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# OPPORTUNITIES FOR INCLUDING PEATLANDS IN NATIONALLY DETERMINED CONTRIBUTIONS (NDCs)

## by linking them to mangroves with special attention to the Caribbean region

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# Content

## Summary

Wetlands play a significant role in climate change mitigation. Under natural conditions, they sequester and store substantial amounts of carbon in their soils. This applies specifically to those wetlands that ensure progressive carbon accumulation at increasingly higher levels and in larger areas by positive feedback between biota and landform.

Such wetlands include peatlands and blue carbon ecosystems such as mangroves, saltmarshes and seagrass meadows. Often, these wetland types coexist in coherent landscapes along the coast where they provide synergetic ecosystem services relevant for climate change mitigation and adaptation, e.g. by protecting inland freshwater resources and contributing to coastal protection.

Degradation, in particular drainage, reverses the carbon pathways in these ecosystems and results in substantial greenhouse gas (GHG) emissions. Therefore, both their conservation and restoration are important for climate change mitigation, which is the focus of this report.

Despite the general preeminence of their carbon stocks, peatlands do not receive the same attention in climate policies as their blue carbon counterparts. To stimulate this attention, we scoped the opportunities for enhancing conservation and restoration of peatlands adjacent to mangroves in countries with mangrove-oriented climate change activities.

First, we identified the countries worldwide where coastal peatlands - here defined as peatlands within 100 km from the coastline - and mangroves co-occur. Then, we checked which of these countries mention activities on mangroves or peatlands in their Nationally Determined Contributions (NDCs), followed by the identification of one region (and associated countries) with a positive attitude towards wetland directed action. Lastly, we selected key countries within that region and formulated priority actions for these countries based on literature research and interviews with experts. For these countries, we also collected information on peatland properties and land use trends.

Worldwide, 58 countries and territories possess both mangroves and adjacent coastal peatlands. Yet, mangroves outweigh peatlands in the NDC commitments of these countries by far. Thirty-five countries have mentioned actions related to mangroves, while only eight mention actions related to peatlands, namely: Colombia, Costa Rica, Ecuador, Honduras, Indonesia, Malaysia, Mexico and Myanmar. No country with both ecosystems coexisting within the 100 km zone has commitments on peatlands only.

Activities on peatlands and mangroves are prominent in and limited to countries in Southeast Asia and in the Caribbean, with a focus on mitigation in the former and adaptation in the latter region. Seven Caribbean countries (Belize, Costa Rica, Colombia, Honduras, Mexico, Nicaragua and Panama) are particularly promising for further action when we look at their peatland/mangrove occurrences and NDC commitments. Most of these commitments currently relate to adaptation-aspects, such as water supply and regulation. Only Costa Rica has peatland specific mitigation activities, whereas Panama has indicated its intention to include peatland mitigation activities in its next NDC update. The other five countries have mangrove mitigation activities only and may therefore be receptive to including also peatland mitigation action in their NDCs. Other countries in the region have substantial areas of peatland, e.g. Cuba, but lack emission reduction measures for both mangroves and peatlands.

In the mentioned seven Caribbean countries, coastal peatlands are concentrated in the tropical rain forest ecological zone, with less peatlands in the moist deciduous forest and dry forest zones. They are often found close to mangroves along the Caribbean coast, except in Costa Rica. The area of coastal peatlands outweighs the mangrove area in all seven countries, suggesting that the peatland carbon stocks will be much larger.

The vegetation of coastal peatlands consists of various lifeforms and functional groups including mangroves, freshwater swamp forests, and open herbaceous communities. Peat depths vary from 50

cm up to 15 m. In the literature, the peatlands are mostly referred to as being ombrotrophic, i.e. solely rainwater fed, but peatlands dominated by herbaceous plants are likely to be minerotrophic, i.e. surface- and/or groundwater fed. No study in any Caribbean peatland thus far considers ecohydrological functionality, i.e. the hydrological factors conditioning peatland ecology.

