OCEAN PANEL SPECIAL REPORT

THE BLUE CARBON HANDBOOK

Blue carbon as a nature-based solution for climate action and sustainable development

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Commissioned by

HIGH LEVEL PANEL *for*
A SUSTAINABLE
OCEAN ECONOMY

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About the Ocean Panel

Established in 2018, the High Level Panel for a Sustainable Ocean Economy (Ocean Panel) is a unique initiative made up of serving world leaders who are building momentum for a sustainable ocean economy in which effective protection, sustainable production and equitable prosperity go hand in hand. By working collaboratively with a wide array of stakeholders, the Ocean Panel aims to identify bold solutions that bridge ocean health, wealth and equity and accelerate and scale responsive action worldwide.

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Foreword

The High Level Panel for a Sustainable Ocean Economy (Ocean Panel), in its *Transformations for a Sustainable Ocean Economy: A Vision for Protection, Production and Prosperity*, included a goal that, by 2030, 'marine and coastal ecosystems are healthy, resilient and productive, and nature-based solutions are key elements in developing coastal infrastructure'. There are many good reasons for this. Marine and coastal ecosystems play key roles in ocean carbon cycling and provide hotspots of biodiversity. Vital coastal ecosystems are key to human well-being, fisheries and tourism. Coastal vegetation protects against erosion, flooding and storms.

To highlight potential pathways towards achieving this goal, the Ocean Panel has commissioned this report, *The Blue Carbon Handbook: Blue Carbon as a Nature-Based Solution for Climate Action and Sustainable Development*, produced in collaboration with the International Partnership for Blue Carbon and the Blue Carbon Initiative. *Blue carbon* is defined by the Intergovernmental Panel on Climate Change (IPCC) as 'all biologically-driven carbon fluxes and storage in marine systems that are amenable to management' (IPCC 2019). At present, three types of coastal wetland ecosystems have internationally adopted methodologies for carbon accounting as defined in the IPCC Wetlands Supplement (IPCC 2013). Thus, these three ecosystems—tidal marshes, mangroves and seagrass meadows—are the focus of this report as they are actionable at present in a climate context.

Since the term *blue carbon* was coined nearly 15 years ago, global recognition of the contribution of blue carbon ecosystems to storing and sequestering carbon, coastal resilience and adaptation to climate change, sustaining biodiversity and supporting human populations has increased. Despite this, we have also witnessed substantial and continuing degradation and destruction of these ecosystems.

This report draws on the comprehensive literature on blue carbon ecosystems developed over the last decade, aiming to distil key concepts and information. The report is intended for non-specialists who are starting to consider blue carbon opportunities, to act as a reference guide to gain a broad understanding of the subject to support decision-making. The report has been collectively composed by a select group of expert blue carbon authors. It offers key information and direction to decision-makers considering topics ranging from the sequestration potential of blue carbon ecosystems, to adaptation and resilience benefits, to the policy landscape surrounding blue carbon for climate action, biodiversity and sustainable development, and to the carbon market and other financing options for blue carbon projects. This report can be read 'cover to cover' or used as a quick reference guide, with key topics flagged by section headings, significant references for further reading listed and categorised, and common questions answered.

Scaling blue carbon action by expanding the number of high-quality projects and national-scale programs is one example of a nature-based solution to climate change that can also contribute to global goals around biodiversity and sustainable development. Achieving the global goal of avoiding the worst impacts of climate change will additionally require prioritising swift and deep emission reductions. Alongside this pressing need to reduce global greenhouse gas emissions, the protection and restoration of blue carbon ecosystems are part of the broader solution set for delivering the ambitions of the Paris Agreement, the Kunming-Montreal Global Biodiversity Framework and an adaptable and resilient sustainable ocean economy that can support thriving, healthy societies now and into the future.

In coming years, scientific understanding of carbon cycling in kelp and seaweed ecosystems may progress to a level which will also make these coastal ecosystems 'amenable to management' and therefore included in future IPCC definitions of blue carbon. At present, tidal marshes, mangroves and seagrass meadows are actionable for climate and therefore are the focus of this report.

As a lead expert within the Ocean Panel Expert Group, I would like to warmly thank the authors, the reviewers and the Ocean Panel Secretariat at World Resources Institute for supporting the production of this resource. I am also extremely grateful for the continued enthusiasm of Ocean Panel members in their work towards realising a global sustainable ocean economy, and I hope that they and others act on the opportunities identified in this report.

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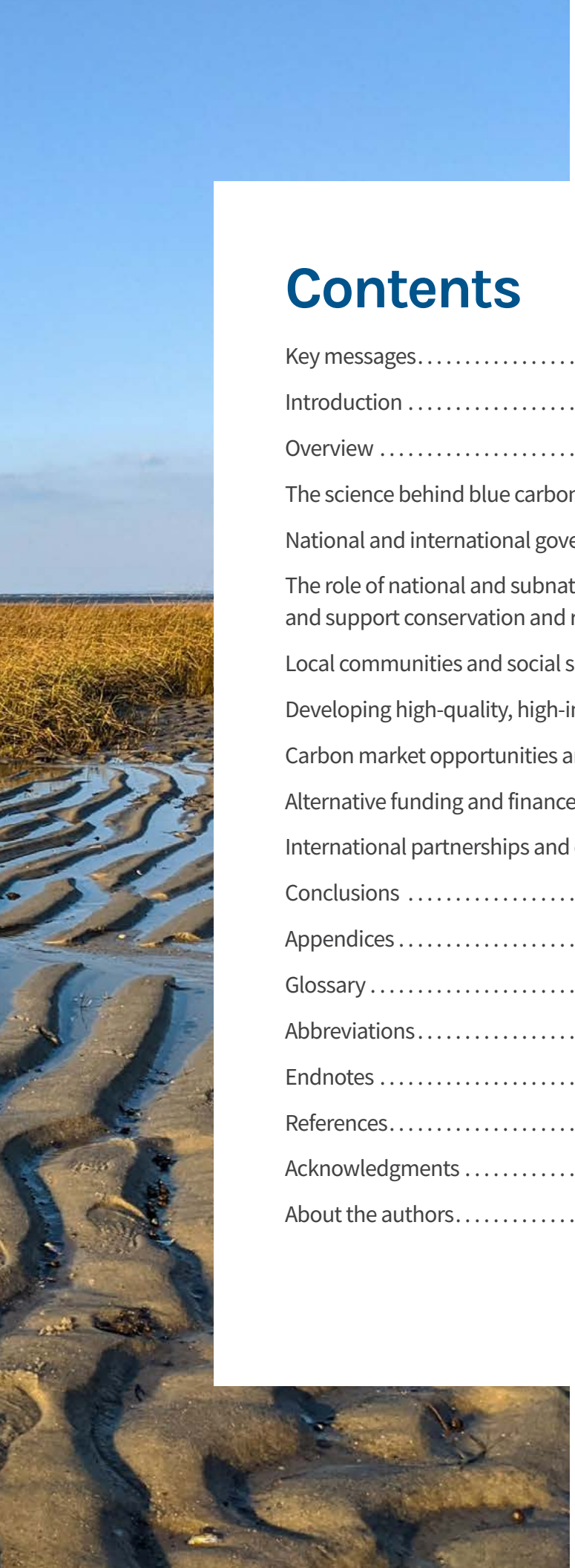
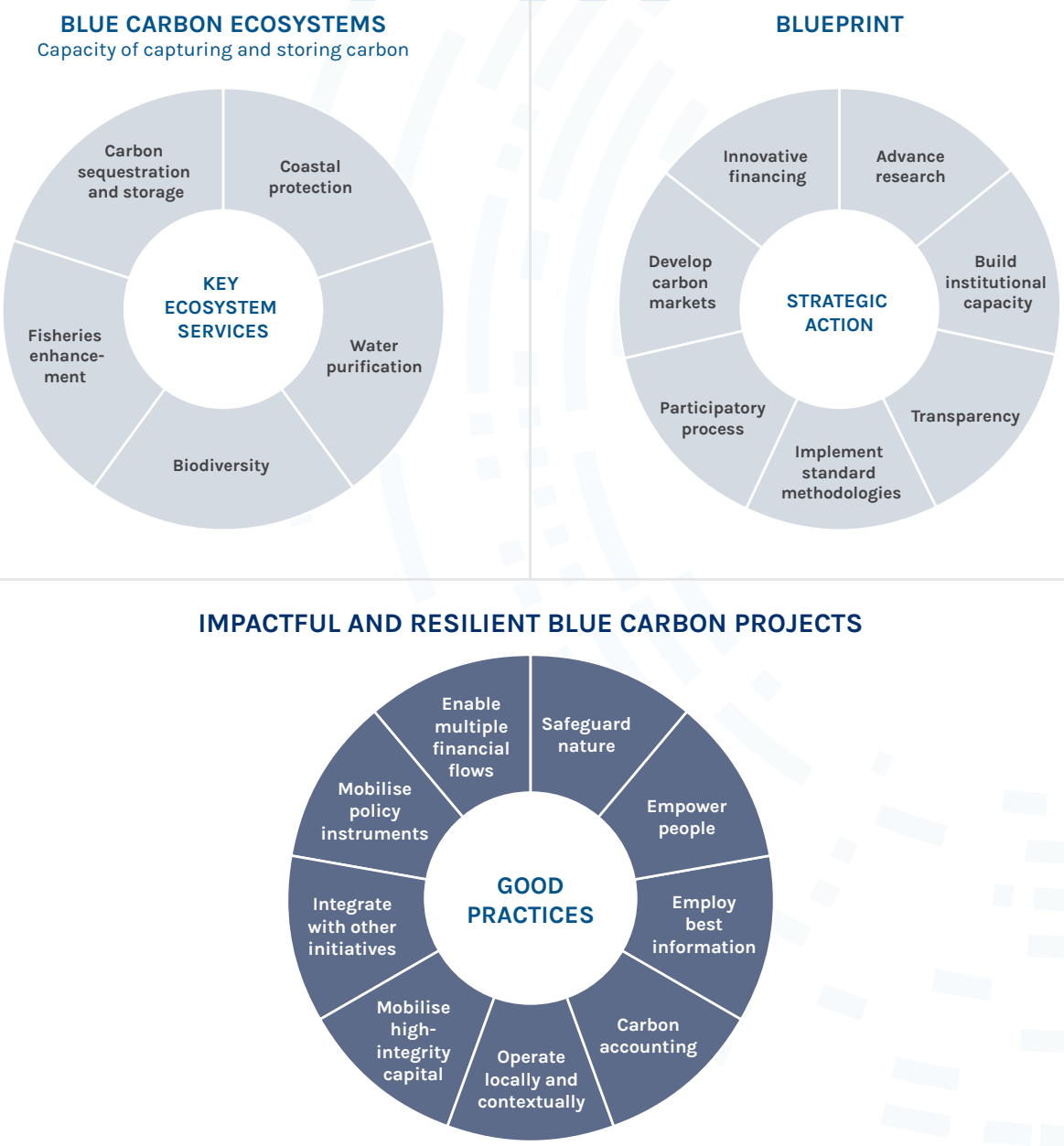


Contents

Key messages

- Currently actionable blue carbon ecosystems—that is, mangroves, seagrass meadows and tidal marshes—are valuable natural assets that capture and store carbon dioxide, contributing to climate change mitigation.
- Sustainable management of blue carbon ecosystems offers further, broader, environmental, social and economic benefits beyond climate action, including resilience, conservation and livelihood support.
- Blue carbon action refers to conservation, restoration or sustainable management of mangroves, seagrass meadows and tidal marshes, and can utilise a variety of financing approaches for implementation, including through utilising market-based or non-market approaches (the latter through blue bonds or development banks, for example).
- Protecting, restoring and sustainably managing blue carbon ecosystems, including through the production of sustainable ocean plans, is an actionable solution within jurisdictional boundaries and internationally recognised greenhouse gas (GHG) accounting methodologies through the Intergovernmental Panel on Climate Change (IPCC) for climate mitigation.
- Governments can advance blue carbon projects and priorities by providing clear policy signals, aligning funding streams and creating the necessary incentives for action.
- National commitments contributing to global goals, like nationally determined contributions (NDCs) for the Paris Agreement or national biodiversity strategies and action plans (NBSAPs) for the Kunming-Montreal Global Biodiversity Framework, can demonstrate government priorities and accelerate action when the multiple benefits of coastal ecosystems are included.
- A holistic approach is needed, integrating adaptation, resilience, biodiversity conservation and community livelihoods alongside implementation of blue carbon actions and relevant financing, including carbon markets or non-market approaches.
- Following good practices and principles builds trust with local communities, national and local governments, and other stakeholders.
- Inclusive and equitable collaboration between government, international organisations, scientific institutions, the private sector and local communities is crucial.

Figure 1. Summary of ecosystem services provided by blue carbon ecosystems, good practices of impactful and resilient blue carbon projects, and opportunities for strategic action to support and advance successful blue carbon projects



Source: Authors.

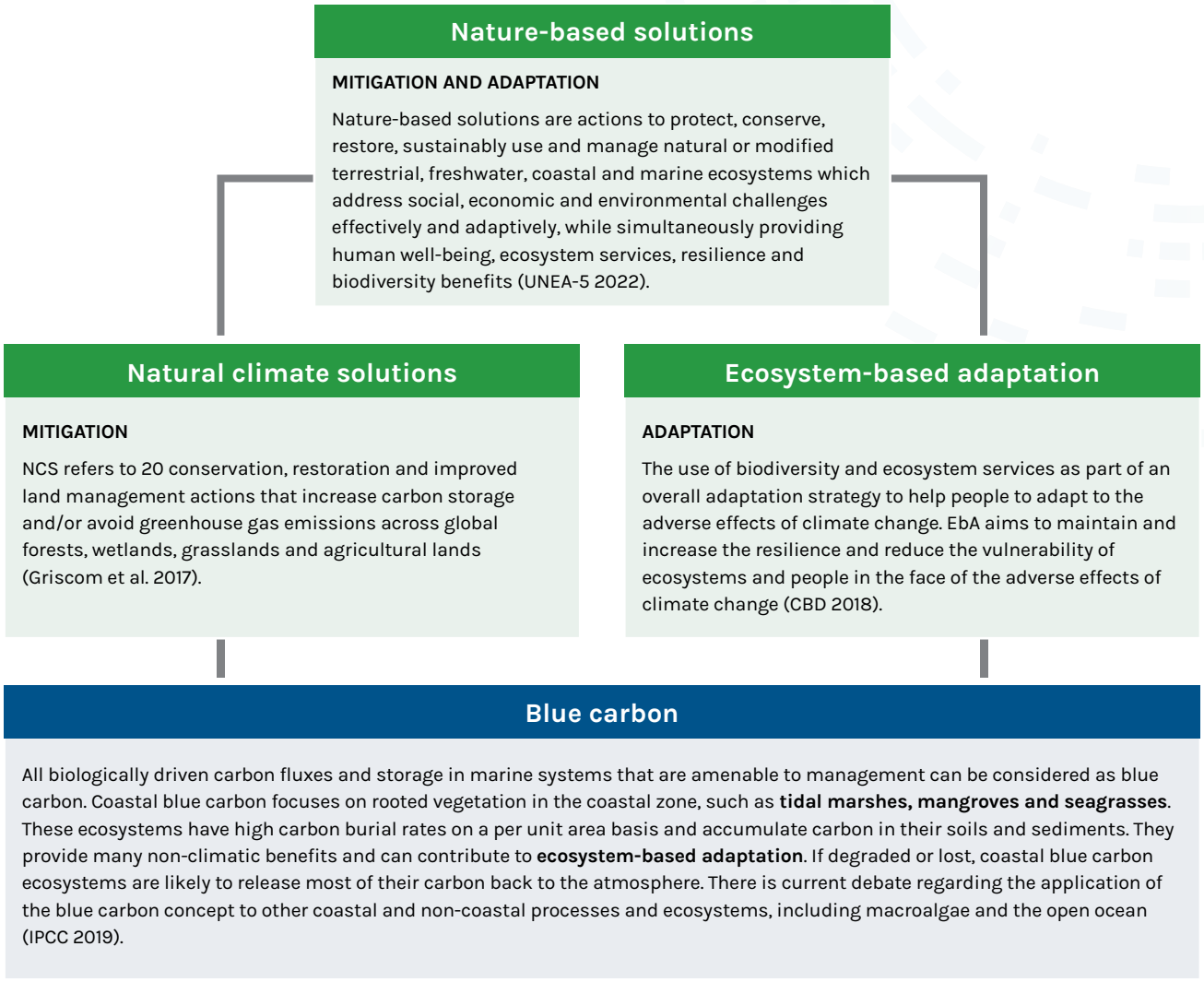
Key messages from Figure 1

Blue carbon projects refer to initiatives aiming to restore, conserve and/or sustainably manage blue carbon ecosystems (here: mangroves, seagrass meadows and tidal marshes) because of their capacity to capture and store carbon dioxide from the atmosphere, contributing to climate change mitigation. These and other marine ecosystems provide additional ecosystem services related to broader environmental, social and economic benefits. Impactful and resilient blue carbon projects should follow good practices and can be advanced by strategic actions.

Introduction

Natural capital underpins our prosperity and well-being (Dasgupta 2021). Marine and coastal ecosystems, for example, provide multiple ecosystem services, such as coastal protection, biodiversity and habitat, recreation and tourism, and cultural ecosystem services (e.g. cultural identity and sense of place) (Barbier 2016; Barbier 2017). Nevertheless, these ecosystems are under threat from multiple anthropogenic pressures, making sustainable management of marine and coastal ecosystems essential. Such management can help maintain biodiversity, build the resilience of coastal communities and make our use of marine assets sustainable, thereby ensuring the long-term well-being and prosperity of humans and the planet (Costanza 1999; Winther et al. 2020). Nature-based solutions (NbS) are one of the approaches for managing natural resources. NbS refers to actions that conserve, restore or sustainably manage ecosystems to address societal challenges, such as climate change and biodiversity loss (Cohen-Shacham et al. 2019).

Figure 2. Internationally agreed definitions of nature-based solutions, natural climate solutions, ecosystem-based adaptation and blue carbon



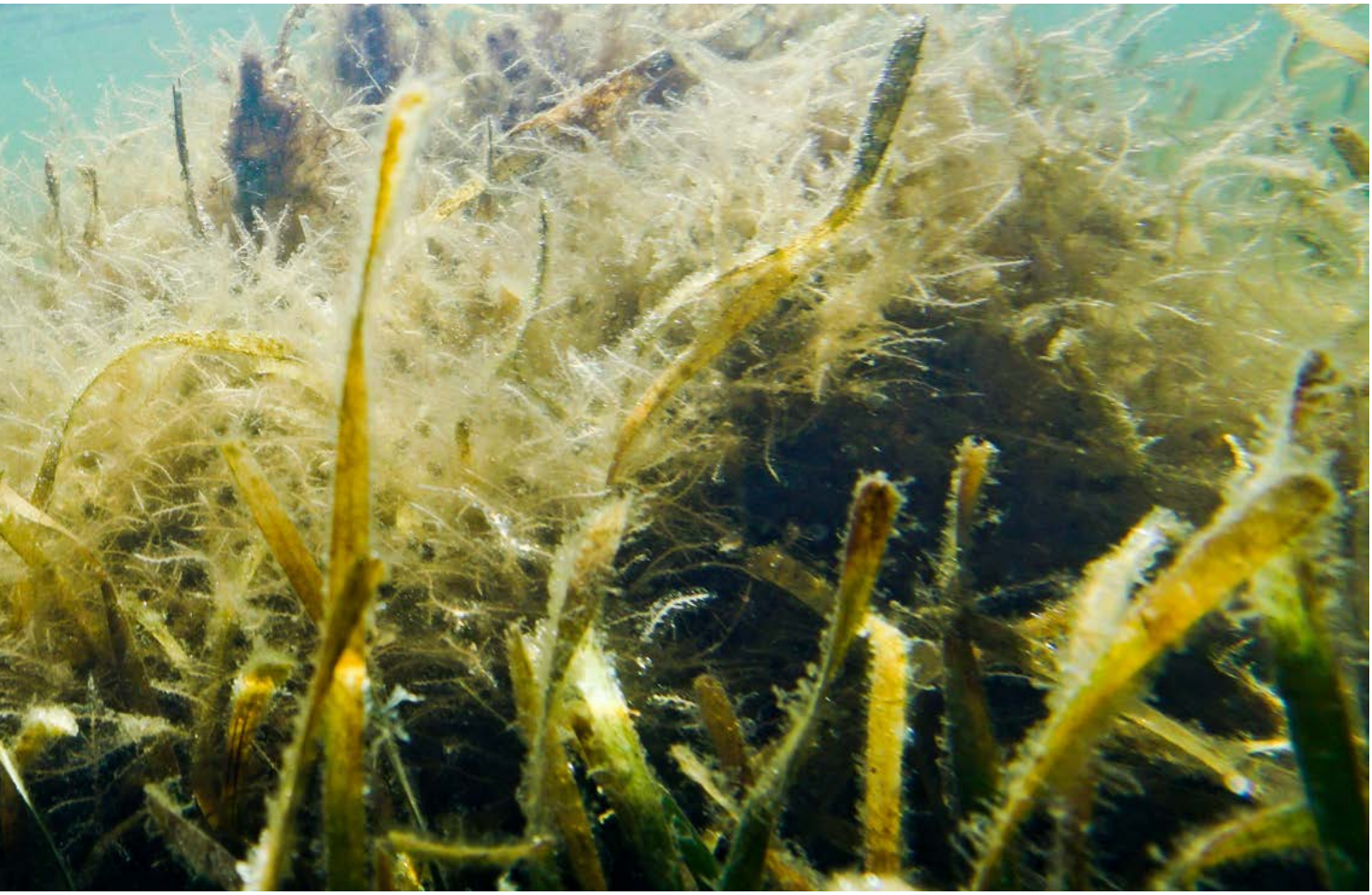
Note: Nature-based solution is an umbrella term, with natural climate solution referring to mitigation, ecosystem-based adaptation referring to adaptation, and blue carbon actions contributing to all of the above. IUCN pioneered the concept of Nature-based Solutions 20 years ago, first developing a formal definition and then the Global Standard for Nature-based Solutions as a safeguard for their use, before it was recently formally adopted during UNEA.

