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Carbon sequestration and storage

In a nutshell

Ecosystems regulate the global climate by storing greenhouse gases. As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues ('sequestration'); thus acting as carbon stores.

1. Role for human well-being

Standing forests are the most well-known form of terrestrial carbon storage; dead organic matter and soils in forests are also important, however. Other ecosystems such as intact peat or wetlands and organic soils can also store large amounts of carbon in high concentrations (i.e. in relatively small areas). The largest active carbon sink on Earth are currently its oceans, mainly due to chemical processes that occur there. More than a quarter of the carbon dioxide released by humans into the air is estimated to enter the oceans. In addition to chemical processes, the biodiversity in the oceans is also important: phytoplankton and crustaceans absorb CO_2 while coral also stores carbon. When they die the carbon is fixed in the oceans' sediments. Carbon sequestration plays an important role in climate change mitigation. It can help to avoid economic and physical harm resulting from sea level rise, extreme events or water shortages.

2. Typical threats

The ability of ecosystems to serve as a sink or store for CO_2 (and other greenhouse gases) depends largely on the current and/or historical use and management of land and resources. The conversion and degradation of forests, wetlands and peat lands lead to high CO_2 emissions. Conversion is mainly driven by the spread of commercial agriculture for pastures or monoculture systems (e. g. soya, palm oil etc.). According to the report Deforestation and forest degradation drivers: synthesis report for REDD+ policymakers the carbon stored in forests is diminished by unsustainable logging used mainly for timber and (especially in Africa) for fuel wood and charcoal production. The overuse of non-forest timber products along with unmanaged small-scale agriculture – mainly for subsistence purposes – can also emit large amounts of CO_2. Additional factors are mining and conversion for urban expansion and infrastructure development. Carbon emissions from peat lands are caused by the drainage of large areas of organic wetlands and other events such as peat fires. Intensive industrial agriculture emits huge amounts of CO_2. Cattle ranching, rice production and emissions from unsustainably managed soils are the main causes. By contrast, soil-friendly extensive agricultural management can store C and capture CO_2. The oceans lose sequestration potential when the water temperature rises. Moreover, high concentrations of CO_2 result in the dying of coral reefs, thereby causing additional emissions.

3. Example indicators

- A widespread indicator is the total amount of living and dead C stored in an ecosystem biomass, measured in above-ground vegetation, roots and soil. However, roots are often excluded from assessments as they are difficult to measure.
- In the MoorFutures project in Germany the amount of C stored is indicated on the basis of the ecological condition and vegetation cover of peat lands.
- The economic value of carbon storage can be expressed by the current market price of stored carbon per hectare or per ton ($/ha; $/t).

- In most countries, carbon stocks and fluxes of greenhouse gases are monitored. Countries which are parties to the UN's climate change convention are obligated to establish a balance of emissions – including emissions/removal per land use type. See: unfccc.int/di/DetailedByCategory.do.

Global available sources for national data:

- FAO and IPCC have estimated geographically the comparative sequestration of carbon among national ecosystems.
- UNSD Environmental Indicators and the World Bank provide information on agricultural emissions by country.

4. Example methods

For **assessing the value** of this ecosystem service:

- Direct market price: Cost of CO_2 avoided expressed as $/ton of CO_2
- Avoided damage cost: (effect on climate parameter)
- Contingent valuation

For **assessing the condition** of this ecosystem service:

- Measuring forest carbon for carbon certification and soil carbon measurement
- InVEST Carbon Storage and Sequestration model
- See the overview in the TESSA toolkit (p.50) for assessing the contribution to global climate regulation of a current and alternative state of an area.
- The TESSA toolkit (p.IV) provides methods for calculating carbon storage, carbon sequestration, carbon dioxide emissions, methane emissions, nitrous oxide emissions and overall greenhouse gas fluxes as well as for calculating carbon stocks in different habitat types (grassland-dominated, tree-dominated and crop-dominated habitats).
- Methodologies and data available for quantifying GHG emissions from peat lands and organic soils are summarised in Peatlands – guidance for climate change mitigation by conservation, rehabilitation and sustainable use (FAO and Wetlands International). The report includes practical solutions on measuring, reporting, verification (MRV) and accounting.
- A Technical guide from the LEAF project provides guidance on the stratification process for developing accurate and statistically rigorous estimates of forest carbon stocks based on available National Forest Inventory (NFI) data.
- The webpage Global Forest Trends offers a global map on forest cover change; satellite data per area can be downloaded. The Global Forest Observation Initiative is developing a similar map and database for selected countries.

5. Managing this service

Typical instruments for managing this service include:

Development and implementation of climate smart land and soil use strategies, especially in agriculture and forestry

- Guidance on approaches, methods and detailed practical steps for enhancing carbon stocks and reducing CO_2 emissions in agriculture and natural resource management projects is provided by this World Bank toolkit.
- The CoopeAgri agroforestry project works with Costa Rica's national forestry financing fund (FONAFIFO) and with farmers to support low-carbon agriculture in symbiosis with forestry. This, in turn, generates associated benefits such as erosion protection and habitat services, while carbon credits that are sold to the BioCarbon Fund create a revenue stream to help make the project sustainable.

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Conservation and restoration of ecosystems with great potential for carbon sequestration and storage

- The Central Kalimantan Peatland Project has found an effective approach to restoring the drained and degraded peat swamp forest of Central Kalimantan, Borneo, Indonesia together with communities and improving the people's livelihoods.
- The Global Map of Forest Landscape Restoration Opportunities (WRI 2011) indicates that more than two billion hectares worldwide offer opportunities for restoration – an area larger than South America. Most of these lands are in tropical and temperate areas.
- Using a decision support tree, the guide Peatlands – guidance for climate change mitigation by conservation, rehabilitation and sustainable use (FAO and Wetlands International) helps users to find opportunities for both cultivated and uncultivated peat lands.
- Ducks Unlimited and its partners developed the Avoided Grassland Conversion Carbon Program to preserve and restore native prairies on private lands in the USA. The project has stimulated discussion with policy makers about potential grassland benefits.

Forest Carbon Projects

- In Sumatra, Indonesia the InVEST model has been used to model the quantity and location of carbon storage and sequestration under a business-as-usual scenario and a sustainable land use scenario. Information on other ecosystem services can be used to lobby for, and help implement, commitments by local government policy makers to establish incentive mechanisms that reward sustainable land use and conservation, such as forest carbon projects.
- The REDD desk is a global knowledge hub for the latest research and developments from the international REDD+ community, providing a comprehensive and easily searchable tool for information on REDD+ for policy makers, researchers and other practitioners.
- The websites of Forest Carbon Asia and the LEAF project includes a variety of resources and tools related to technical capacity building and focused on forest carbon, REDD+, climate change mitigation, gender mainstreaming, and policy and market incentives for improved forest management and land use planning in Asia and beyond.
- CBD Special issue: REDD plus and Biodiversity: General information on risks, safeguards and synergies for REDD-plus and biodiversity

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