A question of standards: Adapting carbon and other PES markets to work for community seagrass conservation

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Abstract

Seagrass meadows deliver multiple ecosystem services that are of particular importance to resource-poor coastal communities, yet they are rapidly declining globally. The Payments for Ecosystem Services (PES) approach has been used to fund the protection of other 'Blue Carbon' Ecosystems (BCE), yet seagrass has been incorporated in just one PES project worldwide. Some of the ecosystem services delivered by seagrass have the potential for inclusion under a PES framework but multiple challenges currently make this difficult, particularly under community-based management. PES programmes typically focus on carbon as the tradable service, but scientific uncertainties regarding seagrass carbon are likely to remain significant barriers to using carbon as the sole commodity under current carbon trading standards and market conditions. It is recommended here that project developers demonstrate the multiple ecosystem services delivered by seagrass meadows, along with their importance to coastal communities, in the planning and marketing of seagrass PES projects. Moreover, they should consider approaches that incorporate seagrass meadows into other blue carbon certified projects. The capacities of the communities that rely most heavily on seagrass are generally very limited. Consequently, demanding high levels of scientific certainty over carbon stocks and flows will exclude most of these communities. Standards, buyers and policy makers should consider building community capacity in the technical and marketing requirements of voluntary carbon standards. The voluntary carbon market has the flexibility to pioneer certified seagrass carbon, potentially leading to the inclusion of seagrass carbon in formal policy instruments, such as Nationally Determined Contributions (NDCs).

Keywords

Seagrass, community-based management, voluntary carbon market

1. Introduction

Seagrass meadows are globally threatened and are disappearing rapidly [1], [2]. Drivers of loss include eutrophication, increased sedimentation, coastal development, climate change and physical impacts from boats, anchors and fishing gear [3], [4], [5]; many of these drivers are underpinned by unsound policies emanating from inadequate consultation among stakeholders [6]. The rate of decline of seagrass meadows has been estimated to be as high as 7% per year [1], but without a global database of seagrass extent compounded by geographically limited knowledge of change in areal extent, makes this estimate highly uncertain. Despite its ecological importance, seagrass is relatively marginalised due the low public awareness of its value; this is arguably the greatest threat to its conservation [7].

Seagrass meadows provide numerous ecosystem services, defined here as the benefits that people gain from the natural environment, including carbon sequestration, nursery habitats for fish and shellfish (including commercially exploited species) and coastal protection (e.g. [2], [8], [9]). They provide food for other marine species, including charismatic megafauna such as sea turtles, manatees and dugongs, which in turn support local marine tourism. These services directly benefit coastal communities, providing a source of food, income and safety, as well as benefitting all of humanity through regulation of the climate. Seagrass meadows are closely ecologically linked with other BCE such as mangroves and tidal marshes [10]. And when these (and other closely linked ecosystems such as coral reefs) occur contiguously, synergies can enhance the services that each habitat delivers [2, 11].

Globally, seagrass meadows and their associated algal beds have been valued at an estimated US$6.4 trillion (out of a total value of services from all ecostsyems and species of US$125 trillion) [12]. The valuation of nature in this way has helped to foster an appreciation of ecosystems and to communicate the importance of their conservation under policy settings; however, assessments such as these are incomplete and can be inherently biased against resource-poor communities. For example, whilst the market value of mangrove fuelwood might be very low, thousands of poor households rely on collecting fuelwood to cook their daily meals [13].

Legislation, policies and spatial plans to protect seagrass meadows are globally patchy and lack consistency between regions and the holistic integration needed to tackle multiple pressures. Where management strategies do exist, implementation of these are often inadequate or absent [14], and seagrass meadows remain one of the least protected marine ecosystems [2]. Low public awareness of seagrass and its importance results in little public pressure on the relevant authorities to punish breaches of legislation.