Source: Authors.

The protection and restoration of blue carbon ecosystems, including mangroves, seagrass meadows and tidal marshes, have gained attention as powerful NbS (Figure 2). Healthy blue carbon ecosystems are vital to enhance resilience, adaptation, biodiversity, livelihoods and climate mitigation. These ecosystems can sequester and store carbon dioxide (CO_2) in their underlying soils over long periods at levels up to five times higher than terrestrial forests on a per hectare basis (Macreadie et al. 2021). Accordingly, blue carbon projects focus on conserving, restoring and sustainably managing these ecosystems and have been advanced at local, national and regional scales. However, to optimise environmental, social and economic outcomes, it is critical to follow specific guidelines, principles and good practices that continue to be refined as the sector develops, and as are outlined in this report.

This report gives particular attention to the role of coastal communities, which are often responsible for managing their coastal resources, the first to feel the impacts of inaction, and thus also the first to recognise and value the services of healthy coastal ecosystems such as food provision, natural hazard protection, erosion regulation and sociocultural services, in addition to climate mitigation (Vierros 2017). Local communities are critical actors, and NbS and blue carbon projects must ensure the implementation of social and environmental safeguards, and transparent legal frameworks for local participation and/or ownership, including benefit sharing and building capacity at all levels.

Governments play a central role in protecting and restoring blue carbon ecosystems, and national and local policies and actions must be effectively implemented and supported. Integrating blue carbon management into nationally determined contributions (NDCs) under the



Paris Agreement for mitigation or adaptation action can effectively support the prioritisation of implementation to protect coastal ecosystems (Blok et al. 2020). However, achieving policy coherence and balancing competing interests and mandates requires clear national and local strategies, frameworks and incentives (Burdon et al. 2019). National governments may provide stable policy signals, align funding streams and create proper incentive structures to promote the conservation and restoration of blue carbon ecosystems. To support a project's implementation and development, multiple financial flows can be used, including public, private and mixed (i.e. public and private) (Vanderklift et al. 2019; Sumaila et al. 2021).

While NbS for climate mitigation is one approach policymakers can use to address the pressing challenges of climate change, biodiversity loss and sustainable development, reducing emissions across all sectors must still be the priority.

This report aims to advance action and understanding of blue carbon actions and their cross-cutting benefits that contribute to sustainable development and protecting biodiversity, in addition to climate adaptation and mitigation. It provides insights and recommendations on effectively implementing blue carbon projects at the national and local levels, ensuring that they are of high quality and have high environmental and social integrity, thus serving as a valuable resource for governments, local communities and other stakeholders across sectors.

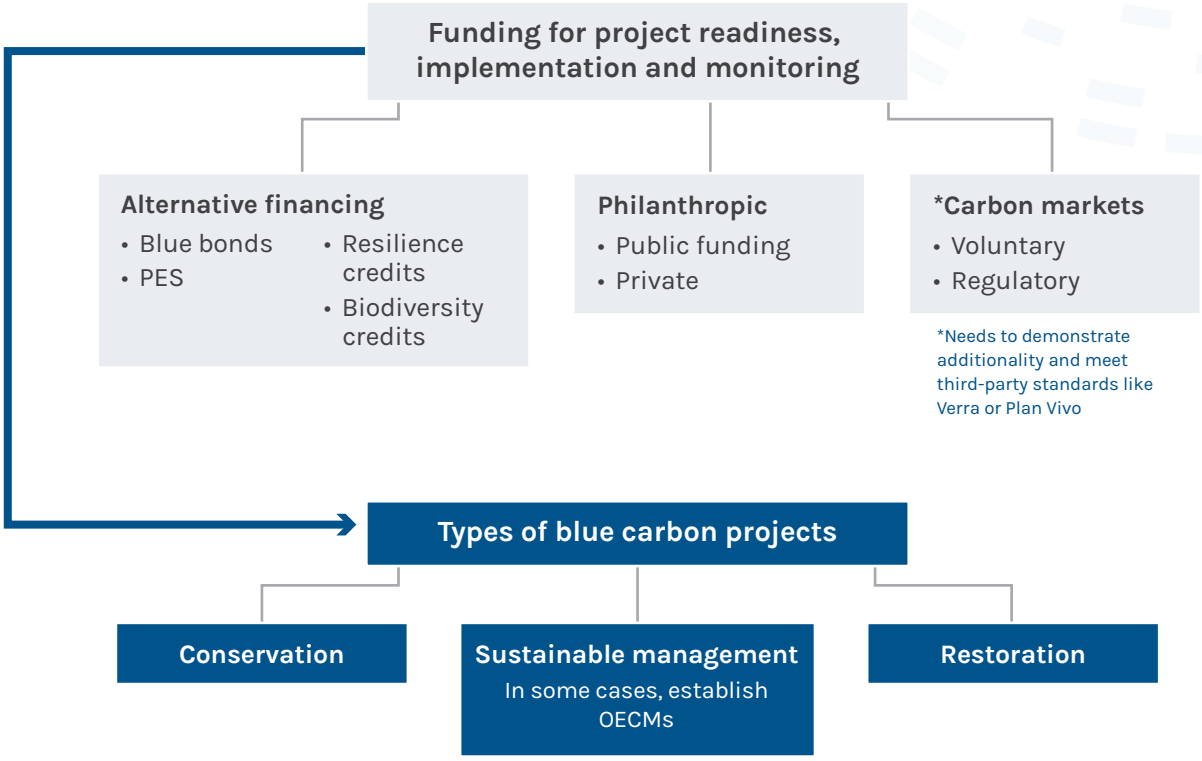
Overview

Ocean and coastal areas are critical in the global carbon cycle and contain much of the world's biodiversity. While the changing climate has many increasing negative impacts on marine and coastal ecosystems, these ecosystems may also be part of the climate solution when effectively protected, restored or sustainably managed. For this report, the term *blue carbon* refers to the carbon sequestered and stored in coastal ecosystems, the carbon emitted from coastal ecosystems when degraded or destroyed, and the adaptation and resilience benefits of healthy ecosystems, following the IPCC definition (IPCC 2019).

This report will focus on blue carbon solutions in ecosystems where actions can be currently taken to enhance sequestration capacity or reduce emissions while also enhancing adaptation and resilience capacity. The three key coastal ecosystems currently amenable to management and actionable in climate mitigation policy are mangroves, seagrass meadows and tidal marshes[1], and throughout the report the term *blue carbon ecosystems* will refer to these three ecosystems only (Figure 2).

Actions to enhance blue carbon stores are sometimes referred to as coastal 'nature-based solutions' (NbS—defined as 'actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits' (UNEP 2022)). These actions have the added benefits of supporting sustainable development and providing ecosystem-based adaptation options (CBD 2018). The conservation, restoration and sustainable management of mangroves, seagrass meadows and tidal marshes are actions aligned with international agreements that define NbS (Figure 3).

Figure 3. Different types of blue carbon projects, and corresponding non-exhaustive list of funding options available



Notes: OECM = other effective area-based conservation measure; PES = payment for ecosystem services.

Source: Authors.

Importantly for the context of this handbook, NbS actions contribute to enhanced carbon sequestration and are often coupled with financial mechanisms that can account for the GHG emission-reduction benefits associated as part of more nascent projects that are market-based (e.g. focused on carbon trading) or non-market-based (financed through blue bonds or development banks, for example, and focused on coastal and community resilience, and/or conservation).

This report covers all aspects of blue carbon activities that contribute to climate mitigation, adaptation and resilience, sustainable development, and improved livelihoods, and that are framed as both relatively nascent market-based, and/or non-market-based, projects. This distinction is important as a reminder that blue carbon refers to more than sequestered carbon or carbon markets. Humankind depends on the health of coastal and marine ecosystems for their global and local contributions to economic well-being, biodiversity, sustainable development, cultural importance and food security, in addition to climate change mitigation, adaptation and coastal resilience. For this reason, blue carbon is sectorally cross-cutting with global impacts around climate

change and local impacts around community livelihood, fisheries and economic security.

The latest Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report identified coastal blue carbon ecosystems as a biological carbon dioxide removal strategy that can concurrently enhance biodiversity, ecosystem services, employment and local livelihoods. This inclusion of blue carbon within the IPCC assessment is an indicator of its global relevance, underpinned by a large catalogue of scientific research and implementation experience at the local level. With growing momentum in addressing the dual crises of climate change and biodiversity loss, blue carbon ecosystems are increasingly relevant in international policy creation, national activities and local action.

It is important to emphasise that blue carbon is already actionable. Blue carbon ecosystems have internationally adopted methodologies through the IPCC, enabling countries to account for the ecosystems' mitigation potential in their NDC targets and related national greenhouse gas inventories. Governments can map these ecosystems within a national jurisdiction, and the ecosystems can contribute to government mitigation and adaptation activities through their protection, restoration or sustainable management in a way that can be monitored and verified. Additionally, countries and independent crediting standards are allowing for carbon trades on the voluntary markets that are inclusive of NbS, such as blue carbon ecosystems. While progress has been made in implementing blue carbon actions to date, challenges and barriers to sustainable implementation remain, including access to financing and equitable community engagement across project design.

This Ocean Panel–commissioned special report is intended to help accelerate action and understanding of the variety of blue carbon benefits and activities necessary to finance, implement and scale action. It aims to be a key resource for governments and other stakeholders working on blue carbon across sectors—from government officials to natural resource managers, small-scale fisheries and their local communities, NGOs, academia, businesses and others.

This report summarises the latest available science, policy trends and experiences, and identifies emerging gaps and needs to help develop sustainable and equitable blue carbon projects on the ground. The report also highlights the variety of partnerships that have been formed to respond to the emerging needs and interests of governments, scientists, policymakers, the private sector and practitioners (see the section 'International partnerships and other initiatives'), and provides an up-to-date collation of key resources on blue carbon (see 'Key resources'). We have further identified frequently asked questions (FAQs) that governments and policymakers have about blue carbon and have included an FAQ section for easy reference.

The science behind blue carbon

Key information

- The benefits of protecting coastal blue carbon ecosystems are diverse, with cross-cutting local and global impacts for climate mitigation and adaptation, coastal resilience, biodiversity, local livelihoods, sustainable development and food security.
- Blue carbon mitigation potential is significant but is far from sufficient to address climate change on its own.
- Blue carbon projects need to be paired with other decarbonisation and emission-reduction strategies and should consider the value of all associated benefits in their design to address climate adaptation, resilience and sustainable development.
- Blue carbon ecosystems are threatened by coastal development (e.g. deforestation for infrastructure, aquaculture) and combined negative effects from climate change (e.g. sea level rise, coastal erosion, stronger and more frequent extreme weather events), which increases the risk of further degradation.
- While discussions have emerged around the definition and applicability of other coastal and marine ecosystems, such as macroalgae, the emphasis in this report is on actionable blue carbon ecosystems.

Current status

Evidence continues to mount on the need for urgent and scaled-up action to address the impacts of a changing climate, increase ambition on mitigating climate change, and prepare to adapt to increasingly changing conditions. Nature-based solutions, such as actions to protect, restore and sustainably manage coastal blue carbon ecosystems, are one of the tools governments and other public and private stakeholders can deploy to address climate change while promoting other sustainable development benefits.

The IPCC (2019) defines blue carbon as 'all biologically-driven carbon fluxes and storage in marine systems that are amenable to management' (Figure 2). The IPCC focuses on coastal blue carbon ecosystems, including mangroves, seagrass meadows and tidal marshes, as these are the three coastal wetland ecosystems with broad distributions that have internationally adopted methodologies for carbon accounting as defined through the IPCC Wetlands Supplement (IPCC 2013). This is why we have made these three ecosystems the focus of this report (Figure 4).

Mangrove, seagrass and tidal marsh plants are able to thrive on the coastal-marine interface where other plants typically cannot. They are adapted to salinity and temperature changes and have extensive root systems that allow them to withstand tidal flows and storm surges and anchor soil to prevent erosion (Duarte et al. 2013; Serrano et al. 2019). In these saltwater-infused conditions, the breakdown of plant material is slowed, and large amounts of organic matter are deposited and accumulate rapidly. This facilitates storage of large amounts of carbon in the soils or sediment. Coastal blue carbon ecosystems can store two to five times more carbon in their soils per unit area than terrestrial ecosystems (Donato et al. 2011; Macreadie et al. 2021). In mangroves alone, carbon stocks average 740 tonnes of carbon per hectare (organic carbon only) and can reach upwards of 1,000 tonnes of carbon per hectare in mangroves—equivalent to CO_2 emissions

Figure 4A. Mangroves, seagrass meadows and tidal marshes as blue carbon ecosystems

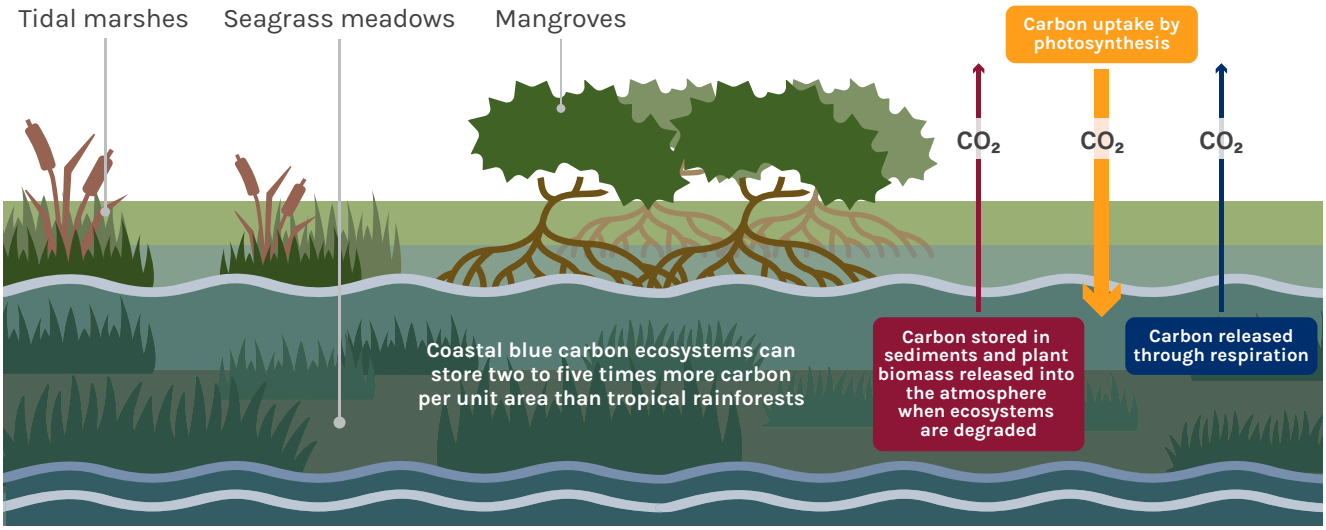


Figure 4B. Global distribution of blue carbon ecosystems

Notes: CO_2 = carbon dioxide; Sediment carbon sequestration is a process in which carbon dioxide is removed from the atmosphere and stored in the soil carbon pool.

Source: Authors. Figure 4B provided by the Blue Carbon Initiative.

from the burning of over 2,000 barrels of oil (USEPA 2023), of which up to 98 percent is stored in the sediment (Donato et al. 2011; Alongi 2020). Worldwide, blue carbon ecosystems store 6–12 gigatonnes (billion metric tonnes) of carbon (Alongi 2020; Kauffman et al. 2020)—equivalent to the carbon emitted by all global gas-fired power stations over the course of four years (USEPA 2023).

These characteristics make these ecosystems extremely valuable as nature-based solutions for mitigating and adapting to climate change (Duarte et al. 2013; Serrano et al. 2019). Preventing the degradation of these ecosystems can potentially avoid the equivalent of 0.141–0.466 gigatonnes CO_2 emissions globally per year—equal to CO_2 emissions associated with the operations of up to 1,150 natural gas–fired power plants in one year—given that disturbed soils from degradation would emit CO_2

(USEPA 2023). The restoration of degraded blue carbon ecosystems could allow them to sequester carbon at a rate of up to 0.621–1.064 gigatonnes CO_2 globally per year (Macreadie et al. 2021), although the exact sequestration potential is not fully understood and depends on a variety of factors (Williamson and Gattuso 2022).

While the mitigation potential is significant, it is critical to prioritise reducing emissions across all sectors to meet the goals of the Paris Agreement to keep the world below 1.5^{0}C (Williamson and Gattuso 2022). Additionally, safeguards are needed to address climate change in a way that protects local livelihoods and does not cause unintended socioeconomic consequences. It is the joint mitigation, adaptation, biodiversity conservation, and sustainable development value that makes blue carbon an attractive prospect to investors, implementers and communities alike.

Healthy blue carbon ecosystems contribute to a sustainable ocean economy, beyond climate mitigation, providing what are often referred to as 'co-benefits' (Griscom et al. 2017; Rahman et al. 2021). These include providing nurseries for commercial and artisanal fisheries (e.g. molluscs and crustaceans such as crabs and shrimp (zu Ermgassen et al. 2021)), thus supporting sustainable food security for coastal communities, alongside increased economic resilience with local income streams from the sustainable extraction of timber and non-timber products (Hutchison et al. 2014), increased ecotourism potential and protected cultural values. Climate adaptation, coastal resilience and natural infrastructure are other co-benefits from these ecosystems: they physically buffer and protect coasts from coastal erosion and flooding and trapping sediment and filtering out contaminants from water (Shah and Ramesh 2022). Economic value estimates of these ecosystem services or co-benefits vary widely and depend on the type and number of co-benefits analysed, together with ecosystem type, geographic locale and even the methods used (Hernández-Blanco et al. 2020; Bertram et al. 2021).

Despite the value and importance of coastal blue carbon ecosystems, coastal blue carbon ecosystems continue to be threatened, degraded and destroyed by climate-derived negative impacts such as sea level rise and the increased frequency and intensity of hurricanes (Hanley et al. 2020; Swapna et al. 2022). In addition, they are negatively affected by human-driven land-use change, such as conversion to aquaculture or agricultural land, destructive fishing practices (e.g. trawl or anchor damage) and coastal infrastructure development (O'Connor et al. 2020). This 'coastal squeeze' (IPCC 2019) and multidimensional set of threats to blue carbon ecosystems has resulted in the loss of 20–35 percent of their global cover since 1970 (Polidoro et al. 2010; Gardner and Finlayson 2018).

While the ability of seagrass meadows to sequester carbon may increase with climate change–related ocean acidification, strengthening the argument for their sustainable management (Garrard and Beaumont 2014), and mangroves appear to be resilient to tropical storm impacts, the cumulative and large-scale impacts of extreme weather events and sea level rise (Charrua et al. 2020; Saintilan et al. 2020) remain uncertain across blue carbon ecosystems. A combination of storm characteristics (i.e. wind speed, cumulative rainfall and subsequent flooding) and previous history of storms and mangrove structure are strong predictors of damage (Taillie et al. 2020). Similar dynamics have been documented for seagrasses (Carlson et al. 2010; Oprandi et al. 2020) but may not apply to tidal marshes (Castagno et al. 2021). For low-lying coastal regions and small island developing states, the loss of the storm-buffering capacity of blue carbon ecosystems could lead to significant and growing economic damage (Mendelsohn et al. 2012). Developed countries do not escape these losses; Tanner and Strong (2023) estimate that a one-metre rise in sea level represents a net loss of $137.5 billion in carbon sequestration ecosystem service value by 2100 in Long Island, New York, alone.

