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REPORT

Investing in Resilience:

Blue Carbon Ecosystems, Communities, and Finance for the Indo-Pacific

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Investing in Resilience: Blue Carbon Ecosystems, Communities, and Finance for the Indo-Pacific

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Acronyms & Abbreviations

ADB	Asian Development Bank
BBNJ	Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction
CCP	Core Carbon Principles
CDP	Carbon Disclosure Project
CIF	Climate Investment Funds
CIFOR	Center for International Forestry Research
CTF	Clean Technology Fund
DNS	Debt-for-Nature Swap
DRR	Disaster Risk Reduction
EEZ	Exclusive Economic Zone
ENSO	El Niño Southern Oscillation
ERP	Emissions Reduction Program
ESG	Environmental, Social, and Governance
EU	European Union
FAD	Fish Aggregating Device
FFA	Forum Fisheries Agency
FSM	Federated States of Micronesia
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GESI	Gender Equity and Social Inclusion
GSSI	Global Sustainable Seafood Initiative
ICMA	International Capital Market Association
ICVCM	Integrity Council for the Voluntary Carbon Market
IOCC	Island-Ocean Connection Challenge
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IUU	Illegal, Unreported, and Unregulated
IUCN	International Union for the Conservation of Nature
LMMA	Locally-Managed Marine Area
MDB	Multilateral Development Bank
MPA	Marine Protected Area
MRV	Measuring, Reporting, and Verification
NAP	National Adaptation Plan
NCS	Natural Climate Solutions
NDC	Nationally Determined Contribution
NGFS	Network for Greening the Financial System
NGO	Non-Governmental Organization
PBAF	Partnership for Biodiversity Accounting Financials

PCAF	Partnership for Carbon Accounting Financials
PNA	Parties to the Nauru Agreement
PNG	Papua New Guinea
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RMI	Republic of the Marshall Islands
RSPO	Roundtable on Sustainable Palm Oil
SBTi	Science Based Targets Initiative
SCF	Strategic Climate Fund
SDGs	Sustainable Development Goals
SFDR	Sustainable Financial Disclosure Regulation
SIDS	Small Island Developing States
SWAMP	Sustainable Wetlands Adaptation and Mitigation Program
TCFD	Taskforce on Climate-related Financial Disclosures
TNFD	Taskforce on Nature-related Financial Disclosures
TTF	Tuvalu Trust Fund
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP FI	United Nations Environment Programme Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USFS	United States Forest Service
VCM	Voluntary Carbon Market
VCS	Verified Carbon Standard
WCPFC	Western and Central Pacific Fisheries Commission
WCS	Wildlife Conservation Society
WRI	World Resources Institute
WWF	World Wildlife Fund

Key Terms

Blue carbon ecosystems are pelagic and coastal ecosystems that remove carbon dioxide from the air and store it as organic carbon in soil, and plant and animal biomass. Long-term removal of carbon dioxide and storage of organic carbon by natural processes can help reduce the impact of climate change.

Blue carbon losses are reductions in biomass production, storage, or sequestration. These losses are typically caused by human activity, such as coastal development and overfishing, or by climate change.

Blue carbon solutions are management interventions, policies, and financing to protect, sustainably manage, or restore blue carbon ecosystems.

Externalities are positive or negative consequences from an economic activity that are not paid for directly in the financial cost of a transaction.

Financial exclusion refers to individuals and populations without access to bank accounts and other financial services.

Financial risk is the possibility of losing money in an investment, business or project. This is different from definitions of risk based on the likelihood of a particular event occurring under a specified set of circumstances

Food security is the physical, social, and economic ability to access sufficient, safe and nutritious food (Charlton et al. 2016).

Financialization refers to the size and importance of the financial sector relative to the size of a country's overall economy.

Greenwashing is making misrepresentative or misleading statements about the environmental benefits of a project or investment. It does not have to be intentional.

Investable or bankable are terms used to describe the likelihood that a project will make money and achieve a profit.

Nature-based solutions are actions that protect, manage, and restore ecosystems (including managed systems such as agricultural lands) that address societal challenges effectively and adaptively (USAID Climate Strategy 2022–2030).

Resilience is the ability of people, households, communities, countries, and systems to mitigate, adapt to, and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth (USAID 2012 Resilience Policy).

Sustainable finance takes into account environmental, social, and governance (ESG) considerations in investment decisions in the financial sector, leading to an increase in longer-term investments in sustainable economic activities and projects.

Executive Summary

USAID's "Investing in Resilience" report brings together the evidence and analyses that can help guide USAID Mission staff, partners, host country governments, and communities to advance local, regional, national, and international blue carbon initiatives in the Indo-Pacific region. In this report, "Indo-Pacific region" refers to Indonesia and the Philippines, the Federated States of Micronesia (FSM), Fiji, Kiribati, Nauru, Palau, Papua New Guinea (PNG), the Republic of the Marshall Islands (RMI), Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

"Blue carbon" refers to carbon stored by coastal and marine ecosystems, such as mangroves, seagrass beds, coastal wetlands and marshes, tidal flats, and by marine organisms themselves, especially fish and other large animals. Human activity and climate change impacts are damaging and destroying blue carbon ecosystems throughout the region, with adverse consequences for Indo-Pacific communities whose livelihoods, economies, cultures, and well-being depend on them. Scaling up the protection and sustainable management of Indo-Pacific blue carbon ecosystems presents opportunities to build on lessons learned from land-based carbon initiatives and to deploy innovative finance mechanisms.

Through literature review and discussions with experts in the Indo-Pacific region, this report analyzes blue carbon trends in the Indo-Pacific, examines risks and potential solutions for communities that depend on blue carbon ecosystems, reviews relevant finance opportunities, and summarizes information gaps and recommended actions. Throughout the report, case studies from the Indo-Pacific showcase proven approaches to conservation and restoration of blue carbon ecosystems.

Indo-Pacific Blue Carbon Trend Analysis

Coastal and marine ecosystems contribute significantly to global climate change mitigation. This analysis determined that carbon sequestered by mangroves, seagrasses, and tuna in the Indo-Pacific account for an estimated 31.2 million metric tons of carbon dioxide equivalent (tCO_2e)[1] each year—roughly matching the emissions from 6.94 million cars driven in one year, which is more than the total number of cars and trucks registered in the Philippines. This estimate is expected to increase with additional seagrass mapping and the inclusion of more fish and shark species.

This report includes estimates of carbon sequestration in Indo-Pacific mangroves and seagrasses, which are the blue carbon ecosystems most recognized for their carbon sequestration potential. Of coastal and marine

[1] Carbon dioxide equivalent, or CO_2e, means the number of metric tons of CO_2 emissions with the same global warming potential as one metric ton of another greenhouse gas.

ecosystems, mangroves sequester the most carbon-per-unit area compared to terrestrial forests, despite extensive losses due to unsustainable practices. Seagrasses are also important to carbon sequestration, particularly given their broad distribution in Pacific island countries (Brodie et al. 2020). When grown together, seagrasses and mangroves sequester even more carbon, trapping more sediment than they would in isolation (Mishra et al. 2023; Huxham et al. 2018). This report also estimates fish transport of carbon to deep ocean sediments, focusing on tuna, the large marine vertebrates for which population sizes, location, and climate-driven migrations are most well documented. Tuna are critical components of Indo-Pacific economies, especially for small island developing states (SIDS). Tuna in the Indo-Pacific sequester an estimated 1.4 million tCO_2e/year in the form of carcasses and 1.1 million tCO_2e/year in the form of waste pellets. This is counterbalanced by tuna removal by industrial fishing for a net carbon sequestration by Pacific tuna of ~1.9 million tCO_2e/year. (See Appendix A for detailed methodology.)

Climate change is altering patterns of sea surface temperature and ocean productivity and causing tuna in the Pacific to migrate eastward, and in some cases northward, into international waters beyond the reach of monitoring and controls intended to maintain their populations. The exodus of tuna from countries' exclusive economic zones (EEZs) has important implications for Indo-Pacific economies that are highly dependent on tuna, such as Kiribati, Tuvalu, RMI, FSM, Nauru, and other SIDS. Projected declines in tuna catch could have significant impacts on these countries' gross domestic products (GDPs) and on local livelihoods.

PHOTO BY JONAS GRATZER

Blue Carbon Ecosystems and Communities

The degradation and loss of blue carbon ecosystems poses serious risks—economic, social and cultural, and food security and nutrition—to communities that depend on these ecosystems. Climate change impacts, such as sea level rise, warming waters, ocean acidification, and increasing frequency and intensity of storms, floods, and droughts exacerbate these risks.

Declines in blue carbon ecosystems increase coastal communities' and structures' exposure to storms and storm surges, threaten infrastructure and operations, and affect the viability of pelagic and coastal fisheries that support Indo-Pacific food security and economies. The diverse peoples and cultures of the Indo-Pacific region link their biocultural heritage and identity with the blue carbon ecosystems that define their environment. These ecosystem losses threaten ways of life and the transfer of traditional ecological knowledge. Indo-Pacific communities, especially low-income and rural households, are highly dependent on blue carbon ecosystems for subsistence and food security. Women, girls, and Indigenous Peoples experience disproportionate impacts of blue carbon ecosystem losses because their livelihoods are so closely tied to local blue carbon ecosystems, and they traditionally have less access to resources for adaptation. Declines in the availability of food sources, through direct habitat loss and overfishing of declining populations, pose significant threats to these communities.

However, many communities are taking action to address these risks to their livelihoods and identities. Through indigenous knowledge and solutions, other nature-based solutions, policy and planning, technologies, capacity building, and integrated approaches that combine these solutions, communities are designing and implementing locally-led actions to protect the vital benefits blue carbon resources provide.

Blue Carbon Finance Assessment

Interest in blue carbon finance is growing, and governments, financial institutions, and other public and private entities are seeking out innovative finance mechanisms to deliver economic, ecological, and social co-benefits. In parallel, global trends in sustainable finance are encouraging public and private entities to invest in nature-based climate solutions and integrate environmental and social safeguards into their investments. New guidance and institutional support, such as the United States Agency for International Development (USAID) supported Taskforce on Nature-related Financial Disclosures (TNFD), are emerging to facilitate the transition to sustainable investments.

Despite data and information gaps and capacity needs, Indo-Pacific governments and investors have opportunities to leverage voluntary carbon markets, national and global climate funds, blended finance, and instruments such as blue bonds[2] and/or debt-for-nature swaps to finance blue carbon nature-based solutions. As blue carbon investments become more mainstream, lessons from land-based carbon finance can help strengthen safeguards, avoid unintended consequences, and improve the accuracy and quality of monitoring, reporting, and verification (MRV) of a project's carbon sequestration and emissions reductions.

Next Steps

This report also describes data and information gaps that future work could address. For example, there is still a need for additional baseline analysis of Indo-Pacific blue carbon ecosystems and their sequestration capacity, especially for seagrass. This research enables quantification and monetization of blue carbon benefits and financial analysis of potential investments. It will be important to develop and test methods and financial mechanisms to improve the measurement of blue carbon projects' livelihood and equity impacts to help ensure that projects align with local needs.

Decision-makers in the public and private sectors, and from communities, can take meaningful actions now to scale up investments that protect blue carbon ecosystems and the communities that depend on them, by:

1. Protecting community rights,
2. Increasing readiness to access blue carbon finance,
3. Strengthening potential investors' capacity to develop and manage blue carbon finance mechanisms, and
4. Building environmental and social safeguards into blue carbon finance.

[2] Blue bonds are a type of debt that companies and sovereigns can use to finance the restoration and maintenance of marine ecosystems and aggregate small projects for funding.

PHOTO BY KEITH BETTINGER

Indo-Pacific Blue Carbon Ecosystems

Blue carbon ecosystems are ocean and coastal ecosystems that absorb carbon dioxide (CO_2) from the atmosphere, store it as organic carbon in living biomass (i.e., plants, microorganisms, and animals), and ultimately, sequester it in sediments. Blue carbon ecosystems include mangroves, seagrass beds, coastal wetlands and marshes, and tidal flats (Bertram et al. 2021). Marine animals, especially fish and other large vertebrates, also store carbon in their biomass and contribute to carbon sequestration in ocean sediments through their waste and carcasses that fall to the ocean floor, known as deadfall (Cavan and Hill 2022). The carbon stored by these coastal and marine ecosystems and organisms is collectively known as "blue carbon."

Blue carbon ecosystems sustain the economies, biodiversity, people, and cultures of the Indo-Pacific region, which, in this report, includes Indonesia and the Philippines, the Federated States of Micronesia (FSM), Fiji, Kiribati, Nauru, Palau, Papua New Guinea (PNG), Republic of the Marshall Islands (RMI), Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. In addition to sequestering carbon and contributing to climate change mitigation, blue carbon ecosystems provide the natural resources that support fisheries, tourism, and coastal and marine livelihoods. They provide natural buffers that protect coastal communities from climate-related impacts and play an important role in communities' adaptation to the increasing frequency and intensity of storms, floods, extreme heat, and droughts. These ecosystems also provide habitats for culturally significant species, support traditional activities, create a sense of place, and sustain livelihood strategies for diverse communities and cultures across the Indo-Pacific region.

Blue Carbon Ecosystems Are Declining

Human activity and climate change are threatening ecologically, economically, and culturally important blue carbon ecosystems throughout the Indo-Pacific region. Seagrass is in decline in much of Southeast Asia, where recent research found declines in more than 60 percent of study sites from 2000–2020 (Sudo et al. 2021). Although seagrass ecosystems are stable in some Pacific island countries (McKenzie et al. 2021a), human activity may place up to 35 percent of seagrasses at risk over the next century (Brodie 2018). Southeast Asia is home to 36 percent of the world's mangroves and has experienced widespread deforestation, driven by expanding shrimp aquaculture, palm oil plantations, and other land uses (Gandhi and Jones 2019). These losses have cascading effects on the fish populations that currently make the Indo-Pacific the world leader in seafood consumption and exports.

At the same time, climate change is increasing sea surface temperatures, ocean acidification, sea levels, and the frequency and intensity of storms—all of which degrade the health of coastal and marine species, habitats, and ecosystems. Although Pacific tuna fisheries are well-managed, climate impacts on fisheries could lead to average losses of $90 million in annual fishing access fees for Pacific island countries, as tuna migrate away from warming waters (Bell et al. 2021). Without more proactive investment and governance to protect blue carbon ecosystems, the potential loss of economically and culturally important species will continue to accelerate and adversely impact the nations and communities that rely on them.

Indo-Pacific Communities are at Risk…And Taking Action

The degradation and loss of blue carbon ecosystems compound climate risks to communities across the Indo-Pacific and impose disproportionate impacts on women, girls, Indigenous Peoples, people with disabilities, and other marginalized groups. These groups have less access to information and resources to adapt their livelihood strategies, they are often excluded from decision-making processes, and their livelihood activities are often undervalued or overlooked in standard economic and market analyses. However, these groups and other members of coastal communities have the traditional ecological knowledge and specialized skills to effect blue carbon solutions and their economic benefits, while protecting these ecosystems through restoration, conservation, and other climate risk management actions and capacity-building measures.

Restoring and protecting blue carbon ecosystems and their many benefits requires a diverse suite of solutions. Both indigenous knowledge and scientific research have provided the basis for many existing locally-led solutions, such as integrated land-sea food production systems and marine area management systems. The integration of indigenous knowledge with modern science informs additional strategies, such as nature-based solutions, policy and zoning strategies, benefits-sharing schemes, technological solutions, and integrated watershed management systems. Building local, national, regional, and international capacity to manage blue carbon ecosystems for multiple goals can help sustain equitable blue carbon co-benefits in the long term. Engaging and empowering local communities to lead the development and implementation of blue carbon solutions is critical to avoiding maladaptation and other unintended consequences, such as increasing gender and social inequities, breaking down traditional land tenure systems, or limiting access to natural resources and livelihood strategies.

PHOTO BY USAID

Financing Blue Carbon Solutions

Multiple financing strategies and mechanisms exist for prospective blue carbon projects. For example, implementing nature-based solutions to protect blue carbon ecosystems can deliver considerable climate change mitigation benefits, which can be monetized and generate returns for impact finance investors.

Voluntary carbon markets, while still facing challenges related to accuracy, verification, and equity, continue to provide investment opportunities for climate action. Some countries have developed national climate funds to channel domestic and international financing for climate mitigation and adaptation measures; these funds can help support blue carbon initiatives that align with national climate goals, Nationally Determined Contributions (NDCs), and National Adaptation Plans (NAPs). Global climate funds—such as the Global Environmental Facility (GEF), Green Climate Fund (GCF), and Climate Investment Funds (CIF)—provide large amounts of financing to develop countries' climate adaptation and transitions to clean energy systems, although securing this funding involves rigorous proposal and evaluation processes. Blue bonds are a relatively new mechanism that enables countries to finance blue carbon and blue carbon ecosystem restoration, protection, and management. Debt-for-nature swaps allow countries or other entities to restructure their sovereign or commercial debt obligations by linking them to the protection of natural resources. Land-based carbon finance offers lessons learned and good practices to design, implement, and adaptively manage these relatively new blue carbon financing opportunities.

Scaling up these or other financing strategies is one of the most immediate challenges to sustaining Indo-Pacific blue carbon ecosystems and their diverse benefits. Addressing the current financing gap requires policy makers and communities to tackle multiple barriers. More robust data and information about prospective blue carbon investments (e.g., the quantification of co-benefits, detailed cost estimates, risk analyses, and cash flow forecasts) is necessary to secure financing, which can be a challenge for countries or communities with limited resources and a lack of historical business cases for blue carbon investments. In addition, many financial institutions lack experience and capacity in analyzing and facilitating climate and carbon investments and their diverse co-benefits. The small geographic scale of individual blue carbon projects in the Indo-Pacific also makes it difficult to attract financing without coordination and aggregation of multiple initiatives. Finally, a strong enabling environment is important to reduce risk, perceived risk, and uncertainty about blue carbon investments. Public institutions and private sector entities should have the appropriate policy, regulatory, and legal structures in place to enable public-private partnerships and to receive and manage blue carbon finance through a variety of mechanisms. Blue carbon project managers must also comply with financial crime policies and human rights protection laws.

USAID's Role in Advancing Indo-Pacific Blue Carbon Solutions

Blue carbon ecosystems provide the foundation for many economic development opportunities in the Indo-Pacific region, and the pace of blue carbon ecosystem losses demands action. By investing in the study and protection of these ecosystems, USAID aims to advance global understanding of blue carbon, while also working toward the goals of the Indo-Pacific Strategy. USAID's broader goals in the region include building resilience in the Pacific islands, developing trade approaches that meet high labor and environmental standards, advancing resilient supply chains, investing in decarbonization, and reducing regional vulnerability to the impacts of climate change and environmental degradation.

In addition to strengthening programming in the Indo-Pacific region, USAID's blue carbon work will contribute to agency-wide goals in its Climate Strategy, Biodiversity Policy, Policy on Promoting the Rights of Indigenous Peoples, and the Gender Equality and Women's Empowerment Policy. The diverse suite of options to restore, protect, and sustainably manage blue carbon ecosystems has the potential to leverage the embedded principles and achieve intermediate results in USAID's Climate Strategy Framework. Finally, USAID aims to increase equity for women, girls, and gender-diverse individuals by better accounting for their livelihood activities and reliance on blue carbon ecosystems; increasing access to the information and resources necessary to adapt to climate change impacts on their livelihoods and well-being; helping to prevent and respond to gender-based violence driven by climate and economic shocks; and helping to shift cultural norms that undervalue their contributions to their families and communities.

The goal of this report is to contribute to the evidence base and analyses that USAID Mission staff, partners, host country governments, and communities need to advance local, regional, national, and international blue carbon initiatives. In conjunction with this report, USAID is developing individual country-level blue carbon profiles for the countries considered in this analysis. To supplement regional estimates provided in the report, the profiles highlight the most extensive blue carbon ecosystems in each country, as well as specific knowledge gaps, risks, and opportunities.

This report contains the following chapters:

1. **Indo-Pacific Blue Carbon Trend Analysis** examines blue carbon ecosystem trends and quantifies carbon sequestration potential, with detailed methods in Appendix A;
2. **Blue Carbon Ecosystems and Communities—Risk and Solutions** describes risks to communities that depend on blue carbon ecosystems and highlights diverse locally-led blue carbon solutions;
3. **Blue Carbon Finance Assessment** describes challenges, opportunities, and mechanisms for scaling up blue carbon financing, and provides lessons learned from land-based carbon initiatives; and
4. **Next Steps** highlights blue carbon information gaps and describes opportunities and actions to advance blue carbon initiatives and align international, regional, and national priorities with local values and interests.

Blue carbon success stories appear throughout the report to showcase innovative blue carbon management in the Indo-Pacific. This report also includes additional data and resources in appendices:

- **A** **Appendix A. Pacific Blue Carbon Storage and Sequestration Estimates** accompanies the Indo-Pacific Blue Carbon Trend Analysis and provides more detailed data and methodology for the carbon sequestration estimates presented in the chapter.
- **B** **Appendix B. Case Studies** includes brief success stories of countries' and communities' blue carbon actions.
- **C** **Appendix C. Finance Primer** accompanies the Blue Carbon Finance Assessment and provides an overview of financial concepts, terms, and products relevant to scaling blue carbon finance and mainstreaming climate and conservation transactions.

CHAPTER 1

Indo-Pacific Blue Carbon Trend Analysis

PHOTO BY USAID

Coastal ecosystems in Indo-Pacific island and archipelagic countries contribute to the net draw-down of CO_2, addressing global climate change while sustaining communities. In these regions, mangrove forests, seagrass meadows, and fish populations represent large carbon pools, and the amount of carbon that some Pacific island countries' coastal ecosystems sequester is greater than their total national-level emissions.

The amount of carbon sequestered by the coastal ecosystems of some Pacific island countries is greater than their total national-level emissions. (See Appendix A for detailed methods.)

Both mangrove forests and seagrass meadows are present in all the countries reviewed below, although countries with less terrestrial surface area tend to have proportionately less carbon sequestration by these ecosystems. In contrast, tuna is equally or more abundant in the SIDs, which are known for their productive ocean territories and EEZs that are larger compared to their land area.

Indonesia has the highest mangrove cover in the world (Arifanti et al. 2021), within an extensive reservoir of blue carbon that reaches across the Philippines, PNG, the Solomon Islands, and Fiji. Mangroves also provide a significant proportion of blue carbon in Palau, Vanuatu, and Tonga. Across the region, mangroves surround smaller islands and line major rivers where they meet the sea, providing important disaster risk reduction (DRR) and economic and cultural benefits to communities (see Chapter 2 below). Mangrove forests also generate their own soil that builds up the islands they live on and contribute more natural carbon sequestration per area than any other source in the region, while also providing food, fuel, and shelter for nearby communities. In the Indo-Pacific, these rapidly-growing trees may even slow the effect of sea level rise where the forests are kept intact (until 2030 to 2050 for different scenarios of climate change) and slow the impacts of damming of rivers and groundwater extraction (Lovelock et al. 2015; Saintilan et al. 2020). Moreover, based on geologic records, mangroves can tolerate rising sea levels of up to six mm per year, which is greater than the current rate of sea level rise in Indonesia of approximately four mm per year (Triana and Wahyudi, 2020). Indonesia has suffered the greatest global loss of mangrove forest due to deforestation, agriculture, aquaculture, and other human activities, with similar trends in the Philippines and other countries. This is not simply an issue of ecosystem degradation; it is also one of shrinking territory. However, in some cases mangroves can also drive sediment accumulation, which helps buffer against sea level rise in Palau and FSM (Mackenzie et al., 2016, Buffington et al. 2021).

Seagrass ecosystems perform similar roles as mangroves on a smaller scale, although they generally receive less attention because the soil stabilization, carbon sequestration, and fish habitat they provide is underwater, and therefore harder to see. Yet, the same five countries that boast more extensive mangrove forests (Indonesia, Philippines, PNG, Fiji, and Solomon Islands) are also surrounded by large seagrass meadows. Adjacent seagrass and mangrove ecosystems trap more sediment and sequester more carbon than either ecosystem growing on its own (Mishra et al. 2023; Huxham et al. 2018). The most populated islands within the archipelagos of Palau, FSM, and Kiribati are also surrounded by seagrass meadows, which line the shoreline inside coral reef lagoons, benefitting low-income fisherfolk and women (see Chapter 2 for more information). Seagrasses in Samoa make significant contributions to blue carbon at a national level.

Tuna and the open water carbon cycle are the largest blue carbon pools for countries with less surface area of mangroves and seagrasses, including RMI, Kiribati, FSM, Tuvalu, Nauru, Tonga, Vanuatu, and Palau. Marine animals, like fish, can respond to climate change by migrating to more productive waters, taking with them the carbon that they store. Wherever they go, they deposit sediment in the form of waste or carcasses. Understanding where climate change may drive the migration of fish is an important consideration for Indo-Pacific communities and blue carbon investors alike (see Chapter 2 and Appendix A).

The Indo-Pacific is a Global Powerhouse for Carbon Capture in the Ocean

This report highlights the global prominence of the Indo-Pacific in the drawdown of carbon by ocean ecosystems, including Indonesia and the Philippines, FSM, Fiji, Kiribati, Nauru, Palau, PNG, RMI, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. The natural capital of these island and archipelagic nations is concentrated in the ocean—in the mangrove forests, wetlands, tidal flats, seagrass meadows, and abundant schools of fish that surround them.


PHOTO BY KEITH BETTINGER

Ocean ecosystems absorb large amounts of CO_2 from the atmosphere and store the resulting carbon in biomass and sediment, while also providing economically important natural resources and supporting livelihoods. This analysis focuses narrowly on the burial of organic matter in the sediment by blue carbon ecosystems, which in the Indo-Pacific region accounts for an estimated 31.2 million metric tons of CO_2 equivalent each year (tCO_2e/yr). This represents a small but significant percentage of the global accumulation of carbon in ocean water and sediments that mitigates the equivalent of 25 percent of anthropogenic CO_2 emissions each year as of 2020 (DeVries 2022). Beneath the open ocean, the organic carbon sequestered in seafloor sediments remains there for decades to millennia, as long as it is not disturbed by human activity (DeVries 2022; Atwood et al. 2015).

Sediment trapped by mangroves and seagrasses in the Indo-Pacific also has important local effects on shoreline stability and food production in these ecosystems. If protected and restored, mangroves in the Indo-Pacific region have the potential to draw down ~24 million tCO_2e every single year. Seagrasses in this region have the potential to draw down an additional ~4.8 million tCO_2e annually. Healthy Indo-Pacific fish populations not only sustain the world's largest tuna fishery, but they also have the potential to draw down more than two million tCO_2e annually from tuna waste and deadfall alone.

However, human activity is threatening the ecological, social, economic, and carbon benefits of these ocean ecosystems throughout the region. Three-quarters of global net losses in coastal mangrove forests and tidal wetlands from 1999 to 2019 took place in Asia (Murray et al. 2022). More than 60 percent of seagrass meadows in Southeast Asia have declined due to human activity since 2000, and in Pacific island countries, human activity is projected to drive losses of up to 35 percent of seagrass meadows over the next century (Brodie and N'Yeurt 2018; Sudo 2021). At the same time, climate change is increasing sea surface temperatures, ocean acidification, sea levels, and the frequency and intensity of storms—all of which degrade the health and overall resilience of ocean ecosystems.

This chapter summarizes the scale, threats, and opportunities for the conservation of ocean carbon sequestration in the Indo-Pacific. Mangroves are the most well-established in terms of mapping and analysis of carbon sequestration, particularly in Indonesia, which has the world's largest expanse of these tidal forests. In Indonesia, recognition of the contribution of mangroves to DRR and to livelihoods, like shrimp farming, has facilitated large-scale investment in restoration. Conversely, seagrass meadows are just as extensive, but have a largely untapped potential for mapping, analysis, and investment in future projects. Finally, although there has been extensive research on commercially valuable fish species, there is less analysis of the role of these marine animals in carbon drawdown. Each of these three ecosystems offers near-term research, management, and policy opportunities to enhance carbon sequestration in the Indo-Pacific.

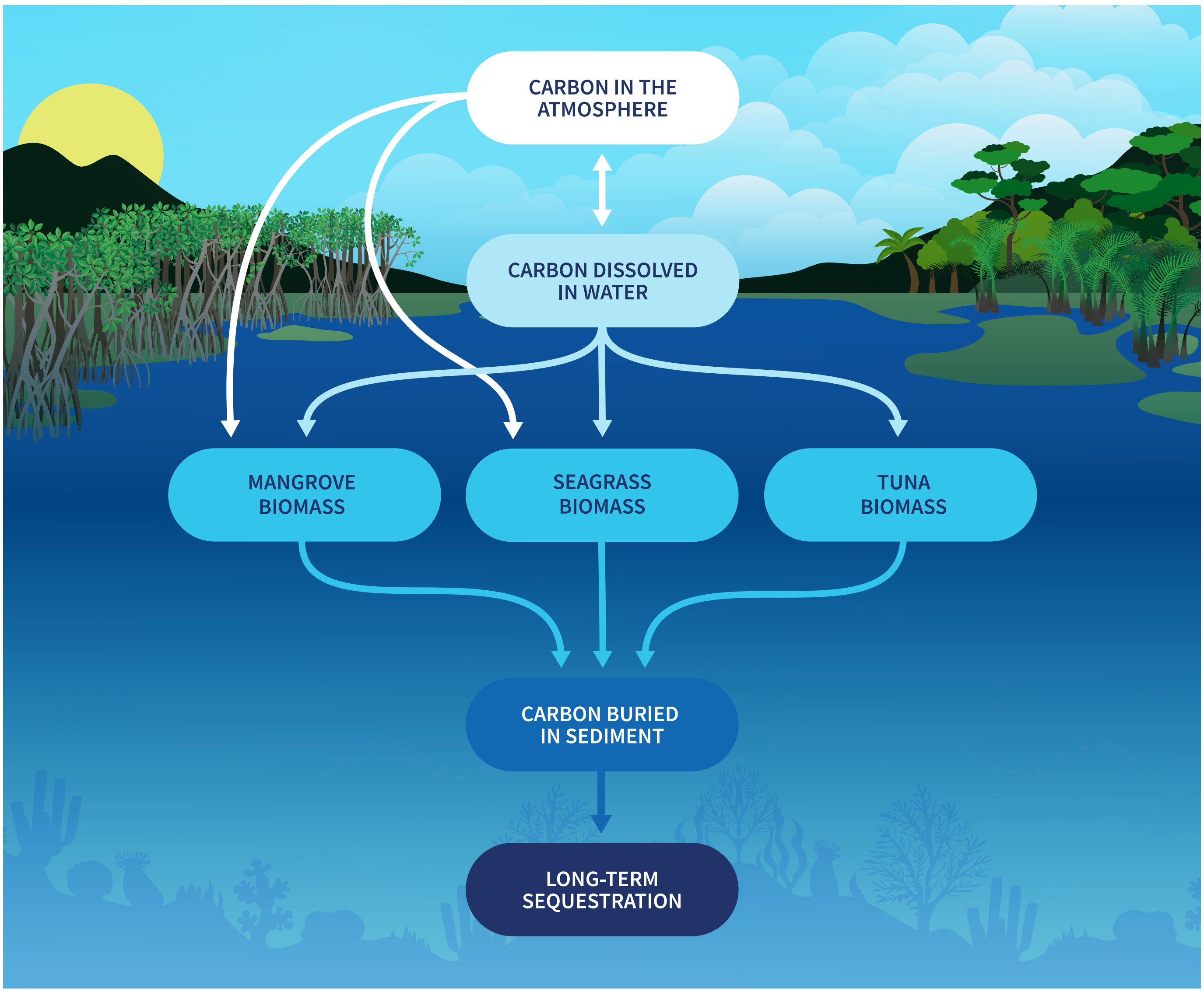


FIGURE 1. Carbon storage and sequestration in ocean ecosystems. Carbon is taken up from the air and water into the living tissue of plants and animals, moving through diverse ecosystems including mangroves, seagrass, and pelagic fish such as tuna. This carbon eventually accumulates in sediments in the seafloor, where it can be sequestered for the long term (not to scale, not all steps included). Figure design by Giada Mannino and Margot Stiles.

Nearshore Carbon Sequestration by Marine Plants

Most marine plants sequester carbon by producing biomass and trapping soil that otherwise would be washed away by waves, just as plant roots stabilize soil on land (Howard et al. 2017). Both plants and algae also take up CO_2 through photosynthesis and store it in their leaves, roots, and other biomass (Howard et al. 2017). Along tropical coastlines in the Indo-Pacific, there is a gradual transition in marine plants from inland mangrove forests to partially or fully submerged seagrass meadows (Valdez et al. 2020). As ocean depth increases, seagrasses, and sediments become interspersed with a patchwork of habitat types that absorb carbon to varying degrees (Figure 1), eventually extending to depths beyond the reach of sunlight.

Mangroves, seagrasses, and other species in the intervening tidal habitats regularly store and exchange carbon across the boundaries of adjacent ecosystems (Cavanaugh et al. 2019; Sheaves et al. 2009) (Figure 2). Although all natural ecosystems include a carbon component, only some ecosystems have a large enough surface area and sequester carbon quickly enough to have a measurable effect on atmospheric greenhouse gasses (Howard et al. 2017). Mangroves and seagrasses are the tropical marine ecosystems most recognized for their role in carbon sequestration (Bertram et al. 2021), including quantitative estimates of their drawdown potential.

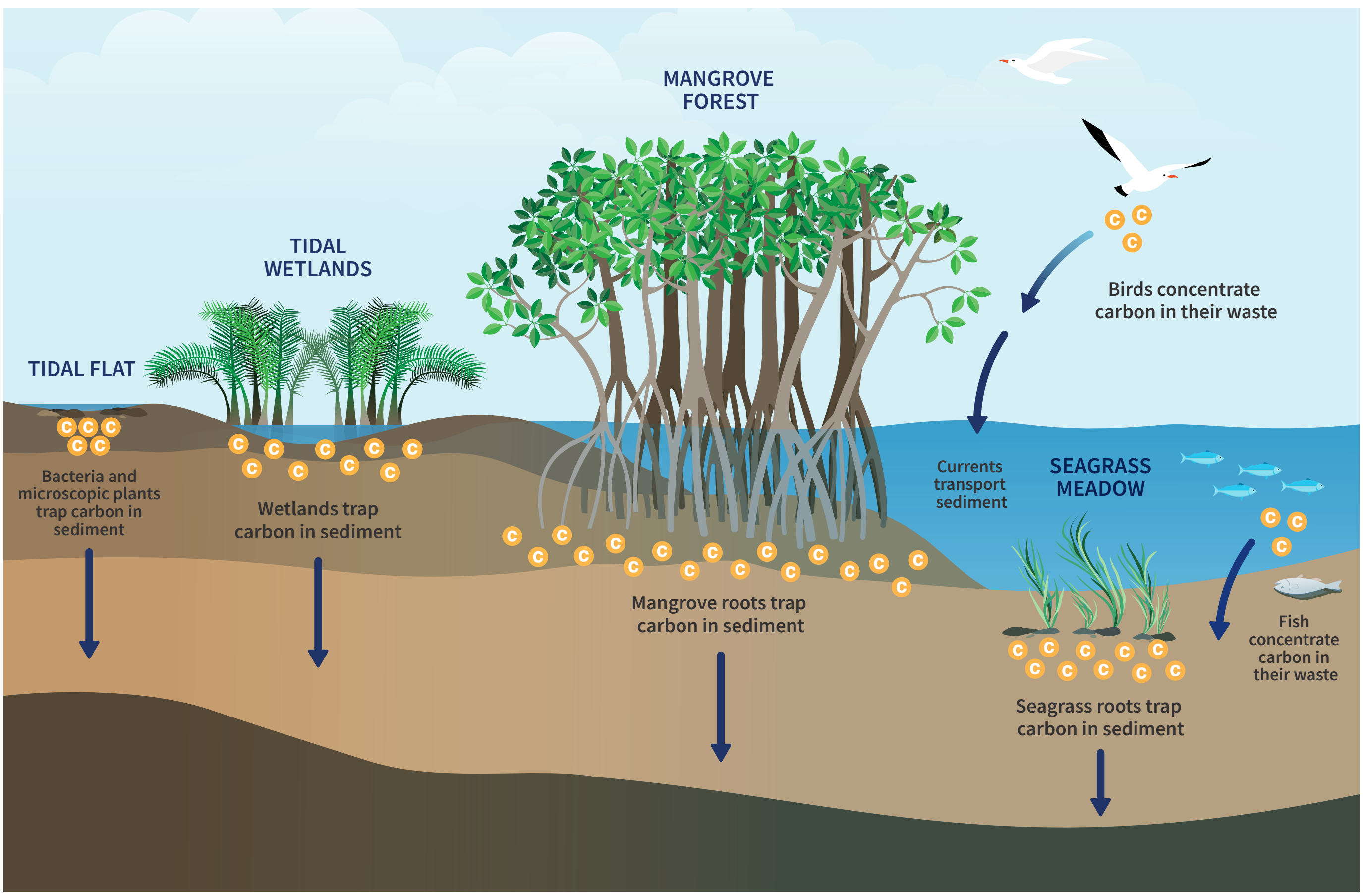


FIGURE 2. Nearshore carbon storage and sequestration. The roots of plants trap carbon in sediments beneath mangrove forests, seagrass meadows, and tidal wetlands. Bacteria similarly capture carbon in sediment in tidal flats. Fish, birds, and other animals concentrate carbon in their waste, which then contributes to sediment on the seafloor. Adapted from Valdez et al. 2020 by Giada Mannino and Margot Stiles (not to scale, not all steps included).

Mangrove Forests

DISTRIBUTION AND EXTENT OF MANGROVE HABITATS IN THE INDO-PACIFIC


PHOTO BY USAID

Mangrove forests grow in many countries and territories in the tropical and subtropical regions of the world. Globally, Indonesia has the greatest mangrove coverage, representing 20 percent of global mangrove area (Bunting et al. 2022). In the Indo-Pacific region, PNG and the Philippines follow Indonesia in total mangrove area according to estimates based on satellite imagery (see Figure 3 below and detailed methods in Appendix A). The Pacific islands support smaller areas of mangrove, primarily in the Solomon Islands and Fiji (Bunting et al. 2022). Regional mangrove diversity declines from west to east, with the most species in PNG, Solomon Islands, FSM, Palau, Vanuatu, and the fewest species in Samoa and Tuvalu (Ellison et al. 2018; Ellison et al. 2000). Mangroves do not occur naturally east of American Samoa due to lack of dispersal over such a large distance and loss of habitat during sea level changes in the distant past (Ellison and Stoddart, 1991).

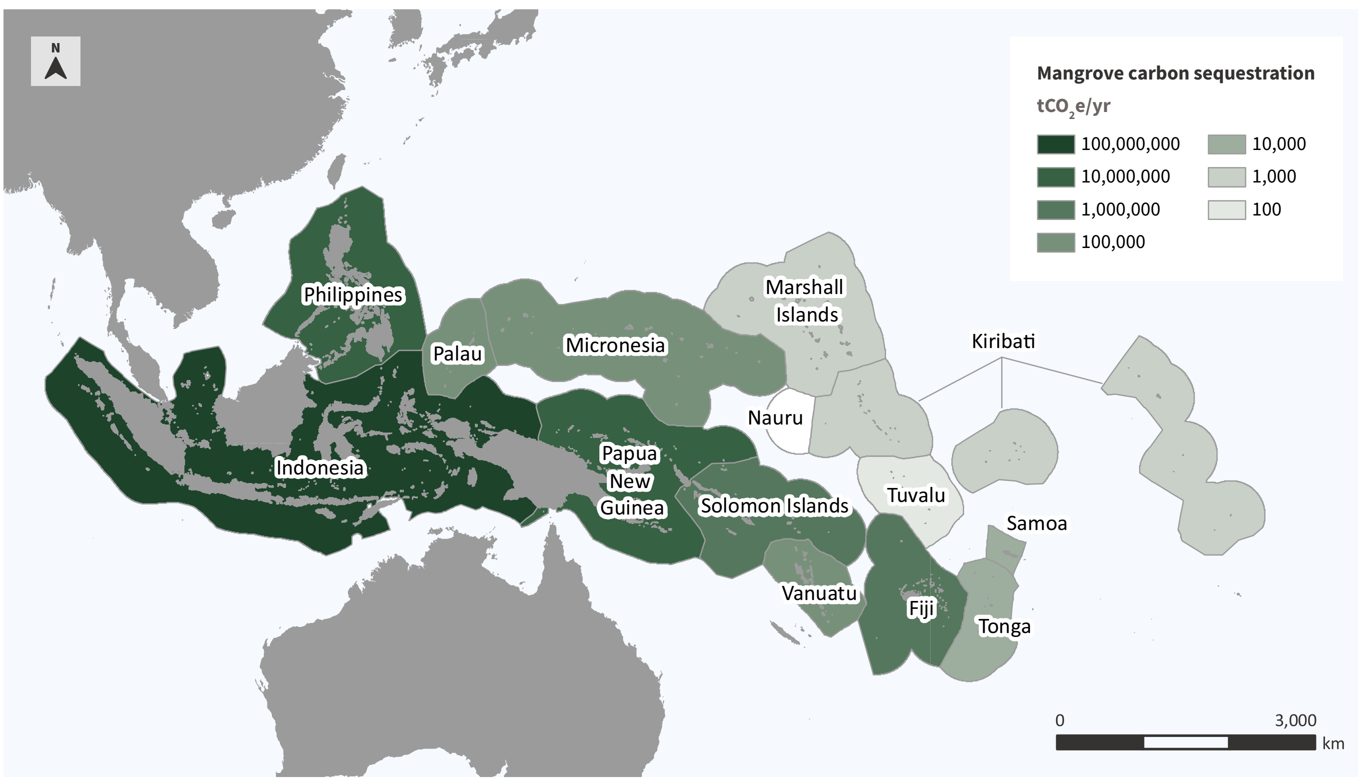


FIGURE 3. Mangrove forest carbon sequestration by country, in metric tons of carbon dioxide equivalent per year. The burial of carbon in mangrove sediments is based on average sequestration rate (Alongi 2012) and area of mangroves per country in 2020 (Bunting et al. 2022).

CARBON SEQUESTRATION IN MANGROVE HABITATS

Healthy mangrove ecosystems annually sequester carbon at ten times the rate of mature tropical forests and store three to five times more carbon per equivalent area of tropical forests (NOAA 2023). The majority of mangrove carbon is stored in the soil and dead roots, with proportionally more carbon below ground and higher versus aboveground carbon mass ratios, compared to terrestrial trees (Alongi 2012). Mangrove forests are among the most carbon-rich habitats in the world, containing an average of 34.5 tCO_2e per square kilometer (km^2). They also capture fine particles, which leads to rapid rates of soil accumulation (~5 mm per year) and carbon sequestration (638.6 tCO_2e annually per km^2) (Alongi 2014). Even though they account for only 0.5 percent of coastal area globally, mangroves contribute 10–15 percent (88 million tCO_2e per year) of carbon storage in coastal sediments and export 10–11 percent of terrestrial carbon to long-term storage in the ocean (Alongi 2014).

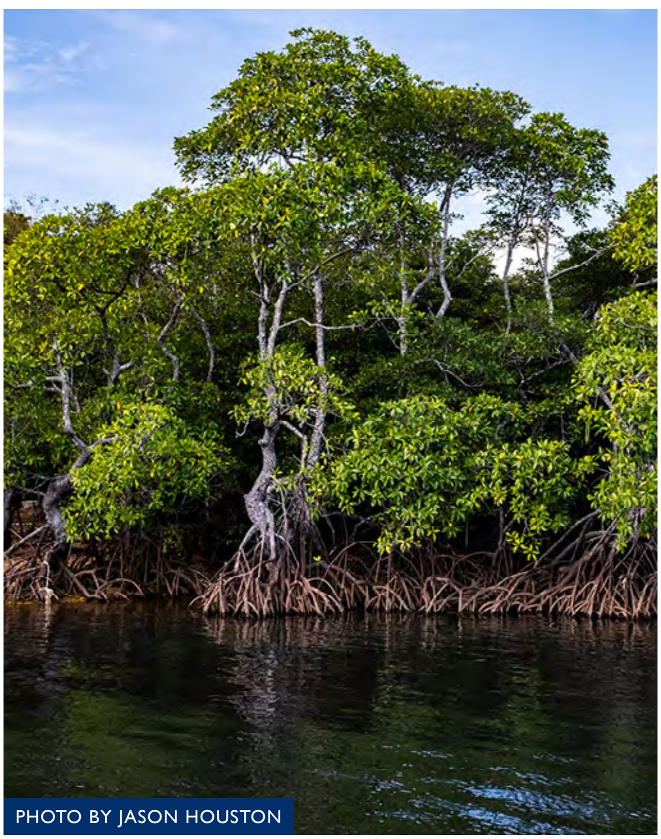


PHOTO BY JASON HOUSTON

Considering the wide range of area covered by mangrove forest in each country, and a conservative estimate for soil burial of organic carbon in mangroves (174 metric tons C per sq.km. per year), this report estimates annual sequestration by country of 58 tCO_2e per year in Tuvalu and nearly 19 million tCO_2e per year in Indonesia based on estimates using satellite imagery (see Figure 3 and detailed methods in Appendix A).

DECLINES AND THREATS TO MANGROVE FORESTS

Previous reviews estimate that, from 1950 to 2000, up to 50 percent of global mangroves were deforested, primarily due to land-use change (Alongi 2002). More recent estimates suggest that global mangrove loss slowed to four percent of global area between 1996 and 2016 (Richards et al. 2020). Deforestation of mangroves releases large amounts of stored carbon into the atmosphere at an estimated rate of 8.18 ± 1.83 million tCO_2e per year (Chatting et al. 2022). At a local scale, any loss can have important impacts to ecosystems and communities. The vast majority of global mangrove carbon is stored in Southeast Asia. Between 2000 and 2016, 87 percent of mangrove losses in this region occurred due to conversion to agriculture or aquaculture—where fish are raised in ponds or nets until they grow to marketable size (Adame et al. 2021). This threat of land use change is discussed later in this chapter.

Once surrounded by mangrove forests, the Philippines has converted more than 70 percent of its mangroves to aquaculture ponds, urban development and other uses (Song et al. 2021). Satellite imagery analysis from recent years (1996–2020) suggests that deforestation has slowed to a loss rate of 80 km^2 of mangrove forest per year, leading to an annual reduction in sequestration of 50,665 tCO_2e (see Figure 4 and detailed methods in Appendix A).

Likewise, in Indonesia, mangrove deforestation between 1980 and 2005 totaled 30 percent of existing mangrove stocks at a rate of 520 km^2 per year (FAO 2007). In more recent years (2009–2019), mangrove deforestation has slowed to 182 km^2 per year, with the majority (89%) occurring in secondary mangrove forests (Arifanti et al. 2021). Satellite imagery analysis from 1996 to 2020 suggests that 1,739 km^2 of Indonesian mangrove forests were lost, leading to an annual reduction in sequestration of 1.1 million tCO_2e (see Figure 4 and detailed methods in Appendix A), which is equivalent to the yearly emissions of more than 220,000 gasoline-powered passenger vehicles.

Progress has been made in slowing deforestation in some areas, but at a regional level mangroves are still in decline based on the analysis in this report (see Figure 4 and detailed methods in Appendix A). Even relatively low levels of mangrove removal have important consequences for ecosystem services provided to local communities (see Table 1). Although most Pacific island countries have much lower rates of recent mangrove deforestation than Indonesia, this is partly due to their lower total areas of mangrove ecosystem (see Figure 4 and detailed methods in Appendix A). From 1996–2020, losses in Pacific island countries ranged from 49 km^2 or one percent of mangroves for PNG to losses of 2.9 km^2 or 3.3 percent of mangroves in the FSM and less than one square kilometer or 2.5 percent of mangroves in Vanuatu, with proportional decreases in annual sequestration (Figure 4). Fiji and Palau showed small increases in mangrove cover, with associated increases in sequestration (Figure 4). Most small Pacific island countries do not have management systems or planning processes in place to protect their mangroves from removal to make space for infrastructure, agriculture, fish farming, hotels, industrial areas, and dumps (Veitayaki et al. 2017). Aside from direct human impacts, there is also consensus that sea level rise could lead to habitat loss and other detrimental impacts for Pacific islands and nations (Ellison 2018).

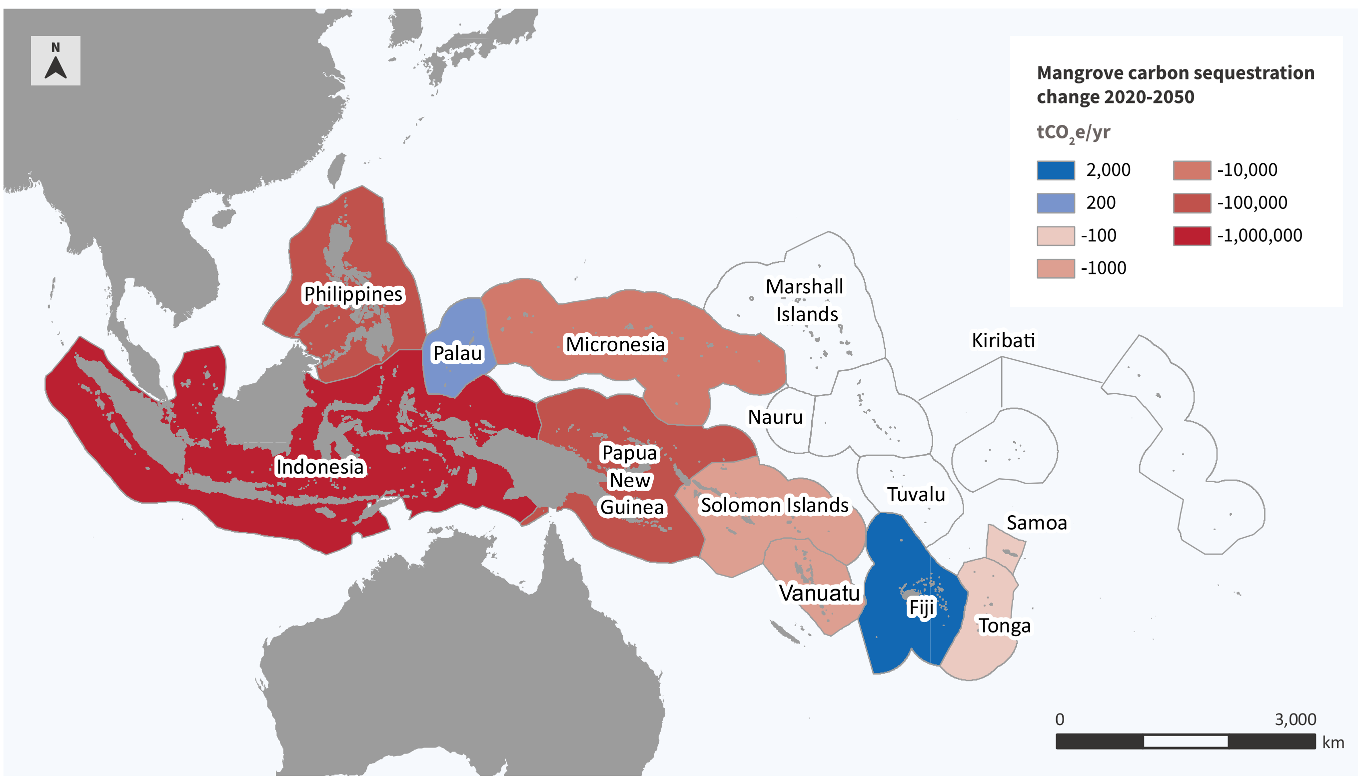


FIGURE 4. Future change in mangrove forest carbon sequestration by country from 2020 to 2050, in metric tons of CO_2 equivalent per year. The projected loss or gain in each country is based on the rate of change in mangrove forest area for each country from 1996 to 2020 (Bunting et al. 2022).

TABLE 1: Change in value of carbon sequestered by mangroves due to projected trends in forest cover from 2020 to 2050, assuming $35 USD per metric ton of carbon dioxide equivalent. Light red indicates a loss of less than $100,000 USD, while dark red indicates a loss that exceeds $100,000 USD. Light blue indicates a gain of less than $100,000 USD, while dark blue indicates a gain that exceeds $100,000 USD. Projected change is estimated on the rates of long-term (1996–2020) and recent (2018–2020) trends in mangrove forest cover in Bunting et al. 2022, Global Mangrove Watch.

Country	2050 value in USD/yr based on long-term trend (1996–2020)	2050 value in USD/yr based on recent trend (2018–2020), in USD/yr
Fiji	+ $64,905	$268,204
Indonesia	-$46,641,679	$41,209,483
Philippines	-$2,127,927	$4,777,377
Solomon Islands	- $77,511	$600,105
Tonga	- $3,218	-$83,814
Palau	+ $6,973	-$167,627
Vanuatu	- $10,460	-$177,685
Micronesia	- $77,511	-$918,597
Papua New Guinea	- $1,307,224	-$6,299,432


PHOTO BY USAID

Seagrass Meadows

DISTRIBUTION AND EXTENT OF SEAGRASS

While a variety of factors make robust area estimates difficult, seagrass grows in extensive meadows throughout the Indo-Pacific region, which is known as the global center of biodiversity for seagrass (Short et al. 2007). Indonesia is thought to have the greatest extent of seagrass meadows in the Indo-Pacific region, with estimates ranging from 2,935 km^2 (Sudo et al. 2021) to 17,862 km^2 (UNEP-WCMC and Short 2021). Seagrass area for the Philippines may be comparable, but estimates vary widely—from 82 km^2 (Sudo et al. 2021) to 27,262 km^2 (Fortes et al. 2018). Several mapping projects are attempting to close the large gaps in seagrass information across the region (McKenzie et al. 2020), but more work is required. Based on current information, among the Pacific islands, PNG appears to have the largest area of seagrass, followed by several countries with extensive seagrass beds, including the Solomon Islands, Fiji, Palau, and FSM (not in order). In the next tier, seagrass is present (with limited mapping) in Kiribati, Tonga, Vanuatu, RMI, and Samoa (Figure 5, Table A1) (McKenzie et al. 2021a).