Community Based Management (CBM) is an increasingly common approach to management and conservation that is centred around the people who depend on the resources and often includes socioeconomic development components (e.g., [15], [16]). When conducted well, CBM can support both environmental conservation and the welfare of communities who live adjacent to the managed ecosystems and who depend on the ecosystem services that they deliver [16]. As CBM should involve a range of perspectives on and approaches to management, including traditional knowledge, the resulting decisions and processes allow for more flexibility than those under top-down frameworks [17]. This may facilitate more adaptive management in the face of environmental and social change; the ability of governance and management structures to adapt will become a key predictor of resilience under accelerating climate change. Here, seagrass conservation under PES frameworks is discussed in the context of CBM, recognising the environmental and social benefits that PES can provide when conducted well.

The PES framework recognises the management and conservation of ecosystems that can be funded and facilitated [18]. PES payments are made by ‘buyers’ to land managers or ‘stewards’, including community groups with tenureship or ownership rights, conditional on the delivery of ecosystem services, such as carbon sequestration or water purification [19]. These ecosystem services are delivered either by protecting existing natural resources or by restoring or creating habitats. Under best practice, PES projects are certified by a third party and the ability of projects to trade is conditional on the adherence by projects to the standards set by the certifying body.

To date, there has been very limited uptake of seagrass under PES projects. Seagrass meadows have been partially included (alongside certified mangrove carbon credits) in only one PES project, Mikoko Pamoja in Kenya [20]. Seagrass restoration in the Virginia Coast Reserve, led by The Nature Conservancy [21], is expected to achieve certification under VCS in early 2022. Blue carbon PES projects have to date focused on carbon sequestration as the only tradable service, despite recognition of the multiple services that mangroves also deliver. Several barriers currently prevent or inhibit the inclusion of seagrass meadow management in certified carbon trading projects; these barriers are discussed here. It is argued that greater flexibility in PES standards should be allowed to facilitate the inclusion of seagrass meadows under certified carbon trading projects. Furthermore, it is recommended that a wider range of ecosystem services delivered by seagrass meadows is recognised under, and incorporated into, PES frameworks. We propose that seagrass meadows may be included in management strategies alongside other coastal ecosystems, such as mangrove forests, that are more aligned with current PES frameworks. This argument is discussed in the context of CBM and the capacity of community groups to achieve the requirements of certification under current PES standards.

2. Payments for Ecosystem Services as a source of funds for conservation

Payments for Ecosystem Services (PES) reflects the economic, social and health benefits that people gain from the natural environment and provides market-based mechanisms to facilitate environmental conservation. PES programmes can be beneficial when sufficient regulation or financing of environmental protection through traditional (e.g., government or philanthropic/grant-funded) routes is lacking. PES payments are conditional on reported indicators of success, meaning that land managers or stewards, and in some cases wider stakeholder groups, are directly incentivised and rewarded for their stewardship of a habitat [18]. Critically, PES provides protection or enhancement of ecosystems over and above what would have been provided in the absence of payment. Interest in PES has grown over recent decades [19]. Most notably, the quantification and commodification of carbon sequestration is commonly utilised as a policy, market and individual response to climate change [22]. Carbon offsets are traded on either the compliance or voluntary carbon markets; the former refers to legally mandated offsetting required of large-scale polluting corporations and industries and the latter to elective payments made by individuals or organisations. Small-scale, nature-based solutions such as seagrass management would almost certainly fall under the voluntary carbon market. To certify a project, a carbon standard must be chosen; these regulate and accredit this market, provide the flexibility needed by small, community-led projects and can allow innovation as well as a better fit to local contexts. Each standard specifies technical methodologies with which accredited projects align. Currently, the only publicly available methodology for seagrass meadows is Verra’s Greenhouse Gas Accounting Methods for Tidal Wetlands and Seagrass Restoration (VM0033)); the scientific and policy rationale for which can be found in [23].