When these ecosystems are degraded or lost, for example when mangroves are converted to shrimp ponds, up to 92 percent of their original carbon stocks are released into the atmosphere (Cifuentes-Jara et al. 2015; Kauffman et al. 2020), thus exacerbating climate change. Globally, soil carbon loss from mangrove forest cover change was calculated to be between 30 and 122 million tonnes CO_2 between 2000 and 2015, with 75 percent of that amount coming from change in land use dynamics in Indonesia, Malaysia and Myanmar alone (Sanderman et al. 2018). In an encouraging trend, the rate of mangrove loss has decreased over the last decade, as conservation and restoration efforts have accelerated (Adame et al. 2021).

Knowledge gaps and emerging issues

Significant research and project development over the last decade is informing successful management, conservation and restoration of blue carbon ecosystems. Based on this, meaningful actions towards meeting the climate change mitigation and adaptation goals of the Paris Agreement are underway. Yet several knowledge gaps, many of them common to nature-based solutions in general, remain and are described in this section.

Scientific gaps and needs for mitigation action

The role and dynamics of non-carbon GHGs, like methane and nitrous oxide, in blue carbon ecosystems need further clarification. Because the climate-warming potential of methane is many times stronger than CO_2, methane needs to be widely studied across blue carbon ecosystems to clarify which human activities and environmental changes can increase its release into the atmosphere (Rosentreter and Williamson 2020; Roth et al. 2023). It is also important to understand the influence of ocean acidification versus the input of carbonates and other inorganic components on plant growth because potential of hydrogen (pH) plays an important role in the balance of greenhouse gases being emitted or sequestered (Macreadie et al. 2019; Saderne et al. 2019). In addition, the impacts of climate change dynamics, including the potential adaptation and migration of blue carbon ecosystems because of sea level rise, must be studied. Similarly, the extent of seagrasses and relevant success rates of restoration efforts are also emerging areas in need of scientific research. The availability and dissemination of national (i.e. IPCC Tier 2) data on carbon stocks, fluxes and economic valuation of ecosystem services are needed to support national policies and management actions.

Scientific gaps for adaptation, resilience and livelihood actions

Scientific evidence, understanding and metrics for adaptation, resilience and improved livelihoods can be greatly expanded. For example, the connection between mangrove or seagrass protection and improved food and economic security given healthy fisheries nursery grounds is recognised, but comparable metrics are limited beyond fish stock count. Robust studies on the relationship between blue carbon and human well-being are lacking in academia and conservation practice (Ban et al. 2019). Studying how blue carbon ecosystems' degradation, loss and restoration impact women and men differently is also an emergent area for research (Mangubhai and Lawless 2021; Tilley et al. 2021).

Emerging blue carbon ecosystems

As scientific knowledge evolves, the possibility remains of incorporating additional coastal and marine ecosystems under actionable blue carbon approaches, such as kelp forests, macroalgae, unvegetated marine sediments and other environmental systems (Howard et al. 2017). However, including these ecosystems requires several scientific advances (Table 1). Additionally, there are questions about the long-term dynamics (i.e. vertical and horizontal flows within the water column) of these potential sinks. Jurisdictional rules and practical management represent large barriers to accommodating these emerging systems within national climate mitigation frameworks and related targets (Lovelock and Duarte 2019). While there is potential for integrating other ecosystems, such as macroalgae (Box 1), into blue carbon initiatives, it is crucial to first consolidate already proven nature-based solutions to achieve scale and global impact.

Table 1. Assessment of whether coastal ecosystems and biota meet the blue carbon criteria ('yes' or 'no') or where further scientific or policy investigation is needed ('?')

	ECOSYSTEM/ BIOTA	SCALE OF GHG REMOVALS OR EMISSIONS ARE SIGNIFICANT	LONG-TERM STORAGE OF FIXED CO_2	ANTHROPOGENIC IMPACTS ON THE ECOSYSTEMS ARE LEADING TO C EMISSIONS	MANAGEMENT IS PRACTICAL/ POSSIBLE TO MAINTAIN/ ENHANCE C STOCKS AND REDUCE GHG EMISSIONS	INCLUDED IN IPCC GHG ACCOUNTING GUIDELINES	CLIMATE ADAPTATION VALUE
Actionable blue carbon ecosystems for mitigation	Mangroves	Yes	Yes	Yes	Yes	Yes	Yes
	Tidal marshes	Yes	Yes	Yes	Yes	Yes	Yes
	Seagrasses	Yes	Yes	Yes	Yes	Yes	Yes
Emerging blue carbon ecosystems	Macroalgae	Yes	Yes	Yes	Yes	No	Yes
	Seafloor sediments	?	Yes	Yes	?	No	?
	Mud flats	?	?	Yes	?	No	Yes
Other ocean ecosystems (not actionable)	Coral reefs	No	No	No	No	No	Yes
	Oyster reefs	No	?	No	No	No	Yes
	Phytoplankton	Yes	?	?	No	No	No
	Marine fauna (fish)	No	No	Yes	No	No	Yes

Notes: C = carbon; CO_2 = carbon dioxide; GHG = greenhouse gas; IPCC = Intergovernmental Panel on Climate Change.

Sources: Lovelock and Duarte (2019); Pidgeon et al. (2021).

Box 1. Scientific elements to integrate macroalgae as a future blue carbon ecosystem

There is growing interest in including macroalgae, such as kelp and other seaweed, in blue carbon frameworks because of their high carbon fixation rates and extensive global distribution (Duarte et al. 2022b; Duarte et al. 2022a). While seaweed and kelp forests may act as significant carbon sources to other marine habitats, further research is required to clarify questions related to carbon fluxes, the permanence and quantities of carbon sequestered, and the proportion of this carbon that can be managed at a national or local scale, and thus whether these ecosystems are valuable as climate-mitigation assets (Frigstad et al. 2021; Hurd et al. 2022; UNEP 2023).

In addition to restoring natural macroalgal ecosystems, kelp and other seaweeds can be farmed, with some carbon assimilated into biomass potentially being sequestered (e.g. by being buried in sediments in the vicinity of farms (Duarte et al. 2022a)). Farmed seaweed products may have climate change mitigation value if they replace carbon-intensive synthetic products (e.g. packaging created from seaweeds can replace plastic packaging), and their overall net climate benefit effect depends on the emissions generated during farming and processing (Coleman et al. 2022).

National and international governance frameworks

Key information

- Integrating the protection and restoration of blue carbon ecosystems into global frameworks, agreements and initiatives sends a strong signal of national policy and investment priorities to the international community, thus driving resources and global, national and local action.
- Coastal blue carbon ecosystems can contribute to tackling the twin crises of climate change and biodiversity loss simultaneously. The UN Framework Convention on Climate Change (UNFCCC), the UN Convention on Biological Diversity (CBD) and Ramsar are key international policy agreements and frameworks that recognise the value of blue carbon ecosystems for addressing these crises.
- Nationally determined contributions (NDCs) take a 'bottom-up' approach towards achieving the climate goals of the Paris Agreement, allowing each country to define the nature of its targets, commitments and implementation. This permits adequate robustness and flexibility based on national context, serving as an important policy lever that captures the multiple benefits of coastal ecosystems and the governance complexities.

Current status

The protection and restoration of blue carbon ecosystems requires action at global, national and local levels. Existing global policy agreements and frameworks, such as the Paris Agreement and the Kunming-Montreal Global Biodiversity Framework (see Table 2), recognise the value of healthy blue carbon ecosystems for climate action and biodiversity protection, and can enable collective action at scale. Governments can prioritise protecting existing habitats and restoring degraded ones by using multilateral frameworks.

Small-scale market-based projects, large-scale conservation efforts and large-scale conservation combined with market-based approaches (e.g. the Lowering Emissions by Accelerating Forest Finance (LEAF) Coalition) can contribute to the protection of these ecosystems. By integrating the protection and restoration of blue carbon ecosystems into global frameworks and agreements, countries can demonstrate their national policy and investment priorities to the international community, as well as their project planning and related funding needs. This is a critical step for driving the necessary resources and action towards these ecosystems.

Given that blue carbon ecosystems are at the intersection of land and sea areas, many government agencies are involved in decisions that affect it, each with different—and sometimes competing—mandates and targets. Also, the lack of reporting on efforts and actions on the ground can pose a significant challenge for global monitoring. In this context, international policy is only as effective as the national and local actions that are successfully implemented, resourced and monitored. For these reasons, there is no single international policy specific to blue carbon ecosystem management; rather, it is governed by a web of frameworks, agreements and initiatives, as seen in Table 2. However, it is important to coordinate these frameworks and agreements to move from isolated approaches to integrated ones, in order to achieve ambitious and high-quality outcomes for blue carbon ecosystems.

Table 2. Summary of key global policy agreements and frameworks that recognise the international relevance and transboundary nature of blue carbon ecosystems

GLOBAL FORUM OR UN CONVENTION	AGREEMENT AND TYPE OF NATIONAL REPORT	RELEVANCE TO BLUE CARBON
UN Framework Convention on Climate Change (UNFCCC)	*Paris Agreement* (2015) Nationally determined contributions Biennial transparency report National adaptation plans	▪ Nature-based solutions (NbS) are an integral component of achieving the goals of the Paris Agreement (UN 2015a). ▪ Parties are required to conserve and enhance areas that are important GHG stores and sinks, such as marine, coastal and terrestrial ecosystems. ▪ Nationally determined contributions (NDCs) are a country's climate action plan and highlight the national-level efforts to reduce emissions and adapt to the impacts of climate change. ▪ NDCs can include plans, policies and measures to protect, conserve and restore their blue carbon ecosystems in their NDCs or adaptation communications (e.g. national adaptation plans). ▪ Blue carbon can be part of the land sector mitigation targets, when included in the national GHG inventory. ▪ Inclusion in the NDC serves as a strong signal of national policy priorities, driving resources and action at the global, national and local scales.
UN Convention on Biological Diversity (CBD) (UN 1992)	*Kunming-Montreal Global Biodiversity Framework* (2022) National biodiversity strategy and action plans (NBSAPs)	▪ Protection, restoration and sustainable use of coastal and marine ecosystems is integral to collective global action on biodiversity needed by 2030 and 2050. ▪ Parties are required to develop, implement and regularly review NBSAPs, which can integrate conservation and sustainable use of biodiversity into decision-making. ▪ Several targets of the Kunming-Montreal Global Biodiversity Framework are relevant to blue carbon: Target 2 (restoration of at least 30% of degraded terrestrial, inland water and coastal and marine areas); Target 3 (conservation of at least 30% of degraded terrestrial, inland water and coastal and marine areas); Target 8 (use of NbS and/or ecosystem-based approaches to minimise impacts of climate change)[a]. ▪ The review and update of NBSAPs, or at least national targets, by 2024, reflected in Decision CBD/COP/DEC/15/6, represent a key opportunity to capture enhanced blue carbon action in support of biodiversity conservation and its sustainable use (CBD 2022).
Ramsar Convention on Wetlands of International Importance (UN 1971)	*Wetlands of international importance* ('Ramsar sites') National reports	▪ The Ramsar Convention provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. ▪ It uses a broad definition of wetlands, including all lakes and rivers, swamps and marshes, peatlands, mangroves and other coastal areas. ▪ Resolution XIII.14 encourages conservation, restoration and sustainable use of coastal blue carbon ecosystems. ▪ Countries can promote blue carbon action through wetland management policies and plans in both Ramsar and non-Ramsar wetland sites and report on implementation through their national reports.
UN Sustainable Development (UN 2015c)	*2030 Agenda for Sustainable Development Goals* (2015)	▪ 17 Sustainable Development Goals (SDGs) are the cornerstone of the UN 2030 Agenda. ▪ The importance of restoring and protecting blue carbon ecosystems is reflected across several goals given its cross-cutting nature. ▪ For example: SDG 6 (Clean Water and Sanitation), through its Target 6.6 on protecting and restoring water-related ecosystems; SDG 13 (Climate Action), calling for urgent action to combat climate change and its impacts; and SDG 14 (Life below Water), calling for action to conserve marine and coastal ecosystems. ▪ SDGs inform and guide their mainstreaming into national planning frameworks through national development plans or sustainable development strategies and can include ecosystem restoration and protection to drive national and local action (UNDESA n.d.).

Table 2. Summary of key global policy agreements and frameworks that recognise the international relevance and transboundary nature of blue carbon ecosystems (Cont.)

GLOBAL FORUM OR UN CONVENTION	AGREEMENT AND TYPE OF NATIONAL REPORT	RELEVANCE TO BLUE CARBON
UN Office for Disaster Risk Reduction (UN 2015b)	*Sendai Framework (SF) for Disaster Risk Reduction* (2015) Voluntary national report to SF	▪ Encourages ecosystem-based approaches to reduce disaster risk, including through transboundary cooperation and new investments, to preserve ecosystem functions that reduce risks, as unsustainable use of natural resources is an underlying driver of disaster risk. ▪ Countries can report damages and losses caused to critical green infrastructure or other strategically important ecosystems. ▪ Blue carbon ecosystems play an important role in disaster risk reduction (DRR) by protecting local communities from natural disasters, such as storms and tidal surges. ▪ Parties provide information on disaster management through voluntary national reports and develop national and local DRR strategies and plans, and could strengthen environmental resilience and ecosystem-based approaches through the conservation, restoration and sustainable management of blue carbon ecosystems.
UNESCO World Heritage Convention (UN 1972)	*World Heritage Marine Programme* Periodic reporting (3rd cycle, 2018–24)	▪ Aims to protect areas for nature conservation and the preservation of cultural properties. ▪ The UNESCO World Heritage List includes over 1,000 globally outstanding sites, 21 of which were specifically recognised for their blue carbon ecosystems. ▪ Listing a site as a UNESCO Marine World Heritage site enables a level of protection and allows for future long-term monitoring and analysis of trends around the extent and health of blue carbon ecosystems.
Global and Regional Initiatives		
UN Decade of Ocean Science for Sustainable Development (UN 2021a)	2021–30	▪ The Ocean Decade, coordinated by the Intergovernmental Oceanographic Commission of the UN Educational, Scientific and Cultural Organization, is a framework to facilitate transformative solutions, connecting people and our ocean. ▪ It sparked the creation of other associated programmes, such as the Global Ocean Decade Programme on Blue Carbon, which is also linked to the International Partnership for Blue Carbon. ▪ Provides a convening platform to co-design and deliver solution-oriented knowledge to enhance blue carbon ecosystem conservation and restoration, and bridge knowledge gaps with capacity-building opportunities.
UN Decade for Ecosystem Restoration (UN 2021b)	2021–30	▪ The Decade for Ecosystem Restoration provides a valuable platform for promoting international cooperation, science-based and ecosystem-based approaches, and developing best practices for ecosystem restoration, including blue carbon ecosystems. ▪ UN partners (the Convention on Biological Diversity, Food and Agriculture Organization, and UN Environment Programme) are among other stakeholders bringing attention to the worldwide need for ecosystem restoration. ▪ Positions restoration of ecosystems, like blue carbon ecosystems, as an important NbS to meet a wide range of global development goals and national priorities.
Bonn Challenge (IUCN 2011)	2011–30	▪ A non-binding global goal to restore 350 million hectares by 2030 for forest landscape restoration, including blue carbon ecosystems. ▪ Can pledge and achieve ambitious targets towards forest landscape restoration, including to restore degraded blue carbon ecosystems.
UN Environment Programme (UNEP) Regional Seas	*5th edition of the Regional Seas Strategic Direction* 2022–25	▪ A global and regional initiative aimed at protecting and sustainably managing marine and coastal ecosystems within specific regional sea areas. ▪ Provides a platform for countries to collaborate on and address common environmental challenges, including the conservation and restoration of blue carbon ecosystems (UNEP n.d.). ▪ Latest Strategic Direction is to achieve a diverse, resilient and pollution-free ocean that supports equitable sustainable livelihoods.

Note: a For the full text of these targets, refer to Annex A.

The Paris Agreement: Contextual policymaking

The protection and recovery of blue carbon ecosystems requires global and local efforts to maximise their contribution to climate mitigation and adaptation. Prioritising blue carbon ecosystem protection for climate action, biodiversity and sustainable development benefits is demonstrated across all of the frameworks and relevant national reports noted in Table 2. This section specifically looks at how blue carbon can be viewed through a UNFCCC lens to support Parties' achievement of the goals of the Paris Agreement through their associated NDCs (UN 2015a), and how Parties can utilise either market-based or non-market approaches to provide resources necessary for successful action. An NDC is one of the main components that drive ambition and implementation of the Paris Agreement and can be viewed as a country's climate action plan. The NDCs allow each country to define the nature and scope of its commitments, including mitigation, adaptation, resilience priorities and long-term low-emissions planning based on its national context. While the NDC demonstrates national commitments and targets at a high level, it is informed and underpinned by a series of other national reports, such as national adaptation plans (NAPs), national inventory reports (technical details of the national GHG inventory), biennial transparency reports (BTRs) or national biodiversity strategy and action plans (NBSAPs). The flexibility of the NDC architecture aligns well with the complexities of blue carbon ecosystems.

The Paris Agreement provides a comparable framework for countries to account for their emissions and mitigation actions, as well as highlighting the other adaptation benefits of blue carbon ecosystem protection. The biennial transparency reports provide a more detailed account of indicators and comparable metrics for mitigation action, and start to capture adaptation co-benefits. For example, countries that have a GHG mitigation target in their NDC that is inclusive of the land sector, including blue carbon ecosystems, must ensure that their national GHG inventories accurately report emissions and removals from these ecosystems. Additional information on the national GHG inventories and the BTR as it relates to NDCs can be found in the section 'The role for national and subnational government action to enable and support conservation and restoration of blue carbon'.

Prioritisation of the protection of blue carbon ecosystems is also a critical way to demonstrate enhanced climate ambition in the context of a country's adaptation and resilience targets within the NDC or NAP. Relevant adaptation priorities noted in current NDCs include but are not limited to ecosystem-based adaptation approaches, sustainable fisheries and small-scale fisheries, and improved livelihoods for coastal communities.

Article 6 of the Paris Agreement may also have direct implications for the development of carbon markets, including potential blue carbon projects. Article 6 sets out modalities and rules to enable countries to cooperate to achieve their NDCs through both market and non-market approaches (Granziera et al. 2023). Although most rules around Article 6 were decided at COP 26 and COP 27, countries are still taking the early steps in developing national approaches to enable Article 6 trades and balancing the financial opportunities of markets with the impacts that exporting carbon credits might have on their NDCs (Granziera et al. 2023) (see section 'Carbon market opportunities and risks').

Detailed examples and guidance on how a country could use a stepwise approach to include blue carbon elements in its NDC for mitigation or adaptation can be found in the 'Key resources' section, particularly the Blue Carbon Initiative's *Guidelines on Enhanced Action: A Guide on How Countries May Include Blue Carbon in Their Nationally Determined Contributions*.

Key knowledge gaps and emerging issues

Climate/biodiversity nexus

The global focus on nature-positive approaches and the recent adoption of the Kunming-Montreal Global Biodiversity Framework under the UN Convention on Biological Diversity (CBD) have brought attention to the need to address the twin crises of climate change and biodiversity loss simultaneously. Governments have prioritised achieving biodiversity goals, including the protection and restoration of at least 30 percent of global land and sea areas by 2030 (e.g. 30×30) while also recognising the urgent need to meet their climate goals. Similarly, the review and update of national biodiversity strategy and action plans by 2024 mandated at COP 15 represents a key opportunity for countries to capture blue carbon action for biodiversity conservation and its sustainable use.

Coastal blue carbon ecosystems can contribute towards both climate and biodiversity goals and attract additional financial investment for their protection and restoration. A dual approach can maximise co-benefits. However, it is important to ensure that marine protected areas (MPAs) or other effective area-based conservation measures (OECMs) are designed with climate-relevant indicators and metrics in mind, as some MPAs or OECMs may only be measuring or managing fish stock or other non-climate indicators. To date, 14 countries have included MPAs or OECMs in their NDCs, showing the relevance of the biodiversity-climate nexus (Northrop et al. 2020). Research is needed to highlight the contributions of MPAs and OECMs to sustainable development from the economic and social perspective as well. Joint climate and biodiversity strategies offer an opportunity to align national policies and advance coordinated restoration and conservation strategies.

