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Constraints and opportunities for market-based finance for the restoration and protection of blue carbon ecosystems

Mathew A. Vanderklift[a,*], Raymundo Marcos-Martinez[b,c], James R.A. Butler[d], Michael Coleman[e], Anissa Lawrence[f], Heidi Prislan[g], Andrew D.L. Steven[h], Sebastian Thomas[i,j]

[a] CSIRO Oceans & Atmosphere, Indian Ocean Marine Research Centre, Crawley, WA, 6009, Australia
[b] CSIRO Land & Water, Black Mountain, ACT, 2601, Australia
[c] School of Commerce, University of South Australia, Adelaide, SA, 5002, Australia
[d] CSIRO Land & Water, Brisbane, QLD, 4001, Australia
[e] Greenfleet, Melbourne, VIC, 8007, Australia
[f] TierraMar, Sutherland, NSW, 1499, Australia
[g] Department of Foreign Affairs & Trade, Canberra, ACT, 2600, Australia
[h] CSIRO Oceans & Atmosphere, St Lucia, QLD, 4072, Australia
[i] Sustainability Science Lab, University of Melbourne, Parkville, VIC, 3010, Australia
[j] School of Ecosystem and Forest Sciences, University of Melbourne, Parkville, VIC, 3010, Australia

ABSTRACT

The restoration and protection of "blue carbon" ecosystems – mangroves, seagrasses, and tidal marshes – has potential to offset greenhouse gas emissions and improve coastal livelihoods. However, realisation of this potential relies on global investment in restoration and protection, which in turn relies on appropriate funding mechanisms that are currently impeded by multiple constraints. Constraints include commercial considerations by private investors (including reliable estimates of financial returns, risk quantification and management, and supply chain impacts), regulatory and legal uncertainty (such as the complexity of property rights in coastal areas, policy coordination across jurisdictions, and stable policy consistent with the duration of blue carbon projects). There are, however, opportunities to improve on current practices, including better stakeholder engagement (including social license to operate, and knowledge transfer to promote best practices), and targeted use of public and philanthropic funding (to subsidise demonstration projects, reduce financial risk through collaterals, and promote low-profit but high co-benefit projects). In this paper, a strategy for the realisation of potential benefits through commercially viable and scientifically robust blue carbon initiatives is presented alongside insights and guidance for the policy, research, civil society, and private sectors to achieve these important long-term outcomes.

1. Background

Blue carbon is organic carbon that is sequestered by specific coastal marine plants — mangroves, seagrasses and tidal marshes [1]. Typically, blue carbon refers to organic carbon that is contained in the soils underneath the plants, and in the long-lived tissues (e.g. wood) of the plants themselves. The ecosystems that support these plants tend to store higher amounts of organic carbon than other ecosystems, and also tend to sequester carbon at greater rates [1]. This is possible due to specific characteristics of those ecosystems, especially the low rates of decomposition resulting from low oxygen concentrations (decomposers need oxygen to survive and function). Like all plants, mangroves, seagrasses and tidal marsh plants photosynthesise, taking carbon dioxide (CO_2) from air (or, in the case of seagrasses, CO_2 and other forms of dissolved inorganic carbon from the surrounding water) and converting it into plant tissue. When plant tissue dies, some carbon accumulates in the underlying soil, where it mixes with organic carbon that has originated elsewhere [2].

However, blue carbon ecosystems are being cleared and degraded at rapid rates [3]. When this happens, they release much of their sequestered carbon into the atmosphere, either as CO_2, or as methane (CH_4), which is an even more potent greenhouse gas. One study estimated that degradation of blue carbon ecosystems causes emissions of between 0.15 and 1.02 billion tons of carbon into the atmosphere each year [4], which is 1–6 times the annual CO_2 release from deforestation in the Amazon [5].

These three processes (i.e. storage, sequestration, emission) can be directly targeted by projects that seek to enhance blue carbon restoration or protection, which in turn help mitigate the effects of global climate change (Fig. 1). For example, restoration activities can enhance sequestration, while protection of mature ecosystems can maintain carbon storage, and avoid emissions.

The magnitude of the potential carbon sequestration that restoration of blue carbon ecosystems offers, combined with the potential

* Corresponding author.
E-mail address: mat.vanderklift@csiro.au (M.A. Vanderklift).