PHOTO BY USAID

Indonesia is thought to have the greatest extent of seagrass meadows in the Indo-Pacific region, with estimates ranging from 2,935 km^2 (Sudo et al. 2021) to 17,862 km^2 (UNEP-WCMC and Short 2021).

CARBON SEQUESTRATION IN SEAGRASS HABITATS

Given seagrass' wide distribution, extent, and capacity for carbon sequestration, it is among the blue carbon ecosystems gaining international recognition as a nature-based solution to help meet climate change mitigation targets (Johannessen 2022; Macreadie et al. 2021). The largest carbon deposits in seagrass beds are located in the soil, formed by root biomass, seagrass detritus, and carbon captured from other habitats/sources (Kennedy et al. 2010). Organic carbon deposits in seagrass soils, if not disturbed, act as long-term carbon sinks, while above-ground biomass is a short-term carbon sink with much lower storage capacity (Fourqurean et al. 2012). The net sequestration (burial) of carbon varies by species, energy of the local environment, meadow connectivity, sediment grain size, and biologic processes (Johannessen 2022). The estimated carbon sequestration rate of seagrass in Indonesia, one of the few published in the Indo-Pacific region, is 0.21–0.31 tCO_2e per km^2 per year (Wahyudi et al. 2020). Based on its area of seagrass habitat, Indonesia has the highest annual sequestration rate (Figure 5).

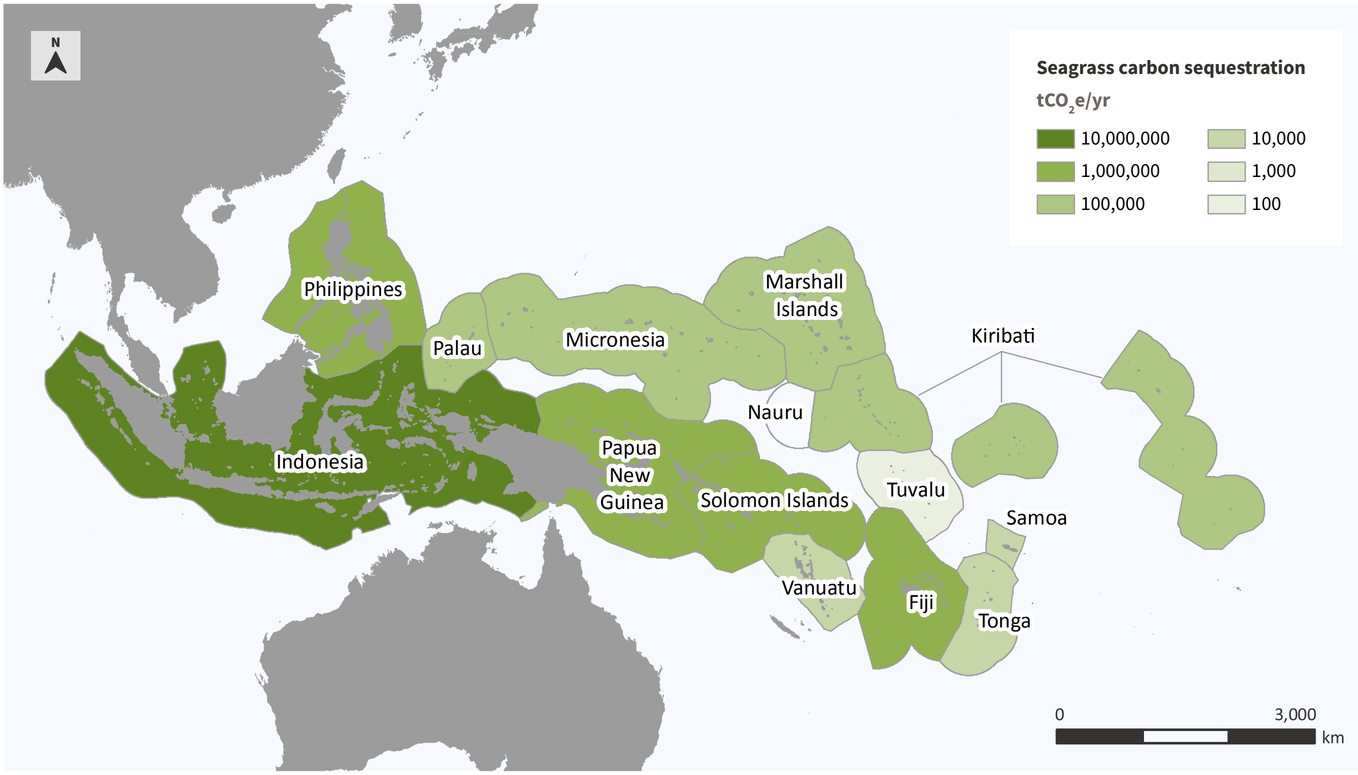


FIGURE 5. Seagrass carbon sequestration by country, in metric tons of carbon dioxide equivalent per year. The burial of carbon in seagrass sediments is based on average sequestration rate (Mcleod et al. 2011) and area of seagrass per country (Allen Coral Atlas 2023).

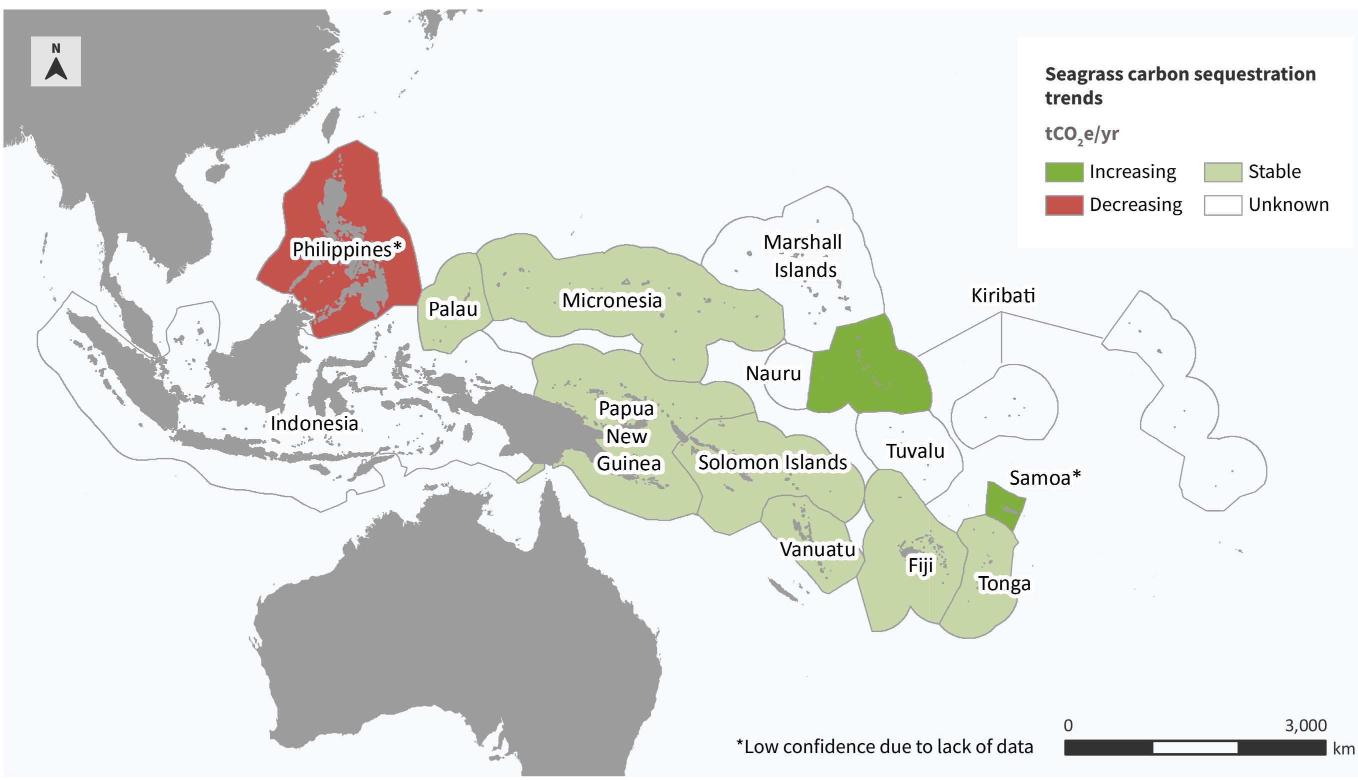


FIGURE 6. Trend in status of seagrass ecosystems and annual carbon sequestration by country. Status is defined as percentage cover, biomass, or extent, adapted from McKenzie et al. 2021a and Sudo et al. 2021.

DECLINES AND THREATS FOR SEAGRASS

Seagrass habitats are declining globally at an estimated annual rate of seven percent (Cullen-Unsworth and Unsworth 2013). A lack of data prevents the accurate assessment of trends in seagrass area in the Indo-Pacific region, but there is evidence of decline in the Philippines (Sudo et al. 2021, Figure 6), an increase in Kiribati and Samoa, and no trend detected elsewhere in the Pacific islands (McKenzie et al. 2021, Figure 6). Changes in seagrass coverage are typically caused by shading that blocks light and slows plant growth, while die-off is caused by excess nutrients, sediment runoff, or direct physical disturbance (Unsworth et al. 2015).

In Indonesia and the Philippines, the primary cause of decline in seagrass area is coastal development, followed by aquaculture activities, destructive fishing, and water quality degradation (Sudo et al. 2021). Tourism, shipping, and mangrove restoration also contribute to the decline (Sudo et al. 2021). In the Pacific islands, stressors to seagrass ecosystems include poor catchment management practices and lack of urban planning (Brodie et al. 2020). However, even in the absence of reliable data for Indo-Pacific seagrasses, it is clear that they confer important benefits to communities, such as supporting species critical to local food security (see Chapter 2). That said, more research and reliable data on these ecosystems is needed to facilitate consideration in finance mechanisms (see Chapter 3).

Climate change could impose multiple impacts on seagrasses. Increased ocean temperature, rainfall, and more intense tropical storms and cyclones will likely contribute to seagrass loss through physical damage, heat stress, and sedimentation and turbidity from increased run-off and coastal flooding (Brodie et al. 2020). In addition, climate change impacts are expected to intensify human impacts on seagrasses and intertidal flats in the Indo-Pacific region (Waycott et al. 2011), some of which are discussed later in this section.

PHOTO BY NINA

Nearshore Ecosystems with Carbon Sequestration Potential

While mangroves and seagrasses are the blue carbon ecosystems most recognized for their carbon sequestration potential (Figure 7), research is still in progress for other ecosystems with potential for carbon sequestration, particularly those where the movement of biomass across ecosystem boundaries has been overlooked in past modeling efforts. Other potential (but largely unquantified) blue carbon sinks in the Indo-Pacific include tidal flats and microbial mats, macroalgae, and oyster reefs—all of which grow in close association with mangroves and seagrasses.

TIDAL FLATS

Tidal flats are found adjacent to mangrove forests in Indonesia, the Philippines, Fiji, Kiribati and along the river deltas of Papua New Guinea (Murray et al. 2022). Until recently, areas lacking conspicuous plants were not considered capable of carbon sequestration, and transitional areas in between terrestrial, riverine, and marine ecosystems were often excluded (Miththapala 2013; Krauss et al. 2018). However, the salty soil of tidal flats where plants are unable to grow still supports microbial mats of bacteria that capture carbon, either through photosynthesis or by processing sulfur (Scherf and Rullkötter 2009). The first estimates of carbon sequestration in tidal flats are from the United Arab Emirates, where microbial mats appear to store up to 4.8 tCO_2e per km^2, second

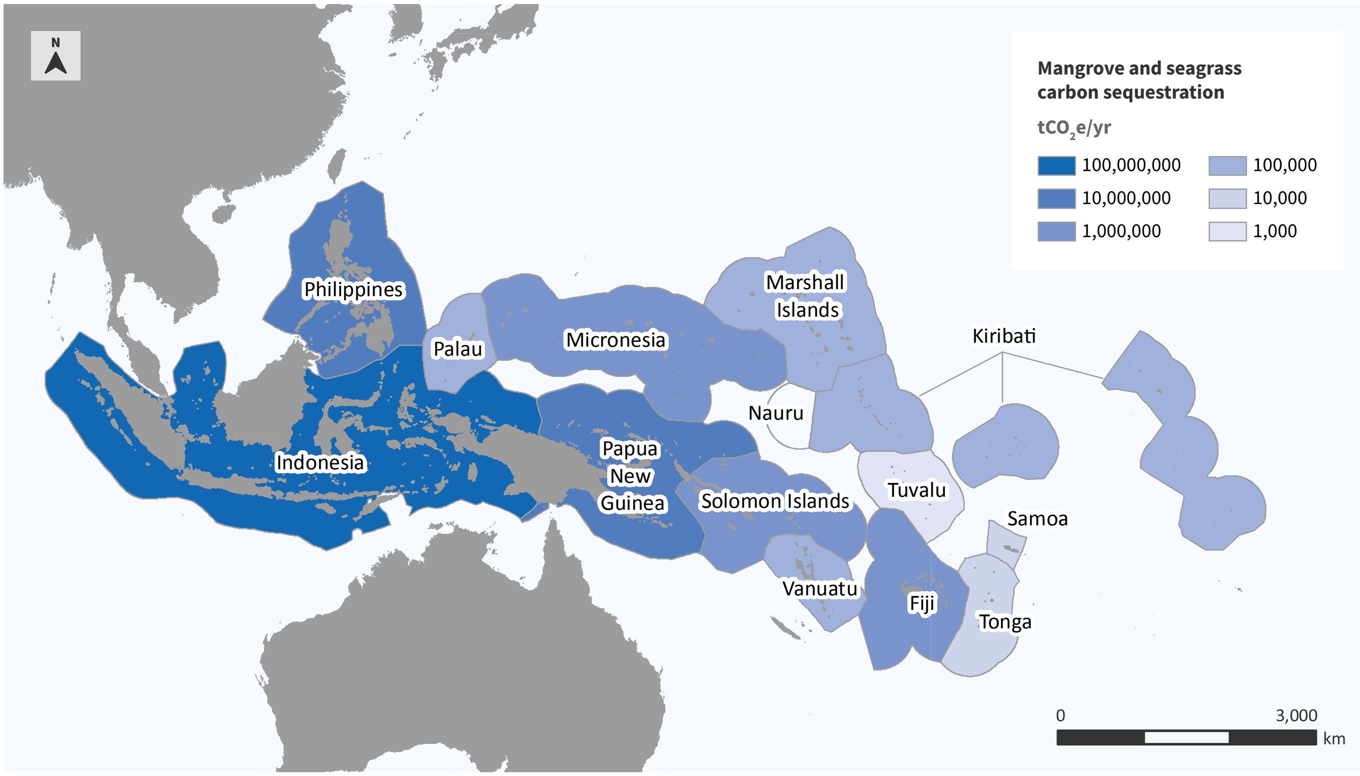


FIGURE 7. Combined mangrove and seagrass annual carbon sequestration by country, in metric tons of carbon dioxide equivalent per year. The burial of carbon in mangrove sediments is based on average sequestration rate (Alongi 2012) and area of mangroves per country in 2020 (Bunting et al. 2022). The burial of carbon in seagrass sediments is based on average sequestration rate (Mcleod et al. 2011) and area of seagrass per country (Allen Coral Atlas 2023).

only to mature mangroves and surpassing the carbon storage capacity of planted mangroves, saltmarsh, and seagrass (Schile et al. 2017). Unvegetated tidal flats, microbial mats, and transitional tidal wetlands may sequester more carbon than expected because of their large area, rapid carbon burial rate, and their role in storing organic carbon from adjacent ecosystems (Schile et al. 2017; Krauss et al. 2018; Chen et al. 2020).

Tidal flats can transition into a mangrove and vice versa, in response to natural conditions (Murray et al. 2022). Unfortunately, tidal flats and other wetlands are being rapidly destroyed for the same reasons as mangroves, resulting in the loss of stored carbon as they are converted to agriculture, aquaculture, urban pavement, or other uses. With sea level rise and other changes in water flow, tidal flats have both expanded and contracted across very large areas, requiring site-specific consideration to assess net losses.

MACROALGAE

Macroalgae or seaweed are highly productive; globally, they represent the largest area of any nearshore vegetation type (Duarte 2017). Macroalgae typically grow on hard or sandy substrates with minimal carbon burial because dead plant matter is carried away by ocean currents before it can be stored. However, in some locations, currents support the growth of macroalgae on soft sediments, where they can accumulate carbon at a burial rate comparable to tidal marshes. In other locations, the currents transport macroalgae to a submarine canyon or other site suitable for long-term sequestration in deep water (Krause-Jensen and Duarte 2016). Recent modeling suggests macroalgae sequester a global total of 16 to 161 million metric tons CO_2e/yr (4 to 44 TgC/yr) (Filbee-Dexter et al. 2024), a significant contribution when compared to other coastal ecosystems (Macreadie et al. 2019; Bertram et al. 2021). Within the Indo-Pacific, carbon sequestration by seaweed is most significant for Indonesia and the Philippines (10.9 and 4.7 million metric tons CO_2e/yr respectively) (Filbee-Dexter et al. 2024), where seaweed cultivation has also been promoted for supplemental income in fishing communities (Rimmer et al. 2021; Steenbergen et al. 2017). Seaweed contributes relatively less to carbon sequestration in Papua New Guinea, Fiji and Palau (1.6, 1.1, and 0.5 million metric tons CO_2e/yr) (Filbee-Dexter et al. 2024).

TROPICAL OYSTERS

Like mangroves, oyster reefs can accumulate carbon in sediment, although they also release small amounts of CO_2 during shell production (Fodrie et al. 2017). Either way, the disturbance and destruction of oyster reefs releases large amounts of accumulated carbon into the atmosphere—emissions that could be avoided if the reefs were protected, along with their many ecosystem co-benefits from water filtration to erosion control (Fodrie et al. 2017).

Additional research and pilot restoration projects can accelerate ecosystem restoration and carbon sequestration in island and archipelagic nations. Detailed mapping and accounting are necessary to track the movement of biomass across ecosystems due to ocean currents and animals that swim. Especially in the ocean, animal movement can no longer be excluded from global carbon accounting (Schmitz et al. 2018).

CASE 1

Urban Wetlands as Nature-Based Solutions for More Resilient and Livable Cities in Demak, Indonesia

With almost half of the world's population living in urban areas, designing resilient and environmentally friendly cities with integrated wetlands can provide economic, social, and cultural benefits for people. Demak, a low lying coastal community in Java, has tackled erosion, flooding, and land subsidence by restoring mangrove forests. In partnership with engineers from Building with Nature and non-governmental organizations (NGOs), Demak's government and its communities successfully restored 119 ha of mangroves. Together, they restored river branches to reduce salt intrusion and allow sediment to flow into a mangrove greenbelt. The project placed the equivalent of 3.4 km of wave-calming, sediment-trapping structures (built with nets and local bamboo) along the 20-km stretch of coastline. Under these new conditions, 12 different species of mangroves have regenerated naturally, shielding about 70,000 people from climate change impacts, protecting the coast from further erosion, and improving fishers' catches in the nearshore areas. Where the coastline had not yet eroded, the project team worked in close collaboration with local communities to revitalize 300 ha of aquaculture ponds with mangroves. Using an innovative financing mechanism, bio-rights, farmers obtained micro-credits in exchange for reducing the use of chemicals and revegetating parts of their ponds. Consequently, shrimp production and farmers' revenues increased. Those credits become definitive payments upon successful delivery of conservation services at the end of a contracting period. Coupling those interventions with capacity development was essential. Training reached government officials, the private sector, students and local communities, and 277 farmers. Since observing the success of the project, 13 districts across Indonesia have replicated this approach.

References: UNEP 2022, UNEP 2023

Offshore Sequestration by Marine Animals

In healthy ocean and coastal ecosystems, animals can have significant impacts on carbon uptake, storage, and release (Schmitz et al. 2014; Schmitz et al. 2018). Even though herbivores and carnivores typically maintain less living biomass compared to plants, they influence 40 percent of global carbon storage by transporting biomass across ecosystem boundaries, adding organic matter to soil, and changing the growth rates of plants and microbes (Schmitz et al. 2018). In the ocean, this role is played by fish, sharks, invertebrates, and marine mammals that move carbon through multiple ecosystem processes, as illustrated in Figure 8 below.

This report presents conservative estimates of tuna transport of carbon in the form of organic matter to deep ocean sediments. Global estimates for open ocean carbon transported to 400m+ depths include fish carcasses and fish waste pellets in the range of 5.5 to 15.8 billion tCO_2e per year, leading to sequestration for more than 100 years (Saba et al. 2021). Tuna in the Indo-Pacific sequester an estimated 1.4 million tCO_2e/year in the form of carcasses and 1.1 million tCO_2e/year in the form of waste pellets. This is counterbalanced by tuna removals by industrial fishing for a net carbon sequestration by Pacific tuna of 1.9 million tCO_2e/year (see Appendix A for complete calculation table).

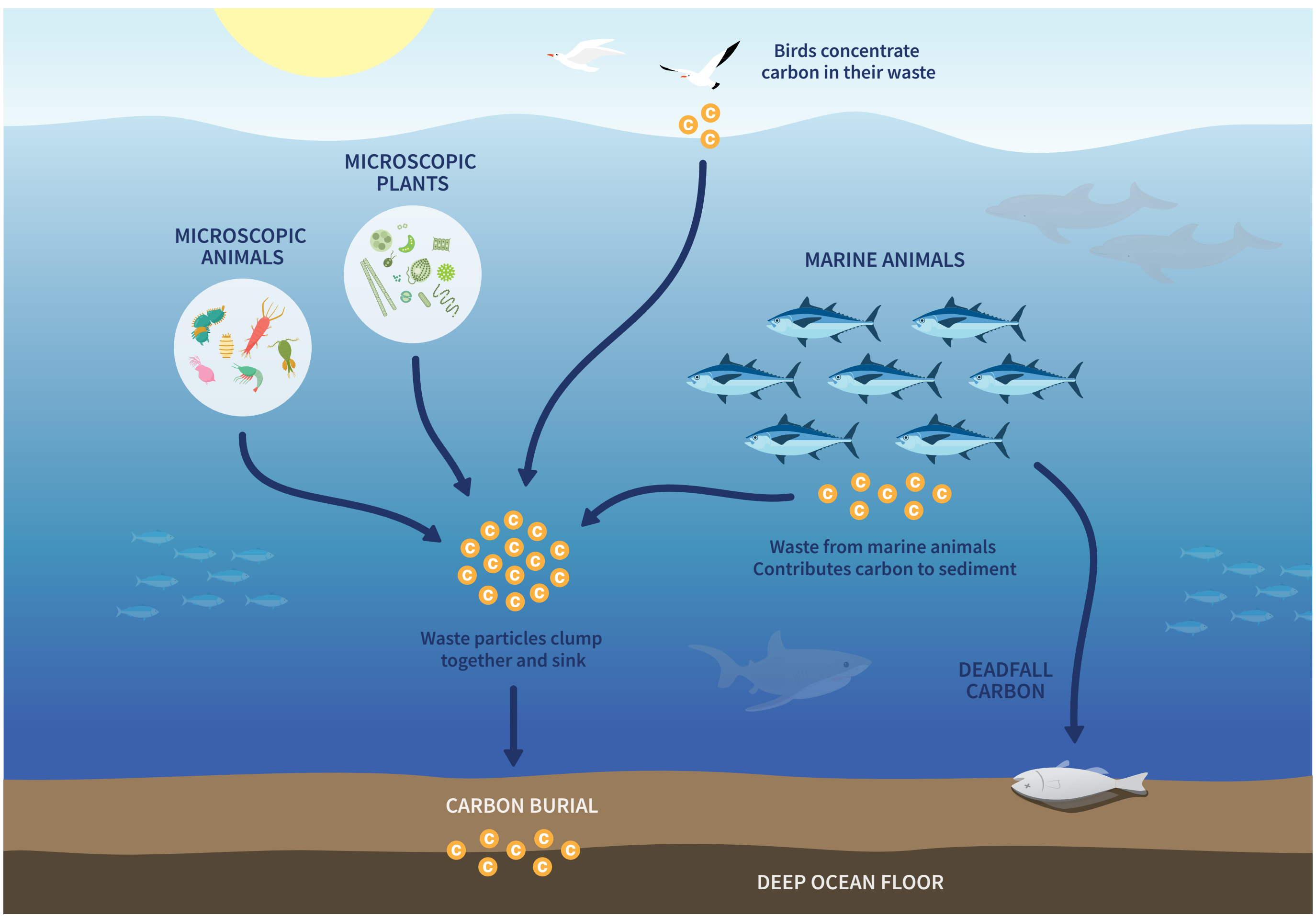


FIGURE 8. Offshore carbon storage and sequestration. Fish, birds, sharks, marine mammals, and other animals concentrate carbon in their waste. Animal waste pellets clump together with microscopic plants, and other organic matter and gradually sink to the sediment on the seafloor. Large animal carcasses may sink directly to the seafloor. Adapted from Bianchi et al. 2021 and Lutz and Martin 2014 by Giada Mannino and Margot Stiles (not to scale, not all steps included).

LARGE ANIMALS SEQUESTER CARBON WHEN THEIR CARCASSES SINK

In the same way that a fossil fuel, such as oil, is made of ocean plants and animals from millions of years ago (Smithsonian 2023), today's seafloor sediments are made of more recent remains. More than half of the deep ocean contains sediments composed of at least 30 percent of skeletal remains of marine animals (Goffredi et al. 2008); these sediments are known as oozes. Fish, shark, and marine mammal carcasses sink, delivering carbon from the surface that drives localized bursts of carbon sequestration on the seafloor (Mariani et al. 2020; Oostdijk et al. 2022; Cavan and Hill 2022; Higgs et al. 2014).

Small fish face the constant threat of predators. For tuna in the Indo-Pacific, natural mortality is highest for juveniles <40 cm long, and fewer than five percent survive in a given year (Peatman et al. 2022; Fonteneau and Pallares 2004). When they reach a certain size (40cm+) adult tuna are safe from natural predators but are more likely to be caught in fishing gear (Peatman et al. 2022; Cooper 2006). Whether they die of natural causes or are discarded from the fishery, their carcasses eventually transport carbon to the seafloor. Large volumes of other large fish, such as blue sharks, silky sharks, oceanic white-tip sharks, mako sharks, thresher sharks, billfish, and other species, are also discarded by the longline and purse seine[3] fisheries in the Pacific islands (Castillo-Jordán et al. 2022; Clarke et al. 2014; Rice and Harley 2013; WCPFC 2022).

LARGE ANIMALS SEQUESTER CARBON IN THEIR WASTE PELLETS

Around 20 percent of the food consumed by fish is excreted as waste pellets (Bianchi et al. 2021). These carbon-rich waste pellets gradually sink toward the seafloor through natural processes. Fish waste then combines with microscopic organisms to form particles known as "marine snow," which spends weeks sinking toward the seafloor (Eloyan 2020; Turner 2015). Although much of this carbon (~85%) is recycled on the way down (Cavan and Hill 2022), around 10 percent sinks out of the surface layer, and three percent sinks past 1000m, where it can be considered "sequestered" for the next ~100 years (Turner 2015).

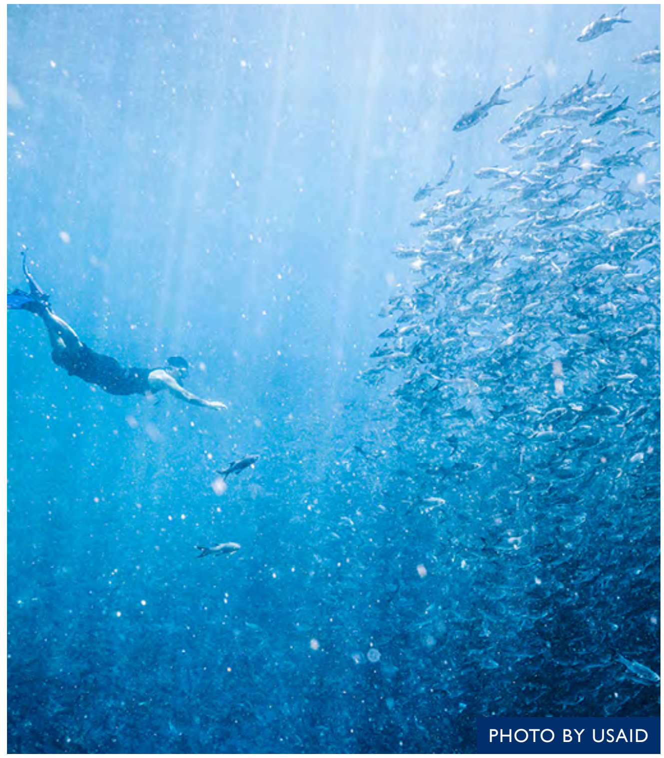


PHOTO BY USAID

For large fish, such as tuna, the contribution of waste to ocean sediments is an estimated 1.1 million tCO_2e/yr, the same order of magnitude as the contribution of carcasses at 1.4 million tCO_2e/yr (see Appendix A for complete calculation table). Giant schools of tropical sardine, *Sardinella spp*., which support a global catch of two million metric tons every year and employ hundreds of thousands of people (Hunnam 2021), also contribute considerably to carbon sequestration in ocean sediments. Before they are eaten, either by natural predators or by people, these schooling fish sequester carbon by excreting waste pellets, which represent as much as seven percent of all carbon sinking to the seafloor in a given region (Cavan and Hill 2022).

[3] A large wall of netting deployed around an entire area or school of fish.

MARINE ANIMALS MOVE CARBON BETWEEN ECOSYSTEMS

One of the most important roles of marine animals in carbon sequestration is the transport of carbon as they swim. This includes daily movements from shallow to deep water (i.e., diel vertical migration, or DVM), and seasonal migration across national and international boundaries (Cavan and Hill 2022; Oostdijk et al 2022; Bell et al. 2021). Carbon sequestration and biomass productivity are highest within the 200 nautical miles managed by national governments (Cavan and Hill 2022). Although pelagic environments produce less biomass overall, these expansive areas are punctuated by dense fish aggregations that create local hotspots of productivity and carbon sequestration (Morais et al. 2021; Hunnam 2021).

Although this analysis does not include daily or seasonal plankton movements to estimate blue carbon storage and sequestration, these microscopic organisms are substantial contributors to ocean absorption of carbon. The movement of CO_2 from the atmosphere to the ocean, and ultimately to the seafloor sediments, is called the biological carbon pump and starts with microscopic plants known as phytoplankton that take up atmospheric CO_2 through photosynthesis. The sequestration potential of plankton, both phytoplankton and zooplankton, and therefore, the biological carbon pump, will be heavily affected by climate change (Basu and Mackey 2018; Wang et al. 2023). This is an area of current research and analysis. For example, ongoing research at Woods Hole Oceanographic Institution is examining the biological carbon pump and its role in regulating climate.

TUNA STORE AND MOVE CARBON ACROSS THE PACIFIC

Fishing is the primary determinant of how much carbon is stored and sequestered by tuna and other large marine animals; strong and responsible governance of fisheries can ensure that this natural process can continue. When an individual fish is caught and consumed, an estimated 94 percent of its stored carbon is released into the atmosphere, with the remainder sequestered in landfills as fish bones (Mariani et al. 2020). In this analysis, the tuna carbon sequestration removed by industrial fishing is estimated at approximately 700,000 million tCO_2e/yr, which still leaves a substantial contribution to ocean sediments from the spawning-sized tuna that remain in the water to produce the next generation.

> The average annual carbon sequestered by tuna in just one of these countries (Indonesia, Kiribati, FSM, and RMI) is comparable to the annual greenhouse gas emissions from 80,000 gasoline-powered cars (EPA 2023).

More than half of all tuna in the world by weight are caught in the western and central Pacific Ocean, and 67 percent of these are skipjack tuna (*Katsuwonus pelamis*) (ISSF 2023, FAO 2022). The incredible productivity of skipjack, as well as bigeye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*) tuna relies on a large standing biomass of fish that remain in the ocean, sequestering carbon through the mechanisms described above. For skipjack tuna, this includes 2.7 million metric tons of spawning biomass and more than four million metric tons of total biomass (Castillo-Jordán et al. 2022). Purse seine nets capture the majority of fish, targeting skipjack tuna and also capturing juvenile yellowfin and bigeye tuna when deployed around fish aggregating devices (FADs) (Castillo-Jordán et al. 2022; ISSF 2023). Many other large-bodied fish are often caught along with the tuna (billfish, escolar, wahoo, mahi mahi, rainbow runner, and opah), in addition to several shark species (silky shark, blue shark, oceanic white-tip shark) (WCPFC 2022).

TUNA SUPPORT BOTH CARBON SEQUESTRATION AND FISHING


PHOTO BY USAID

This analysis estimates net carbon sequestration by tuna to deep ocean sediments for each Indo-Pacific country by combining production of sinking carcasses, waste pellets, and production removed by fishing (see Appendix A for complete country-specific methods and results). Indonesia, Kiribati, FSM, and RMI currently have the highest rates of net carbon sequestration by tuna because of the robust populations of adult tuna in their waters, ranging between 202 to 544 thousand tCO_2e/yr per country. The average annual carbon sequestered by tuna in just one of these countries is comparable to the annual greenhouse gas emissions from 80,000 gasoline-powered cars (EPA 2023). This includes some, but not all the countries producing the largest tuna catches, based on ten-year average estimates of catch and biomass from the SEAPODYM model (Senina et al. 2020; see model outputs in Bell et al. 2021). Tuna in the Solomon Islands and the Philippines sequester an estimated 144 and 102 thousand tCO_2e/yr respectively (Figure 9, Table A2). Despite landing large volumes of tuna, only modest fish-based carbon sequestration is estimated for PNG and Nauru, precisely because less adult tuna biomass remains in the water.

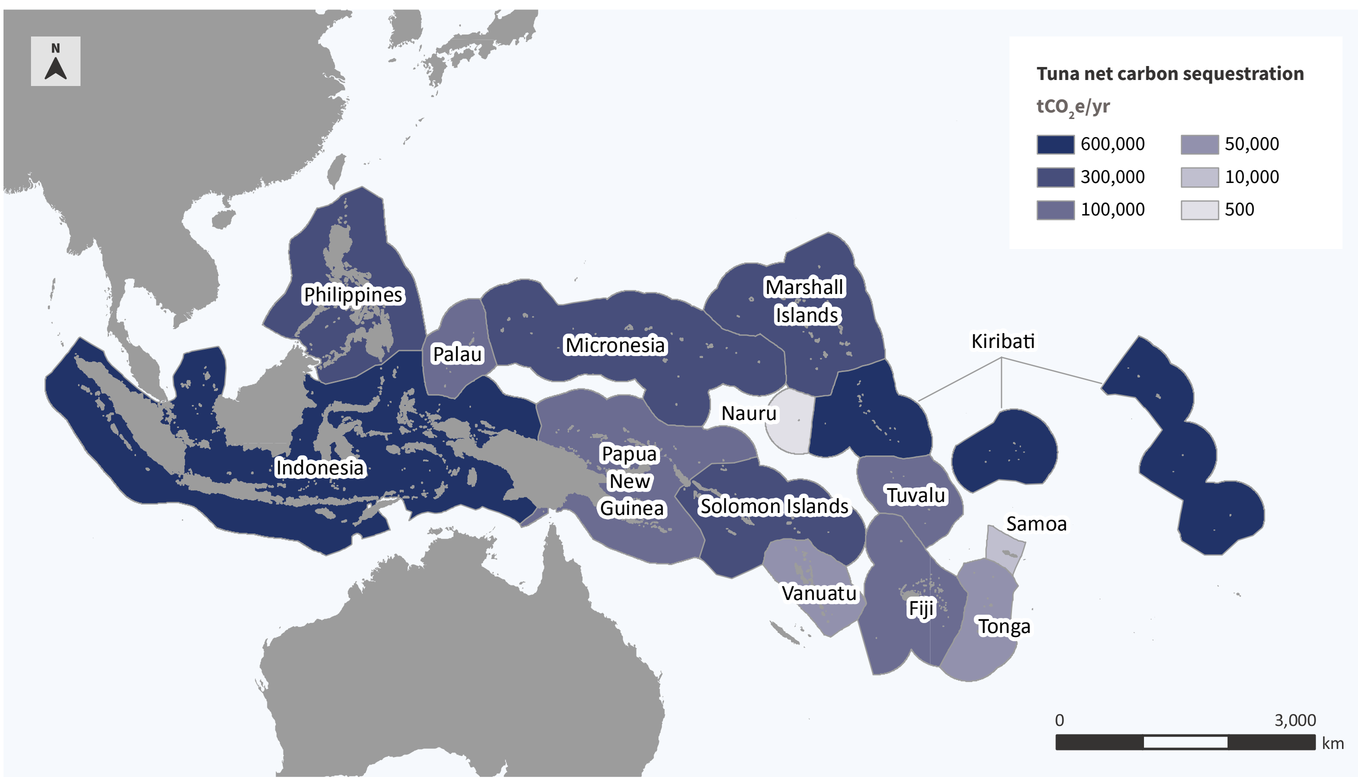


FIGURE 9. Present net carbon sequestration by tuna across the study countries, in metric tons of carbon dioxide equivalent per year. Calculated as the mean annual sequestration by skipjack, bigeye, yellowfin tuna populations through the production of waste pellets and deadfall minus carbon removed by fisheries catches for 2011–2020. Tuna populations from SEAPODYM model; waste pellets and deadfall after Bianchi et al. 2021 and Mariani et al. 2020 (see detailed methods in Appendix A).

WEAK GOVERNANCE OF FISHERIES REDUCES FISH CARBON STORAGE

Tuna populations are abundant when fisheries are managed with science-based catch limits (Pons et al. 2017). When governance is weak, unsustainable practices reduce this standing biomass and lead to smaller catches, as well as smaller individual fish. Overfishing also tends to increase the amount of fossil fuel consumed, because fishing vessels must travel further to find enough catch (Ferrer et al. 2022, Parker et al. 2018).

Tuna carbon storage is currently protected by effective regional governance for tuna harvesting in the Pacific islands, which manages fishing to maintain spawning stocks, particularly for skipjack and yellowfin tuna. Strong regional institutions, such as the PNA or Parties to the Nauru Agreement (FSM, Kiribati, RMI, Nauru, Palau, PNG, Solomon Islands, and Tuvalu) (Aqorau et al. 2018) and the Western and Central Pacific Fisheries Commission (WCPFC), provide backing for Pacific island countries and territories, Indonesia, and the Philippines to monitor and influence the activities of distant water fleets. National harvest strategies in Indonesia and Fisheries Management Areas in the Philippines also provide needed governance for this valuable fishery.

In Pacific island countries and territories, the yield of bigeye tuna has decreased because too many undersized fish are being caught in association with drifting FADs, as illustrated below (ISSF 2023; WCPFC 2002). Although some amount of unregulated fishing is tolerated (Yeeting et al. 2018), current governance has maintained all three major tuna stocks within sustainable fishing rates and spawning biomass levels (ISSF 2023), while ensuring maximum revenue from tuna catches under changing climate conditions (Aqorau et al. 2018).

PHOTO BY GUIDO

Fish Aggregating Devices

Fish aggregating devices (FADs) are floating rafts that attract fish and have a long history in the Indo-Pacific region (SPC 2012; Barbaran et al. 2008). Conventional FADs are anchored close to shore and made of biodegradable materials, like palm fronds or bamboo (Figure 10). Chapter 2 discusses their links to Pacific communities' traditional knowledge. When located relatively close to the shore (within 5km), but far enough away from coral reefs to avoid disturbing those ecosystems, these nearshore FADs offer an immediate investment opportunity to provide short-term relief from declining catches by increasing safe access to tuna and other pelagic fish for coastal fishing communities (Bell et al. 2018; Bell et al. 2015; Tilley et al. 2019).

In contrast, offshore drifting FADs are much larger, include synthetic materials like old ropes and fishing nets that can entangle marine animals (Gomez et al. 2020; Murua et al. 2023), and range so widely that they are tracked with satellites (Figure 11). Drifting FADs often cross jurisdictional boundaries and may exacerbate the "unreported and unregulated" element of offshore fishing (Gomez et al. 2020). Escalle and Phillips (2019) estimate that "30,000 to 65,000 [industrial] FADs are released every year in this region, but we have very little understanding of where they ended up." Although their use may reduce fuel use because the vessels can go directly to the fish, they attract juvenile fish, and their debris can pollute reefs and remote islands. Economic models suggest that a reduction in drifting FAD use would increase profits by $180 million USD by preventing the capture of juvenile yellowfin and bigeye tuna (Bailey and Sumaila 2010). Recent progress in the development of non-entangling offshore FADs that are still effective at catching tuna suggest opportunities for additional investment (Murua et al. 2023).

FIGURE 10. Nearshore fish aggregating devices (FADs) can increase access to tuna, sardines, and other pelagic fish for small-scale fishers. When appropriately located, nearshore FADs can complement efforts to reduce fishing pressure on coral reefs. Adapted from Barbaran et al. 2008 and SPC 2012 by Giada Mannino and Margot Stiles.

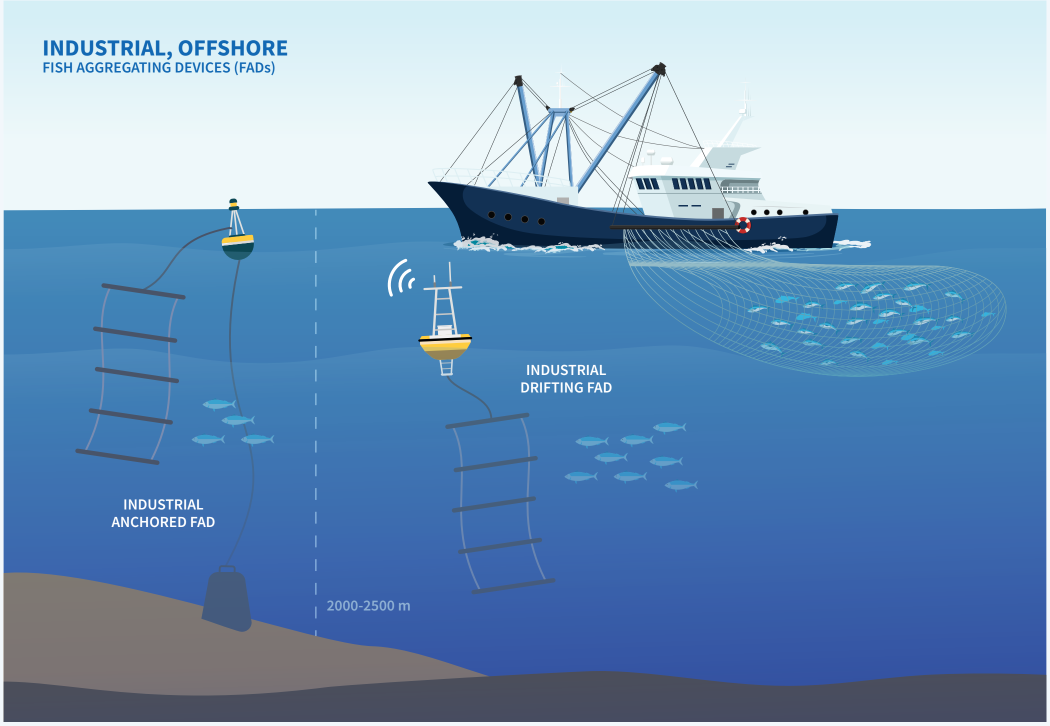


FIGURE 11. Offshore industrial fish aggregating devices (FADs) attract fish, detect their presence with sonar, and transmit their location to industrial fishing vessels. Drifting FADs can contribute to pollution and to overfishing of juvenile tuna, sharks, and turtles. Adapted from Escalle et al. 2023 and SPC 2012 by Giada Mannino and Margot Stiles.

CLIMATE CHANGE MAY REDUCE FISHERIES PRODUCTIVITY IN SOME LOCATIONS

Global warming is changing ocean currents, and fish like tuna and sardines are moving to follow their prey (Puspasari et al. 2019; Bell et al. 2021). This migration is expected to enhance catches in some countries while it declines in others (Bell et al. 2021, Figure 12). At the same time, other effects of climate change are likely to reduce fish productivity by damaging coral reefs and other essential habitats, while reducing nutrients and prey availability in some locations (Barange et al. 2018).

> Warming waters are likely to shift skipjack, yellowfin, and bigeye tuna eastward, with an average of 13% less tuna biomass available in national waters for the nine Pacific small island developing states (Bell et al. 2021).

For the Philippines and Indonesia, temperature changes are likely to drive movement of commercially valuable fish species away from traditional fishing grounds (see Geronimo 2018 and Kaczan et al. 2023 for more detail). In the Philippines, temperature could drive declines of nine to 24 percent in maximum catch potential for a range of fish species (Geronimo 2018). Severe declines in the Philippines are most likely for species such as sailfish or *malasugi* (*Istiophorus platypterus*), dorado or mahimahi (*Coryphaena hippurus*), ponyfish or *sapsap* (*Gazza minuta*), and rainbow runners or salmon (*Elegatis bipinnulata*) (Geronimo 2018). In Indonesia, temperature changes could drive declines of 20–30

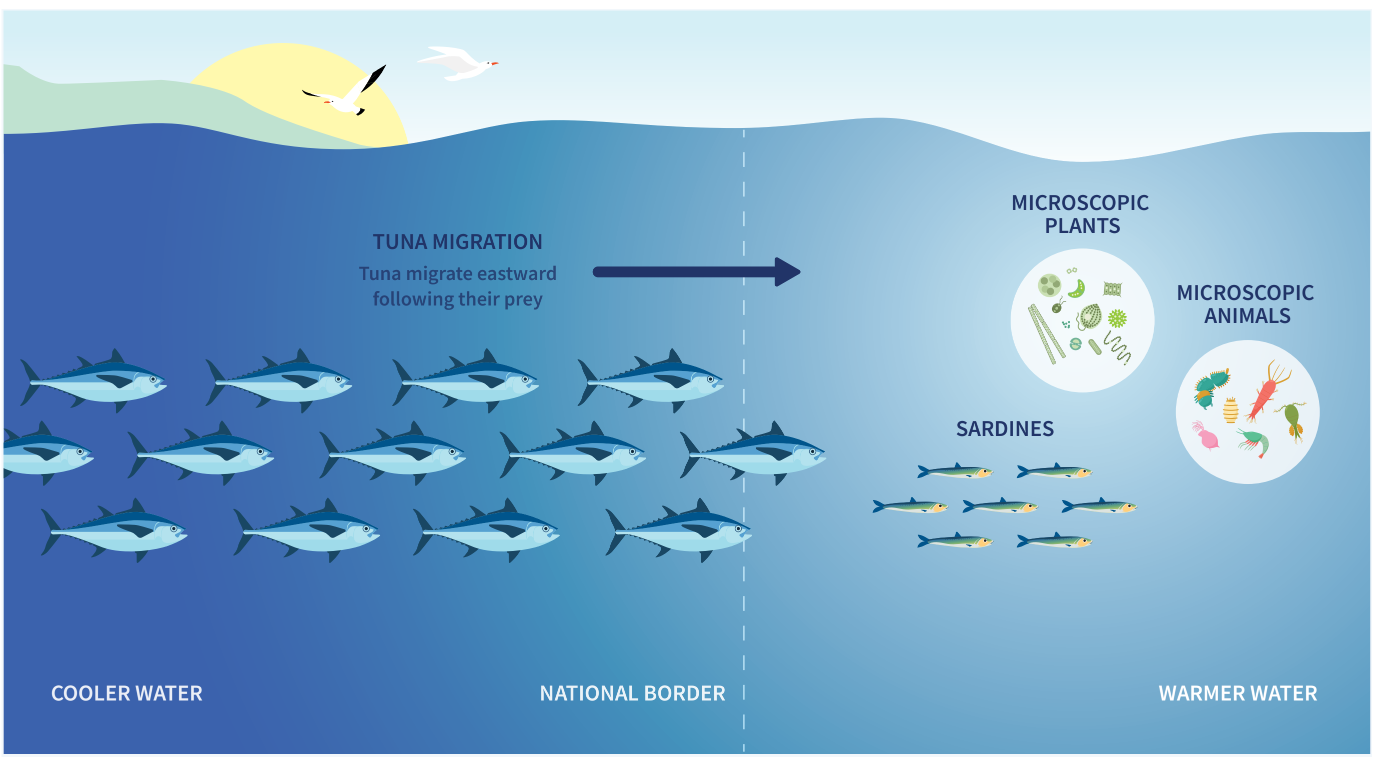


FIGURE 12. Pacific tuna and the fish they prey on may shift eastward in response to climate-driven changes in ocean productivity. This migration could move tuna across national borders, away from current governance that has maintained their populations at sustainable levels (See the high-emissions scenario in Bell et al. 2021 (RCP 8.5 2050)). Figure design by Giada Mannino and Margot Stiles.

percent in maximum catch potential for a range of species (Kaczan et al. 2023). Indonesian catch declines are most likely for species such as Toli shad (*Tenualosa toli*), Indo-Pacific king mackerel (*Scomberomorus guttatus*), blacktip shark (*Carcharhinus limbatusa*), and kawakawa (*Euthynnus affinis*) (Kaczan et al. 2023).

This report focuses on climate-driven changes in tuna because of its high biomass, economic importance, and availability of data across all Indo-Pacific countries. Current modeling projects catch reductions in many Pacific island countries, with a few examples of increased catches (Bell et al. 2021, Figure 13). Climate-driven tuna migration is projected to cause substantial losses (both carbon and fishing) in FSM, Indonesia, and PNG (Figure 13, Table A3). Noticeable losses of tuna carbon storage are projected in the Philippines, Solomon Islands, and Tuvalu, and to a lesser extent in RMI and Nauru (Figure 13, Figure 14, Table A3). On the other hand, significant gains in tuna carbon sequestration are projected in Kiribati, and modest gains in Fiji, Palau, Vanuatu, Tonga, and Samoa (Figure 13, Figure 14, Table A3).

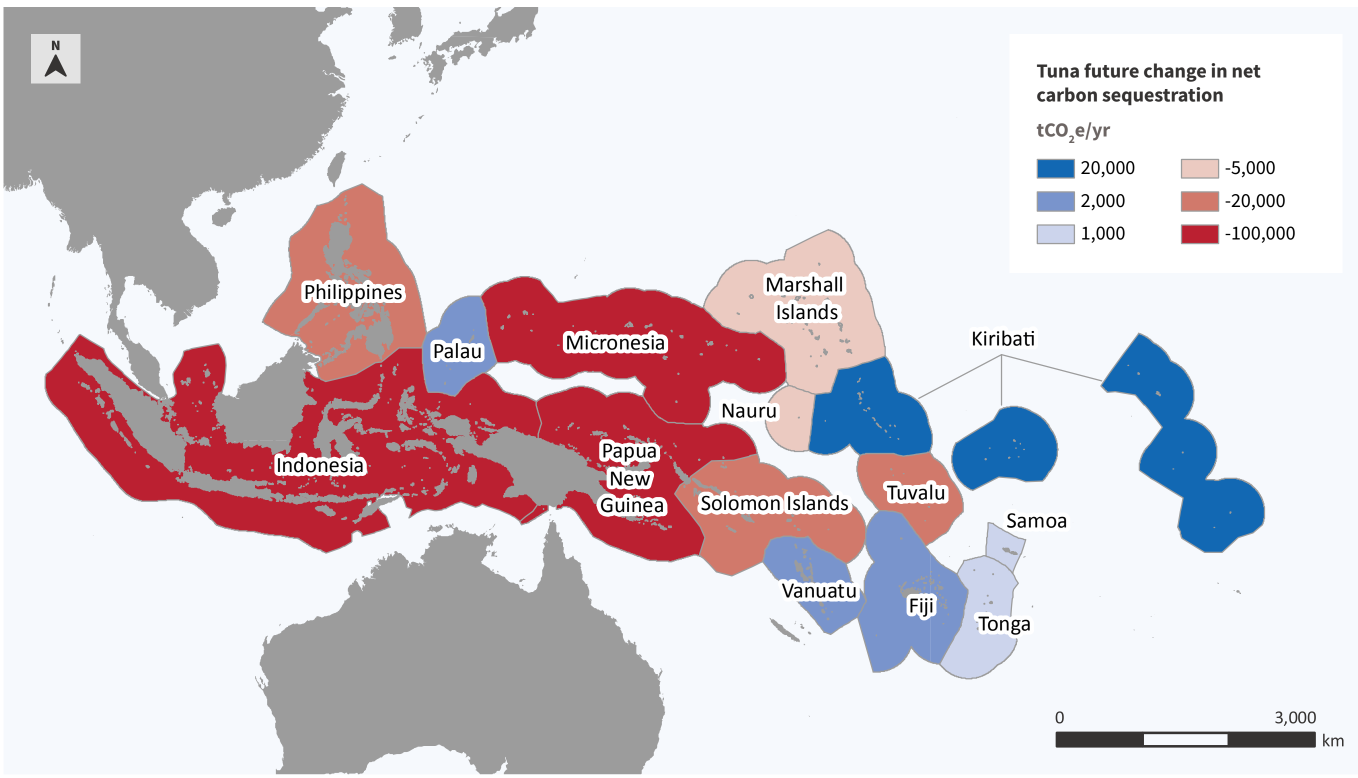


FIGURE 13. Future net carbon sequestration by tuna (skipjack, bigeye, and yellowfin) across the study countries, in metric tons of carbon dioxide equivalent per year. Calculated as the mean annual sequestration by skipjack, bigeye, yellowfin tuna populations through the production of waste pellets and deadfall minus carbon removed by fisheries catches for 2044–2053. Future tuna populations from the SEAPODYM model; waste pellets and deadfall after Bianchi et al. 2021 and Mariani et al. 2020 (see detailed methods in Appendix A).