Coastal PES schemes are rare in comparison with projects based in terrestrial ecosystems such as watersheds and terrestrial forests. This is not due to lack of ecosystem service provision as mangrove forests sequester 3-4 times as much carbon per hectare than terrestrial forests [24]; rather, scientific, technical and policy barriers and complexities had prevented their inclusion in PES schemes until relatively recently [25]. These barriers include greater relative uncertainty about natural processes such as carbon sequestration and storage, relatively under-developed standards for design and implementation, greater cost and expertise required for implementing and monitoring projects and complexities or uncertainties in the policy context of coastal ecosystem governance.

3. Challenges in implementing carbon certified, community-based seagrass management projects

3.1 Scientific, technical and conceptual challenges

Carbon standardsensure that project design and methodologies, including carbon calculations, are sufficiently robust. Certain voluntary standards, such as the Plan Vivo Standard and the Verra's Standard (VM0033), encourage the engagement and empowerment of local communities. These allow projects that would be otherwise unfeasible under more technically onerous compliance standards to be implemented. By explicitly identifying and encouraging social outcomes, such standards locate PES projects in complex socio-ecological systems, rather than viewing them as technical means to ensure only physical, chemical or biological outcomes (such as tonnes of carbon). Despite this different perspective, such voluntary carbon standards still require considerable scientific and technical capacity; meeting these technical requirements is especially challenging in remote locations in developing nations, where access to the appropriate equipment and facilities may be difficult or impossible. These scientific challenges are discussed in [25] and [26] and are summarised below.

All carbon standards require projects to demonstrate: a) additionality (that the carbon would not otherwise have been sequestered in the absence of the project); b) permanence (that the carbon that is traded can be reasonably assumed to remain in situ on at least a 100-year timeframe) and c) avoidance or mitigation of leakage (that the instigation of the project at one site will not simply displace damaging activities elsewhere). All three requirements present significant conceptual as well as technical challenges. None of them can be known for certain since they all assume knowledge of the future. Whilst this is taken to be a fundamental conceptual problem by some critics (see e.g. [27]), uncertainty applies to any proposals for human action; in such cases, the usual tools of prediction, risk assessment and judgement can be employed. However, such tools may be expensive and difficult to apply or simply unavailable or unconvincing for many seagrass sites. For example, demonstrating additionality may require the documentation of historic trends in seagrass meadow extent (and potential losses), providing a baseline scenario against which to compare the impact of project interventions. Sourcing historical data (e.g. from satellite imagery), particularly at fine scales and/or in turbid settings, is often difficult as remote sensing in coastal settings is relatively under-developed and can require ground truth data collection in remote areas.

Projects are also required to meet the specific annual or longer-term targets, congruent with assumptions about the provenance, sequestration and storage of carbon, that are mandated by individual carbon standards. Project developers considering using the carbon market for seagrass conservation will generally be working with lower carbon intensities (and therefore carbon stocks per unit area) than those found in other habitats(e.g., [29]). Seagrass projects relying on avoided emissions are therefore likely to need larger areas than those based on mangroves in order to be viable. Seagrass ecosystems are often patchy and variable over space and time. This means projects may need to monitor and sample large areas and to increase the per unit area sampling intensity in order to understand and document changes in average stocks and flows. Knowing the carbon stocks and how these are changing following a project intervention may still not be enough for seagrass carbon projects. Discussions about the nature, provenance and fate of carbon in seagrass meadows in the scientific literature suggest that further technical challenges may arise, as illustrated by current debates over the importance of calcification and carbon provenance in seagrass meadows.

The production of calcium carbonate (calcification) by marine organisms can generate CO_2. Some authors (e.g. [30]) have argued that calcification by seagrass epiphytes as well as snails, bivalves and crabs living in the seagrass meadows could offset the burial of organic carbon in seagrass soil, thereby reducing the net carbon sequestration of a meadow. The scientific basis of this argument is strongly contested [31]. When applied to a PES context it does not account for the food security value of the calcifying organisms to coastal communities, demonstrating the value of a holistic approach to ecosystem service provision. Seagrass can store carbon originating within the meadow, but it also traps carbon coming from elsewhere. Uncertainties in the provenance of seagrass sediment carbon have led Verra, in their Methodology for Tidal Wetland and Seagrass Restoration under the Verified Carbon Standard [32], to stipulate that projects demonstrate empirical evidence of carbon provenance or assume a fixed rate deduction; the assumption being that carbon that originated outside of the seagrass ecosystem cannot be claimed as tradable seagrass carbon. However, this is not a requirement imposed on carbon projects in other habitats, such as mangroves, that may also trap carbon from elsewhere; the technical barriers for seagrass accreditation seem unjustly high.