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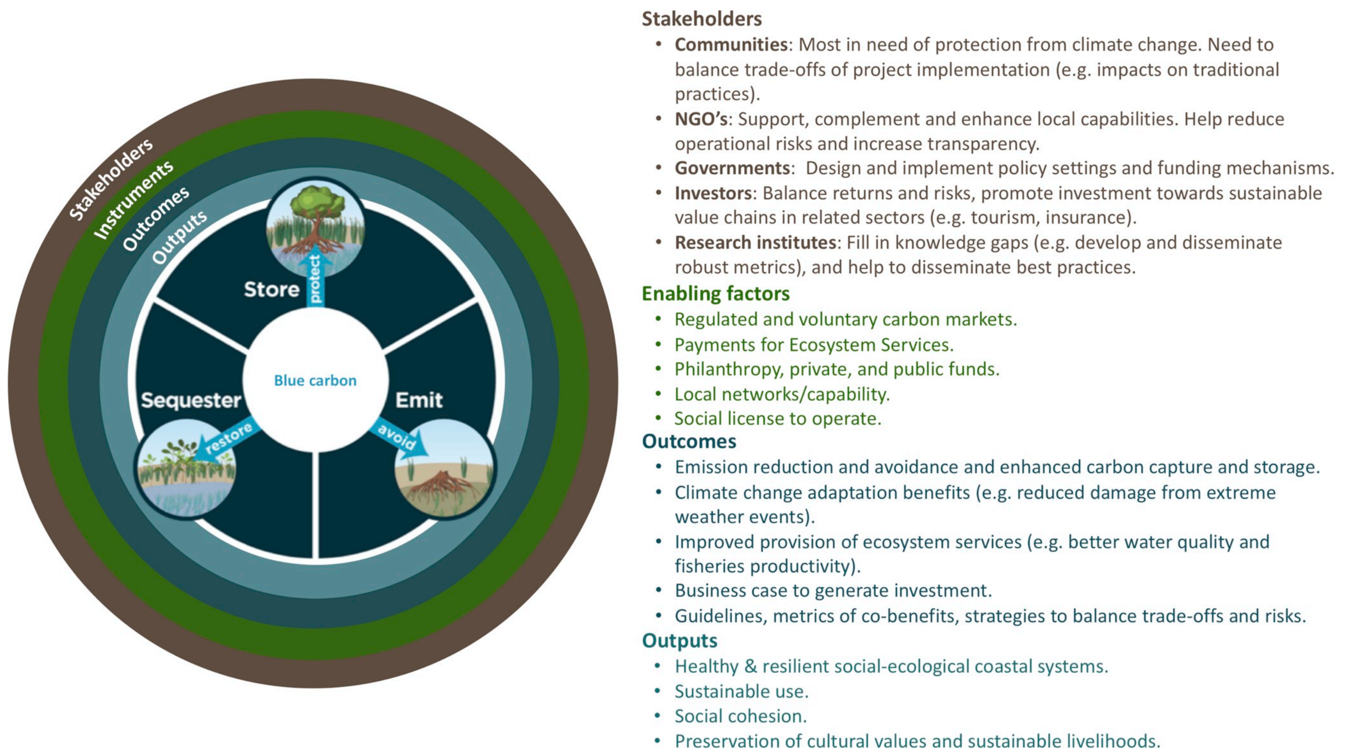

Fig. 1. Conceptual framework incorporating the three primary biogeochemical process relevant to blue carbon, the types of outputs and outcomes expected from blue carbon investment, the finance instruments that might be used, and the various stakeholders with interests in blue carbon. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

magnitude of the carbon emissions prevented by slowing their degradation and clearing, make these ecosystems a potentially very useful tool for climate change mitigation. To meet the widely-agreed target of limiting global temperature increase to less than 2 °C (with an aspiration to keep warming below 1.5 °C), reducing carbon emissions is essential, but emissions reduction alone is unlikely to be sufficient — mitigation efforts also need to encompass enhanced sequestration [6]. Protecting blue carbon ecosystems in order to reduce emissions, combined with restoration to enhance sequestration, can be part of a portfolio of nature-based solutions that also bring a broader suite of benefits, like more extensive habitat for juvenile fish and protection from storm waves and tidal surges. For example, the presence of wide stands of mangroves can dampen the effects of storms and tsunamis, and erosion caused by sea level rise [7] while simultaneously offering diversified livelihoods and income through enhanced fisheries, timber and tourism (e.g. Ref. [8].

