tenure and blue carbon governance is not simple, and formalizing rights to either land and/or coastal resources does not guarantee fair outcomes (distributional justice) for local communities. Case study research illustrates that at its best, formalization of rights might provide certainty, but at its worst, may restrict access to common resources (Herr et al., 2019). For this reason, recent reviews note, 'processes of formalisation should be founded on principles of deliberation, community partnership and co-production, and should avoid entrenching historical inequalities and setting-up new ones, whilst recognising customary (and historical) rights to resources' (Dencer-Brown et al., 2022, p. 1983). Picking up on the thread of 'care', Dencer-Brown et al. (2022) also recently warn of imposing a Western governance model to questions of tenure and resource use upon communities that is incoherent with traditional notions of land management.

Third, land tenure issue is part of a broader challenge of reconciling local governance structures with a notion like blue carbon, that is both a biogeographic, geochemical and ecological phenomena and now manifests as part of State-led and market-focused systems. As the articles we reviewed note, blue carbon as climate mitigation in fact requires the input of local knowledge and frameworks that go 'beyond the state-centric regimes' (Contreras & Thomas, 2019, p. 227) and address recognition (or representation) justice. Multi-nation policy analysis suggests this lends legitimacy to decision-making, maximizes participation and supports local values and customs (Hejnowicz et al., 2015). This is especially so in regions where blue carbon stocks are common pool resources (Thomas, 2014, p. 34), because in these situations, there is also a risk that top-down approaches could marginalize or exclude local and Indigenous communities' knowledge and traditions, and can affect livelihoods and subsistence.

Such marginalization is apparent, for example, through criminalizing the taking of timber that has typically been used for fuelwood (Herr et al., 2019; see also Wittman & Caron, 2009), or fish traditionally taken by small-scale fishers (Bennett et al., 2021), and in the marine-protected areas (not blue carbon) domain, where communities have been prevented from undertaking traditional subsistence activities (Vierros, 2017). Blue carbon scholars have noted that where projects fail to design to include communities, they can lead to disempowerment and embed benefit-sharing inequalities (Hejnowicz et al., 2015, p. 14) and can cause mistrust, opposition, and a lack of knowledge and understanding of policies (Cormier-Salem, 2017; Herr et al., 2019, p. 475). In some circumstances, scholars suggest conflicts may even arise between traditional users of resources and blue carbon proponents, especially where the traditional users are excluded from use without compensation (Espinoza-Tenorio et al., 2019). Accordingly, top-down blue carbon governance also risks leading to displacement of communities (Herr et al., 2019) including through green gentrification (the exclusion or displacement of residents through environmental programs) (Reiter et al., 2021) and land- and carbon-grabbing by foreign investors or state governments (Bennett et al., 2021; Reiter et al., 2021; see also

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Fairhead et al., 2012; Rights Resources Initiative, 2014). Outside blue carbon contexts, some report this risk has become a reality for local communities in Canada, the US, and Iceland, where there has been evidence of lost access to fisheries resources due to privatization (Bennett et al., 2021). The foreshadowed risk of displacement is also understood to stem from the fact that most markets for blue carbon are in highly developed regions of the world, while projects themselves are often located in developing regions (Cisneros-Montemayor et al., 2022).

The literature reviewed offered potential mechanisms to address such governance and design problems. In some circumstances, potential impacts on livelihoods may be addressed through the terms of a blue carbon project, as the degree to which natural resource use is restricted can have serious impacts on long-term livelihood prospects (Herr et al., 2019). Another suggestion is to establish marine-protected areas alongside PES schemes, which can ensure the underlying (fish) resource base is safeguarded (Hejnowicz et al., 2015), although we note concerns from other contexts involve critique of NGO established MPAs as 'ocean grabbing' (Bennett et al., 2015). Locally managed marine areas or responsible fishing areas were also suggested as mechanisms to 'create socially inclusive and participatory governance' by involving local communities in monitoring and compliance activities (Dencer-Brown et al., 2022, p. 6). Decentralization was noted as a potentially useful middle ground between top-down and bottom-up governance (Schröter et al., 2018). Decentralization may deliver other advantages also, as centralized administration has been observed as stifling local-scale innovations (Hejnowicz et al., 2015). A decentralized regime may involve intermediaries including 'public players (such as agencies and ministries), … civil society players (such as environmental associations) or … private (market) players (such as carbon companies)' (Schröter et al., 2018, p. 637). Such an approach could ensure connections are made across stakeholders from different backgrounds (Schröter et al., 2018).