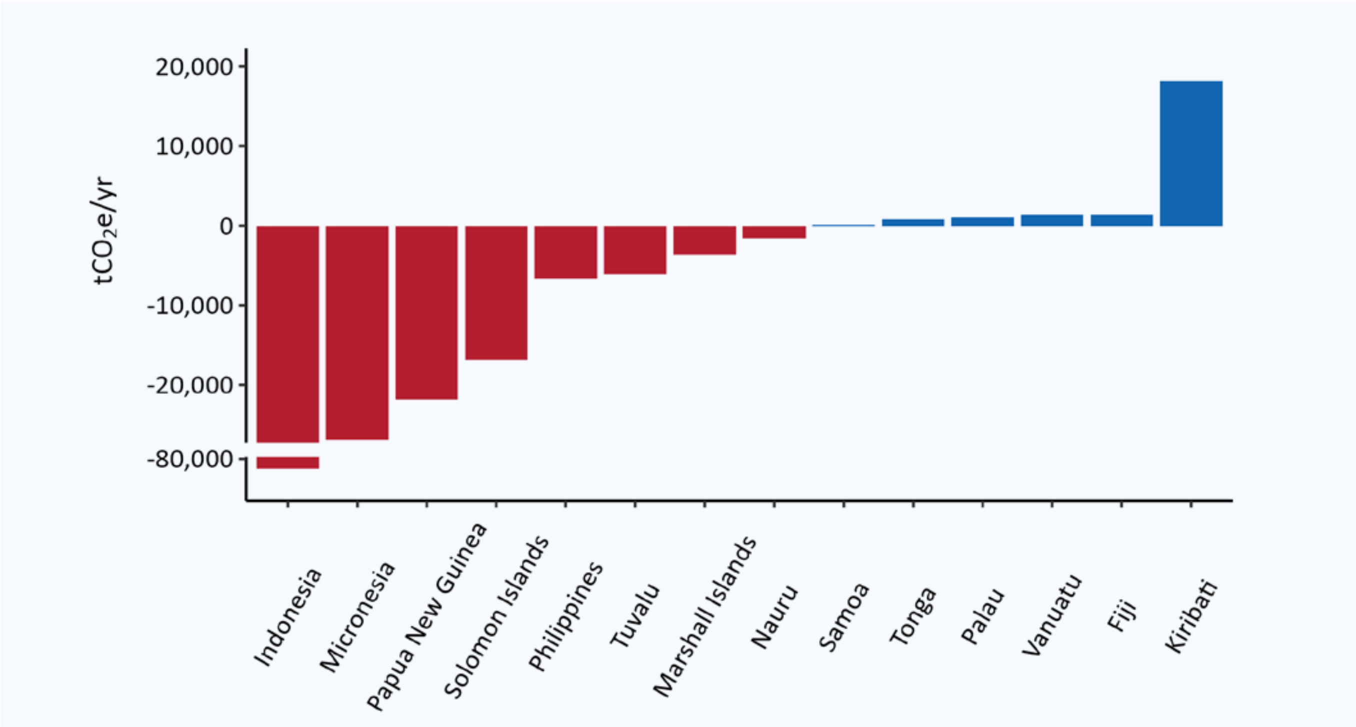


FIGURE 14. Change in future net carbon sequestration by tuna (skipjack, bigeye, and yellowfin) across the study countries, in metric tons of carbon dioxide equivalent per year. Calculated as the mean annual sequestration by skipjack, bigeye, yellowfin tuna populations through the production of waste pellets and deadfall minus carbon removed by fisheries catches for 2044–2053. Future tuna populations from the SEAPODYM model; waste pellets and deadfall after Bianchi et al. 2021 and Mariani et al. 2020 (see detailed methods in Appendix A).

CLIMATE CHANGE MAY MOVE TUNA INTO AREAS OF WEAK GOVERNANCE

For the western and central Pacific as a whole, warming waters are likely to shift skipjack, yellowfin, and bigeye tuna eastward, with an average of 13 percent less tuna biomass available in national waters for the nine Pacific SIDS of this analysis (Bell et al. 2021). This means that a greater percentage of the catch will be caught in international waters (Bell et al. 2021).

As tuna move eastward with climate change, they are more likely to be overfished as a greater proportion of fishing would take place in international waters. Under the United Nations Convention on the Law of the Sea (UNCLOS, signed in 1982), areas beyond 200 nautical miles from shore are considered international waters under shared jurisdiction. Practical constraints and weak international law limit the ability of coastal states to defend their natural resources on the high seas, where illegal, unregulated, and unreported (IUU) fishing is commonplace despite the efforts of regional fishery management organizations (Österblom et al. 2015; Goodman et al. 2022; Pons et al. 2017). The recent High Seas Treaty, also known as the Biodiversity Beyond National Jurisdiction (BBNJ) treaty, aims to address some of the impacts of increased high-seas fishing. Chapter 2 discusses the BBNJ in more detail.

CASE 2

Diversifying Livelihoods and Food Sources with Nearshore FADs in Solomon Islands

Like many countries in the Pacific region, the Solomon Islands' nearshore fisheries may not be able to meet local people's needs by 2030. In response, technologies like nearshore FADs, if designed appropriately, can increase access to fish and play an important role in future food security for coastal communities. With support from New Zealand, the Mekem Strong Solomon Islands Fisheries programme funded WorldFish, the Ministry of Fisheries and Marine Resources, the Secretariat of the Pacific Community, and the University of Queensland to develop a National Inshore FAD Programme (2010–2013). Together, they deployed 21 nearshore FADs, anchored to the seafloor and using four designs, across the Solomon Islands to evaluate their contribution to local food security. The study found that fishers preferred FADs that are accessible by paddle canoes, particularly if deployed less than 5 km from the shore, with a preference for 2 km. Deploying those devices can provide alternative habitat for food sources, redirect fishing pressure, diversify livelihoods, and provide a mechanism for climate adaptation. In addition, fishing closer to shore can help reduce CO_2 emissions, protect lives, and potentially reduce conflicts with industrial fishing (in other nations). Coastal communities with a high dependence on fish and limited access to diverse or productive fishing grounds can benefit from nearshore FADs. Future steps should focus on capacity building so fishers can improve their catch rates and the longevity of FADs. However, nearshore FADs led men to spend more time fishing, and they neglected food gardens, which affected the labor burden of women gardeners. There is a need for recurrent and readily available funds at the national level to support women and to deploy, redeploy, and provide ongoing support to communities (i.e., training, technical advice, site surveys, FAD maintenance). Other nations, such as Palau, RMI, and FSM, are exploring those solutions.

Reference: Albert et al. 2015

PHOTO BY USAID

Opportunities for Investment in Pacific Blue Carbon

This trend analysis strongly supports investment in a bundle of interventions diversified across Indo-Pacific geographies and coastal ecosystems, to secure more than 31 million tCO_2e/yr. Investing in sustainable management of mangrove forests, seagrass meadows and tuna populations across eight countries could enhance and protect the majority of present-day blue carbon sequestration capacity across the region.

Indonesia represents the largest opportunity for a single-country investment because of its large geographic area, with 77 percent of the region's mangroves, 59 percent of known seagrasses, and 27 percent of tuna totaling 22 million tCO_2e/yr. Four additional countries offer opportunities to secure blue carbon in all three ecosystem types, totaling 7.6 million tCO_2e/yr in PNG, the Philippines, Solomon Islands, and Fiji combined (Figure 15).

Mangroves represent the largest single-ecosystem contribution, with 78 percent of carbon sequestration in this analysis. Indonesia's mangrove forests sequester 60 percent of the carbon in this analysis. The top five countries by land area provide the largest opportunities for investment in both seagrass and mangrove carbon sequestration, including Indonesia, PNG, the Philippines, Solomon Islands, and Fiji (Figure 16). There is an extensive and sophisticated community of local organizations working in marine conservation distributed across Indonesia and the Philippines, including in mangrove conservation and restoration, and in seagrass research. However, because mangrove and seagrass interventions are inherently site-specific, investment is also needed in Pacific island countries to secure co-benefits for storm protection, food, and income for communities in sensitive locations, as Chapter 2 discusses in more detail.

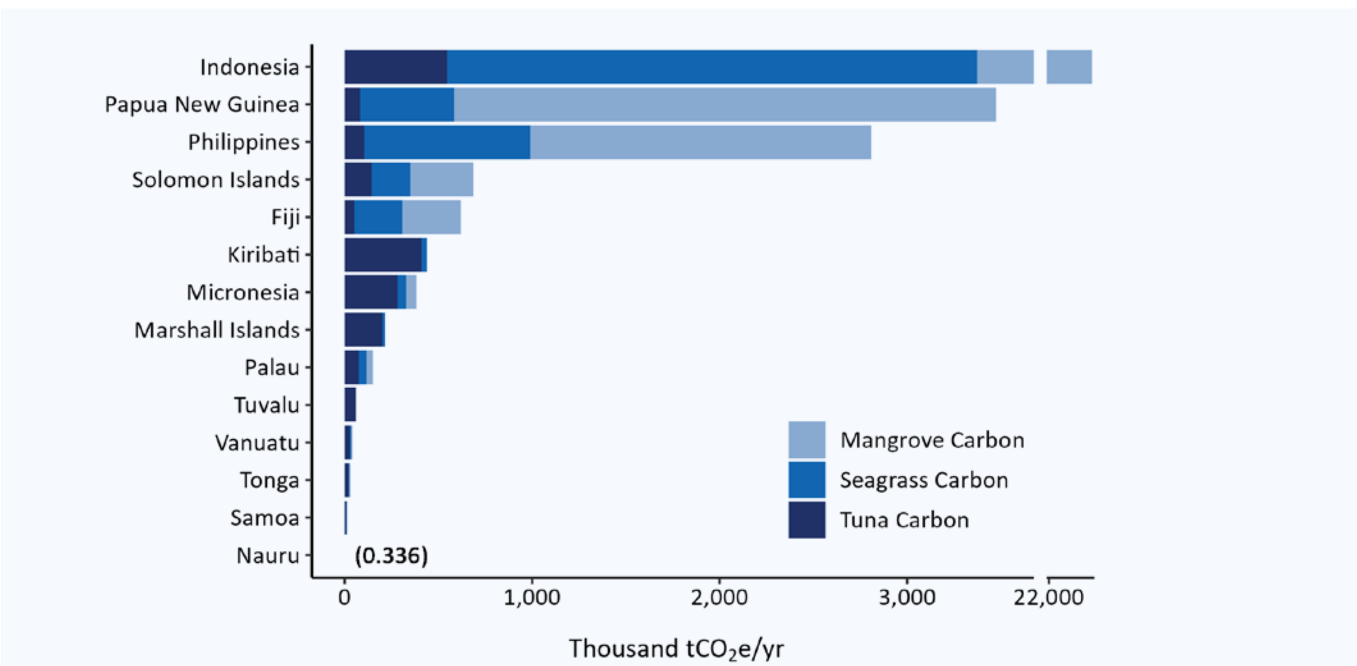
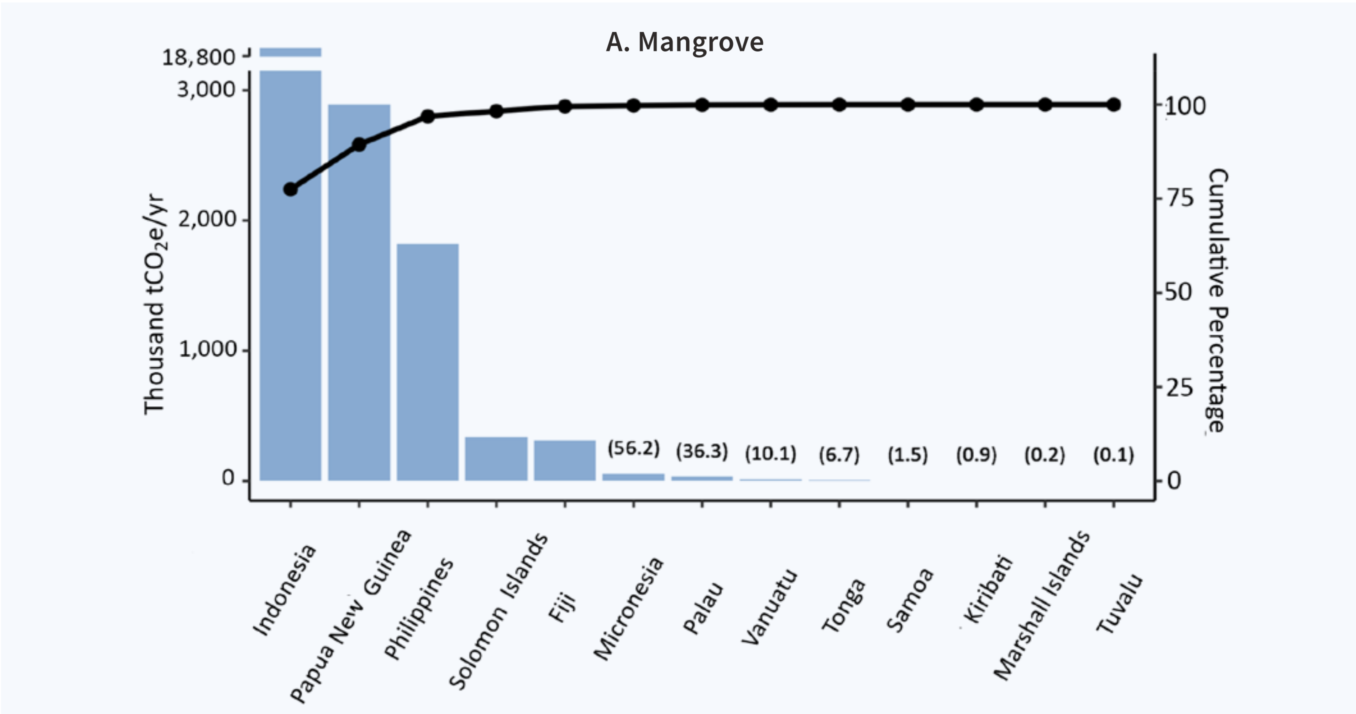


FIGURE 15. Present net carbon sequestration by mangroves, seagrass, and tuna across the study countries, in metric tons of carbon dioxide equivalent per year. The burial of carbon in mangrove sediments is based on average sequestration rate (Alongi 2012) and area of mangroves per country in 2020 (Bunting et al. 2022). The burial of carbon in seagrass sediments is based on average sequestration rate (Mcleod et al. 2011) and area of seagrass per country (Allen Coral Atlas 2023). Net tuna sequestration is estimated for skipjack, bigeye, yellowfin tuna populations through the production of waste pellets and deadfall minus carbon removed by fisheries catches for 2011–2020. Tuna populations from the SEAPODYM model; waste pellets and deadfall after Bianchi et al. 2021 and Mariani et al. 2020 (see detailed methods in Appendix A).



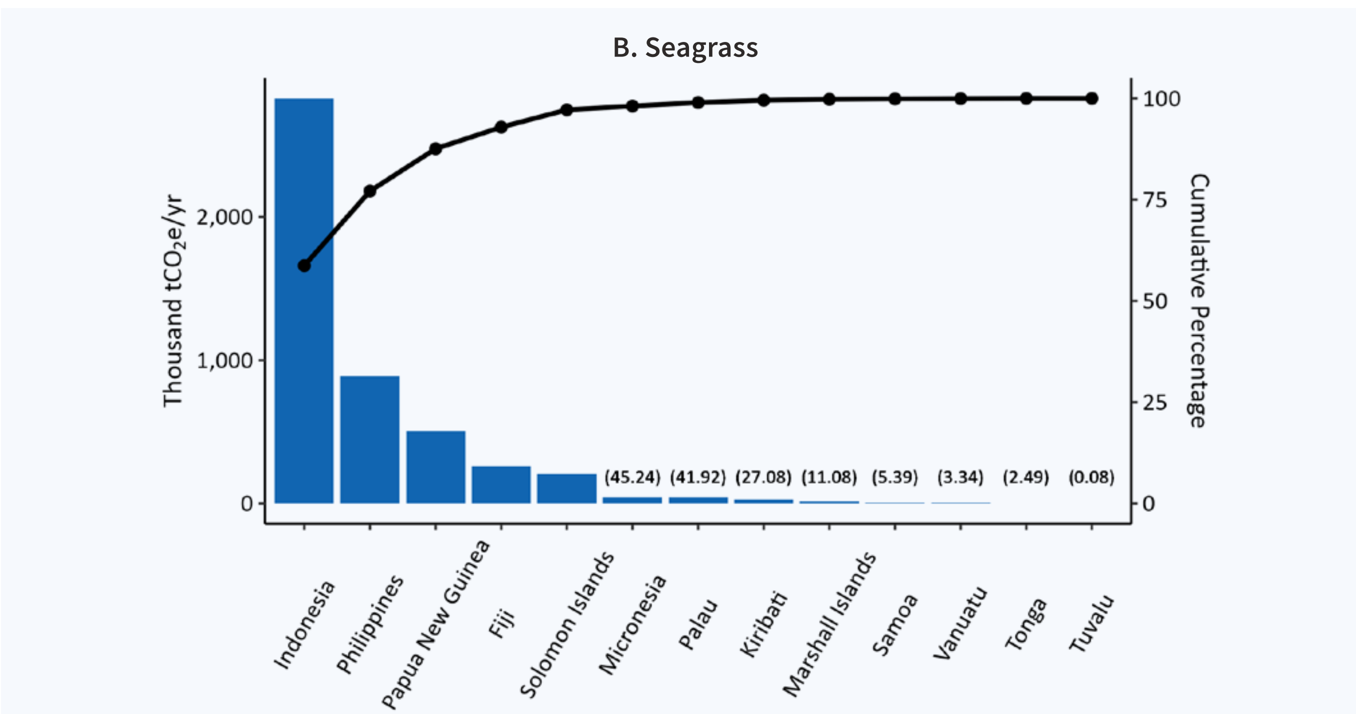


FIGURE 16. Five countries sequester the most carbon in sediment beneath (A) mangroves and (B) seagrass: Indonesia, PNG, the Philippines, Solomon Islands, and Fiji. In panel (A), the burial of carbon in mangrove sediments is estimated in thousands of tons of carbon dioxide equivalent per year (thousand tCO_2e/yr on the left axis), based on average sequestration rate (Alongi 2012) and area of mangroves per country in 2020 (Bunting et al. 2022). In panel (B), the burial of carbon in seagrass sediments is estimated in thousands of metric tons of carbon dioxide equivalent per year, based on average sequestration rate (McLeod et al. 2011) and area of seagrass per country (Allen Coral Atlas 2023). In both panels, the dotted line shows the cumulative progress toward the regional total carbon sequestration potential (percentage on the right axis), with each node indicating the additional carbon sequestration contributed by each country.

Abundant schools of tuna are more evenly distributed than seagrass and mangroves, and these large fish send carbon to the seafloor slowly but steadily across the Indo-Pacific. The national waters of Kiribati, RMI, and FSM stand out for the amount of carbon stored by schools of tuna, in addition to the five countries highlighted above (Figure 17). Unlike seagrass and mangroves, many more Indo-Pacific countries offer significant opportunities to protect and enhance carbon storage by abundant schools of tuna (Figure 17). Tuna is managed at a regional level in Pacific island countries with assessment, management, and technical support provided through the Pacific Community (SPC), Forum Fisheries Agency (FFA), the WCPFC, and other shared resources. The management of tuna for local consumption has the greatest potential for improvement with additional investment (and co-benefits for human health and community resilience, as Chapter 2 describes).

PHOTO BY USAID PHILIPPINES

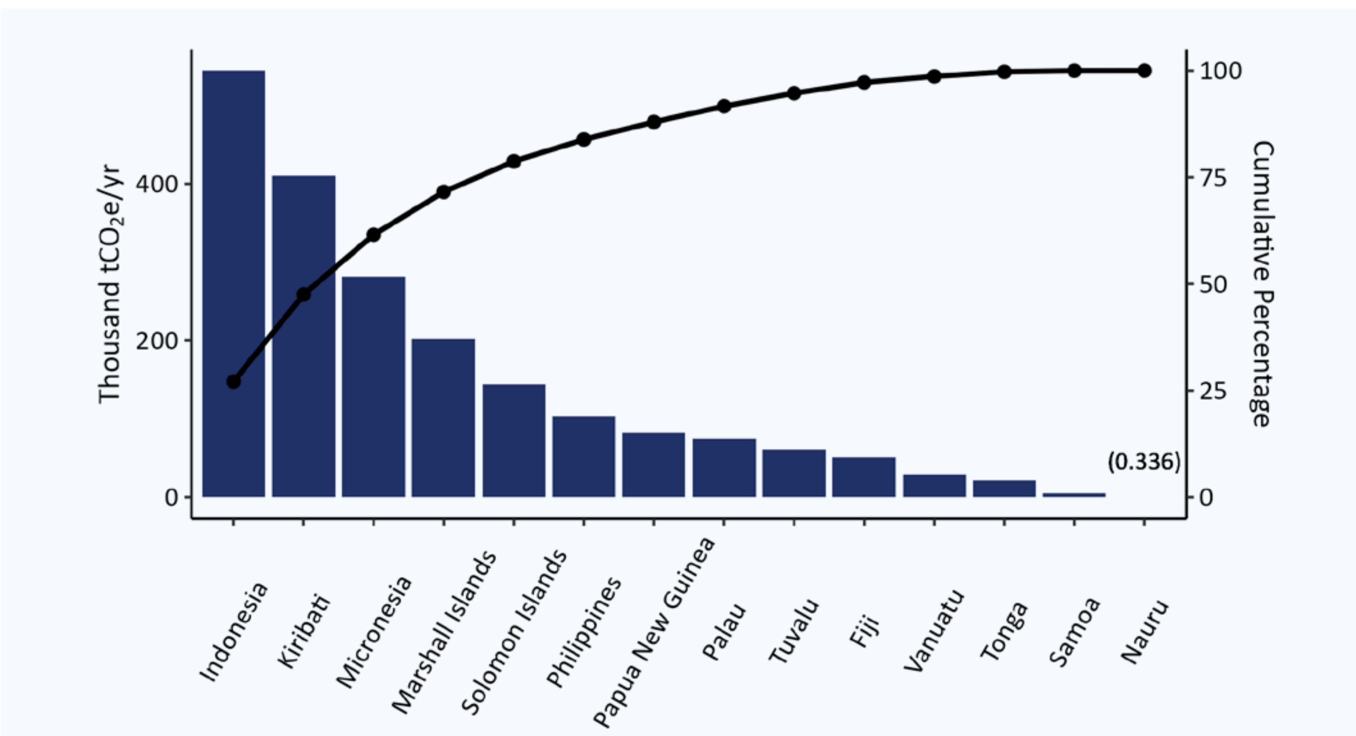


FIGURE 17. Present net carbon sequestration by tuna across the study countries, in metric tons carbon dioxide equivalent per year. Calculated as the mean annual sequestration by skipjack, bigeye, yellowfin tuna populations through the production of waste pellets and deadfall minus carbon removed by fisheries catches for 2011–2020. Tuna populations from SEAPODYM model; waste pellets and deadfall after Bianchi et al. 2021 and Mariani et al. 2020 (see detailed methods in Appendix A). The dotted line shows the cumulative progress toward the regional total carbon sequestration potential (percentage on the right axis), with each node indicating the additional carbon sequestration contributed by each country.

COMPLETE NATIONAL INVENTORIES FOR BLUE CARBON ECOSYSTEMS

In addition to a regional management approach, improving national-level inventories and mapping could advance the conservation of seagrasses, marshes and tidal flats, oyster reefs, and marine fish across the Indo-Pacific, and in some countries' mangroves. For seagrasses, the lack of detailed mapping undermines their legal protection against the constant pressure of coastal development and reclamation, where tidal areas are filled in to extend buildable land. More comprehensive MRV is necessary across the Indo-Pacific to refine an understanding of the distribution and rates of decline, particularly for seagrass meadows and coastal fisheries (Sudo et al. 2021; McKenzie et al. 2021). This trend analysis is conservative because it is limited by current data, and additional monitoring will only expand the total number of opportunities. For seagrasses, most trend estimates are site-specific, and in many places, national maps do not exist. For marine fish, the current estimate is based only on tuna because information on coastal fisheries, and other pelagic fisheries, is very limited for Pacific island countries. The lack of data and technical capacity hinders appropriate investments in blue carbon ecosystems in the Indo-Pacific region.

National forest inventories provide information that helps countries understand, manage, and conserve forests. Although many countries are beginning to recognize the importance of including mangroves in their forest inventories, these ecosystems, which are often located in remote areas that are difficult to access and measure due to tides and dense roots, are often excluded. The Sustainable Wetlands Adaptation and Mitigation Program (SWAMP), a USAID activity jointly implemented by the Center for International Forestry Research (CIFOR) and the United States Forest Service (USFS), assists countries with measuring and monitoring biomass and associated carbon stocks in mangrove forest ecosystems. This could apply to both seagrass and mangroves, helping countries to map the resources while building capacity for the MRV approaches necessary to implement blue carbon projects (R. MacKenzie, USDA, pers. comm.). SWAMP's mangrove inventories have increased the collective understanding of current carbon stocks and losses driven by changing land use in FSM, Indonesia, Palau, PNG, and the Philippines. Projects under the SWAMP program also aim to help these countries reduce their forest carbon emissions and maintain healthy or restore degraded mangroves and peat swamp forests so they continue to support local communities.

PROTECT INTACT MANGROVE AND SEAGRASS FROM COMPETING LAND USES

The conservation of intact mangrove forest is the most effective way to protect or build back associated carbon stocks, sequester carbon, and prevent carbon losses. For both mangroves and seagrasses, changing land use in the coastal zone is a primary threat, often for urbanization and tourism development. Mangroves are often cut to make way for these competing land uses, and seagrasses may be covered up by fill to produce new land. Both mangroves and seagrasses are also vulnerable to upland changes in water and sediment flow.

Successful mangrove conservation projects require commitments from both governments and local communities who need continued access to forest resources (Shackleton et al. 2012). In Indonesia, protected areas have been successfully implemented to slow deforestation in an estimated 14,000 ha from 2000 to 2010 (Miteva et al. 2015). To achieve local cooperation and buy-in, the benefits of conservation must be communicated in ways that are meaningful to local communities, and projects should propose alternative forms of income (Schwerdtner Máñez et al. 2014). At the national scale, including mangrove areas in international agreements, such as the Ramsar Convention, may reinforce national protection actions by stressing international accountability (Lugo et al. 2014).

Protecting intact seagrass meadows from disturbance is the primary intervention to ensure continued carbon sequestration (Statton et al. 2018). An estimated 25 percent of seagrass area lies within existing marine protected areas (MPAs) in Indonesia; however, a large proportion of these are in MPAs with unspecified levels of protection (Sudo et al. 2021). An estimated 22 percent of known seagrass area in the Philippines is located in MPAs, the majority of which have International Union for Conservation of Nature (IUCN) protection level V—protected landscape/seascape (Sudo et al. 2021). Of the Pacific island countries, the largest combined area of seagrass located in MPAs is in Fiji, followed by Palau, PNG, Solomon Islands, Kiribati, and RMI, respectively.

TRANSITION FROM UNSUSTAINABLE AQUACULTURE TO MANGROVE REFORESTATION

Land conversion for aquaculture and agriculture is a primary driver of mangrove deforestation, both globally (Bhowmik et al. 2022) and in Indonesia and the Philippines (Fauzi et al. 2019). An economically viable transition to more sustainable aquaculture is critical to prevent further deforestation. For example, in Ca Mau, Vietnam, shrimp aquaculture operations are required to maintain a minimum forest-to-pond ratio, with ongoing adaptive management to ensure the arrangement continues (Ha et al. 2012 in Romañach et al. 2018). In Guang Xi, China, abandoned shrimp aquaculture ponds have been reforested with mangroves, together with the installation of artificial habitats to raise fish and crabs in underwater tubes as the mangroves regrow (Chen et al. 2021). Ten years into this transition, carbon sequestration has increased, and aquaculture production has ensured continued support for reforestation in local communities (Chen et al. 2021). This approach increases the tree canopy over time, in contrast with the usual approach of clearing mangroves for shrimp ponds, and is economically viable with profits estimated between $27,000 to 45,000 per ha annually (Fan et al., 2013 in Romañach et al. 2018). Bankable projects like these demonstrate the potential for a reliable return on blue carbon investments (more on this in Chapters 2 and 3).

PHOTO BY USAID

CASE 3

Designation of RAMSAR Sites Across the Region to Protect Wetlands and their Social and Ecological Benefits

Across the region, parties to the Ramsar Convention include Fiji, Indonesia, Kiribati, Palau, Philippines, PNG, RMI, Samoa, and Vanuatu. The protection, management, and restoration of blue carbon ecosystems can become stronger through the designation of new Ramsar Sites and the enhanced management of existing sites to mitigate threats leading to wetland degradation and loss (Denyer et al. 2018; Fennessy and Schille Beers 2021). In 2018, the Ramsar Site Information Service listed approximately one-third of the 319 Ramsar Sites in the Philippines (six sites—247,292 ha), Indonesia (seven sites—1,372,976 ha), and 80 wetlands in Oceania (9,051,211 ha) as marine or coastal wetlands. The Ramsar Strategic Plan 2016–2041 encourages Contracting Parties to promote and strengthen the participation of Indigenous Peoples and local communities as key stakeholders for conservation and integrated wetland management. Cultural values of the Ramsar Sites in these two regions are relatively high, with 94 percent in Asia and 98 percent in Oceania, where wetlands are strongly linked to either the presence of sacred sites, interaction with local communities or Indigenous Peoples, or the application of traditional knowledge and practices. A number of case studies from across Asia and Oceania illustrate how cultural values and practices, including traditional knowledge and community participation, have contributed to sustainable development and positive conservation outcomes for wetlands (Denyer et al. 2018).

PHOTO BY JASON HOUSTON

INNOVATIVE FINANCING FOR MANGROVE AND SEAGRASS CONSERVATION

A number of seagrass conservation projects are now underway and are assessed for additionality (i.e., the carbon sequestration that occurs because of the project intervention). Japan has two blue carbon ecosystem projects focused on seagrass, in Yokahama Bay and in Hakata Bay (Fukuoka City) (Kuwae et al. 2022). Local financing to manage existing eelgrass beds in Sea Park Yokohama first came from offsets for emissions from short-term events in the city, based on assessment of the 7.8 ha of eelgrass bed area conducted by hand using GPS loggers. This financing is now available as a credit to corporations to offset ongoing activities starting in 2016 (Kuwae et al. 2022). The area for 15.6 ha of existing eelgrass beds in Fukuoka was estimated using photos from an aerial drone and corrected using field measurements by divers.

Local financing to manage the Hakata Bay seagrass beds comes from 2.5 percent of port fees and is channeled through a fund managed by the city of Fukuoka, the "Port Environment Improvement and Conservation Fund Reserve" (Kuwae et al. 2022). On a local scale, seagrass meadows in the Pacific could be assessed by divers, drones, and remote sensing in the same way, and financed through port fees, hotel fees, or other enterprises in the blue economy (blue carbon finance options are discussed in the final section of this report). On a national scale, estimates of investable seagrass carbon in the Indo-Pacific could also follow the example applied to mangroves, where current rates of habitat loss were applied to existing stocks using the Verifiable Carbon Standard (VCS), the most widely used voluntary greenhouse gas program globally (Zeng et al. 2021).

Earnings from sustainable non-timber forest products from mangroves can also provide incentives for conservation. For example, the Mangoro Market Meri (women's mangrove market) has developed a local market for crabs and shellfish gathered sustainably from the mangrove forest in PNG (Maniwavie and Konia 2020). In Indonesia, mangrove honey has been developed as a non-timber forest product (ELTI 2023), which became increasingly popular as an immunity booster during the pandemic (IDH 2020). Mangrove fruits have also been developed as a coffee supplement in Indonesia, and as a sustainable product contributing to mangrove conservation (Kaha 2023; Zahriani Alvina pers. comm.).

Payments for ecosystem services (PES) also have potential to address the externalities of coastal land development, while stabilizing the financial incentives for communities to conserve mangroves. For example, economic analysis of India's fisheries investment and production found that states with more mangroves produce 23 percent more fish (Anneboina and Kumar 2017). The impact of mangrove restoration on marine fish production nationwide is estimated at 1.86 metric tons per ha of mangrove, worth INR 68 billion in 2013, or $1.09 billion in 2023 values (Anneboina et al., 2017 in Romañach et al. 2018). Mangrove ecosystem services in Southeast Asia have been estimated in more than 100 sites, with a mean value of $4,185 per ha annually (Brander et al. 2012 in Romañach et al. 2018).


PHOTO BY JASON HOUSTON

RESTORE DEGRADED MANGROVE AND SEAGRASS AREAS

Achieving resilient coastlines will require restoration along with conservation to help sustain progress in reducing the rates of loss. World Wildlife Fund (WWF) reported in 2021 that 51 countries included restoration of coastal wetlands in their updated NDCs; 43 of those explicitly mention mangroves, including Fiji, Indonesia, and PNG (Bakhtary et al. 2021). In 2020, Indonesia announced a target of rehabilitating mangroves in 600,000 ha by 2024, with support from World Bank funding (World Bank 2023). However, this ambition may be limited to ~200,000 ha by land ownership in potential restoration sites (Sasmito et al. 2023). Planting to date included the Ngurah Rai Grand Forest Park, Bali in 2022 and a reported 33,000 ha in 2021 (Abdullah 2022).

Reforesting land that was previously mangrove provides greater restoration success and has also been shown to have greater carbon storage potential compared to planting mangroves in other areas (Song et al. 2023). It is important to tailor restoration project designs to the specific hydrology and species composition of each site, and to protect the water and sediment flows that sustain restored mangroves. Many mangrove restoration projects face challenges due to poor site selection, leading to tree planting in unfavorable environmental conditions or without community support (Lovelock and Brown 2019).

PHOTO BY USAID

However, this trend can be reversed by addressing key enabling conditions, such as landholder preferences, government support, strong commodity markets and incentives, or payments for blue carbon, restoration, or ecosystem services (Lovelock et al. 2022).

One well-known example of successful seagrass restoration has been ongoing (since 1999) in the coastal lagoons of Virginia, USA. The large-scale seed restoration of an area with virtually no seagrass coverage resulted in a total of 36 km^2 of vegetated substrate (Orth et al. 2020). These well-developed seagrass meadows now support productive and diverse animal communities, improve water quality, and sequester substantial amounts of carbon and nitrogen (Orth et al. 2020). Successful seagrass restoration projects have also been documented in Florida, USA (Rezek et al. 2019), Australia and New Zealand (Tan et al. 2020), and Japan (Kuwae et al. 2022, see text box below).

The Virginia case study exemplifies best practices, such as careful site selection, removal of threats prior to planting, and introduction of large numbers of plants/seeds to: 1) increase trial survival by spreading risks, and 2) increase population growth by enhancing self-recruitment (Van Katwijk et al. 2015). Seagrass habitats of the Pacific islands have also shown some resilience to human impacts (McKenzie et al. 2021). However, successful seagrass restoration projects are currently limited to a scale that is orders of magnitude lower than the scale of loss (Statton et al. 2018).

STRENGTHEN REGIONAL, NATIONAL, AND LOCAL FISHERIES MANAGEMENT

While it is not possible to prevent tuna from migrating, there are several opportunities to ensure abundant marine fish populations continue sequestering carbon and supporting communities. At the national level, climate-driven losses of tuna carbon sequestration will fall most heavily on Indonesia, the FSM, PNG, and Solomon Islands. In terms of blue carbon, FSM may be most affected by declines in tuna because marine fish are the largest natural source of blue carbon sequestration with more modest estimates for mangroves and seagrasses.

Although Indonesia is projected to experience the largest absolute reduction in tuna populations due to climate change, the mangrove forests offer a more immediate opportunity for investment in blue carbon conservation and protection. FSM, PNG, and the Solomon Islands also face immediate financial losses due to tuna migration, which will place at risk the $41 million to $134 million annual fishing access fees charged by each of these three countries (Bell et al. 2021).

Since Pacific island countries manage fisheries primarily at the regional level, the tuna example suggests that strengthening the existing mechanisms for regional governance is a key starting point to address climate-driven fisheries declines. As tuna migrate into the high seas, they will be exposed to the currently minimal management capacity and regulatory controls on distant-water fleets in international waters. To maintain a sustainable spawning stock biomass of tuna despite increased illegal, unregulated and unreported fishing on the high seas, overall fishing effort could be reduced. This would create a buffer for future risk of population declines under weakened governance on the high seas, by increasing the number of adult fish sequestering carbon and contributing to population growth. However, the more durable solution is to increase compliance with regional governance agreements.

There are abundant national-scale opportunities to increase the populations of tuna and other marine fish in the Philippines and Indonesia, as USAID activities such as Fish Right (USAID) in the Philippines and Ber-Ikan (USAID) in Indonesia have demonstrated. Measures that reduce other sources of fish population declines, such as IUU fishing, can prepare the ecosystem to be more climate-resilient. Despite greater data collection compared to the regional standard, Indonesia and the Philippines also offer extensive opportunities for investment in fisheries monitoring and stock assessment, which could enable the recovery of increased spawning stock biomass of marine fish, increasing their resilience and contribution to carbon sequestration.

BUFFERING CATCH DECLINES IN COASTAL COMMUNITIES

Near-term interventions in the national waters of FSM, PNG, and the Solomon Islands can ensure that vulnerable coastal communities retain access to tuna for as long as possible. Increasing the allocation of tuna to coastal fisheries, and responsible fishing on anchored FADs (as in Bell et al. 2018; Tilley et al. 2019) can reserve tuna that remain in national waters for food security and slow the pace of climate-driven tuna migrations. Small island communities may also need a combined approach where traditional subsistence is supplemented with alternatives, as both tuna and coral reef fishing become less reliable in some locations (Andrew et al. 2022). Chapter 2 provides more in-depth perspectives on how these changes will affect communities.

Climate information services also have potential to increase access to tuna on nearshore FADs for coastal communities during changes in weather patterns and fish distribution (Dunstan et al. 2018; Hobday et al. 2018; Bell et al. 2018). With additional capacity-building and technical support, coastal fisheries management measures could be tuned to changing ocean conditions to generate information or incentives for part-time fishers to invest time in agriculture vs. fishing on a daily or weekly basis (Dunstan et al. 2018).

In the long-term, transformational adaptation will be needed (Hobday et al. 2018), in this case to address persistent redistribution of tuna resources. Multi-year swings in productivity during El Niño Southern Oscillation (ENSO) cycles are moderated by the vessel day scheme for fisheries management[4] in the west and central Pacific, which allows countries with less tuna to sell their fishing rights to countries with more tuna (Bell et al. 2021). However, lasting catch declines in the most affected countries may require new measures, potentially adapting how tuna access fees are distributed and considering additional sources of income from regional approaches to blue carbon across both coastal and offshore ecosystems.

[4] Vessel day scheme is a management measure that sets a limit on the number of days purse seine vessels are allowed to fish in the waters of the Parties to the Nauru Agreement group of countries and Tokelau.

CHAPTER 2

Blue Carbon Ecosystems and Communities—Risks and Solutions

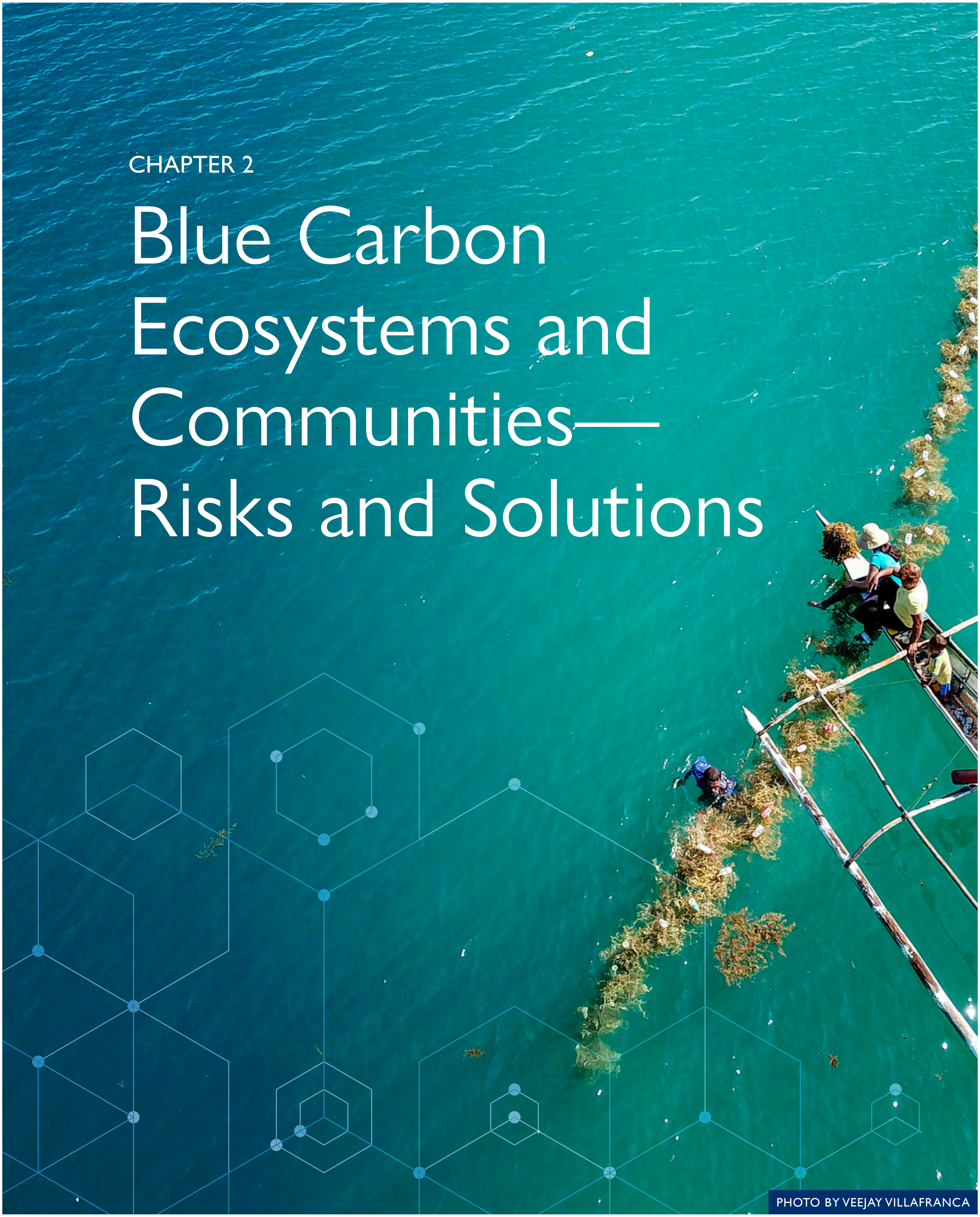


PHOTO BY VEEJAY VILLAFRANCA

Blue carbon ecosystems support livelihoods, economies, cultures, and climate adaptation in Indo-Pacific nations. The degradation and loss of blue carbon ecosystems therefore poses multiple risks to Indo-Pacific communities. Without coastal protection from intertidal wetlands, mangroves, and seagrass, people and infrastructure along the coast are more vulnerable to climate impacts, such as storm surges (Costanza et al. 2021). The loss of nursery habitats and fishing grounds critical to subsistence and commercial activities jeopardizes the viability of local economies, livelihoods, food security, and public health (Bennet et al. 2023). Pacific societies view their associations with their environments as integral to their identity and systems of knowledge (Smith and Jones 2007), but migration driven by economic and climate threats removes people from place-based systems of knowledge (Smith and Jones 2007). These threats disproportionately affect women, children, Indigenous Peoples, people with disabilities, and other marginalized groups whose livelihoods are often undervalued in standard economic and market analyses, and who have less access to information, resources, and decision-making power (Benett et al. 2021). In response, Indo-Pacific nations are taking action to address the risks associated with blue carbon ecosystem degradation and the climate impacts that exacerbate these risks.

PHOTO BY OUIE SANCHEZ

This chapter describes the diverse and complex risks—economic, social and cultural, nutritional, and food security—that communities face as a result of the degradation of blue carbon ecosystems, and how climate change exacerbates these risks. The chapter also presents a suite of solutions that integrate indigenous knowledge-practice-belief systems and modern ecosystem-based approaches and policy instruments to empower coastal communities in restoring, protecting, and more sustainably managing blue carbon ecosystems.

Risks to Indo-Pacific Communities

This section discusses several categories of risk that local communities face due to the degradation and rapid loss of blue carbon ecosystems and natural resources across the Indo-Pacific region (Figure 18).

ECONOMIC RISKS

The degradation and loss of blue carbon ecosystems causes direct economic risks to Indo-Pacific nations by diminishing the provision of ecosystem services that support communities. At national and local scales, the loss of blue carbon ecosystems jeopardizes tourism operations, shoreline protection, sources of food and materials, and fisheries livelihoods (Barbier 2017). For example, mangroves alone provide an estimated \$2.7 trillion in ecosystem services per year in some cases (\$194,000 per ha) (Costanza et al. 2014). Table 2 provides estimates of the value of mangrove ecosystem services for the countries considered in this report.

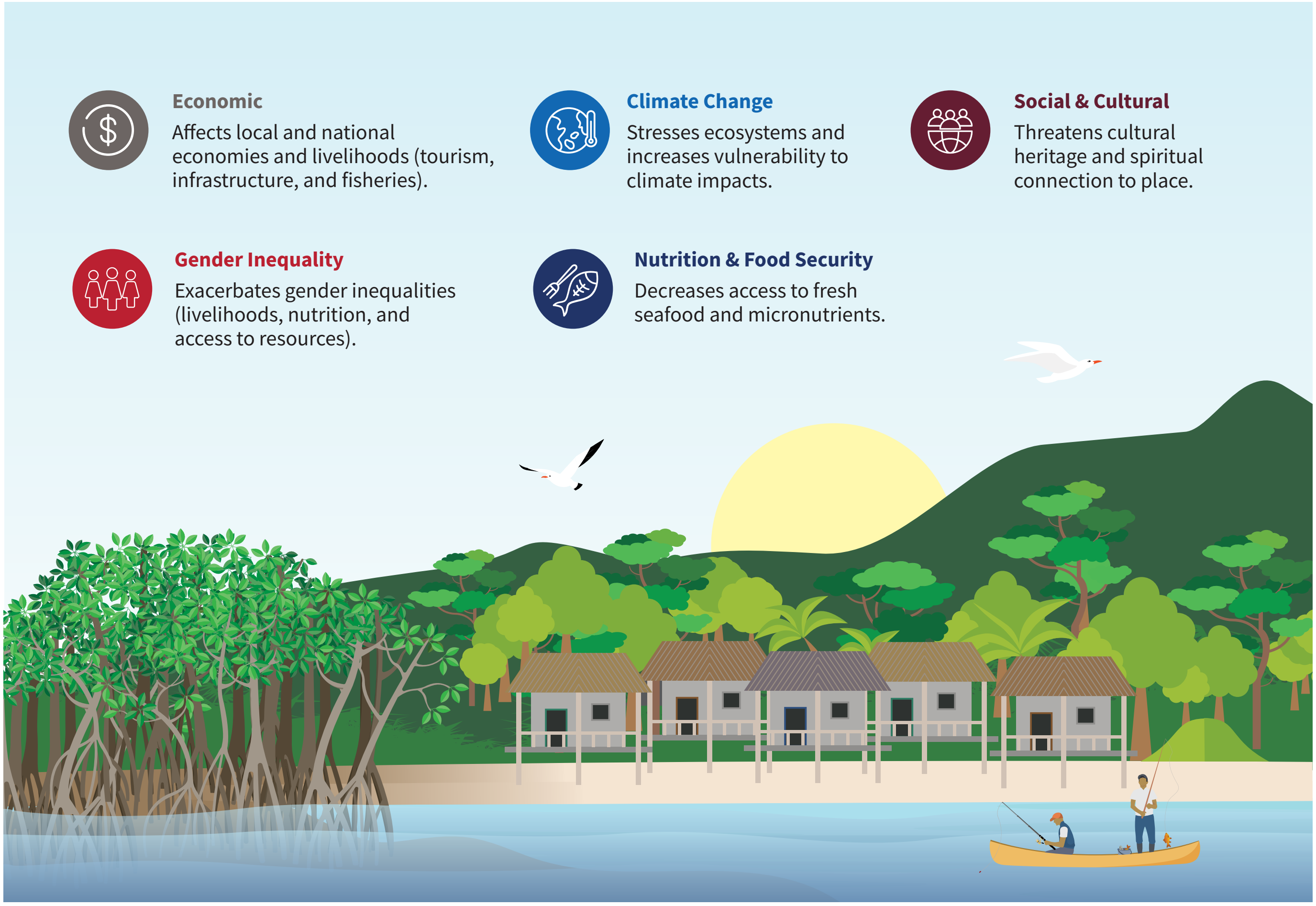


FIGURE 18. The degradation and loss of blue carbon ecosystems poses multiple types of risks to communities—economic, social and cultural, gender inequity, nutrition and food security, and climate-related risks. Climate change exacerbates other types of risks and leaves blue carbon ecosystems and communities more vulnerable to future climate impacts. Figure design by Giada Mannino and Jade Delevaux.

TABLE 2. Area of mangroves and market value of carbon sequestered by mangrove ecosystems. Mangrove area is based on Global Mangrove Watch (Bunting et al. 2022) and value per hectare is based on analysis in this report.

Country	Mangrove area (ha)	Market value of carbon sequestered by mangrove ecosystems (USD)
Fiji	48,810	$10,910,075
Indonesia	2,953,000	$660,093,313
Kiribati	146	$32,632
Marshall Islands	33	$7,376
Micronesia	8,794	$1,965,486
Nauru	0	$0
Palau	5,688	$1,271,285
Papua New Guinea	452,500	$101,129,296
Philippines	284,800	$63,653,207
Samoa	232	$51,853
Solomon Islands	52,651	$11,767,657
Tonga	1,043	$233,114
Tuvalu	9	$2,011
Vanuatu	1,584	$354,029

Tourism

Tourism is an important contributor to economic growth and employment in many national and local economies in the Indo-Pacific. Recreational fishing and boating outfitters, ecotourism operations, lodging facilities, restaurants, and other guest services have valuable infrastructure in coastal areas and depend on blue carbon ecosystems and local natural resources to attract tourists and support their businesses. The tourism sector constitutes 10–40 percent of GDP in Fiji, Palau, Samoa, and Vanuatu. Visitation nearly tripled in the two decades preceding the COVID-19 pandemic, from 686,000 in 2000 to 1,870,000 in 2019 (Balasundharam and Koepke 2021). Tourism's contribution to GDP is lower in this study's focal Asian countries—2.4 percent in 2021 for Indonesia (OECD 2023) and 6.2 percent in 2022 for the Philippines (Philippine Statistics Authority 2023), but is still closely tied to these countries' blue carbon ecosystems and the communities that surround them. In Indonesia, tourism provided 10.95 million jobs in 2021, representing 8.3 percent of total employment (World Travel & Tourism Council 2022). In the Philippines, employment in tourism in 2022 was 5.35 million, or 11.4 percent of total employment (Philippine Statistics Authority 2023). If degradation or the loss of blue carbon ecosystems reduces the ability to attract tourists, blue carbon-based tourism economies will experience significant impacts.

Shoreline protection and coastal infrastructure

Approximately 71 percent of the Indo-Pacific's population (excluding PNG) live within one km of the coast (Andrew et al., 2019). Mangroves, seagrass beds, and coastal wetlands act as a buffer against storms and wave energy and play an important role in protecting shorelines and infrastructure in coastal communities. At the global scale, coastal wetlands provide storm protection valued at $447 billion per year (Costanza et al. 2021). Mangroves alone provide $65 billion in flood protection for 15 million people worldwide per year (Menéndez et al. 2020). Due to their high ratio of coastal-to-inland areas, Indo-Pacific communities especially benefit from blue carbon ecosystems' capacity to buffer storm impacts. For example, in the Philippines, mangroves prevent damages of more than $1 billion in built capital every year and protect more than 600,000 people from flooding impacts, many of whom live in poverty (WAVES 2017). In Indonesia, mangroves avert land flooding over 84,000 km^2 and prevent damage for 250,000 people (Menéndez et al. 2020). Similarly, in the Solomon Islands, mangroves avert flood damages to property in an amount equivalent to 1.07 percent of GDP (Menéndez et al. 2020).