Despite the potential to meet multiple goals through restoring and protecting blue carbon ecosystems – ranging from climate mitigation to saving lives and improving livelihoods – the financial mechanisms and policy frameworks that are needed to facilitate investment are still poorly developed. Policymakers, purchasers of offsets and other stakeholders are actively exploring the constraints to, enablers of, and opportunities for investment in blue carbon. In this paper, the mechanisms that provide finance for blue carbon protection and restoration are reviewed, the impediments and risks associated with these mechanisms identified, and actions to move forward are suggested. The focus is on market-based mechanisms, which will be an important tool in efforts to minimise global warming.

2. Review of blue carbon finance

The amount of conservation finance available globally is currently insufficient to efficiently protect or restore all environmental assets [9]. This generates a competitive setting in which projects need to demonstrate clear and measurable impacts with low financial, operational and reputational risk. The majority of climate finance is currently allocated through mechanisms designed to help countries reduce net carbon emissions. The Clean Development Mechanism (CDM), which was formalised through the Kyoto Protocol (an international treaty that commits parties to reducing greenhouse gas [GHG] emissions), uses emission trading to achieve its aims, and has been important in terms of the total number of projects funded and volume and value of traded offsets (https://cdm.unfccc.int/Statistics/Public/CDMinsights/index.html, accessed 20 June 2018). The CDM has established methods, processes and standards that are likely to influence global carbon offset approaches and governance for the near future [10,11]. However, the high costs and administrative requirements of the CDM have favoured large scale, low cost and long-term emission reduction efforts [12,13]. As a consequence, more than 80% of its portfolio is concentrated on projects that seek to improve energy efficiency [14]. In contrast, afforestation and reforestation projects account for less than 1% of the funded projects (https://cdm.unfccc.int/Statistics/Public/CDMinsights/index.html, accessed 20 June 2018), and only one blue carbon project (mangrove afforestation in Indonesia) has received CDM certification.

Directing finance to support conservation and restoration of coastal ecosystems is an example of Payments for Ecosystem Services (PES) – these can include payments for carbon sequestration and storage. The modern history of the ecosystem services (ES) concept began in the 1970s, as an effort to educate the public about the benefits of biodiversity [15]. This approach to ES has evolved to focus increasingly on the commercial and economic benefits of different services (including, for example, provision of fresh water, supply of forest products, pollination, nutrient cycling, and cultural values), and their treatment as commodities that can be traded in financial markets.

In this paradigm, blue carbon can be understood as a product (or service) supplied through a value chain stretching from the ecosystems, and the human communities that use them, through various frameworks to international markets. Within this value chain, carbon as a commodity is measured using a standard metric – the tonne of carbon dioxide equivalent (tCO_2e) – which can be bought and sold at variable prices. The value chain is populated by different stakeholders: project owners and operators, governance agencies and institutions (including policymakers), and private buyers and investors.

These global frameworks provide the context and impetus for private investment in carbon offsets. However, different buyers have different motivations. Some are motivated simply to meet regulatory or compliance requirements, while others are motivated by a broader agenda that includes social responsibility. These different motivations have generated two broad types of markets — regulatory (or compliance) markets, and voluntary markets.

Regulations requiring adherence to carbon emission targets exist in many countries. Private sector buyers motivated primarily to reduce carbon liabilities are likely to pursue low-cost offsets without necessarily considering their provenance (credits available through regulated markets must meet formal criteria, so cost will be the principal factor). In this case, blue carbon activities will be competitive only if the cost per tonne of abatement is equal to or lower than other types of offsets.

In contrast to regulatory markets, buyers that purchase offsets through voluntary markets typically do so to support wider strategic priorities, including corporate social responsibility (CSR). Voluntary carbon markets allow entities without regulated carbon reduction commitments (e.g. local governments, corporations or individuals) to offset emissions through certified methods [16]. Transactions in these markets have been more balanced in terms of volumes, prices and value across project types than compliance markets [17]. The voluntary market has been the main source of finance for blue carbon projects to date (e.g., of the 12 projects listed in Ref. [18] for which financial mechanisms can be identified, eight were through voluntary markets). However offset oversupply has resulted in relatively low and volatile prices in voluntary markets [19]. Carbon offset prices in voluntary markets have ranged from US$0.1/$tCO_2e$ to more than US$40/$tCO_2e$ from 2015 to the first quarter of 2018 [20]. The price depends on a number of variables, such as the type of project (e.g. prices for offsets generated from renewable energy tend to be lower than those from other sectors) and economies of scale (large projects can afford to sell at low prices and remain profitable). Perceptions of value depend on buyers' motivations: those interested only on emission offsetting will rank prices differently to buyers interested in co-benefits, source and location of the carbon offsets [19].

