Capturing and conserving natural coastal carbon

Building mitigation, advancing adaptation

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Carbon stores in seagrass beds and coastal wetlands—including coastal peats, tidal freshwater wetlands, salt marshes and mangroves—are vast, unaccounted natural carbon sinks. The continued degradation of these coastal ecosystems through disturbance, drainage, reclamation and conversion to other land uses has resulted in substantial emissions of greenhouse gases (GHGs) and loss of natural carbon sequestration. Conserving and rebuilding these critical ecosystems not only mitigates GHG emissions, but delivers important co-benefits including ecosystem-based adaptation to climate change. A drive to protect and rebuild coastal wetlands and seagrass beds calls for closer integration of these fragile land-ocean interfaces into national climate change actions and their inclusion into the activities of the international climate change dialogue.

Importance of coastal wetlands and seagrass beds for climate change mitigation

Coastal wetlands and seagrass beds sequester significant amounts of carbon

Coastal wetlands and seagrass beds sequester large amounts of carbon within plants above and below sea-level as well as within soils. In comparison to terrestrial ecosystems, these ecosystems are continuously building carbon pools, providing for an ongoing and long-term removal of carbon dioxide from the atmosphere (see table 1). Occupying only 2% of seabed area, vegetated wetlands represent 50% of carbon transfer from oceans to sediments. In many cases these soils have been continuously building for 5,000 years or more, and carbon stored in these sediments remain sequestered for millennia. Saline wetlands, like salt marshes, have the added advantage of emitting negli-

<table>
<thead>
<tr>
<th>Ecosystem type</th>
<th>Standing carbon (gC/m²)</th>
<th>Total global area (10⁶m²)</th>
<th>Global carbon stock (10¹⁵gC)</th>
<th>Long-term rate of carbon accumulation in sediment (gC/m²·y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plants</td>
<td>Soil</td>
<td>Plants</td>
<td>Soil</td>
</tr>
<tr>
<td>Tropical forests</td>
<td>12,045</td>
<td>12,273</td>
<td>17.6</td>
<td>212</td>
</tr>
<tr>
<td>Temperate forests</td>
<td>5,673</td>
<td>9,615</td>
<td>10.4</td>
<td>59</td>
</tr>
<tr>
<td>Boreal forests</td>
<td>6,423</td>
<td>34,380</td>
<td>13.7</td>
<td>88</td>
</tr>
<tr>
<td>Wetlands</td>
<td>4,286</td>
<td>72,857</td>
<td>3.5</td>
<td>15</td>
</tr>
<tr>
<td>Tidal salt marshes</td>
<td>—</td>
<td>—</td>
<td>Unknown (0.22 reported)</td>
<td>—</td>
</tr>
<tr>
<td>Mangroves</td>
<td>7,990</td>
<td>—</td>
<td>0.152</td>
<td>1.2</td>
</tr>
<tr>
<td>Seagrass meadows</td>
<td>184</td>
<td>7,000</td>
<td>0.30</td>
<td>0.06</td>
</tr>
<tr>
<td>Kelp forests</td>
<td>120–720</td>
<td>n.a.</td>
<td>0.02–0.4</td>
<td>0.009–0.02</td>
</tr>
</tbody>
</table>


n.a. = not available
gible quantities of methane (see table 2). Although some coastal wetlands emit other GHGs, over multi-century time scales all coastal wetlands are net sinks for GHGs.

**Degradation and loss of coastal wetlands releases large amounts of stored carbon**

Just as coastal wetlands capture and store carbon, drainage and other forms of degradation of these ecosystems release stored carbon from soils and plants. From an important carbon sink, the degraded wetlands become a significant source of GHG emissions. Clearance of mangroves immediately releases much of the carbon held within woody biomass. Drainage of all coastal wetlands immediately releases carbon from pools sequestered over recent centuries, and in following decades releases carbon that accumulated in soils over millennia. The rate of carbon emissions from coastal wetlands directly to the atmosphere is greatest in the immediate years after drainage and slows over time. Over the multi-decadal timeframe carbon emissions continue from the more organic-bearing, or peat-like, coastal wetland soils. Conserving all coastal wetlands and seagrass beds has an immediate benefit of preventing carbon dioxide release to the atmosphere.