3.2 The politics and ethics of the voluntary carbon market and implications for project sustainability

In its early days, the carbon market was heralded as a financial 'accumulation strategy' for nature [33]. However, it has since fluctuated and remains unstable. Demand for offsets is driven partly by changing public perspectives, notably influenced by popular media, on the value of carbon offsetting as well as the role of the carbon market within and alongside international agreements, most notably the Paris Agreement. As community-based seagrass carbon trading projects are best suited to the voluntary carbon market, they are dependent on the willingness of buyers to pay. This is in turn influenced by individual ethical attitudes, the drive amongst corporations to create ethical brands, and the broader political context surrounding carbon offsetting. The carbon market is also inherently linked to the economies of western countries, where most carbon buyers are located, and to unpredictable global events. For example, initial media reports [34] show that air travel decreased by almost 80% globally and by more than 90% in Europe during April 2020 because of the COVID-19 pandemic. Such a drop may be welcome news to those alarmed at the apparently inexorable rise in emissions from air travel, but since these constitute a considerable proportion of emissions offset on the voluntary carbon market, this could have a sharp economic impact on carbon-financed projects.

The COVID-19 crisis illustrates both the financial and moral vulnerabilities of voluntary carbon offsetting. Projects need to anticipate and deal with market downturn and have an incentive to establish long-term and stable relationships with regular buyers; this may include, for example, people or institutions anticipating regular long-haul flights. However, offsetting has been denounced as a 'permit to pollute' which simply allows the persistence of unsustainable lifestyles, rather than tackling emissions [35]. Whilst the logic and justice of this critique is disputed [36], it is both prudent and ethical for projects to plan for and develop alternative sources of income, and to do what they can to encourage systemic change rather than perpetuate the status quo. If voluntary carbon projects are 'one small step on the road' to the Paris Agreement, then they are helping us move towards a world of zero carbon emissions. Such a world will have little use for voluntary offsets that currently exist (although there *will* continue to be a need to invest in the conservation and expansion of natural carbon sinks). It is incumbent on projects to work with buyers as part of a broader strategy of carbon reduction, ensuring that offsetting is utilised as one small part of the buyers' wider response to the climate change crisis. For example, the Kenyan mangrove conservation project Mikoko Pamoja is committed to communicating 'the three Ps' to buyers and stakeholders; action on climate change requires, in order of priority: 1) Political change towards a zero-carbon economy; 2)

Personal action to reduce carbon footprints; and 3) Paying for carbon offsets to responsible projects. Projects should, from the outset, plan for life beyond the current model of voluntary offsetting and position themselves clearly on the side of systemic change, rather than risk being seen as an excuse for political inaction.

4. Strengths and opportunities of community PES-based seagrass conservation

Despite the challenges of implementing a seagrass-based PES project described above, there remain many potential opportunities and strengths of doing so. These strengths are primarily social and environmental in nature and demonstrate how conservation can work for both people and nature. In a forecasting exercise to identify research priorities for achieving healthy marine ecosystems, Friedman et al. [37] conclude that increased opportunities for coproduction are essential. This means that cross-sector, interdisciplinary, participatory work (including for example academics, development agencies, indigenous and local stakeholders and the private sector) is needed to address the complex socio-ecological challenges that their diverse experts prioritised. PES projects, in their conception, development and operation, exemplify this kind of coproduction. Done well, PES projects can help develop new collaborative working, show the links between nature and human wellbeing and foster institutions that build community resilience.