Fourth, a further layer of potential governance issues arise when designing PES schemes, with a number of scholars noting establishing a scheme in the coastal zone may have socio-ecological trade-offs (Dencer-Brown et al., 2022; Thomas, 2016; Thompson et al., 2017; see also Daw et al., 2015; Granek et al., 2010). These are broadly described as occurring when an action enhances one aspect to the detriment of another; for example, 'a policy designed to improve ecological status might lead to improvements of the well-being of some people and to a decrease in the well-being of others' (Galafassi et al., 2017, p. 1). Thus, the literature we examined focused on how schemes *should* be designed so benefits may be shared in an equitable fashion. These trade-offs may be difficult to perceive, but should, according to some, be made explicit to decision-makers as they can be a barrier to just use of PES, and can allow for terms to be written into contracts directing where monies can and cannot be spent (Thompson et al., 2017). Linking design to practice (below), Aziz et al. (2016), based on stakeholder analysis in Malaysia, advocated for the early identification of stakeholders and their objectives and concerns, to assist decisions about trade-offs and holistic consideration of services to avoid negative impacts. Others concur, noting identification must endeavor to incorporate considerations of procedural and distributional justice, gender equity, and seasonal flows of migrant works (Dencer-Brown et al., 2022).

Finally, even a well-designed governance regime will have limits because it cannot protect against external factors, and livelihood outcomes of a project could be affected by factors such as changes in climate policy, shocks such as natural disasters, or seasonal price fluctuations (Herr et al., 2019). In this sense, blue carbon governance issues are not dissimilar to other environmental governance issues, but the often decades-long time scales associated with blue carbon contracting and crediting make them particularly pertinent (see e.g. Bell-James, 2023), linking to questions of practice.

3.3 Emerging lessons: what emergent issues and lessons are apparent in projects so far (in practice)?

The conceptual and governance design issues identified above provide an opportunity to draw out key lessons from existing blue carbon projects. Embedding considerations of these dimensions are noted by many as a key aspect of meaningful, equitable, and indeed successful projects (Cisneros-Montemayor et al., 2019; Thomas, 2014; Warner et al., 2016). However, current implementation examples are noted to continue to lack clarity and practicality (Song et al., 2021). We identified three emerging lessons related to: community involvement; addressing the limitations of current knowledge; and the actual and equitable distribution of benefits.

First, one consistently identified measure of 'success' in blue carbon projects is the meaningful participation of local communities (Quevedo et al., 2021b; Thomas, 2014). However, exactly how this can or should be achieved continues to be a point of contention. While scholars assert local communities should be included and consulted in planning and implementation, prioritized for employment and leadership, and project benefits should flow to them (design issues noted above), there is broad consensus that practical implementation may prove challenging (Cisneros-Montemayor et al., 2022, 2019; Song et al., 2021). Warner et al. (2016), drawing on empirical work in Vietnam, attest to the need for sustained involvement of communities throughout project lifetimes, including by initially acknowledging community values, which are used to inform and motivate projects. Important avenues of initial engagement with local communities, including significant contributions from the Philippines, include investing in education (Dencer-Brown et al., 2022; Quevedo et al., 2020b), raising community awareness of blue carbon management and opportunities for participation (Quevedo et al., 2021b), and capacity building through, for example, training initiatives (Quevedo et al., 2021c; Vierros, 2017; Warner et al., 2016). Establishing meaningful partnerships, where communities and scientists are positioned as equal, is also underscored as critical (Quevedo et al., 2021b; Vierros, 2017), given the complexity of carbon accounting processes (Dencer-Brown et al., 2022). Quevedo et al.'s (2021b) study based on perception surveys about mangrove eco-parks reported benefits for local stakeholders, particularly where there was local management providing a local income source (2021b).