The carbon content of soils across the landscape varies and across different types of coastal wetlands but a ‘typical’ coastal wetland soil releases 0.25 million tons of CO₂ per square kilometer (km²) for every depth meter of soil lost. More detailed quantification is required but likely carbon emissions from brackish and freshwater tidal wetlands and oceanic mangroves (such as those found in open coastal/island settings) hold 50% or more carbon than this estimated average value, and some salt

<table>
<thead>
<tr>
<th>Wetland type</th>
<th>Carbon sequestration</th>
<th>Methane production</th>
<th>Net GHG sink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mudflat (saline)</td>
<td>Low</td>
<td>Very low</td>
<td>Low to medium</td>
</tr>
<tr>
<td>Salt marsh</td>
<td>High</td>
<td>Very low</td>
<td>High</td>
</tr>
<tr>
<td>Freshwater</td>
<td>Very high</td>
<td>High to very high</td>
<td>Neutral or variable</td>
</tr>
<tr>
<td>Estuarine forest</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Mangrove</td>
<td>High</td>
<td>Low to high*</td>
<td>Low to high*</td>
</tr>
<tr>
<td>Seagrass</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>


* dependent on salinity

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Table 2. Summary of potential GHG reductions due to soil building in coastal wetlands
marshes and mangroves in deltaic settings may be 50% lower than this average value. Some coastal systems have over the past 100–300 years released carbon from soils to a depth of 5–10 meters. The current rate of degradation and loss of coastal wetlands and submerged vegetated habitats is, in some instances, up to four times greater than that of tropical forests and leads to decreased carbon sequestration.

With the loss of seagrass, carbon stored in underlying soils is released back into circulation. Some portion of this carbon will be released into the atmosphere and some portion eventually reburied. Additional research is required to reduce current uncertainties. Carbon emissions from degraded (e.g. drained) and lost coastal wetlands are sufficiently significant to warrant inclusion in carbon accounting

Examples of GHG emissions from wetland degradation

- In the Sacramento–San Joaquin Delta, California, drainage of 1,800 km² of wetlands has released some 2 GtCO₂ (Giga tons, or thousand million tons of carbon dioxide), a mass of about half of the total above ground pool of carbon in Californian forests. This carbon was sequestered over four thousand years but released in just over 100 years. Each year, between 10 and 15 million tons of CO₂ continue to be released from this Delta, equivalent to 2–3% of California’s annual GHG emissions.
- Case study examination of only a few large deltas finds several to have each released over 1 billion tons of CO₂ due to land-use change: the Mekong Delta (4.7 GtCO₂), the Po (2.5 GtCO₂), the Nile (1.4 GtCO₂), the Wash (1.4 GtCO₂), the Indus (1.2 GtCO₂) and the Changjiang (1.1 GtCO₂). These emissions from only six of many degrading deltas and coastal areas, >12 GtCO₂, is approximately equivalent to estimated emissions arising from burning tropical forests in Brazil and Indonesia over 15 years (approximately 0.75 GtCO₂ annually). Addressing emissions from coastal wetlands will complement a global approach to natural carbon management for climate change mitigation.
- 13.5 GtCO₂ will be released within the next 50 years as a result of mangrove clearance of 35,000 km² between 1980 and 2005, equivalent to all transport-related emissions in 27 EU countries over a 15 year period from 1997 to 2005. Loss of the remaining 152,308 km² of mangroves would release 58 GtCO₂ over the same time.
- Remaining coastal wetlands with peat-rich soils, which release higher than average amounts of CO₂ (0.25 GtCO₂ per km² for every depth meter of soil lost), are being rapidly converted for palm oil plantations and aquaculture in parts of Southeast Asia.
and GHG inventories. Next steps should also include development of financial incentive mechanisms for improved management and amendments to national and international policy frameworks to reduce loss of these ecosystems. With these in place, improved management of coastal wetlands and sea grass beds could slow or reverse ongoing loss of carbon sequestration capacity.

Management of coastal wetlands and marine ecosystems can mitigate GHG emissions
Coastal wetlands are under severe threat as human population and development pressures in coastal areas continue to grow. In the last 25 years alone, between 1980 and 2005, about 20% of the total area of mangroves was lost. Salt marshes and freshwater tidal marshes have declined at similar but poorly quantified rates over the same period. Seagrass beds have declined by 29% since the 19th century, with an upsurge in decline in recent decades. Rates of loss for coastal wetlands are estimated at 1–2% per year. Reducing carbon emissions through conservation and restoration of these ecosystems presents an opportunity for coastal nations to mitigate and adapt to climate change. Mitigation opportunities through wetlands management are immediately available and can be cost effective as they generate a wide range of co-benefits from ecosystem services.

Conservation
The most effective way to maintain coastal wetland carbon pools is avoiding degradation and conversion through protection and sustainable management.