Institutional barriers

There is an acute need for integrated long-term strategies and cooperation among international frameworks to tackle challenges in climate change, biodiversity loss and sustainable development. A lack of government coordination and duplicated effort at the national level also threatens countries' ability to effectively address these challenges. Notwithstanding the need to enhance global coordination, strengthening domestic policy coherence and reporting within global frameworks is essential to make efficient use of limited resources. A participatory approach and consultation among all relevant stakeholders can enable the achievement of environmentally sound policies and legislation.

The role of national and subnational government action to enable and support conservation and restoration of blue carbon

Key information

- Governments—national, subnational and local—are important custodians of blue carbon ecosystems. As policymakers, they set policies and define targets (national and international); as implementers and enforcers, they are the key drivers of change on the ground.
- Governments have the full toolbox of 'command-and-control' measures and incentive mechanisms at their disposal.
- While governments act within the technically and politically feasible and by design must balance and reconcile a multitude of public interests, core blue carbon milestones have become non-negotiable and governments must provide suitable technical, regulatory and incentive frameworks to help implementation.

Current status

The inclusion of targets, policies and/or measures in nationally determined contributions aimed at protecting and restoring blue carbon ecosystems is one example of national governments utilising international policy to prioritise action. As noted in the section 'National and international governance frameworks', many relevant international frameworks may inform action on blue carbon. Using climate change as an example, analysis of the latest round of NDCs communicated has shown that 95 include at least one target, policy or measure (for either mitigation, adaptation or both) aimed at conserving and restoring a blue carbon ecosystem (Khan et al. 2022). Most common is the protection and restoration of mangroves (a total of 29 NDCs), while eight address seagrasses (Khan et al. 2022).

Nineteen long-term low GHG emission development strategies (LTS, introduced in Article 4, paragraph 19 of the Paris Agreement) include blue carbon ecosystems, demonstrating an increasing recognition of the importance of these ecosystems in long-term planning for decarbonisation (Khan et al. 2022). However, few countries are implementing the 2013 IPCC Wetlands Supplement and utilising it to inform their NDC targets. Since 2016, when Australia became the first country making such a commitment, recognition of the need to build technical capacity has increased, with Canada, Fiji, Jamaica, Korea, Lebanon, Norway, Panama, Singapore and the United Kingdom following Australia's lead (von Unger et al. 2023). The United States includes mangroves, seagrass meadows and tidal marshes in its national GHG inventory but makes no reference to the sector when defining the applicable NDC accounting methodologies in its 2021 NDCs). Several other countries are working on updating their inventories to include blue carbon in their national GHG inventories, such as Belgium, Costa Rica Denmark, Fiji, Finland, France, and Sweden.

Coastal and marine planning tools, like MPAs, OECMs and integrated coastal zone management, are increasingly being used to address national targets for biodiversity and livelihoods, as well as climate change. Countries can utilise different policy instruments beyond the NDC and LTS to incentivise protection and restoration, including community-focused and incentive-based governance schemes, or other national reports like NBSAPs or national adaptation plans. This diverse set of policies represents a range of process and priority areas for the country as relevant to nature-based solutions, including blue carbon (participatory and decentralised governance, different ecosystems and species, sustainable use and development, etc.).

Select opportunities and actionable policy options for national and subnational governments

NATIONAL GOVERNMENTS

A critical role for national governments is to provide clear and permanent policy signals, align funding streams and build the right incentive structure. Establishing clear policy signals, through area-based management tools such as sustainable ocean plans (SOPs) and marine spatial planning, can also help to resolve many of the conflicts mentioned above and provide clarity on government priorities[2].

Regulatory incentives: National governments can provide regulatory incentives to encourage the restoration of blue carbon ecosystems. For example, where land tenure is clear and legal frameworks allow for this, governments may be able to provide regulatory (and tax) relief or exemptions to landowners who restore or conserve blue carbon ecosystems.

Financial incentives: As knowledge of the economic, environmental and social value is often missing or sidelined by policies that treat the destruction of natural capital as an externality, it is important for governments to create frameworks for blue sustainable investments and taxonomies, while also incentivising targeted blue carbon ecosystem restoration and conservation through subsidies or tax credits for businesses investing in restoration projects. In this context, it is also crucial to consistently replace harmful subsidies (those that encourage the destruction or removal of existing blue carbon ecosystems) with incentives for regenerative and sustainable activities. Carbon-pricing mechanisms (see section 'Carbon market opportunities and risks') are important, as are alternative funding and finance opportunities (see section 'Alternative funding and finance opportunities for blue carbon'). Governments also need to create opportunities and incentives for blended-financing options that incorporate sustainable and scalable investments for coastal ecosystem protection and rehabilitation actions. Finally, governments can also establish payment for ecosystem services (PES) programs to reward landowners and communities for the ecological services provided by restored blue carbon ecosystems. PES programs can provide financial incentives for restoration projects while also offering benefits to local communities.

Funding for research and knowledge development: National public funding and research grants are crucial in bridging knowledge gaps. The funding should be directed towards policies set nationally and internationally to ensure their effective implementation. Prioritising funding for national agencies and laboratories within budgets to enhance technical expertise and capacity is crucial for governments to integrate blue carbon into their policies and strategies, including NDCs, NBSAPs and LTS. Alignment with subnational funding and activities also creates opportunities to scale.

Global and regional peer exchange: National governments are well suited to contribute to regional and global coalitions, partnerships and opportunities for peer exchange (see section 'International partnerships and other initiatives'). These offer the opportunity for access to leading technical guidance but also serve as a platform to share lessons and best practices from governments in a similar position (see section 'International partnerships and other initiatives').

Build community awareness and support: National governments can launch awareness campaigns to build the social license for protecting and restoring blue carbon ecosystems and increase the number of stakeholders actively engaged in efforts and projects.

Short-term opportunities for national decision-makers:

- Assess national blue carbon opportunities including area extent, ecosystem health, threats, carbon stores, ecological importance and socioeconomic dependence of local communities.
- Develop a comprehensive blue carbon assessment by estimating coastal carbon stocks and rates of change over the last 10 years. Also, estimate emissions from conversion activities to create tier 2 emission factors.

- Analyse legal and policy frameworks to include blue carbon in sustainable development, climate change, forestry, biodiversity and marine resource management regulations; also consider providing for an explicit mandate for government agencies to engage in blue carbon (project) development on state land.
- Develop a road map for national GHG inventory inclusion of blue carbon ecosystems, specifying suggested inclusion levels and data requirements: see, for example, Box 2, and Box 3 for an overview of Australia's blue carbon inventory and associated methodologies.
- Establish monitoring capabilities for ecosystem loss using satellite, remote-sensing, in situ and community data.

SUBNATIONAL GOVERNMENTS

Subnational governments can protect and restore blue carbon ecosystems through integrated planning, including MPAs and OECMs, coastal zone management, spatial planning, and Indigenous governance and by incorpo-

Box 2. Including blue carbon ecosystems in national GHG inventories

All countries are encouraged to use the latest guidance from the Intergovernmental Panel on Climate Change (IPCC) to develop their national GHG inventories and biennial transparency reports (BTRs) under the Paris Agreement beginning in 2024. The latest IPCC-approved methodologies include information on the mitigation potential of blue carbon ecosystems as detailed in the IPCC Wetlands Supplement, and generally integrated in the land use, land-use change and forestry (LULUCF) section (IPCC 2013). The supplement provides a tiered, stepwise approach, which allows countries to incorporate emissions and reservoirs from blue carbon ecosystems based on national circumstances and capacity and thus allows for improvements over time. The inclusion of blue carbon ecosystems in the LULUCF section of the national GHG inventory is critical to account for these ecosystems towards a mitigation target in a nationally determined contribution. The common reporting tables used for BTRs can enable mangroves to be represented as either forests or wetlands within the LULUCF category, based on the national forest definition, whereas seagrasses and tidal marshes can only be accounted for under wetlands.

- Tier 1 requires only preliminary information, allowing countries to view it as a starting point. Tier 1 requires an understanding of the change in distribution of mangroves, with default values assigned to the carbon stocks. Datasets like Global Mangrove Watch can be used to inform the inventory, allowing countries without their own remote-sensing abilities to start implementing the supplement.
- Tier 2 requires country-level data on biomass and soil carbon, which requires country-specific land-use data and can help inform national-level decisions on reducing LULUCF emissions, including from blue carbon ecosystems and enhanced carbon stocks.
- Tier 3 also requires country-level data and more detailed information about the carbon pools, and fluxes activity data and repeated measures over time that provide emission factors. Tier 3 is the most robust and comprehensive standard for the inventory.

Please refer to Appendix B in Northrop et al. (2020) for a detailed overview of publicly available data sources to support the inclusion of blue carbon ecosystems in national inventories and policies.

Source: Adapted from Box 3 in Northrop et al. (2020).

Box 3. Australia's blue carbon approach

Australia hosts approximately 12 percent of the world's mangroves, seagrass meadows and tidal marsh ecosystems.

Reflecting this significant custodianship, Australia is protecting and restoring blue carbon ecosystems to harness their capacity as a nature-based solution for the challenges of biodiversity loss and climate change, while generating diverse benefits for economies and communities. Australia supports a portfolio of activities to contribute to this objective:

- Pursuing greater recognition, protection and restoration of coastal blue carbon ecosystems, domestically and abroad, through engagement with international frameworks, such as the Ramsar Convention, the UN Framework Convention on Climate Change and the Convention on Biological Diversity.
- Reporting coastal wetlands within its greenhouse gas inventory. Australia continues to incorporate new data, improve its spatial analysis and apply new modelling approaches in the land sector in line with IPCC guidance.
- The Australian Blue Carbon Conservation, Restoration and Accounting Program, which demonstrates the biodiversity, climate and livelihood benefits of blue carbon while enhancing the business case for private sector investment in coastal blue carbon ecosystems.
- Delivery of the National Ocean Ecosystem Account, with a focus on coastal blue carbon to demonstrate the social and economic value of these ecosystems.
- Delivery of a method for securing blue carbon credits with the reintroduction of tidal flows under the Australian Emission Reduction Fund.
- Knowledge exchange and collaboration among researchers, project managers and policymakers through the International Partnership for Blue Carbon and by establishing a national blue carbon restoration and accounting community of practice. Australia is also supporting the Global Ocean Accounts Partnership to build ocean accounting capability internationally.
- Supporting international programs such as the Blue Carbon Accelerator Fund, delivered by the International Union for Conservation of Nature. The fund supports blue carbon restoration and conservation projects internationally and helps pave the way for private sector finance into projects.

rating carbon value or other social livelihoods indicators (e.g. fish stock for food security) into ecosystem assessment. This can provide a more comprehensive picture for decision-making, promoting better coastal management and benefitting coastal communities.

Establish new protected areas or expand existing ones: Subnational governments can establish new MPAs or OECMs in areas with a large extent of blue carbon ecosystems, or expand existing protected areas, including OECMs or locally managed protected areas. The establishment of new MPAs and OECMs can provide legal protection, promote ecosystem and community resilience and restore degraded ecosystems.

Enhance MPA and OECM connectivity and management: Connecting protected areas to one another and to adjacent coastal habitats can improve the resilience of blue carbon ecosystems and other marine habitats. Subnational governments can work to establish networks and promote ecosystem connectivity through the creation of ecological corridors or stepping-stone habitats.

Effective management is also essential for the durability of interventions. One way to improve implementation is to integrate local communities into maintenance activities, including surveillance, restoration and erosion protection inside and outside conservation areas (Herr et al. 2017). Effective area-based approaches demonstrate how blue carbon can be a priority to achieve biodiversity, livelihoods and in some cases climate outcomes.

Foster partnerships and collaborations: Subnational governments can partner with local communities, academic institutions and other stakeholders to leverage resources and expertise to support establishment and management of protected areas, including locally managed ones. Additionally, they can share experiences to support implementation of ecosystem-based adaptation metrics in monitoring and reporting that highlights the benefits of protecting blue carbon ecosystems.

Table 3. Taxonomy of national, jurisdictional or local government policy and regulation mechanisms, scored by efficacy (high, considerable and low efficacy)

TYPE	NATIONAL	JURISDICTIONAL	LOCAL
Planning and governance (MPAs, PPPs)			
Plans to harmonise and promote policy coherence	High	Considerable	Low
MPAs	High	Low	High (local MPA management)
PPPs	Considerable	Considerable	High
Indigenous and community governance models	Considerable	Considerable	High
Incentives: subsidies, taxes and fees			
Subsidies	High (replacing destructive subsidies with subsidies to reward landowners for enhancing ecosystem services oriented towards carbon capture and sequestration)	Considerable (can provide direct and indirect funding)	Low
Taxes	High (strictly regulated and controlled by national governments)	Considerable (if through delegation of powers)	Low (local taxes could be used but limited in scope)
Fees	High (particularly when looking at MPA usage and visitation)	Considerable (but often restricted)	Considerable
Debt finance, investment rules and carbon-pricing mechanisms			
Debt instruments (blue bonds, debt for nature swaps)	High (all instruments available)	Considerable	Low applicability
Corporate information	High	Low	N/A
Carbon pricing (compliance)	High	Considerable	N/A
Carbon pricing (voluntary)	N/A	High	High (project-based approaches)

Notes: MPA = marine protected area; PPP = public-private partnership.

Source: Adapted from von Unger and Castillo Cartin (2022).

Key knowledge gaps, emerging issues and areas for further development

Capacity building for project design and measurement, reporting and verification

There is a clear need for increased capacity at the government level to implement and understand the scientific, technical, policy and institutional aspects of emissions and removals from natural sinks and reservoirs, including from blue carbon ecosystems. Capacity building could range from national GHG inventories to the establishment of high-quality projects. Despite growing recognition of the importance of blue carbon ecosystems, there is still much to learn about the ecological functions and carbon storage potential of these habitats. Incomplete scientific knowledge can make it difficult for governments to design effective policies and management strategies (IPCC 2013) (see section 'The science behind blue carbon'). This can be particularly challenging for developing countries with limited financial resources. International and regional collaborative networks exist that seek to support increasing capacity on these topics, including the International Partnership for Blue Carbon and the Blue Carbon Initiative (see section 'International partnerships and other initiatives').

Technical assistance for mapping and monitoring

Detailed maps are necessary as a foundational step towards implementation of a conservation or market-based project. More observation and research are needed to assess belowground biomass and effects of sea level rise. Increased data collection and knowledge is needed, along with new collaborations with mobile technology providers (using both satellite and seabed cable infrastructure) to overcome monitoring and data challenges and gaps. Increased monitoring through the implementation of integrated coastal zone management and marine spatial planning, in coordination with year-to-year inventories of mangroves and other coastal ecosystems, would help identify synergies and gaps with coastal carbon and climate policymaking (Herr et al. 2017).

Policy and institutional coherence

As at the international level, the national level requires clear policies and regulations that prioritise conservation or sustainable use over competing interests. However, this can often conflict with economic development and coastal infrastructure goals (see Table 3). More research and resources are needed in-country and at the local level to establish policy coherence and provide clear signals on the importance of protecting and restoring these ecosystems, including through accounting for all (positive and negative) externalities when operating economic models or impact assessments related to policies. Knowledge and implementation gaps exist, and there is a need to align incentive structures to avoid subsidising activities that could undermine ecosystem health, such as some fisheries and agriculture practices. This approach benefits

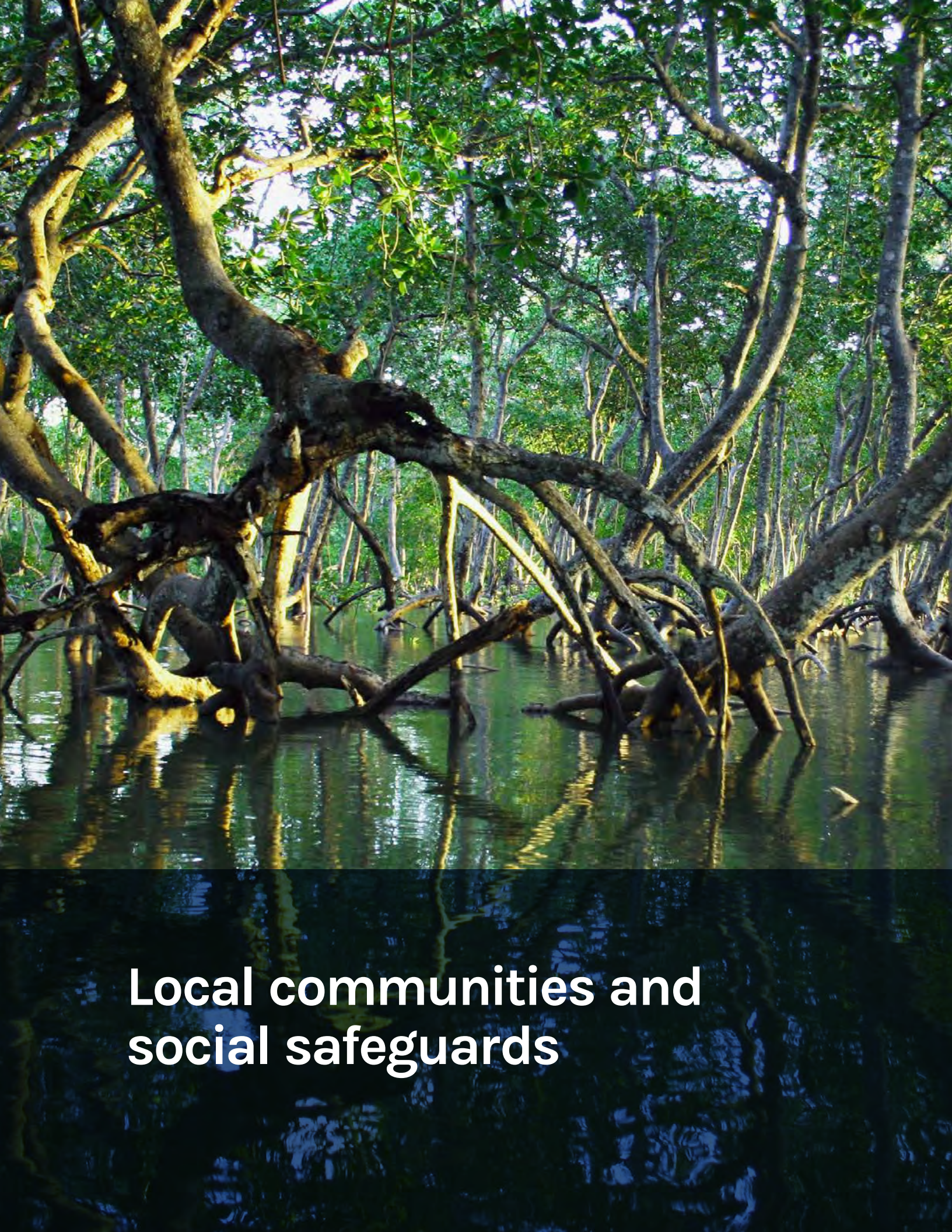
coastal communities, fishing industries and coastal infrastructure, as well as the environment and society.

Ocean accounts and the economic and social value of blue carbon

The economic value of blue carbon ecosystems is often unknown or poorly communicated. Thus, they are seen only for their conservation or mitigation value, which vastly underappreciates their asset value. This is why establishing ocean accounts, natural capital taxonomies and economic valuation exercises can be important for aligning national policymaking and investment. Even for countries that have a clear policy and/or a legislative framework prioritising the protection and restoration of these ecosystems and strong political will, a number of practical barriers remain for national and/or subnational governments to overcome to conserve or restore these ecosystems, as outlined below.

Complexity of ownership and land rights

Coastal and marine resource conservation and restoration efforts can be hindered by legal uncertainties arising from overlapping land tenure systems (Merk et al. 2022). While this topic is addressed in more detail in the section 'Local communities and social safeguards', it is worth noting it as a gap and an emerging area of recognised complexity. It creates complicated and lengthy negotiation processes, which require legal reforms, community engagement and stakeholder agreement. Additionally, lack of formal recognition of many coastal and marine ecosystems as protected areas compounds the difficulties in acquiring the legal rights necessary for conservation and restoration, which can limit funding and access.



Local communities and social safeguards

Key information

- Coastal communities are often the first to recognise and value the services that healthy coastal ecosystems provide beyond carbon sequestration, such as food provision, climate and natural hazard protection, erosion regulation and sociocultural services.
- Blue carbon ecosystems and local communities rely on each other, and are particularly critical for gender equity. Promoting women's participation in implementation does not imply changing culture or customs but ensuring that women have a voice.
- While local communities are vital actors in successful nature-based solution projects, including blue carbon, it is essential that steps be taken by project developers or policy-makers to safeguard local communities against potentially negative consequences in the following ways:
  - Ensure and identify clear legal pathways to enable them to secure land tenure or management rights to their natural assets.
  - Carefully follow free, prior and informed consent (FPIC) procedures.
  - Co-develop social safeguards and relevant systems for responsible implementation.
  - Ensure that transparent legal frameworks are in place for local participation and leadership, including benefit-sharing, to avoid political uncertainty and gain consensus.
  - Build capacity at all levels as necessary.