Buyers of blue carbon credits might choose to finance projects in areas that support their supply chain. For instance, seafood companies recognise the importance of blue carbon habitats to fisheries productivity, and so might be motivated to invest in their protection or restoration for reasons beyond the carbon emission offsets they can provide. For such investors, blue carbon projects might be attractive because of these associated benefits. These 'co-benefits' are diverse, and can include habitat and species protection, nutrient cycling, protection from extreme events, mitigation of erosion and salination, and improved livelihoods for humans. However, these benefits are typically poorly quantified, which constrains investment. Providing information about these associated benefits could contribute to increased private investments.

Buyers' preferences are also likely to depend on organisational cultures and specific business activities. For instance, companies that operate in particular geographic areas may wish to support projects in those locations. Strategic competitive advantage can be achieved by directing investment to activities that can be marketed to the company's client base, highlighting social and environmental goods in line with customer characteristics and values.

Additional demand for carbon offsets from the global airline industry is likely to occur after 2020, driven by the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) initiative [21]. The International Air Transport Association (IATA) estimates 2.6 billion tonnes of CO_2 will need to be offset by the sector between 2021 and 2035, more than the total amount of offset credits produced through the history of the CDM (http://www.iata.org/policy/environment/Documents/paper-offsetting-for-aviation-18march2018.pdf, accessed 20 June 2018). However, access to new funds will continue to be highly competitive and offset projects would need to demonstrate clear potential for success, low implementation costs and the generation of co-benefits [9,17]. Strategies for offset differentiation and monetization of co-benefits could improve attractiveness to investors, and might improve prices from customers looking for added value (e.g. community development or biodiversity protection) [16,18]. Even if blue carbon offsets do not attract price premiums, the demonstration of co-benefits could improve their chances of attracting investment.

2.1. The future of blue carbon markets

Blue carbon is currently a niche opportunity offering social and environmental benefits relevant to CSR, rather than low-cost abatement opportunities [22]. Blue carbon credits, however, can be considered an example of a market innovation, and as such should follow a standard pathway of growth from niche concept to mainstream activity [23,24]. Understanding this market development process will allow blue carbon projects to more effectively design packages to attract buyers [25–27]. This process remains constrained by the diverse and non-binding aspects of global climate policy [28].

The future of the voluntary carbon market will also depend on implementation of Article 6 of the Paris Agreement, which encourages international cooperation in emissions reduction through a market-based approach involving both public and private entities [29]. It cautions, however, that double counting of carbon mitigation outcomes should be avoided through transparent and effective governance processes. This means that if a regional, national, or sub-national jurisdiction implements a mitigation scheme through regulation, then commercial organisations within that jurisdiction will be able to purchase carbon credits. If credits are generated and surrendered within the same jurisdiction, there is no double counting. If, however, firms purchase credits from an international market and surrender those credits in a domestic scheme, the nation in which the offsets were generated should not be able to consider those units as part of its reported obligations to the UNFCCC. The fundamental challenge for future market-based blue carbon initiatives thus arises from the tensions that exist between a commercial approach and the demands of meeting international climate obligations. If the constraints and uncertainties can be overcome – including questions about permanence of carbon stocks, tenure and governance, development robust methods to quantify carbon benefits, and so on [30] – commercial finance can be directed to specific local conservation and restoration projects to generate blue carbon offsets. However, if nations determine that their coastal carbon resources should be included in national carbon inventories under the international climate policy regime, there will be no direct investment pathway for commercial buyers. In short, a key question for future markets is: "who owns the blue carbon?"

3. Impediments and risks with current frameworks

Current mechanisms for investment in blue carbon — whether voluntary or through regulatory frameworks — face a set of risks and impediments that need to be resolved before investments will advance to the scale needed. The impediments include a lack of standardised and robust methods to estimate blue carbon offsets and co-benefits, uncertainty about financial returns, poor understanding of the types and magnitudes of risks, a paucity of finance mechanisms tailored to blue carbon ecosystems, lack of guidance on best practices, and a dearth of clear government policy and legal frameworks. While some progress towards addressing these issues has been made, there is still need for coordinated effort to improve existing methods, and provide the certainty needed by investors.