We noted that suggested ways to enhance local communities' involvement are often unclear and couched in vague terms including establishing partnerships, improving community knowledge, and undertaking stakeholder engagement, perhaps indicating a lack of clear policy direction or connection to learning from practice. Equally, this linguistic ambiguity may reflect local communities should themselves be empowered to identify project objectives tailored to the specific needs and conditions of that area. A positive example was noted in the Vanga Blue Forest project in Kenya, which took a collaborative approach,

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and was undertaken under legislation supporting co-management rights to the forest (Dencer-Brown et al., 2022). The research undertaken by Quevedo et al. (2020a, 2020b, 2021a, 2021b), into local perceptions of seagrass and mangrove ecosystems in the Philippines, demonstrates the importance of accounting for individual communities' viewpoints and experiences with blue carbon ecosystems.

Importantly, the discussion of local community involvement solely within the realm of stakeholder engagement is a potential pitfall for effectively integrating social and cultural dimensions of blue carbon. Some concisely note inclusion alone is insufficient (Merk et al., 2022); others emphasize the importance of self-determination and empowerment in local communities' involvement in projects (Contreras & Thomas, 2019). Thomas's seminal 2014 paper framed success as dependent on 'effective stakeholder engagement *and* participation of local communities' (emphasis ours). This dual perspective could inform iterative design of processes to ensure meaningful and sustained inclusion of local communities and their concerns throughout projects. But continued consideration of this issue indicates engagement might require legal rather than voluntary frameworks to be meaningful (Cisneros-Montemayor et al., 2022). Clarity around the role of local communities is articulated as a priority (Vanderklift et al., 2019). These scholars indicate future projects should position communities as part of the overarching objective for projects, rather than as one element of consideration in decision-making.

Second, concerns emerged in the literature about a lack of readily available social and cultural data with which to inform blue carbon projects, reflecting neglect of recognition justice (noted above). Informational deficit was observed in relation to both the identification and measurement of social factors to guide decision-making, consistent with other studies (see Ascough II et al., 2008). At a global scale, language and translation issues are apparent in terms of studies available for ready comparison (see Table 1). However, measuring social and cultural values and/or services, particularly in conventional economic terms, is not always possible. The well-established complexity of the intertidal zone identified decades ago (Kunstadter & Bird, 1986) exacerbates the challenge of articulating its values to people, something blue carbon scholars are continuing to note (Raw et al., 2021; Ruiz-Frau et al., 2017), including for example in empirical analysis from Mexico (Espinoza-Tenorio et al., 2019). As Thomas (2014) opined, this is a task complicated by the diversity of possible stakeholders with potentially varying values. In practice, some scholars have adopted substitute values for Indigenous values due to methodological limitations (Sangha et al., 2019). The implication of the lack of social and cultural data for projects is the long-term and distributed social impacts (distributional justice) of blue carbon interventions – to aspects such as human well-being – may not become clear until years later, and that causation can be difficult to establish (Herr et al., 2019). For example, Herr et al. (2019) identified, from coastal offset projects across South-East Asia and Africa, both positive improvements to literacy and education but also negative impacts resulting in social conflict. In this regard, improved and ongoing monitoring that fed project outcomes into ongoing management was required.

A further concern regarding information deficit lies in the incorporation of local data accounting for spatial variation. Scholars note this aspect has lacked research focus to date, likely due to local financial and/or research constraints and historical exclusion of certain social groups from environmental governance processes in less developed countries (Cisneros-Montemayor et al., 2019; Hejnowicz et al., 2015). Effective blue carbon initiatives are informed by local knowledge and data across project lifetimes (Mateos-Molina et al., 2021), though a persistent deficit has been observed in relation to current understandings of the role of local and Indigenous knowledge in projects, including in the developed world (Contreras & Thomas, 2019; Macreadie et al., 2022; Vierros, 2017). The place of Indigenous knowledge in conservation more broadly is highlighted in recent commentary, underscoring the need for both recognition of the legitimacy of Indigenous and local knowledge, and attention to how knowledge is gathered and utilized (Folke, 2004; Reyes-Garcia & Benyei, 2019). Helpfully, as some note regarding blue carbon, information-gathering initiatives could help to incorporate vital local traditional Indigenous knowledge about ecosystems, ecosystem connections, and the impacts of management actions, in turn enhancing identification of best-practice sites and approaches (Vierros, 2017). Recent coastal habitat mapping from the United Arab Emirates provides an example of how local ecological knowledge could be meaningfully incorporated into projects (Mateos-Molina et al., 2021).

