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Markets to Watch:
Blue Carbon

Executive Summary

Forests, soils, and oceans play a critical role in stabilizing the climate because they naturally remove carbon dioxide (CO_2) from the atmosphere. Projects that conserve and restore these ecosystems are becoming strategic investments as companies and governments seek opportunities to invest in these "nature-based solutions" to climate change. In particular, coastal and marine carbon projects—or "blue carbon" projects—are attracting interest because these ecosystems have the potential to store five times as much carbon per square foot as terrestrial ecosystems.[1]

In recent years, Apple[2], Netflix[3] and Procter & Gamble[4] have committed to investing in blue carbon projects as part of an overall strategy to offset their carbon emissions. Salesforce has also pledged to purchase 1 million tons of blue carbon credits by 2026.[5] The largest project on record—the 350,000-hectare Delta Blue Carbon Project in Pakistan—has demonstrated that blue carbon projects can be done at scale. While most major blue carbon credit transactions right now are large pre-purchases, opportunities also exist to invest in the technology needed for restoring and monitoring ecosystems. In the future, mapping and remote sensing in coastal areas will be critical for verification of climate change impacts, and new technologies for growing and sinking macro-algae like kelp forests may qualify for carbon credits. With high carbon storage potential and willing financiers, blue carbon projects are increasingly viable carbon removal investments.

The Market

Nature-based solutions to climate change have the potential to provide up to 37% of the carbon mitigation needed to keep the global average temperature rise under 2°C.[6] Increasingly, governments, conservation organizations, and companies are willing to invest in these projects. These projects are monetized by awarding "carbon credits" (also called "emission reduction credits") for each ton of CO_2 equivalent stored or avoided from being emitted—credits which can then be sold to companies to offset their own carbon emissions.

Participation in carbon credit markets is mandatory in some regions (such as the European Union's Emission Trading

Scheme) and voluntary in others. The global carbon market was valued at $851 million in 2021.,[7] creating a pathway for private financing to mobilize investment in nature-based solutions, which offer some of the cheapest and most effective climate investment opportunities.[8]

Types of blue carbon projects

There are several potential types of blue carbon sequestration, including:

- **Mangrove, salt marsh, and seagrass conservation and restoration.** Most blue carbon projects currently in development focus on protecting or restoring mangrove forests, salt marshes, or seagrasses. Part of the reason for the high rates of carbon sequestration in these ecosystems is the large storage of sediment organic carbon.[9] These coastal ecosystems are being lost at a rate of 1-2% per year globally,[10] due to agricultural activity, aquaculture, and real estate and infrastructure development.[11] Coastal vegetated ecosystems sequester CO_2 at significantly higher rates, per unit of area, than terrestrial forests, so protecting and restoring these ecosystems is an important and measurable source of climate mitigation. McKinsey & Co. estimates that, in aggregate, conserving and restoring mangroves, seagrass, and salt marshes could account for about 40% of the total blue carbon potential.[12] Importantly, these are the only activities that have accepted carbon crediting methodologies on the major carbon market registries today.

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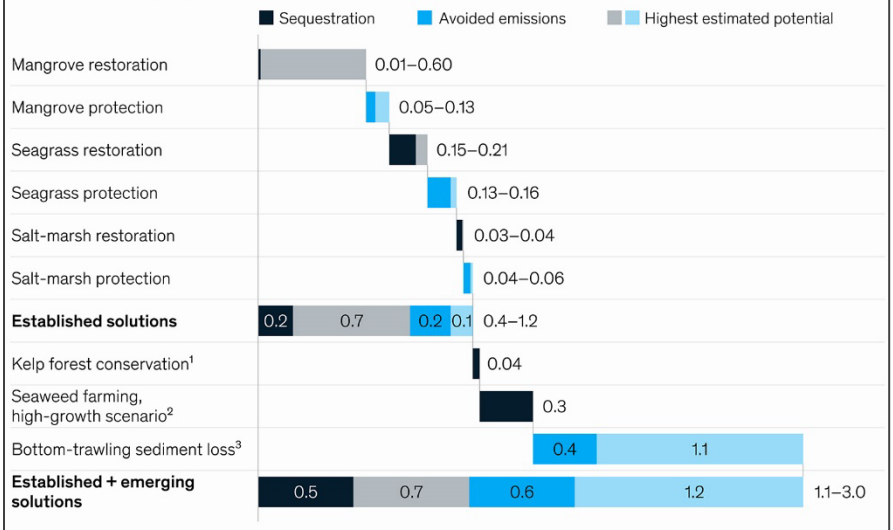
Using geospatial data and rates of average annual carbon sequestration for mangroves, salt marshes and seagrass meadows, researchers found that Australia, the U.S. and Indonesia offered the largest annual carbon sequestration potential across all three blue carbon types.[13] Projects currently seeking credits are based in geographies ranging from Mexico to Senegal to Papua New Guinea.