Land use trends in the identified countries indicate deforestation and expansion of grazing and cropland in the coastal peatlands, associated with drainage. These trends are confirmed by the interviewed experts working in the Caribbean region.

Recommended priority actions in this region are: peatland mapping, with a strong ground-truthing component, setting-up a monitoring system for GHG fluxes and biodiversity, quantifying water regulation adaptive capacity of peatlands, developing and improving monitoring, verification and reporting methodologies for land use and GHG emissions, piloting peatland conservation and restoration projects in catchments with mangroves using a landscape approach to increase synergies, and building on existing project experiences. All these activities should go hand in hand with capacity building of personnel and technology as well as with raising awareness of the public, administrative authorities and policy makers.

# 1. Introduction

Of all carbon capturing and storing ecosystems of our planet, biogeomorphic wetlands are the most space-efficient ones (Temmink et al. 2022). Their carbon sequestration rate (g C $m^{-2}$ $yr^{-1}$) and carbon density (g C $m^{-2}$) exceed those of all other oceanic and terrestrial ecosystems (Figure 1). Whereas they cover only 1 % of the Earth's surface, they store 20 % of the global organic ecosystem carbon. The basis of these assets are positive feedbacks: biogeomorphic wetlands are characterized by self-reinforcing interactions between biota and geomorphology, by which vegetation engineers landforms to its own benefit. In peatlands, for example, the died-off plant remains are conserved by oxygen exclusion under water, dam-up water flow and thereby ensure peat accumulation at increasingly higher levels and wider areas (Couwenberg 2021). Coastal wetlands, i.e. blue carbon ecosystems (seagrass meadows, saltmarshes, mangroves), are driven by productivity stimulating feedbacks. With their aboveground vegetation they attenuate currents and waves from the ocean and from rivers and trap large amounts of nutrients (which stimulate plant growth) and organic particles (which help building up the carbon stocks in the root-stabilized anoxic soils) (Temmink et al. 2022). From a perspective of Nature-Based Solutions (NBS) for climate change mitigation, there is no way around biogeomorphic wetlands.

Next to climate change mitigation, biogeomorphic wetlands provide other important ecosystem services in conjunction with one another. Seagrass meadows form a first line of defense against waves, whereas coral reefs break the biggest waves, thereby facilitating mangrove establishment. Mangroves stabilize the coastline with their roots and coastal peatlands function as buffers between oceanic salt- and inland freshwater. Peatlands store freshwater, block salt-water intrusion in the inland aquifers and provide permanent water supply for local communities. In return, peatlands and mangroves filter nutrients and sediments from upland and riverine sources, preventing excessive nutrient loading and siltation in neighboring coral reefs and seagrass meadows (Figure 2). This reciprocal interaction is particularly important in regions prone to hurricanes and with large economic risks from such natural disasters, for instance the Caribbean region (Miranda et al. 2020; del Valle Alejandro et al. 2020).