Pelagic fisheries

The previous chapter describes pelagic tuna fisheries' key role in the local and national economies of Indo-Pacific countries. Commercial tuna fisheries represent a significant part of the blue economy, with seven species (skipjack, albacore, bigeye, yellowfin, Atlantic bluefin, Pacific bluefin, and southern bluefin) among the most valuable fishes on the planet. Indonesia and the Philippines produce more than 20 percent of the tuna landed in the Western and Central Pacific Ocean. Tuna fishing license fees generate 30–100 percent of all government revenue for six of the Pacific island nations. In 2018, commercial fishing vessels landed roughly 5.2 million metric tons of the seven species. The estimated dock value (i.e., total paid to fishers) was $11.7 billion, while the end value of the commercial fisheries (i.e, total paid by final customers) was $40.8 billion. These estimates do not include the substantial subsistence and artisanal fisheries values, unreported catch, and ecosystem benefits of tunas (Pew 2020). They also do not account for the social value of blue carbon ecosystems, which this report highlights in the accompanying case studies (distributed throughout this report and in Appendix B) and in the country profiles that accompany this report (in press at the time of report publication).

> Globally, fisheries in the high seas have extracted an estimated 43.5 percent of the blue carbon in areas that would be economically unprofitable without subsidies (Mariani et al. 2020).

Globally, fisheries in the high seas have extracted an estimated 43.5 percent of the blue carbon in areas that would be economically unprofitable without subsidies, considering the proportion of fish biomass of many commercially targeted species that would otherwise have sunk as a carcass to the deep ocean (Mariani et al. 2020). Government subsidies have enabled fishing fleets to burn large amounts of fossil fuel to reach remote fishing grounds in the high seas (an issue exacerbated by climate change, as Chapter 1 described). Subsidies support unsustainable fishing activities, even when fish stocks and catch rates

PHOTO BY MARGOT STILES

are low because of overexploitation. Therefore, overexploiting fish stocks has likely reduced the contribution of marine vertebrates to blue carbon sequestration over vast ocean areas for decades. Limiting blue carbon extraction or disincentivizing overextraction by fisheries in unprofitable areas would reduce CO_2 emissions by burning less fuel and would expand the carbon sink by rebuilding fish stocks and the increase of carcass deadfall (Mariani et al. 2020).

Coastal fisheries

In many communities across the Indo-Pacific region, fishing is the primary livelihood strategy when alternatives are limited (Béné et al., 2016). In Indonesia, small-scale coastal fisheries are valued at $2.4 billion, providing livelihoods for 80 percent of 2.4 million fishers and 50 percent of the fish catch (Rare 2023). Likewise, small-scale coastal fisheries in the Philippines are valued at $981 million, supporting 85 percent of 1.9 million fishers and providing 50 percent of the fish catch (Green et al., 2003; Rare 2023). Across the Pacific region, 70–80 percent of inshore fisheries catch (reefs, estuaries, and freshwater) is used for subsistence (Lambeth et al. 2002), while 20 percent goes to commercial markets (Dalzell et al. 1996; Gillett and Lightfoot 2001). Small-scale fisheries employ 90 percent of people who work in capture fisheries, although this is often part-time, marginalized work that can come into conflict with industrial fishing (FAO 2016; Quiros et al. 2021).

Although the annual seafood market from mangroves is valued at $7,500–167,500 per square kilometer (Crooks et al. 2011), mangrove forests are being destroyed and the land converted to aquaculture that produces mainly fish, shrimp, and crabs (Hashim et al. 2021). In some cases, aquaculture is highly dependent on inputs that can further damage the surrounding ecosystem (Sulit et al. 2005; Froehlich et al. 2018). The conversion of mangroves to other uses leads to estimated economic losses of $500–1,550 per ha/year by reducing fish catch and fishing revenues (Song et al. 2021), as well as increasing environmental risks, as discussed in the previous section.

Seagrass meadows also support high-value fisheries, although their contribution is not as well quantified as that of mangroves. In Derawan, Indonesia, capture and shellfish fisheries associated with seagrass beds have a total value of $49,233 per ha/year (Kurniawan et al. 2020). In Lombok, Indonesia, the estimated annual total economic value of fish and marine biota from seagrass beds is $61,774 per ha (Zulkifli et al. 2021).

Disruption of subsistence or local fishing opportunities due to the ongoing decline of blue carbon ecosystems causes people to look for opportunities further afield. This may mean migrating away from their homes and into urban areas, or being recruited onto distant water fishing vessels, which are sometimes operated illegally and/or with abusive labor practices (Selig et al. 2022; Maefiti 2021; Dauost 2021). This increases their vulnerability by removing them from their communities and place-based systems of knowledge (see the next section), as well as risking exposure to human rights violations (Syddall et al. 2022).

Women's Livelihoods Depend on Blue Carbon Ecosystems

The decline of blue carbon ecosystems affects women disproportionately. Women make up nearly half of the workforce in the fisheries sector in developing countries, 90 percent of seafood processing workers, and more than half of coastal tourism jobs (World Bank 2022). They depend on mangroves more than any other user group (Steele et al. 2006; Iftekhar and Takama 2008) for firewood, nearshore fisheries and gleaning, and livelihood strategies. However, women generally have lower capacity to adapt to climate change impacts on blue carbon-dependent livelihoods because they often lack access to information, technical assistance, and resources.

Women also experience other conditions that exacerbate their vulnerabilities to blue carbon ecosystem losses. Many women work in lower-value activities, such as processing areas of the value chain, where they endure harsh conditions (e.g., long hours in fish processing plants without restrooms or breaks), while men work in higher-value activities (e.g., high-value export tuna and shrimp fisheries). Women also carry out many forms of informal labor related to supporting their homes and communities (e.g., subsistence fisheries, household chores, child care, gardening). These activities and women's other contributions to the economy and society are often undervalued and not adequately captured in statistics.

Preserving and restoring blue carbon ecosystems provides opportunities for women's climate adaptation. Women depend more on mangroves and seagrass ecosystems for fishing and gleaning. These ecosystems are more resilient to climate change than offshore tuna, given its predicted climate-induced range shifts in distribution. Global markets are increasingly demanding shellfish, which can be sourced from mangroves and seagrass habitats, and sustainably farmed in coastal areas (see silvofisheries section and case study #5). Initiatives such as the non-binding voluntary commitment blue carbon project code of conduct (Blue Forests Project 2017) can support the development of fair, socially just, and accountable blue carbon projects that can help sustain women's blue carbon-dependent livelihoods (based on Bennett et. al. 2017).

SOCIAL AND CULTURAL RISKS

The decline of blue carbon ecosystems also threatens the biocultural heritage of the region, diminishes the well-being of Indigenous Peoples, and exacerbates social inequities (McNamara et al. 2021).

Biocultural heritage and identities

Mangroves and seagrass beds support a traditional way of life, spiritual fulfillment, and identity for fishers and communities (McKenzie et al. 2021). For thousands of years these communities have inhabited coastal areas and selectively used coastal and mangrove species for firewood, construction and boat building materials, woodcarving, medicines and ritual foods, food security, and contributions to cultural heritage and identity (Thaman 2002; Bennett et al. 2023). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' (IPBES) recent global assessment reported negative trends in 72 percent of the indicators that Indigenous Peoples and local communities have developed to monitor changes in ecosystem services (Bennett et al. 2023).

Although the contribution of seagrass to people's well-being is not well documented in peer-reviewed literature, its value to local fisheries is apparent. Seagrass beds are accessible fishing grounds that host high abundance of fish and invertebrates and contribute to food security and livelihoods by providing opportunities for intertidal gleaning and nearshore free diving (McKenzie et al. 2021; Quiros et al. 2021). Gleaning is one of the oldest and most widely used fishing methods at any time of day or night (McKenzie et al. 2021) and is conducted primarily by women. It is also a more accessible subsistence and livelihood strategy for people with disabilities or mobility issues. Traditionally, men fish beyond the reef, while women fish and collect invertebrates in lagoons and inshore areas (Lambeth et al. 2002). Low-income fishers favor seagrass beds over coral reefs, mangroves, or open ocean because seagrass beds are accessible, do not require boats, and are less likely to damage fishing gear (Jones et al. 2022).

Gender inequity

The decline of mangrove and seagrass ecosystems and associated fisheries benefits affects women disproportionately (see text box above). Although women are typically overrepresented in informal, lower-value, dock-side, and unpaid activities of seafood supply chains (such as subsistence fishing, catch processing, and marketing), these numbers are rarely represented in fisheries statistics (FAO et al. 2022).

Patriarchal norms in some parts of the Pacific region increase the likelihood that women and youth are overlooked in community consultations or in the provision of resources, such as funding, training, and livelihood opportunities (Mangubhai & Lawless 2021). For example, women do not receive the same level of government support as men following a crisis (Bennett et al. 2023). Furthermore, women are frequently excluded from land and resource tenure and decision-making (Barclay et al. 2022; Mangubhai & Lawless 2021), and 55 percent of aquatic food production policies do not reference gender (Hicks et al. 2022). Indigenous women's and girls' vulnerability to fisheries' decline threatens the transfer and use of traditional ecological knowledge related to fisheries (Bennett et al. 2023). However, women play a critical role in achieving food security (Gustafson et al. 2016), and there is evidence that blue foods tend to be more affordable and economically accessible when there is gender equality (Hicks et al. 2022).

NUTRITION AND FOOD SECURITY RISKS

The loss of coastal and marine ecosystems affects the productivity of fisheries and human health in Indo-Pacific island countries (Charlton et al. 2016; McNamara et al. 2021), with a loss of up to 670 kg in fish catch for every hectare of clear-cut mangroves (Song et al. 2021). Changes in access to seafood affects food security, dietary compositions, and overall nutrition, especially micronutrients and protein (Partelow et al. 2023; Charlton et al. 2016). In Pacific nations, seafood provides 50–90 percent of dietary protein (Charlton et al. 2016), and average fish consumption reaches up to 110 kg per person per year (Bell et al. 2015), compared to the average global consumption of about 20.6 kg per person per year in 2021 (FAO 2024). In Indonesia, seafood is also important with an average fish consumption up to 44.2 kg per person per year (FAO 2018). Indonesia ranked second highest after China in total amount of seafood consumed in a year (Partelow et al. 2023).

However, Pacific diets today are increasingly characterized by imported foods, such as canned meats, instant noodles, cereals, rice, and sugar-sweetened beverages (Hughes and Lawrence 2005). Fish consumption in the Philippines fell from 36 kg to 14 kg per capita per year from 1993 to 2019, particularly in low-income and rural households (Lagniton 2022). Urbanization contributes to the increased availability of imported, nutrient-poor foods, which exacerbates malnutrition, micronutrient deficiencies, and infectious diseases, accompanied by non-communicable diseases. For example, iron-deficiency anemia, which is associated with impaired cognitive and motor development, low birth weight, and prematurity, affects up to 57 percent of the population in some Pacific island nations (mostly children and women) (Charlton et al. 2016). In Kiribati, high risk of both calcium deficiency and vitamin A deficiency (Hicks et al. 2019) could be addressed by replacing imported foods with locally caught fish. Consumption of marine fish and shellfish can improve health outcomes by reducing micronutrient deficiencies (including vitamin A, B12, calcium, iron and zinc), by providing omega-3 fatty acids, and by displacing consumption of red meat and processed food (Golden et al. 2021; Hicks et al. 2019).


PHOTO BY USAID PHILIPPINES

Although tuna populations can play a greater role in maintaining the food security of Pacific island people (Charlton et al. 2016), large-scale climate change impacts and unsustainable fishing practices threaten tuna availability in the region (Bell et al. 2021 and discussed in Chapter 1). More broadly, climate change could reduce future tropical fisheries catch by 40 percent over the next 30 years (Lam et al. 2020). These projected declines in fisheries and marine aquaculture are especially acute in tropical Pacific island countries, with more than 30% reductions by 2050 in the availability of calcium, iron, and omega-3 fatty acids (Cheung et al. 2023).

CLIMATE CHANGE EXACERBATES RISKS

Extreme weather events, increasing average temperatures, rising seas, saltwater intrusion, droughts, heatwaves, and acidification stress mangroves, saltmarshes, seagrass beds, and pelagic species and associated biodiversity (Bennett et al. 2023). These climate change-driven hazards and impacts are degrading blue carbon ecosystems more quickly than they can recover, reducing their natural capacity to buffer coastal communities from storms and leaving them more vulnerable to future economic, social, and climate-related impacts.

Climate change is changing the risk profile for coastal communities, and affects the frequency, distribution, and intensity of extreme events. Low-lying coastal areas with high human populations, such as those in Indonesia and the Philippines, and Pacific atoll nations (including Kiribati, RMI, Nauru, and Tuvalu) are especially vulnerable to impacts of sea level rise and storm surges (Bennett et al. 2023), which pose greater risks as the natural protections from blue carbon ecosystems decline. Climate change also threatens access to clean water, food availability, livelihoods, and health and physical security. In PNG, community members have observed climate-induced local extinctions of wild foods and medicinal and ritual plants that are central to well-being and biocultural heritage (McNamara et al. 2021). As Chapter 1 describes, warming oceans and acidification also cause shifts in the abundance, productivity, and location of fish stocks and shellfish, affecting fisheries jobs, revenues, and food security across the region (Bennett et al. 2023; Barange et al. 2018; Bell et al. 2021).

Climate-driven migration can disrupt physical, socio-cultural, and ancestral connections to land and critical resources, leading to the abandonment of belief systems and giving rise to mental health impacts characterized by sadness, anger, anxiety, depression, stress, loss, and grief (McNamara et al. 2021). Pacific island customs and traditions closely identify with a sense of place and collective ownership of land and sea (e.g., the notion of Fenua in Tuvalu and Vanua in Vanuatu and Fiji) (Pascua et al. 2017; Yee et al. 2022). For instance, in Fiji, 83 percent of the land is customary land, meaning it is communally owned by Indigenous Fijians (Yee et al. 2022). Land is the foundation of cultural, psychological, and spiritual well-being of Pacific islanders, and it engenders a sense of place and identity. Climate-driven migration can erode subsistence livelihoods, limit opportunities for indigenous knowledge transfer, and drive dislocation from ancestral lands (McNamara et al. 2021). Community relocation has a lasting negative mental health impact on women, primarily as a result of losses to livelihood and socio-cultural activities, such as weaving, tapa making, traditional textiles, and seafood gathering (McNamara et al. 2021). The Rising Seas Initiative, led by UN Member States, recognizes the potentially catastrophic impacts that climate change and climate-driven migration pose to Pacific island nations' statehood, sovereignty, and heritage, and aims to mobilize global support for these countries.

Indo-Pacific Nations and Communities are Taking Action

Indo-Pacific nations and communities are taking a variety of actions to mitigate increasing climate-related risks (Figure 19). The recognition that ecosystems play a fundamental role in sustaining human well-being is a cornerstone of many indigenous knowledge-practice-belief systems, also known as traditional ecological knowledge (Cohen-Shacham et al. 2016). Today, traditional ecological knowledge provides the foundation for climate adaptation across the Indo-Pacific region (McMillen et al. 2014; McMillen et al. 2017). These locally-led adaptation initiatives integrate traditional ecological knowledge with western science to improve the management, restoration, and conservation of the blue carbon ecosystems that sustain local economies, livelihoods, and cultures in the Indo-Pacific. Securing the benefits of blue carbon ecosystems that support human wellbeing include implementing nature-based solutions, policy and technological solutions, and capacity development initiatives. These integrated solutions also promote climate resilience and secure sustainable livelihoods.

In addition to providing climate mitigation benefits (assessed in Chapter 1), blue carbon ecosystems can help communities adapt to climate-related impacts by providing natural buffers against storms, food sources that support public health and food security, and diversified livelihood options, such as attracting tourism and recreation. Because of these climate mitigation and adaptation benefits, blue carbon ecosystems can contribute to achieving countries' NAPs and NDCs to the United Nations Framework Convention on Climate Change (UNFCCC). Incentivizing community-based conservation and management of blue carbon ecosystems, for example through PES programs (Sharma et al. 2022) or the recently proposed "Conservation Basic Income" (de Langue et al. 2023), can also contribute to climate goals. Accounting for the value of blue carbon ecosystems' non-monetary benefits and co-benefits in emerging blue carbon markets can further inform investments in restoration and conservation (Macreadie et al. 2021). The third chapter of this report discusses these financing strategies in more detail.

Indo-Pacific nations and communities face the challenge of contributing to climate action and supporting sustainable development while balancing the needs of local communities and their customary practices (McKenzie et al. 2021). These communities face significant policy, financial, and technical challenges implementing blue carbon projects at a scale that contributes substantially to national and international mitigation and adaptation goals (Macreadie et al. 2019). Despite these challenges, communities have traditional knowledge and practices that help them reduce climate risks and ecosystem degradation.

This section describes several categories of blue carbon solutions, with recognition that many of these solutions are cross-cutting and do not fit exclusively into a single category.

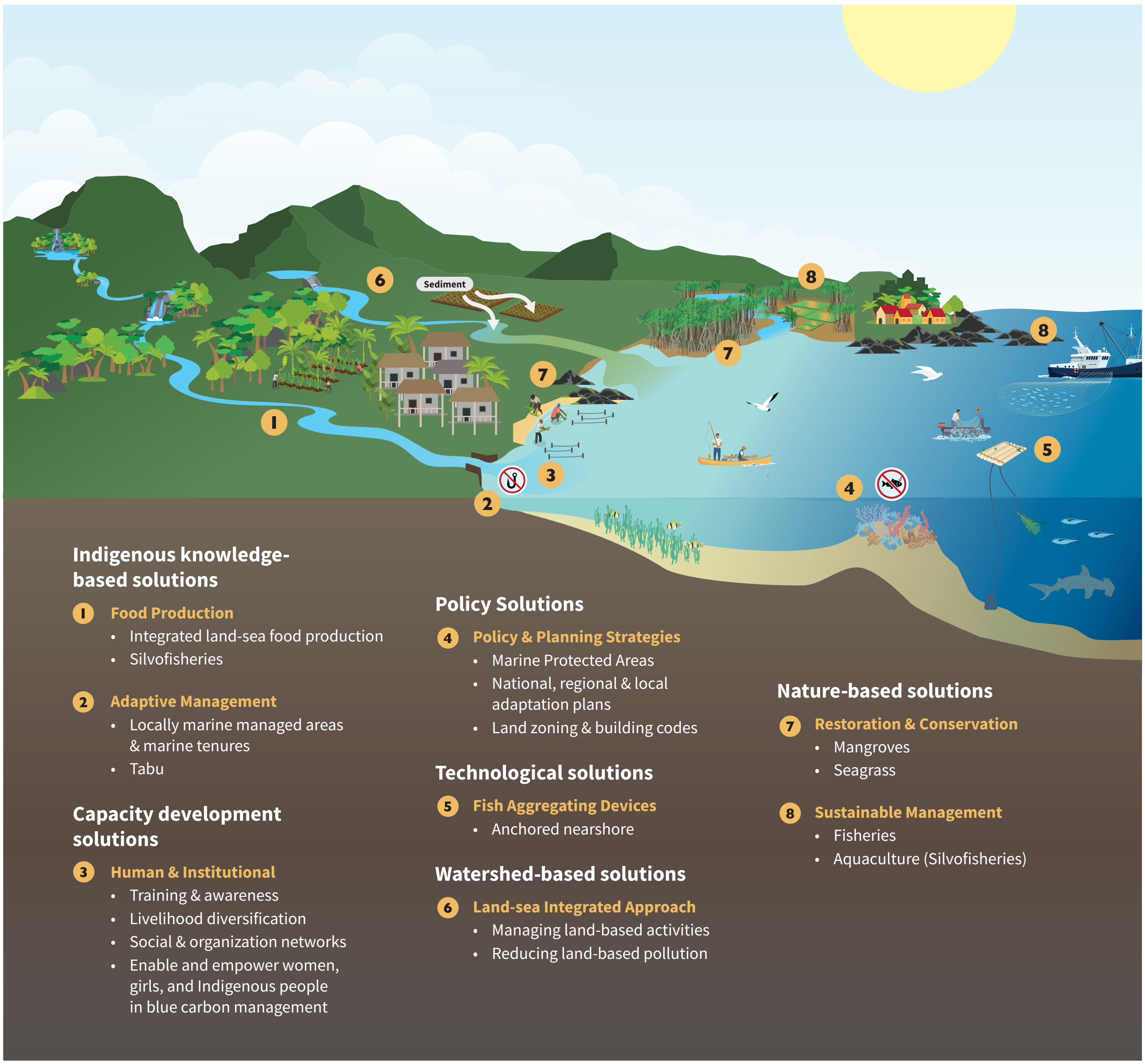


FIGURE 19. Indo-Pacific nations and communities are implementing locally-led measures to protect blue carbon ecosystems and sustain their benefits to local communities. Sustainable management of blue carbon ecosystems involves diverse types of solutions across inland, coastal, and offshore environments. Figure design by Giada Mannino and Jade Delevaux.

INDIGENOUS KNOWLEDGE AND SOLUTIONS

Indigenous knowledge and traditional ecological knowledge refer to place-based knowledge that is rooted in the culture and practices of a community (McNamara et al. 2021) and provides an understanding of the relationships among living things and their environments (Whyte 2013; McKenzie et al. 2021b). Many indigenous worldviews consider people holistically as part of the ecosystem, rather than positioning humans as separate environmental managers (Berkes 2000). The cumulative indigenous knowledge-practice-belief systems about how to utilize and manage coastal ecosystems has evolved through continuous human-landscape interaction over hundreds of years (Granderson 2017).

Local and indigenous knowledge provides the basis for many modern western blue carbon management approaches, such as nature-based solutions, marine protected areas, and technological solutions, such as nearshore FADs. Integrating Indo-Pacific community members' specialized skills and traditional ecological knowledge with western sciences can help optimize the effectiveness of blue carbon ecosystem management, climate adaptation, and capacity-building measures.

Integrated land-sea food production systems and traditional systems of natural resources management are two examples of indigenous knowledge-based practices for managing blue carbon ecosystems and climate risks.

Integrated land-sea food production systems

Food production systems, such as agriculture and aquaculture, are traditionally woven into the land-sea continuum. For example, estuarine polyculture fish ponds or, in Indonesia, tambak, combine the cultivation of fish, vegetables, and tree crops. Mangroves surround the ponds, which are often located downstream from a constructed wetland growing wet taro or integrated rice-fish culture (Figure 20). Nutrient-rich water flowing from rice-fish systems can be directed into fish ponds as fertilizer (Berkes et al. 1998). Tambak, such as those in Java,

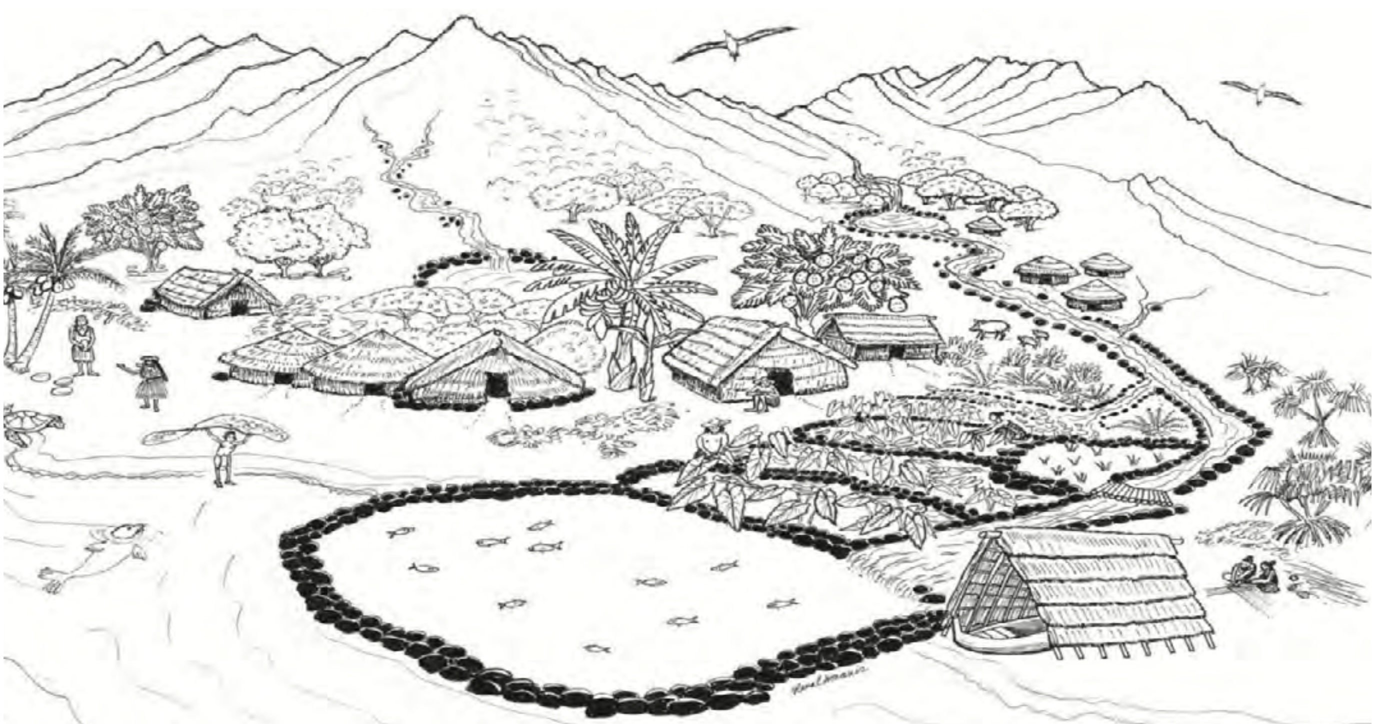


FIGURE 20. Customary Hawaiian ahupua'a system of integrated land-sea food production. Illustration from Mālama Learning Center 2020.

Indonesia, date back to the 15th century, with many local variations across Southeast Asia (Berkes et al. 1998). However, population growth, urbanization, and international markets replaced many estuarine polyculture systems with shrimp-pond monoculture (Berkes et al. 1998). Nevertheless, those food production systems provide models for designing modern productive, human-dominated ecosystems that couple land and water systems (Hasler 1974) and have the potential to secure livelihoods and food sources across land and sea (Tonneijck 2018).

Silvofisheries are one example of indigenous knowledge-based land-sea food production. Silvofisheries integrate mangrove tree culture with low-input brackish water aquaculture. Ponds are stocked naturally with juveniles of species that enter with incoming tides, and farmed species can include siganids, mullet, milkfish, tilapia, shrimp, mangrove crab, jacks, and seabass. Once the species are ready for harvest, fishers catch them with gill nets during low tide. Reported annual profit from silvofisheries can be up to $2,000/ha/year for a milkfish and shrimp (Tonneijck 2018). Silvofisheries can be a win-win option that enables local communities to generate revenue by marketing sustainable certified fisheries and aquaculture products (Blue Natural Capital 2021), while protecting mangrove ecosystem health (Hadyanafi et al. 2022). Silvofisheries are promoted in Indonesia as part of a mangrove rehabilitation, conservation, and management program (see case study below).

PHOTO BY BLUE MOTUS

CASE 4

Mangroves Restoration Secures Livelihoods in Sumatra, Indonesia

The coastal regions of north Sumatra and Aceh have lost more than 110,000 ha of mangroves over recent decades due to the expansion of shrimp production, rice fields, and palm oil plantations. The loss of this habitat has left villages exposed and vulnerable to the impact of coastal hazards, such as the 2004 tsunami that claimed 220,000 lives. In 2011, 125 villages mobilized with the support of the NGO Yagasu and planted 18 million trees over 5,000 ha. The restored mangrove belt provides coastal protection, improves food security, and contributes to climate mitigation through the sequestration of up to 2 million tons of CO_2 over the next 20 years. In 2018, Yagasu launched the Launch Livelihoods Carbon Fund to help restore an additional 5,000 ha of mangroves, develop livelihood opportunities, and sequester an additional 2.5 million tons of carbon over 20 years. Local farmers received a revolving microcredit of $1,350, on average, to transition to a silvofishery approach. By planting mangroves around and in the fishponds, farmers increased the production of fish, shrimp, and crabs. This renewed species diversification led to more varied incomes to farmers, with the highest income resulting from selling soft-shell crabs for export. About 20,000 people increased their revenues by selling goods from mangroves, including natural dyes and farmed seafood. The median household income increased by 57 percent. Yagasu provides capacity development through multiple avenues. It helps 174 cooperatives develop their branding and marketing strategies and secure their licensing permits from the local government to sell their products. It facilitates exchange of information and resources between the public and private sector and provides training to communities in batik production techniques. Following this success, Yagasu is receiving support from the Indonesian government and USAID to replicate this approach across Indonesia.

References: Livelihoods Funds 2020a, Livelihoods Funds 2016, Livelihoods Funds 2020b

PHOTO BY USAID

Marine tenures, locally managed marine areas, and Tabu systems

Blue carbon projects should recognize, strengthen, and build on existing customary management systems and ownership structures (Vierros 2017), which include marine tenure systems (Ruddle et al. 1992). Customary management systems often align with local spiritual beliefs and may include a variety of tools and approaches to promote sustainability, including seasonal bans on harvesting, temporary closures and no-take areas, and restrictions on time, places, species, gear, or taking by certain groups of resource users (Vierros 2017). These management systems encourage the sustainable use of resources at the local level, and it is important that blue carbon projects protect communities' sustainable resource use in accordance with their cultural and spiritual beliefs, while also generating contemporary economic benefits (Sharp 2002; Hunt et al. 2009).

Across the Indo-Pacific, locally managed marine areas (LMMAs) are rooted in traditional knowledge, customary tenure, inclusive governance, and local awareness of the need for action (Vierros 2017). LMMAs can help enhance blue carbon conservation and restoration efforts while increasing carbon sequestration (Moraes 2019) and securing buy-in from local communities. In addition, LMMAs can support the recovery of ecosystems, strengthen food security, improve governance, increase access to information about blue carbon ecosystems, provide health benefits, secure tenure, and maintain culture (Govan 2009). Most Pacific island countries have established LMMAs; given their successful use, multilateral efforts are underway to leverage LMMAs as a tool for empowering locally-led natural resources management (UN-DESA 2020; LMMA International 2023).

Communities also implement localized natural resource management strategies to address food and water insecurity associated with climate variability. While the local names of these strategies vary across the diverse cultures of the Indo-Pacific (e.g., *tabu* in Fiji and Vanuatu, *bul* in Palau), each involves responsive and adaptive management to avoid overuse of resources. For example, communities could place *tabu* or *bul* for a certain length of time to restrict fishing in marine areas or harvesting fruits and nuts in the forests. Communities also use these local management systems to regulate certain uses of rainwater or activities that affect water quality (e.g., raising livestock near water sources) (Granderson 2017). This traditional knowledge about adaptive resource management, including planting techniques, innovative water storage practices, and food preservation, was critical to managing impacts of cyclones and droughts (McNamara et al. 2021). For instance, communities plant hardy, slow-growing "disaster crops" (e.g., legumes) and surplus crops in *tabu* gardens or switch their food sources to *tabu* marine areas in times of crises (Granderson 2017).

PHOTO BY BLUE MOTUS

NATURE-BASED SOLUTIONS

"Nature-based solutions are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature" (IUCN 2023). Similarly, natural climate solutions are nature-based solutions implemented specifically to increase carbon storage and/or avoid greenhouse gas emissions across ecosystems (Griscom et al. 2017). Nature-based solutions encompass established approaches from ecological restoration to engineering solutions, ecosystem-based climate adaptation and mitigation, disaster risk reduction, and natural/green infrastructure (Cohen-Shacham et al. 2016; Chales et al. 2023). For blue carbon ecosystems, nature-based solutions could include restoration and/or conservation of mangroves, marsh, seagrass, and other coastal ecosystems; restoration and/or conservation of upstream lands and resources that affect downstream environmental quality and climate risk; and integration of green infrastructure elements into new and existing coastal infrastructure. Nature-based solutions' broad suite of co-benefits also provide an opportunity to strengthen collaboration between practitioners in climate change and biodiversity on the national and international levels (Vierros 2013).

Despite the growing interest in nature-based solutions for blue carbon ecosystems, countries and communities face challenges in implementing and financing these projects (Arkema et al. 2023). Nature-based solutions can require complex coordination to develop and implement technical approaches that are culturally appropriate and complement local land and resource governance systems and capacities (Wickenberg et al. 2021). In addition, the delivery of benefits and financial return on investments from nature-based solutions may occur over a longer and more uncertain period of time than other types of actions because it takes time for restored ecosystems to mature and deliver ecological or sequestration benefits. Their success usually requires regular maintenance and adaptive management. These demands and longer payback periods can create uncertainty for investors and communities because the costs and benefits of investments in nature-based solutions can be difficult to assess (these types of challenges are further discussed in the following section). Integrating projected climate impacts on new projects and assessing their capacity to deliver long-term climate resilience benefits makes these calculations even more complex. However, accounting for the substantial co-benefits of nature-based solutions can make these investments more bankable and attractive, and could reduce perceived risk, for more diverse funders. Capacity development will be important to help investors conduct MRV of blue carbon trends.

Blue nature-based solutions provide a promising but underutilized pathway to bolster NDCs (Arkema et al. 2023). NDCs describe measures that each country aims to take to help achieve the Paris Agreement global goal of keeping warming "well below" 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C.

CASE 5

Indigenous Women Lead Mangrove Restoration in the Philippines

The communities of Busuanga Island, Philippines are vulnerable to recurring typhoons and climate change impacts. Local communities are highly dependent on fishing and farming. The island was designated as the Palawan Mangrove Swamp Forest Reserve in 1981. However, illegal logging between 2004 and 2015 severely decreased mangrove forests. In November 2013 when typhoon Haiyan hit the island, the remaining mangroves provided little protection against strong waves and wind. The town suffered extensive damages and destroyed wooden fishing boats and thatch-roofed houses. The community realized that mangroves could have shielded them from these impacts, so indigenous women volunteered as citizen scientists to restore mangroves. Since 2014, they have revitalized 159 ha of bare coastal patches across Busuanga Island. They also monitor seedling growth and every month, replace mangroves afflicted by parasite barnacles that reduce root growth. Indigenous men and women are mobilized to volunteer as coastal guards to ensure the protection of the newly restored mangroves. Consequently, their effort resulted in an 80 percent survival rate. They strengthened their initiative by passing an ordinance that bans further mangrove forest clearing. The community partnered with the Busuanga municipal government to craft a mangrove conservation plan to form part of the municipality's comprehensive land use plan. To raise awareness around the benefits that mangroves provide, they also developed a curriculum to educate local communities.

Source: Fabro 2021

PHOTO BY JOHN BAÑADERA

POLICY SOLUTIONS

A number of policy mechanisms at the local, national, regional, and global scales aim to increase the effectiveness and sustainability of blue carbon management for economic development, conservation and environmental quality, social and economic equity, and climate resilience.

Spatial planning, zoning, and building codes

Spatial zoning and plans often guide the design and implementation of policy and finance mechanisms and can have a direct effect on blue carbon management, for example, by designating certain coastal areas for development or conservation and establishing building codes to manage environmental quality and public health impacts of coastal land uses. Spatial zoning strategies can also establish setback and elevation requirements for coastal development, which can protect coastal ecosystems from development impacts and protect infrastructure from climate-related impacts.

Designing effective climate risk management strategies for coastal areas, including spatial plans and setbacks, requires spatial information about blue carbon ecosystem benefits to people, ideally coupled with climate risk scenarios and nature-based interventions (Arkema et al. 2015; Arkema et al. 2023). However, understanding current and projected climate risks at the local level remains a challenge in many countries because of the lack of highly localized data about climate change impacts (Faivre et al. 2022). This is particularly relevant in the Indo-Pacific region because homes, gardens, buildings, roads, and major infrastructure (e.g., schools, hospitals, and airports) are typically located in the coastal zone, and flood-plains are exposed to coastal hazards, including coastal erosion, inundation, and shoreline recession (Piggott-McKellar et al. 2020). To address these data and information needs, emerging earth observation technology, open access global data, and software (e.g., marine InVEST) are becoming more available and flexible for applications in marine spaces in data-limited regions (Ruckelshaus et al. 2020; Delevaux et al. 2023).

Effective spatial planning and zoning should integrate perspectives of diverse stakeholders across sectors and scales (regional, national, and local) to assess benefits and trade-offs of planning decisions, while accounting for traditional systems of land tenure. For instance, coastal and marine spatial planning can be a participatory process through which government institutions, local authorities, local communities, and the private sector work together to preserve blue carbon coastal and marine ecosystems and generate economic return (Ehler and Douvere 2009). These planning processes can also reduce carbon emissions while promoting gender equality, sustainable livelihoods, and job creation through the distribution of human activities over marine spaces and over time (Ross et al. 2019).

Marine Protected Areas (MPAs)

MPAs are areas of the ocean designated by government and/or community leaders that operate under a set of rules, ranging from no-take restrictions, to regulated non-extractive activities (Blue Natural Capital 2021). MPAs help protect, maintain, and restore biodiversity, biomass, and associated benefits to people (Sala et al. 2018; Worm et al. 2006) and can contribute to climate change mitigation by protecting marine carbon stocks (Roberts et al. 2017). MPAs can produce ecological, social (e.g., food security), and economic (e.g., income) benefits when implemented under a broader management program (UNEP 2024, Nowakwoski et al. 2023). Although MPA designs rarely incorporate carbon services and currently fully protect less than three percent of the oceans (MPA map AtlasMarine Protection Atlas 2024), 50 World Heritage Sites currently cover 21 percent of the global area of documented blue carbon ecosystems (29% of seagrass, 7.2% of tidal marsh, and 8–9% of mangrove forest) (UNESCO, 2021). To increase the area of ocean protected under MPAs and other conservation measures, the United Nations Biodiversity Conference (COP15) in 2022 established the 30x30 ocean target, led by the Global Ocean Alliance (United Kingdom, gov.uk), which aims to protect at least 30 percent of the ocean by 2030 and involves many Indo-Pacific island countries. However, as climate change affects the distribution of species, Dynamic MPAs, which have boundaries that shift in response to species movements over time, have also been proposed as a possible solution for preserving species (Cashion et al. 2020).

In Indonesia, MPAs reduced mangrove loss by about 14,000 ha and avoided approximately 13 million tCO_2e of blue carbon emissions over a 10-year period (Miteva et al. 2015), amounting to $540 million in social welfare benefits (Pendleton et al. 2012). Together, these benefits contribute to several of the Sustainable Development Goals (SDGs), including reducing poverty (Goal 1), improving food security (Goal 2), tackling climate change (Goal 13) and, of course, protecting life below water (Goal 14) (UNEP 2023). Recent data reveal that seagrasses are among the least protected coastal habitats, with 26 percent of recorded seagrass beds in MPAs, compared to 40 percent of coral reefs, and 43 percent of mangroves (UNEP 2020).

PHOTO BY JASON HOUSTON

Typically, governments and grants fund MPA operations. However, these may not be stable sources of revenue because priorities change as governments change, and grants are short-lived and not guaranteed over the long term (Blue Natural Capital 2022). Private funding of MPAs can provide an alternate funding model that could include: user fees, ecotourism opportunities, and blue carbon credits, among others (Blue Natural Capital 2022). A few of these approaches rely heavily on tourism, which can be volatile, as observed around the world during the COVID-19 pandemic, and during and after natural disasters or periods of political or economic instability. On the other hand, too many tourists can have a negative impact on the environment and can counteract conservation goals (WEF 2019). Privately-managed MPAs—for example, marine reserves managed by a private hotel (Hotel Managed Marine Reserves (HMMRs))—have potential to draw ecotourists interested in contributing to local conservation efforts, while delivering ecological benefits. Surveys in an HMMR in Vietnam found significantly higher fish density, size, and diversity within the reserve than in areas outside the reserve (Svensson et al. 2008).

Blue carbon rights and benefit sharing policies

Inadequate or insecure tenure and property rights are a longstanding barrier to community-based natural resource management (Dencer-Brown et al. 2022). Opportunities to equitably scale up blue carbon ecosystem restoration, conservation, or finance requires resolving local tenure issues (Rakotonarivo et al. 2023). The first critical step for any prospective blue carbon project is to identify and define carbon rights by engaging local, regional, and national government departments, community leaders, and indigenous groups and traditional governments (Moraes 2019; Howard et al. 2017). Land jurisdiction and secure customary tenure, access, and benefits for local communities must be clearly defined before implementing blue carbon solutions

(Pricillia et al. 2021; Song et al. 2021; Macreadie et al. 2022). Clear and secure blue carbon rights and tenure can help achieve equity in blue carbon projects by determining who owns and who can benefit from blue carbon, and how and to whom carbon is sold and under what circumstances (UN-REDD 2022). However, a central challenge is the potential complex convergence of jurisdictions, property and resource rights, and land tenure systems in coastal and marine areas, especially as climate change impacts reshape and affect access to coastal zones and resources.

National governments could establish and implement safeguards (Barletti et al. 2021), a set of principles, rules, and procedures to protect communities against unintended outcomes of blue carbon projects (Hadyanafi et al. 2022). For instance, Fiji's benefit-sharing plan, which is reflected and acknowledged in the current Climate Change Act, follows the National Reducing Emissions from Deforestation and forest Degradation Emissions Reduction Program (REDD+ ERP) benefit-sharing guidelines. The Fijian Government recently endorsed this plan of 80 percent (communities) and 20 percent (government) share, which is consistent with the Fair Share of Mineral Royalties Act of 2018.

International agreements

Given the complex jurisdictional and governance considerations related to managing marine environments, international cooperation is necessary to achieve multiple goals of blue carbon resource management across large geographic scales. In addition to international climate bodies and agreements (e.g., the UNFCCC and the Paris Agreement) and country-level finance mechanisms (discussed in the next section) and climate commitments (e.g., NDCs, NAPs), international policy mechanisms can provide frameworks, incentives, and financial support for national-level blue carbon accounting and project-level activities, including conservation, restoration, and sustainable use of blue carbon ecosystems.

For example, the Blue Carbon Initiative, coordinated by Conservation International, the Intergovernmental Oceanographic Commission, and IUCN (and supported by the International Blue Carbon Scientific Working Group) integrates blue carbon into policy and financing mechanisms that support nature-based climate change solutions (Ross et al. 2019). Building on international marine governance agreements established under UNCLOS, the new 'High Seas Treaty,' also known as the BBNJ treaty, signed by the UN Member States, aims to ensure responsible use of the marine environment, and maintain the integrity of ocean ecosystems and biodiversity in unregulated international waters. This agreement will be especially important for preventing overfishing as climate change impacts drive tuna and other economically important species beyond EEZs and into international waters (see Chapter 1). The treaty will: 1) establish large-scale marine protected areas, 2) regulate countries and companies that can access and share benefits from the commercialization of "marine genetic resources," 3) enhance access and inclusivity for research in international waters, and 4) set global standards for environmental impact assessments on commercial activities in the ocean (UN News 2023; European Commission 2023 TNC 2023). The treaty is a step toward protecting 30 percent of the ocean by the year 2030, in line with the 30x30 goals. The discussion about tuna fisheries management in Chapter 1 of this report also highlights the need for international cooperation on blue carbon management. While international agreements can be effective for strengthening governance and protections for blue carbon ecosystems, countries may also benefit from capacity development to effectively adopt, administer, and enforce international agreements at the national or regional level.

CASE 6

The Regional Flyway Initiative: A Nature-Based Solution for People, Nature, and Climate

Nearly 200 million people rely on the wetlands that lie along the East Asian–Australasian Flyway for livelihoods, food, clean water, opportunities in recreation and tourism, flood mitigation, carbon sequestration, and climate adaptation. More than 50 million migratory waterbirds (210 species, and many other animal and plant species) also depend on the East Asian–Australasian Flyway wetlands for food, shelter, and other essential needs. The Regional Flyway Initiative (2022) is a partnership between the Asia Development Bank (ADB), the East Asian–Australasian Flyway Partnership, and BirdLife International. The partnership seeks to mobilize $3 billion to invest in viable nature-based solutions that can deliver for people, nature, and climate across the vast network of wetlands along the Flyway (Figure 21).

This initiative covers 18 countries and includes the Philippines, Indonesia, and PNG from the focal region. Over the next two years, the ADB technical assistance will invest one million dollars to identify wetland sites of international importance that protect migratory waterbirds and support livelihoods. The long-term vision is to deliver projects across the region that support the protection, restoration, and sustainable management of at least 50 priority sites along the East Asian–Australasian Flyway. This initiative will provide a pilot that could be extended to the West Pacific Flyway region, which spans all the other Pacific nations.

References: ADB 2022, Development Asia 2023, ADB 2021

FIGURE 21. Implementation of nature-based solutions along the East Asian–Australasian flyway helps conserve critical habitat for migratory birds and sustain livelihoods tied to wetland ecosystems. Illustration from ADB 2022.

TECHNOLOGICAL SOLUTIONS—FISH AGGREGATING DEVICES (FADS)

FADs are floating structures that attract pelagic fish. Pacific island countries have been placing nearshore FADs behind reefs to increase food availability for coastal populations (Sokimi 2020). Larger, offshore drifting FADs cover wide areas and are used by commercial fishing operations. Despite the sustainability challenges inherent with technologies that attract or capture multiple species of fish (some of them non-target bycatch), island nations and the industrial fishing industry are concerned that limiting fishing on FADs could have negative economic impacts, because 50–80 percent of government revenue in some Pacific island countries comes from fishing boat access fees (Sokimi 2020). Although FADS and similar technologies have the potential to increase the availability of tuna and other large pelagic fish and to provide protein for food security and nutrition, these devices, especially larger offshore FADs, require appropriate monitoring and management to ensure their sustainable use (Charlton et al. 2016). (See the detailed discussion about FADs in the textbox in Chapter 1.)

CAPACITY DEVELOPMENT

Strengthening capacities of Indo-Pacific communities and institutions is key to long-term management of blue carbon ecosystems for productivity, sustainable use, climate change mitigation and resilience, and cultural value. Capacity development initiatives can include training and awareness programs, livelihood diversification programs, and fostering social networks and exchange across communities and island nations.

Training and awareness

Capacity development is particularly important for blue carbon project managers and beneficiaries because benefits and co-benefits may not be initially obvious, and implementing blue carbon projects requires entrepreneurial, technical, financial, operational, and communications skills (Dencer-Brown et al. 2022; Beeston et al. 2020). In addition, accessing finance for blue carbon projects requires knowledge and skills to navigate complex funding requirements and to develop detailed technical proposals, which communities and small organizations sometimes lack. Training, training-of-trainers, and other awareness programs can help build skills necessary to design, register, implement, and manage a blue carbon project (Beeston et al. 2020). For example, Australia recently hosted a successful training program for young professionals from developing countries. The training strengthened participants' capacity to communicate to researchers, policymakers, and the public about the value of blue carbon ecosystems, including knowledge of biology, remote sensing, carbon assessments, policy, and restoration (Gorman et al. 2023).

Effective implementation of blue carbon projects may require capacity development at multiple levels, including for individuals; community organizations; local, regional, and national governments; and private sector entities and even financial institutions. (Chapter 3 describes capacity building for financial institutions in more detail). It is important to assess the capacities of each target group and tailor capacity development programs to each one accordingly. Training and awareness-raising initiatives could address a variety of topics related to technical, financial, cultural, and institutional aspects of managing blue carbon (e.g., climate change impacts on blue carbon and managing blue carbon ecosystems for climate resilience; blue carbon mapping, measuring, and monitoring; identifying and developing potential blue carbon projects; options for increasing readiness to access blue carbon financing; strengthening the enabling environment for blue carbon public-private partnerships; assessing costs, benefits, and risks of blue carbon investments; sustaining transfer of traditional ecological knowledge about blue carbon ecosystems; and many other potential topics).

Capacity development not only builds skills and knowledge in specific topics, but it can also contribute to broader goals at the local and even international scales. For example, increasing understanding of blue carbon among decision-makers and the broader public can build support and buy-in for blue carbon projects and increase national public attention (IUCN 2015). Engaging community members in capacity development initiatives can also help reveal perspectives that trainers and facilitators may not have been familiar with, thus avoiding unintended consequences or maladaptation in blue carbon project design. Governments and financial institutions at all levels need capacity to participate in and contribute to international agreements, for example through MRV of blue carbon projects' contributions to the goals of NDCs and NAPs (IUCN 2015).

Livelihood diversification

As blue carbon ecosystems degrade and as climate change accelerates blue carbon losses, Indo-Pacific countries and communities that depend on blue carbon economies must seek out other activities to sustain their livelihoods or create new blue carbon-based livelihoods with new systems of local knowledge. For example, a partnership among local women leaders across PNG, provincial and national government, academic institutions, NGOs (The Nature Conservancy), and businesses came together to create the Mangoro Market Meri ("Mangrove Market Women"), an initiative that links sustainable mangrove management to improved livelihoods, including tourism, women's empowerment, food security, storage of blue carbon, and the protection of coastal communities from sea level rise and storm surges. In the short term, the partnership builds local markets for sustainably harvested mangrove products (shellfish and mud crabs). In the medium and long terms, the initiative is exploring potential avenues to develop ecotourism and increase blue carbon sequestration.

Developing capacity to diversify livelihood strategies is an important adaptation strategy for blue carbon-dependent economies and individuals. For example, some fishers in the Philippines exit the fishery when seagrass and mangrove habitat is degraded because catch quantity and quality declines. To adapt and diversify their incomes, fishers turn to farming, tourism, construction, transportation, and salaried employment, including working for pearl farms, schools, the service industry, and retail. Salaried jobs can mitigate sensitivity to blue carbon ecosystem loss because they do not rely on the health of the habitat, unlike tourism or fishing (Quiros et al. 2021).

Empowering women, girls, and Indigenous Peoples to manage blue carbon

> "Those who are most affected by climate change today—women, girls and marginalized communities—must be involved in the design and implementation of climate response actions to ensure the equal sharing of benefits" (UN 2022).

Gender inequalities are often rooted in social and legal norms and can determine roles and responsibilities related to natural resource access, use, and management. These dynamics affect how women, girls, Indigenous Peoples, and others whose livelihood strategies are closely tied to blue carbon ecosystems experience and respond to declines in blue carbon ecosystems. In many contexts, women's participation in carbon projects has been limited because local social systems and structures often exclude women from participation in and ownership over natural resources. Although women make up a large proportion of the stakeholders in conservation of coastal ecosystem resources, women's roles are rarely recognized (Cormier-Salem 2017). Fostering women's leadership and the meaningful inclusion of women in biodiversity conservation and natural resource management can lead to a more sustainable use of resources, reduction of conflict, and more equitable benefits for all users (USAID 2023).

Increasing representation of women at all levels of government can help advance climate action. For example, placing more women in national parliaments can lead to more stringent climate change policies, resulting in lower emissions (Mavisakalyan and Tarverdi 2019). It is essential to strengthen the capacity of women, girls, Indigenous Peoples, and other groups who are agents of positive change and role models for

"Supporting Indigenous Peoples and Local Communities in their efforts to secure legal rights and control over their lands and waters is the cornerstone for effective governance leading to improved livelihoods but also conservation of ecosystems and biodiversity."

Lilian Painter, Director of the Bolivia Program, Wildlife Conservation Society


PHOTO BY MATT ABBOTT

sustainability and climate adaptation (UN 2022). Including women in the planning, design, and implementation of context-appropriate climate adaptation solutions, along with capacity-building strategies, can help foster community resilience, reduce poverty, and achieve the SDGs (UNFCCC 2023).

Social networks and capital

In addition to diversifying economic livelihoods, fostering social networks and social capital can build individuals' and communities' capacity to mitigate and adapt to impacts on blue carbon ecosystems. A diverse and strong social network can connect various groups that depend on coastal or marine ecosystems. These connections can foster a common identification and understanding of the issues, and facilitate self-organization, access to more resources within or across islands, and sustainable governance of blue carbon ecosystems (Orchard et al. 2015; Granderson 2017). Social networks, identity, reciprocity, and other features of intangible cultural heritage are already strong features of Pacific communities, providing sources of adaptive capacity to respond to the impacts of climate change on blue carbon ecosystems (McNamara et al. 2021). For example, Pacific communities pool and exchange labor, seasonally migrate, and gain access to more resources (Orchard et al. 2015; Granderson 2017). Social networks can provide access to food and water in times of climate crises through requests from kin relationships on the same or neighbor islands (Granderson 2017).

The degradation and loss of blue carbon ecosystems and the increasing frequency and intensity of climate impacts on blue carbon, including the movement of people, can stress and fray social networks. However, targeted efforts to create social cohesion can help build individuals' and communities' adaptive capacity. For example, donors can leverage social media and other types of communication aids, like radio, to foster connections and facilitate information exchange among distant communities (Love et al. 2023). Organizing knowledge exchange workshops among communities and inter-generations can help support the sharing of knowledge and lessons learned.

PHOTO BY MATT ABBOTT

Empowering Indigenous Communities in Blue Carbon Management

To empower indigenous communities in managing their coastal and marine blue carbon resources, an adapted toolkit, co-developed by indigenous communities and Wildlife Conservation Society (WCS) in the Amazon, identified 10 key processes of relevance to the Indo-Pacific context:

- Establish rights of indigenous people to manage local resources;
- Set up a community-led organization to oversee the management of natural resources;
- Elaborate natural resources management plans;
- Design the spatial zoning;
- Establish rules on access and use of natural resources;
- Establish production and supply chains of harvested natural resources;
- Establish a monitoring plan;
- Administration training;
- Sustainable financing training; and
- Monitoring of social, cultural, economic, and environmental impacts on the community.