Finally, there is much critique and further scope to improve the provision of benefits, to close the loop between governance and project generated experience. A key aspect raised is how benefits are distributed; specifically, to whom and how benefits flow affects the delivery of socially and culturally equitable (and accordingly successful) projects (Aziz et al., 2016; Bennett et al., 2021; Macreadie et al., 2022; Vierros, 2017). Some scholars question whether benefits foreshadowed do in fact contribute to local livelihoods (Thompson et al., 2017; Vierros, 2017). Merk et al. (2022) pointed in their review to aquaculture cases where benefits have accrued to a select few managers, rather than the broader coastal community. In the Philippines, payments have been 'in cash' or 'in kind', to individual households or across communities (Thompson et al., 2017). But, as others note, decisions could cause conflict around benefits (Vierros, 2017), create unequal income opportunities (Herr et al., 2019), and risk the flow of economic benefits to developers or the already wealthy (Bennett et al., 2021; Herr et al., 2019). Cisneros-Montemayor et al. (2022) highlighted the need for work to establish appropriate guidance or regulations in relation to benefit sharing, to address social equity. Connected to our discussion on tenure, equitable sharing of benefits may be complicated by ambiguous arrangements in the coastal zone (Thompson et al., 2017), including where community members may not have legal title (Vierros, 2017).

The successful provision of benefits is further complicated by accessibility. For example, Wylie et al. (2016) noted costs and administrative requirements for projects within other climate programs (such as REDD+) may prevent local communities' involvement. In fact, Cormier-Salem (2017) criticizes REDD+ and other mechanisms as both inaccessible and damaging for local communities, in the context of long-term research on coastal mangroves in Africa. The stability, quality, and longevity of jobs and employment offered by blue carbon projects is another aspect that can intersect with benefits, as well as the equitable distribution of those jobs (Herr et al., 2019; Vierros, 2017). For example, projects could lead to perverse outcomes where community members feel pressured to take part owing to unequal socioeconomic conditions (Herr et al., 2019). Suggested solutions include making payments at a community level, rather than to individual households to negate unfair distribution (Thompson et al., 2017), or hybridized PES schemes used to develop other social or economic

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initiatives. Such an approach, it is argued, would maintain community autonomy and stimulate the local economy, without jeopardizing credibility and sustainability (Thompson et al., 2017), something also noted in the wider PES literature (Petheram & Campbell, 2010; Van Hecken & Bastiaensen, 2010).

3.4 Future directions: what are the implications of these findings for future research on the development of effective, feasible, and just blue carbon initiatives?

The literature we reviewed illustrates important progress in consideration of the social and cultural dimensions of blue carbon. In particular, research is beginning to address gaps related to issues of 'community-level experiences and motivations', previously noted by (Thomas, 2014). Despite this progress, key issues remain in terms of the political and reasonable consequences of blue carbon as transformative climate action. Here we synthesize concerns to aid future research directions.

First, addressing questions of the social and cultural acceptability of blue carbon is paramount. Answers will be geographically contingent and future research may illustrate those differences. But, and as we have shown, assumptions related to acceptability, including the argument blue carbon will build livelihood resilience (Espinoza-Tenorio et al., 2019; Vanderklift et al., 2019), are problematic. Assertions about contributions to livelihood resilience, and other social and cultural benefits, may be made to shore up investment, but they require greater interdisciplinary and critical input. Without it, such transformation represents 'more of the same'; Cisneros-Montemayor et al. (2022, p. 5) for example, found that despite a proclaimed 'focus on social equity' as part of broader Blue Economy discourse, 'much of the attention on blue carbon and ocean (or blue) economy currently focuses on aspects of economic viability, ecological sustainability, and technological innovation (UN-DESA, 2017) rather than distributional equity *per se*'. At worst, it represents an expansion of green colonialism (Normann, 2021), (the exacerbation or result of social marginalization and/or exclusion of Indigenous and local peoples from their sovereign territories resulting from interventions that aim to benefit the environment). Regarding livelihoods specifically, the direct and often technical application of ecological resilience theory to livelihood contexts leads to 'weak engagement' with social and cultural systems, lacking sufficient attention to human agency, institutional politics and power relationships, and complex cultural histories (Tanner et al., 2015). Fortunately, there is a wealth of empirical work on resilience for blue carbon to learn from (see e.g. Glaser et al., 2010).