4.1 Ecosystem services and benefits delivered to coastal communities

The benefits of seagrass conservation to coastal communities are likely to be much more diverse than the ecosystem services that are the focus of a PES project. These benefits include food provision, in the form of fish and shellfish that use the seagrass meadows as a nursery habitat and feeding ground, coastal protection, tourism opportunities, cultural value, water purification, educational and research opportunities, and raw materials (e.g., as fertiliser). These services are of particular importance to resource-poor communities. Fish and shellfish are often important for food security (e.g. [38]), coastal tourism can be a source of income, and coastal protection will become increasingly valuable under projected climate change scenarios, particularly in developing countries. Economic valuation of these services may be challenging [39] and trade-offs between services and their impacts on local communities, such as the exclusion of mobile fishing gear in order to preserve carbon stocks and resulting loss of livelihood, should be considered. However, their collective value to coastal communities should not be underestimated and seagrass-based PES projects should be designed and assessed with the full range of services in mind. Whilst the focus in the voluntary market remains on carbon accreditation, relevant standards such as Plan Vivo already require benefits to biodiversity and communities and encourage reporting against the Sustainable Development Goals (SDGs) and some frameworks, such as Verra, have developed standards that privilege SDGs as the main objectives. Hence opportunities are emerging to formally incorporate wider services and benefits into PES approaches.

4.2 Communities and stakeholders as owners and beneficiaries of environmental conservation

Fisherfolk are likely to be the primary beneficiaries of a seagrass conservation project as they will benefit from enhanced stocks [38]. Management measures may also directly impact fishing activities, as physical damage from fishing gear is one of the primary threats to seagrass meadows [1], particularly in less-developed regions where nearshore fishing is prevalent.

Conflict between management measures and the needs of those who directly depend on ecosystems for sustenance and/or income can be minimised through direct and meaningful involvement of stakeholders in the planning and implementation of management strategies This stakeholder involvement can also instil a sense of ownership of a project, encourage buy-in from stakeholders, and improve the likelihood of stakeholder adherence to management measures. These factors contribute to an enhanced likelihood of success of the seagrass conservation project, thereby improving project sustainability and conservation outcomes. The success of well-run community-based fisheries management has been evidenced (e.g. [40], [41]), particularly in the Pacific Islands (e.g. [42]) although no published examples to date have illustrated seagrass-based fisheries management.

PES schemes allow for 'participants' to be direct beneficiaries of project interventions. This may be in the form of direct payments to individuals or community groups, who are undertaking management interventions to protect a habitat. This 'benefits sharing' framework allows for direct involvement of stakeholders both as environmental stewards and as beneficiaries of this management; directly through PES payments and indirectly through enhanced ecosystem services. This framework also directly links environmental conservation with economic gain, alleviating conflict between the two that can arise through top-down approaches to management that do not engage and involve stakeholders.

4.3 Contributions to national and international policy commitments

Conserving and restoring carbon-rich ecosystems, including seagrass meadows, is an essential part of achieving the goals of the Paris Agreement [43]. Seagrass meadows have been identified, among other ecosystems, to contain 'irrecoverable carbon' – carbon that, if lost, cannot be recovered on a timescale in line with avoiding catastrophic climate change [44]. To date, there has been very limited incorporation of Blue Carbon ecosystems into Nationally

Determined Contributions (NDCs), despite their potential to contribute to both mitigation and adaptation strategies (see [45] for existing examples). Only 10 of the 159 countries containing seagrass countries include an explicit reference to seagrasses, though these do not necessarily include a measurable target [46]. This is partly due to initial lack of guidance on accounting methodologies for carbon in wetlands and coastal habitats. The Intergovernmental Panel on Climate Change (IPCC) issued the Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for Wetlands (Wetlands Supplement) in 2013 to provide guidance on accounting methodologies. Additional information comes from the Guiding principles for delivering coastal wetland projects [47]. Both examples give only limited guidance for seagrass meadows. More recently, community accessible guidance for protecting seagrass through PES was produced by UNEP [48].