Investors need access to reliable metrics to estimate blue carbon offsets (losses avoided or gains made), predict survival rates of new or restored vegetation in blue carbon ecosystems, and quantify the risks and co-benefits that might impede or enhance revenue streams. Several guidelines have been developed in recent years to help standardise the assessment of changes in carbon stocks attributable to blue carbon projects, and to facilitate access to financing mechanisms (see Refs. [31,32] for some examples). However, such guidelines need to be disseminated more widely, and using language accessible to different stakeholders (investors, project developers, politicians).

There is also uncertainty about how to predict carbon accumulation rates over the term of an investment. Investors typically need estimates of rates of carbon accumulation specific to the location and project they are considering, in order to estimate returns on investment. Knowledge of plant survival rates in restored coastal ecosystems, and best practice methods that enhance survival, needs to be developed and disseminated to avoid costly mistakes. Such information can be provided by empirically-based measurements and models of carbon yield curves (and uncertainty bounds). The development of tools based on approaches tested in terrestrial ecosystems (e.g. the Australian Full Carbon Accounting Model: [33], but that are specific to blue carbon ecosystems, could also facilitate the estimation of returns on investment. Similarly, investors need ways of predicting and quantifying the different suite of co-benefits that they are interested in. These metrics and tools to predict and measure outcomes, whether of carbon or of a specific co-benefit, should be repeatable (yield the same outcome under unchanged conditions), transferable (valid and adaptable to different socio-economic and environmental conditions), and replicable (be measured using metrics that enable comparison of multiple investment options).

3.1. Uncertain legal and policy frameworks

Due to the long periods of time required to fulfil the requirement of "permanence" (recognising that natural carbon sinks, like soil, can release as well as store carbon, projects must ensure that carbon is sequestered for long periods of time, such as 25 or 100 years: [34], blue carbon investments are particularly sensitive to regulatory and policy uncertainty. The evolution of government priorities, changes in carbon market mechanisms (or lack of effective mechanisms), reduced availability of public funds for environmental conservation, or relaxation of regulations that directly or indirectly impact blue carbon ecosystems could compromise cash flows and increase risks. Unintended outcomes from uncoordinated regulations could also compromise the viability of investments in the sector (e.g. subsidies to aquaculture could lead to mangrove clearing).

To address these risks, the legal and policy frameworks relevant to carbon offsets need to be adapted to account for conditions specific to blue carbon projects. Property rights over coastal offset sites need to be properly defined within the legal framework. Definitions of such legal rights could be based on procedures and experiences followed through marine spatial planning approaches, such as allocation of aquaculture leases.

4. Strategies to promote investment

Key strategies to effectively engage stakeholders and promote investment include building on existing local capacity, proactively managing risks (in a transparent manner), bundling (or stacking: [35] non-carbon co-benefits, and promoting project success through appropriate site selection. Perhaps most important at this stage of the blue carbon innovation curve is successful demonstration and pilot projects that can fill scientific knowledge gaps, attract investor interest, and build operational capabilities.

Trade-offs and externalities associated with blue carbon projects (e.g. reduced access to fishing grounds, or perceived loss of amenity values if mangroves are re-established) could generate conflicts with local communities [30]. To reduce potential reputational damages to private investors the support of local communities should be obtained (i.e. social license to operate). As a result, building on existing local capabilities and incorporating local concerns is a priority. Experience in conservation and restoration of blue carbon ecosystems suggests that the outcomes of a project are more dependent on stakeholder engagement, site selection, and the restoration techniques used, than on the extent of financial resourcing [36]. Local communities are particularly important in facilitating or constraining positive outcomes. Local involvement in developing and operating blue carbon projects contributes to building social resilience, preserving cultural values and promoting ecosystem services on which livelihoods are based [37,38]. Community ownership of projects might constrain investment if responsibility and accountability for guaranteeing outcomes, applying best practices, and timely information flows is unclear. This can be mitigated through the presence of established legal community organisations or legitimate third parties (e.g. civil society organisations or research institutes), who assume or support project development, implementation, and operations.