INTEGRATED WATERSHED MANAGEMENT

Roughly 80 percent of marine pollution originates on land, and this pollution from upstream human activities affects the health of mangroves and seagrass beds (UNEP 2019). Yet marine, coastal, and watershed management efforts often lack integration, reducing the potential effectiveness of marine conservation efforts (Delevaux et al. 2018). Integrated watershed management is a strategy that aims to balance environmental, economic, and social goals to enhance nature's benefits and ensure equity for all land, water, and marine users (Delevaux et al. in review). Traditionally, Pacific islanders have managed their terrestrial and marine resources holistically from ridge to reef using systems such as the Hawaiian ahupua'a, the Yap tabinau, the Fijian vanua, and the Marovo puava in the Solomon Islands (Berkes et al. 2000). This interconnected view of the land and sea aligns with traditionally held Pacific values and provides a model for the sustainable management of these landscapes.

Integrated watershed management can help mitigate upstream drivers of blue carbon ecosystem degradation and protect blue carbon investments from future damage. For example, blue carbon and terrestrial resource managers could collaborate to identify critical areas in a watershed, and target interventions to protect human and ecosystem health and reduce downstream impacts, such as erosion, flood risk, and contaminant transport (Wakwella et al. 2023; Delevaux and Stamoulis 2022; Delevaux et al. in review). This could especially benefit seagrass beds affected by land-based source runoff from poor catchment management practices and unplanned urban expansion (Brodie et al. 2020). Furthermore, implementing integrated management plans on a watershed scale can foster collaboration among government agencies, civil societies, the private sector, and landowners located both within and outside the watershed, which can help enhance community resilience (Begg et al. 2023).

Recommendations for Designing and Implementing Blue Carbon Solutions

Blue carbon projects around the world have offered useful lessons learned and recommendations for decision-makers, practitioners, and communities. Considering these recommendations can help blue carbon projects avoid unintended consequences and maladaptive actions.

Strengthen capacity of local communities that manage, use, and interact with blue carbon ecosystems. This requires significant investment in community capacity building and the development of alternative livelihood opportunities (Friess et al. 2022). Engaging and strengthening the role of local communities in the design and implementation of blue carbon solutions can help build social resilience, preserve cultural values, and secure livelihoods (Vanderklift et al. 2019).

Confirm customary, historical rights to resources and land tenure of Indigenous Peoples in areas considered for blue carbon projects (Vierros 2017; Dencer-Brown et al. 2022). To ensure investments make their way to communities, first confirm blue carbon property rights because obtaining blue carbon credits through mangrove restoration or conservation requires demonstrating a legitimate right to carbon (Bell-James 2016). Many countries have issued legislation to permit community tenureship of blue carbon (Dencer-Brown et al. 2022).

Establish policies to clarify how benefits will be shared between communities and governmental units to ensure fair outcomes and equitable distribution of benefits (Macreadie et al. 2022).

Incorporate indigenous and customary knowledge systems of natural resource stewardship into solution design and implementation to leverage existing, localized understanding of blue carbon ecosystems and to ensure the sustainability of blue carbon ecosystems management (Pricillia et al. 2021).

Integrate gender equity and social inclusion (GESI) into the design and implementation of blue carbon solutions. At the local level, women's participation in natural resource management results in better resource governance and conservation outcomes (UN OHCHR 2019). Women's and girls' daily activities and roles build specialized skills and knowledge about blue carbon ecosystems that can inform effective solutions and avoid maladaptation and inequitable distribution of benefits.

Diversify livelihood strategies for blue carbon-dependent communities. Restoration and sustainable management of blue carbon ecosystems provides opportunities to diversify income sources, for example, through the voluntary carbon market, PES, and other types of financial compensation schemes (Dencer-Brown et al. 2022), in addition to providing new economic opportunities, such as ecotourism.

Target blue carbon projects to incentivize conservation, for example, by focusing not only on areas subject to high deforestation rates, but also to reward places and communities that are already stewarding their resources effectively. Other critical considerations for long-term blue carbon projects success include inclusive governance, legitimizing local work into policies, and simplifying carbon accounting and verification methodologies to lower barriers to entry (Dencer-Brown et al. 2022).

Maximize and measure co-benefits of blue carbon solutions. The co-benefits of blue carbon solutions can be more attractive for investors than single purpose projects. Co-benefits could include increases in storm protection, tourism opportunities, gender equity, biodiversity conservation, incomes, and climate mitigation. New forms of crediting are emerging to recognize these broader aims, such as SDG credits or "resilience credits" (i.e., carbon and coastal protection), and to make these benefits explicit to buyers (Macreadie et al. 2022). Accounting for and monitoring co-benefits in financial and accounting tools can attract more diverse funding sources and mechanisms to blue carbon projects. Implementing more holistic blue carbon solutions will require developing efficient, cost-effective technologies and standardized protocols to monitor changes in blue carbon ecosystem distribution, their carbon abatement, and associated co-benefits (Macreadie et al. 2022).

CHAPTER 3

Blue Carbon Finance Assessment

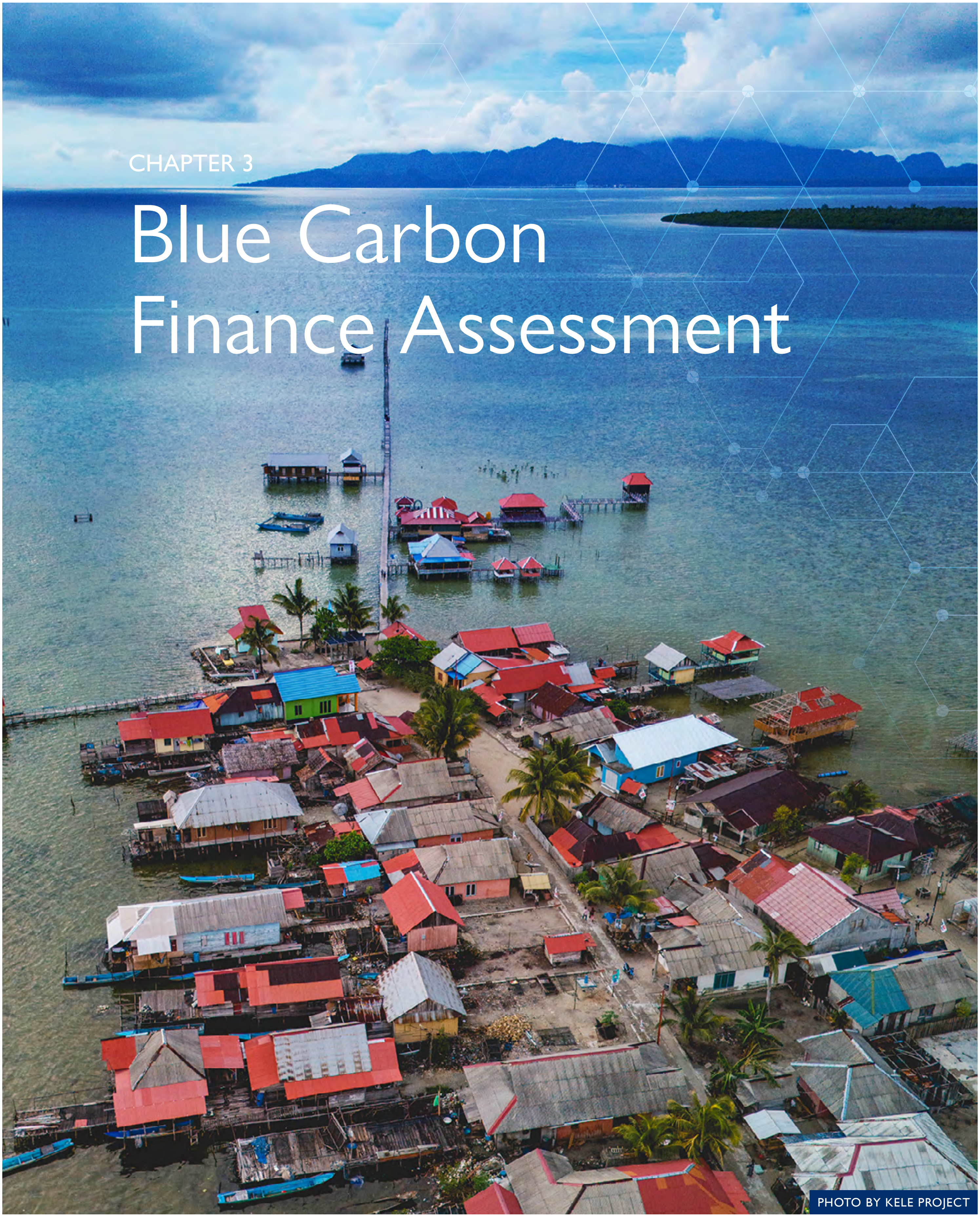


PHOTO BY KELE PROJECT

Securing and scaling up financing is essential to restoring and protecting valuable blue carbon ecosystems in the Indo-Pacific. Today, finance targeting blue carbon solutions is small in scale compared to mainstream climate and conservation finance, both globally and in the Indo-Pacific. However, blue carbon initiatives have the potential to access these larger and more diverse financing sources because they contribute to a broad range of climate and conservation goals. For example, according to Bloomberg New Energy Finance (BloombergNEF), in 2021, $166 billion was spent worldwide on restoring and protecting biodiversity. The majority of this funding came from domestic government spending. However, funding must rapidly increase to address the climate and biodiversity crises. A 2020 report by Paulson Institute, The Nature Conservancy, and Cornell Atkinson Center for Sustainability (Deutz et al. 2020) estimated that an additional $996 billion per year is needed by 2030 to manage biodiversity and maintain ecosystem integrity. Public financing sources alone will not be able to meet this target. Accelerating blue carbon finance in the real economy requires a combination of public and private sector actions.

> An additional USD 996 billion per year is needed by 2030 to manage biodiversity and maintain ecosystem integrity (Deutz et al. 2020).

Private sector interest in sustainable finance, specifically for biodiversity initiatives that include blue carbon finance, is increasing as a growing number of organizations set decarbonization goals. For example, the new Taskforce on Nature-related Financial Disclosures (TNFD) has 40 members committed to creating a framework of risk management and financial systems that helps companies understand how nature impacts their performance overall. The taskforce members include senior personnel from three different sectors: financial (16), corporate (17), and market-service providers (7). More than 1,100 organizations are members of the TNFD forum, and private sector adoption is expected to increase over time. The final part of this chapter provides more information about TNFD, including USAID's support and how it can help accelerate blue carbon finance.

USAID's agency-wide Private-Sector Engagement Policy (USAID 2021) recognizes the critical role of private finance and provides the mandate and guidance for working directly with the private sector to implement development programs. For example, USAID Green Invest Asia (USAID 2022) advanced the U.S. Government's Indo-Pacific Framework and its commitment to market-driven development by fostering private sector engagement on sustainable supply chains. It also supported the USAID Climate Strategy by mobilizing finance to invest in the transition to a net-zero economy. A set of engagement tools is available in USAID's Private Sector Engagement Hub (USAID).

In 2017, the Network for Greening the Financial System (NGFS 2023), a group of central banks and supervisors, was established to strengthen financial systems' response to meet the goals of the Paris Agreement, manage risks, and mobilize capital for low-carbon investments. NGFS has 125 members across five continents, including the central banks from the U.S., Malaysia, Indonesia, and large multilateral development banks (MDBs). The members of NGFS have a key role to play in sustainable finance as they supervise and set the rules for the financial system in their respective countries. NGFS also helps countries coordinate with one another to ensure the interconnected global financial system is resilient to potential financial shocks, such as widespread climate change impacts. For example, NGFS supports the consistent implementation of financial regulations globally by sharing detailed information about new actions. MDBs specifically have an additional role in facilitating new types of finance, such as blue carbon, by derisking projects and making them more bankable and investible. This helps bring more mainstream banks and institutional investors to sectors and geographies that may have traditionally excluded blue carbon finance because of a perception of higher risk. For example, the Asian Development Bank (ADB) is working to finance the blue economy in Asia and the Pacific by scaling up funding for coastal and marine ecosystem restoration, inclusive livelihoods, food security, and small and medium enterprises. The World Bank's PROBLUE fund supports sustainable development of marine and coastal resources in alignment with SDG 14 (UN-DESA 2024). In September 2023, NGFS published its Conceptual Framework for Nature-related Financial Risks (NGFS 2023), which established a common understanding of and language for nature-based financial risks to help operationalize the management of these risks at national central banks.

In response to the growing interest in blue carbon financing, this chapter provides an overview of financing options for blue carbon projects in the Indo-Pacific and identifies challenges and potential actions to move blue carbon finance from niche to mainstream. It describes tools, frameworks, and strategies for Indo-Pacific communities and governments to leverage global financial markets to protect valuable ecosystems and natural resources throughout the Indo-Pacific. Since blue carbon finance is a relatively new topic for global financial markets, this chapter also offers lessons learned from land-based carbon finance initiatives.

PHOTO BY USAID

Blue Carbon in Indo-Pacific Economies

Before detailing the financial opportunities and mechanisms related to blue carbon, it is important to provide more context about Indo-Pacific economies themselves. The size of the national economy, industry sector concentration, exposure to global supply chains, and levels of financialization influence which financial mechanisms are most appropriate for blue carbon. The overall goal of blue carbon finance is to contribute to sustainable economic growth in each country by valuing the carbon sequestration potential of natural ecosystems and the organisms that inhabit them. Financing for blue carbon can also protect valuable natural resources that sustain local livelihoods and communities and help limit future global carbon emissions by preventing habitat destruction.

Table 3 below breaks down GDP for each Indo-Pacific country considered in this report. These data can help contextualize the size of each economy. There is not yet a full reliable set of data summarizing the financial contribution that specific ecosystems, such as mangroves, make to national GDP. However, a breakdown of GDP in Indo-Pacific countries by large industrial sectors is available from the World Bank (2024). The table below includes the percentage contribution of export fishing to GDP in each country.[5] These data capture economic activities in each country, including fish processing, and indicate the importance of sustaining fisheries blue carbon in Indo-Pacific economies. The table also shows the total financial value of exports for each Indo-Pacific island country. This includes goods and services exported via global supply chains. Where data are available, the table includes the percentage of exports related to fishing. For readability, the two largest economies in size are presented at the top of the table.

[5] Subsistence fishing is often not accounted for in national statistics. This results in an underestimation of their contribution to national economies and food systems (Roscher et al. 2023)

TABLE 3. Contributions of fisheries, total exports, and fisheries exports to Indo-Pacific countries' GDPs (percent GDP), and their financial values (US dollars). Sourced from publicly available data from the World Bank for 2020 and 2021.

Country	GDP (USD millions) 2021	Fisheries' contribution to GDP 2020	Total Exports (USD millions) 2021	Fisheries' contribution to exports (USD millions) 2020
Indonesia	1,186,505	2.7%	253,912	4,832
Philippines	394,087	1.2%	101,674	804
Fiji	4,296	0.7%	1,173	35
Micronesia	404	12.1%	96	127
Kiribati	228	N/A	26	155
Palau	218	1.6%	N/A	0
Marshall Islands	260	9.9%	121	65
Samoa	844	2.0%	99	10
Nauru	146	N/A	54	N/A
Papua New Guinea	26,312	N/A	N/A	278
Solomon Islands	1,580	N/A	414	37
Tonga	469	1.9%	59	2
Tuvalu	60	N/A	N/A	10
Vanuatu	972	0.6%	89	122

The previous chapters of this report describe how the loss of coastal and marine ecosystems affects human health, livelihoods, and the productivity of fisheries in many Indo-Pacific island countries. Every hectare of clear-cut mangrove results in a loss of up to 670 kg in fish catch (Song et al. 2021), which negatively affects GDP. National governments in some Indo-Pacific island countries have a license system for international boats to access tuna. For some Pacific island nations (excluding Indonesia and the Philippines), these access fees provide approximately half or more of annual government revenues (Bell et al. 2021). Indo-Pacific economies could experience significant losses—on average $90 million annually (Bell et al. 2021)—in the future if blue carbon ecosystem losses and fisheries declines limit the ability to issue licenses. The Indo-Pacific Blue Carbon Trends Analysis (Chapter 1) also describes the implications for fisheries economies as fish migrate in response to climate change.

More detailed feasibility studies in specific geographic areas can help assess the potential for future economic losses and the application of specific financial mechanisms to mitigate losses. These studies would benefit from a collaborative regional research approach to assess projected losses and actions at a scale that is meaningful for potential investors. Alternatively, domestic finance solutions can support national or community-level projects in these countries.

It is also important to understand the additional benefits and socio-cultural significance these ecosystems bring to global, regional, and national economies, which GDP figures do not quantify separately. Blue carbon habitats provide numerous ecosystem services and other co-benefits, such as protecting coastlines from storm impacts and erosion, supporting tourism, providing habitat for biodiversity, and supporting fisheries. Co-benefits of blue carbon investment can be bundled to make an investment more attractive to financiers. In many cases, it is possible to quantify these blue carbon co-benefits, but translating that value into investment can be complicated because of the timelines of ecological conservation and restoration and delivery of intervention results. Valuating intangible co-benefits of ecosystems, such as spirituality, cultural identity, and human well-being, is a key challenge of assessing and aligning financing with the value of blue carbon ecosystems.

Challenges for Policymakers

Understanding linkages between national economies and blue carbon ecosystems in the Indo-Pacific region is an important first step to determining the most appropriate financial mechanisms. Next steps include conducting a thorough assessment of coastal and ocean areas to identify habitats that could benefit from restoration or protection; quantifying social, cultural, and livelihoods co-benefits; and engaging stakeholders, such as traditional landholders, local communities, and financial institutions, to further assess and evaluate blue carbon alternatives.

DATA AND INFORMATION

Blue carbon finance is a relatively untapped opportunity for private sector decarbonization activities, despite the growing global interest in blue carbon investments (Friess et al. 2022). Performing detailed financial assessments, including developing robust cost estimates for setting up new projects, can be a challenge to identifying appropriate sources of funding for blue carbon initiatives. Before making a decision to invest, potential funders often require minimum asset valuations and detailed supporting documentation, including financial cash flow forecasts from potential blue carbon investments with clear and stable contractual terms and conditions. A lack of information and/or historical business cases or pilot projects can hold back investments.

From a mainstream finance perspective, commercial banks and institutional investors consider economic conditions and project scale in their risk management processes for new lending and investing, both domestically and globally. Financial institutions have certain risk tolerances for the types and sizes of nature-based solutions they finance (Federal Reserve 2021), and these decisions depend on their position on the spectrum of capital (Jackson 2021) (Appendix C).

Different types of organizations are appropriate for different private finance needs. Organizations themselves have different strategic objectives that drive their business models and are influenced by their position on the spectrum of capital. Typically, financial institutions generate revenue by charging fees for the financial services they provide and by managing the risk/return profiles of their investments.

Using the spectrum of capital (Jackson 2021), traditional finance, such as mainstream banking and investment, mainly focuses on maximizing financial returns while mitigating potential financial risks, such as risks related to currency exchange and inflation. Traditional finance does not take into account potential negative externalities arising from investment, such as ecosystem destruction, unless it impacts financial performance in the short-run. Therefore, from a traditional finance perspective, a tree is often worth more dead than alive (Mooney 2000).

Traditional finance is the basis for the largest portion of global assets under management today. Responsible, sustainable, impact, and philanthropic finance made up 36% of global assets under management or USD35.3 trillion in 2021 (Baskar 2022). This is estimated to rise to 50% by 2025. The largest portion of this financing is responsible finance, which involves measuring and mitigating to the extent possible the environmental, social, and governance (ESG) risks of an investment. For example, integrating ESG into traditional financial investment decision-making involves acknowledging

Types of Financial Institutions and Institutional Investors

Financial institutions and intermediaries consist of a broad range of organizations that deal with public and private financial transactions. This primer introduces six types of financial organizations relevant to blue carbon opportunities:

- **Central banks:** Responsible for overseeing all other banks, usually at a national level. Communities and individuals are not directly connected to central banks.
- **Multilateral development banks (MDBs):** Organizations created by a group of countries, which provide finance and financial advice to support development.
- **Commercial banks:** Offer financial products, such as loans, deposit accounts, and financial advice, to businesses of varying sizes in the real economy, including sectors such as agriculture. In the Indo-Pacific islands, most commercial banks are national or regional.
- **Investment banks:** Offer more complex financial services used by governments and international businesses. They also act as financial advisors to clients, such as pension funds and institutional investors, and they assist in raising new capital securities (for example, by underwriting new blue bond transactions). In the Indo-Pacific islands, most investment banks are regional or international.
- **Insurance:** Organizations that help transfer the potential risk of loss, therefore providing financial protection. In the Indo-Pacific islands, most insurance organizations are regional or international.
- **Broker / Dealer:** An organization that acts as intermediary and is authorized to buy and sell securities.
- **Institutional investors:** Financial institutions and other organizations that invest money on behalf of other people. They often buy and sell large amounts of securities via brokers.

and quantifying negative externalities. In some cases, ESG risks can influence decisions about whether an investment proceeds. Impact finance integrates ESG risk analysis and has stated positive sustainability objectives. In 2022, impact finance was just over $1 trillion (Hand et al. 2022). An example of award-winning impact finance is a blue capital fund (Karner Blue Capital 2021).

Completing an ESG risk analysis requires reliable data related to blue carbon ecosystems. Carbon sequestration rates or carbon emissions reduced or avoided can be key performance indicators for new types of blue carbon finance. ESG analyses can also account for impacts on livelihoods, environmental quality, and GESI. For example, impact finance investments can integrate a set of indicators into a sustainability-linked loan or blue bond (see Appendix C for details).

KNOWLEDGE AND CAPACITY

Blue carbon finance is relatively new, and many stakeholders still have limited knowledge about the types of available funding and the MRV data requirements associated with some private finance opportunities. Levels of knowledge are low, even among financial institutions, because typical financial training, such as accountancy and investment management exams, do not address the data and analyses relevant to blue carbon investments—for example, analyzing and managing carbon emissions.

In addition, traditional financial analyses do not assign a financial value to negative externalities, such as ecosystem destruction. Therefore, they are usually excluded from financial models that assess potential investments, such as discounted cash flow analysis. As a result, a project that causes environmental harm may receive funding, while projects that have a positive environmental impact do not get funding. Financial institutions and accountants also use specific technical language and modeling techniques that are different from other sectors and therefore can create barriers to investments.

To help address these challenges, financial institutions and professionals need more training and capacity development in climate change and its impacts on investments, environment and climate externalities, and the data necessary to analyze them. In addition, programs that increase financiers' exposure to local communities' and national governments' perspectives on blue carbon investment can help raise awareness and encourage growth.

From a private finance perspective, using common and widely accepted industry standards to measure new types of data is key to accelerating biodiversity, climate, and blue carbon finance. Training on emerging international standards for blue carbon, described later in this chapter, is also necessary to help investors understand, compare, de-risk, and finance projects appropriately. Project stakeholders, such as decision-makers at national and local levels, would also benefit from financial training to understand what makes a project investment-worthy.

GEOGRAPHIC SCALE AND MOVING TARGETS

To date, most of the blue carbon private sector opportunities relate to specific habitats in discrete locations—for example, restoring a particular mangrove forest or coastal area. If funded in isolation, these projects can be difficult to scale due to their small size. In addition, blue carbon investments are likely to be spread across a variety of industry classifications in a commercial bank or institutional investor's portfolio, such as "agricultural commodities for fishing." Some blue carbon systems, such as fisheries, do not exist in a static location in a single country or geography. The industry and geographic classification at financial institutions can make it difficult to characterize blue carbon in the context of a specific investment opportunity.

Collaborations among local environmental organizations, research institutions, financial institutions, and policymakers to gather data and information about the current state of blue carbon ecosystems, blue carbon-dependent communities and livelihoods, and related industries in specific geographic areas can help expand the number of potential funding sources. Actions to align Indo-Pacific blue carbon and financial lexicons can further encourage cooperation.

PHOTO BY PETER MOUS

ENABLING ENVIRONMENT

From a traditional finance perspective, a stable enabling environment that avoids regulatory capture, combined with a solid understanding of the applicable legal and voluntary frameworks, is necessary to scale up blue carbon financing. A stable enabling environment also reduces uncertainty and risk associated with investment decisions.

For example, it is important that both public institutions and private sector entities have the appropriate policy, regulatory, and legal structures in place to enable public-private partnerships, receive and manage blue carbon finance through a variety of mechanisms, and allow for effective redress. Financial institutions have existing financial crime compliance policies and practices that apply to all customers and broader stakeholders, including suppliers and partners (Murphy et al. 2020). These include anti-money laundering, anti-bribery, and anti-corruption policies. Requirements for transparency can also help build confidence in blue carbon investments—for example, project documentation should be required to disclose estimates or assumptions underlying project data or information. This is especially important for long-term projects, such as ecosystem restoration projects that occur on timelines of years, rather than months. Human rights protections are also required to access responsible financing from banks and institutional investors. The geographic context of the Indo-Pacific could make this challenging—for example, if illegal fishing takes place far offshore or fish processing is completed out of sight in poor conditions.

Blue Carbon Finance Opportunities

Various mechanisms and strategies are available to secure funding for activities related to the protection, restoration, and sustainable management of coastal and marine ecosystems. These investments contribute to carbon sequestration and climate change mitigation, climate change adaptation and DRR, economic development, conservation, and environmental quality. This section describes several types of blue carbon finance opportunities, although some of these opportunities may be cross-cutting and do not fit into a single category.

NATURE-BASED SOLUTIONS

Impact financing for nature-based solutions includes the sustainable management, restoration, and/or protection of seagrasses, mangrove forests, and coastal wetlands that store carbon, provide ecosystem services, and support the well-being of human and natural systems. When harnessed effectively, these ecosystems can hold more than 110,100 million tCO_2e across nearly 1.85 million square kilometers globally (calculated based on estimates in Macreadie et al. 2021). The benefits of nature-based solutions projects can also be monetized to generate returns when impact investors have an objective to achieve both financial returns and explicit sustainability objectives for a project. Client demand for sustainable investment is growing, which drives the focus on environmental impacts of investment. For example, some retail investors demand impact finance from the institutional investors who manage their money.

PHOTO BY TONY DJOGO

Impact finance requires measurement and transparency about the co-benefits of a project—for example, landscape restoration or increased gender equity. These additional evaluations can add costs to an investment strategy compared to traditional financial analyses. However, impact finance brings other local economic co-benefits, such as shoreline protection and support for local livelihoods. This can attract more diverse investors and can improve the net benefit of investments. Chapter 2 of this report discusses these co-benefits in more detail. For example, some island countries are rewilding nearshore ecosystems to restore ecosystem services and protect blue carbon-dependent livelihoods. The objective of rewilding ecosystems, specifically island ecosystems, is to help reverse ecological degradation, manage invasive species, and slow or reverse biodiversity loss. Through partners and funders, such as Island Conservation, Re:wild, Scripps Institution of Oceanography, and many others, the Island-Ocean Connection Challenge (IOCC) has a goal of restoring and rewilding 40 island-ocean ecosystems by 2030 (IOCC 2023).

VOLUNTARY CARBON MARKETS

Voluntary Carbon Markets (VCMs) are one of the most complex and controversial mechanisms for financing blue carbon and terrestrial carbon initiatives. VCMs are mainly private sector initiatives, usually led by corporations, that generate and purchase carbon credits to offset or inset[6] carbon emissions. Each carbon credit is the equivalent of reducing or removing one ton of CO_2e. The size of the VCM is

[6] Insetting involves implementing NBS to reduce greenhouse gas emissions from an entity's own supply chain (Bhatia 2022).

determined by the financial value institutional investors place on carbon sequestration from ecosystem protection and restoration and the carbon emissions these investments offset. Today the approximate annual size of the VCM is $2 billion per year, and this is expected to increase to approximately $34 billion globally by 2050 (BNEF 2024).

It is possible to develop an indicative financial value for Indo-Pacific blue carbon using a simple methodology based on carbon credits and Indo-Pacific countries' mangrove, seagrass, and tuna carbon sequestration potential (see Appendix A for carbon sequestration data). The estimated price-per-blue-carbon-credit in Asia is between $13–35 (L 2023). Table 4 shows the estimated total financial value of carbon sequestered through seagrass and mangrove restoration and in tuna in Indo-Pacific nations. These estimates use the high-end of this price range—$35, the price at which recent blue carbon projects have been sold (Drake 2022). A fair distribution of proceeds from sales of carbon credits is important to ensure a project's success, including fair distribution of economic benefits to the local community.

TABLE 4. Size of Indo-Pacific countries' mangrove and seagrass blue carbon ecosystems in 2020 and the present net CO_2e ocean sequestration for tuna per year (minus the emissions from the catch). Estimated financial values of aggregated CO_2e sequestration of mangroves, seagrass, and tuna in US dollars. Underlying data is sourced from Global Mangrove Watch, Betram et al. (2021), and Mariani et al. (2020).

Country	Mangrove area km²	Seagrass area km²	Tuna (net uptake tCO_2e)	Total sequestration tCO_2e/yr	Estimated absolute financial value (thousands USD / yr)
Fiji	488.14	507.45	50,808	619,528	21,683
Indonesia	29,533.98	5,582.48	544,495	22,231,607	778,106
Kiribati	1.46	53.46	410,330	438,338	15,342
Marshall Islands	0.33	21.88	201,815	213,107	7,459
Micronesia	87.94	89.32	281,350	382,744	13,396
Nauru	0.00	0	336	336	12
Palau	56.88	82.77	74,252	152,494	5,337
Papua New Guinea	4,524.74	992.02	82,476	3,474,303	121,601
Philippines	2,847.98	1,749.36	102,881	2,807,525	98,263
Samoa	2.32	10.65	5,325	12,200	427
Solomon Islands	526.51	405.93	143,951	685,757	24,001
Tonga	10.43	4.91	21,662	30,809	1,078
Tuvalu	0.09	0.16	61,144	61,283	2,145
Vanuatu	15.84	6.59	28,431	41,884	1,466
TOTAL	**38,097**	**9,507**	**2,009,256**	**31,151,913**	**1,090,317**

Indo-Pacific countries have the opportunity to participate in VCMs because of their abundant nearshore natural resources and the potential for restoration and conservation. To enter VCMs for blue carbon, often a country's first task is to establish a baseline of the current stock of blue carbon ecosystems, which can be costly and time-consuming if these data are not already available. However, for market credibility, it is important that VCM projects have a well-established baseline, and robust monitoring protocols, to ensure they are truly additional. The concept of additionality (i.e., that a project's carbon emission reduction or increase in sequestration occurred due to the carbon finance) is crucial for investors because it prioritizes adding new projects and sequestration, rather than trading existing carbon offsets or credits via a brokerage.

The price paid for each carbon credit varies depending on project quality and overall market integrity. Recent debates about VCM credibility have raised questions about greenwashing, "phantom" credits that do not reduce or remove carbon, double-counting offsets, trends of overstating project benefits, and inequitable values of VCMs in developing vs developed countries. There are also concerns that funds raised from carbon credits have not reached local communities that are stewards of these natural resources. Some observers of the VCM view its unintended consequences as a form of neocolonialism that transfers projects and land rights from communities to international private sector entities.

To help address some of these issues, the Integrity Council for the Voluntary Carbon Market (ICVCM) is a new global governance mechanism that supports scaling the VCM and Article 6 of the Paris Agreement. ICVCM is an independent governance body with members from across the world, including the United Nations. It has defined a single global threshold for projects, called the Core Carbon Principles (CCPs) Assessment Framework. Furthermore, standard-setters and verifiers operating in VCMs have developed specific guidance related to blue carbon, which is relevant for Indo-Pacific countries. For example, Gold Standard has a practitioner's guide for digitizing project data collection and registering and certifying a project. It also provides guidance for aligning voluntary projects with a country's NDC. Improving the quality and credibility of VCM credits could raise the price of carbon credits and increase the value of the VCM considerably.

For some Indo-Pacific countries, the scale of single nearshore habitats may not be large enough to support project development costs. In this case, projects can be grouped together at a national or regional level to benefit from economies of scale. Aggregating projects into a themed blue carbon accelerator or impact fund brings down costs and makes it more financially viable for private investors. However, it is important for blue carbon VCM project managers to be aware that other activities occurring within a VCM project area—even if they contribute to emissions reductions—can interfere with carbon accounting for the VCM, especially if they receive financing from sources external to the VCM.

An initiative in Australia created reef credits (Green Collar 2020), an innovative type of financial instrument based on a method similar to carbon credits. Each reef credit represents a quantifiable, verified volume of pollutants (e.g., sediment, pesticides, and dissolved inorganic nitrogen) removed from water flowing from land to the reef. The project was a partnership between an environmental markets investor and project partners, and it received support from a regional policymaker initiative. Given the local support and umbrella policymaker initiative, the reef credits were successfully sold to large financial institutions and companies.

CASE 7

Ocean Accounts for Fiji's Mangroves Make Progress Toward SDGs and the Paris Agreement

Ocean accounts provide countries with the means to go beyond GDP (European Commission 2024) by integrating social, economic, and environmental information to track progress toward a country's domestic and global commitments (GOAP Secretariat 2022(a)). Blue economy is fundamental to Fiji's national economy and local livelihoods. Ocean accounts enable the comparison of ocean environment assets (e.g., extent/condition of mangroves), economic activity (e.g., sale of fish), and social conditions (e.g., coastal employment) (GOAP Secretariat 2022(a)). Fiji has one of the highest mangrove coverages in the South Pacific region, which plays a critical role in the local economy. Ocean accounts for mangroves were created to capture the contribution of mangroves to the Fijian society and economy (GOAP 2022(c)) because the economic value of mangroves currently accrue to fisheries and aquaculture, construction, and professional scientific services industries. The economic value is about $20–30 million of direct UN System of National Accounts benefits of mangroves annually. Mangroves support about 0.5 percent of Fiji's GDP and Gross Value Added. Mangrove related activities support about 3,500 direct jobs, which represents about two percent of all jobs created in these industries.

References: GOAP Secretariat 2022(a), GOAP Secretariat 2022(c)

PHOTO BY USAID

NATIONAL CLIMATE FUNDS

Indo-Pacific countries could consider creating national climate funds that channel financing to blue carbon initiatives and help ensure that the financial benefits of their natural resources remain in the country. These funds obtain finance from both domestic and international sources, including taxes and foreign direct investment budgets. They have a broad mandate to tackle climate change, often through sector-level actions that align with national climate plans and development strategies.

> "By helping raise private sector awareness and supporting new funding opportunities, and by creating Blue Carbon Zones, governments can unlock private sector access [and] enable the protection of ecosystems."
>
> **Lauren Drake**, Executive Director, Pollination Group (2023).

National climate funds can direct finance to local communities through national budgeting processes, and through mechanisms such as loans and grants. External funders often require transparency; therefore, tracking the use of fund disbursements from national climate funds, and pre-arranging stakeholder engagement around fund use, can also be an important feature of these funds. For example, in Kenya, stakeholders participate in fund management committees to ensure communities have a voice in decision-making. With conditions in place to help ensure transparency and equity, national climate funds can effectively channel finance from national budgets and international funders to local communities. Of the Indo-Pacific countries considered in this report, Indonesia, FSM, Philippines, and Tuvalu have national climate funds. The United Nations Development Program (UNDP) highlighted the Tuvalu Trust Fund (TTF) in a case study (Petrini et al. 2013). The TTF has international donors, a clearly stated financial model with objectives, and strong management processes.

> The IFC estimates that the climate commitments made by 21 emerging market countries will require as much as $23 trillion in investments by 2030. However, current funding flows are "insufficient for, and constrain implementation of, adaptation options, especially in developing countries" (IPCC 2023). More work to overcome the shortage of 'bankable' blended finance projects in developing and middle-income countries can increase investor confidence and mobilize capital for climate action.

BLENDED FINANCE

Blended finance is another impact finance mechanism that can accelerate financial flows into blue carbon. Blended finance is the strategic use of development finance and philanthropic funds to mobilize private capital flows for emerging and frontier markets, resulting in positive results for both investors and communities (World Economic Forum, 2015). Blended finance involves a larger number of stakeholders, including policymakers, MDBs, and investment banks. For example, blended finance can include private funding and development funding from public and philanthropic donors. Blended finance lets institutional investors choose different risk tolerances while participating in the same project. This funding approach also allows intermediaries to match different sustainable development projects to the investment capital. This type of financing can bring together partners from philanthropy, government, and the private sector in a collective effort along the spectrum of capital, including technology. For example, Sofar Ocean (Sofar Ocean 2024) uses blended finance to fund projects using their "backyard buoy" technology to track water temperature and monitor wave movement to inform decisions about responding to certain weather events. Blended finance helps de-risk funding, attract investors, and enable access to a larger pool of capital.

GLOBAL CLIMATE FUNDS

Blue carbon projects can access multilateral international funding through three main global funds: the Global Environment Facility (GEF), the Green Climate Fund (GCF), and the Climate Investment Funds (CIF). While there are other smaller funding opportunities, these funding pools have more than $50 billion in funds that blue carbon projects can apply for. However, sometimes these funds can take more than a year to be disbursed due to project application cycles and the amount and complexity of documentation required.

The GEF funds projects that combat biodiversity loss, climate change, pollution, and stressors to land and ocean health. The organization consists of 185 participating countries, a council of 32 member countries who serve as the main governing body, and 18 partner organizations who help implement projects. The GEF provides opportunities in blended finance, grants, and policy support. GEF provides funding through four avenues: full-sized projects, medium-sized projects, enabling activities, and programmatic approaches. It has funded more than 5,000 projects dating back to 1991, with over 2,000 projects approved for the current cycle.

The GCF targets investments in four major areas: the built environment; energy & industry; human security, livelihoods and wellbeing; and land-use, forests, and ecosystems. Currently the GCF's portfolio value is more than $45 billion, with a mix of loans, grants, equity, results-based payments, and guarantees. The GCF has a 10-stage project cycle, and each project must align with the GCF investment framework, portfolio targets, and financial policies. Additional evaluation criteria include project impact, growth of the project beyond the first year, and sustainability of project activities and impact. GCF aims to maintain a 50/50 balance of climate adaptation and mitigation projects that span various sectors and result areas, such as health and well-being, climate information and early warning systems, energy efficiency, water security, low emission transport, ecosystems and ecosystem services, forest and land use, and agriculture and food security. A consortium of Pacific island countries[7], with support from Conservation International, is currently preparing a full proposal for $70 million (USD) in GCF funding to help manage climate change impacts on communities and economies that depend on Pacific tuna fisheries.

The CIF is a multilateral funding group that supports low- and middle-income countries in responding to the effects of climate change. The CIF receives funds from MDBs, such as the World Bank Group, the Inter-American Development Bank, the African Development Bank, the European Bank for Reconstruction and Development, and the ADB. CIF focuses on projects related to technology, technical assistance, and strategic climate strategies, working through two central funds—Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF)—and by mobilizing private capital funds. Individuals who want to access these funding streams are required to work with MDBs directly to develop and implement projects.

Takeaway for Donors

Supporting financial literacy, reducing barriers to access financing, and increasing participation in global efforts to streamline blue carbon funding can contribute to ambitious climate action and transformative change in partner countries. The Intergovernmental Panel on Climate Change (IPCC) recognizes the value of diverse sources of knowledge in building climate resilience, and highlights the importance of targeting adaptation finance to vulnerable groups, regions, and sectors (IPCC 2023).

[7] Cook Islands, FSM, Fiji, Kiribati, Niue, Nauru, Palau, PNG, RMI, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

BLUE BONDS

Blue bonds are a type of debt that companies and sovereigns can use to finance the restoration and maintenance of ecosystems and aggregate small projects for funding. National governments issue blue bonds themselves to fund projects, often working with investment banks and MDBs. Institutional impact investors provide capital. One benefit of using blue bonds for blue carbon financing is that they are issued on a case-by-case basis specifically to fund blue ecosystems and economies and climate and/or sustainability initiatives in blue systems. Limitations can include incurring high debt and addressing the challenges of working with private actors.

In 2018, the Government of the Seychelles, a small island state, issued the world's first blue bond. The total amount of sovereign and corporate debt issued in 2021 by organizations in Asia Pacific, excluding China and Japan, was over $100 billion (ICMA 2021). Where relevant a portion of this could be issued in a blue bond format, as it would contribute to positive environmental, economic, and climate outcomes. Fiji's blue bond, issued in November 2023 for $20 million, was oversubscribed by three times the issuance amount, indicating strong interest among investors in blue financing mechanisms (Vula 2023).

DEBT-FOR-NATURE SWAPS

Debt-for-nature swaps (DNS) allow countries or other entities to restructure either their sovereign or commercial debt obligations by linking them to the protection of natural resources. Through DNS, countries reduce their debt by trading it for climate/nature initiatives. Governments work together with investment banks to structure these financial products. The main limitation of DNS is the time required—sometimes years—to negotiate fair and equitable terms. In addition, initial implementation of national climate and nature initiatives can be costly. Depending on the amount of debt a country has, a DNS is likely most effective as one tool of an overall blue carbon financing strategy, not as a stand-alone solution.

In 2021 the Government of Belize entered into a DNS linked to the protection of its barrier reef. This transaction raised $364 million and reduced Belize's debt by 12 percent of GDP, in return for conserving 30 percent of Belize's ocean and other conservation measures (Egolf 2001).

> The IMF and World Bank have identified debt-for-climate swaps as tools to leverage additional finance for climate actions in Pacific SIDS, while reducing their debt burdens.

Integrated Initiatives for Blue Carbon Finance and Climate Adaptation

Recognizing the importance of blue carbon ecosystems to the future prosperity of the Seychelles, in 2018 the Government ratified, "Seychelles Blue Economy Strategic Policy Framework and Roadmap." The innovative policy framework and roadmap takes an integrated approach to ocean-based sustainable development, bringing together environmental, societal, and economic considerations. A number of initiatives have followed:

- The aforementioned **Blue Bond** supports sustainable fisheries, with proceeds helping to expand Marine Protected Areas (MPAs).
- Seychelles **Blue Economy Debt-for-Nature Swap** aims to convert over $21 million of national debt, helping to finance adaptation, implement marine spatial planning, create new MPAs, and establish legal frameworks around the use of marine resources.
- Seychelles' **Conservation and Climate Adaptation Trust** provides funds for supporting new and existing MPAs and sustainable use zones, empowers fisheries with science, promotes rehabilitation of degraded areas, develops and implements social resilience plans and risk reduction plans for climate adaptation, and develops business models to support sustainable development.

Indo-Pacific Blue Carbon Finance Options

Sustainable finance is a dynamic field with many new ideas and solutions, especially technological ones. Internet access can help financially excluded communities access finance via mobile phone applications, therefore limiting the need for a physical banking infrastructure. Web3 technologies, such as blockchain, can facilitate traceability and verification of local conservation actions. For example, integrating blockchain technology in the end-to-end supply chain, including access at the community level, delivered significant environmental benefits in global black tea supply chains (Paul et al. 2021). In addition, it is possible to tokenize assets, such as blue carbon credits, by adding them to a blockchain (Aki 2021). Using a democratic financialization model to access new and diverse international retail, investors who use the same technology can help scale up blue carbon finance. Piloting these innovations could help Indo-Pacific communities and policymakers develop new context-appropriate approaches to scale blue carbon investments. Table 5 below lists the countries considered in this report and the potential suitability of different types of finance at different geographic scales.

The analyses and assessments in this report have considered Indo-Pacific countries collectively where possible. However, the Philippines and Indonesia have the largest economies (based on GDP), and therefore, they have greater opportunity to access international capital markets for blue bonds and blended finance. Indonesia's relatively high percentage of fisheries exports suggests blue bonds and supply chain finance could provide financing opportunities. However, smaller island nations that may not have the economic scale to access some opportunities individually could consider a regional grouping to increase access to certain financing sources. This strategy can help diversify offerings for countries with fewer blue carbon resources. For example, given Nauru's lack of mangrove and seagrass sequestration, it does not have high potential for participation in the VCM, but it could join other nations to offer a portfolio of blue carbon projects (World Economic Forum 2022). For all the financial mechanisms below, more detailed feasibility studies can identify the most appropriate financing opportunities for a particular geography.

TABLE 5. Potential national and regional blue carbon financing mechanisms by country. A darker color indicates higher potential for use based on the presence and extent of blue carbon ecosystems in each country. This initial assessment does not replace detailed feasibility studies and analysis of the financing enabling environment. Further analysis could also help determine how these mechanisms could be used individually or in combination in a certain country context.

Country	Voluntary Carbon Market	National Climate Fund	Blended Finance	Blue Bonds and Supply Chain Finance	Debt-for-Nature Swaps
Indonesia					
Philippines					
Fiji	•		•		
Micronesia	•		•		
Kiribati	•		•		
Palau	•		•		
Marshall Islands	•		•		
Samoa	•		•		
Nauru			•		
Papua New Guinea	•		•		
Solomon Islands	•		•		
Tonga	•		•		
Tuvalu	•		•		
Vanuatu	•		•		

• indicates potential for a regional financing mechanism

Experience from Land-Based Carbon Finance

Land-based carbon projects have expanded through partnerships and collaboration among various stakeholders, including governments, financial institutions, communities, and non-profit organizations. Blue carbon initiatives can leverage existing networks, partnerships, and platforms to enhance project implementation and attract funding. Collaboration can also facilitate knowledge sharing, capacity building, and the exchange of best practices, ultimately promoting the scalability and replicability of successful blue carbon projects. By learning from land-based carbon projects, blue carbon initiatives can benefit from established practices, methodologies, and investment pathways and networks. Adaptation of these lessons can contribute to the successful financing and implementation of blue carbon projects, enhancing climate change mitigation efforts and the conservation of coastal and marine ecosystems. This section discusses two key principles for blue carbon finance, based on existing work from commercial banks, the insurance industry, and standards and training initiatives.

ENVIRONMENTAL AND SOCIAL SAFEGUARDS FOR INVESTMENT STRATEGIES

Commercial banks have made progress strengthening terrestrial deforestation risk policies (Triantafilidis 2021). For example, 19 percent of 150 banks surveyed globally had introduced a policy to implement minimum standards for deforestation into their lending strategies. Some commercial banks have already introduced voluntary internal policies that prevent lending to projects that would damage Ramsar Wetlands (IUCN 2014). These policies can expand to new areas, such as unprotected mangroves. These types of safeguards often apply to new lending and require ongoing monitoring, for example by working with independent standard setters and verification bodies.

This approach is similar to the EU's Sustainable Finance Disclosure Regulation (SFDR), in effect since 2023. SFDR requires institutional investors who sell sustainable finance products to EU-based clients to disclose annually how they "do no significant harm" to the environment. Although sustainable finance regulations have progressed globally, it is likely that minimum standards will increase over time.

Financing for palm oil offers another example of linking environmental safeguards to investment strategies and global supply chains. The destruction of habitats for the planting of palm oil has slowed in recent years, due in part to the insistence of investors and consumers and regulations, like SFDR, that require disclosures. Financial institutions and companies can obtain environmental and social standards and certifications, such as the Roundtable on Sustainable Palm Oil (RSPO). Some commercial banks now only finance farmers in the sector who meet RSPO standards through the introduction of minimum sustainability risk lending standards. The implementation of risk policies can vary by size of customer. Independent verifiers review RSPO compliance and report back to the commercial bank throughout the entire lifetime of the financial product. If standards are not met, smallholder farmers receive more time and support to implement the RSPO policy, a period of patience to adapt, and advance warnings prior to withdrawing funding. Since smallholders often do not have direct access to banks, it is important for them to engage locally with trained bank risk officers and community groups on the ground.

This new approach to palm oil can be applied to fisheries—for example, by introducing and/or expanding banking agricultural commodities policies at commercial banks to include minimum standards and referencing organizations such as fair trade or Global Sustainable Seafood Initiative (GSSI). Policymakers can help support these approaches by bringing together stakeholders, including local communities, for training and to share best practice examples.

MONITORING, REPORTING, AND VERIFICATION

Land-based carbon projects have established robust MRV systems to accurately measure and verify carbon sequestration and emission reductions. Blue carbon projects can adopt similar standardized methodologies and protocols for quantifying and monitoring carbon stocks and fluxes in coastal and marine ecosystems. This ensures transparency, credibility, and comparability of results, which are crucial for accessing carbon markets and attracting finance. Policymakers can help by supporting incorporation of international standards domestically.

In 2023, Ørsted was the first energy company in the world to issue a blue bond. The proceeds from the bond support sustainable shipping and ecosystem restoration, including salt marsh and seagrass. The International Finance Corporation (IFC) blue finance guidelines determined the metrics and targets embedded in the Ørsted blue bond. These guidelines recommend impact reporting during the length of a blue bond with independent verification. Because of the international standing of the IFC, integrating its guidelines can help attract private capital, while increasing adoption of standards for MRV. In September 2023, the International Capital Markets Association (ICMA) launched a new practical guide for blue themed bonds to help unlock finance for a sustainable ocean economy. ICMA developed this guidance in collaboration with the IFC, United Nations Global Compact, United Nations Environment Programme Finance Initiative (UNEP FI), and ADB. It defines eligibility criteria, suggests key performance indicators, and highlights case studies from the field (ICMA 2023).

Many financial institutions, companies, and public entities in Japan, Hong Kong, Singapore, and Malaysia, among others, are currently, or will soon be subject to mandatory reporting using the Taskforce on Climate-related Financial Disclosures (TCFD) standards and methodologies (Naik 2021). TCFD requires financial institutions to identify and disclose information about climate change impacts on their operations and customers, and how their operations contribute to climate change, including their carbon footprints. Identification and disclosure lead to a greater awareness of the externalities, such as carbon emissions associated with financing both inside the financial institutions and among institutional investors. Heightened awareness, in turn, can lead to more sustainable finance opportunities that help mitigate the externalities. A study by CDP (formerly Carbon Disclosure Project) found that more than 3,000 companies from 21 Asian Pacific markets reported TCFD-aligned disclosures in 2020 (Divgi 2021).

Building on TCFD, the TNFD, launched in 2023, focuses on biodiversity. Public and private organizations around the world can use TNFD to identify and assess biodiversity-related risks and opportunities based on their business actions and processes. TNFD recommends additional external measurement and disclosures on biodiversity, explicitly including marine ecosystems where positive or negative environmental impacts are relevant. Therefore, TNFD facilitates investments by helping carbon project planners identify and publicly disclose negative impacts on biodiversity from a business or investment portfolio, thus accelerating financial opportunities as project planners work to mitigate negative impacts.

In 2015 the Dutch central bank established the Partnership for Carbon Accounting for Financials (PCAF). It is the most common global industry standard that financial institutions, including banks, institutional investors, and insurers use to measure financed carbon emissions from customers in the real economy. PCAF has dedicated resources in Asia Pacific, and it can help support action, such as improving carbon data to enable compatibility and comparison across organizations and facilitating sustainable finance. In 2022, the Partnership for Biodiversity Accounting for Financials (PBAF) published its first framework for accounting, including the ocean and marine ecosystems.

Integrating new types of data into private finance underwriting, investment, and lending decisions is also necessary to advance from simply measuring to taking action—for example, by setting business targets that expand private financing of projects that remove or absorb carbon. The Science Based Targets Initiative (SBTi) provides guidance for organizations internationally, including financial institutions (Anderson et al 2022). SBTi is a partnership among CDP, World Resources Institute (WRI), WWF, and the UN Global Compact. It supports low-carbon lending and investing to the real economy by providing guidance for Forest, Land, and Agriculture (i.e., SBTi's FLAG sector), including mangroves. In 2023, the SBTi released its first nature-related targets guidance. This guidance considers the carbon emissions removal potential of mangroves, seagrass, and marshes and encourages financial/corporate/natural capital accounting and mitigation actions, which had not been included in the past. This new initiative includes an Ocean Hub (Anderson 2022), which will provide more resources related to fisheries in 2024.

In natural capital accounting, target-setting, and public disclosure, it is important to report the coverage and scope of the information. External verification can establish a higher standard of sustainable financial product and environmental disclosure. For example, organizations receive additional points through the global CDP questionnaire process (2024) for auditing companies' reports. Sustainability-related financial products, such as blue bonds, also have verification recommendations (Climate Bonds Initiative 2024) to reduce the potential for greenwashing (Nemes et al. 2022). Minimum standards and legal clauses (Chancery Lane Project 2024) in financial contracts can also build in protections for communities.

Lessons Learned from Land-Based Carbon Finance

Designing MRV plans that use standardized methodologies and protocols (e.g., ICVCM, TNFD, and PBAF standards) enables carbon projects to share and compare data and outcomes more easily. This includes avoiding greenwashing practices that can damage reputation and ensuring a fair share of economic benefits remain with local communities (Nemes et al. 2022).

Assessing and quantifying the co-benefits of blue carbon finance (e.g., job creation, increased incomes, DRR, gender equity, environmental quality improvements, and human health benefits), can increase the total benefits of an investment and make it more bankable. Various economic valuation methods exist for analyzing and quantifying diverse types of co-benefits.

Tailoring investment risk policies to individual customers or groups of customers accounts for diversity in customer capacities, knowledge, and experience in blue carbon investments. It makes carbon project financing more attainable for disadvantaged populations and/or non-traditional customers.

Several partnerships and networks already exist for land-based carbon finance. Leveraging these established cohorts can facilitate development of adjacent networks, partnerships, and initiatives for blue carbon finance.

Using third-party verification of a business's natural capital accounting systems and targets increases transparency with customers, clients, and the public, and raises standards for system-wide MRV.

Revising organizational/departmental goals and performance evaluation metrics can help support more rigorous MRV and align organizational values with investment outcomes for nature and climate—for example, supporting fishers' livelihoods, improving environmental quality, and protecting human health.

