
Photo: D. Laffoley/IUCN

Capturing and conserving natural coastal carbon

Building mitigation, advancing adaptation

THE WORLD BANK IUCN ESA PWA

November 2010

Capturing and conserving natural coastal carbon

Building mitigation, advancing adaptation

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 1. Carbon stores in coastal wetlands and seagrass beds

	Standing carbon (gCm^2)			*Global carbon stock (*1015gC)*		
Ecosystem type	*Plants*	*Soil*	*Total global area ($*10^{12}m^2$)*	*Plants*	*Soil*	*Long-term rate of carbon accumulation in sediment ($gCm^{-2}y^{-1}$)*
Tropical forests	12,045	12,273	17.6	212	216	2.3–2.5
Temperate forests	5,673	9,615	10.4	59	100	1.4–12.0
Boreal forests	6,423	34,380	13.7	88	471	0.8–2.2
Wetlands	4,286	72,857	3.5	15	225	20.0
Tidal salt marshes	—	—	Unknown (0.22 reported)	—	—	210.0
Mangroves	7,990	—	0.152	1.2	—	139.0
Seagrass meadows	184	7,000	0.30	0.06	2.1	83.0
Kelp forests	120–720	n.a.	0.02–0.4	0.009–0.02	n.a.	n.a.

Source: E. Pidgeon. 2009. "Carbon Sequestration by Coastal Marine Habitats: Important Missing Sinks." In D. Laffoley and G. Grimsditch (eds.), *The Management of Natural Coastal Carbon Sinks*. Gland, Switzerland: IUCN.
n.a. = not available

Table 2. Summary of potential GHG reductions dues to soil building in coastal wetlands

Wetland type	*Carbon sequestration*	*Methane production*	*Net GHG sink*
Mudflat (saline)	Low	Very low	Low to medium
Salt marsh	High	Very low	High
Freshwater	Very high	High to very high	Neutral or variable
Estuarine forest	High	Low	High
Mangrove	High	Low to high*	Low to high*
Seagrass	High	Low	High

Source: Philips Williams & Associates, Ltd. and Science Applications International Corporation (2009).
* dependent on salinity

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

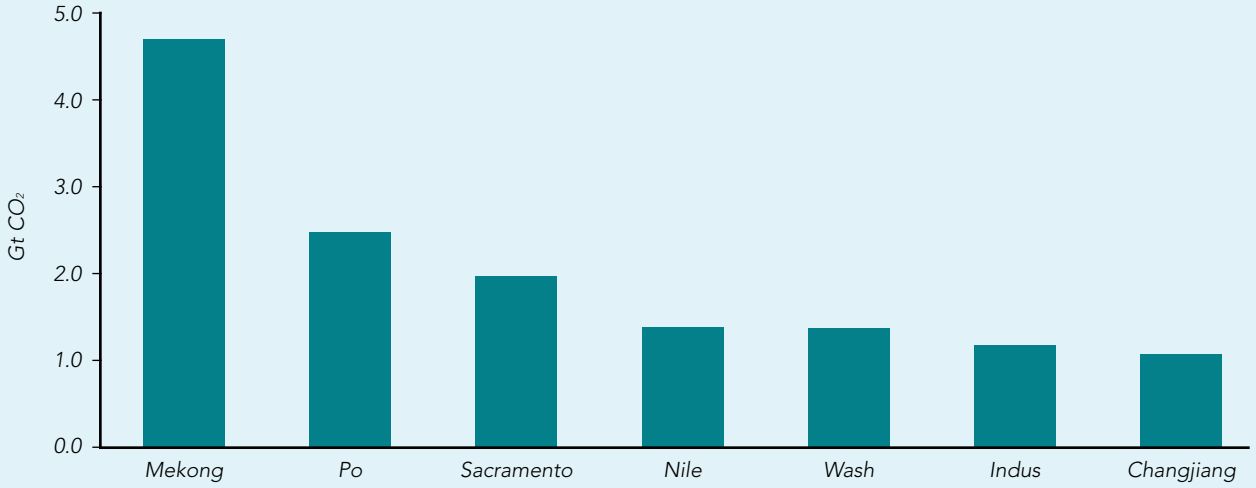
Just as coastal wetlands capture and store carbon, drainage and other forms of degradation of these ecosystems release stored carbon from soils and plants. From an important carbon sink, the degraded wetlands become a significant source of GHG emissions. Clearance of mangroves immediately releases much 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 CO_2 per square kilometer (km^2) 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

Photo: D. Laffoley/IUCN

Examples of GHG emissions from wetland degradation

- In the *Sacramento–San Joaquin Delta*, California, drainage of 1,800 km^2 of wetlands has released some 2 $GtCO_2$ (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 CO_2 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 CO_2 due to land-use change: the Mekong Delta (4.7 $GtCO_2$), the Po (2.5 $GtCO_2$), the Nile (1.4 $GtCO_2$), the Wash (1.4 $GtCO_2$), the Indus (1.2 $GtCO_2$) and the Changjiang (1.1 $GtCO_2$). These emissions from only six of many degrading deltas and coastal areas, >12 $GtCO_2$, is approximately equivalent to estimated emissions arising from burning tropical forests in Brazil and Indonesia over 15 years (approximately 0.75 $GtCO_2$ annually). Addressing emissions from coastal wetlands will complement a global approach to natural carbon management for climate change mitigation.
- 13.5 $GtCO_2$ will be released within the next 50 years as a result of mangrove clearance of 35,000 km^2 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 km^2 of mangroves would release 58 $GtCO_2$ over the same time.
- Remaining coastal wetlands with peat-rich soils, which release higher than average amounts of CO_2 (0.25 $GtCO_2$ per km^2 for every depth meter of soil lost), are being rapidly converted for palm oil plantations and aquaculture in parts of Southeast Asia.



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

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.


Photo: J. Tamelander/IUCN

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 tCO_2/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).

tiveness of restoration activities. Management of coastal wetlands and seagrass beds is particularly important in developing countries, where co-benefits related to reduced vulnerability to climate change are particularly important.

Co-benefits

Managing coastal wetlands and seagrass beds for climate change mitigation offers a wide range of co-benefits for climate change adaptation and for sustaining community resilience and coastal livelihoods. Wetlands provide shoreline protection and flood water attenuation; they cycle nutrients and improve water quality; they provide important habitat for harvestable resources such as fish, other wildlife and migrating birds; and provide for recreation. The annual seafood market value of mangroves, for example, has been reported at US$7,500–$167,500 per km^2.

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 Convention[1], 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,

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'.


Photo: J. Tamelander/IUCN

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 seas grasses releases considerable quantities of carbon back in to 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-

Photo: D. Herr/IUCN

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 CO_2 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.

This summary is based on Crooks, S., Herr, D., Laffoley, D., Tamelander, J. and Vandever, J. 2010. "New Opportunities to Regulate Climate Change through Restoration and Management of Coastal Wetlands and Marine Ecosystems." World Bank, IUCN, ESA PWA. It is currently being finalized. Please cite this information brief as Capturing and Conserving Natural Coastal Carbon: Building mitigation, advancing adaptation. 2010. World Bank, IUCN, ESA PWA.

For more information, please contact:

Stephen Crooks
ESA PWA
s.crooks@pwa-ltd.com

Marea Hatziolos
World Bank
mhatziolos@worldbank.org

Dorothée Herr
IUCN
Dorothee.HERR@iucn.org