Current status

Indigenous People and local communities (IPLCs, individuals and groups who maintain an intergenerational historical connection to place and nature through livelihoods, cultural identity, languages, worldviews, institutions and ecological knowledge (IPBES 2020)) play a key role as stewards of the marine and coastal environment, managing its natural resources sustainably in line with cultural traditions (Vierros 2017).

Coastal communities are often the first to recognise the value of healthy coastal ecosystems (including natural hazard protection, sociocultural services and food provision), beyond carbon sequestration. Local knowledge is crucial to developing and implementing sustainable blue carbon actions at all levels, from the local to the international. Implementation requires engaging and empowering communities to integrate their valuable insights considering local context, including cultural norms, gender dynamics, resource use, land tenure and governance structures (Lauer and Aswani 2010; Loch and Riechers 2021). Women often rely on fisheries associated with blue carbon ecosystems to feed their families, as these can be accessed on foot without the need for a boat (Bosold 2012). The integration of a gender perspective is vital to the success of blue carbon initiatives and to achieve more effective and sustainable results (Bosold 2012). Promoting women's participation does not mean changing culture and local customs but rather ensuring that women have a voice (Bosold 2012).

Blue carbon ecosystems provide essential ecosystem services for coastal communities, and their ongoing loss can have dire consequences for both nature and humans.

The governance of blue carbon ecosystems is complex, and legal rights to manage these resources are often unclear (Merk et al. 2022). This can lead to communities being disproportionately impacted by limitations to coastal resources resulting from blue carbon projects. Blue carbon initiatives that recognise and build upon pre-existing traditional management systems tend to be more successful (Rocliffe et al. 2014; Newell et al. 2019). The Mikoko Pamoja project in Gazi Bay, Kenya, is an example of a successful community-led blue carbon initiative where local people have a clear mandate to manage their mangroves (Wylie et al. 2016; Kairo et al. 2018). Indigenous Peoples and local communities should have clear legal pathways to secure land tenure or management rights to their natural assets. Institutional arrangements and land tenure complexity must be considered when developing projects in coastal and marine environments. An equitable approach to engagement supports sustainable management techniques that both benefit IPLCs and contribute to climate action through the protection or management of blue carbon ecosystems.

Protecting blue carbon ecosystems as a climate strategy and the development of Reducing Emissions from Deforestation and Forest Degradation (REDD+)[3] projects or jurisdictional programs is one way to channel finance to IPLCs. Indigenous-led groups and organisations working to support Indigenous Peoples across over 40 countries recently published an open letter to the global finance community supporting high-integrity forest protection carbon credits (FRC-IF 2023). The letter details the importance of climate finance projects such as REDD+ as the most direct pathway to recognising, safeguarding and receiving compensation for traditional conservation efforts (FSC-IF 2023). To enable this, especially given the increasing interest in blue carbon protection and restoration, international agreements including the UN Declaration on the Rights of Indigenous Peoples and Free, Prior, and Informed Consent must be adhered to, with IPLCs involved from the outset of blue carbon initiatives (see section 'Developing high-quality, high-impact blue carbon projects').

Key knowledge gaps and emerging issues

Social and environmental safeguard implementation

Attracting finance for ecosystem conservation or restoration through carbon markets or other finance mechanisms has gained international attention, including for blue carbon. While the coastal and marine environments are unique in many ways, lessons learned from the experience and history of developing, implementing and monitoring REDD+ programmes and respective safeguards can inform the development of future blue carbon projects (Barletti et al. 2021; Lofts et al. 2021). Blue carbon actions can take note of how mangroves are included in some REDD+ programs and build on that capacity accordingly. The Cancún Safeguards established critical guidelines for jurisdictional-scale REDD+ and could serve as a baseline for safeguards specific to coastal ecosystems and local communities (UNFCCC 2023) (Box 4). Where applicable, governments must enforce the use of safeguard information systems (SIS) that are established in collaboration with communities in the early stages of project development along with tools like grievance mechanisms to ensure equitable outcomes for all stakeholders[4]. These systems should clearly articulate social safeguard policies and provide transparent information on how safeguards like the Cancún Safeguards are being addressed and respected.

Indonesia has been recognised as a leader in the development of its REDD+ framework, having completed and legalised its SIS in 2017 (Lasheras et al. 2023). The development process was focused on a multi-stakeholder approach, resulting in the Principles, Criteria and Indicators framework. SIS REDD+ has been tested in Jambi and East Kalimantan Provinces (Lasheras et al. 2023). As interest and international attention in blue carbon has increased in recent years, social and environmental safeguards should receive greater attention and resources. Given the unique location and common-pool resource status of blue carbon ecosystems, it is important to document and share lessons learned related to the social component of these projects.

Addressing land tenure and carbon rights

It is important to note that projects involving nature, including REDD+ projects, have historically faced complexities regarding land tenure and have sometimes resulted in the eviction or marginalisation of IPLCs (Rights and Resources Initiative and McGill University 2021). The opposite can also be true when the needs of local communities are fully taken into account, where REDD+ projects have laid the foundation and enabling conditions necessary to help secure land tenure for IPLCs (Goldstein 2016). It is essential that blue carbon initiatives adhere to international agreements and norms, including with respect to FPIC, to empower communities and avoid past social injustices. Additionally, project developers should ensure that the necessary capacity and communication channels are built to enable communities to be involved with a project's design from its inception. This can help prevent instances of 'land grabbing' or 'ocean grabbing' by investment groups and project developers.

Local leadership and equitable benefit-sharing

Project developers must prioritise community involvement in decision-making processes beyond simply 'checking the box' to meet prescribed requirements (Cheney et al. 2015). To achieve lasting outcomes, local leadership and ownership of blue carbon projects can be championed throughout all phases of development and implementation (Beeston et al. 2020). Governments can support this by promoting and facilitating communities' participation in decision-making processes and benefit-sharing arrangements (Rakotomahazo et al. 2019). This includes ensuring that legal frameworks are in place to avoid political uncertainty and gain consensus while building capacity at all levels.

Rural coastal communities rely on blue carbon ecosystems for food and financial security, and they are disproportionately impacted by limitations to coastal resources resulting from blue carbon projects. To address this, equitable and transparent benefit-sharing plans must be developed in consultation with all relevant stakeholders (Pham et al. 2013). Beyond policymaking, governments can also support financial management capacity building among communities to ensure that benefits are shared fairly when included in either project-scale or jurisdictional approaches, including with marginalised and vulnerable groups (Barletti et al. 2022). Ultimately, successful blue carbon initiatives must prioritise community involvement and equitable benefit-sharing to ensure sustainable outcomes.

Box 4. REDD+ Cancún Safeguards (from paragraphs 70 and 71 and Appendix 1 of Decision 1/CP.16):

1. That actions complement or are consistent with the objectives of national forest programmes and relevant international conventions and agreements;
2. Transparent and effective national forest governance structures, taking into account national legislation and sovereignty;
3. Respect for the knowledge and rights of indigenous peoples and members of local communities, by considering relevant international obligations, national circumstances and laws, and noting that the United Nations General Assembly has adopted the United Nations Declaration on the Rights of Indigenous Peoples;
4. The full and effective participation of relevant stakeholders, in particular indigenous peoples and local communities, in the actions referred to in paragraphs 70 and 72 of this decision;
5. That actions are consistent with the conservation of natural forests and biological diversity, ensuring that the actions referred to in paragraph 70 of this decision are not used for the conversion of natural forests, but are instead used to incentivise the protection and conservation of natural forests and their ecosystem services, and to enhance other social and environmental benefits, taking into account the need for sustainable livelihoods of indigenous peoples and local communities and their interdependence on forests in most countries, reflected in the United Nations Declaration on the Rights of Indigenous Peoples, as well as the International Mother Earth Day.
6. Actions to address the risks of reversals;
7. Actions to reduce displacement of emissions.

Source: UNFCCC (2023).

Developing high-quality, high-impact blue carbon projects

Key information

- Although not all projects will be suitable for market-based approaches, building the enabling policy conditions for successful conservation or restoration projects by focusing on a resilience or sustainable development benefit can contribute to a project with mitigation co-benefits.
- While carbon markets are an important tool to finance the protection or restoration of blue carbon ecosystems and channel resources to local communities, they do not replace the need to reduce GHG emissions. Corporate strategies and commitments which include offsetting must be paired with a robust science-based decarbonisation target or policy.
- According to the Blue Carbon High-Quality Principles document, which resulted from a consultative process, the five core principles of high-quality projects are safeguard nature; empower people; employ the best information, interventions and carbon accounting practices; operate locally and contextually; and mobilise high-integrity capital.
- An often-overlooked aspect of a high-quality blue carbon project is building trust with local communities and other relevant stakeholders, including municipal governments or small-scale fishing communities who live and work in the area.

Current status

The demand for blue carbon credits and recognition of the value of blue carbon ecosystems has grown significantly in recent years. The overall size of the voluntary carbon market in 2021 was more than US$1 billion annually (Ecosystem Marketplace 2021) and is projected to increase by a factor of 15 by 2030 and by 100 by 2050 (Blaufelder et al. 2021). While blue carbon is currently a small slice of the carbon market 'pie' (blue carbon credits made up 0.15 percent of all credits issued by Verra in 2022 (Verra 2023)), blue carbon finance has the potential to grow overall investment in coastal and ocean nature-based solutions and resilience (see 'Carbon market opportunities and risks').

Government and other initiatives have provided scaling opportunities but also attracted project developers who may not produce scientifically robust methodologies and equitable market-based projects. It is crucial that all stakeholders align around a shared vision for high-quality blue carbon that achieves lasting and meaningful results for people, nature and the climate. The Blue Carbon High-Quality Principles and Guidance document was launched in November 2022 at UNFCCC COP 27 to provide guardrails for defining and assessing project quality (Box 5) (Conservation International et al. 2022). The Principles, while voluntary, aim to develop pathways to achieving high-quality projects, and objective metrics around each principle are being developed.

The implementation of the High-Quality Blue Carbon Principles and Guidance is valuable in efforts to address climate mitigation and adaptation, and builds on the experience of other nature-based programmes like REDD+ (Conservation International et al. 2022). The stated goal, in accordance with the Paris Agreement, is to limit global warming to no greater than 1.5 degrees Celsius above pre-industrial levels. Investments that value

Box 5. High-quality, high-impact blue carbon principles

The Blue Carbon High-Quality Principles and Guidance document defines the following as aims of high-quality projects and programs: sequester and store carbon with high fidelity; restore the ecological integrity and resilience of the ecosystem; and open pathways for Indigenous and local communities to equitably participate in and benefit from the voluntary carbon market.

These aims can be met by following these five principles, each of equal importance. These principles are foundational to the development and deployment of high-quality blue carbon projects and programs.

1. **Safeguard nature**: Blue carbon projects provide unique opportunities to preserve and enhance ecosystem resilience.
   - Conserve our planet's remaining intact ecosystems.
   - Design projects in accordance with science-based ecological protocols.
   - Do no harm.
2. **Empower people**: Most blue carbon projects take place where people live and work. Blue carbon practitioners must implement social safeguards (see section 'Local communities and social safeguards') to protect and enhance community member rights, knowledge use and leadership, and foster equitable access to the global carbon market.
   - Ensure that free, prior and informed consent (FPIC) is established.
   - Ensure inclusive participation and leadership of Indigenous Peoples and local communities (IPLCs), women and other marginalised groups in project design, governance and management.
   - Ensure that feedback, accountability and grievance mechanisms are available to all rightsholders and stakeholders.
   - Respect traditional land use practices and legal rights to land, resources and carbon.
   - Provide equitable access to the global voluntary carbon market by empowering local communities with the means to participate and lead.
   - Ensure locally relevant gender integration.
   - Empower local communities to define equitable benefit-sharing.
3. **Employ the best information, interventions and carbon accounting practices**: The integrity of the voluntary carbon market hinges, in part, on the quality of information used to design projects and communicate the resulting carbon value of the credits generated.
   - Use the most appropriate interventions and the best available scientific knowledge, including Indigenous, traditional and local knowledge.
   - Ensure transparent and accurate greenhouse gas accounting and monitoring by using a scientifically sound methodology or protocol.
   - Establish accurate carbon baselines through evidence-based assessments.
   - Demonstrate additionality using clear evidence and reasoning.
   - Assess threats to durability.
   - Establish measures to mitigate risk of reversal.
   - Employ adaptive management protocols.
   - Weigh the trade-offs between actual and anticipated credit types.
4. **Operate locally and contextually**: Blue carbon ecosystems are incredibly heterogeneous with respect to their role in local customs; gender and power dynamics; resource use, management and ownership regimes; social, policy and governance structures; and ecological context.
   - Design projects according to the local social and ecological context.
   - Account for the local implications of international policies.
   - Advance local policies to promote high-quality blue carbon project development.
   - Establish a diverse network of local partners to ensure project success and longevity.
5. **Mobilise high-integrity capital**: We cannot achieve the best outcomes for people, nature and climate without high-integrity financial flows.
   - Set science-based targets for limiting global average temperature increase to 1.5 degrees Celsius and compensate for remaining emissions with high-quality carbon credits.
   - Design agreements and contracts to promote fair and transparent pricing and compensation.

Source: Conservation International et al. (2022).

nature and build resilience are important, but they must not replace efforts to drastically reduce global greenhouse gas emissions.

Nature-based solutions should meet the needs of local communities and other stakeholders, and have clear decision-making strategies (Cohen-Shacham et al. 2019). Market-based projects may not be feasible in all cases, but other approaches, such as setting enabling policy conditions or stakeholder engagement, can be effective (Vanderklift et al. 2019). Conservation and restoration projects also benefit from non-market approaches where finance is channelled to the protection of ecosystems for biodiversity or livelihood benefits, without the expectation of generating carbon credits.

Key knowledge gaps and emerging issues

Clarity on high-quality metrics

Due diligence is a necessary component of maintaining the integrity of blue carbon projects. The involvement of project developers, nature-based solution experts, corporate sustainability officers, local communities, Indigenous Peoples and government agency representatives brings diverse expertise and understanding to the table. However, this may also result in confusion around the different types of existing standards and methodologies (e.g. Verra), and what 'counts' as high-quality. Corporate sustainability officers, for instance, may not be familiar with the technicalities of carbon measurement or FPIC processes. This makes investment opportunities challenging to assess, leading to demands for additional due diligence that may increase project implementation costs. Clear metrics for objectively evaluating projects against fundamental principles are necessary to ensure that all parties have the same expectations when engaging in blue carbon projects.

Capacity building for governments, buyers and project developers

Given the high stakes of climate mitigation, it is crucial that mitigation outcomes be robust and accurate. However, it is also important not to disregard actors who may have made mistakes in the past but are making efforts to improve. To this end, a clear pathway for capacity building and guidance on acceptable practices is essential. For instance, using carbon data from a recent publication rather than in situ carbon measurements may be acceptable if the data are refined over time, while poor implementation of FPIC processes is unacceptable. These boundaries must be established and defined.

Carbon market opportunities and risks

Key information

- The demand for high-quality blue carbon projects and related carbon assets (e.g. blue carbon credits) has been growing over the past years. It is currently driven by companies' and non-state actors' voluntary net-zero emission plans as well as by consumer emission-compensation pursuits, and should have strong safeguards to ensure climate justice.
- The supply potential of blue carbon credits is favourable. Prices that buyers or investors are willing to pay for blue carbon credits are reaching levels that can cover the costs of many restoration and conservation initiatives in ecosystems rich in blue carbon.
- Barriers to the realisation of the potential of blue carbon credits and natural assets include high start-up and feasibility costs; limited measurement, reporting and verification capacity; concerns about uncertainty risks for project continued operation; and the need for an investable project pipeline.
- Up to 20 percent of mangrove forest conservation projects (2.5 million hectares) could potentially qualify for blue carbon market participation. Given the high demand, blue carbon credits could be worth more than US$10 billion[5].

Current status

Overview of relevant market opportunities

Carbon markets have been operating for about 25 years and have delivered finance for emission-reduction and removal projects around the globe. Since 2007, 4.7 gigatonnes CO_2e of carbon credits—where 1 credit is equal to 1 tonne CO_2e of reduced or removed emissions ('emission reduction')—have been issued, and 478 million carbon credits were issued from international, domestic and independent carbon credit markets in 2021 alone (World Bank 2022). Removals and emission reductions from protecting or restoring blue carbon ecosystems are a relatively nascent component within the broader financing mechanism—with approximately 970,000 carbon credits being issued by the Verra Standard from blue carbon projects in 2021 (Jones 2021).

In 1997, the UNFCCC Kyoto Protocol introduced the first global carbon compliance market for allocated emission allowances (under the cap-and-trade system) and carbon credits (under the baseline-and-credit system)[6]. More recently, Article 6 of the Paris Agreement (PA) and its Glasgow Climate Pact have established guidance, modalities and rules for using international market approaches to support the achievement of countries' NDCs (UN 2015a). Article 6 includes approaches for exchanging international mitigation outcomes under 'cooperative approaches' (PA Article 6.2) and sets up a new emission-reduction crediting and trading mechanism supervised by the UNFCCC (PA Article. 6.4), both allowing the participation of companies. Cooperative implementation through carbon markets compatible with PA Article 6 may enable countries to achieve their NDC targets with greater economic efficiency while channelling climate funding to the selling countries.

Many countries are in the process of establishing internal or domestic rules on how to participate in these new market approaches[7]. Though operationalisation will take time, the tools are expected to have a significant impact in driving carbon finance for action in the real economy (Yu et al. 2021) and for nature restoration and conservation. As pressures mounts for faster decarbonisation, around 77 percent of new and updated NDCs show support for participation in Article 6, with almost 50 percent of countries stating a strong interest (Michaelowa et al. 2021).

Additionally, industry-wide global compliance carbon credit markets exist, including the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation, as well as national and subnational carbon credit markets for compliance. Some compliance market opportunities include NbS emission reductions, including through blue carbon credits, but are still nascent in operation. The most prevalent carbon credit markets, however, in terms of traded annual volumes, are the independent voluntary carbon markets where verified emission reductions are exchanged, mainly to meet the voluntary net-zero 2050 targets of companies, municipalities and organisations. The vast majority of traded emission reductions and removals (as of April 2023) have been verified according to Verra's independent crediting Verified Carbon Standard (71.5 percent), followed by the Gold Standard (16.6 percent), the American Carbon Registry (6.2 percent), Climate Action Reserve (5.2 percent) and Plan Vivo (0.5 percent) (VCMI 2023).

Carbon credits standards operate as 'baseline-and-credit' instruments; they define approved methodologies to calculate in detail the 'baseline' greenhouse gas emissions and issue credits when and after a project verifies that climate change mitigation has been achieved compared to this baseline. Carbon credits have a unique serial number and are issued, tracked and cancelled by means of an electronic registry. Carbon credits, used to offset emissions on a voluntary basis, are often referred to as 'carbon offsets'. Specific mangrove, seagrass and coastal wetland restoration–based blue carbon verification methodologies are offered by various independent voluntary carbon market standards like Verra (VM0007 REDD+ Methodology Framework (REDD+MF), v1.6; VM0033 Methodology for Tidal Wetland and Seagrass Restoration,

v2.0; upcoming methodology around seascapes), Plan Vivo (afforestation, REDD+), the UNFCCC Clean Development Mechanism (afforestation and reforestation), and the Gold Standard (afforestation) (Table 4). Verra is developing additional methodologies for the storage of blue carbon in seascapes. France recently approved a methodology to generate blue carbon credits from the protection of Posidonia seagrass meadows for use under its domestic offsetting label Bas-Carbone, with the first projects in the pipeline (République française 2023). The European Union is preparing a regulatory framework for the certification of carbon removals, including from natural carbon removal activities, such as in wetlands, potentially leading to the establishment of an EU-wide voluntary removal carbon market.

Current pipeline of blue carbon credit or mitigation outcomes

In 2021 about 970,000 tonnes of carbon dioxide equivalent (tCO_2e) were issued by the Verra Standard from blue carbon projects (Jones 2021). However, these projects account for only about 10 of the 1,829 projects listed by Verra (2023)[8]. The Plan Vivo Standard hosts the world's first blue carbon credit project, the 117-hectare (ha) Mikoko Pamoja project from Kenya (Plan Vivo 2023), and has recently added two other projects to its list, one in Madagascar (Vanga project) and the other in Kenya (Tahiry-Honko project). A little over 20 mangrove blue carbon projects are at advanced stages of preparation globally (Jones 2021), while around 120–150 blue carbon credit projects are at early or very early stages of development globally, including in Kenya, Tanzania, Benin, Cameroon, Madagascar, Senegal, Guinea-Bissau, India, Colombia, Honduras, Mexico, the Philippines and Indonesia[9]. For a detailed overview of the advanced global blue carbon project pipeline status as of June 2022, see IFC (2023) and this report's 'Key resources'.