At present, projects on voluntary markets are not accounted for in national and international-level carbon accounting, and therefore do not contribute to nations' climate policies and commitments. Currently, the administrative burden of compliance mechanisms, such as the Clean Development Mechanism (CDM), is too high for Blue Carbon projects to qualify. Development of Article 6 (dealing with cooperation and market mechanisms) to the Paris Agreement may contribute to the accessibility of mechanisms such as the Sustainable Development Mechanism (successor to the CDM) for smaller Blue Carbon projects. Article 6 aims to encourage international cooperation and cost-effective and globally recognised centralised crediting, providing opportunities for countries that have lacked the capacity to develop their own crediting systems. Whilst Article 6 presents opportunities for the conservation of coastal ecosystems and other carbon dense habitats at scale, it also raises the risks of international actors using offsetting in bad faith to delay or obscure emissions reductions. Policy discussion over Article 6 will need to engage explicitly with this risk if a credible international system is to emerge.

In addition to climate policies, CBM and restoration of seagrass meadows has the potential to contribute directly to 26 targets of Sustainable Development Goals (SDGs) 1, 2, 5, 6, 8, 11, 12, 13, 14 and 17, and achieve multiple international commitments and objectives, such the Aichi Biodiversity Targets, the United Nations Decade on Ecosystem Restoration, the United Nations Decade of Ocean Science for Sustainable Development, the Ramsar Convention on Wetlands and the Sendai Framework on Disaster Risk Reduction, amongst others [2].

5 Adapting PES frameworks to facilitate seagrass management

Seagrass carbon trading projects face multiple scientific, technical and political challenges in achieving certification and reporting under carbon standards, increasing the costs of running such projects. These challenges are linked to the need for carbon standards to ensure robust, accountable and transparent project design, certification and monitoring.

5.1 Carbon standards and seagrass conservation

Current carbon standards embed the scientific rigour required by the international carbon market to meet the objective of carbon offsetting. However, the high costs and specialist expertise implied by these protocols in effect exclude most seagrass community-based conservation projects. There is a contradiction here between the focus on the natural sciences, which emphasises reducing uncertainty about stocks and flows of carbon, and the findings of social science which show that well designed community-based conservation is likely to be more effective in the long run than top-down management designed and imposed from outside (e.g. [49]). Carbon standards that aim to facilitate CBM should consider how their methodologies can be adapted to accommodate their intended project audience whilst maintaining scientific rigour.

Because the voluntary carbon market is not subject to regulation as stringent as the compliance market, it allows flexibility for innovation and experimentation by projects that would otherwise be ineligible to claim carbon benefit under larger compliance standards [50]. This flexibility has allowed voluntary carbon standards to certify projects under diverse community governance structures that are locally appropriate and that ensure benefit sharing among local communities. It has also allowed the inclusion of environmentally, economically and socially valuable yet logistically, technically and politically challenging ecosystems such as mangroves to be included under carbon trading. For example, four (Mikoko Pamoja and Vanga Blue Forest in Kenya, Tahiry Honko in Madagascar and a mangrove restoration project in Myanmar) of the five (those previously named and a mangrove restoration project in Fiji on the CDM) certified mangrove carbon trading projects to date have been certified under voluntary carbon standards. This flexibility has arguably led to more ethically and socially robust projects; the CDM, as the most active compliance market program, is more technically demanding but has been widely criticised for lack of consideration of social principles and human rights (e.g. [51]). By taking flexible approaches to project design, voluntary carbon standards provide the flexibility to facilitate innovation in the carbon market (e.g. [53]). This capacity for innovation may mean that voluntary carbon trading projects could bridge the gap in skills, knowledge and finance that is a barrier to certain sectors, including blue carbon, being included in NDCs (e.g. [50], [52]). Here it is argued that the capacity of the voluntary carbon market to foster innovation can facilitate the inclusion of seagrass meadows under certified projects, and in doing so stimulate scientific, financial and policy advancements that can support the inclusion of seagrass in the compliance carbon market and other policy frameworks such as NDCs. Facilitating this will require careful consideration of the scientific criticisms of seagrass carbon, discussed in more detail in [25], as well as novel approaches to project design discussed below.