Restoration
Substantial gains can be achieved by restoring degraded coastal wetlands. Clearly, some coastal wetlands cannot easily be restored, but management activities such as rewetting of drained soils or replanting of mangroves can slow or halt carbon loss and reverse GHG emissions. Sequestration rates during restoration are lower than rates at which carbon is lost when disturbed, reducing the mitigation potential in the short-term, but not in the long-term. Restoration of freshwater tidal reed marshes is a demonstrated exception; by simple management of water, organic soils can be rapidly rebuilt, sequestering particularly high quantities of carbon through soil even within a decade (up to net 65 tCO₂/ha/yr). Further efforts are needed to increase the number and effec-
Immediate next steps

- Through the Intergovernmental Panel on Climate Change (IPCC), existing guidance and guidelines for estimating and reporting on GHG emissions from peatlands and inland agricultural wetlands should be amended to also encompass coastal wetlands, with appropriate revision including clarification on and alignment of definitions.
- A financial approach, similar to REDD, could be developed for coastal wetlands and seagrass beds that currently fall outside existing agreements and mechanisms, with a focus on providing financial incentives for protection of soil carbon stocks and increases in carbon uptake.
- At the national level, conservation and management actions for coastal wetlands and marine ecosystems should be recognized as components that may be included as part of developing countries’ National Appropriate Mitigation Actions (NAMAs); and mangrove preservation and restoration activities should be included in national REDD+ strategies, policies and measures.
- Under the UNFCCC, ‘wetland management’ should be defined as an activity under land use, land-use change and forestry (LULUCF) for follow-up commitment periods of the Kyoto Protocol that encompasses both coastal and terrestrial wetlands. The Subsidiary Body for Scientific and Technological Advice (SBSTA) work program should be expanded to address accounting for anthropogenic emissions by sources and removals by sinks in LULUCF that embraces coastal and marine areas, as well as possible additional LULUCF activities under the Clean Development Mechanism (CDM).

Policy change can reduce emissions and enhance coastal carbon stocks

Ongoing losses of carbon from degradation and conversion of these ecosystems are enormous but, unlike forests, currently are neither accounted for in national GHG inventories, nor included in mitigation or off-set activities within the United Nations Framework Convention on Climate Change (UNFCCC). Despite coastal and marine ecosystems being included in Art 4(d) of the Climate Convention1, the current UNFCCC process does not adequately include restoration activities and does not prevent drainage or damage of these systems, a significant shortcoming in the global approach to natural carbon management. Opportunities are available to include coastal wetlands into existing and potentially new carbon accounting and offsetting mechanisms.

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1 Art. 4(d) All Parties […] shall ‘promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all GHG not controlled by the Montreal protocol, including […] oceans as well as other […] coastal and marine ecosystems’.
provided that guidance is developed, necessary environmental and social safeguards are put in place, and actions are consistent with the principle of environmental integrity.

**Further research, economic analysis and methodological development is needed**

Much can already be done based on available knowledge in terms of management of coastal wetlands and seagrass beds for enhancing carbon sequestration or avoiding emissions. However, additional ecological as well as socio-economic research is needed, as is further development and testing of tools and approaches.

- There is compelling evidence amassing to indicate that GHG emissions from degraded coastal wetlands are of sufficient magnitude to warrant consideration within global and national GHG budgets. These emissions are direct to the atmosphere. There is growing evidence that degradation of seagrasses releases considerable quantities of carbon back into circulation within coastal waters. The ultimate fate of this carbon is not known but should be determined. Further research is required, especially in the tropics.
- Additional detailed studies on the economic feasibility and viability of including coastal wetland management projects in the carbon market are needed. Current carbon prices could be sufficient for benefits of management and preservation of coastal wetlands to outweigh the opportunity costs of wetland-uses such as low-to-average income shrimp farming. This case is strengthened if environmental externalities of short term, highly profitable but unsustainable wetland uses are accounted for in cost-benefit analysis.
- At the national level, further work on ecosystem services valuation needs to be undertaken to quantify the value of ecosystem services provided by coastal wetlands, along with the cost of their loss. Such analysis can support the establishment of payment for ecosystem services (PES) and “polluter/degrader pays” schemes, as well as possible emis-
sions taxes on newly drained wetlands to align economic incentives with better management practices.

- Activities are underway seeking to bring coastal wetland management into the carbon market through science and policy guidance. These activities provide an opportunity for shared learning on both methodology development and implementation. Actions include those of the U.S. National Blue Ribbon Panel on the Development of a Greenhouse Gas Offset Protocol for Coastal Wetlands Restoration and Management.

- Restoring drained coastal wetlands presently used for agriculture or aquaculture could require reducing or relocating these activities, with implications for food production, local livelihoods and income. In such cases, tradeoffs need to be carefully assessed and ways to mitigate near-term social impacts addressed.

**Conclusion**

The carbon stored in healthy coastal wetlands and seagrass habitats represents a substantial and as yet unaccounted for sink in discussions of CO₂ mitigation. Under conditions of disturbance, modified hydrology and exposure of submerged soils to oxidation, these ecosystems can become a huge source of GHG emissions. Protecting and restoring these ecosystems present significant opportunities for climate change mitigation not yet factored into UNFCCC accounting or the financial architecture for carbon markets linked to REDD+. Avoiding future emissions associated with wetlands loss remains a challenge that countries need to address urgently, through national wetlands management programs, ecosystem services valuation, and more rigorous carbon accounting with the aid of robust science and remote sensing technology.

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