Blue carbon finance methods are relatively new and training protocols are still in development. Seeking out the latest information about blue carbon finance (i.e., natural capital accounting, including carbon emission removal sources, etc.) and training opportunities can help potential investors and clients strengthen collective understanding of blue carbon finance.

Sharing organizational best practices, scalability strategies, and additional lessons learned from blue carbon finance can support collaboration on blue carbon investments and increase the efficiency of blue carbon transactions.

PHOTO BY ADY SANJAYA

National and subnational governments, the private sector, civil society organizations, and communities are at the forefront of the challenge of linking blue carbon quantification to investments in community and ecosystem resilience. However, additional steps are necessary to:

1. Improve quantification of blue carbon,
2. Align investments with the values and priorities of local communities, and
3. Scale up innovative financing.

This section outlines outstanding information gaps and proposes action items for policymakers, financial institutions, communities, and donors like USAID.

Blue Carbon Information Gaps

This section organizes potential areas of research based on the three sections of this report.

INDO-PACIFIC BLUE CARBON TRENDS

- **Improve baseline analysis and quantification of Indo-Pacific blue carbon.** Comprehensive mapping of Indo-Pacific blue carbon ecosystems and their protection status can help researchers and decision-makers quantify blue carbon sequestration and translate current and potential sequestration into monetary values and co-benefits to people and nature. For example, these efforts can build on the approach of Mapping Ocean Wealth (2023) to help summarize potential financial returns on blue carbon ecosystem restoration, including carbon sequestration and co-benefits to communities.
- **Prioritize seagrass mapping** to address a large gap in the baseline inventory of Indo-Pacific blue carbon. The majority of blue carbon ecosystem research has focused on mangroves. However, seagrass plays a key role in blue carbon sequestration, and seagrass ecosystems deliver important benefits to coastal communities, including storm protection and the provision of habitats for species that support food security. Comprehensive mapping of seagrass ecosystems can contribute to blue carbon quantification, the development of community-based management actions, scoping of opportunities for investments in seagrass ecosystems, and the development of MRV methods to link seagrass blue carbon to markets.

COMMUNITY RISKS AND SOLUTIONS

- **Map local use of and dependence on blue carbon ecosystems.** Prioritizing, designing, and implementing blue carbon projects that are equitable and fair requires a better understanding about how local people depend on nature and which aspects of that dependence are critical to livelihoods and well-being.
- **Develop methods to improve measurement of livelihood and equity impacts in blue carbon project design.** Many blue carbon restoration and conservation project designs account for ecological outcomes, such as ecosystem productivity, biodiversity conservation, and environmental quality improvements such as cleaner water. While USAID and other organizations already focus on local economic and social outcomes, it is important to increase the use of people-centered indicators to help align blue carbon project design with local needs. For example, in addition to developing indicators for and measuring blue carbon ecosystem health and blue carbon sequestration, blue carbon initiatives should also focus on the number of people, disaggregated by gender, with income from sustainable blue carbon ecosystems management, their levels of incomes, working conditions in blue carbon economies, and changes in social equity, especially among marginalized groups. In addition, improving and testing methods to assess and apply the social costs of carbon in analyses of investments will facilitate measurement of project costs and benefits and the social impacts avoided by protecting blue carbon resources.

BLUE CARBON FINANCING OPPORTUNITIES

- **Develop and test financial mechanism designs that better account for ecological and social outcomes.** Financial mechanisms, for example blue bonds, can build in sustainable use targets, which help contribute to conservation outcomes. Piloting enhanced financial mechanism designs can help funders and implementers assess, evaluate, and manage trade-offs among ecological outcomes and impacts on local livelihoods. It is especially important to account for women's livelihood activities that rely on blue carbon ecosystems to sustain local food security, health and nutrition, and local economies, as they are often overlooked or undervalued in economic and financial assessments.
- **Test and improve existing methods for quantifying and valuating co-benefits of protecting blue carbon ecosystems.** In addition to sequestering carbon, blue carbon projects can deliver a suite of co-benefits. Some co-benefits, such as cultural significance and human well-being, cannot be quantified or monetized. However, there are methods for quantifying and valuating other co-benefits, such as supporting coastal tourism operations, improving water quality and reducing the incidence of water-borne illness, protecting coastal infrastructure from storm damage, and strengthening local food security. These co-benefits often deliver more financial value than blue carbon itself. Including co-benefits in financial assessments of blue carbon investments can increase the projected long-term value of blue carbon projects. In addition, the ability to measure and quantify expected co-benefits more effectively can expand the pool of potential funding sources. Blue carbon investments can contribute to diverse goals of organizations working in conservation and biodiversity, environmental protection, public health, gender equity, and disaster preparedness, among other areas.

Blue Carbon Action Items

This section organizes blue carbon action items around four objectives:

1. Protect community rights,
2. Increase readiness to access blue carbon finance,
3. Strengthen potential investors' capacity to develop and manage blue carbon finance mechanisms, and
4. Build environmental and social safeguards into blue carbon finance.

PROTECT COMMUNITY RIGHTS

- **Establish and/or clarify property rights.** One of the central challenges to managing blue carbon is the complex convergence of jurisdictions, property and resource rights, and land tenure systems in coastal and marine areas, especially as climate change impacts reshape and affect access to coastal zones and resources. Some blue carbon projects can unintentionally restrict local communities' access to natural resources that support livelihoods, and community members may not have recourse under customary land tenure systems that are not accounted for in formal property rights schemes. Blue carbon projects should engage local communities in clarifying property rights and co-creating project designs that protect ecosystems and local sustainable use of blue carbon resources.

INCREASE READINESS TO ACCESS BLUE CARBON FINANCE

- **Leverage MPAs and LMMAs as opportunities to access blue carbon finance.** MPAs and LMMAs not only protect and conserve critical habitat and biodiversity (often through existing governance and financial structures), but they also help preserve the blue carbon within their boundaries. Communities and external funders should build the capacity of MPA/LMMA managers and stewarding communities to put their blue carbon on the market as a way to channel funds to MPA/LMMA management.

- **Build local capacity to access financing for blue carbon projects.** Requirements for blue carbon project financing can be complex, and pursuing funding can require considerable investment of time and money. Many local communities (i.e., local governments, community-based organizations, indigenous groups) lack experience with these funding processes. Training local leaders to develop and/or access support for project proposals, interact with financial institutions, and navigate funding processes can increase readiness to access blue carbon finance. WCS has developed a model (Lehm 2021) for this type of training through its work with indigenous communities.
- **Strengthen regional networks that enable small projects to pursue collective financing.** Many community-based blue carbon projects are too small to attract investors, even though they can deliver a suite of valuable co-benefits to local communities. Communities and countries must work together to aggregate local projects into more bankable portfolios of blue carbon projects through a collaborative platform. This coordination will require strong networks and technical support to collectively pursue blue carbon financing.

STRENGTHEN POTENTIAL INVESTORS' CAPACITY TO DEVELOP AND MANAGE BLUE CARBON FINANCE MECHANISMS

- **Provide support for central banks to develop sustainable finance taxonomies.** Central banks play a critical domestic role. To help identify and classify investments that contribute to green and blue economies, USAID and other external funders and donors can provide technical assistance to central banks and policymakers to establish sustainable finance taxonomies, which can include activities related to blue carbon and define the framework for financial products that can support blue carbon investments. Singapore's Sustainable Finance Taxonomy, Indonesia's Green Taxonomy, and the Philippines' Sustainable Finance Taxonomy Guidelines provide models for this type of financial taxonomy (Monetary Authority of Singapore 2024; Sustainable Finance Indonesia 2022; Walker 2024) .
- **Assess and strengthen investor readiness to manage blue carbon investments.** To assess current capacity for blue carbon finance at the national and regional scales, countries can consider the following conditions among financial institutions, organizations, and companies: 1) Does an entity have a greenhouse gas emissions reduction target or commitment? (e.g., Glasgow Financial Alliance for Net Zero, membership in SBTi); 2)What is the minimum standard for lending/investing? (e.g., does the entity have a policy related to Ramsar wetlands, anti-deforestation, agricultural commodities and over-fishing); 3) Is the entity transparent about the potential cash flows relating to a financial transaction? and 4) Is executive compensation linked to achieving sustainability metrics? Donors can strengthen investor readiness by continuing to facilitate multi-stakeholder engagement and capacity building activities, such as training for the financial sector on the role and co-benefits of blue carbon ecosystems and how the protection of blue carbon ecosystems can contribute to the broader climate resilience of investment portfolios.

BUILD ENVIRONMENTAL AND SOCIAL SAFEGUARDS INTO BLUE CARBON FINANCE

- **Require monitoring, reporting, and verification for blue carbon project impacts on livelihoods and social indicators.** Building these indicators into funding requirements will encourage blue carbon project teams to design projects that account for impacts on local communities and help avoid unintended consequences, such as disconnecting communities from livelihood sources or increasing inequities in access to blue carbon ecosystems. Integrating these indicators into evaluations of blue carbon investments will require capacity building for financial institutions and other funders, which should include perspectives from local communities, including women and indigenous groups, and scientists.

- **Align blue carbon finance with targets of the UN SDG14 Life Below Water.** National central banks could convene the banks they supervise, scientists, community leaders, and companies to foster dialogue about the region's blue carbon contributions to broader development goals under SDG14. The forum would provide an opportunity to share models for financing sustainable development, for example the world's first UN SDG sukuk, an Islamic financial certificate that is similar to a bond (UNDP 2018).
- **Promote TNFD recommendations and guidance.** The TNFD has developed recommendations and guidance for disclosure about nature-related dependencies, impacts, risks, and opportunities. Trading markets, policymakers, and central banks can require organizations over a certain size in their country to comply with TNFD and can encourage the use of Science Based Targets (2024).

Appendix A. Methodology for Carbon Storage and Sequestration Estimates

Operational Assumptions

The objective of this analysis is to compare long-term trends in carbon storage across ocean ecosystems in 14 Indo-Pacific countries. The blue carbon project team made several simplifying assumptions to conduct this analysis of temporal and geospatial patterns possible:

1) The team estimated trends where data are publicly available for the majority of the 14 countries. The Indo-Pacific spans both data-rich and data-poor geographies, and the regional approach taken here intends to complement rather than replace ongoing national and subnational research. This regional approach is only possible because of extensive prior research with public data sharing for mangroves by Global Mangrove Watch, for seagrasses by the Allen Coral Atlas, and for tuna by SEAPODYM and the Pacific Community. Qualitative trend data for seagrasses are drawn from McKenzie et al. 2021.
2) Carbon sequestration is operationally defined as the rate of sediment accumulation of carbon contained in organic matter. This focus on long-term sediment storage facilitates comparison of inputs from very different demersal and pelagic ecosystems, with the acknowledged tradeoff of underestimating total carbon sequestration. In addition, mangrove-related carbon storage in this report excludes live biomass, and the open ocean biological pump is represented by a few examples of large-bodied tuna species.
3) Estimates in this report are conservative, leaning toward the low end of published estimates. The addition of country-specific and site-specific data will likely increase the amount of blue carbon available for finance and interventions. Additional species groups and ecosystems participate in carbon storage and sequestration but are excluded here. These include sharks, non-tuna large pelagic fish, small pelagic fish, and other nearshore ecosystems described in Chapter 1 under "Nearshore Ecosystems with Carbon Sequestration Potential." Analysis by Mariani et al. 2020 suggests that tunas sequester the most carbon among large pelagics, followed by mackerels, and then sharks.

Geospatial Data and Units

The project team derived boundaries for exclusive economic zones (EEZs) from the Marineregions.org database (Marineregions v11, 2019), which includes detailed documentation regarding boundaries in disputed areas. The team converted all units for carbon storage and sequestration to carbon dioxide equivalent using a conversion factor of 3.67 from the Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator (2023).

Greenhouse gas emissions for Pacific countries taken from the World Bank as of 2019. For four Pacific countries—Tuvalu, Kiribati, Republic of the Marshall Islands, and the Federated States of Micronesia—the carbon sequestered by mangroves, seagrass, and tuna exceeds their annual greenhouse gas emissions.

Estimating Mangrove Carbon

The project team estimated country-specific carbon sequestration in mangrove forests as the area of habitat in square km in each country multiplied by the sequestration rate per square kilometer. The team derived mangrove aerial extents and change in areas from 1996 to 2020 in square kilometers for each country from the Global Mangrove Watch public database (Bunting et al. 2022). The team estimated the mangrove area for 2050 in table A1 by calculating the average annual rate of change between 1996 and 2020 and applying the same rate to future years. This estimate for 2050 assumes that long-term trends continue, despite short-term changes in these trends in some countries, as Chapter 1, Table 1 indicates.

Soils are the largest pool of carbon storage in mangrove ecosystems (Alongi 2014), and the rate of carbon storage varies with environmental conditions, including "sediment dynamics, hydrodynamics, landform and vegetation" (Kusumaningtyas et al. 2019). The team estimated the rate of mangrove carbon sequestration through soil burial of organic matter using the global average of 174 metric tons C / km^2 / year from Alongi (2012, 2014), and then converted to carbon dioxide equivalent. This focus on long-term sequestration (>100 years) in sediment does not include above-ground biomass in mangrove trees or the biomass of roots, some of which represent relatively short-term carbon storage. This global average is "based on data largely collected from Oceania and Southeast Asia, which have larger ecosystem C stocks than other regions." The Alongi rate matches the range of available published "soil carbon burial rates" for the Pacific (176 ± 125 metric tons C / km^2 / year, from Sharma et al. 2023), despite the lack of data from low-lying Pacific islands including Kiribati, Nauru, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. The Alongi rate is conservative compared to most published estimates for Southeast Asia, as summarized in Sharma et al. 2023 (321 ± 386 metric tons C / km^2 / year) and Kusumanintyas et al. 2019 (~ 100 to 700 metric tons C / km^2 / year).

With support from USAID, the SWAMP research program measured total ecosystem carbon stocks for 190 mangrove sites around the world, as Kauffman et al. 2020 reported. The SWAMP approach considers carbon in mangrove roots and aboveground biomass in addition to the sediment organic carbon that is the focus of this report. For this analysis, the project team focused on rates of long-term carbon sequestration; accounting of total carbon stocks is a necessary next step to quantify emissions from deforestation and avoided emissions due to forest conservation.

Estimating Seagrass Carbon

The project team estimated country-specific carbon sequestration in seagrass meadows as the area of habitat in each country multiplied by the sequestration rate per square kilometer. Seagrass aerial extents in square kilometers were based on satellite imagery collected in 2017–2020, and derived from the Allen Coral Atlas (2023) public database by querying the total seagrass aerial extent within each country's EEZ. Based on EEZ data in the Marineregions.org database (Marineregions v11, 2019), the team generated a minimum bounding polygon to align exactly with the EEZ boundaries of neighboring countries (inclusive of land areas) to minimize discrepancies due to complex coastline features. The team converted these polygon shapefiles to GeoJSON format and uploaded them to the Allen Coral Atlas online interface to perform the seagrass area calculations.

The team calculated seagrass carbon sequestration through soil burial of organic matter using the global average of 138 metric tons C per km^2 per year from McLeod et al. (2011) and converted to CO_2 equivalent. Accumulation of organic carbon in seagrass sediments ranged from 2.97 to 16.1 metric tons C per km^2 per year in Japan and Thailand (Miyajima et al. 2021). In Zanzibar, recent seagrass carbon sequestration was as high as 35 metric tons C per km^2 per year (Dahl et al. 2022). And in the Caribbean, seagrass carbon sequestration was 122 metric tons C per km^2 per year (Serrano et al. 2021). Variation in the rate of organic carbon sequestration in seagrass sediments is influenced by "seagrass species, meadow connectivity, bioturbation, grain size, the energy of the local environment, and calcium carbonate formation" as well as the size of the seagrass meadow (Johanneson 2022). Additional factors identified for Indo-Pacific seagrasses in Australia include rainfall, solar radiation, and wind energy (Mazarrasa et al. 2021), which highlights the importance of site-specific measurements.

TABLE A1. Mangrove and seagrass annual sequestration estimates by country, in metric tons carbon dioxide equivalent and value in USD per year. Sequestration due to the burial of carbon in mangrove and seagrass sediments is estimated based on average sequestration rate (Alongi 2012, Mcleod et al. 2011) and area of mangrove and seagrass ecosystems (Bunting et al. 2022, Allen Coral Atlas 2023).

Country	Mangrove 2020 area km^2	Mangrove 2050 area km^2	Seagrass 2020 area km^2	Mangrove 2020 seq tCO_2e/yr	Mangrove 2050 C seq tCO_2e/yr	Seagrass 2020 seq tCO_2e/yr	Total 2020 seq tCO_2e/yr	Total 2020 seq value USD
TOTAL	**7,101,137**	**1,660,455**	**5,440,682**	**1,473,585**	**1,098,201**	**704,573**	**1,867,216**	**-142,035**
Fiji	488.14	491.04	507.45	311,716	313,571	257,003	568,720	$19,905,185
Indonesia	29,533.98	27,447.13	5,582.48	18,859,809	17,527,190	2,827,303	21,687,112	$759,048,912
Kiribati	1.46	1.46	53.46	932	932	27,075	28,008	$980,269
Marshall Islands	0.33	0.33	21.88	211	211	11,081	11,292	$395,223
Micronesia	87.94	84.47	89.32	56,157	53,942	45,237	101,394	$3,548,781
Nauru	0.00	0.00	0	0	0	0	0	$0
Palau	56.88	57.19	82.77	36,322	36,522	41,920	78,242	$2,738,474
Papua New Guinea	4,524.74	4,466.25	992.02	2,889,408	2,852,059	502,418	3,391,827	$118,713,942
Philippines	2,847.98	2,752.77	1,749.36	1,818,663	1,757,865	885,981	2,704,644	$94,662,538
Samoa	2.32	2.30	10.65	1,482	1,466	5,394	6,875	$240,636
Solomon Islands	526.51	525.55	405.93	336,219	335,606	205,587	541,806	$18,963,212
Tonga	10.43	10.29	4.91	6,660	6,568	2,487	9,147	$320,149
Tuvalu	0.09	0.09	0.16	57	57	81	139	$4,848
Vanuatu	15.84	15.37	6.59	10,115	9,816	3,338	13,453	$470,844

Estimating Tuna Carbon

To compare present and future carbon storage by marine animals to marine plants in the Pacific region, the project team estimated carbon cycling for tuna and applied these estimates to future climate change scenarios building on the work of Bell et al. 2021, Bianchi et al. 2021, and Mariani et al. 2020. Tuna is the focus of this report because of its primacy in volume of marine fish production in Pacific island countries and territories, and the availability of species- and country-specific catch estimates and climate projections, which the Western and Central Pacific Fisheries Management Commission member countries have recognized.

Tuna carbon storage and sequestration estimates are based on published model outputs for the top three tropical tuna species caught in the Indo-Pacific region: skipjack (Katsuwonus pelamis), yellowfin (Thunnus albacares), and bigeye (Thunnus obesus). For each country, the team extracted unfished tuna biomass estimates for the three species from the Spatial Ecosystem and Population Dynamics Model (SEAPODYM, http://www.seapodym.eu/ and https://github.com/PacificCommunity/seapodym-codebase) as Bell et al. (2021) described.

The overall estimation of blue carbon stored and sequestered by tuna through offshore ecosystems and the biological pump is based on modeled biomass from yellowfin, bigeye, and skipjack tuna at a regional scale. Albacore tuna was not included in the blue carbon estimates or maps in the main body of this report because it is present at relatively modest levels in ten of the country EEZs compared to other tuna species (Senina et al. 2020).

The "reference biomass" in Table A2 is the annual estimate for tuna biomass for the present day in metric tons (t), if fishing did not occur. Present and future unfished biomass values in metric tons (t) represent average total modeled biomass from 2011–2020 and 2044–2053 under an RCP 8.5 emissions scenario, if fishing did not occur. The team calculated tuna biomass for each EEZ from data layers summarizing the SEAPODYM outputs for each tuna species downloaded from https://pccos.spc.int/. The team calculated total tuna species biomass values in metric tons (t) for each EEZ and each time period by multiplying the mean biomass values (t/km^2) within each EEZ by the EEZ areas (km^2) from Marineregions.org (Marineregions v11, 2019). The team then summed the results for each of the three tuna species to calculate total tuna biomass for each EEZ and time period.

Estimates of present and future catch in metric tons (t) represent average total catch during 2009–2018 and the projected percent change in biomass for each species in 2050 under an RCP 8.5 emissions scenario, relative to present species proportions in purse seine catches (which represent the majority of tuna catch), as Bell et al. (2021) reported. The team estimated future tuna catches for Fiji, Indonesia, Philippines, Samoa, Tonga, and Vanuatu (not provided by Bell et al. 2021) from total present catch levels proportional to future change in total biomass. The team calculated tuna ocean biomass in the EEZs of each country and for each time period as unfished biomass minus catch.

The project team calculated annual sequestration from deadfall—natural mortality and sinking of tuna carcasses—for each country and time period by multiplying tuna ocean biomass by a sequestration factor for tuna (0.6, from Mariani et al. 2020) that incorporates species-specific natural mortalities and represents the proportion biomass that would sink into the deep ocean if not fished. The team calculated the mass of carbon in the sinking biomass by applying a ratio of carbon mass to total biomass (12.3%, from Czamanski et al. 2011 in Mariani et al. 2020), based on measurements for a closely related species (Atlantic mackerel, Scombridae). Finally, the team converted the carbon mass to carbon dioxide equivalent using a conversion factor of 3.67.

The team calculated annual sequestration from fish waste—production and sinking of fecal pellets—from tuna ocean biomass in each country and time period by applying a particle production factor of 1 that Bianchi et al. (2021) derived from a peak catch scenario for targeted species for their global model. The team converted the resulting value for mass of fish waste to carbon based on measurements from Atlantic salmon (36.6%DW) by Wang et al. (2023). The team used this measurement from Atlantic salmon because there were no measurements available for tuna, and it is the largest bodied and highest trophic level species (closest to tuna) for which an estimate of fecal carbon was available in the literature. The team converted dry weight percent of carbon to wet weight based on reported moisture content in bluefin tuna waste of 85 percent (Aguado et al. 2004). Thus, the team multiplied dry weight carbon percentage by 0.15 to convert to a wet weight carbon percentage of 5.5%WW, which is applied to the fish waste mass to calculate associated carbon content. Finally, the team converted carbon mass to carbon dioxide equivalent using a conversion factor of 3.67.

The project team calculated carbon loss due to tuna catch biomass for each country and time period following the approach of Mariani et al. (2020) by applying the ratio of carbon mass to total catch biomass (12.3%, from Czamanski et al. 2011) as above, and then subtracting six percent of the biomass represented by fish bones (buried and sequestered in landfills). The team then converted the resulting carbon mass to carbon dioxide equivalent using a conversion factor of 3.67.

The team calculated net annual carbon sequestration from tuna for each country by adding sequestered carbon from deadfall and fish waste and subtracting carbon lost due to catch biomass in metric tons of carbon dioxide per year. The team performed identical calculations for the modeled biomass for the year 2050 (average of 2044–2053) under an RCP 8.5 emissions scenario.

TABLE A2. Present net carbon sequestration by tuna across the study countries, in metric tons carbon dioxide equivalent per year. Calculated as the mean annual sequestration by skipjack, bigeye, and yellowfin tuna populations through the production of waste pellets and deadfall minus carbon removed by fisheries catches for 2011–2020. Tuna populations from the SEAPODYM model; waste pellets and deadfall after Bianchi et al. 2021 and Mariani et al. 2020.

Country	Reference biomass t	Catch t	Ocean biomass t	Sequestration deadfall $tC0_2e/yr$	Sequestration waste tCO_2e/yr	Loss due to catch $tC0_2e/yr$	Net uptake tCO_2e/yr
TOTAL	**8,207,482**	**2,085,112**	**6,122,370**	**1,658,218**	**1,235,799**	**884,767**	**2,009,256**
Fiji	124,476	8,953	115,523	31,289	23,318	3,799	50,808
Indonesia	2,015,627	455,155	1,560,472	422,648	314,981	193,134	544,495
Kiribati	1,660,562	417,617	1,242,945	336,647	250,888	177,206	410,330
Marshall Islands	508,821	43,146	465,675	126,126	93,996	18,308	201,815
Micronesia	947,793	185,802	761,991	206,382	153,808	78,841	281,350
Nauru	211,176	110,907	100,269	27,157	20,239	47,061	336
Palau	168,291	5,907	162,384	43,981	32,777	2,506	74,252
Papua New Guinea	1,056,839	464,970	591,869	160,305	119,469	197,299	82,476
Philippines	534,177	166,799	367,378	99,503	74,155	70,777	102,881
Samoa	16,520	2,769	13,751	3,724	2,776	1,175	5,325
Solomon Islands	565,799	137,678	428,121	115,955	86,416	58,420	143,951
Tonga	48,251	1,278	46,973	12,722	9,482	542	21,662
Tuvalu	274,713	76,600	198,113	53,658	39,989	32,503	61,144
Vanuatu	74,437	7,531	66,906	18,121	13,505	3,196	28,431

TABLE A3. Future net carbon sequestration by tuna (skipjack, bigeye, and yellowfin) across the study countries, in metric tons carbon dioxide equivalent per year. Calculated as the mean annual sequestration by skipjack, bigeye, and yellowfin tuna populations through the production of waste pellets and deadfall minus carbon removed by fisheries catches for 2044–2053. Future tuna populations from the SEAPODYM model; waste pellets and deadfall after Bianchi et al. 2021 and Mariani et al. 2020.

Country	Reference biomass t	Catch t	Ocean biomass t	Sequestration deadfall $tC0_2e/yr$	Sequestration waste tCO_2e/yr	Loss due to catch $tC0_2e/yr$	Net uptake tCO_2e/yr	Change in net uptake tCO_2e/yr
TOTAL	**7,101,137**	**1,660,455**	**5,440,682**	**1,473,585**	**1,098,201**	**704,573**	**1,867,216**	**-142,035**
Fiji	127,722	9,186	118,536	32,105	23,926	3,898	52,133	1,325
Indonesia	1,714,986	387,267	1,327,719	359,607	268,000	164,327	463,281	-81,214
Kiribati	1,596,249	363,520	1,232,729	333,880	248,826	154,251	428,455	18,126
Marshall Islands	488,905	36,728	452,177	122,470	91,272	15,585	198,158	-3,657
Micronesia	833,244	155,407	677,837	183,589	136,821	65,943	254,468	-26,882
Nauru	162,347	86,886	75,461	20,438	15,232	36,868	-1,198	-1,534
Palau	164,372	2,646	161,726	43,803	32,644	1,123	75,324	1,073
Papua New Guinea	713,464	308,404	405,060	109,709	81,761	130,864	60,607	-21,869
Philippines	499,559	155,990	343,569	93,054	69,349	66,190	96,213	-6,667
Samoa	16,835	2,822	14,013	3,795	2,829	1,197	5,427	102
Solomon Islands	432,799	86,399	346,400	93,821	69,921	36,661	127,081	-16,870
Tonga	50,099	1,327	48,772	13,210	9,845	563	22,491	830
Tuvalu	222,660	55,992	166,668	45,141	33,642	23,759	55,024	-6,119
Vanuatu	77,896	7,881	70,015	18,963	14,133	3,344	29,752	1,321

Appendix B. Case Studies

The case studies in this appendix are the same case studies that appear in text boxes throughout the report.

Case 1: Urban Wetlands as Nature-Based Solutions for More Resilient and Livable Cities in Demak, Indonesia

With almost half of the world's population living in urban areas, designing resilient and environmentally friendly cities with integrated wetlands can provide economic, social, and cultural benefits for people. Demak, a low-lying coastal community in Java, has tackled erosion, flooding, and land subsidence by restoring mangrove forests. In partnership with engineers from Building with Nature and NGOs, Demak's government and its communities successfully restored 119 ha of mangroves. Together, they restored river branches to reduce salt intrusion and allow sediment to flow into a mangrove greenbelt. The project placed the equivalent of 3.4 km of wave-calming, sediment-trapping structures (built with nets and local bamboo) along the 20-km stretch of coastline. Under these new conditions, 12 different species of mangroves have regenerated naturally, shielding about 70,000 people from climate change impacts, protecting the coast from further erosion, and improving fishers' catches in the nearshore areas. Where the coastline had not yet eroded, the project team worked in close collaboration with local communities to revitalize 300 ha of aquaculture ponds with mangroves. Using an innovative finance mechanism, bio-rights (van Eijk and Kumar 2009), farmers obtained micro-credits in exchange for reducing the use of chemicals and revegetating part of their ponds. Consequently, shrimp production and farmers' revenues increased. Those credits become definitive payments upon successful delivery of conservation services at the end of a contracting period. Coupling those interventions with capacity development was essential. Training reached government officials, the private sector, students, local communities, and 277 farmers. Since observing the success of the project, 13 districts across Indonesia have replicated this approach.

References: UNEP 2022, UNEP 2023

Case 2: Diversifying Livelihoods and Food Sources with Nearshore FADs in Solomon Islands

Like many countries in the Pacific region, the Solomon Islands' nearshore fisheries may not be able to meet local people's needs by 2030. In response, technologies like nearshore FADs, if designed appropriately, can increase access to fish and play an important role in future food security for coastal communities. With support from New Zealand, the Mekem Strong Solomon Islands Fisheries programme funded WorldFish, the Ministry of Fisheries and Marine Resources, the Secretariat of the Pacific Community, and the University of Queensland to develop a National Inshore FAD Programme (2010–2013). Together, they deployed 21 nearshore FADs, anchored to the seafloor and using four designs, across the Solomon Islands to evaluate their contribution to local food security. The study found that fishers preferred FADs that are accessible by paddle canoes, particularly if deployed less than 5 km from the shore, with a preference for 2 km. Deploying those devices can provide alternative habitat for food sources, redirect fishing pressure, diversify livelihoods, and provide a mechanism for climate adaptation.

In addition, fishing closer to shore can help reduce CO_2 emissions, protect lives, and potentially reduce conflicts with industrial fishing (in other nations). Coastal communities with a high dependence on fish and limited access to diverse or productive fishing grounds can benefit from nearshore FADs. Future steps should focus on capacity building so fishers can improve their catch rates and the longevity of FADs. In addition, nearshore FADs led men to spend more time fishing, and they neglected food gardens, which affected the labor burden of women gardeners. There is a need for recurrent and readily available funds at national level to support women and to deploy, redeploy, and provide ongoing support to communities (i.e., training, technical advice, site surveys, FAD maintenance). Other nations, such as Palau, RMI, and FSM, are exploring those solutions.

Reference: Albert et al. 2015

Case 3: Designation of RAMSAR Sites Across the Region to Protect Wetlands and their Social and Ecological Benefits

Across the region, parties to the Ramsar Convention include Fiji, Indonesia, Kiribati, Palau, Philippines, PNG, RMI, Samoa, and Vanuatu. The protection, management, and restoration of blue carbon ecosystems can become stronger through the designation of new Ramsar Sites and the enhanced management of existing sites to mitigate threats leading to wetland degradation and loss (Denyer et al. 2018, Fennessy 2021). In 2018, the Ramsar Site Information Service listed approximately one-third of the 319 Ramsar Sites in the Philippines (six sites—247,292 ha), Indonesia (seven sites—1,372,976 ha), and 80 wetlands in Oceania (9,051,211 ha) as marine or coastal wetlands. The Ramsar Strategic Plan 2016–2041 encourages Contracting Parties to promote and strengthen the participation of Indigenous Peoples and local communities as key stakeholders for conservation and integrated wetland management. Cultural values of the Ramsar Sites in these two regions are relatively high, with 94 percent in Asia and 98 percent in Oceania, where wetlands are strongly linked to either the presence of sacred sites, interaction with local communities or Indigenous Peoples, or the application of traditional knowledge and practices. A number of case studies from across Asia and Oceania illustrate how cultural values and practices, including traditional knowledge and community participation, have contributed to sustainable development and positive conservation outcomes for wetlands (Denyer et al. 2018).

Case 4: Mangroves Restoration Secures Livelihoods in Sumatra, Indonesia

The coastal regions of north Sumatra and Aceh have lost more than 110,000 ha of mangroves over recent decades due to the expansion of shrimp production, rice fields, and palm oil plantations. The loss of this habitat has left villages exposed and vulnerable to the impact of coastal hazards, such as the 2004 tsunami that claimed 220,000 lives. In 2011, 125 villages mobilized with the support of the NGO Yagasu and planted 18 million trees over 5,000 ha. The restored mangrove belt provides coastal protection, improves food security, and contributes to climate mitigation through the sequestration of up to 2 million tons of CO_2 over the next 20 years. In 2018, Yagasu launched the Launch Livelihoods Carbon Fund to help restore an additional 5,000 ha of mangroves, develop livelihood opportunities, and sequester an additional 2.5 million tons of carbon over 20 years. Local farmers received a revolving microcredit of $1,350, on average, to transition to a silvofishery approach. By planting mangroves around and in the fishponds, farmers increased the production of fish, shrimp, and crabs. This renewed species diversification led to more varied incomes to farmers, with the highest income resulting from selling soft-shell crabs for export. About 20,000 people increased their revenues by selling goods from mangroves, including natural dyes and farmed seafood. The median household income increased by 57 percent. Yagasu provides capacity development through multiple avenues. It helps 174 cooperatives develop their branding and marketing strategies and secure their licensing permits from the local government to sell their products. It facilitates exchange of information and resources between the public and private sector and provides training to communities in batik production techniques. Following this success, Yagasu is receiving support from the Indonesian government and USAID to replicate this approach across Indonesia.

References: Livelihoods Funds 2020a, Livelihoods Funds 2016, Livelihoods Funds 2020b

Case 5: Indigenous Women Lead Mangrove Restoration in the Philippines

The communities of Busuanga Island, Philippines are vulnerable to recurring typhoons and climate change impacts. Local communities are highly dependent on fishing and farming. The island was designated as the Palawan Mangrove Swamp Forest Reserve in 1981. However, illegal logging between 2004 and 2015 severely decreased mangrove forests. In November 2013 when typhoon Haiyan hit the island, the remaining mangroves provided little protection against strong waves and wind. The town suffered extensive damages and destroyed wooden fishing boats and thatch-roofed houses. The community realized that mangroves could have shielded them from these impacts, so indigenous women volunteered as citizen scientists to restore mangroves. Since 2014, they have revitalized 159 ha of bare coastal patches across Busuanga Island. They also monitor seedling growth and every month, replace mangroves afflicted by parasite barnacles that reduce root growth. Indigenous men and women are mobilized to volunteer as coastal guards to ensure the protection of the newly restored mangroves. Consequently, their effort resulted in an 80 percent survival rate. They strengthened their initiative by passing an ordinance that bans further mangrove forest clearing. The community partnered with the Busuanga municipal government to craft a mangrove conservation plan to form part of the municipality's comprehensive land use plan. To raise awareness around the benefits that mangroves provide, they also developed a curriculum to educate local communities.

Reference: Fabro 2021

Case 6: The Regional Flyway Initiative: A Nature-Based Solution for People, Nature, and Climate

Nearly 200 million people rely on the wetlands that lie along the East Asian–Australasian Flyway for livelihoods, food, clean water, opportunities in recreation and tourism, flood mitigation, carbon sequestration, and climate adaptation. More than 50 million migratory waterbirds (210 species, and many other animal and plant species) also depend on the East Asian–Australasian Flyway wetlands for food, shelter, and other essential needs. The Regional Flyway Initiative (2022) is a partnership between the ADB, the East Asian–Australasian Flyway Partnership, and BirdLife International. The partnership seeks to mobilize $3 billion to invest in viable nature-based solutions that can deliver for people, nature, and climate across the vast network of wetlands along the Flyway (Figure B1).

FIGURE B1. Implementation of nature-based solutions along the East Asian–Australasian flyway helps conserve critical habitat for migratory birds and sustain livelihoods tied to wetland ecosystems. Illustration from ADB 2022.

This initiative covers 18 countries and includes the Philippines, Indonesia, and PNG from the focal region. Over the next two years, the ADB technical assistance will invest one million dollars to identify wetland sites of international importance that protect migratory waterbirds and support livelihoods. The long-term vision is to deliver projects across the region that support the protection, restoration, and sustainable management of at least 50 priority sites along the East Asian–Australasian Flyway. This initiative will provide a pilot that could be extended to the West Pacific Flyway region, which spans all the other Pacific nations.

References: ADB 2022, Development Asia 2023, ADB 2021

Case 7: Ocean Accounts for Fiji's Mangroves Make Progress Toward SDGs and the Paris Agreement

Ocean accounts provide countries with the means to go beyond GDP (European Commission 2024) by integrating social, economic, and environmental information to track progress toward a country's domestic and global commitments (GOAP Secretariat 2022(a)). Blue economy is fundamental to Fiji's national economy and local livelihoods. Ocean accounts enable the comparison of ocean environment assets (e.g., extent/condition of mangroves), economic activity (e.g., sale of fish), and social conditions (e.g., coastal employment) (GOAP Secretariat 2022(a)). Fiji has one of the highest mangrove coverages in the South Pacific region, which plays a critical role in the local economy. Ocean accounts for mangroves were created to capture the contribution of mangroves to the Fijian society and economy (GOAP Secretariat 2022(c)) because the economic value of mangroves currently accrue to fisheries and aquaculture, construction, and professional scientific services industries. The economic value is about $20–30 million of direct UN System of National Accounts benefits of mangroves annually. Mangroves support about 0.5 percent of Fiji's GDP and Gross Value Added. Mangrove related activities support about 3,500 direct jobs, which represents about two percent of all jobs created in these industries.

References: GOAP Secretariat 2022(a), GOAP Secretariat 2022(c)

Appendix C. Finance Primer

Purpose: This finance primer is a non-exhaustive overview of financial concepts, terms, and products relevant to scaling blue carbon finance and mainstreaming climate and conservation transactions. The primer aims to facilitate constructive discussions about blue carbon finance among a wide range of stakeholders inside and outside the financial industry.

Overview: Public and Private Finance and the Economic System

Public finance encompasses a government's financial affairs and their economic impact. It refers to the collection and payment of funds from individuals and companies. For example, revenue, expenditure, budget, debt/surplus, and national debt are part of public finance.

Private finance refers to financial activities and decisions of individuals and private sector entities. Individuals and the private sector finance diverse activities and investments—from personal mortgages, household or community wells, and community health care facilities to large-scale energy infrastructure, fisheries operations, and insurance programs.

Financial activities and decisions are part of the wider economic system. In the economic system, public finance comes from national and regional governments. Private finance operates within voluntary and mandatory governance frameworks, such as regulation and government policy.

Public and private finance have an important role to play in restoring and protecting blue carbon ecosystems. Governments face many competing demands and often shift priorities quickly to respond to emergent needs. Organizations such as the Climate Policy Initiative (Chin et al. 2024) can help coordinate public and private finance to drive economic growth while addressing climate change. Private finance will play a key role in protecting and managing blue carbon ecosystems while balancing ESG (World Bank 2021) risks and opportunities. Private finance can help limit environmental degradation and accelerate funding for innovative blue carbon solutions, as it allocates capital to the real economy (CFI 2024) both directly and indirectly (for example, by financing fishing in domestic markets and providing export finance via international supply chains).

SUMMARY OF THE ECONOMIC SYSTEM

Public Finance
Revenue and expenditure from taxes, central banks, international and domestic treaties, voluntary initiatives

Private Finance
Ownership or claims of ownership in the real economy via debt and equity; involves financial institutions, institutional investors (asset owner, asset manager), insurers

Real Economy
Sector-level actors such as construction, real estate, agriculture (including fishing), etc.

Types of Financial Institutions and Institutional Investors

Financial institutions and intermediaries refer to a broad range of organizations who deal with public and private financial transactions. This primer briefly describes six types of financial organizations relevant to blue carbon opportunities:

- **Central banks:** Responsible for overseeing all other banks, usually at a national level. Communities and individuals are not directly connected to central banks.
- **Multilateral development banks (MDBs):** Organizations created by groups of countries, which provide finance and financial advice to support development.
- **Commercial banks:** Offer financial products such as loans, deposit accounts, and financial advice to businesses of varying sizes in the real economy, including sectors such as agriculture. In the Indo-Pacific islands most commercial banks are national or regional.
- **Investment banks:** Offer more complex financial services used by governments and international businesses. They also act as financial advisors to clients such as pension funds and institutional investors, as well as assist in raising new capital securities (for example, by underwriting new blue bond transactions). In the Indo-Pacific islands most investment banks are regional or international.
- **Insurance:** Organizations that help transfer the potential risk of loss, thereby providing financial protection. In the Indo-Pacific islands most insurance organizations are regional or international.
- **Brokers / Dealers:** Organizations that act as intermediary and are authorized to buy and sell securities.
- **Institutional investors:** include some financial institutions and other organizations that invest money on behalf of other people. They often buy and sell large amounts of securities via brokers.

Different types of organizations are appropriate for different private finance needs. Organizations themselves have different strategic objectives that drive their business models and are influenced by their position on the spectrum of capital. Typically, financial institutions generate revenues by charging fees for the financial services they provide and by managing the risk/return profile of their investments.

One way to consider how investments are managed is through the spectrum of capital (Jackson 2021). Traditional finance, such as mainstream banking and investment, mainly focuses on maximizing financial returns while mitigating potential financial risks such as those related to currency exchange and inflation. Traditional finance does not take into account potential negative externalities arising from investment, such as ecosystem destruction, unless it impacts financial performance. Therefore, from a traditional finance perspective, a tree is worth more dead than alive (Mooney 2000). Grants and philanthropy are also on the spectrum of capital, where funds are provided without explicitly seeking a financial return. However, measurable positive impacts on ecosystems and communities would be expected.

Types of Capital Markets and Financial Products

Capital markets are exchange systems that transfer capital from institutional investors, who wish to put their money to use, into businesses that require finance for projects (Spendelow 2024). Examples of international capital markets include stock exchanges for buying and selling equity or shares, such as the New York Stock Exchange, Singapore Stock Exchange, and Nasdaq. Equity, or shares, are a type of security issued to the public, which creates partial ownership of a company or project.

Other types of capital markets include foreign exchange (FX), derivatives, and commodities, the latter including carbon markets. Today there are regulated carbon markets and Voluntary Carbon Markets (VCMs). VCMs are most relevant for blue carbon because blue carbon natural resources can be used to create a carbon credit or offset. Carbon credits or offsets programs enable businesses to earn a permit to emit a certain amount of carbon (usually 1 metric ton per credit) into the atmosphere (Kenton 2024). Businesses can trade the permits as necessary.

In addition, debt securities, or bonds, facilitate borrowing at a pre-established interest rate with a promise to pay back at a specified point in the future. They can be traded on international fixed income markets. A positive sign of the blue bond market investor demand is the creation of the world's first blue bond index by a German financial services provider called Solactive (Lord 2023). In comparison, the world's first green bond index was set up in 2014. Lessons from land-based carbon initiatives can help accelerate blue carbon finance. For example, in 2017 the world's first green loan was issued in Europe. This and other land-based carbon mechanisms provide models for blue carbon; in 2023 a blue loan was financed to improve water access and sanitation in Brazil (IFC 2023).

Sustainability-linked loans are financial products provided to businesses, which aim to facilitate and support environmentally and socially sustainable economic activity and growth. A portion of the interest rate is linked to the borrower's ability to meet sustainability targets, for example by reducing greenhouse-gas emissions or restoring natural habitats.

Financial Exclusion

Many communities in the Indo-Pacific islands are subject to financial exclusion and do not have access to financial institutions and/or institutional investors. This financial exclusion occurs in part because they do not meet the requirements for organizations and capital markets; instead, they operate in the informal economy. The Blue Carbon Finance Assessment (Chapter 3) in this report provides more information about challenges of and opportunities for financing blue carbon in Indo-Pacific countries.

BLUE BONDS

Blue bonds are a type of sustainability bond similar to traditional debt securities. However, they differ in that the entity issuing the bond must use proceeds to protect and conserve the ocean and ocean ecosystems. Blue bonds are usually issued to finance projects that increase sustainability of fisheries, aquaculture, solid waste management, circular economy, marine renewable energy, coastal/marine tourism, and other activities that benefit blue resources and environments.

The typical process of a blue bond begins when an investor provides capital to a government, sovereign, or business, which uses the capital to finance blue projects that deliver benefits to ocean ecosystems and/or added value to local coastal economies and communities. The investor can see a financial return via beneficial social and environmental impacts or through the projected increase of financial cash flows.

References

Abdullah, Gafur. "Indonesia's mangrove revival hindered by conflicting policies." Mongabay, December 12, 2022. https://news.mongabay.com/2022/12/indonesias-mangrove-revival-hindered-by-conflicting-policies/

Adame, Maria F., Rod M. Connolly, Mischa P. Turschwell, Catherine E. Lovelock, Temilola Fatoyinbo, David Lagomasino, Liza A. Goldberg et al. "Future carbon emissions from global mangrove forest loss." *Global change biology* 27, No.12 (2021): 2856-2866. https://doi.org/10.1111/gcb.15571

Aguado, F., F. J. Martinez, and B. Garcia-Garcia. "In vivo total nitrogen and total phosphorous digestibility in Atlantic bluefin tuna (Thunnus thynnus thynnus Linnaeus, 1758) under industrially intensive fattening conditions in Southeast Spain Mediterranean coastal waters." *Aquaculture Nutrition* 10, No. 6 (2004): 413-419. https://doi.org/10.1111/j.1365-2095.2004.00315.x

Aki, Jimmy. "Guide to tokens and NFTs: what is 'tokenization' and how does it work?'" *forkast* March 9, 2021. https://forkast.news/tokens-nfts-tokenization/

Albert J. A., S. Albert, N. Andrew, M. Blanc, A. Carlos, L. Luda, F. Tofuakalo, R. Masu, C. Oengpepa, J. Oeta, R. Posala, A. M. Schwarz, S. Sibiti, F. Siota, W. Sokimi, S. Tan, A. Tawaki, J. Teri, and R. Warren. "Nearshore fish aggregating devices (FADs) for food security in Solomon Islands." Penang, Malaysia: CGIAR Research Program on Aquatic Agricultural Systems, Program Brief: AAS (2015). https://hdl.handle.net/20.500.12348/484

Allen Coral Atlas. "Imagery, maps and monitoring of the world's tropical coral reefs." 2023. https://doi.org/10.5281/zenodo.3833242

Alongi, D. M. "Carbon Cycling and Storage in Mangrove Forests." Annual Review of Marine Science 6 (2014): 195–219. https://doi.org/10.1146/annurev-marine-010213-135020

Alongi, D. M. "Carbon sequestration in mangrove forests." *Carbon Management* vol 3 Issue 3 (2012): 313–322. https://doi.org/10.4155/cmt.12.20

Alongi, D. M. "Present state and future of the world's mangrove forests." *Environmental Conservation* 29 (2002): 331–349. https://doi.org/10.1017/S0376892902000231

Anderson, C. M., T. Bicalho, E. Wallace, T. Letts, and M. Stevenson. "Forest, Land and Agriculture Science-Based Target-Setting Guidance." World Wildlife Fund, Washington, DC. (2022). https://sciencebasedtargets.org/resources/files/SBTiFLAGGuidance.pdf

Andrew, Neil L., Edward H. Allison, Tom Brewer, John Connell, Hampus Eriksson, Jacob G. Eurich, Anna Farmery, et al. "Continuity and Change in the Contemporary Pacific Food System." *Global Food Security* 32 (March 1, 2022): 100608. https://doi.org/10.1016/j.gfs.2021.100608

Andrew, Neil L., Phil Bright, Luis de la Rua, Shwu Jiau Teoh, and Mathew Vickers. "Coastal proximity of populations in 22 Pacific Island countries and territories." *PLoS One* 14 (2019). https://doi.org/10.1371/journal.pone.0223249

Anneboina, Lavanya Ravikanth, and K. S. Kavi Kumar. "Economic Analysis of Mangrove and Marine Fishery Linkages in India." *Ecosystem Services* 24 (2017): 114–123. https://doi.org/10.1016/j.ecoser.2017.02.004.

Aqorau, Transform., Johann Bell, and John N. Kittinger. "Good governance for migratory species." *Science* 361, 1208–1209 (2018). https://doi.org/10.1126/science.aav2051

Arifanti, V. B., N. Novita, Subarno, and A. Tosiani. "Mangrove deforestation and CO_2 emissions in Indonesia." *IOP Conference Series: Earth and Environmental Science* 874, 012006 (2021). https://doi.org/10.1088/1755-1315/874/1/012006

Arkema, Katie K., Jade M. S. Delevaux, , Jessica M. Silver, et al. "Evidence-based target setting informs blue carbon strategies for nationally determined contributions." *Nature Ecology and Evolution* 7 (2023): 1045–1059. https://doi.org/10.1038/s41559-023-02081-1

Arkema, Katie K., Gregory M. Verutes, Spencer A. Wood, Chantalle Clarke-Samuels, Samir Rosado, Maritza Canto, Amy Rosenthal, Mary Ruckelshaus, Gregory Guannel, Jodie Toft, Joe Faries, Jessica M. Silver, Robert Griffin, Anne D. Guerry. "Embedding ecosystem services in coastal planning leads to better outcomes for people and nature." *PNAS* Vol. 112 No. 24 (2015). https://doi.org/10.1073/pnas.140648311

Atwood, Trisha B., Rod M. Connolly,, Euan G. Ritchie,, Catherine E. Lovelock,, Michael R. Heithaus,, Graeme C. Hays,, James W. Fourqurean,, Peter I. Macreadie. "Predators help protect carbon stocks in blue carbon ecosystems." *Nature Climate Change* 5 (2015): 1038–1045. https://doi.org/10.1038/nclimate2763

Asia Development Bank. "Regional Flyway Initiative Investing in the East Asian–Australasian Flyway for Nature and People." 2021. https://www.adb.org/sites/default/files/publication/799301/east-asian-australasian-flyway.pdf

Asia Development Bank. "Regional Flyway Initiative Investing in Sustainable Wetlands Management in the East Asian–Australasian Flyway." 2022. https://www.adb.org/sites/default/files/publication/808321/nature-based-solutions-people-nature-climate.pdf

Bailey, Megan, and U. R. Sumaila. "The Cost of Juvenile Fishing: FADs Management in the Western and Central Pacific Ocean Tuna Fishery," 2010. https://www.semanticscholar.org/paper/The-cost-of-juvenile-fishing-%3A-FADs-management-in-Bailey-Sumaila/872fedc695048e4bcb52aad405d7e74a3c216765

Bakhtary, Haseeb, Franziska Haupt, and Jana Elbrecht. "NDCs—A Force for Nature?" WWF-UK 2021. https://wwfint.awsassets.panda.org/downloads/wwf_ndcs_for_nature_4th_edition.pdf

Balasundharam, Vybhavi, Robin Koepke. "Diversion of Tourism Flows in the Asia & Pacific Region: Lessons for COVID-19 Recovery." IMF Working Paper 2021.

Barange, Manuel, Tarûb Bahri, Malcolm C. M. Beveridge, Kevern L. Cochrane,, Simon Funge-Smith,, Florence Poulain. "Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options." *FAO Fisheries and Aquaculture Technical Paper,* No. 627 (2018). Food and Agriculture Organization of The United Nations, Rome. https://openknowledge.fao.org/server/api/core/bitstreams/9aeb8ade-a623-4954-8adf-204daae3b5de/content

Babaran, Ricardo P., Kazuhiko Anraku, Munechika Ishizaki, Kenji Watanabe, Tatsuro Matsuoka, and Hideaki Shirai. "Sound Generated by a Payao and Comparison with Auditory Sensitivity of Jack Mackerel Trachurus Japonicus." *Fisheries Science* 74, No. 6 (December 2008): 1207–14. https://doi.org/10.1111/j.1444-2906.2008.01644.x

Barbier, Edward B. "Marine ecosystem services. *Current Biology* Vol. 27, Issue 11 (2017): R507-R510. https://doi.org/10.1016/j.cub.2017.03.020

Barclay, Kate M., Arlene N. Satapornvanit, Victoria M. Syddall, Meryl J. Williams. "Tuna Is Women's Business Too: Applying a Gender Lens to Four Cases in the Western and Central Pacific," 2021.

Barletti, Juan Pablo Sarmiento, Anne M. Larson, Katherine Lofts, and Alain Frechette. "Safeguards at a glance: Supporting the rights of Indigenous Peoples and local communities in REDD+ and other forest-based initiatives," *Center for International Forestry Research (CIFOR)*, December 2021. https://www.cifor-icraf.org/publications/pdf_files/Flyer/REDD-safeguards-1.pdf

Baskar, C. "ESG in asset management: Breaking the glass ceiling." Forbes. 2022. https://www.forbes.com/sites/forbesbusinesscouncil/2022/11/07/esg-in-asset-management-breaking-the-glass-ceiling/?sh=7a2a09c96131

Basu, Samarpita, and Katherine R. M. Mackey. "Phytoplankton as Key Mediators of the Biological Carbon Pump: Their Responses to a Changing Climate." *Sustainability* 10, No. 3 (March 2018): 869. https://doi.org/10.3390/su10030869.