Addressing the acceptability of blue carbon will also need to more deliberately involve understanding social norms, and relational ethics, the significance of which is noted in broader transition agendas (Byskov et al., 2021). Tangible ways forward are charted by scholars of the blue economy who are calling for reviews of agreements and how these are integrated into projects (Cisneros-Montemayor et al., 2022). Blue carbon planning would also do well to urgently integrate the insights and recommendations for recognitional, procedural, and distributional justice and codes of conduct generated through critique of the blue economy (Bennett et al., 2017, 2021; Cisneros-Montemayor et al., 2019). Further practical considerations are collective action initiatives that may help to scale the local efforts of communities alongside driving national or global agendas (Dencer-Brown et al., 2022). More broadly, the 'convergence' of multiple eco-social crises should prompt more robust and interdisciplinary attention to how ontologies are interrelated and politicized, and how ideologies and value systems manifest within blue carbon agendas (Borras et al., 2020; Tramel, 2020). This requires understanding and recognition of the scientific ontologies of climate change and their power for 'slow violence' (O'Lear, 2016, p. 4). Like others (Shoreman-Ouimet & Kopnina, 2015), we also call for scientists to attend to, collaborate, and/or work beyond their biases, where relevant in collaboration with the NGO sector (e.g. Conservation International, 2022). We also call on researchers to consider the implications of ontological difference, as part of the critical thinking required for climate action (Harris, 2022), about, for, and with the people that blue carbon interventions may impact.

Second, further research is required to understand and track social justice and sustainability outcomes of projects, in line with frameworks for implementation (Malloy & Ashcraft, 2020). A key issue relates to the lack of meaningful engagement with local participants, with this sometimes perceived as an afterthought. Indeed such criticism was raised in Australia during the blue carbon methodology consultation process, when Indigenous stakeholder groups expressed concerns about the lack of co-design and genuine participation (see Indigenous Carbon Industry Network, 2021; Kimberley Land Council, 2021). The development of this methodology has elsewhere been praised for its process which included co-design between governments, industry, science, and academia (Bell-James, 2023; Lovelock et al., 2023), but co-design processes should meaningfully include Indigenous groups (Vanderklift et al., 2019). Elaboration from past involvement might help to uncover these differing experiences.

Genuine inclusion involves grappling with the question of how to center people, or put them 'at the core' (Reiter et al., 2021, p. 2). We noted effective achievement of inclusion is contentious and will require targeted efforts at building capacity. Capacity building was also suggested as one way to measure resilience (Espinoza-Tenorio et al., 2019). Again, we identified limitations in the use of resilience theory, but it may provide a starting point for centering and supporting communities. The comparatively early stage of blue carbon operationalization may explain the lack of community capacity, and represent an opportunity to learn from related climate mitigation fields, such as previous REDD+projects, in recognizing the importance of capacity building (Gordon et al., 2011; Warner et al., 2016). Capacity building also relates to the mutual learning of scientists, proponents, and other interests in order to understand and adapt to local expertise. Recent declarations on research capacity provides an indication of where communities (AOSIS, 2022) and scientists (Alexander et al., 2022) are leading this agenda. Considerations of inclusion and capacity building could also be enhanced through reflections on the conceptual scholarship on care; considering how care is normalized, practiced, and/or contested, and opportunities to enhance institutional and governance approaches.