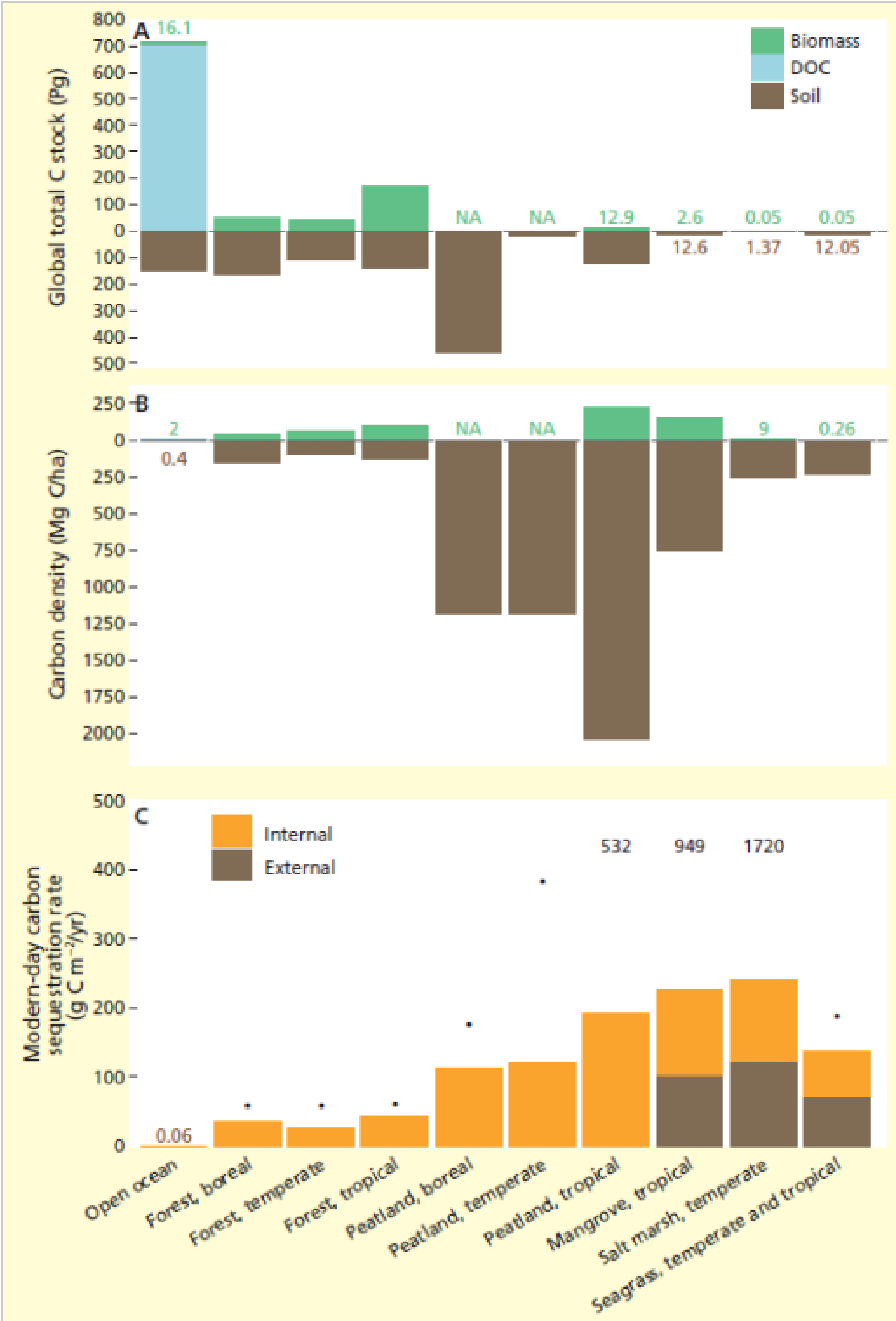


**Figure 1.** Carbon stocks (a), carbon density (b) and annual modern-day carbon sequestration rate (c) in biogeomorphic wetlands (Source: Temmink et al. 2022).