Beeston, M., L. Cuyvers, J. Vermilye. "Blue Carbon: Mind the Gap." Gallifrey Foundation:, 2020. https://gallifrey.foundation/wp-content/uploads/2020/10/Blue-Carbon-Mind-the-Gap-V2.2.pdf

Begg, Shereen Sabina, Antoine De Ramon N'Yeurt,Shabnam Begg. "Interweaving resource management with indigenous knowledge to build community resilience in the Pacific Islands: case of the Waimanu Catchment in Viti Levu, Fiji." *Regional Environmental Change* 23, 86 (2023). https://doi.org/10.1007/s10113-023-02079-2

Bell, Johann D., Inna Senina, Timothy Adams, Olivier Aumont, Beatriz Calmettes, Sangaalofa Clark, Morgane Dessert, Marion Gehlen,, Thomas Gorgues,, John Hampton, Quentin Hanich, Harriet Harden-Davies, Steven R. Hare, Glen Holmes, Patrick Lehodey, Matthieu Lengaigne, William Mansfield, Christophe Menkes, Simon Nicol, Yoshitaka Ota, Coral Pasisi, Graham Pilling, Chis Reid, Espen Ronneberg, Alex Sen Gupta, Katherine L. Seto, Neville Smith, Sue Taei, Martin Tsamenyi, and Peter Williams. "Pathways to sustaining tuna-dependent Pacific Island economies during climate change." *Nature Sustainability* 4 (2021): 900–910. https://doi.org/10.1038/s41893-021-00745-z

Bell, Johann D., Andrés Cisneros-Montemayor, Quentin Hanich, Johanna E. Johnson, Patrick Lehodey, Bradley R. Moore, Morgan S. Pratchett, Gabriel Reygondeau, Inna Senina, John Virdin, and Colette C. C. Wabnitz. "Adaptations to maintain the contributions of small-scale fisheries to food security in the Pacific Islands." *Marine Policy* 88 (2018): 303–314. https://doi.org/10.1016/j.marpol.2017.05.019

Bell, Johann D., Valerie Allain, Edward H. Allison, Serge André-fouët, Neil L. Andrew, Michael J. Batty, Michel Blanc, et al. "Diversifying the Use of Tuna to Improve Food Security and Public Health in Pacific Island Countries and Territories." *Marine Policy* 51 (January 1, 2015): 584–91. https://doi.org/10.1016/j.marpol.2014.10.005.

Bell-James, J. "Developing a Framework for 'Blue Carbon' in Australia: Legal and Policy Considerations." *UNSW Law Journa*l 39(4) (2016). https://classic.austlii.edu.au/au/journals/UNSWLawJl/2016/60.html

Béné, Christophe, Robert Arthur, Hannah Norbury, Edward H. Allison, Malcolm Beveridge, Simon Bush, Liam Campling, Will Leschen, David Little, Dale Squires, Shakuntala H. Thilsted, Max Troell, and Meryl Williams. "Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence." *World Development* 79 (2016): 177–196. https://doi.org/10.1016/j.worlddev.2015.11.007

Bennett, Nathan J., Juan José Alava, Caroline E. Ferguson, Jessica Blythe, Elisa Morgera, David Boyd, Isabelle M. Côté. "Environmental (in)justice in the Anthropocene ocean." *Marine Policy*, Vol. 147 (2023). https://doi.org/10.1016/j.marpol.2022.105383

Bennett, Nathan James, Jessica Blythe, Carole Sandrine White, Cecilia Campero. "Blue growth and blue justice: Ten risks and solutions for the ocean economy," *Marine Policy*, Vol. 125 (2021). https://doi.org/10.1016/j.marpol.2020.104387

Bennett, Nathan J., Lydia Teh, Yoshitaka Ota, Patrick Christie, Adam Ayers, Jon C. Day, Phil Franks, David Gill, Rebecca L. Gruby, John N. Kittinger, J. Zachary Koehn, Nai'a. Lewis, John Parks, Marjo Vierros, Tara S. Whitty, Aulani Wilhelm, Kim Wright, Jaime A. Aburto, Elena M. Finkbeiner, Carlos F. Gaymer, Hugh Govan, Noella Gray, Rebecca M. Jarvis, Maery Kaplan-Hallam, Terre Satterfield. "An appeal for a code of conduct for marine conservation." *Marine Policy*, Vol. 81 (2017): 411–418. https://doi.org/10.1016/j.marpol.2017.03.035

Berkes, Fikret, Johan Colding, and Carl Folke. "Rediscovery of traditional ecological knowledge as adaptive management." *Ecological Applications* Vol. 10 No. 5 (2000): 1251–1262. https://doi.org/10.2307/2641280

Berkes, Fikret,Mina Kislalioglu, Carl Folke, and Madhav Gadgil. "Minireviews: Exploring the Basic Ecological Unit: Ecosystem-like Concepts in Traditional Societies." *Ecosystems* 1 (1998): 409–415. https://doi.org/10.1007/s100219900034

Bertram, Christine, Martin Quaas, Thorsten B. H. Reusch, Athanasios T. Vafeidis, Claudia Wolff, and Wilfried Rickels. "The blue carbon wealth of nations." *Nature Climate Change* 11 (2021): 704–709. https://doi.org/10.1038/s41558-021-01089-4

Bhatia, Vidhi. "Explainer: Carbon insetting vs offsetting." *World Economic Forum Sustainable Development Impact Meetings*. March 18, 2022. https://www.weforum.org/agenda/2022/03/carbon-insetting-vs-offsetting-an-explainer

Bhowmik, Avit K., Rajchandar Padmanaban, Pedro Cabral, and Maria M. Romeiras. "Global Mangrove Deforestation and Its Interacting Social-Ecological Drivers: A Systematic Review and Synthesis." *Sustainability* 14, No. 8 (January 2022): 4433. https://doi.org/10.3390/su14084433.

Bianchi, Daniele, David A. Carozza, Eric D. Galbraith, Jérôme Guiet, and Timothy DeVries. "Estimating Global Biomass and Biogeochemical Cycling of Marine Fish with and without Fishing." *Science Advances* 7, No. 41 (October 8, 2021): eabd7554. https://doi.org/10.1126/sciadv.abd7554

Bloomberg NEF. "Carbon Credits Face Biggest Test Yet, Could Reach $238/Ton in 2050, According to Bloomberg NEF Report." February 6, 2024. https://about.bnef.com/blog/carbon-credits-face-biggest-test-yet-could-reach-238-ton-in-2050-according-to-bloombergnef-report/#:~:text=Under%20the%20Voluntary%20market%20scenario%2C%20prices%20reach%20just%20%2413%2Fton,up%20from%20%242%20billion%20today

Blue Natural Capital. "Investing for Ocean Impact, Nature-based Solutions: investments for the planet." Podcast, November 16, 2021. https://omny.fm/shows/investing-for-ocean-impact/nature-based-solutions-investments-for-the-planet

Blue Forests Project. "Blue Carbon Code of Conduct." June 8, 2017. https://news.gefblueforests.org/blue-carbon-code-of-conduct

Brodie, Gilianne, Elisabeth Holland, Antoine De Ramon N'Yeurt, Katy Soapi, and Jeremy Hills. "Seagrasses and Seagrass Habitats in Pacific Small Island Developing States: Potential Loss of Benefits via Human Disturbance and Climate Change." *Marine Pollution Bulletin* 160 (November 2020): 111573. https://doi.org/10.1016/j.marpolbul.2020.111573

Brodie, Gilianne, and Antoine De Ramon N'Yeurt. "Effects of Climate Change on Seagrasses and Seagrass Habitats Relevant to the Pacific Islands." *Science Review* 2018: (112–131). https://www.sprep.org/attachments/Publications/CC/8-sea-grass.pdf

Buffington, Kevin J., Richard A. MacKenzie, Joel A. Carr, Maybeleen Apwong, Ken W. Krauss, and Karen M. Thorne. "Mangrove Species' Response to Sea-level Rise Across Pohnpei, Federated States of Micronesia." U.S. Geological Survey Open-File Report 2021–1002, 44 p., https://doi.org/10.3133/ofr20211002.

Bunting, Pete, Ake Rosenqvist, Lammert Hilarides, Richard M. Lucas, Nathan Thomas, Takeo Tadono, Thomas A. Worthington,, Mark Spalding, Nicholas J. Murray, and Lisa-Marie Rebelo. "Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0." *Remote Sensing* Vol. 14 No. 15 (2022): 3657. https://doi.org/10.3390/rs14153657

Cashion Tim, Tu Nguyen, Talya ten Brink, Anne Mook, Juliano Palacios-Abrantes, and Sarah M. Roberts. "Shifting seas, shifting boundaries: Dynamic marine protected area designs for a changing climate." *PLoS One* Vol. 15 No. 11 (2020). https://doi.org/10.1371/journal.pone.0241771

Castillo-Jordán, Claudio, Thom Teears, John Hampton, N. Davies, Joe Scutt Phillips, S. Mckechnie, Tom Peatman, et al. "Stock Assessment of Skipjack Tuna in the Western and Central Pacific Ocean: 2022." *Western and Central Pacific Fisheries Commission Scientific Committee 18th Regular Session*, August 2022. https://doi.org/10.13140/RG.2.2.31285.96480

Cavan, Emma. L. and Simeon L. Hill. "Commercial fishery disturbance of the global ocean biological carbon sink." *Global Change Biology* 28 (2022): 1212–1221. https://doi.org/10.1111/gcb.16019

Cavanaugh, Kyle C., Emily M. Dangremond, Cheryl L. Doughty, A. Park Williams,, John D. Parker, Matthew A. Hayes,, Wilfrid Rodriguez, and Ilka C. Feller. "Climate-driven regime shifts in a mangrove–salt marsh ecotone over the past 250 years." *Proceedings of the National Academy of Sciences* 116 (2019): 21602–21608. https://doi.org/10.1073/pnas.1902181116

CDP. "The CDP portal and response window is now open for disclosures." *CDP, Disclosure Insight Action*, 2024. https://www.cdp.net/en/companies

CFI Team. "Real Economy." *Corporate Financial Institute*, 2024. https://corporatefinanceinstitute.com/resources/economics/real-economy/

Châles, Fanny, Manuel Bellanger, Denis Bailly, Leo X. C. Dutra, and Linwood Pendleton. "Using standards for coastal nature-based solutions in climate commitments: Applying the IUCN Global Standard to the case of Pacific Small Island Developing States." *Nature-Based Solutions*, Vol. 3 (2023). https://doi.org/10.1016/j.nbsj.2022.100034

Chancery Lane Project. "Reduce emissions using the power of legal documents and processes." 2024. https://chancerylane-project.org/

Charlton, Karen. E., Joanna Russell, Emma Gorman,. et al. "Fish, food security and health in Pacific Island countries and territories: a systematic literature review." *BMC Public Health* 16, 285 (2016). https://doi.org/10.1186/s12889-016-2953-9

Chatting, Mark, Ibrahim Al-Maslamani, Mark Walton, Martin W. Skov,, Hilary Kennedy, Y. Sinan Husrevoglu, and Lewis Le Vay. "Future Mangrove Carbon Storage Under Climate Change and Deforestation." *Frontiers in Marine Science* 9 (2022) https://doi.org/10.3389/fmars.2022.781876

Chen, Jie, Dongqi Wang, Yangjie Li, Zhongjie Yu, Shu Chen, Xiyong Hou, John R. White, and Zhenlou Chen. "The Carbon Stock and Sequestration Rate in Tidal Flats from Coastal China." *Global Biogeochemical Cycles* 34 (2020). https://doi.org/10.1029/2020GB006772

Chen, Luzhen, Hangqing Fan, Zhinan Su, Qiulian Lin, and Yancheng Tao. "Enhancing Carbon Storage in Mangrove Ecosystems of China through Sustainable Restoration and Aquaculture Actions." In *Wetland Carbon and Environmental Management,* edited by Ken W. Krauss, Zhiliang Zhu, Camille L. Stagg, 127–41. American Geophysical Union (AGU), 2021. https://doi.org/10.1002/9781119639305.ch6.

Cheung, William W. L., Eva Maire, Muhammed A. Oyinlola, James P. W. Robinson, Nicholas A. J. Graham, Vicky W. Y. Lam, M. Aaron MacNeil, and Christina C. Hicks. "Climate Change Exacerbates Nutrient Disparities from Seafood." *Nature Climate Change* Vol. 13, No. 11 (November 2023): 1242–49. https://doi.org/10.1038/s41558-023-01822-1.

Chin, Neil, Nicole Pinko, Jide Olutoke, Claire Eschalier, Luis Zamarioli Santos and Sarah Bendahou. "Approaches to meeting the Paris Agreement Goals." *Climate Policy I nitiative*, July 2, 2024.

Clarke, Shelley, Mayumi Sato, Cleo Small, Ben Sullivan, Yukiko Inoue, and Daisuki Ochi. "Bycatch in Longline Fisheries for Tuna and Tuna-like Species: A Global Review of Status and Mitigation Measures." *FAO Fisheries and Aquaculture Technical Paper* 588 (2014). Rome. https://openknowledge.fao.org/server/api/core/bitstreams/e55aaa87-9271-4c20-be9f-6670126c8591/content

Climate Bonds Initiative. "Certification Under the Climate Bonds Standard." 2024. https://www.climatebonds.net/certification

Cohen-Shacham, E., Gretchen Walters, C. Janzen. and Stewart Maginnis. "Nature-based Solutions to address global societal challenges." Gland, Switzerland: IUCN 2016. https://doi.org/10.2305/IUCN.CH.2016.13.en

Cooper, Andrew B. and Kirstin Weir. "A Guide to Fisheries Stock Assessment: From Data to Recommendations." *University of New Hampshire, Sea Grant College Program* (2006). https://repository.library.noaa.gov/view/noaa/38414

Cormier-Salem, Marie-Christine. "Let the Women Harvest the Mangrove. Carbon Policy, and Environmental Injustice." *Sustainability* 9, No. 8 (2017): 1485 https://doi.org/10.3390/su9081485

Costanza, Robert, Sharolyn J. Anderson, Paul Sutton, Kenneth Mulder, Obadiah Mulder, Ida Kubiszewski, Xuantong Wang, Xin Liu, Octavio Pérez-Maqueo, M. Luisa Martinez, Diane Jarvis, Greg Dee. "The global value of coastal wetlands for storm protection." *Global Environmental Change*, Vol. 70 (2021). https://doi.org/10.1016/j.gloenvcha.2021.102328

Costanza, Robert, Rudolf de Groot, Paul Sutton, Sander van der Ploeg, Sharolyn J. Anderson, Ida Kubiszewski, Stephen Farber, and R. Kerry Turner. "Changes in the Global Value of Ecosystem Services." *Global Environmental Change* 26 (May 1, 2014): 152–58. https://doi.org/10.1016/j.gloenvcha.2014.04.002.

Crooks, Stephen, Dorothée Herr, Jerker Tamelander Dan Laffoley, and Justin Vandever. "Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems: Challenges and Opportunities." *Environment Department Papers* 121 (2011). Marine Ecosystem series, World Bank, Washington, DC. http://hdl.handle.net/10986/18318

Cullen-Unsworth, Leanne and Richard Unsworth. "Seagrass Meadows, Ecosystem Services, and Sustainability." *Environment: Science and Policy for Sustainable Development* 55 (2013): 14–28. https://doi.org/10.1080/00139157.2013.785864

Czamanski, Marie, Adi Nugraha, Philippe Pondaven, Marine Lasbleiz, Annick Masson, Nicholas Caroff, Robert Bellail, and Paul Treguer. "Carbon, nitrogen and phosphorus elemental stoichiometry in aquacultured and wild-caught fish and consequences for pelagic nutrient dynamics." *Marine Biology* 158 (2011): 2847–2862. DOI: 10.1007/s00227-011-1783-7

Dahl, Martin, Rashid Ismail, Sara Braun, Pere Masqué, Paul S. Lavery, Martin Gullström, Ariane Arias-Ortiz, Maria E. Asplund, Andrius Garbaras, Liberatus D. Lyimo, Matern S. P. Mtolera,Oscar Serrano, Chanelle Webster, and Mats Björk. "Impacts of land-use change and urban development on carbon sequestration in tropical seagrass meadow sediments." *Marine Environmental Research* Vol. 176 (2022). https://doi.org/10.1016/j.marenvres.2022.105608

Dalzell, Paul, T. Adams,and N. Polunin. "Coastal fisheries in the Pacific Islands." *Oceanography and Marine Biology Annual Review* 33 (1996): 395–531. https://www.researchgate.net/publication/237838487_Dalzell_P_Adams_T_Polunin_N_1996_Coastal_fisheries_in_the_Pacific_Islands_Oceanography_and_Marine_Biology_Annual_Review_33_395-531

Dauost, Quinne. "Human Rights Abuses & Organized Crime on IUU Fishing Vessels." *American Security Project*: November 9, 2021. https://www.americansecurityproject.org/iuufishing-crimes/#:~:text=Human%20Rights%20Violations&text=As%20a%20result%2C%20IUU%20fishing,for%20extended%20periods%20of%20time.

de Lange, Emiel, Jocelyne S. Sze,, James Allan, et al. "A global conservation basic income to safeguard biodiversity." *Nature Sustainability* 6 (2023): 1016–1023. https://doi.org/10.1038/s41893-023-01115-7

Delevaux, Jade, Jessica Silver, Samantha Winder, Nadia Bood, Luis Chevez, Pilar Velásquez, Alejandra Calzada Vásquez Vela, Ryan Barlett, Maria Amalia Porta, Stacie Wolny,, Allison Bailey, Melanie McField, Aarón Muñiz-Castillo, and Katie Arkema. "Supporting people and nature across neighboring nations with land-sea planning at multiple scales." Preprint, Version 1 (May 3, 2023). https://doi.org/10.21203/rs.3.rs-2778578/v1

Delevaux, Jade M. S. and Kostantinos A. Stamoulis. "Prioritizing Forest Management Actions to Benefit Marine Habitats in Data-Poor Regions." *Conservation Biology* 36 (2) (2022): e13792. https://doi.org/10.1111/cobi.13792

Delevaux, Jade M. S., S. D. Jupiter, Konstantinos A. Stamoulis,et al. "Scenario planning with linked land-sea models inform where forest conservation actions will promote coral reef resilience." *Scientific Reports* 8 (2018): 12465. https://doi.org/10.1038/s41598-018-29951-0

Dencer-Brown, Amrit Melissa, Robyn Shilland, Daniel Friess, et al. "Integrating blue: How do we make nationally determined contributions work for both blue carbon and local coastal communities?" *Ambio* 51 (2022): 1978–1993. https://doi.org/10.1007/s13280-022-01723-1

Denyer, Karen, Yaiphaba Akoijam, Mariam Kenza Ali, Solongo Khurelbaatar, Gonzalo Oviedo, and Lew Young. "Learning from Experience: How indigenous peoples and local communities contribute to wetland conservation in Asia and Oceania." *Ramsar Convention Secretariat* (2018).

Deutz, Andrew., Geoffrey M. Heal,, Rose Niu, Eric Swanson, Terry Townshend, Zhu Li, Alejandro Delmar, Alqayam Meghji, Suresh A. Sethi, and John Tobin-de la Puente. "Financing Nature: Closing the global biodiversity financing gap." *The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability* (2020). https://www.paulsoninstitute.org/wp-content/uploads/2020/09/FINANCING-NATURE_Full-Report_Final-Version_091520.pdf

Development Asia. "The Regional Flyway Initiative: Building a Business Case for Sustainable Wetlands." February 28, 2023. https://development.asia/insight/regional-flyway-initiative-building-business-case-sustainable-wetlands

DeVries, Tim "The Ocean Carbon Cycle." *Annual Review of Environment and Resources* 47 (2022): 317–341. https://doi.org/10.1146/annurev-environ-120920-111307

Divgi, Pratima "Asia Pacific's race to net-zero: CDP's regional analysis of 2020 corporate environmental disclosures." *CDP* (2021). https://www.cdp.net/en/articles/climate/asia-pacifics-race-to-net-zero

Drake, Lauren "Blue carbon in action." Pollination group, Global Perspectives (2022). https://pollinationgroup.com/global-perspectives/blue-carbon-in-action/

Duarte, Carlos M. "Reviews and syntheses: Hidden forests, the role of vegetated coastal habitats in the ocean carbon budget." *Biogeosciences* 14 (2017): 301–310. https://doi.org/10.5194/bg-14-301-2017

Dunstan, Piers K., Bradley R. Moore, Johann D. Bell, Neil J. Holbrook, Eric C. J. Oliver, James Risbey, Scott D. Foster, Quentin Hanich, Alistair J. Hobday, and Nathan J. Bennett. "How Can Climate Predictions Improve Sustainability of Coastal Fisheries in Pacific Small-Island Developing States?" *Marine Policy* 88 (2018): 295–302. https://doi.org/10.1016/j.marpol.2017.09.033.

Egolf, Suzanne. "The Belize debt-for-nature swap. Mobilizing funding for biodiversity conservation: A user-friendly training guide." 2001 https://www.cbd.int/doc/nbsap/finance/CaseStudy-DebtforNature_Belize_Nov2001.pdf

Escalle, Lauriane, Jennyfer Mourot, Paul Hamer, Steven R. Hare, Naiten Bradley Phillip, and Graham M. Pilling."Towards Non-Entangling and Biodegradable Drifting Fish Aggregating Devices—Baselines and Transition in the World's Largest Tuna Purse Seine Fishery." *Marine Policy* 149 (2023): 105500. https://doi.org/10.1016/j.marpol.2023.105500

Ehler, Charles and Fanny Douvere. "Marine Spatial Planning: a step-by-step approach toward ecosystem-based management." *Intergovernmental Oceanographic Commission and Man and the Biosphere Programme* 2009. http://dx.doi.org/10.25607/OBP-43

Ellison, Joanna C. "Effects of climate change on mangroves relevant to the Pacific Islands." *Centre for Environment, Fisheries and Aquaculture Science* (2018): 99–111.. https://assets.publishing.service.gov.uk/media/5b1907ffe5274a1905e8e944/7_Mangroves.pdf

Ellison, Joanna C. "How South Pacific Mangroves May Respond to Predicted Climate Change and Sea-level Rise." In *Climate Change in the South Pacific: Impacts and Responses in Australia, New Zealand, and Small Island States, Advances in Global Change Research*, edited by Andrew Gillespie and William C.G. Burns, 289–300. Springer Netherlands: Dordrecht, 2000. https://doi.org/10.1007/0-306-47981-8_16

Ellison, Joanna C. and David R. Stoddart. "Mangrove Ecosystem Collapse during Predicted Sea-Level Rise: Holocene Analogues and Implications." *Journal of Coastal Research* 7 (1991): 151–165. https://www.jstor.org/stable/4297812

Eloyan, Lilian. "Marine Snow: The Largest Snowfall on Earth." *Berkeley Scientific Journal* 24, No. 2 (2020). https://doi.org/10.5070/BS3242049337.

ELTI (Environmental Leadership and Training Institute). "Supporting Honey Production to Help Conserve Mangrove Forests." *Yale School of the Environment, Environment Leadership and Training Institute*, 2015. https://elti.yale.edu/our-stories/supporting-honey-production-help-conserve-mangrove-forests

EPA (Environmental Protection Agency). "Greenhouse Gas Equivalencies Calculator." Accessed 2023. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results

Escalle, Lauriane and Joe Scutt Phillips. "More than 2000 FADs Wash up on WCPO Beaches Every Year." *Fish Information & Services; Seafood Media Group*, 2019. http://www.fis-net.com/fis/worldnews/worldnews.asp?monthyear=&day=3&id=104787&l=e&special=&ndb=1%20target=.

European Commission. "A win for the ocean: High Seas Treaty signed at United Nations." September 20, 2023. https://oceans-and-fisheries.ec.europa.eu/news/win-ocean-high-seas-treaty-signed-united-nations-2023-09-20_en#:~:text=Once%20ratified%2C%20the%20High%20Seas,30%25%20of%20the%20planet%20by

European Commission. "Beyond GDP." 2024. https://environment.ec.europa.eu/economy-and-finance/alternative-measures-progress-beyond-gdp/beyond-gdp-publications_en?ref=oceanaccounts.org

Fabro, Keith Anthony S. "Women on storm-hit Philippine island spearhead Indigenous effort to restore mangroves." *Ecobusiness*. October 8, 2021. https://www.eco-business.com/news/women-on-storm-hit-philippine-island-spearhead-indigenous-effort-to-restore-mangroves/

FAO (Food and Agriculture Organization of the United Nations). "The State of World Fisheries and Aquaculture 2024. Blue Transformation in Action." *Rome, FAO*, 2024. https://openknowledge.fao.org/handle/20.500.14283/cd0683en

FAO (Food and Agriculture Organization of the United Nations). "The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation." *Rome, FAO*, 2022. https://doi.org/10.4060/cc0461en

FAO (Food and Agriculture Organization of the United Nations). Duke University, and WorldFish. "Small-scale fisheries and sustainable development: Key findings from the Illuminating Hidden Harvests report." *Rome, FAO*; Durham, USA, Duke University; Penang, Malaysia, WorldFish 2022. https://www.fao.org/3/cc0386en/cc0386en.pdf

FAO (Food and Agriculture Organization of the United Nations). "The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all." *Rome, FAO*, 2016. https://openknowledge.fao.org/server/api/core/bitstreams/20e618b3-93a1-488a-9697-798f6b6c6b35/content

FAO (Food and Agriculture Organization of the United Nations). "The world's mangroves 1980–2005." *Forestry, Economics, and Policy Division, FAO*, 2006. https://openknowledge.fao.org/handle/20.500.14283/a1427e

Faivre, Gaelle, Rodger Tomlinson,, Daniel Ware,et al. "Effective coastal adaptation needs accurate hazard assessment: a case study in Port Resolution, Tanna Island Vanuatu." *Climatic Change* 170 (2022). https://doi.org/10.1007/s10584-021-03304-9

Fauzi, Adam, Anjar Sakti, Lissa Yayusman, Agung Harto, Lilik Prasetyo, Bambang Irawan, Muhammad Kamal, and Ketut Wikantika. "Contextualizing Mangrove Forest Deforestation in Southeast Asia Using Environmental and Socio-Economic Data Products." *Forests* 10, No. 11 (November 2019): 952. https://doi.org/10.3390/f10110952

Federal Reserve. "Types of Financial System Vulnerabilities and Risks." 2021. *Board of Governors of the Federal Reserve*, Accessed 2024. https://www.federalreserve.gov/financial-stability/types-of-financial-system-vulnerabilities-and-risks.htm

Felicani-Robles, Francesca. "Carbon Rights and the Importance of Benefit Sharing." *UN-REDD Programme*. June 3, 2022. https://www.un-redd.org/post/carbon-rights-and-importance-benefit-sharing

Fennessy, M. S. and L. Schille Beers. "The Contribution of Blue Carbon Ecosystems to Climate Change Mitigation." *Ramsar Briefing Note 12, Secretariat of the Convention on Wetlands* (2021). https://www.ramsar.org/sites/default/files/documents/library/bn12_blue_carbon_ccmitigation_e.pdf

Ferrer, Erica M., Alfredo Giron-Nava, and Octavio Aburto-Oropeza. "Overfishing Increases the Carbon Footprint of Seafood Production from Small-Scale Fisheries." *Frontiers in Marine Science* 9 (2022). https://www.frontiersin.org/articles/10.3389/fmars.2022.768784.

Filbee-Dexter, Karen, Albert Pessarrodona, Morten F. Pedersen, Thomas Wernberg, Carlos M. Duarte, Jorge Assis, Trine Bekkby, Michael T. Burrows, Daniel F. Carlson, Jean-Pierre Gattuso, Hege Gundersen, Kasper Hancke, Kira A. Krumhansl, Tomohiro Kuwae, Jack J. Middelburg, Pippa J. Moore, Ana M. Queirós, Dan A. Smale, Isabel Sousa-Pinto, Nobuhiro Suzuki, Dorte Krause-Jensen. "Carbon Export from Seaweed Forests to Deep Ocean Sinks." *Nature Geoscience*, May 22, 2024: 1–8. https://doi.org/10.1038/s41561-024-01449-7.

Fodrie, F. Joel, Antonio B. Rodriguez,, Rachel K. Gittman, Jonathan H. Grabowski, Niels L. Lindquist, Charles H. Peterson, Michael F. Piehler, and Justin T. Ridge. "Oyster reefs as carbon sources and sinks. Proceedings of the Royal Society B: Biological Sciences 284, (2017). https://doi.org/10.1098/rspb.2017.0891

Fonteneau, A. and P. Pallares. "Tuna natural mortality as a function of their age: the bigeye tuna case." *Pacific Data Hub*, Noumea, New Caledonia: SPC, Secretariat of the Pacific Community, Standing Committee on Tuna and Billfish, Majuro, Marshall Islands, August 2004. https://pacific-data.sprep.org/dataset/tuna-natural-mortality-function-their-age-bigeye-tuna-thunnus-obesus-case

Fortes, Miguel D., Jillian Lean Sim Ooi, Yi Mei Tan,, Anchana Prathep, Japar Sidik Bujang, and Siti Maryam Yaakub. "Seagrass in Southeast Asia: a review of status and knowledge gaps, and a road map for conservation." *Botanica Marina* 61 (2018): 269–288. https://doi.org/10.1515/bot-2018-0008

Fourqurean, James W., Carlos M. Duarte, Hilary Kennedy, Núria Marbà, M. Holmer, Miguel Angel Mateo, Eugenia T. Apostolaki, Gary A. Kendrick, Dorte Krause-Jensen, Karen J. McGlathery, and Oscar Serrano. "Seagrass ecosystems as a globally significant carbon stock." *Nature Geoscience* 5 (2012): 505–509. https://doi.org/10.1038/ngeo1477

Friess Daniel A., Jen Howard, Mark Huxham, Peter I. Macreadie, and Finnley Ross. "Capitalizing on the global financial interest in blue carbon." *PLOS Climate* 1(8) (2022). https://doi.org/10.1371/journal.pclm.0000061

Friess, Daniel A., Yasmine M. Gatt, Rio Ahmad, Benjamin M. Brown, Frida Sidik, and Dominic Wodehouse. "Achieving ambitious mangrove restoration targets will need a transdisciplinary and evidence-informed approach." *One Earth* 5(5) (2022): 456–460. https://doi.org/10.1016/j.oneear.2022.04.013

Froehlich, Halley E., Nis Sand Jacobsen, Timothy E. Essington, Tyler Clavelle, and Benjamin S. Halpern. "Avoiding the ecological limits of forage fish for fed aquaculture. *Nature Sustainability* 1 (2018): 298–303. https://doi.org/10.1038/s41893-018-0077-1

Gandhi, Samir and Trevor Gareth Jones. "Identifying Mangrove Deforestation Hotspots in South Asia, Southeast Asia and Asia-Pacific." *Remote Sensing* 11, No. 6 (January 2019): 728. https://doi.org/10.3390/rs11060728

Geronimo, Rollan C. "Projected Climate Change Impacts on Philippine Marine Fish Distributions." *USAID and Philippines Department of Agriculture-Bureau of Fisheries and Aquatic Resources*, 2018. https://www.climatelinks.org/sites/default/files/asset/document/2021-11/Projected%20Impacts%20of%20CC%20on%20Fisheries.pdf

Gillett, Robert and Chris Lightfoot. "The Contribution of Fisheries to the Economies of Pacific Island Countries. A report prepared for the Asian Development Bank, the Forum Fisheries Agency, and the World Bank." December 2001. https://www.adb.org/sites/default/files/publication/28819/contribution-fisheries.pdf

Global Mangrove Alliance. "Mangrove Market Meri." https://www.mangrovealliance.org/mangoro-market-meri/

Global Ocean Alliance. *United Kingdom*, Accessed 2024. https://www.gov.uk/government/topical-events/global-ocean-alliance-30by30-initiative/about

Global Oceans Accounts Partnership (GOAP) Secretariat(a). "What are ocean accounts?" May 18, 2022. https://www.oceanaccounts.org/what-are-ocean-accounts/

GOAP Secretariat(b). "Why are ocean accounts important?" May 18, 2022. https://www.oceanaccounts.org/why-are-ocean-accounts-important/

GOAP Secretariat(c). "Ocean Accounting for Fiji: a focus on Mangroves." June 16, 2022. https://www.oceanaccounts.org/ocean-accounts-for-fiji-a-focus-on-mangroves/

Goffredi, Shana K., Regina Wilpiszeski, Ray Lee, and Victoria J. Orphan. "Temporal Evolution of Methane Cycling and Phylogenetic Diversity of Archaea in Sediments from a Deep-Sea Whale-Fall in Monterey Canyon, California." *The ISME Journal* 2, No. 2 (February 2008): 204–20. https://doi.org/10.1038/ismej.2007.103

Golden, Christopher D., J. Zachary Koehn, Alon Shepon, Simone Passarelli, Christopher M. Free, Daniel F. Viana, Holger Matthey, Jacob G. Eurich, Jessica A. Gephart, Etiene Fluet-Chouinard, Elizabeth Al. Nyboer, Abigail J. Lynch, Marian Kjellevold, Sabri Bromage, Pierre Charlebois, Manuel Barange, Stefania Vannuccini, Ling Cao, Kristin M. Kleisner, Eric B. Rimm, Goodarz Danaei, Camille DeSisto, Heather Kelahan, Kathryn J. Fiorella, David C. Little, Edward H. Allison, Jessica Fanzo and Shakuntula H. Thilsted. "Aquatic Foods to Nourish Nations." *Nature* 598, No. 7880 (October 2021): 315–20. https://doi.org/10.1038/s41586-021-03917-1.

Gomez, Guillermo, Samantha Farquhar, Henry Bell, Eric Laschever, and Stacy Hall. "The IUU Nature of FADs: Implications for Tuna Management and Markets." *Coastal Management* 48, No. 6 (November 1, 2020): 534–58. https://doi.org/10.1080/08920753.2020.1845585.

Goodman, Camille, Ruth Davis, Kamal Azmi, Johann Bell, Grantly R. Galland, Eric Gilman, Bianca Haas, Quentin Hanich, Patrick Lehodey, Lara Manarangi-Trott, Simon Nicol, Pablo Obregon, Graham Pilling, Inna Senina, Katherine Seto, and Martin Tsamenyi. "Enhancing cooperative responses by regional fisheries management organisations to climate-driven redistribution of tropical Pacific tuna stocks." *Frontiers in Marine Science* 9 (2022). https://doi.org/10.3389/fmars.2022.1046018

Gorman, Daniel, Mark. Wilson, and Andrew D. L. Steven. "Communicating Blue Carbon Science Across the Indo-Pacific Region Through Capacity Building Fellowships. *Science Communication* Vol. 45 No. 3 (2023): 402–-413. https://doi.org/10.1177/10755470221143740

Govan, Hugh, et al. "Status and potential of locally-managed marine areas in the Pacific Island Region: meeting nature conservation and sustainable livelihood targets through wide-spread implementation of LMMAs." *University Library of Munich, Germany, MPRA Paper*, 2009. https://mpra.ub.uni-muenchen.de/id/eprint/23828

Government of Indonesia, National Development Planning Agency (Bappenas). "Low Carbon Development Initiative." 2019. https://lcdi-indonesia.id/

Granderson, Ainka A. "The Role of Traditional Knowledge in Building Adaptive Capacity for Climate Change: Perspectives from Vanuatu." *Weather, Climate and Society* 9(3) 545–561: (2017). https://doi.org/10.1175/WCAS-D-16-0094.1

Green Collar. "Case study: Reef credits - a new environmental market-based instrument to improve water quality in the Great Barrier Reef, Queensland, Australia." *The Commonwealth* 2020. https://thecommonwealth.org/case-study/case-study-reef-credits-new-environmental-market-based-instrument-improve-water-quality

Griscom, Bronson W., Justin Adams, Peter W. Ellis, and Joseph Fargione. "Natural climate solutions." *PNAS* Vol 114 No 44 (2017). https://doi.org/10.1073/pnas.1710465114

Gustafson, David, Alona Gutman, Whitney Leet, Adam Drewnowski, Jessica Fanzo, and John Ingram. "Seven Food System Metrics of Sustainable Nutrition Security." *Sustainability* 8, No. 3 (March 2016): 196. https://doi.org/10.3390/su8030196

Hadyanafi, Karizki, Bimo Dwisatrio, Sandy Nofyanza. "Indonesia's 'blue carbon credits' are crucial for global climate mitigation. Here's how to help them flourish." *The Conversation*, December 21, 2022. https://theconversation.com/indonesias-blue-carbon-credits-are-crucial-for-global-clima@lote-mitigation-heres-how-to-help-them-flourish-192019

Hand, Dean, Ben Ringel, Alexander Danel. "Sizing the Impact Investing Market: 2022." *The Global Impact Investing Network (GIIN)*. New York 2022. https://thegiin.org/publication/research/impact-investing-market-size-2022/

Hashim, Tengku Mohd Zarawie Tengku, Engku Azlin Rahayu Engku Ariff, and Mohd Nazip Suratman. "Aquaculture in Mangroves," In book *Mangroves: Ecology, Biodiversity, and Management* (October 2021): 419–438. https://www.researchgate.net/publication/355015712_Aquaculture_in_Mangroves

Hasler, A. D. *Coupling of land and water systems*. New York: Springer-Verlag: 1974.

Hazen, Elliott L., Kylie L. Scales, Sara M. Maxwell, Dana K. Briscoe, Heather Welch, Steven J. Bograd, Helen Bailey, et al. "A Dynamic Ocean Management Tool to Reduce Bycatch and Support Sustainable Fisheries." *Science Advances* 4, No. 5 (May 30, 2018): eaar3001. https://doi.org/10.1126/sciadv.aar3001

Hicks, Christina C., Jessica A. Gephart, J. Zachary Koehn, Shinnosuke Nakayama, Hanna J. Payne, Edward H. Allison, Dyhia Belhbib, Ling Cao, Philippa J. Cohen, Jessica Fanzo, Etienne Fluet-Chouinard, Stefan Gelcich, Christopher D. Golden, Kelvin D. Gorospe, Moenieba Isaacs, Caitlin D. Kuempel, Kai N. Lee, Aaron M. MacNeil, Eva Maire, Jemimah Njuki, Nitya Rao, U. Rashid Sumaila, Elizabeth R. Selig, Shakuntala H. Thilsted, Colette C.C. Wabnitz, Rosamond L. Naylor. "Rights and Representation Support Justice across Aquatic Food Systems." *Nature Food* 3, No. 10 (October 2022): 851–61. https://doi.org/10.1038/s43016-022-00618-4

Hicks, Christina C., Philippa J. Cohen, Nicholas A. J. Graham, Kirsty L. Nash, Edward H. Allison, Coralie D'Lima, David J. Mills, Matthew Roscher, Shakuntula Thilsted, Andrew Thorne-Lyman, Aaron M. MacNeil. "Harnessing Global Fisheries to Tackle Micronutrient Deficiencies." *Nature* 574, No. 7776 (October 2019): 95–98. https://doi.org/10.1038/s41586-019-1592-6

Higgs, Nicholas D., Andrew R. Gates, and Daniel O. B. Jones. "Fish Food in the Deep Sea: Revisiting the Role of Large Food-Falls." *PLOS One* 9 (2014). https://doi.org/10.1371/journal.pone.0096016

Hill, Narelle K., Bradlely K. Woodworth, Stuart R. Phinn, Nicholas J. Murray, and Richard A. Fuller. "Global protected-area coverage and human pressure on tidal flats." *Conservation Biology* 35 (2021): 933–943. https://doi.org/10.1111/cobi.13638

Hobday, Alistair J., Claire M. Spillman, J. Paige Eveson, Jason R. Hartog, Xuebin Zhang, and Stephanie Brodie. "A Framework for Combining Seasonal Forecasts and Climate Projections to Aid Risk Management for Fisheries and Aquaculture." *Frontiers in Marine Science* 5 (2018). https://www.frontiersin.org/articles/10.3389/fmars.2018.00137

Howard, Jennifer, Ariana Sutton-Grier, Dorothée Herr, Joan Kleypas, Emily Landis, Elizabeth Mcleod, Emily Pidgeon, and Stefanie Simpson. "Clarifying the Role of Coastal and Marine Systems in Climate Mitigation." *Frontiers in Ecology and the Environment* 15, No. 1 (2017): 42–50. https://doi.org/10.1002/fee.1451

Hughes Robert G. and Mark A. Lawrence. "Globalization, food and health in Pacific Island countries." *Asia Pacific journal of clinical nutrition* Vol. 14,4 (2005): 298–306. https://pubmed.ncbi.nlm.nih.gov/16326635/

Hunnam, Kimberley, Imelda Carlos, Michael P. Hammer, Joctan Dos Reis Lopes, David J. Mills, and Natasha Stacey. "Untangling Tales of Tropical Sardines: Local Knowledge from Fisheries in Timor-Leste." *Frontiers in Marine Science* 8 (2021). https://www.frontiersin.org/articles/10.3389/fmars.2021.673173.

Hunt J., J. C. Altman, and K. May."Social benefits of Aboriginal engagement in natural resource management. Working Paper No. 60." *Centre for Aboriginal Economic Policy Research*, ANU 2009. https://openresearch-repository.anu.edu.au/server/api/core/bitstreams/455bc938-2caf-47c8-bac6-9549e23279be/content

Huxham, M., D. Whitlock, M. Githaiga, and A. Dencer-Brown. "Carbon in the Coastal Seascape: How Interactions Between Mangrove Forests, Seagrass Meadows and Tidal Marshes Influence Carbon Storage." *Current Forestry Reports* 4, No. 2 (June 2018): 101–10. https://doi.org/10.1007/s40725-018-0077-4.

ICMA (International Capital Market Association). "The Asian International Bond Markets: Development and Trends." March 2021. https://www.icmagroup.org/assets/documents/About-ICMA/APAC/The-Asian-International-Bond-Markets-Development-and-Trends-March-2021-03032021.pdf

ICMA (International Capital Market Association). "Bonds to finance the sustainable blue economy: a practitioner's guide." 2023. https://www.icmagroup.org/assets/documents/Sustainable-finance/Bonds-to-Finance-the-Sustainable-Blue-Economy-a-Practitioners-Guide-September-2023.pdf

ICMA (International Capital Market Association). "New Guidance on Blue-Themed Bonds to Help Unlock finance for a Sustainable Ocean Economy." September 6, 2023. https://www.icmagroup.org/News/news-in-brief/new-guidance-on-blue-themed-bonds-to-help-unlock-finance-for-a-sustainable-ocean-economy

IDH. "Honey farms in West Kalimantan enjoy increased demand during COVID-19." 2020. https://www.idhsustainabletrade.com/news/honey-farms-in-west-kalimantan-enjoy-increased-demand-during-covid-19/

IFC (International Finance Corporation). "IFC's Blue Loan to Sanasa Will Help Improve Access to Water and Sanitation in Brazil." International Finance Corporation, World Bank, July 25, 2023. https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=27681

Iftekhar, M. S. and T. Takama."Perceptions of biodiversity, environmental services and conservation of planted mangroves: A case study on Nijhum Dwip Island, Bangladesh." *Wetlands Ecology Management* Vol. 16, No. 2 (2008): 119–137. DOI: 10.1007/s11273-007-9060-8

IOCC. "Island-Ocean Connection Challenge." 2023. https://jointheiocc.org/

IPCC (Intergovernmental Panel on Climate Change). "Climate Change 2023: Synthesis Report. Summary for Policymakers." *Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 2023. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

ISSF (International Seafood Sustainability Foundation). "Status of the World Fisheries for Tuna." *International Seafood Sustainability Foundation*. 2023. https://www.iss-foundation.org/tuna-stocks-and-management/our-tuna-stock-tools/status-of-the-stocks/

IUCN (International Union for Conservation of Nature and Natural Resources). "Financial giant HSBC commits to further protecting World Heritage sites." April 13, 2014. https://www.iucn.org/content/financial-giant-hsbc-commits-further-protecting-world-heritage-sites

IUCN (International Union for Conservation of Nature and Natural Resources). "Guidance for national blue carbon activities: Fast-tracking national implementation in developing countries." 2015. https://www.iucn.org/sites/default/files/import/downloads/national_recommendations_final.pdf.

IUCN (International Union for Conservation of Nature and Natural Resources). "Nature-based Solutions." 2023. https://www.iucn.org/our-work/nature-based-solutions

Jackson, Edward. "Widening the lens, looking further ahead: Options for Australian support for gender lens investing post-investing in women." E. T. Jackson and Associates, LTD. 2021. https://www.researchgate.net/publication/358794614_Widening_the_Lens_Looking_Further_Ahead_Options_for_Australian_Support_for_Gender_Lens_Investing_Post-Investing_in_Women

Johannessen, Sophia C. "How can blue carbon burial in seagrass meadows increase long-term, net sequestration of carbon? A critical review." *Environmental Research Letters* Vol. 17, No. 9 (2022). https://doi.org/10.1088/1748-9326/ac8ab4

Jones, Benjamin L. H., Richard K. F. Unsworth, Lina M. Nordlund, Johan S. Eklöf, Rohani Ambo-Rappe, Filipo Carly, Narriman S. Jiddawi, Yayu A. La Nafie, Susantha Udagedara, Leanne C. Cullen-Unsworth. "Dependence on seagrass fisheries governed by household income and adaptive capacity." *Ocean & Coastal Management*, Vol. 225 (2022). https://doi.org/10.1016/j.ocecoaman.2022.106247

Kaczan, D., F. Nurhabni, William Cheung, Thomas Frölicher, A. Kuswardani, Vicky Lam, U. Muawanah, et al. "Hot Water Rising: The Impact of Climate Change on Indonesia's Fisheries and Coastal Communities." Washington DC World Bank, 2023. https://doi.org/10.1596/40564.

Kaha, Oleh Kornelis "Menyeruput kopi mangrove olahan mama-mama Desa Daiama." *Antara News, Indonesia* 2023. https://www.antaranews.com/berita/3600735/menyeruput-kopi-mangrove-olahan-mama-mama-desa-daiama

Karner Blue Capital. "About Blue Capital." 2021. https://www.karnerbluecapital.com/aboutkbc

Kennedy, Hilary, Jeff Beggins, Carlos M. Duarte, James W. Fourqurean, Marianne Holmer, Núria Marbà, and Jack J. Middelburg. "Seagrass sediments as a global carbon sink: Isotopic constraints." *Global Biogeochemical Cycles* 24 (2010). https://doi.org/10.1029/2010GB003848

Kenton, Will. "Carbon Credits and How They Work." *Investopedia*, June 13, 2024. https://www.investopedia.com/terms/c/carbon_credit.asp

Krauss, Ken W., Gregory B. Noe, Jamie A. Duberstein, William H. Conner, Camille L. Stagg, Nicole Cormier, Miriam C. Jones, et al. "The Role of the Upper Tidal Estuary in Wetland Blue Carbon Storage and Flux." *Global Biogeochemical Cycles* 32, No. 5 (2018): 817–39. https://doi.org/10.1029/2018GB005897

Krause-Jensen, Dorte and Carlos M. Duarte. "Substantial role of macroalgae in marine carbon sequestration." *Nature Geoscience* 9 (2016): 737–742. https://doi.org/10.1038/ngeo2790

Kurniawan, F., M. N. Arkham, A. Rustam, Y. P. Rahayu, N. S. Adi, L. Adrianto, and A. Damar. "An ecosystem services perspective for the economic value of seafood production supported by seagrass ecosystems: An exercise in Derawan Island, Indonesia." *IOP Conference Series: Earth and E nvironmental Science* Vol. 414 (2008). https://doi.org/10.1088/1755-1315/414/1/012008

Kusumaningtyas, Mariska Astrid, Andreas A. Hutahaean, Helmut W. Fischer, Manuel Pérez-Mayo, Daniela Ransby, and Tim C. Jennerjahn. "Variability in the Organic Carbon Stocks, Sources, and Accumulation Rates of Indonesian Mangrove Ecosystems." *Estuarine, Coastal and Shelf Science* 218 (March 5, 2019): 310–23. https://doi.org/10.1016/j.ecss.2018.12.007

Kuwae, Tomohiro, Atsushi Watanabe, Satoru Yoshihara, Fujiyo Suehiro, and Yoshihisa Sugimura. "Implementation of blue carbon offset crediting for seagrass meadows, macroalgal beds, and macroalgae farming in Japan." *Marine Policy* 138 (2022). https://doi.org/10.1016/j.marpol.2022.104996

L, Jennifer. "What are blue carbon credits? Everything you need to know." Carbon Credits.com. 2023. https://carboncredits.com/what-are-blue-carbon-credits-everything-you-need-to-know/

LMMA International. "The LMMA Network 100 Percent Solution." 2023. https://lmmanetwork.org/

Lagniton, Liz. "Filipinos' Consumption of Seafood Falling in Worrying Trend." *Maritime Fairtrade*, November 21, 2022. https://maritimefairtrade.org/filipinos-consumption-seafood-falling-worrying-trend/

Lam, Vicki W. Y., Edward H. Allison Johann D. Bell, Jessica Blythe, William W. L. Cheung, Thomas L. Frölicher, Maria A. Gasalla, and U. Rashid Sumaila "Climate change, tropical fisheries and prospects for sustainable development." *Nature Review Earth and Environment*, Vol. 1 (2020): 440–454. https://doi.org/10.1038/s43017-020-0071-9

Lambeth, L., B. Hanchard, H. Aslin, L. Fay-Sauni, P. Tuara, K. D. Rochers, and A. Vunisea. "An overview of the involvement of women in fisheries activities in Oceania." *World Fish*, 2002. https://hdl.handle.net/20.500.12348/2233

Lehm Ardaya, Z., K. Lara Delgado, H. Álvarez, A. Kovach, A. Reinaga, W. Acahuana, O. Loayza, X. Sandy, C. Miranda, V. García, J. Martínez and R. Cueva. 2021. "Toolbox for indigenous territorial management and natural resource management by communities." *Wildlife Conservation Society* (WCS), 2021. https://herramientasgti.org/#/home

Lehodey, Patrick, Inna Senina, Simon Nicol, and John Hampton. "Modelling the impact of climate change on South Pacific Albacore Tuna", Deep Sea Research Part II: Topical Studies in *Oceanography*, Vol. 113 (2015): 246–259, ISSN 0967–0645, https://doi.org/10.1016/j.dsr2.2014.10.028

Livelihoods Funds. "Indonesia: Mangroves Revitalizing Coastal Villages With Fishery & New Businesses." n.d. https://livelihoods.eu/portfolio/yagasu-indonesia/

Livelihoods Funds. Interview With Bambang Suprayogi, "Indonesia: 'Livelihoods relies on a resilient model that can be replicated at global level." February 13, 2020. https://livelihoods.eu/interview-with-bambang-suprayogi-yagasu/

Livelihoods Funds. "Indonesia: Mangroves Spurring New Businesses." February 16, 2016. https://livelihoods.eu/indonesia-mangroves-spurring-new-businesses/

Lord, James. "Solactive unveils world's first blue bond index." *ETF Strategy*, July 27, 2023. https://www.etfstrategy.com/solactive-unveils-worlds-first-blue-bond-index-10339/

Love, Mark, C. Beal, S. Pene, Rt. T. Rarokolutu, A. Whippy, S. Taivoce, S. Shrestha, and R. T. Souter. "Social networks and other forgotten components of the WaSH enabling environment in Fiji." *Water Policy* 25(1) (2023): 38–58. https://doi.org/10.2166/wp.2022.202

Lovelock, Catherine E., Edward Barbier, and Carlos M. Duarte. "Tackling the mangrove restoration challenge." *PLOS Biology* 20 (2022). https://doi.org/10.1371/journal.pbio.3001836

Lovelock, Catherine E. and Benjamin M. Brown. "Land tenure considerations are key to successful mangrove restoration." *National Ecology and Evolution* 3, (2019): 1135–1135. https://doi.org/10.1038/s41559-019-0942-y

Lovelock, Catherine E., Donald R. Cahoon, Daniel A. Friess, Glenn R. Guntenspergen, Ken W. Krauss, Ruth Reef, Kerrylee Rogers, et al. "The Vulnerability of Indo-Pacific Mangrove Forests to Sea-Level Rise." *Nature* 526, No. 7574 (October 2015): 559–63. https://doi.org/10.1038/nature15538.

Lugo, Ariel E., Ernesto Medina, and Kathleen McGinley. "Issues and Challenges of Mangrove conservation in the Anthropocene." *Madera y Bosques* 20, (2014): 11–38. https://doi.org/10.21829/myb.2014.200146

Lutz Stephen J., and Angela H. Martin. "Fish Carbon: Exploring Marine Vertebrate Carbon Services." *GRID-Arendal and Blue Climate Solutions*, Arendal, Norway, 2014. https://bluecsolutions.org/dev/wp-content/uploads/2015/07/Fish-Carbon-2014.pdf

MacKenzie, Richard A., Patra B. Foulk, J. Val Klump, Kimberly Weckerly, Joko Purbospito, Daniel Murdiyarso, Daniel C. Donato, and Vien Ngoc Nam. "Sedimentation and Belowground Carbon Accumulation Rates in Mangrove Forests That Differ in Diversity and Land Use: A Tale of Two Mangroves." *Wetlands Ecology and Management* 24 (2) (2016): 245–61. https://doi.org/10.1007/s11273-016-9481-3.