The inclusion of seagrass meadows in voluntary carbon market projects may be an iterative process through which project developers and standards work together to hone approaches and find solutions. Current methodologies for citizen science monitoring of seagrass could be applied, allowing community-accessible protocols that can provide sufficient rigour for the assessment of seagrass extent and condition. Current scientific understanding of carbon sequestration and storage, combined with some local sampling and appropriate risk buffers, justifies reasonable assumptions on the carbon benefit provided by seagrass protection and restoration. Potential issues surrounding the source of carbon in seagrass meadows and the fate of this carbon in disturbance scenarios require further research [54]. However, it is argued that given that the complexities of doing so, are a barrier to the financing of environmentally, economically and socially valuable ecosystems that are a known carbon sink. Voluntary carbon market standards should consider flexible approaches to the inclusion of seagrass meadows in certified projects whilst being clear about the uncertainties involved.

5.2 Beyond carbon: community-based management under a multi-ecosystem and ecosystem services approach

Community-based mangrove management has been certified under existing carbon trading projects. Along with saltmarsh and coral reefs, there is a high degree of ecological connectivity between these BCEs(e.g. [10], [11]) and they frequently occur adjacent to one another and the delivery of services by any one ecosystem is likely to be dependent on the health of connected ecosystems [55]. This synergy provides an opportunity for seagrass to be included in existing, certified projects under a co-benefits approach that incorporates multiple ecosystems. This approach has been taken by the Mikoko Pamoja project; under the Plan Vivo standard, the project has included the protection of seagrass meadows as a co-benefit alongside carbon credits generated by avoided deforestation and restoration of mangroves. The fishing community as primary stakeholders have been engaged in the design and implementation of the management measures and are considered the primary beneficiaries of community development activities linked to the protected area. The protected area and associated community benefits are financed through donations leveraged alongside certified carbon offset sales which are marketed under a multi-ecosystem service approach that communicates the carbon sequestration, fisheries enhancement and coastal protection services delivered by the seagrass meadows. Buyers are therefore purchasing standard carbon credits, certified against monitoring targets for mangroves, but may choose to make additional donations against quantified benefits (which include carbon sequestration) based on seagrass conservation. These benefits are monitored and reported to Plan Vivo, the accrediting standard, following a citizen science seagrass monitoring protocol. Hence a hybrid model combining the rigorous and expensive accounting of mangrove carbon credits with additional seagrass monitoring and protection allows an existing PES framework to secure investment in seagrass conservation.

A future in which carbon offsetting may not be necessary as a strategy for global carbon mitigation will require alternative sources of income for the conservation of blue carbon projects. It is therefore recommended here that buyers, standards, project developers and policy makers consider holistic approaches to the assessment and financing of ecosystem service delivery in seagrass ecosystems. By incorporating services beyond carbon sequestration, including fisheries enhancement, coastal protection and tourism, PES project developers have the opportunity to create more financially robust projects that explicitly protect and enhance the benefits that seagrass meadows deliver to coastal communities.

Monitoring and measuring indicators against a baseline are essential components of PES schemes, ensuring that conditions are met for PES transactions. As seagrass PES is relatively underdeveloped and gaps exist in the scientific literature, challenges may arise in quantifying certain ecosystem services. Projects and certifying bodies may need to take flexible and adaptive approaches in monitoring requirements; risk assessments and proxies may be incorporated alongside direct monitoring, such as the use of fisheries yield as a proxy for nursery habitat functioning [55].