- **Restoration or cultivation of kelp forests.** Kelp and seaweed forests are fast-growing and store CO_2 in their biomass. However, because they tend to drift, measuring their carbon storage potential is difficult. Additionally, kelp forests do not have the sediment carbon sink like other blue carbon ecosystems. Tradeable carbon credits are not yet available for the preservation or development of kelp forests, though many organizations are eager to get methodologies approved. Oceans 2050, Ostrom Climate Solutions, the Kelp Forest Foundation, and other organizations are currently researching kelp's carbon-storing potential.[14] Becoming eligible for carbon credits could make seaweed farming more financially attractive at scale in the future.

- **Changes to fishing practices and protection of marine fauna.** Nascent approaches to blue carbon sequestration include modifying fishing practices to eliminate bottom trawling (which releases carbon into the ocean and atmosphere) and protecting or restoring fish and whale populations, which indirectly improves deep-sea carbon sequestration. There is the potential for climate impact in this area, but more work needs to be done to measure carbon impacts and develop protocols for these types of projects.

Established blue-carbon solutions offer abatement of 0.4 to 1.2 metric gigatons of carbon dioxide ($GtCO_2$) per year; emerging solutions could add up to about 1.8 $GtCO_2$ per year for a total of approximately 3 $GtCO_2$ per year.

Abatement potential from established and emerging blue-carbon solutions by 2050, $GtCO_2$ equivalent per year



[1] High-level, high-uncertainty estimate.
[2] Seaweed farming sequestration depends on area of implementation and is potentially much higher. Potential shown is the reported 14% per annum growth-based estimate in the ocean as a solution.
[3] Lower bound is estimated as the long-term abatement potential (40% of current emissions rates) of emissions from bottom trawling in areas shallower than 50 meters.
Source: Source: Peter Macreadie et al., "Blue carbon as a natural climate solution," *Nature Reviews Earth & Environment*, November 2021, Volume 2; Ove Hoegh-Guldberg et al., *The ocean as a solution to climate change: Five opportunities for action*, World Resources Institute, 2019; Enric Sala et al., "Protecting the global ocean for biodiversity, food and climate," *Nature*, March 2021, Volume 592; McKinsey analysis

McKinsey & Company

Source: McKinsey & Co., "Blue carbon: The potential of coastal and oceanic climate action," May 2022.

Coastal blue carbon projects often also deliver valuable co-benefits like preventing erosion, providing habitat for marine species, and ensuring food security for coastal communities. The "carbon plus co-benefits" value proposition has allowed blue carbon credits to be valued at a significant premium, increasing the interest from both blue carbon buyers (e.g. companies pursuing Net-Zero goals) and sellers (e.g. blue carbon project developers).

Monetizing projects

The Verified Carbon Standard (VCS), managed by the nonprofit organization Verra, is the most widely used carbon standard, having certified more than 1,800 projects representing the reduction or removal of almost 1 billion tons of carbon from the atmosphere. Verra updated its methodology in 2020 to cover blue carbon conservation and restoration activities. The expanded framework allows for the financing of restoration and conservation of coastal wetlands—mangrove forests, seagrass meadows and salt marshes—through carbon crediting mechanisms. In 2022, several blue carbon projects were registered in the Verra Registry, with others in development, including the first project looking to issue credits through seagrass restoration.