Macreadie, Peter I., Alistar I. Robertson, Bernadette Spinks, Matthew P. Adams, Jennifer M. Atchison, Justine Bell-James, Brett A. Bryan, Long Chu, Karen Filbee-Dexter, Lauren Drake, Carlos M. Duarte, Daniel A. Friess, Felipe Gonzalez, R. Quentin Grafton, Kate J. Helmstedt, Melanie Kaebernick, Jeffrey Kelleway, Gary A. Kendrick, Hilary Kennedy, Catherine E. Lovelock, J. Patrick Megonigal, Damien T. Maher, Emily Pidgeon, Abbie A. Rogers, Rob Sturgiss, Stacey M. Trevathan-Tackett Melissa Wartman, Kerrie A. Wilson, and Kerrylee Rogers. "Operationalizing marketable blue carbon." *One Earth* Vol. 5 No. 5 (2022): 485–492. https://doi.org/10.1016/j.oneear.2022.04.005

Macreadie, Peter I., Andrea Anton, John A. Raven, Nicola Beaumont, Rod M. Connolly, Daniel A. Friess, Jeffrey J. Kelleway, Hilary Kennedy, Tomohiro Kuwae, Paul S. Lavery, Catherine E. Lovelock, Dan A. Smale, Eugenia T. Apostolaki, Trisha B. Atwood, Jeff Baldock, Thomas S. Bianchi, Gail L. Chmura, Bradley D. Eyre, James W. Fourqurean, Jason M. Hall-Spencer, Mark Huxham, Iris E. Hendriks, Dorte Krause-Jensen, Dan Laffoley, Tiziana Luisetti, Núria Marbà, Pere Masque, Karen J. McGlathery, J. Patrick Megonigal, Daniel Murdiyarso, Bayden D. Russell, Rui Santos, Oscar Serrano, Brian R. Silliman, Kenta Watanabe, and Carlos M. Duarte. "The future of Blue Carbon science." *Nature Communications* Vol. 10, Article 3998 (2019). https://doi.org/10.1038/s41467-019-11693-w

Macreadie, Peter I., Micheli D. P. Costa, Trisha B. Atwood, Daniel A. Friess, Jeffrey J. Kelleway, Hilary Kennedy, Catherine E. Lovelock, Oscar Serrano, and Carlos M. Duarte. "Blue carbon as a natural climate solution. *Nature Reviews Earth Environment* 2, (2021): 826–839. https://doi.org/10.1038/s43017-021-00224-1

Maefiti, John. "Time to Lift the Veil on Human Rights Abuses in Global Fisheries." *Global Fishing Watch*. December 9, 2021. https://globalfishingwatch.org/forced-labor/human-rights-abuses/

Mālama Learning Center. "Aloha Āina P acket: Ahu a wa Is Super Pa'a!" *Wai a nae Wellness and Place-Based Learning Alliance*, 2020. https://www.malamalearningcenter.org/uploads/9/3/5/0/93506112/aloha_aina_packet_week_7.pdf

Mangubhai, Sangeeta and Sarah Lawless. "Exploring gender inclusion in small-scale fisheries management and development in Melanesia. *Marine Policy* Vol 123 (2021). https://doi.org/10.1016/j.marpol.2020.104287

Maniwavie, Mazzella and Ruth Konia. "Meet PNG's Female Mangrove Scientist. Women's resilience to climate change and disaster risks." *Women in Fisheries Information Bulletin* No.32 (2020). https://purl.org/spc/digilib/doc/gbr3y

Mapping Ocean Wealth. *The Nature Conservancy*, 2023 https://oceanwealth.org/

Mariani, Gäel., William W. L. Cheung, Arnaud Lyet, Enric Sala, Juan Mayorga, Laure Velez, Stephen. Gaines, Tony Dejean, Marc Troussellier, and David Mouillot. "Let more big fish sink: Fisheries prevent blue carbon sequestration—half in unprofitable areas." *Science Advances* 6 (2020), https://doi.org/10.1126/sciadv.abb4848

Marineregions.org. "Marine georeference database." https://www.marineregions.org/

"The Marine Protection Atlas." *Marine Conservation Institute*, 2024. https://mpatlas.org/

Martin, Chase. "In remote Pacific, popular fishing method spells trouble for tuna." *Conservation International*, October 12, 2016. https://www.conservation.org/blog/in-remote-pacific-popular-fishing-method-spells-trouble-for-tuna

Mavisakalyan, Astghik and Yashar Tarverdi. "Gender and climate change: Do female parliamentarians make difference?" *European Journal of Political Economy* 56 (2019): 151–164. https://doi.org/10.1016/j.ejpoleco.2018.08.001

Mazarrasa, Inés, Paul Lavery, Carlos M. Duarte, Anna Lafratta, Catherine E. Lovelock, Peter I. Macreadie, Jimena Samper-Villarreal, Cristian Salinas, Christian J. Sanders, Stacey Trevathan-Tackett, Mary Young, Andy Steven, Oscar Serrano. "Factors Determining Seagrass Blue Carbon Across Bioregions and Geomorphologies." *Global Biogeochemical Cycles* 35, No. 6 (2021): e2021GB006935. https://doi.org/10.1029/2021GB006935

McKenzie, Len J., Lina M. Nordlund, Benjamin L. Jones, Leanne C. Cullen-Unsworth, Chris Roelfsema, and Richard K. F. Unsworth. "The global distribution of seagrass meadows." *Environmental Research Letters*, Vol. 15 No. 7 (2020). https://doi.org/10.1088/1748-9326/ab7d06

McKenzie, Len J., Rudi L. Yoshida, John W. Aini, Serge Andréfouet, Patrick L. Colin, Leanne C. Cullen-Unsworth, Alec T. Hughes, Claude E. Payri, Manibua Rota, Christina Shaw, Posa A. Skelton, Roy T. Tsuda, Veikila C. Vuki, and Richard K. F. Unsworth. "Seagrass ecosystems of the Pacific Island Countries and Territories: A global bright spot." *Marine Pollution Bulletin*, Vol. 167 (2021a). https://doi.org/10.1016/j.marpolbul.2021.112308

McKenzie, Len J., Rudi L. Yoshida, John W. Aini, Serge Andréfouet, Patrick L. Colin, Leanne C. Cullen-Unsworth, Alec T. Hughes, Claude E. Payri, Manibua Rota, Christina Shaw, Roy T. Tsuda, Veikila C. Vuki, and Richard K. F. Unsworth, 2021b. "Seagrass ecosystem contributions to people's quality of life in the Pacific Island Countries and Territories." *Marine Pollution Bulletin*, Vol. 167 (2021b) . https://doi.org/10.1016/j.marpolbul.2021.112307

McLeod, Elizabeth, Gail L. Chmura, Steven Bouillon, Rodney Salm, Mats Bjork, Carlos M. Duarte, Catherine E. Lovelock, William H. Schlesinger, Brian R. Silliman. "A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2." *Frontiers in Ecology and the Environment* (2011). https://doi.org/10.1890/110004

McMillen, Heather L., Tamara Ticktin., and Hannah Kihalani Springer. "The future is behind us: traditional ecological knowledge and resilience over time on Hawai'i Island." *Regional Environmental Change*, Vol. 17 (2017): 579–592. https://doi.org/10.1007/s10113-016-1032-1

McMillen, Heather L., Tamara Ticktin, Alan Friedlander, Stacy D. Jupiter, Randolph Thaman, John Campbell, Joeli Veitayaki, Thomas Giambelluca, Salesa Nihmei, Etika Rupeni, Lucille Apis-Overhoff, William Aalbersberg, and Dan F. Orcherton. "Small islands, valuable insights: systems of customary resource use and resilience to climate change in the Pacific." *Ecology and Society*, Vol. 19 No. 4 (2014). http://www.jstor.org/stable/26269694

McNamara, Karen E., Ross Westoby, and Alvin Chandra. "Exploring climate-driven non-economic loss and damage in the Pacific Islands." *Current Opinion in Environmental Sustainability*, Vol. 50 (2021): 1–11. https://doi.org/10.1016/j.cosust.2020.07.004

McNamara, Karen E. and Sherleen Shermilla Prasad. "Coping with extreme weather: communities in Fiji and Vanuatu share their experiences and knowledge." *Climatic Change*, Vol. 123, (2014): 121–132. https://doi.org/10.1007/s10584-013-1047-2

Menéndez, Pelayo, Iñigo J. Losada, Saul Torres-Ortega,. et al. "The Global Flood Protection Benefits of Mangroves." *Scientific Reports*, Vol. 10, Article 4404 (2020) https://doi.org/10.1038/s41598-020-61136-6

Mishra, Amrit Kumar, Prasannajit Acharya, Deepak Apte, and Syed Hilal Farooq. "Seagrass Ecosystem Adjacent to Mangroves Store Higher Amount of Organic Carbon of Andaman and Nicobar Islands, Andaman Sea." *Marine Pollution Bulletin* 193 (August 1, 2023): 115135. https://doi.org/10.1016/j.marpolbul.2023.115135

Miteva, Daniela A., Brian C. Murray, and Subhrendu K. Pattanayak. "Do Protected Areas Reduce Blue Carbon Emissions? A Quasi-Experimental Evaluation of Mangroves in Indonesia." *Ecological Economics* 119 (November 1, 2015): 127–35. https://doi.org/10.1016/j.ecolecon.2015.08.005

Miththapala, S., 2013. Tidal flats (No. Vol 5), Coastal Ecosystems Series. IUCN, Colombo, Sri Lanka.

Miyajima, Toshihiro, Masami Hamaguchi, and Masakazu Hori. "Evaluation of the Baseline Carbon Sequestration Rates of Indo-Pacific Temperate and Tropical Seagrass Meadow Sediments." *Ecological Research* 37, no. 1 (2022): 9–20. https://doi.org/10.1111/1440-1703.12263

Monetary Authority of Singapore. "Taxonomy." 2024. https://www.mas.gov.sg/development/sustainable-finance/taxonomy

Mooney, H. A. "Worth more dead than alive." Nature, Vol. 403, Issue 6770 (2000), Nature Publishing Group.

Moraes, Oliver. "Blue carbon in area-based coastal and marine management schemes—a review." *Journal of the Indian Ocean Region* Vol. 15 Issue 2, (2019): 193–212, DOI: 10.1080/19480881.2019.1608672

Morais, Renato A., Alexandre C. Siqueira, Patrick F. Smallhorn-West, and David R. Bellwood. "Spatial subsidies drive sweet spots of tropical marine biomass production." *PLOS Biology* 19 (2021). https://doi.org/10.1371/journal.pbio.3001435

Murphy, Adrian, Kate Robu, and Matthew Steinert. "The investigator-centered approach to financial crime: Doing what matters." *McKinsey & Company*, 2020. https://www.mckinsey.com/capabilities/risk-and-resilience/our-insights/the-investigator-centered-approach-to-financial-crime-doing-what-matters

Murray, Nicholas J., Thomas A. Worthington, Pete Bunting, Stephanie Duce, Valerie Hagger, Catherine E. Lovelock, Richard Lucas, Megan I. Saunders, Marcus Sheaves, Mark Spalding, Nathan J. Waltham, and Mitchell B. Lyons, 2022. "High-resolution mapping of losses and gains of Earth's tidal wetlands." *Science* 376 (2022): 744–749. https://doi.org/10.1126/science.abm9583

Murua, Jefferson, Gala Moreno, Laurent Dagorn, David Itano, Martin Hall, Hilario Murua, and Victor Restrepo. "Improving Sustainable Practices in Tuna Purse Seine Fish Aggregating Device (FAD) Fisheries Worldwide through Continued Collaboration with Fishers." *Frontiers in Marine Science* 10 (2023). https://www.frontiersin.org/articles/10.3389/fmars.2023.1074340

Naik, Gautam. "Companies, investors face new pressure from compulsory disclosure of climate risk." *S & P Global* (2021). https://www.spglobal.com/esg/insights/companies-investors-face-new-pressure-from-compulsory-disclosure-of-climate-risk#:~:text=Another%20early%20mover%2C%20the%20U.K.%2C%20has%20declared%20that,TCFD%20reporting%20into%20law%20and%20make%20it%20%22binding.%22

Nemes, Noémi, et al. "An integrated framework to assess greenwashing." *University of Aberdeen*, 2022. https://abdn.elsevierpure.com/en/publications/an-integrated-framework-to-assess-greenwashing

Network for Greening the Financial System. "Nature-related financial risks: a conceptual framework to guide action by central banks and supervisors." *Network of Central Banks and Supervisors for Greening the Financial System*, 2023. https://www.ngfs.net/sites/default/files/medias/documents/ngfs_conceptual-framework-on-nature-related-risks.pdf

NOAA (National Oceanic and Atmospheric Association). "Coastal Blue Carbon." *National Oceanic and Atmospheric Association*, 2023, Accessed 23 Jan 2024. https://oceanservice.noaa.gov/ecosystems/coastal-blue-carbon/#:~:text=Current%20studies%20suggest%20that%20mangroves,equivalent%20area%20than%20tropical%20forests

Nowakowski, A. Justin, Steven W. J. Canty, Nathan J. Bennett, Courtney E. Cox, Abel Valdivia, Jessica L. Deichmann, Thomas S. Akre, Sara E. Bonilla-Anariba, Sebastien Costedoat, and Melanie McField. "Co-benefits of Marine Protected Areas for Nature and People." *Nature Sustainability* 6, (2023): 1210–18. https://doi.org/10.1038/s41893-023-01150-4

OECD (Organization for Economic Cooperation and Development). "Tourism Trends and Policies 2020: Indonesia." *OECD* iLibrary. Accessed March XX 2024. https://doi.org/10.1787/20767773

Oostdijk, Maartje, Laura G. Elsler, Paulina Ramirez-Monsalve, Kirill Orach, and Mary S. Wisz. "Governing Open Ocean and Fish Carbon: Perspectives and Opportunities." *Frontiers in Marine Science* 9, No. 1 (May 18, 2022). https://doi.org/10.3389/fmars.2022.764609

Orchard, Steven E., Lindsay C. Stringer, and Clair H. Quinn. "Impacts of Aquaculture on Social Networks in the Mangrove Systems of Northern Vietnam." *Ocean & Coastal Management* 114, (September 2015): 1–10. https://doi.org/10.1016/j.ocecoaman.2015.05.019

Orth, Robert J., Jonathan S. Lefcheck,, Karen S. McGlathery, Lillian Aoki, Luckenbach, Mark W., Moore, Kenneth A., Oreska, Matthew P.J., Snyder, Richard, David J. Wilcox, and Bo Lusk. "Restoration of Seagrass Habitat Leads to Rapid Recovery of Coastal Ecosystem Services." *Science Advances* 6, No. 41 (October 7, 2020). https://doi.org/10.1126/sciadv.abc6434

Österblom, Henrik, Örjan Bodin, Anthony J. Press, and U. Rashid Sumaila. "The High Seas and IUU Fishing", in: *Routledge Handbook of Ocean Resources and Management*, Routledge: 2015. https://www.taylorfrancis.com/chapters/edit/10.4324/9780203115398-16/high-seas-iuu-fishing-henrik-%C3%B6sterblom-%C3%B6rjan-bodin-anthony-press-rashid-sumaila

Parker, Robert W. R., Julia L. Blanchard, Caleb Gardner, Bridget S. Green, Klaas Hartmann, Peter H. Tyedmers, and Reg A. Watson. "Fuel Use and Greenhouse Gas Emissions of World Fisheries." *Nature Climate Change* 8, No. 4 (April 2018): 333–37. https://doi.org/10.1038/s41558-018-0117-x.

Partelow, Stefan, Ben Nagel, Adiska Octa Paramita, and Nurliah Buhari. "Seafood Consumption Changes and COVID-19 Impact Index in West Nusa Tenggara, Indonesia." *PLoS ONE* 18, No. 1 (January 18, 2023). https://doi.org/10.1371/journal.pone.0280134

Pascua, Pua'ala, Heather McMillen, Tamara Ticktin, Mehana Vaughan, and Kawika B. Winter. "Beyond Services: A Process and Framework to Incorporate Cultural, Genealogical, Place-based, and Indigenous Relationships in Ecosystem Service Assessments." *Ecosystem Services* 26, Part B (2017): 465–475. https://doi.org/10.1016/j.ecoser.2017.03.012

Paul, Tripti, Sandeep Mondal, Nazrul Islam, and Sandip Rakshit. "The impact of blockchain technology on the tea supply chain and its sustainable performance." *Technical Forecasting and Social Change*, Vol. 173, December 2021, Elsevier. https://doi.org/10.1016/j.techfore.2021.121163

PCAF (Partnership for Carbon Accounting Financials). "Regional implantation team: PCAF APAC." *Partnership for Carbon Accounting Financials,* 2024. https://carbonaccountingfinancials.com/en/team/pcaf-asia-pacific

Peatman, Tom, Matthew T. Vincent,, Joe Scutt Phillips, and Simon Nicol. "Times Are Changing, but Has Natural Mortality? Estimation of Mortality Rates for Tropical Tunas in the Western and Central Pacific Ocean." *Fisheries Research* 256 (December 1, 2022): 106463. https://doi.org/10.1016/j.fishres.2022.106463

Pendleton, Linwood, Daniel C. Donato, Brian C. Murray, Stephan Crooks, W. Aaron Jenkins, Samantha Sifleet, Christopher Craft, James W. Fourqurean, J. Boone Kauffman, Nuria Marba, Patrick Megonigal, Emily Pidgeon, Dorothee Herr, David Gordon, and Alexis Baldera. "Estimating Global "Blue Carbon" Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems." *PLoS ONE* 7, (September 4, 2012). https://doi.org/10.1371/journal.pone.0043542

Petrini, et al. "Case Study Report: Tuvalu Trust Fund. A UNDP working paper." *UNDP and Tuvalu Trust Fund*, 2013. https://www.undp.org/asia-pacific/publications/national-climate-fund-case-study-report-tuvalu-trust-fund

Pew Charitable Trust. "Netting Billions 2020: A Global Tuna Valuation." *Pew Charitable Trusts*, October 6, 2020. https://www.pewtrusts.org/en/research-and-analysis/reports/2020/10/netting-billions-2020-a-global-tuna-valuation

Philippine Statistics Authority. "Tourism Contributes 6.2 Percent to GDP in 2022." *Republic of the Philippines Philippine Statistics Authority*, 2023. https://psa.gov.ph/content/tourism-contributes-62-percent-gdp-2022

Piggott-McKellar, Annah E., Patrick D. Nunn, Karen E. McNamara, and Seci T. Sekinini. "Dam(n) Seawalls: A Case of Climate Change Maladaptation in Fiji." In *Managing Climate Change Adaptation in the Pacific Region. Climate Change Management*, edited by W. Leal Filho, 69-84. Springer, Cham. March 4, 2020. https://doi.org/10.1007/978-3-030-40552-6_4

Pons, Maite, Trevor A. Branch,, Michael C. Melnychuk, Olaf P. Jensen, Jon Brodziak, Jean M. Fromentin, Shelton J. Harley, Alan C. Haynie, Laurie T. Kell, Mark N. Maunder, Ana M. Parma, Victor R. Restrepo, Rishi Sharma, Robert Ahrens, and Ray Hilborn. "Effects of Biological, Economic and Management Factors on Tuna and Billfish Stock Status." *Fish and Fisheries* 18, No. 1 (2017): 1–21. https://doi.org/10.1111/faf.12163

Pricillia, C. C., Mufti Patria, and Herdis Herdiansyah. "Social Consideration for Blue Carbon Management." *IOP Conference Series Earth and Environmental Science* 755, No. 1 (April 2021). http://dx.doi.org/10.1088/1755-1315/755/1/012025

Puspasari, Reny, Pupit Fitri Rachmawati, and Umi Muawanah. "Climate Variability Impact on Bali Sardine Fishery: Ecology and Fisheries Perspective." *Fisheries Management and Ecology* 26, No. 6 (December 2019): 540–47. https://doi.org/10.1111/fme.12374

Quiros, T. E. Angela L., Kenji Sudo, Reynante V. Ramilo, Helbert G. Garay, Muammar Princess G. Soniega, Alvin Baloloy, Ariel Blanco, Ayin Tamondong, Kazuo Nadaoka, and Masahiro Nakaoka. "Blue Carbon Ecosystem Services Through a Vulnerability Lens: Opportunities to Reduce Social Vulnerability in Fishing Communities." *Frontiers in Marine Science* 8 (August 3, 2021). https://doi.org/10.3389/fmars.2021.671753

R Project. "The R Project for Statistical Computing." *R Foundation for Statistical Computing*, Vienna, Austria, 2023. https://www.R-project.org/

Rakotonarivo, O. Sarobidy, Mirindra Rakotoarisoa, H. Manoa Rajaonarivelo, Stefana Raharijaona, Julia P. G. Jones, and Neal Hockley. "Resolving Land Tenure Security is Essential to Deliver Forest Restoration. *Communications Earth & Environment* 4, No. 179 (2023). https://doi.org/10.1038/s43247-023-00847-w

Rare, Indonesia. "Rare in Indonesia." *Rare*, 2023. https://rare.org/program/fish-forever-in-indonesia/

Rare, Philippines. "Fish Forever in the Philippines." *Rare*, 2023. https://rare.org/program/philippines/

Rezek, Ryan J., Bradley T. Furman, Robin P. Jung, Margaret O. Hall, and Susan S. Bell. "Long-Term Performance of Seagrass Restoration Projects in Florida, USA." *Scientific Reports* 9, No. 1 (October 29, 2019): 15514. https://doi.org/10.1038/s41598-019-51856-9.

Rice, Joel and Shelton Harley. "Updated Stock Assessment of Silky Sharks in the Western and Central Pacific Ocean." *Western and Central Pacific Fisheries Commission*, August 6–14, 2013. https://www.wcpfc.int/system/files/Rice%20FAL%20Assessment%202013.pdf

Richards, Daniel R., Benjamin S. Thompson, and Lahiru Wijedasa. "Quantifying Net Loss of Global Mangrove Carbon Stocks from 20 Years of Land Cover Change." *Nature Communications* 11, No. 4260 (2020). https://doi.org/10.1038/s41467-020-18118-z

Rimmer, Michael A., Silva Larson, Imran Lapong, Agus Heri Purnomo, Petrus Rani Pong-Masak, Libby Swanepoel, and Nicholas A. Paul. "Seaweed Aquaculture in Indonesia Contributes to Social and Economic Aspects of Livelihoods and Community Wellbeing." *Sustainability*, Vol. 13 No. 19 (January 2021). https://doi.org/10.3390/su131910946

Roberts, Callum M., Bethan C. O'Leary, Douglas J. McCauley, Philippe Maurice Cury, Carlos M. Duarte, Jane Lubchenco, Daniel Pauly, Andrea Sáenz-Arroyo, Ussif Rashid Sumaila, Rod W. Wilson, Boris Worm, and Juan Carlos Castilla. "Marine Reserves Can Mitigate and Promote Adaptation to Climate Change." *Proceedings of the National Academy of Sciences* 114, No. 24 (2017): 6167–6175. https://doi.org/10.1073/pnas.1701262114

Romañach, Stephanie S., Donald L. DeAngelis, Hock Lye Koh, Yuhong Li, Su Yean Teh, Raja Sulaiman Raja Barizan, and Lu Zhai. "Conservation and Restoration of Mangroves: Global Status, Perspectives, and Prognosis." *Ocean & Coastal Management* 154, (2018): 72–82. https://doi.org/10.1016/j.ocecoaman.2018.01.009

Roscher, M. B., H. Eriksson, M. Sharp, O. Menaouer, and N. Andrew. "Decadal Characteristics of Small-Scale Fishing Livelihoods in 13 Pacific Island Countries and Territories." *ICES Journal of Marine Science*, Vol. 80, Issue 7 (September 2023): 1963–1975. https://doi.org/10.1093/icesjms/fsad125

Ross, Helen, Dedi S. Adhuri, Ali Yansyah Abdurrahim and Anna Phelan. "Opportunities in Community-Government Cooperation to Maintain Marine Ecosystem Services in the Asia-Pacific and Oceania." *Ecosystem Services* 38 (2019). https://doi.org/10.1016/j.ecoser.2019.100969

Ruckelshaus, Mary, Borja G. Reguero, Katie Arkema, Roberto Guerrero Compeán, Khafi Weekes, Allison Bailey and Jessica Silver. "Harnessing New Data Technologies for Nature-Based Solutions in Assessing and Managing Risk in Coastal Zones." *International Journal of Disaster Risk Reduction* 51 (2020). https://doi.org/10.1016/j.ijdrr.2020.101795

Ruddle, Kenneth, Edvard Hviding and Robert E. Johannes. "Marine Resources Management in the Context of Customary Tenure." *Marine Resource Economics* Vol. 7, No. 4 (1992). https://doi.org/10.1086/mre.7.4.42629038

Saba, Grace K., Adrian B. Burd, John P. Dunne, Santiago Hernández-León, Angela H. Martin, Kenneth A. Rose, Joseph Salisbury, et al. "Toward a Better Understanding of Fish-Based Contribution to Ocean Carbon Flux." *Limnology and Oceanography* 66, No. 5 (2021): 1639–1664. https://doi.org/10.1002/lno.11709

Saintilan, N., N. S. Khan, E. Ashe, J. J. Kelleway, K. Rogers, C. D. Woodroffe, and B. P. Horton. "Thresholds of Mangrove Survival under Rapid Sea Level Rise." *Science* 368, No. 6495 (June 5, 2020): 1118–21. https://doi.org/10.1126/science.aba2656

Sala, Enric, Juan Mayorga, Christopher Costello, David KroodsmaMaria L. D. Palomares, Daniel Pauly, U. Rashid Sumaila, and Dirk Zeller. "The Economics of Fishing the High Seas." *Science Advances,* Vol. 4, Issue 6, (June 6, 2018). https://doi.org/10.1126/sciadv.aat2504

Sasmito, Sigit D., Mohammad Basyuni, Age Kridalaksana, Meli F. Saragi-Sasmito, Catherine E. Lovelock, and Daniel Murdiyarso. "Challenges and Opportunities for Achieving Sustainable Development Goals through Restoration of Indonesia's Mangroves." *Nature Ecology & Evolution* 7, No. 1 (January 2023): 62–70. https://doi.org/10.1038/s41559-022-01926-5.

Scherf, Ann-Katherin and Jurgen Rullkötter. "Biogeochemistry of High Salinity Microbial Mats—Part 1: Lipid Composition of Microbial Mats Across Intertidal Flats of Abu Dhabi, United Arab Emirates." *Organic Geochemistry* 40, (September 2009): 1018–1028. https://doi.org/10.1016/j.orggeochem.2009.04.002

Schile, Lisa M., J. Boone Kauffman, Stephan Crooks, James W. Fourqurean, Jane Glavan, and J. Patrick Megonigal. "Limits on Carbon Sequestration in Arid Blue Carbon Ecosystems." *Ecological Applications* 27, (December 19, 2016): 859–874. https://doi.org/10.1002/eap.1489

Schmitz, Oswald J., Christopher C. Wilmers, Shawn J. Leroux, Christopher E. Doughty, , Trisha B. Atwood, Mauro Galetti, Andrew B. Davies, and Scott J. Goetz. "Animals and the Zoogeochemistry of the Carbon Cycle." *Science* 362, No. 6419 (December 7, 2018). https://doi.org/10.1126/science.aar3213.

Schmitz, Oswald J., Peter A. Raymond, James A. Estes, Werner A. Kurz, Gordon W. Holtgrieve, Mark E. Ritchie, Daniel E. Schindler, Amanda C. Spivak, Rod W. Wilson, Mark A. Bradford, Villy Christensen, Linda Deegan, Victor Smetacek, Michal J. Vanni, and Christopher C. Wilmers. "Animating the Carbon Cycle." *Ecosystems* 17, No. 2 (March 2014): 344–59. https://doi.org/10.1007/s10021-013-9715-7.

Schwerdtner Máñez, Kathleen, Gesche Krause, Irene Ring, and Marion Glaser. "The Gordian Knot of Mangrove Conservation: Disentangling the Role of Scale, Services and Benefits." *Global Environmental Change* 28 (September 1, 2014): 120–28. https://doi.org/10.1016/j.gloenvcha.2014.06.008

Science Based Targets. "The Science Based Target Network (SBTN)". 2024. https://sciencebasedtargets.org/about-us/sbtn

Selig, Elizabeth R., Shinnosuke Nakayama, Colette C. C. Wabnitz, Henrik Osterblom, Jessica Spijkers, Nathan A. Miller, Jan Bebbington and Jessical L. Decker Sparks. "Revealing global risks of labor abuse and illegal, unreported, and unregulated fishing." *Nature Communications* 13, 1612 (2022). https://doi.org/10.1038/s41467-022-28916-2

Senina, Inna, Patrick Lehodey, John Sibert, and John Hampton. "Integrating Tagging and Fisheries Data into a Spatial Population Dynamics Model to Improve Its Predictive Skills." *Canadian Journal of Fisheries and Aquatic Sciences* 77, No. 3 (March 2020): 576–93. https://doi.org/10.1139/cjfas-2018-0470

Serrano, Oscar, Diana Isabel Gómez-López, Laura Sánchez-Valencia, et al. "Seagrass blue carbon stocks and sequestration rates in the Colombian Caribbean." *Scientific Reports* 11, 11067 (2021). https://doi.org/10.1038/s41598-021-90544-5

Shackleton, Sheona, Bruce Morgan Campbell, Eva Wollenberg, and David Edmunds. "Devolution and Community-Based Natural Resource Management: Creating Space for Local People to Participate and Benefit?" *Natural Resource Perspectives* 76, (2012). https://www.researchgate.net/publication/42764409_Devolution_and_Community-Based_Natural_Resource_Management_Creating_Space_for_Local_People_to_Participate_and_Benefit

Sharma, Sahadev, Raghab Ray, Christopher Martius, and Daniel Murdiyarso. "Carbon Stocks and Fluxes in Asia-Pacific Mangroves: Current Knowledge and Gaps." *Environmental Research Letters* 18, No. 4 (March 2023). https://doi.org/10.1088/1748-9326/acbf6c.

Sharma, Sahadev, Rempei Suwa, Raghab Ray, Mohammad Rozaimi, Richard A. MacKenzie, and Masahiro Nakaoka. "Preface: Blue carbon Studies in Asia-Pacific Regions: Current Status, Gaps, and Future Perspectives," *Ecological Research* 37, No. 1 (2022). https://doi.org/10.1111/1440-1703.12290

Sharp, Nonie. *Saltwater People: The Waves of Memory*. University of Toronto Press: Toronto, Buffalo, 2002.

Sheaves, Marcus. "Consequences of Ecological Connectivity: The Coastal Ecosystem Mosaic," *Marine Ecology Progress Series* 391 (2009): 107–115. https://doi.org/10.3354/meps08121

Short, F., T. Carruthers, W. Dennison, and M. Waycott. "Global Seagrass Distribution and Diversity: A Bioregional Model," *Journal of Experimental Marine Biology and Ecology, The Biology and Ecology of Seagrasses* 350 (2007): 3–20. https://doi.org/10.1016/j.jembe.2007.06.012

Smith, Anita and Kevin L. Jones. "Cultural Landscapes of the Pacific Islands," *ICOMOS Thematic Study*, (2007). https://openarchive.icomos.org/id/eprint/2654/1/cultural-landscapes-pacific.pdf

Smithsonian. "What are Fossil Fuels?" *Smithsonian National Museum of Natural History*, Accessed 23 Jan 2024. https://ocean.si.edu/conservation/gulf-oil-spill/what-are-fossil-fuels#:~:text=III.-,FOSSIL%20FUELS%20FORM,wells%20on%20land%20and%20offshore

Sokimi William, Michael Blanc, Boris Colas, Ian Bertram and Joelle Albert. "Manual on anchored fish aggregating devices (FADs): an update on FAD gear technology, designs and deployment methods for the Pacific Island region." *Noumea, New Caledonia: Pacific Community*, 2020. https://purl.org/spc/digilib/doc/xrz3p

Sofar Ocean. 2024. https://www.sofarocean.com/sofar-approach

Song, Shanshan, Yali Ding, Wei Li, Yuchen Meng, Jian Zhou, Ruikun Gou, Conghe Zhang, Shengnin Ye, Neil Saintilan, Ken W. Krauss,, Stephen Crooks, Shuguo Lv, and Guanghui Lin. "Mangrove Reforestation Provides Greater Blue Carbon Benefit than Afforestation for Mitigating Global Climate Change." *Nature Communications* 14, No. 1 (2023): 756. https://doi.org/10.1038/s41467-023-36477-1

Song, Andrew M., Wolfram H. Dressler, Paula Satizábal, and Michael Fabinyi. "From Conversion to Conservation to Carbon: The Changing Policy Discourse on Mangrove Governance and Use in the Philippines," *Journal of Rural Studies* 82, (2021): 184–95. https://doi.org/10.1016/j.jrurstud.2021.01.008

SPC (Secretariat of the Pacific Community). "Fish aggregating devices (FADs)." *Secretariat of the Pacific Community Policy Brief*, 2012. https://www.spc.int/DigitalLibrary/Doc/FAME/Brochures/Anon_12_PolicyBrief19_FADs.html

Spendelow, Ryan. "Capital Markets." Corporate Finance Institute, 2024. https://corporatefinanceinstitute.com/resources/career-map/sell-side/capital-markets/capital-markets/

Statton, John, Kingsley W. Dixon, Andrew D. Irving, Emma L. Jackson, Gary A. Kendrick, Robert J. Orth, and Elizabeth A. Sinclair. "Decline and Restoration Ecology of Australian Seagrasses." In *Seagrasses of Australia: Structure, Ecology and Conservation*, edited by Anthony W. D. Larkum, Gary A. Kendrick, and Peter J. Ralph, 665–704 Springer International Publishing, Cham, July 28, 2018. https://doi.org/10.1007/978-3-319-71354-0_20

Steele, Paul, Gonzalo Oviedo, and David McCauley. "Poverty, Health, Governance and Ecosystems: Experiences from Asia." *International Union for Conservation of Nature and Natural Resources: Gland and Asian Development Bank*, Manila. 2006. https://portals.iucn.org/library/sites/library/files/documents/2007-036.pdf

Steenbergen, Dirk J., Cliff Marlessy and Elisabeth Holle. "Effects of Rapid Livelihood Transitions: Examining Local Co-Developed Change Following a Seaweed Farming Boom." *Marine Policy* 82 (August 1, 2017): 216–23. https://doi.org/10.1016/j.marpol.2017.03.026

Sudo, Kenji, T.E. Angela L. Quiros, Anchana Prathep, Cao Van Luong, Hsing-Juh Lin, Japar Sidik Bujang, Jillian Lean Sim Ooi, Miguel D. Fortes, Muta Harah Zakaria, Siti Maryam Yaakub, Yi Mei Tan, Xiaoping Huang, and Masahiro Nakaoka. "Distribution, Temporal Change, and Conservation Status of Tropical Seagrass Beds in Southeast Asia: 2000–2020," *Frontiers in Marine Science* 8 (2021). DOI: 10.3389/fmars.2021.637722

Sulit, Virgilia T., Isidro T. Tendencia, Arvee S. Ledesma, Maria Eva T. Aldon, and Stephen B. Alayon. "Report of the Regional Technical Consultation for the Development of Code of Practice for Responsible Aquaculture in Mangrove Ecosystems." *ASEAN and SEAFDEC Aquaculture Department*, Thailand, March, 2005. https://repository.seafdec.org.ph/bitstream/handle/10862/1716/RTC-Code-of-Practice-Mangrove.pdf?sequence=1

Sustainable Finance Indonesia. "Indonesia Green Taxonomy Edition 1.0—2022." January 20, 2022. https://www.ojk.go.id/keuanganberkelanjutan/en/publication/detailsflibrary/2352/taksonomi-hijau-indonesia-edisi-1-0-2022

Svensson, Patrik, Lynda D. Rodwell, and Martin J. Attrill. "Hotel managed marine reserves: A willingness to pay survey." *Ocean & Coastal Management*, Vol. 51 No. 12 (2008):. 854-861. https://doi.org/10.1016/j.ocecoaman.2008.08.001

Syddall, Victoria Margaret, Karen Fisher, and Simon Thrush. "What Does Gender Have to Do with the Price of Tuna? Social-ecological Systems View of Women, Gender, and Governance in Fiji's Tuna Fishery," *Maritime Studies* 21 (2022): 447–463. https://link.springer.com/content/pdf/10.1007/s40152-022-00281-2.pdf

Tan, Yi Mei, Oliver Dalby, Gary A. Kendrick, John Statton, Elizabeth A. Sinclair, Matthew W. Fraser, Peter I. Macreadie, Chris L. Gilles, Rhys A. Coleman, Michelle Waycott, et al. "Seagrass Restoration Is Possible: Insights and Lessons From Australia and New Zealand." *Frontiers in Marine Science* 7 (2020). https://www.frontiersin.org/articles/10.3389/fmars.2020.00617

The Nature Conservancy (TNC). "Ten Things You Should Know About the High Seas Treaty.: April 11, 2023. https://www.nature.org/en-us/what-we-do/our-insights/perspectives/ten-things-high-seas-treaty/

Tilley, Alexander, Shaun P. Wilkinson, Jeppe Kolding, Juliana López-Angarita, Mario Pereira, and David J. Mills. "Nearshore Fish Aggregating Devices Show Positive Outcomes for Sustainable Fisheries Development in Timor-Leste." *Frontiers in Marine Science* 6 (2019). https://www.frontiersin.org/articles/10.3389/fmars.2019.00487

Thaman, Randy. "Threats to Pacific Island Biodiversity and Biodiversity Conservation in the Pacific Islands," *Hawaii Biological Survey, Bishop Museum Technical Report* (2002). http://hbs.bishopmuseum.org/fiji/pdf/thaman2002.pdf

Tonneijck, Femke. "Building with Nature in Indonesia." *Wetlands International*, April 2018. https://www.genieecologique.fr/sites/default/files/documents/rex/building-with-nature-en-vf.pdf

Triana, Karlina & Wahyudi, A'an. "Sea Level Rise in Indonesia: The Drivers and the Combined Impacts from Land Subsidence." *ASEAN Journal on Science and Technology for Development* 37 (2020).

Triantafilidis, Beate."The 19%: the pioneering financial institutions leading the way on deforestation." *Global Canopy*, 2020. https://globalcanopy.org/insights/insight/the-19-the-pioneering-financial-institutions-leading-the-way-on-deforestation/

Turner, Jefferson T. "Zooplankton Fecal Pellets, Marine Snow, Phytodetritus and the Ocean's Biological Pump." *Progress in Oceanography* 130 (January 1, 2015): 205–48. https://doi.org/10.1016/j.pocean.2014.08.005.

UN-DESA (United Nations Department of Economic and Social Affairs). "Conserve and sustainably use the oceans, seas, and marine resources for sustainable development." *United Nations Department of Economic and Social Affairs*, 2024. https://sdgs.un.org/goals/goal14

UN-DESA (United Nations Department of Economic and Social Affairs). "The Locally Managed Marine Area Network." *United Nations Department of Economic and Social Affairs*, Last updated 2020. https://sdgs.un.org/partnerships/locally-managed-marine-area-network

UNDP (United Nations Development Programme). "HSBC Amanah Malaysia issues world's first SDG sukuk." *United Nations Development Programme*, October 3, 2018. https://www.undp.org/press-releases/hsbc-amanah-malaysia-issues-worlds-first-sdg-sukuk

UNEP (United Nations Environment Programme). "Promoting Effective Marine Protected Areas." *United Nations Environment Programme*, 2024. Accessed March XX 2024. https://www.unep.org/explore-topics/oceans-seas/what-we-do/promoting-effective-marine-protected-areas

UNEP (United Nations Environment Programme). "Protection of Seagrasses Key to Building Resilience to Climate Change, Disasters - New UN Report." *United Nations Environment Programme (Press release)*. June 8, 2020. https://www.unep.org/news-and-stories/press-release/protection-seagrasses-key-building-resilience-climate-change#:~:text=But%20an%20estimated%207%20per,the%20globe%20has%20been%20lost

UNEP (United Nations Environment Programme). "United Nations Environment Programme Contributions to Secretary-General's Background Note for the Preparatory Meeting of the 2020 United Nations Conference to Support the Implementation of Sustainable Development Goal 14." *United Nations Environment Programme*, October 31, 2019. https://www.un.org/sites/un2.un.org/files/2020/02/unep.pdf

UNEP-WCMC and F.T. Short. "Global Distribution of Seagrasses (version 7.1), Seventh Update to the Data Layer Used in Green and Short (2003)." *UN Environment World Conservation Monitoring Centre*, Cambridge. 2021. http://data.unep-wcmc.org/datasets/7

UNESCO Marine World Heritage. "Custodians of the Globe's Blue Carbon Assets." *United Nations Educational, Scientific, and Cultural Organization*, 2021. https://whc.unesco.org/en/blue-carbon-report/

UNFCC (United Nations Framework Convention on Climate Change). "Five Reasons Why Climate Action Needs Women." *United Nations Framework Convention on Climate Change*, March 8, 2023. https://unfccc.int/news/five-reasons-why-climate-action-needs-women#:~:text=Empowering%20women%20in%20agriculture%20can,the%20effects%20of%20climate%20change

UN (United Nations). "Beyond Borders: Why New 'High Seas' Treaty Is Critical for the World." *United Nations News*, June 20, 2023. https://news.un.org/en/story/2023/06/1137857#:~:text=The%20new%20agreement%20contains%2075,value%20of%20marine%20biological%20diversity

UN (United Nations). "Women, Girls, as Agents of Positive Change, Must be Included in All Efforts to Combat Gender Inequality, Climate Change, Delegates Tell Commission." *United Nations*, March 17, 2022. https://press.un.org/en/2022/wom2216.doc.htm

UN OHCHR (United Nations Office of the High Commissioner for Human Rights). "Analytical Study on Gender-responsive Climate Action for the Full and Effective Enjoyment of the Rights of Women." *Report of the Office of the United Nations High Commissioner for Human Rights*, 2019. https://digitallibrary.un.org/record/3807177?ln=en

USAID. "Ber-Ikan: Improve Sustainable, Resilient, and Equitable Fisheries Management." *USAID*, https://www.usaid.gov/indonesia/fact-sheets/usaid-ber-ikan-improve-sustainable-resilient-and-equitable-fisheries-management-1

USAID. "Fish Right." *USAID* Biodiversity Links, https://biodiversitylinks.org/projects/mission-projects/fish-right

USAID. "Gender Equality in Environment, Climate and Energy." *USAID*, 2023. https://www.usaid.gov/gender-equality-and-womens-empowerment/gender-equality-environment-climate-and-energy

USAID. "USAID Green Invest Asia." *USAID*, 2022. https://www.usaid.gov/asia-regional/fact-sheets/usaid-green-invest-asia

USAID. "USAID Private Sector Engagement Hub." *USAID*, nd. https://www.usaid.gov/work-usaid/private-sector-engagement/PSE-at-USAID/PSE-Hub

USAID. "USAID Private-Sector Engagement Policy." *USAID*, 2021. https://www.usaid.gov/sites/default/files/2022-05/usaid_pse-policy_final.pdf

Unsworth, Richard K.F., Catherine J. Collier, Michelle Waycott, Len J. Mckenzie, and Leanne C. Cullen-Unsworth. "A Framework for the Resilience of Seagrass Ecosystems," *Marine Pollution Bulletin* 100, No. 1 (November 15, 2015): 34–46. https://doi.org/10.1016/j.marpolbul.2015.08.016

Valdez, Stephanie R., Y. Stacy Zhang, Tjisse van der Heide, Matthew A. Vanderklift, Flavia Tarquinio, Robert J. Orth, and Brian R. Silliman. "Positive Ecological Interactions and the Success of Seagrass Restoration", *Frontiers in Marine Science* 7, (2020). https://doi.org/10.3389/fmars.2020.00091

Van Eijk, Pieter and Ritesh Kumar. "Bio-rights in theory and practice: A financing mechanism for linking poverty alleviation and environmental conservation." *Wetlands International*, 2009. https://www.wetlands.org/publication/biorights-in-theory-and-practice/#:~:text=Bio%2Drights%20is%20an%20innovative,poverty%20alleviation%20and%20environmental%20conservation

Van Katwijk, Marieke M., Anitra Thorhaug, Nuria Marbà, Robert J. Orth, Carlos M. Duarte, Gary A. Kendrick, Inge H. J. Althuizen, Elena Balestri, Guillaume Bernard, Marion L. Cambridge, Alexandra Cunha, Cynthia Durance, Wim Giesen, Qiuying HanShinya Hosokawa, Wawan Kiswara, Teruhisa Komatsu, Claudio Lardicci, Kun-Seop Lee, Alexandre Meinesz, Masahiro Nakaoka, Katherine R. O'Brien, Erik I. Paling, Chris Pickerell, Aryan M. A. Ransijn, and Jennifer J. Verduin. "Global Analysis of Seagrass Restoration: The Importance of Large-Scale Planting," *Journal of Applied Ecology* 53, No. 2 (October 28, 2015): 567–578. https://doi.org/10.1111/1365-2664.12562

Vanderklift, Matthew A., Raymundo Marcos-Martinez, James R. A. Butler, Michael Coleman, Anissa Lawrence, Heidi Prislan, Andrew D. L. Steven, and Sebastian Thomas. "Constraints and Opportunities for Market-based Finance for the Restoration and Protection of Blue Carbon Ecosystems," *Marine Policy* 107, No. 103429 (September 2019). https://doi.org/10.1016/j.marpol.2019.02.001

Veitayaki, Joeli, Viliame Waqalevu, Robert Varea, and Nick Rollings. "Mangroves in Small Island Development States in the Pacific: An Overview of a Highly Important and Seriously Threatened Resource." In *Participatory Mangrove Management in a Changing Climate: Perspectives from the Asia-Pacific, Disaster Risk Reduction*, edited by Rajarshi DasGupta and Rajib Shaw, 303–327. Tokyo, Japan: Springer, 2017. https://doi.org/10.1007/978-4-431-56481-2_19

Vierros, Marjo. "Communities and Blue Carbon: The Role of Traditional Management Systems in Providing Benefits for Carbon Storage, Biodiversity Conservation and Livelihoods," *Climatic Change* 140, (2013): 89–100. https://doi.org/10.1007/s10584-013-0920-3

Vula, Timoci. "Fiji's Sovereign Blue Bond Oversubscribed," *The Fiji Times*, November 11, 2023. https://www.fijitimes.com.fj/fijis-sovereign-blue-bond-oversubscribed/

Wahyudi, A'an J., Susi Rahmawati, Andri Irawan, Hadiyanto Hadiyanto, Bayu Prayudha, Muhammad Hafizt, Afdal Afdal, Novi S. Adi, Agustin Rustam, Udhi E. Hernawan, Yusmiana R. Rahayu, Marindah Y. Iswari, Indarto H. Supriyadi, Tubagus Solihudin, Restu Nur Afi Ati, Terry L. Kepel, Mariska A. Kusumaningtyas, August Daulat, Hadiwijaya L. Salim, Nasir Sudirman, Devi D. Suryono, and Wawan Kiswara. "Assessing Carbon Stock and Sequestration of the Tropical Seagrass Meadows in Indonesia," *Ocean Science Journal* 55, (2022): 85–97. https://doi.org/10.1007/s12601-020-0003-0

Wakwella, Ama, Ameila Wenger, Aaron Jenkins, Joleah Lamb, Caitlin D. Kuempel, Danielle Clarr, Chris Corbin, Kim Falinski, Antonella Rivera, Hedley S. Grantham, and Stacy D. Jupiter. "Integrated Watershed Management Solutions for Healthy Coastal Ecosystems and People," *Cambridge Prisms: Coastal Futures* 1, 27 (May 5, 2023). doi:10.1017/cft.2023.15

Walker, Ingrid. "Philippines to launch green taxonomy." *Hong Kong Monetary Authority, Bangko Sentral ng Philipinas*, Januray 17, 2024. https://greencentralbanking.com/2024/01/17/round-up-philippines-to-launch-green-taxonomy/

Wang, Wei-Lei, Weiwei Fu, Frédéric A. C. Le Moigne, Robert T. Letscher, Yi Liu, Jin-Ming Tang, and François W. Primeau. "Biological Carbon Pump Estimate Based on Multidecadal Hydrographic Data." *Nature* 624, No. 7992 (December 2023): 579–85. https://doi.org/10.1038/s41586-023-06772-4

WAVES (Wealth Accounting and the Valuation of Ecosystem Services). "Valuing the Protection Services of Mangroves in the Philippines." *Wealth Accounting and the Valuation of Ecosystem Services*. 2017. https://openknowledge.worldbank.org/server/api/core/bitstreams/3449e683-109d-5991-858f-e649d4a83151/content

Waycott, Michelle, Len J. McKenzie, Jane Mellors, Joanna Ellison, Marcus Sheaves, Catherine J. Collier, Anne-Maree Schwarz, Johanna E. Johnson, and Claude Payri. "Vulnerability of Mangroves, Seagrasses and Intertidal Flats in the Tropical Pacific to Climate Change," In *Vulnerability of Fisheries and Aquaculture in the Pacific to Climate Change*, edited by J. Bell and J. Johnson, 97–168. Secretariat of the Pacific Community: New Caledonia, 2011. https://www.researchgate.net/publication/259649359_Vulnerability_of_mangroves_seagrasses_and_intertidal_flats_in_the_tropical_Pacific_to_climate_change

WCPFC (Western and Central Pacific Fisheries Commission). "Proposed Revisions to the Conservation and Management Measure for Sharks," *Proposal by the United States of America and Canada*, Commission Nineteenth Regular Session, October 28, 2022. https://meetings.wcpfc.int/node/17859

WFP (World Food Programme). "Indonesia, COVID-19: Economic and Food Security Implications (3d Edition)," August, 2020. https://docs.wfp.org/api/documents/WFP-0000118525/download/

Whyte, Kyle Powys. "On the Role of Traditional Ecological Knowledge as a Collaborative Concept: A Philosophical Study", *Ecological Processes*, Vol. 2, No. 7 (April 05, 2013). https://doi.org/10.1186/2192-1709-2-7

Wickenberg, Björn, Kes McCormick, and Johanna Alkan Olsson. "Advancing the Implementation of Nature-Based Solutions in Cities: A Review of Frameworks," *Environmental Science & Policy* 125 (2021): 44–53. https://doi.org/10.1016/j.envsci.2021.08.016

World Bank. "Problue and Gender Equality." *World Bank Group*, January, 2022. https://thedocs.worldbank.org/en/doc/34a2f0d-94821b4c63f42d769c44a7cb8-0320072022/original/PROBLUE-factsheet-gender-jan2022.pdf

World Bank. "Planting Mangrove Forests Is Paying Off in Indonesia." *World Bank Group*, November, 2023. https://www.worldbank.org/en/news/feature/2023/11/30/planting-mangrove-forests-is-paying-off-in-indonesia

World Bank. "Sustainable Finance." *World Bank Group*, August 5, 2021. https://www.worldbank.org/en/topic/financialsector/brief/sustainable-finance

World Bank. "World Development Indicators." World Bank Group, Accessed March 14, 2024. https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.CD&country

World Economic Forum. "Tourism is Damaging the Ocean. Here's What We Can Do to Protect It." March 26, 2019. https://www.weforum.org/agenda/2019/03/tourism-is-killing-our-oceans-heres-what-we-can-do-to-protect-them/

World Economic Forum. "Blended Finance Vol. 1: A Primer for Development Finance and Philanthropic Funders. An Overview of the Strategic Use of Development Finance and Philanthropic Funds to Mobilize Private Capital for Development," 2015. https://www3.weforum.org/docs/WEF_Blended_Finance_A_Primer_Development_Finance_Philanthropic_Funders.pdf

World Economic Forum. "High-Quality Blue Carbon Principles and Guidance. A Triple-Benefit Investment for People, Nature, and Climate." 2022. https://www3.weforum.org/docs/WEF_HC_Blue_Carbon_2022.pdf

World Travel & Tourism Council. "Indonesia, 2022 Annual Research: Key Highlights," 2022. https://wttc.org/DesktopModules/MVC/FactSheets/pdf/704/131_20220613162338_Indonesia2022_.pdf

Worm, Boris, Edward B. Barbier, Nicola Beaumont, J. Emmett Duffy, Carl Folke, Benjamin S. Halpern, Jeremy B. C. Jackson, Heike K. Lotze, Stephen R. Palumbi, Enric Sala, Kimberley A. Selkoe, John J. Stachowicz, and Reg Watson. "Impacts of Biodiversity Loss on Ocean Ecosystem Services," *Science*, 314 (2006): 787–790. DOI: 10.1126/science.1132294

Xu, Shuangbin, Meujun Chen, Tingze Feng, Li Zhan, Lang Zhou, and Guangchuang Yu. "Use ggbreak to Effectively Utilize Plotting Space to Deal with Large Datasets and Outliers," *Frontiers in Genetics*, 12 (2021). DOI: 10.3389/fgene.2021.774846

Yee, Merewalesi, Karen E. McNamara, Annah E. Piggott-McKellar, and Celia McMichael. "The role of Vanua in Climate-related Voluntary Immobility in Fiji," *Frontiers in Climate* (4), (2022). https://doi.org/10.3389/fclim.2022.1034765

Yeeting, Agnes, Hans-Peter Weikard, Megan Bailey, Vina Ram-Bidesi, and Simon Bush. "Stabilising Cooperation through Pragmatic Tolerance: The Case of the Parties to the Nauru Agreement (PNA) Tuna Fishery," *Regional Environmental Change* 18 (March 1, 2018): 1–13. https://doi.org/10.1007/s10113-017-1219-0

Zeng, Yiwen, Daniel A. Friess, Tasya Vadya Sarira, Kelly Siman, and Lian Pin Koh. "Global Potential and Limits of Mangrove Blue Carbon for Climate Change Mitigation," *Current Biology* 31, (2021): 1737–1743. https://doi.org/10.1016/j.cub.2021.01.070

Zulkifli, Lalu, Abdul Syukur, and Lalu Patech. "Seagrass Conservation Needs Based on the Assessment of Local Scale Economic Value on the Diversity of its Associated Biota in the South Coast East Lombok, Indonesia." *IOP Conference Series: Earth and Environmental Science* 712(1) (2021). http://dx.doi.org/10.1088/1755-1315/712/1/012037

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