The involvement of experienced organisations with capacity and established expertise reduces operational risks. A long-term objective, however, should be to enable not only local community ownership but also local management. Mechanisms previously used in terrestrial conservation projects can inform strategies for reducing risk, an example being the application of discount rates to create a risk of failure buffer to cover financial losses if forecasted outcomes are not realised. This approach is applied in the Australian Emission Reduction Fund (http://www.environment.gov.au/climate-change/government/emissions-reduction-fund, accessed 20 June 2018). The impact of discount rates on investment returns for blue carbon projects should, however, be carefully evaluated to balance strategic precaution and investment appeal [39]. Publicly-funded options would improve the risk and return profiles of blue carbon activities, making these projects more competitive. For instance, public subsidies to establish price 'floors' (i.e. guaranteed minimum prices for blue carbon credits) could minimise financial risks from price volatility. Also adaptations to mechanisms applied in carbon forestry are needed. Reverse bid auctions for carbon offsets in terrestrial ecosystems allocate contracts based on costs. This might not be the best strategy to promote blue carbon projects. Auctions targeting exclusively blue carbon activities, or differential treatment between terrestrial and coastal offset projects during standard auctions may be needed to reduce competitive disadvantages.

The non-carbon co-benefits associated with blue carbon projects provide opportunities to attract investors and generate additional financial support. It may be possible to take an approach in which bundling or stacking financial mechanisms focused on outcomes including improved water quality, protecting habitat, or reducing the impacts of extreme weather events on coastal villages. Indeed, this is already being done implicitly by accrediting social and biodiversity benefits alongside carbon sequestration in several of the major voluntary market standards (e.g. Verra, Gold Standard). This would demand transparent measurement methods, but insights from existing carbon offsetting and PES initiatives could guide the design of bundled environmental financing mechanisms. Stakeholders and industries that benefit directly or indirectly from coastal conservation activities (e.g., tourism, fishing, insurance [38]; should be encouraged to participate in the creation and funding of such financing mechanisms. The significant potential to generate social and environmental co-benefits will also probably benefit from links with strategies to achieve other goals (e.g. Sustainable Development Goals).

Not all coastal sites can be cost-effectively protected or restored within existing regulatory frameworks and market settings [40], so selecting appropriate sites will significantly enhance the likelihood of project success. Hydrological and climatic conditions that support natural recruitment and ecological regeneration should be favoured if additionality of the abatement is not compromised. Evidence from existing coastal conservation projects show that locally-sourced plant propagation material can be more resilient, therefore improving survival rates [36]. While some experiences suggest small-scale conservation projects (particularly in regions with low land and labour costs) are more profitable, large-scale initiatives may be more cost-efficient and thus competitive in international markets. Joint implementation of projects across regions with different environmental and social conditions (project diversification) could contribute to improved chances of successful outcomes. Reliable and up-to-date mapping of blue carbon 'hotspots' –places where restoration or protection is most needed and where probability of success is also high – are needed to guide targeted investments to areas with genuine potential to generate major social, economic, and environmental returns.

4.1. Demonstration projects to advance best practices

An important current priority should be the implementation of 'no regrets' investment in demonstration projects. Such demonstration projects are needed to build investor confidence, improve project delivery capabilities in implementing organisations, and provide the evidence base necessary to mobilise public and private investment and drive changes to regulatory frameworks. They can also trial tailored versions of existing methods and support the creation of tools to expose challenges and risks, reduce transaction costs, and calibrate estimates of carbon offset yields and co-benefits. Demonstration projects are likely to highlight current policy gaps. Given that project outcomes will be influenced by location-specific social, economic, and environmental conditions, as well as the nature of stakeholder involvement and techniques used, case studies should be implemented across different geographic areas and ecosystems types to characterise variability across heterogeneous conditions. This will provide more representative results and transferable approaches and tools.

Voluntary markets – and specific private sector organisations – can be targeted to finance pilot case studies. These markets are more accessible to small-scale and community-level projects, though generally provide lower returns on investment [18]. Experienced agencies with deep networks in target regions should be involved, and projects should pay particular attention to methods for bundling or stacking of non-carbon benefits, and the creation of sustainable livelihoods.

Finally, the development of demonstration projects should occur in combination with other approaches to data collection, such as the systematic collection of biological and biogeochemical information from existing projects (e.g. rates of carbon sequestration or accumulation) and model-based integration of biophysical, social, and economic data to aid forecasting in future projects, and enhance methodological rigour.