Due to the low volume of verified projects, it is difficult to gather exact cost estimates for blue carbon projects. That said, mangrove conservation and restoration has been the focus of the majority of blue carbon projects to date because it is comparatively inexpensive and provides many co-benefits.[15] Mangroves are estimated to provide at least $1.6 billion annually in ecosystem services—protecting against erosion, filtering pollutants, and supporting local fisheries by providing habitat for fish. McKinsey & Co. estimates that protecting mangrove forests costs, on average, less than $6 per avoided ton of CO_2, while restoring lost or degraded forests costs between $15 to $250 per sequestered ton of CO_2.[16] By comparison, a recent Bloomberg New Energy Finance (BNEF) report projected that the market prices for carbon offsets could be worth anywhere between $47/ton to $120/ton by 2050.[17]

Trends & Uncertainties

Several trends are likely to shape the market for blue carbon projects going forward.

An evolving carbon credit marketplace

In 2021, more than 362 million credits were traded in the voluntary market, up 92% from 2020. Forestry and land-use credits, which cover blue carbon, increased 159% since 2020, representing more than one third of total credit issuances in 2021.[18] Thanks to an increasing number of corporate pledges to reduce and offset emissions, the market is likely to continue expanding. Some economists predict the demand (in tons of carbon sequestered) to increase 100-fold by 2050.[19]

Despite this momentum, the effectiveness of carbon markets in abating climate change is still debated. For nature-based solutions, methodological challenges include: *double-counting*, when two parties claim value from the same credit; *leakage*, whereby deforestation is outsourced to unprotected areas; *additionality*, whether the carbon-generating activity was going to happen anyway; and *permanence*, whether the carbon will stay sequestered for long periods. To address these challenges, a new Taskforce on Scaling Voluntary Carbon Markets has been created to improve transparency and permanence.

Ecosystem losses

Though the demand for blue carbon credits is growing rapidly, coastal and marine ecosystems face a variety of profound threats. Mangrove forests, saltmarshes, and seagrass meadows are among the most threatened ecosystems on Earth.[20] This is especially concerning because these ecosystems can become significant sources of greenhouse gases when degraded. Compounding the problem, climate change effects like sea level rise, ocean warming, and increasingly severe storms directly affect the ability of coastal ecosystems to serve as long-term carbon sinks. In addition to policy approaches, blue carbon investments have the potential to create much more robust incentives to protect and restore these ecosystems in the face of these multiple threats.

Monitoring, reporting & verification (MRV)

Assessing and valuing carbon stocks in blue carbon ecosystems is an imperfect science at this point, as sequestration rates differ across diverse coastal vegetated ecosystems and sites. More work needs to be done to evolve the monitoring, reporting, and verification (MRV) of projects to enhance the credibility of these credits in the carbon market. While significant progress has been made in terms of measuring blue carbon stocks, the lack of site-specific expertise and data is still a bottleneck for many potential projects. Paying for additional research and measurement systems can make blue carbon projects expensive, raising concerns that the value of credits may not cover project costs.

Social concerns and carbon rights

Blue carbon rights are difficult to navigate, as coastlines are typically common or public property and many larger parcels are already protected, disqualifying them for crediting. There are also concerns around equity: The World Forum of Fisher Peoples suggested that blue carbon projects may be "ocean-grabbing in disguise," warning that market-based solutions may come at the expense of traditional uses of resources (like mangroves for fuel), and benefits would not trickle down to local communities.[21] Some coastal nations, though, have instead taken matters into their own hands: the Bahamas is currently completing a blue carbon inventory with the intention of selling the credits and using the resulting revenue to make nationwide investments in climate-resilient infrastructure and renewable energy.[22]

New sources of financing

In the strongest signal of corporate interest so far, the Blue Carbon Buyers Alliance (BCBA) was launched at the COP26 climate meetings in 2021. BCBA, an offshoot of the Business Alliance to Scale Climate Solutions, is designed to leverage the power of buyers to scale the market.[23] BCBA is co-chaired by Salesforce, which has already committed to purchasing the equivalent of $10 million in blue carbon credits, as well as several global environmental organizations.[24] Salesforce is not the only tech leader investing in natural climate solutions: Apple launched its $200 million Restore Fund in 2021 and is currently applying learnings from its first blue carbon effort, a verified mangrove project in Colombia, to a new effort in Maharashtra, India.[25,26]

Examples of companies that have made commitments to develop projects or purchase blue carbon credits
(not a comprehensive list)

Apple	Netflix
Gucci	Procter & Gamble
J-POWER (Japan Power)	Salesforce
Microsoft	Shell
Mitsui O.S.K. Lines	Trafigura
MSC Cruises	

Sources: Publicly available information on company websites and ESG reports

Business Opportunities

With this nascent market come several potential business opportunities.