6 The future of PES as a facilitator of conservation

The sustainability of PES programmes has been questioned in the literature (e.g. [56], [57]). These debates include whether the value of nature is embedded in land management as a result of PES programmes, or if managers are driven only by financial incentives (e.g., [57], [58]). This argument is less clear-cut when considering resource-poor communities who depend on the presence of seagrass meadows, particularly for fishing, for survival and other basic needs and for whom the restriction of damaging activities would be challenging without the provision of financial incentives, whether or not other values exist already or are instilled through a PES programme. By embedding capacity-building such as skills development and securing land tenure and property rights agreements, local institutions can be developed to facilitate sustainable management beyond the project lifespan, mitigating the need for PES and any external support that a certified programme requires. Broadly, projects should seek to address drivers of degradation such as poverty, damaging land and coastal use practices and education gaps that perpetuate ecosystem degradation.

Debate exists as to whether PES, in particular carbon trading, should be used as a solution for conservation. Considering carbon trading alone, the carbon market allows businesses and individuals to achieve carbon reduction targets that would otherwise be unachievable through emissions reductions alone without a systematic shift to a low-carbon society and economy. At the same time, new international climate change frameworks and tools, in particular NDCs, may reduce the need for private finance to fund emissions reductions or sequestration activities, including nature-based solutions. Indeed, in an ideal world, there would be little to no need for carbon offsetting. For now, however, it bridges the gap between climate change targets and global progress towards those targets, whilst engaging the private sector in climate action and empowering communities to engage in ecosystem management. It also allows individuals and organisations to take responsibility for legacy as well as current emissions, going beyond 'net-zero'. The need for PES based on water quality, biodiversity or other ecosystem services may be more long-lived without the same systematic shift that is focused on climate change. Examples of PES arrangements exist between local buyers and providers, demonstrating how such arrangements can provide mutual benefits for tourism and coastal ecosystems (e.g., in Fiji [59]) or for water providers and agricultural land managers (e.g., [60]). Non-carbon PES markets have yet to see the same degree of development that the carbon market has and continues to demonstrate; however, their relevance and application may outlast that of carbon.

7 Conclusion

Community-based conservation of seagrass meadows through PES schemes presents an opportunity to fund environmental conservation, facilitate community empowerment and assist countries in achieving their commitments under international agreements such as the Paris Agreement under a structured, transparent and accountable mechanism. As the majority of PES programmes focus on carbon as the tradable ecosystem service, small-scale, community-based projects that aim to protect seagrass meadows face considerable and often insuperable challenges in certification under existing carbon standards, even when these standards are specifically tailored towards such projects. These challenges arise from a lack of scientific certainty and subsequent burden on projects to fill these gaps with project-level empirical data. In certain cases, this has led to an arguably unfairly high burden of proof falling on community groups, creating bottlenecks to the creation of seagrass PES projects. Here, it is recommended that carbon standards initially allow for the inclusion of seagrass in existing certified projects, such as those targeted at mangrove conservation, under an ‘added benefits’ approach, minimising the financial, scientific and technical burdens of a seagrass-only project. Many of these burdens arise from concerns that PES projects based on carbon offsets may be individually fraudulent or ineffective, or that collectively such projects may slow progress towards a net zero carbon emissions world by distracting policy makers, corporations and individuals from the necessary systemic changes. Such concerns are undoubtably important, but so are those of the climate scientists, ecologists, conservationists and seagrass-dependent communities around the world who know the value of these ecosystems for humans and for nature and who document and experience their decline. New and better ways of financing and supporting seagrass conservation are required and PES can be one of these ways. There are many people and organisations of good will who understand that purchasing carbon credits does not and will not remove the need for systemic change, but who are still interested in purchasing credits as one positive response to the emissions they currently find hard or impossible to avoid. There are project developers looking to help communities conserve their seagrass who would never present seagrass conservation as an alternative to emissions or a solution to the climate emergency, but know it is one small part of a solution. Carbon standards (and other PES certification bodies) should consider the ability of community groups to meet stringent standards and whether compromises between scientific robustness and accessibility can be made to facilitate community seagrass conservation. The importance of seagrass meadows is recognised scientifically and by the communities who live adjacent to and depend upon them; adapting our approaches to conservation frameworks will help to facilitate and finance seagrass conservation for the benefit of people and the environment.

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