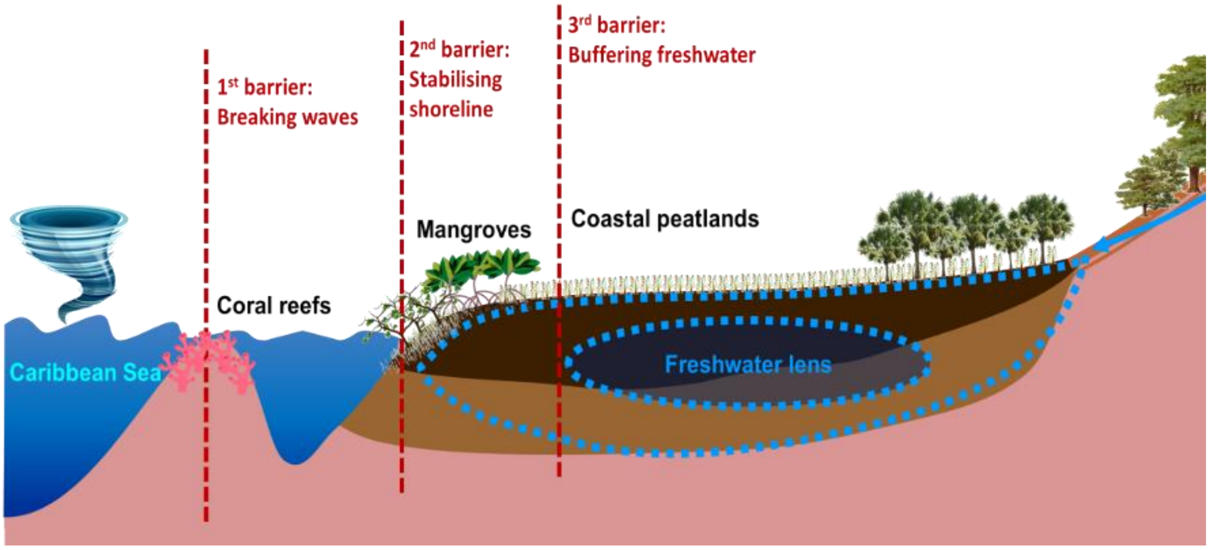


**Figure 2.** Examples of coastal wetland interconnectedness in the Caribbean (Source: Peters & Tegetmeyer 2019).

## Aim and general approach

Despite the multitude of reasons to conserve and restore peatlands (See Box 1), awareness of the role of peatlands in the international climate policy arena is not on the same footing as the attentiveness to other wetland types, such as mangroves (cf. "Blue carbon"). In this document, we aim to clarify the role of peatlands in climate change mitigation, especially in tropical countries with established interests in conserving mangroves to expand this interest to peatlands.

We started by identifying countries with mangroves and with peatlands within 100 km distance from the coastline. Then, we searched the Nationally Determined Contributions (NDCs) of these countries to identify their activities related to mangroves and to cross-reference them against their peatland related activities. We used these political commitments to identify one priority region and a series of associated countries with a basic receptiveness to engage with peatlands. Subsequently, we selected priority countries based on peatland distribution, properties and land use trends, and identified priority actions based on literature review and expert interviews. Finally, we scoped the opportunities for organizations interested in peatland conservation and restoration to engage in these countries.

**Box 1: Reasons to conserve and restore peatlands (Adapted from Ramsar Convention on Wetlands 2021)**

'Peatland' is a general term to denominate land with a naturally accumulated layer of peat at the surface. Peatlands include both ecosystems actively accumulating peat, and degraded peatlands that no longer accumulate but in contrast lose peat.

Peat is actually nothing more than partly decomposed (but still macroscopically recognizable) plant remains that have been conserved on the spot where they have been produced (in situ). Peat is formed when microbial decomposition of dead organic matter is hampered by anoxic (oxygen-free conditions) or very low temperatures. By accumulating peat, peatlands store carbon that plants have extracted as $CO_2$ (carbon dioxide) from the atmosphere and have converted by photosynthesis into living plant material, which later forms peat. About 50 - 60% of this material consists of carbon (Joosten et al. 2022).

A decisive feature of peat-accumulating peatlands ("mires") is their high and stable water table, which creates the anoxic conditions necessary for peat accumulation and preservation. Peat-accumulating peatlands are always wetlands: only in arctic regions, peat may also pile up because organic material is conserved by rising permafrost. Degraded peatlands no longer accumulate peat/carbon and often – e.g. after severe drainage - are not wetlands anymore. However, although they lose carbon, they still may have significant (but continuously diminishing) carbon stocks in their residual peat layers (Joosten et al. 2022).

Peatlands restoration is at a global level mainly motivated by climate change mitigation (Ramsar Convention on Wetlands 2021). However, other reasons for peatlands conservation and restoration include water regulation and prevention of biodiversity loss. Between these aims, trade-offs occur.