Observed and expected prices

Reported prices for blue carbon credits range from $5 to $35 per tCO_2e, with the upper end of the price range being paid for mangrove restoration and afforestation or reforestation (Zeng et al. 2021; IFC 2023). Some buyers are willing to go above this price range for high-quality blue carbon removal projects (see section 'Developing high-quality, high-impact blue carbon projects'). This price premium can mostly be reached for blue carbon projects that exhibit additional sustainability certifica-

Table 4. Examples of systems to help guide the implementation of voluntary carbon market projects

METHODOLOGY	DESCRIPTION
Verra: VM0007 REDD+ Methodology Framework (REDD+MF), v1.6	Provides guidance for implementing projects that reduce emissions from deforestation and forest degradation (REDD+). It offers a framework for measuring and monitoring carbon emissions and removals associated with forest conservation and sustainable management practices.
Verra: VM0033 Methodology for Tidal Wetland and Seagrass Restoration, v2.0	Provides guidelines for assessing carbon stocks and emission reductions associated with restoring and conserving tidal wetlands and seagrasses.
Plan Vivo	Focuses on community-based projects aimed at sustainable land use and livelihood development.
UNFCCC Clean Development Mechanism (CDM)	Allows developed countries to invest in emission-reduction projects in developing countries as a way to meet their own emission-reduction targets. The CDM covers a wide range of project types, including afforestation and reforestation activities, and these projects can generate certified emission reductions, which can be traded and used to offset emissions in compliance markets.
Gold Standard	Goes beyond emission reductions to address sustainable development and environmental integrity. It is well known for its focus on renewable energy projects but also covers afforestation initiatives. It provides rigorous criteria related to project design, stakeholder engagement, environmental safeguards and social co-benefits.

tions and are using standards with a strong sustainable development or livelihoods focus, integrating socioeconomic considerations into project design and operation (Donofrio et al. 2021). While the International Monetary Fund predicts that a global carbon price of $75 per tCO_2e would need to be in place by 2030 to reach the Paris Agreement goals (Black et al. 2022; World Bank 2023), further price increases, relative to 2023 levels, in coming years for high-quality blue carbon projects are a realistic scenario, driven by increasing regulation and more ambition in implementing net-zero targets at the company level.

Supply and demand for blue carbon credits

Globally, natural climate solutions (NCS) as a whole could generate up to 12 gigatonnes of CO_2e in mitigation benefits per year, at maximum potential and across all ecosystem pathways that are inclusive of blue carbon ecosystems (von Unger et al. 2022). However, currently, there is an emission-reduction supply potential of 3 gigatonnes globally until 2030 from nature-based sequestration such as reforestation, leaving room for expansion (Taskforce on Scaling Voluntary Carbon Markets 2021).

Considering only mangroves, research shows that 20 percent of mangrove forest conservation projects (2.5 million hectares) could qualify for blue carbon financing, and half of them (1.1 million to 1.3 million hectares) could be financially sustainable over 30 years at $5–$9.4/tCO_2e, contributing to approximately 30 million tCO_2e/year in reductions (Zeng et al. 2021). The demand forecast for the global voluntary carbon market is 1–2 gigatonnes CO_2e by 2030 (Taskforce on Scaling Voluntary Carbon Markets 2021). It is estimated that the demand for high-quality blue carbon credits from companies and investors is potentially worth $10 billion (Friess et al. 2022).

Advantages of using carbon markets to fund blue carbon ecosystem restoration and conservation

- Compliance and voluntary carbon credit markets provide emission-reduction price signals that can complement government pricing incentives.

- Established methodologies and standards, along with market rules and infrastructure, enable funding for blue carbon ecosystems.
- Carbon finance can fill local financing gaps and potentially help indebted nations. It can also serve as a revenue source for sustainability and blue debt-for-nature swaps.
- Demand for blue carbon credits is high, creating an opportunity for addressing structural weaknesses and enforcing socioeconomic and environmental integrity and equity (Vanderklift et al. 2019).

Disadvantages of using carbon markets to fund blue carbon ecosystem restoration and conservation

- High costs and capacity limitations hinder high-quality project development, while monitoring and verification processes are costly.
- Belowground blue carbon estimation is lacking or inaccessible (requiring local direct measurement), and this may limit blue carbon activities available for market approaches.
- Land tenure uncertainties and missing long-term land management plans impede project development in blue carbon areas and limit local ownership and empowerment.
- Blue carbon rights are often unclear and subject to regulatory changes.
- Few operational blue carbon projects and past failures contribute to perceived risks.
- Most projects are small, and market uncertainties and lack of government clarification on internal or domestic rules slow the scaling up of investments.
- Many countries are in the first steps of establishing their Article 6 national frameworks, and this might create uncertainty regarding how projects feed into the broader NDC achievement strategy.

Key knowledge gaps and emerging issues

Opportunities for government action to support blue carbon markets

Governments with blue carbon ecosystems can leverage their value for climate adaptation and mitigation both through more nascent market-based, and non-market-based mechanisms, which could be included in an NDC or other national policies that support restoration and conservation. This can be achieved by disseminating information or working with communities on the value of coastal ecosystem protection and associated good practices and principles, embedding projects into global NbS standards, and following science-led international collaborations like the Blue Carbon Initiative and the International Partnership for Blue Carbon (see section ‘International partnerships and other initiatives‘).

Sovereign governments with mitigation or adaptation priorities around the protection of coastal wetlands (including blue carbon ecosystems) could consider participating in PA Article 6.2 and Article 6.4 mechanisms with full stakeholder inclusion to channel international finance towards these priorities. Funding is available from bilateral and multilateral sources for related capacity building.

Opportunities for private sector action to support blue carbon activities

A force for direct investment, especially in sustainable blue carbon removal activities (afforestation, restoration) could come from companies, including financial market actors, that are already or will be subject to sustainability disclosure regulations, as currently observed in the European Union and other parts of the world.

Alternative funding and finance opportunities for blue carbon

Key information

- Blue carbon projects provide a wide range of ecosystem services that could be monetised, but they have faced challenges associated with ecosystem service valuation (e.g. adaptation or resilience metrics) and the small-scale nature of the project areas.
- Integrating blue carbon activities, and blue natural capital asset companies, into broader coastal infrastructure projects can help to make finance more accessible, more efficiently and from a wider range of sources, including through blue bonds or development banks, while simultaneously increasing ecosystem resilience and asset protection.
- Advancing nature finance expertise, capacity building and blended approaches will be required.

Current status

A broad perspective on financial mechanisms is necessary to address funding gaps in developing coastal communities. The proposed approach involves viewing blue carbon projects as blue natural capital asset companies (BNCACs), which considers a range of ecosystem services such as coastal resilience, biodiversity protection and ancillary livelihood opportunities. Currently, most ecosystem services are not optimally financed because of a focus on carbon market project development and origination (UNEP 2020).

Blue carbon projects face financing challenges because of their small scale, remote locations and harsh operating conditions (Sumaila et al. 2021; Vanderklift et al. 2022). Currently, traditional financing routes have limited traction, and progressive opportunities are not yet widespread (UNEP 2021). Project companies have limited access to basic commercial finance such as loans, factoring or asset finance (Sumaila et al. 2021). These financial products will gain importance as the blue carbon market matures, necessitating local banking capacity. Thus, investing in financial institutions and building capacity in these areas is crucial for attracting international investment (Sumaila et al. 2021).

Development of the equity segment for blue carbon is in its infancy, as limited activity from impact investors and a lack of exit opportunities have slowed progress (Vanderklift et al. 2022). Smaller-scale funding options, such as microfinance and insurance, are also in their early stages (Sumaila et al. 2021). However, bundled approaches, such as structured finance and blue bonds, can attract international capital markets into the space (Vanderklift et al. 2022).

Public-private partnerships, including those focused on technology transfer and capacity building, can be funded through international support (e.g. bilateral and multilateral partnership, grants for research and knowledge networks) and help implement effective financing tools for blue ecosystem restoration (Sumaila et al. 2021). Governments can also collaborate with the insurance industry to apply natural catastrophe insurance, political risk insurance and extended blue carbon credit buffer pools to reduce risks of blue carbon transactions on the risk-structuring level and help with diversification of revenue streams and environmental and socioeconomic analysis (Knight et al. 2022). Efforts such as the Blue Natural Capital Financing Facility (BNCFF), the Blue Carbon Accelerator Fund (BCAF) or other incubators and accelerator programs are vital for improving the business case for NCS and blue carbon restoration projects (Box 6).

While standards and methodologies for assessing blue carbon ecosystem services as revenue streams are still developing (Himes-Cornell et al. 2018), uncertainties around land tenure and risk considerations have limited engagement from traditional financiers (Vanderklift et al. 2022). Additionally, a lack of long-term funding sources and investor exit opportunities has hindered exploration of alternative financing and funding approaches. However, several emerging financing pathways are being discussed and tested in multiple locations (UNEP 2021):

- An effort to identify, develop and monetise blue carbon ecosystem services (including livelihood activities, such as mud crab husbandry and honey production in mangroves) (Himes-Cornell et al. 2018). These are often termed 'co-benefits' or 'non-carbon-benefits' when they are in fact de facto core ecosystem services. Nature (or biodiversity) certificates and resilience credits are examples of emerging concepts in this regard.
- The conscious integration of BNCACs into broader coastal planning to increase access to finance (Thiele et al. 2021). For instance, BNCACs can be aligned as climate or biodiversity refugia alongside tourism activities, artisanal and small-scale fisheries or mariculture production, and clean energy projects. Under this model, for example, a seaweed farm utilising floating solar infrastructure may be located adjacent to an MPA with mangroves, all jointly managed by the local community and further supported by ecotourism activities. Such an approach benefits from multiple and diverse revenue streams as well as the potential for cost savings.
- The framing of BNCACs as valuable blue infrastructure (Thiele et al. 2021), providing services such as natural water treatment. Such an approach could provide significantly cheaper and reliable access to finance than traditional infrastructure investments, for instance from development banks, while increasing long-term ecosystem resilience and asset protection (with relevance to wind farms, for example).
- Integration of BNCACs into the wider scope of the sustainable blue economy, with an emphasis on innovation, entrepreneurship and use of modern technologies (Hoegh-Guldberg et al. 2019). The development of marine clusters (i.e. collaborative platforms focused on promoting and supporting innovations related to marine resources) that integrate blue bio-economy approaches and provide access to needed science and research will be a critical part of this integration.

Key knowledge gaps and emerging issues

Nature finance literacy and capacity

There is a need to build capacity for nature finance at every level, including municipal or state governments, local communities, small-scale fishers, the international community, and the public and private sectors (Sumaila et al. 2021). This includes a need to reassess basic finance tools to support emerging blue carbon projects, including blue carbon market project origination, blue carbon non-market development, and climate action for

protecting or restoring blue carbon ecosystems (UNEP 2021). Nature finance literacy training is crucial for both the public and financial sectors, and there is a need to scale up blended finance to integrate commercial funding with grants and technical assistance support (Vanderklift et al. 2022).

Adaptation and resilience metrics

Effective impact assessment (i.e. evaluating the outcomes and effects of an initiative) is critical to facilitate credible investment. To ensure credible and effective assessments for any financing mechanism, clear, consistent, and robust metrics and indicators are necessary to ensure monitoring and the tracking of progress reporting (see section 'Carbon market opportunities and risks'). At the same time the more traditional conservation community would benefit from capacity building in business skills and relevant support (Sumaila et al. 2021).

Untapped multilateral funding

As the need for greater finance from public funding and multilateral development banks to support coastal infrastructure and SDG 14 is increasingly recognised, there is an opportunity to integrate blue carbon activities in making the case for investments in development priorities (Thiele et al. 2021).

Accordingly, highlighting the potential co-benefits and synergies between blue carbon activities and development priorities, including SDG 14 targets, can make a compelling case for securing increased finance from public funding and multilateral development banks. It involves demonstrating how investing in blue carbon initiatives not only addresses environmental challenges but also supports economic growth, social well-being and the achievement of broader sustainable development objectives.

International partnerships and other initiatives

Key information

- The Blue Carbon Initiative (BCI) and the International Partnership for Blue Carbon (IPBC) are the two long-standing global initiatives focusing on the protection and restoration of coastal blue carbon ecosystems for climate change mitigation and adaptation, and both aim to support countries' implementation and prioritisation of blue carbon–relevant policies and actions.
- At the global level, several other initiatives have been launched to address the multiple dimensions of blue carbon—including science, policy, project implementation and increasingly finance—contributing to developing a diverse community that is available to governments, scientists and practitioners as platform for exchange and collaboration.
- At the regional level, there is an opportunity for countries, scientists and practitioners to increase collaboration to benefit from exchanges at a smaller scale.

Current status

Over time, several alliances, initiatives and partnerships have formed (Figure 5) to address the multiple dimensions of blue carbon—including science, policy, project implementation and increasingly finance—or to focus on the protection of one specific ecosystem. In 2022, the IPBC started a mapping of the numerous organisations that are now working on blue carbon at the global and regional levels, resulting in a non-exhaustive list of about 40 actors. A selection of relevant partnerships and initiatives is surveyed below.

The Blue Carbon Initiative was established in 2010 by Conservation International, UNESCO's Intergovernmental Oceanographic Commission (IOC-UNESCO) and IUCN. It aims to mitigate climate change through the conservation, restoration and sustainable use of coastal blue carbon ecosystems, including mangroves, seagrass meadows and tidal marshes. Foremost, the BCI supports scientific research into the role of coastal blue carbon ecosystems for climate change mitigation and aims to develop comprehensive methods for assessing blue carbon stocks and emissions. It also informs the development of management approaches, financial incentives and policy mechanisms to ensure the conservation, restoration and sustainable use of coastal blue carbon ecosystems. In addition, it engages local, national and international governments in order to promote policies that support coastal blue carbon conservation, management and financing.

The International Partnership for Blue Carbon was established in 2015 by nine founding members, following Australia's initiative, to connect governments with NGOs, intergovernmental organisations and research institutions globally. The partnership aims to sustainably manage coastal blue carbon ecosystems, benefitting climate change mitigation and adaptation, biodiversity, ocean economies, and coastal communities' livelihoods.

Through sharing expertise and building capacity, the IPBC supports governments in making informed commitments and plans. It has grown to over 50 partners, including 17 governments. The IPBC provides direct access to leading global blue carbon experts and practitioners, enabling governments to stay up-to-date with the latest blue carbon science and policy developments.

Several initiatives not specifically focused on blue carbon have also been active in the blue carbon space since 2018, contributing to increasing awareness of the benefits of coastal ecosystems. The Global Mangrove Alliance (GMA) was formed in 2018 to increase the global area of mangrove habitat through conservation, restoration and equitable management. With over thirty members, including NGOs, governments, scientists, industry and local communities, the alliance coordinates initiatives and shares best practices. The GMA curates *The State of the World's Mangroves* report and the remote-sensing data and monitoring platform Global Mangrove Watch, providing open access to data on habitat extent, change, alerts, biomass, height and blue carbon.

In 2018, Commonwealth countries adopted the Commonwealth Blue Charter (CBC), aimed at encouraging collaboration to manage and protect the ocean. The Mangrove Ecosystems and Livelihoods Action Group (led by Sri Lanka) and the Ocean and Climate Change Action Group (led by Fiji) share best practices and cooperate to conserve, restore and sustainably use mangroves. They also share technical know-how on valuing the economic contribution of mangroves to coastal livelihoods and creating strategies to strengthen legal frameworks for conservation. Commonwealth members are also receiving small grants from the Commonwealth Blue Charter Project Incubator to implement on-the-ground projects across the 10 CBC thematic areas. The first round of the incubator closed in January 2023, with 45 applications received, 9 of which focused on the blue economy, 7 on ocean and climate change, 5 on MPAs and 4 on mangroves.

Attending more to the adaptation benefits of coastal ecosystems, the Ocean Risk and Resilience Action Alliance brings together insurers, banks, governments, academia and civil society to drive investments into coastal and

ocean natural capital, with the goal of positively impacting the resilience of climate-vulnerable people living in coastal areas, especially in developing countries.

The years 2021 and 2022 have seen an acceleration in the global blue carbon space, with the creation of the Blue Carbon Accelerator Fund (see Box 6), the Global Ocean Decade Programme for Blue Carbon, and the Friends of Ocean Action and 1t.org Mangrove Working Group.

The Global Ocean Decade Programme for Blue Carbon (GO-BC) is a global scientific initiative under the umbrella of the UN Decade of Ocean Science for Sustainable Development (2021–30), which aims to enhance understanding of the ocean-climate nexus and generate new knowledge and solutions to mitigate, adapt and build resilience to the effects of climate change by leveraging coastal ecosystems. The GO-BC programme is led by the University of St. Andrews with support from the United Kingdom, in partnership with the BCI, IPBC and IOC-UNESCO. GO-BC will benefit countries across all ocean basins by enhancing scientific cooperation at the global and regional levels, coordinating capacity building and communicating results to policymakers and communities.

Box 6. The value of partnerships to drive action globally: The example of the Blue Carbon Accelerator Fund

The Blue Carbon Accelerator Fund (BCAF) was established in 2021 by Australia and the International Union for Conservation of Nature (IUCN) as a dedicated funding scheme to support blue carbon restoration and conservation projects in developing countries and help pave the way for private sector financing. The need to increase the global supply of investment-ready projects and the opportunity to increase project value (through recognition and valuation of non-carbon benefits for biodiversity, livelihoods and climate adaptation) was identified by governments and blue carbon practitioners as part of their ongoing dialogue within the International Partnership for Blue Carbon (IPBC). The resulting BCAF was inspired by the work of the Blue Natural Capital Financing Facility (BNCFF)—which is dedicated more widely to the conservation and restoration of marine and coastal ecosystems and also managed by the IUCN—and provides support to project developers in several ways, including readiness support for early stage projects, to help them get ready for implementation and future private sector finance; implementation support for more mature projects and to help measure the multiple benefits of the project; and capacity building, in the form of access to technical guidance, collaborative networks and exposure to opportunities for future financing. Currently, the BCAF supports eight projects in Benin, Indonesia, Madagascar, Papua New Guinea, Peru and the Philippines. The BCAF is also open to governments that are willing to contribute as donors or that are looking for ways to support blue carbon activities within their countries.

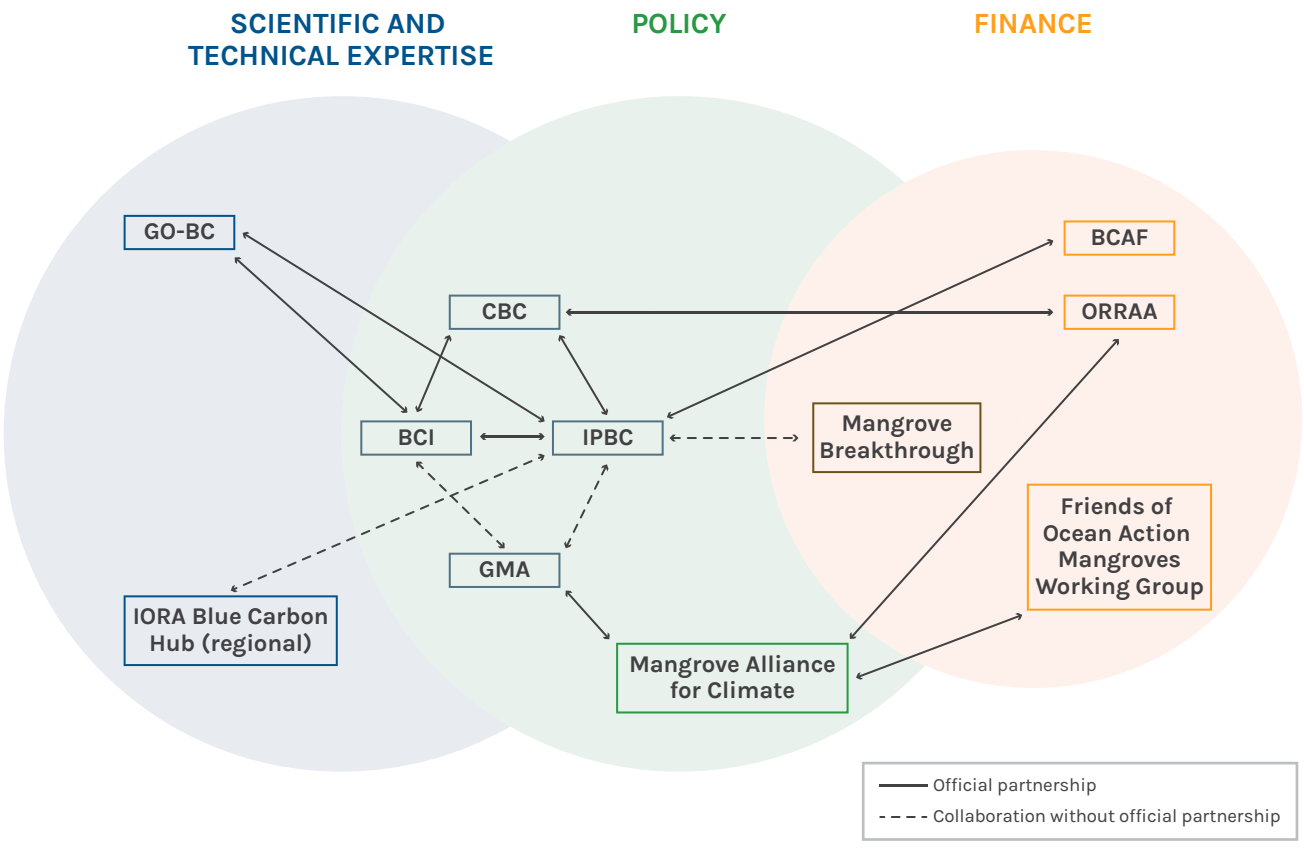
The World Economic Forum, through the Friends of Ocean Action and 1t.org, created the Mangroves Working Group to enable companies and investors to contribute to the conservation and restoration of mangrove forests with support from the nonprofit sector, with the aim of enhancing the blue carbon market and strengthening the resilience of coastal ecosystems and communities.