A second element regarding inclusion is the need for more comprehensive research and assessment of current and predicted future benefits for communities (Hejnowicz et al., 2015; Thompson et al., 2017). Design and implementation should be 'truly inclusive' with fairness defined by marginalized groups (Bennett et al., 2019; Cisneros-Montemayor et al., 2019), who are encouraged to participate and access schemes and their benefits from the outset (Hejnowicz et al., 2015; see also Mahanty et al., 2013). Law and policy could mandate projects in disadvantaged areas or require the flow of benefits to local communities;

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Reiter et al. (2021) noted efforts were made toward this goal in Californian coastal adaptation policy. Cisneros-Montemayor et al. (2022) also advocate for the use of benefits agreements between governments, communities, and companies, which could include guaranteed local hiring, procurement of goods and services, and other funding arrangements. Done well, project design provides an opportunity to establish and indeed strengthen outcomes for community organizations (Herr et al., 2019). Issues of land tenure also require attention. Whilst some literature points to a lack of clarity as an impediment, imposing land tenure regimes may lead to disempowerment and inequality, presenting an opportunity for research to consider how rights and entitlements are considered, and secured when necessary.

Third, there is a clear need to rectify the knowledge and information deficit concerning the assessment and incorporation of local data and cultural values for blue carbon. It is critical gaps in knowledge are not replicated in frameworks as initiatives progress (Song et al., 2021). Addressing this gap will require interdisciplinary research input and is an opportunity to enhance community involvement and harness local knowledge, aiming to establish 'future adaptive and collaborative co-management' (see also Baldwin & Oxenford, 2014; Mateos-Molina et al., 2021, p. 2). This approach was apparent in Reiter et al.'s (2021) suggested framework for operationalizing climate-just ocean commitments, which sought to enable co-design with local stakeholders, integrate traditional ecological knowledge, and establish co-management structures, supported by financing mechanisms that incorporate socio-ecological values. That framework envisages a shift in the measurement of carbon stocks to incorporate participatory mapping methodologies, as well as ecosystem service valuation (McCall, 2012; Reiter et al., 2021; UNFCCC, 2009), which may work toward rectifying knowledge gaps and promote ethical incorporation of local and Indigenous knowledge.

Finally, governance reform is required at the institutional level to re-evaluate both the fragmented and overlapping nature of governance frameworks, the extent to which they intersect with local regimes, and how they are implemented on ground. This direction links with scholarship on the fragmented nature of environmental laws, where legal frameworks regulate resources or species individually, rather than ecosystems as a whole (Craig, 2002). A large number of laws regulating a particular issue can impact their effectiveness as a whole, causing confusion or inconsistency in application (Allott, 1980; Baldwin, 1997; Bell-James et al., 2020; UNEP, 2019). Accordingly, reform may be necessary to clarify processes and enable blue carbon projects. Alternatively, as our review illustrated, decentralization may offer innovation not presently envisaged. Calls for governance reform have been made in the context of the ambitious aims of REDD+ (Clements, 2010); such processes are an opportunity for research to evaluate and provide critical input into the development of new arrangements that center local communities and institutions.

4. Conclusion

The rapid progress of blue carbon science is stimulating significant interest in effective, feasible, and scalable nature-based solutions to climate change. Blue carbon presents opportunities for urgent climate action, necessarily elevating environmental priorities and addressing pressing threats to the biosphere, its inhabitants and a quality life on earth. On this basis, projects are emerging everyday. We have cited examples from such projects where they have appeared in the literature to date. Yet our review highlights key conceptual, operational, and practice issues, concerning the social and cultural dimensions of blue carbon, which, if not addressed, have the potential to stymie momentum or cloud support. Worse, inadequate consideration may lead to unjust outcomes, underscoring fears blue carbon is another manifestation of colonial and institutionalized power dynamics in the pursuit of a green agenda. It will be critical that future projects are comprehensively reported so that others can continue to learn from implementation experiences and to establish an evidence base. Future research should center discussions about the integration of social and cultural dimensions into questions about feasibility and social justice, and address knowledge gaps and institutional reform in both project design (bottom-up) and legal/policy design (top-down), to better align the urgency of climate reform with social justice. This priority is especially relevant where those blue carbon environments targeted intersect with concerns about inequality and marginalization.

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