5. A strategy to expedite action

A long-term goal is a functioning blue carbon market that fosters healthy and resilient ecological and social systems that underpin multiple services provided by coastal blue carbon ecosystems (Fig. 2). Such ecological and social systems would support, and be supported by, the sustainable use of blue carbon ecosystems. Some finance will necessarily come from public investment, but private investment will also be essential (Fig. 2). A three-stage strategy to generate the appropriate types and magnitudes of financial investment should help reach this challenging (but achievable) goal (Fig. 2).

First, blue carbon practitioners need to understand the motivations and expectations of potential investors, and how these align with current opportunities and policy frameworks. With this understanding, a second stage would comprise the development of demonstration projects in concert with tailored financial products to support blue carbon restoration or protection that meet the expectations of investors. As described earlier, these need to ensure that transaction costs are significantly reduced, and include robust and transparent mechanisms for external auditing and risk management strategies. With these demonstration projects and financial products, a third stage would involve refining and customising investment opportunities that can accommodate the variation in socioeconomic, environmental, institutional and regulatory contexts in which they would be applied. To streamline and fast-track development of financial mechanisms, these three stages do not need to be completely sequential, but could overlap.

Many stakeholders — ranging from policymakers and investors to local communities — will need to work together for the ultimate goal to be reached. Clarifying the role that each of these stakeholders need to play, and how they can best work together, is critical for success. In addition, efforts are needed to empower the various stakeholders to convert theories and concepts into practical actions, such as generation of a business partnership program that can be used to test strategies, develop tools and standardised reporting, and share experiences. Support for such a business partnership program could be provided through a market intelligence platform that provided information about relevant projects, potential partners, updates on the state of the carbon offset market, funding options and best practices.

Development of financial mechanisms for blue carbon should be coupled with development of tools (such as guidelines and software) for investors to assess the potential profitability of a project. Such tools should enable reliable, robust estimates of the return on investment (for investors, but also more broadly for other stakeholders like local communities and governments). Such return will not always be measured by standard performance measures, but will sometimes include a range of social and ecological benefits, and these need to be included.

Blue carbon offers great potential as a nature-based tool to mitigate the rising concentrations of greenhouse gases, while simultaneously achieving multiple co-benefits, but development of projects that aim to restore or protect blue carbon remains slow due to a range of impediments. A framework that leads to the realisation of this potential requires (1) sets of demonstration projects that resolve key issues of methodological approach and carbon co-benefits, (2) the design of tailored financial mechanisms that balance risk and commercial opportunity, and (3) policy clarity around carbon rights and public/private relationships, whether at global or national levels. By pursuing

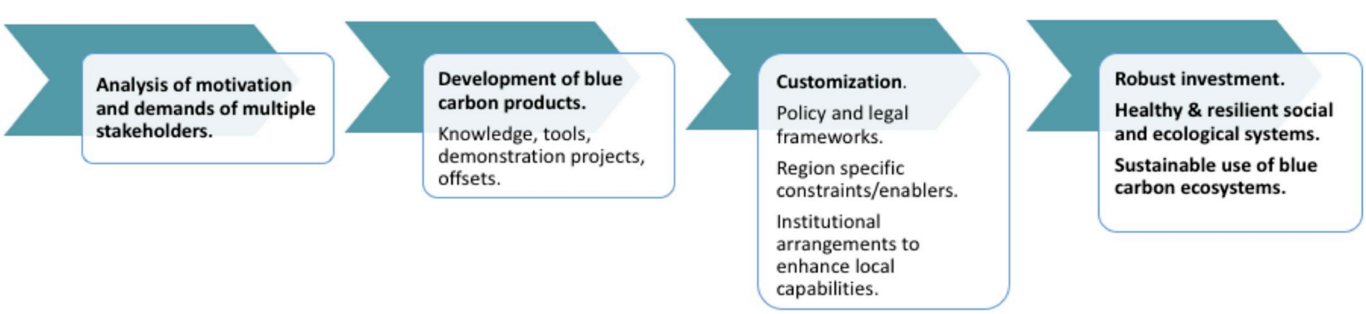

Fig. 2. Three-stage strategy to expedite action.

these objectives, we can harness the multiple services provided through blue carbon initiatives to sustain and regenerate healthy and resilient coastal ecosystems and communities.

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Appendix A. Supplementary data

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