UN Conferences of the Parties (COPs), like the UNFCCC and CBD, have also increasingly become a space for announcements of new initiatives aimed at keeping momentum and stepping up ambition. At COP 27 in 2022 in Sharm El-Sheikh, Egypt, the United Arab Emirates and

Indonesia announced the Mangrove Alliance for Climate, aimed at scaling up and accelerating the conservation and restoration of mangrove ecosystems for the benefit of communities worldwide. India, Sri Lanka, Australia, Japan and Spain are current members of the Alliance. At COP 27, recognising the need for a unified global approach towards mangrove conservation, the Global Mangrove Alliance, in collaboration with the UN Climate Change High-Level Champions, launched the Mangrove Breakthrough, which aims to secure the future of 15 million hectares of mangroves globally through protection and restoration activities and an investment of $4 billion by 2030. The Breakthrough currently has thirty signatories (non-state actors and governments). It contributes to delivering the 2030 Breakthrough and the Sharm El-Sheikh Adaptation Agenda.

While the global space is populated by a significant number of complementary coalitions and partnerships, the only regional partnership on blue carbon is the Indian Ocean Rim Association (IORA) Blue Carbon Hub. The IORA Blue Carbon Hub was established in 2019 with the aim of building knowledge about and capacity in protecting and restoring blue carbon ecosystems throughout the Indian Ocean, in a way that enhances livelihoods, reduces risks from natural disasters and helps mitigate climate change. The hub operates in blue carbon science and blue carbon finance, providing advice and capacity-building expertise to the IORA Member States, conducting and facilitating research, establishing and disseminating best practices, and developing partnerships to implement activities on the ground.

Figure 5. Schematic of different initiatives in the blue carbon space, and relationships among them



Notes: BCAF = Blue Carbon Accelerator Fund; BCI = Blue Carbon Initiative; CBC = Commonwealth Blue Charter; GMA = Global Mangrove Alliance; GO-BC = Global Ocean Decade Programme for Blue Carbon; IORA = Indian Ocean Rim Association; IPBC = International Partnership for Blue Carbon; ORRAA = Ocean Risk and Resilience Action Alliance.

Source: Authors.

Key knowledge gaps and emerging issues

Regional collaboration

Governments that engage with neighbouring countries have opportunities for new collaborative initiatives. Regional blue carbon coalitions and partnerships provide better access to data, funding and expertise, while allowing for knowledge exchange and learning.

Continued collaboration

The global blue carbon space is abundant with partnerships working on science, policy, project implementation and finance. Engaging in ongoing collaboration with partners at all levels is key to serving the needs of countries, local communities and stakeholders, and driving blue carbon action worldwide. This creates trusted relationships and credible advice for communities and governments.

Capacity development

Capacity development plays a key role in equipping governments, scientists, practitioners and stakeholders with the necessary knowledge, skills and resources to engage in blue carbon initiatives effectively. This includes enhancing technical expertise in areas such as blue carbon assessment methodologies, project design and implementation, policy development and financing mechanisms. Capacity development should also focus on fostering collaboration, knowledge-sharing and learning among different actors involved in blue carbon projects, at both the global and regional levels. By investing in capacity development, international partnerships can strengthen their ability to support countries in implementing blue carbon–relevant policies and actions, and foster innovation and entrepreneurship.

Conclusions

Nature-based solutions like the protection, restoration and sustainable management of blue carbon ecosystems have the potential to address multiple global challenges such climate change adaptation, climate mitigation and biodiversity loss, and support local livelihoods when healthy and intact. Coastal ecosystems offer a range of benefits to people, nature and climate, as indicated throughout this special report. This report aims to be a functional resource to provide policymakers and implementers with guidance on tools and partnerships to effectively implement blue carbon actions at the national and local levels, while ensuring environmental and social integrity.

Blue carbon projects cover a range of actions to promote conservation, restoration and sustainable management, and can be advanced through both relatively nascent market-based and non-market-based actions, including co-benefits and innovative financial approaches. Carbon markets are an important tool to fill the financing gap necessary for immediate action and funding, but holistic considerations of adaptation, resilience, biodiversity and livelihoods are equally critical and should be addressed through additional financial mechanisms that take equity and appropriateness into consideration. Technical carbon accounting, land-use change drivers and community needs must also be given careful consideration to ensure equitable and high-quality blue carbon projects. This is true for the market-based projects which are often top of mind, as well as non-market projects focused on sustainable management, biodiversity or conservation.

Reducing emissions is crucial to meeting the UNFCCC Paris Agreement's goal of limiting global temperature increase to 1.5^{0}C, or well below 2^{0}C. There is great value in national governments' prioritising the protection and management of blue carbon ecosystems, with support from international policies that establish transparent rules and reporting standards. Similarly, protecting blue carbon ecosystems is important to achieving the targets outlined in the CBD's Kunming-Montreal Global Biodiversity Framework. Given the cross-sectoral importance of healthy blue carbon ecosystems, every country is invited to consider enhancing its ambition on climate change, development, biodiversity and the like and to integrate and prioritise, in its relevant national plans and reports, key actions that support the sustainable management, protection or restoration of blue carbon ecosystems (in a wider sense than the three special ecosystems focussed on in this report). For project development and implementation, local communities should be involved from the beginning, as they tend to be the most affected by the impacts of environmental change.

Progress on nature-based solutions, such as blue carbon action, will require addressing key challenges and filling existing knowledge and methodological gaps. To improve project design, implementation, financing and monitoring, research, policy development, capacity building and financial mechanisms are necessary. Financial support for scientific evidence and research that encompass the environmental, social and economic aspects of blue carbon projects, as well as technical expertise and capacity building, would help bridge these knowledge gaps. Additionally, supporting capacity building to implement standardised methodologies for measurement, verification and reporting when accounting for mitigation potential, refining methods to quantify the economic value of ecosystem services, and establishing metrics for measuring adaptation, resilience and biodiversity outcomes are important steps. Improving the ability to incorporate local communities' knowledge and priorities and strengthen participatory processes and stakeholder engagement also has value. Finally, collaborative efforts among governments, international organisations, scientific institutions, private sector actors and local communities are valuable for effectively implementing blue carbon projects and maximising their multiple benefits for climate mitigation, adaptation, biodiversity, food security, tourism, livelihoods and sustainable development. The science, need and opportunity are clear: nature-based solutions, like blue carbon, are part of the solution set to address climate change and biodiversity loss, while also ensuring that the needs of both people and nature are met.

Appendices

The Kunming-Montreal Global Biodiversity Framework: Select targets critical for blue carbon action

The targets listed here are a selection with direct links to blue carbon action. Other targets may also be relevant. Find the full list of targets here.

Target 2

'Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity.'

Target 3

'Ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures, recognizing indigenous and traditional territories, where applicable, and integrated into wider landscapes, seascapes and the ocean, while ensuring that any sustainable use, where appropriate in such areas, is fully consistent with conservation outcomes, recognizing and respecting the rights of indigenous peoples and local communities, including over their traditional territories.'

Target 8

'Minimize the impact of climate change and ocean acidification on biodiversity and increase its resilience through mitigation, adaptation, and disaster risk reduction actions, including through nature-based solution and/or ecosystem-based approaches, while minimizing negative and fostering positive impacts of climate action on biodiversity.'

Frequently asked questions

General

Q: Does protecting and restoring all possible coastal blue carbon significantly change the climate mitigation trajectory?

A: Protecting and restoring all possible coastal blue carbon ecosystems is one tool to address climate change, as combating global climate change requires all 'tools in the toolbox'. Carbon sequestration and storage is a strong argument for actively promoting conservation and restoration of these ecosystems for climate mitigation (Goldstein et al. 2020) and adaptation and resilience benefits. Mangroves, for example, are estimated to account, on an annual basis, for between 1.3 and 8 percent of the total organic carbon sequestered by terrestrial ecosystems. However, because of their large carbon stocks already sequestered, their loss represents a disproportionate 20 percent of the CO_2 emissions associated with changes to tropical coastal ecosystems (Alongi 2020). In Costa Rica, for instance, restoring the approximately 14,000 hectares of mangroves lost between 1999 and 2014 will represent a carbon sequestration equivalent to over twice the country's national emissions, as reported to the UNFCCC (Cifuentes-Jara et al. 2015). However, it is vital not to overstate the carbon mitigation potential, as emission reductions in other sectors are critical for the economy-wide approach necessary to meet the goals of the Paris Agreement. Additionally, given the significant adaptation and resilience benefits of protecting these ecosystems for local coastal communities, the avoided loss and damages realised when these ecosystems are conserved in place and restored can represent between 2 and 20 percent of developing countries' annual income, or 1.2 percent of the U.S. GDP (Hsiang et al. 2017), another compelling rationale for their protection from a climate perspective.

Q: If these ecosystems are so vital for many reasons, why are we still losing them and not able to restore them fast enough?

A: Global and national economic and political development pathways, as well as coastal management and inadequate protection measures (Turschwell et al. 2020), largely undermine the complex land-use dynamics governing the persistence, loss, degradation and rehabilitation of blue carbon ecosystems. During the twentieth century, commodity-driven land-use changes, such as the conversion of mangroves to shrimp aquaculture and rice, oil palm and other crops, together with mangrove forest clearing for timber extraction, were largely driven by rapid coastal population growth and urban expansion, in addition to industrialisation (Sejati et al. 2020). Also responsible was an increase in global aquaculture demand (Richards and Friess 2016; Friess et al. 2016; Thomas et al. 2017), although the exact dynamics vary regionally (Goldberg et al. 2020) and locally. Although much of these dynamics persist worldwide, deforestation hotspots still exist, and restoration efforts still lag, losses of blue carbon ecosystems decreased between 2000 and 2016, possibly because of stronger conservation measures, large-scale restoration efforts and the ironic fact that, in some regions, mangroves are no longer available for conversion to expand human activities (Goldberg et al. 2020). Further understanding of these dynamics and increasing awareness of the relationship between the persistence of blue carbon ecosystems and the reduction of economic and social losses and damages (Hochard et al. 2019) may provide a tipping point to reverse the historical loss of these ecosystems.

Local communities and social safeguards

Q: How can governments leverage local and Indigenous knowledge to support the development, implementation and monitoring of blue carbon initiatives?

A: Governments can leverage local and Indigenous knowledge to support the development, implementation, and monitoring of blue carbon initiatives by incorporating their perspectives into decision-making processes and working closely with them to co-design and co-implement initiatives. Local and Indigenous knowledge can provide valuable insights into the ecology and dynamics of coastal ecosystems, as well as traditional practices and customs that have been used to manage these areas sustainably. Additionally, collaborations with local and Indigenous communities can provide opportunities for capacity building and knowledge-sharing that support the long-term success of blue carbon initiatives. Through such partnerships, governments can cultivate a participatory approach to policy development that takes into account the diverse perspectives and knowledge of all stakeholders involved.

Q: Which community engagement practices should be encouraged, and which avoided, when developing carbon projects?

A: When developing carbon projects, it is important to encourage community engagement practices that prioritise local stakeholder input and ensure equitable distribution of benefits (monetary and non-monetary). This can be achieved through transparent communication, consultation and collaboration with community members, including traditional knowledge holders and Indigenous Peoples. It is also important to avoid practices that result in social or environmental harm, such as exploitative land acquisitions, displacement of communities or degradation of vital ecosystems in the project area or neighbouring areas. Additionally, ensuring effective monitoring and evaluation mechanisms for carbon accounting and for

social and environmental safeguards can help to identify and mitigate any negative impacts of carbon projects on local communities.

Q: What is a safeguard information system, and how do I develop one?

A: A safeguard information system (SIS) is a tool to monitor and evaluate the potential social and environmental impacts of government policies and programs. While an SIS is often required at a jurisdictional or landscape scale, smaller-scale and/or voluntary projects would also benefit from developing clarity and systems for safeguards. Specifically, an SIS is designed to identify potential risks and provide mitigation measures to ensure that these policies and programs do not harm people or the environment. Developing an effective SIS requires a thorough understanding of the contexts in which policies and programs will operate, as well as the potential risks and benefits associated with implementation. Key components of a successful SIS include clear indicators, measurable targets, and effective monitoring and reporting mechanisms. In order to develop an SIS that meets the needs of your specific context, it is essential to engage with stakeholders, including local communities, civil society organisations and relevant government agencies, to ensure that their perspectives are taken into account.

National implementation

Q: My government department is new to blue carbon—where do I start?

A: The popularity of the term *blue carbon* may be overwhelming, and the breadth of information and uncertainty that surrounds some of these discussions may seem daunting, so the first step is to find out if it is relevant to you. First, although the term is used frequently, *blue carbon* is referring actionable ecosystems like mangroves, seagrass meadows and tidal marshes. If these ecosystems are present in country, the next step is to identify whether there are current data on their location, spatial distribution, historical changes, knowledge of the ecosystem services these ecosystems are providing, social interactions and the pressures and threats to those ecosystems. These data may be available from another government department or from NGOs. Once this is understood, the next step is considering whether further science and research are required. This may lead to further science through a mapping of the blue carbon ecosystems in your territory.

Second, the government department may consider conserving or restoring blue carbon ecosystems. This requires undertaking a cost-benefit analysis, including understanding the financial implications of such a commitment. On the one hand, these ecosystems are important in terms of the benefits they provide to the local communities, in terms of livelihoods, protecting coastal areas and supporting economic sectors, such as fisheries and tourism. On the other hand, protecting these ecosystems may curtail other activities, such as aquaculture development. The department may also take into consideration global opportunities to position itself as a global leader on blue carbon. Hence, governments will have to undertake the delicate balancing exercise between conservation and development based on a cost-benefit analysis.

From here, the next steps include thinking about whether conserving or restoring blue carbon ecosystems requires a specific policy or whether this is already addressed in other policy documents. The government department may need to engage with other government departments to understand how to implement such a policy. A government department must also think about the financial implications and opportunities this aspiration entails. This may lead to the creation of a new policy document and exploration and development of financing options.

Key resources

At the time of the publication of this report, the author team has collated the latest available resources, tools and scientific literature for easy reference to gain further knowledge about any of the topics discussed. Most of the resources and tools listed below are from 2020 or later.

Table A1. Key resources

CATEGORY	TITLE	DESCRIPTION	URL	SCOPE
Case studies	Community-Led Mangrove Restoration and Conservation in Gazi Bay, Kenya: Lessons from Early Blue Carbon Projects (on-going)	Published in 2020. An overview of an early blue carbon project in Kenya.	https://thecommonwealth.org/case-study/case-study-community-led-mangrove-restoration-and-conservation-gazi-bay-kenya-lessons	Regional (Africa)
Case studies	Lessons from the Restoration of a Mangrove System in Point Lisas, Trinidad and Tobago	Published in 2020. Shares the experience of a restoration project in the vicinity of Point Lisas Industrial Park, initiated in 1999. This example shows that the key success factor for this mangrove restoration project was not the planting but rather the restoration of the hydrology in the area to create the right conditions for natural colonisation and recovery.	https://thecommonwealth.org/case-study/case-study-lessons-restoration-mangrove-system-point-lisas-trinidad-and-tobago	Regional (Caribbean)
Coalitions	The Inventory of Global Blue Carbon Actors	A non-exhaustive list of global and regional organisations working on blue carbon, maintained by the Coordinator Team of the International Partnership for Blue Carbon.	https://bluecarbonpartnership.org/document/ipbc-inventory-of-blue-carbon-actors/	Global
Coalitions	UK Blue Carbon Evidence Partnership	An example of national-level partnership to facilitate coordination and collaboration on blue carbon.	https://www.cefas.co.uk/impact/programmes/uk-blue-carbon-evidence-partnership/	National (United Kingdom)
Markets and finance	A Guide to Private Sector Investment in Coastal Resilience	Published in 2022. Details how private sector actors can mitigate certain types of risk they are facing currently, or will be facing in the near future.	https://climatechampions.unfccc.int/a-guide-to-private-sector-investment-in-coastal-resilience/	Global
Markets and finance	Blue Forest Finance: Financing the Protection and Restoration of Blue Forests and Meadows	Published in 2022. Serves as a primer to explain some of the key concepts and language associated with blue carbon finance, aiming to help practitioners develop partnerships with the private sector.	https://research.csiro.au/iora-blue-carbon-hub/wp-content/uploads/sites/321/2022/11/Blue-forest-finance-guide-FINAL.pdf	Global
Markets and finance	Blue Natural Capital Financing Facility	Provides a range of examples of project finance approaches and relevant knowledge products.	https://bluenaturalcapital.org/	Global
Markets and finance	Criteria for High-Quality Carbon Dioxide Removal	Published in 2022. Provides carbon removal project developers with expert guidance to improve the quality of their projects and their resulting removal credits.	https://www.carbon-direct.com/insights/carbon-direct-and-microsoft-release-2022-update-to-the-criteria-for-high-quality-carbon-dioxide-removal	Global
Markets and finance	Deep Blue: Opportunities for Blue Carbon Finance in Coastal Ecosystems	Published in 2023. Provides an overview of the emerging blue carbon market.	https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/financial+institutions/resources/blue-carbon-finance-in-coastal-ecosystems	Global

Table A1. Key resources (Cont.)

CATEGORY	TITLE	DESCRIPTION	URL	SCOPE
Markets and finance	Finance in Common: Joint Declaration of All Public Development Banks in the World	Published in 2020. Outlines the joint approaches of the global public development banks.	https://financeincommon.org/sites/default/files/2021-06/FiCs%20-%20Joint%20declaration%20of%20Public%20Development%20Banks.pdf	Global
Markets and finance	Financing a Sustainable Ocean Economy	Published in 2021. Identifies key barriers to sustainable ocean economy financing, and suggests solutions to them.	https://www.nature.com/articles/s41467-021-23168-y.pdf	Global
Markets and finance	Financing the Earth's Assets: The Case for Mangroves as a Nature-Based Climate Solution	Published in 2022. Provides investment decision-makers with a business case to invest in mangrove restoration.	https://www.earthsecurity.org/reports/financing-the-earths-assets-the-case-for-mangroves	Global
Markets and finance	Guidance for Financing the Blue Economy, Building on the Green Bond Principles and the Green Loan Principles	Published in 2022. Identifies eligible blue project categories to guide International Finance Corporation investments to support the blue economy, in line with the Green Bond Principles and Green Loan Principles.	https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/financial+institutions/resources/guidelines-for-blue-finance	Global
Markets and finance	Info Brief: Global. REDD+ Safeguards Informational Systems: Moving from Design to Operation	Published in 2020. Provides an overview of the objectives and requirements of a safeguard information system (SIS) and outlines necessary national-level steps to start operationalising the SIS. Also provides links to other critical sources about technical design needs. While this focuses on REDD+, the design of an SIS is relevant for blue carbon and other nature-based projects.	https://www.un-redd.org/sites/default/files/2023-03/InfoBrief_Global_UNREDD_SIS_MovingFromDesignTo%20Operation.pdf	Global
Markets and finance	MDB Engagement: Mainstreaming Blue Nature-Based Solutions into Infrastructure Finance	Published in 2021. Provides case studies to illustrate efforts by different multilateral development banks to transform coastal infrastructure projects through integration of nature-based solutions such as blue carbon.	https://bluenaturalcapital.org/wp2018/wp-content/uploads/2021/05/BNCFF-MDB-FINAL-web.pdf	Global
Markets and finance	Operationalizing Marketable Blue Carbon	Published in 2022. Provides advice on key actions to enhance blue carbon as a natural climate solution.	https://www.sciencedirect.com/science/article/pii/S2590332222002068	Global
Markets and finance	Plan Vivo Standard 5.0	Documents describing the Plan Vivo standard (version 5). This is one of the leading carbon credit standards globally.	https://www.planvivo.org/standard-documents	Global
Markets and finance	Rising Tide: Mapping Ocean Finance for a New Decade	Published in 2021. Describes current trends in lending, underwriting and investment activities for blue carbon ecosystems.	https://www.unepfi.org/wordpress/wp-content/uploads/2021/02/The_Rising_Tide-Mapping_Ocean_Finance_for_a_New_Decade.pdf	Global
Markets and finance	The Sustainable Blue Economy Finance Principles	Published in 2018. The foundational keystone to invest in the ocean economy. Launched in 2018, it is the world's first global guiding framework for banks, insurers and investors to finance a sustainable blue economy.	https://www.unepfi.org/blue-finance/the-principles/	Global

Table A1. Key resources (Cont.)