Imaging technology and mapping

Advanced modeling and mapping may provide game-changing opportunities for blue carbon investors. Remote sensing technologies can help to fill in critical gaps in global mapping of blue carbon systems.[27] The Google Earth

Engine Mangrove Mapping Methodology (GEEMMM) is one such remote sensing approach that harnesses the power of cloud computing to allow, for example, rapid monitoring of changes in mangrove cover.[28]

Models that either simulate carbon cycling via biogeochemical processes, or those that utilize mapping to streamline project site selection and contribute to ongoing site monitoring will also play a role in future project development. The Invest BlueCarbon model, for example, attempts to predict both how much carbon is stored in a specific coastal area at a specific period of time, and estimate the monetary value for the carbon storage and sequestration activities.[29]

Reforestation and agtech

One limitation on the supply side is the cost of implementing restoration activities. Startup Distant Imagery Solutions uses drones, made from scalable 3D-printed components, coupled with precision planting, to restore mangrove forests. Its technology can drop 2,000 germinated seeds or 500 seed balls in ten minutes.[30] Abu Dhabi's Environment Agency and French energy company ENGIE are partnering with Distant Imagery on a mangrove restoration project.[31]

Corporate investment in blue carbon

Blue carbon provides a unique opportunity for companies that rely on the ocean—e.g., shipping, fishing, tourism—to customize their decarbonization goals to their industry, as well as take advantage of co-benefits like healthier fish stocks and improved coastal community livelihoods. MSC Cruises, the first carbon-neutral global cruise line, has committed to buying blue carbon credits and supporting new projects.[32] Mitsui O.S.K. Lines, Ltd, the Japanese shipping giant, is working to protect and restore mangroves in Indonesia, a project slated for registration in 2022.[33]

Seaweed/kelp farming

Widespread and fast-growing, kelp forests absorb carbon while growing up to 18 inches per day.[34] Kelp farming has seen growth in investor interest, both for its carbon removal potential and its usefulness as a marketable ingredient in food products, nutritional supplements, fertilizers, and other products. Research is still ongoing to quantify the full sequestration potential—including via the Oceans 2050 Global Seaweed project led by Alexandra Cousteau—but startups like Phykos and Running Tide have been successfully raising capital with business models based on growing seaweed and sinking it to the ocean floor as a carbon sequestration strategy. Startup Kelp Blue is piloting growing kelp that can be harvested for animal feed, fiber, and pharmaceutical inputs as well as climate benefits.

"Stacked" credits

Blue carbon projects are especially suitable for additional certifications, which generate higher credit prices, like Verra's Climate, Community and Biodiversity (CCB) Standards.[35] In 2021, Conservation International said it planned to sell blue carbon credits generated through a mangrove conservation project in Colombia—the first VCS+CCB certified credits—for 2-4 times more than peer forestry credits.[36,37] New credits specific to blue carbon are also being developed, including The Nature Conservancy's Blue Carbon Resilience Credits, which quantify both the carbon sequestration and resilience value of the project in terms of coastal damage avoided. Resilience credits are being piloted in Mexico and the Caribbean, and The Nature Conservancy expects the credits to drive significant corporate demand.[38, 39]

Takeaways for MBAs

1. As the urgency of climate change continues to grow, both compliance and voluntary carbon markets will likely also expand, and blue carbon will be an increasingly important part of that portfolio.
2. Blue carbon presents unique challenges with vexing methodological questions around permanence and equity, but also attractive opportunities to invest in high-carbon-potential projects and secure valuable co-benefits.
3. Large corporations are beginning to commit investments to scale blue carbon projects and are counting on nature-based solutions to help meet their Net-Zero emissions goals.

Further Reading

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The Blue Carbon Initiative

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