CATEGORY	TITLE	DESCRIPTION	URL	SCOPE
Markets and finance	TREES: The REDD+ Environmental Excellence Standard	Published in 2021. Architecture for REDD+ Transactions' standard for the quantification, monitoring, reporting and verification of greenhouse gas emission reductions and removals from REDD+ activities at jurisdictional and national scales.	https://www.artredd.org/trees/	Global
Markets and finance	What Makes a High-Quality Carbon Credit?	Published in 2020. High-level starter for current and potential carbon credit buyers.	https://www.worldwildlife.org/publications/what-makes-a-high-quality-carbon-credit	Global
Policy	2013 Supplement to the 2006 IPCC *Guidelines for National Greenhouse Gas Inventories: Wetlands*. Methodological Guidance on Lands with Wet and Drained Soils, and Constructed Wetlands for Wastewater Treatment	Published in 2013. Extends the content of the 2006 IPCC *Guidelines for National Greenhouse Gas Inventories* by filling gaps in the coverage and providing updated information reflecting scientific advances, including updating of emission factors. It covers inland organic soils and wetlands on mineral soils, coastal wetlands including mangroves, seagrass meadows and tidal marshes and constructed wetlands for wastewater treatment. For context, the coverage of the 2006 IPCC *Guidelines* on wetlands was restricted to peatlands drained and managed for peat extraction, conversion to flooded lands, and limited guidance for drained organic soils.	https://www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf	Global
Policy	Article 6: Q&A on what was decided and next steps after COP 26	Published in 2021. Outlines major updates from the UNFCCC Article 6 negotiations around carbon markets following the COP 26 in Glasgow in 2021. Explains the different elements of the negotiations and their implications for implementation. Also provides a brief on how past policy decisions are being considered, such as the Clean Development Mechanism.	https://www.nature.org/content/dam/tnc/nature/en/documents/Article_6_Common_Questions_V2.pdf	Global
Policy	Blue Carbon Policy Assessment Activity	Published in 2018. Provides a template for undertaking an assessment of the policy conditions impacting the health and resilience of coastal blue carbon ecosystems, and identifying pathways to ensure their long-term conservation for climate action.	https://bluecarbonpartnership.org/wp-content/uploads/2020/11/Policy-Assessment-Tool-Final-for-publication-December-2018-IPBC-Full-activity-booklet.pdf	Global
Policy	Coastal Blue Carbon Ecosystems in International Frameworks and Conventions: Overview Report	Published in 2021. Provides an overview of the main international frameworks and conventions that address the conservation, restoration and sustainable use of coastal blue carbon ecosystems.	https://bluecarbonpartnership.org/wp-content/uploads/2021/10/IPBC_Overview-Report-on-Coastal-Blue-Carbon-Ecosystems-in-International-Frameworks-and-Conventions_First_Edition_October_2021.pdf	Global
Policy	Coastal Blue Carbon Ecosystems: Opportunities for Nationally Determined Contributions	Published in 2016. Examines the existing intended nationally determined contributions (INDCs) and ratified nationally determined contributions (NDCs) with regards to the inclusion of specific efforts addressing blue carbon ecosystems as climate mitigation or adaptation solutions.	https://www.unep.org/resources/policy-and-strategy/coastal-blue-carbon-ecosystems-opportunities-nationally-determined	Global

Table A1. Key resources (Cont.)

CATEGORY	TITLE	DESCRIPTION	URL	SCOPE
Policy	Enhancing Nationally Determined Contributions: Opportunities for Ocean-Based Climate Action	Published in 2021. Presents a set of options for ocean-based sectoral mitigation targets, policies or measures for countries to include in new or updated NDCs. Also includes a set of options for ocean-based adaptation measures for those countries that continue to include an adaptation component in their NDCs.	https://files.wri.org/d8/s3fs-public/2021-04/enhancing-nationally-determined-contributions-opportunities-ocean-based-climate-action.pdf?VersionId=zEIY0PuwHyP_zzc7UGjt.QFF4ooK0Vmu	Global
Policy	Guidelines on Enhanced Action: A Guide on How Countries May Include Blue Carbon in Their Nationally Determined Contributions	Published in 2020. Provides guidance to support countries seeking to promote and preserve coastal blue carbon ecosystems as a climate mitigation or adaptation strategy. The resource offers a 'tiered approach' to demonstrate how a variety of motivations and starting points all represent viable pathways for the inclusion of coastal wetlands in NDCs. The guidelines are being updated with a new version due to be released during the summer of 2023.	https://www.thebluecarboninitiative.org/policy-guidance	Global
Policy	National Blue Carbon Policy Assessment Framework: Towards Effective Management of Coastal Carbon Ecosystems	Published in 2016. Provides countries with a five-step assessment framework to apply and develop blue carbon policies. Helps countries to achieve a first-order analysis leading to a more comprehensive and integrated approach to coastal management, with clear answers of whether and when climate- and carbon-related policies and mechanisms make sense for them, and how they can be aligned with existing coastal regulations and policies.	https://www.iucn.org/resources/publication/national-blue-carbon-policy-assessment-framework	Global
Policy	Ocean-Based Climate Action in New and Updated Nationally Determined Contributions	Published in 2022. Analyses ocean-based climate actions in new or updated nationally determined contributions and 'long-term low greenhouse gas emission development strategies' ('long-term strategies' or LTS) from island and coastal states.	https://files.wri.org/d8/s3fs-public/2022-11/ocean-based-climate-action-ndcs.pdf?VersionId=zDTcLITGIc5.sIWS7YyzGFp7YkDLGt3G	Global
Policy	Opportunities for Increasing Ocean Action in Climate Strategies	Published in 2019. Assesses 18 ocean-based measures to support climate policies and the revision of NDCs in the areas of mitigation and adaptation.	https://www.iddri.org/en/publications-and-events/policy-brief/opportunities-increasing-ocean-action-climate-strategies	Global
Policy	The State of the World's Mangroves 2022	Published in 2022. Highlights the latest available science, describes critical policy approaches and on-the-ground actions and stories for and about mangrove conservation and restoration. Was developed by the Global Mangrove Alliance, which aims to catalyse further conservation activities and to unlock new funding opportunities for mangrove restoration. The report also highlights the recently updated Global Mangrove Watch platform and mangrove maps.	https://www.mangrovealliance.org/wp-content/uploads/2022/09/The-State-of-the-Worlds-Mangroves-Report_2022.pdf	Global

Table A1. Key resources (Cont.)

CATEGORY	TITLE	DESCRIPTION	URL	SCOPE
Policy	UNESCO Marine World Heritage: Custodians of the Globe's Blue Carbon Assets	Published in 2021. Responds to the request that the UN Educational, Scientific and Cultural Organization (UNESCO) study the current and potential impacts of climate change on the world heritage properties and to the request to explore UNESCO's strategy for action on climate change. Outlines the areal extent of mangroves, seagrass meadows and tidal marshes in UNESCO World Heritage sites.	https://unesdoc.unesco.org/ark:/48223/pf0000375565	Global
Practitioner general advice	Blue Carbon Manual	Published in 2019. Manual for standardising protocols for producing robust blue carbon data.	https://www.thebluecarboninitiative.org/manual	Global
Practitioner general advice	Climate, Community, and Biodiversity Standards	Certification standard that aims to provide assurance that a given project is delivering tangible climate, community and biodiversity benefits.	https://verra.org/programs/ccbs/	Global
Practitioner general advice	High-Quality Blue Carbon Principles and Guidance: A Triple-Benefit Investment for People, Nature, and Climate	Published in 2022. Provides a consistent and understandable approach to guide the development and management of blue carbon projects that are equitable, fair and credible.	https://merid.org/high-quality-blue-carbon/	Global
Practitioner general advice	Manual for the Creation of Blue Carbon Projects in Europe and the Mediterranean	Published in 2021. Provides knowledge-based guidance for developing project-based interventions using the carbon finance mechanisms to improve seagrass and coastal wetland conditions for climate change mitigation and adaptation. Complementary to this, it can be used for other interventions such as addressing how to robustly quantify blue carbon stocks to identify gains and losses and inform national greenhouse gas inventories.	https://www.iucn.org/resources/file/manual-creation-blue-carbon-projects-europe-and-mediterranean	Europe + Mediterranean
Science	Blue Carbon as a Natural Climate Solution	Published in 2021. Examines the potential for blue carbon ecosystems to act as carbon sinks, and the opportunities to protect or restore ecosystems for this function.	https://www.nature.com/articles/s43017-021-00224-1	Global
Science	Decades of Mangrove Forest Change: What Does It Mean for Nature, People and the Climate?	Published in 2023. Reviews the extent of mangrove forest cover and considers the potential consequences of changes in mangrove extent for more than 1,000 mangrove-associated species. Also analyses the potential consequences of changes in mangrove extent for carbon storage and for small-scale fishers.	https://www.unep.org/resources/report/decades-mangrove-forest-change-what-does-it-mean-nature-people-and-climate	Global
Science	Into the Blue: Securing a Sustainable Future for Kelp Forests	Published in 2023. Provides the most comprehensive knowledge review on kelp to date, revealing the state of science on the world's kelp forests and providing recommended actions to build the recovery of the world's kelp forests.	https://www.unep.org/resources/report/blue-securing-sustainable-future-kelp-forests	Global

Table A1. Key resources (Cont.)

CATEGORY	TITLE	DESCRIPTION	URL	SCOPE
Science	Potential Role of Seaweeds in Climate Change Mitigation	Published in 2023. Provides an overview of the research needs surrounding the potential role of seaweed in climate change mitigation and the current scientific consensus.	https://www.sciencedirect.com/science/article/pii/S0048969723023203	Global
Science	The Future of Blue Carbon Science	Published in 2019. Summarises discussions of leading experts in the field of blue carbon to agree upon the top-10 pending questions in blue carbon science and provide a comprehensive road map for the coming decades of blue carbon research.	https://www.nature.com/articles/s41467-019-11693-w	Global
Science	The Importance of Mangroves to People: A Call to Action	Published in 2014. Synthesis of the importance of mangroves to people.	https://wedocs.unep.org/handle/20.500.11822/9300;jsessionid=230404698C307436196ED12F26B91F36	Global
Science	The Ocean as a Solution to Climate Change: Five Opportunities for Action	Published in 2019. Offers a comprehensive, integrated assessment of the mitigation potential of a suite of ocean-based activities: renewable energy, transport, food production and ecosystems, as well as the potential future contribution from carbon storage. Each of these five areas is assessed for its potential to close the emissions gap in 2030 and 2050 relative to a 1.5°C degree and 2°C degree pathway. Each activity is evaluated for its wider benefits to society (beyond mitigation). Also highlights the enabling policy measures and research required for success.	https://oceanpanel.org/wp-content/uploads/2022/06/HLP_Report_Ocean_Solution_Climate_Change_final.pdf	Global
Science	Towards Responsible and Informed Ocean-Based Carbon Dioxide Removal: Research and Governance Priorities	Published in 2022. Distils the potential scale of carbon dioxide removal, expected costs, risks, co-benefits and areas of research needed for seven ocean carbon dioxide removal (CDR) approaches. Proposes an overall approach centred on informed and responsible development and deployment of ocean CDR that balances the urgency of emission reductions against the environmental and social risks of ocean CDR, including halting development where risks outweigh expected benefits.	https://www.wri.org/research/responsible-informed-ocean-based-carbon-dioxide-removal	Global
Social	Free, Prior and Informed Consent (FPIC): An Indigenous Peoples' Right and a Good Practice for Local Communities	Published in 2016. Provides advice to practitioners on incorporating free, prior and informed consent (FPIC) into project and programme design and implementation, ensuring that Indigenous Peoples' rights are duly respected.	https://www.fao.org/3/i6190e/i6190e.pdf	Global

Table A1. Key resources (Cont.)

CATEGORY	TITLE	DESCRIPTION	URL	SCOPE
Social	Free, Prior and Informed Consent (FPIC): An Indigenous Peoples' Right and a Good Practice for Local Communities (online course)	Focuses on how to practically operationalise the Indigenous Peoples' right to FPIC throughout all stages of the project cycle. The course describes each of the recommended six steps of the process and the related actions to be undertaken.	https://elearning.fao.org/course/view.php?id=500	Global
Social	Ocean Literacy for All: A Toolkit	Published in 2018. Provides educators and learners worldwide with the innovative tools, methods and resources to understand complex ocean processes and functions and alert them to the most urgent ocean issues.	https://unesdoc.unesco.org/ark:/48223/pf0000260721	Global
Social	Study on Consultation and Free, Prior and Informed Consent with Indigenous Peoples in Africa	Published in 2022. Provides an analysis of the implementation in Africa of international human rights related to Indigenous Peoples and free, prior and informed consent, and provides recommendations for FPIC's implementation in Africa.	https://www.iwgia.org/en/resources/publications/4976-study-consultation-free-prior-informed-consent-indigenous-peoples-africa.html	Regional (Africa)

Glossary

additionality In the context of carbon credits, demonstration that greenhouse gas reductions would not have occurred in the absence of a carbon market.

blended finance The use of public sources of capital to attract private investment.

carbon credit Unit of trade for the carbon market. One credit is equal to one tonne CO_2e of avoided, reduced or removed emissions ('emission reduction').

ecosystem-based adaptation The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change

gigatonne billion metric tonnes

impact investor Investor with the aim of generating positive social and environmental impact alongside a financial return.

Indigenous People Earliest known inhabitants of an area.

nature-based solutions actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits

natural climate solutions conservation, restoration and improved land management actions that increase carbon storage and/or avoid greenhouse gas emissions across global forests, wetlands, grasslands and agricultural lands

permanence The condition of greenhouse gases being removed from the atmosphere for long periods of time, with 100 years often being used.

30x30 30x30 is a campaign to protect 30 percent of the global land and sea areas by 2030. The Convention on Biological Diversity Kunming-Montreal Global Biodiversity Framework's Target 3 refers to 30x30 by aiming to conserve 30% of the world's lands, inland waters, coastal areas and oceans by 2030. Please see exact language in annex.

Abbreviations

BCAF	Blue Carbon Accelerator Fund
BCI	Blue Carbon Initiative
BNCAC	blue natural capital asset company
BNCFF	Blue Natural Capital Financing Facility
BTR	biennial transparency report
CBC	Commonwealth Blue Charter
CBD	Convention on Biological Diversity
CDR	carbon dioxide removal
CER	certified emission reduction
COP	Conference of the Parties
CO2e	carbon dioxide equivalent
DRR	disaster risk reduction
FAO	Food and Agriculture Organization of the United Nations
FPIC	free, prior and informed consent
GDP	gross domestic product
GHG	greenhouse gas
GMA	Global Mangrove Alliance
GO-BC	Global Ocean Decade Programme for Blue Carbon
IOC-UNESCO	Intergovernmental Oceanographic Commission of the UN Educational, Scientific and Cultural Organization
IORA	Indian Ocean Rim Association
IPBC	International Partnership for Blue Carbon
IPCC	Intergovernmental Panel on Climate Change
IPLC	Indigenous People and local communities
IUCN	International Union for Conservation of Nature
LEAF	Lowering Emissions by Accelerating Forest Finance Coalition
LTS	long-term strategy
LULUCF	land use, land-use change and forestry
MPA	marine protected area
NbS	nature-based solution
NBSAP	national biodiversity strategy and action plan
NCS	natural climate solution
NDC	nationally determined contribution
OECM	other effective area-based conserva tion measure
PA	Paris Agreement
PES	payment for ecosystem services
PPP	public-private partnership
REDD+	Reducing Emissions from Defor estation and Forest Degradation (including the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks)
SDG	Sustainable Development Goal
SIS	safeguard information system
SOP	sustainable ocean plan
UNEP	UN Environment Programme
UNESCO	UN Educational, Scientific and Cultural Organization
UNFCCC	UN Framework Convention on Climate Change
VCM	voluntary carbon market

Endnotes

1. Kelp and seaweed (macroalgae) are also coastal vegetation, containing carbon and having many ecosystem roles similar to those of mangroves, seagrass meadows and tidal marshes (see Box 1). However, understanding of the role of kelp and seaweed in carbon sequestration is less developed. They appear to rely on the transport of material to areas with sediments, which is challenging to account for and track. Greenhouse gases cannot currently be mitigated through kelp and seaweed carbon sequestration to the same extent as through other blue carbon ecosystems.

2. Sustainable ocean plans were first advanced by the High Level Panel for a Sustainable Ocean Economy (Ocean Panel) in 2019 as part of its headline commitment to achieve 100 percent sustainable management of member countries' ocean area under their national jurisdictions, guided by SOPs, by 2025. As part of this call to action, the Ocean Panel (2021) has also encouraged all coastal and ocean states to join in this process.

3. Mangroves can be included as part of a REDD+ project or program based on if these coastal ecosystems are considered forests in the national context, which can be determined through the country's national forest definition.

4. An SIS is a tool to monitor and evaluate the potential social and environmental impacts of government policies and programs for jurisdictional REDD+.

5. Based on current price assumptions of US$5-$9.4 per tonne of carbon dioxide equivalent (tCO_2e) (Zeng et al. 2021), noting that in the most recent 2023 IFC report blue carbon credit prices are anticipated to range from US$11–$35 per tCO_2e (IFC 2023).

6. 'The Clean Development Mechanism, defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets' (UNFCCC n.d.).

7. For example, in May 2023, the Pakistani government authorised its Delta Blue Carbon Project—restoration of 600,000 hectares of mangroves in the Indus River Delta—to sell carbon credits in the international carbon market. Authorisation here means that Pakistan will not use the emission reductions from mangrove restoration towards its NDC target to ensure no double counting (Pollination Group n.d.).

8. These are the 350,000 hectare 'Delta Blue' mangrove afforestation, reforestation and revegetation, and wetland restoration and conservation project in Pakistan; a much smaller REDD+ mangrove project, Vida Manglar, located in Colombia's Gulf of Morrosquillo; and projects located in Mexico, Brazil, Colombia, Mozambique and China.

9. Based on information of the number of project submissions received by the IUCN, based on the blue carbon credit call for proposals from the Blue Accelerator Fund (BCAF), managed by the Blue Natural Capital Financing Facility (BNCFF).

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The Blue Carbon Initiative was established in 2010 to accelerate the recognition of the importance of coastal and marine ecosystems for climate change mitigation and facilitate the integration of science and policy such that efforts to mitigate climate change are science-driven and include conservation, restoration, and sustainable use of coastal and marine ecosystems. It is coordinated by Conservation International (CI), the International Union for Conservation of Nature (IUCN), and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization (IOC– UNESCO). The BCI advances blue carbon science through syntheses and methodological guidance to facilitate development and implementation of climate-relevant policy, management and, more broadly, climate change actions at the local, national, and international levels.

The International Partnership for Blue Carbon (IPBC) is a global network of government agencies, non-governmental organizations, intergovernmental organizations and research institutions that share a vision that all global coastal blue carbon ecosystems (mangroves, tidal marshes and seagrasses) are protected, sustainably managed or restored – contributing to climate change mitigation, adaptation, biodiversity, ocean economies and livelihoods of coastal communities. The Partnership provides an open forum for Partners to connect, share and collaborate to build solutions, take actions, and benefit from the experience and expertise of the global community. The Partnership was launched at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties in Paris in 2015 (COP21) by nine founding Partners, and has since expanded to over fifty Partners in 2023. The Partnership is coordinated by Australia with the support of IOC-UNESCO.

the BLUE CARBON initiative

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