**Mitigation:** The huge emissions from drained and otherwise degrading peatlands can be significantly reduced by raising the long-term average water table to near the surface and by restoring undrained degraded sites. Even when rewetting drained peatlands re-installs methane emissions and may even produce an initial methane peak, the overall longer-term effect of rewetting is climate cooling. This is because $CH_4$ has a much shorter atmospheric lifetime compared to $CO_2$ and $N_2O$, which steadily accumulate in the atmosphere, whereas the atmospheric concentrations of $CH_4$ quickly reach a steady state. However, because of the possible methane peak, it is necessary i) to rewet as fast as possible (i.e., between 2020 and 2040) to prevent the initial emissions from amplifying peak global warming (Günther et al. 2020) and ii) to limit methane emissions as far as possible by appropriate management (Ramsar Convention on Wetlands 2021).

**Adaptation:**

Water regulation and supply:

The provision of good quality drinking water from peat-dominated catchments is generally limited to peatlands with little drainage and human use. More disturbed sites release substantial quantities of humic acids, nitrogen, sulphur, heavy metals, and suspended solids (Price et al. 2016; Nieminen et al. 2018), whereas drain-blocking generally leads to a substantial reduction in the outflow of such substances (Clymo et al. 1982; Wallage et al. 2006; Menberu et al. 2017; Taylor et al. 2018). Furthermore, simply re-vegetating bare peat can reduce loss of carbon particles dramatically (Thom et al. 2016).

Denitrification as a nitrate removing process takes place when nitrate-enriched water encounters water-saturated, anoxic peat (Hayden & Ross 2005). Removal of organic matter, solids, phosphorus, and nitrogen from incoming water is a function of wet peatland vegetation and therefore restricted to little or non-disturbed and specifically managed sites (including paludiculture) (Joosten et al. 2012; Vroom et al. 2020). In some cases, restoration may result in a temporarily increased flush of nutrients into downstream watercourses, but the release of nutrients decreases in the longer term (Menberu et al. 2016, 2017).

Wet peatland vegetation and crops can in general withstand inundation for much longer periods than dryland vegetation. Peatlands may thus, in favourable settings, function as water retention and flood control areas, also after rewetting. Flood mitigation is especially possible in peatlands that are unused or used for paludiculture and therefore less vulnerable to inundation (Joosten et al. 2015).

Biodiversity:

Although the number of species found in a peatland may, in certain cases, be relatively low, peatlands have a higher proportion of specialised, characteristic species than dryland ecosystems in the same biogeographic zone. As a result of habitat isolation and heterogeneity, peatlands play a special role in maintaining biodiversity at the genetic level (Minayeva et al. 2008, 2016, 2017). Peatlands may furthermore have a high ecosystem diversity, reflected in conspicuous surface patterns on various hierarchical and spatial scales, which express hundreds or thousands of years of sophisticated self-organisation and self-regulation (Couwenberg 2021).

Peatlands also support biodiversity far beyond their borders by regulating the hydrology and meso-climate of adjacent areas. Peatlands are often the last remaining more or less natural areas in degraded landscapes. They, thus, provide both refuge areas for endangered species with an originally much wider distribution (e.g., great apes in tropical Asia and Africa) and cool shelters for species displaced by climate change (Minayeva et al. 2008, 2016, 2017).

# 2. Methods

## Peatlands and mangroves distribution

We scrutinised datasets on peatlands, mangroves, coastlines, and country boundaries and selected the ones deemed most accurate in terms of spatial resolution, up-to-dateness, and comparability (Table 1). All spatial data were processed with the Geographical Information System QGIS (versions 3.16 and 3.22) using the World Mollweide coordinate reference system (54009). Data not provided in that reference system were transformed prior to analysis. As a first step to identify mangroves and coastal peatlands, we determined a 100 km wide zone along the coastlines[1] (see Table 1). Additionally, we determined a second zone consisting of the mangrove area and a 100 km zone surrounding it. Within both these zones, we identified peatland distribution and determined peatland and mangrove area per country using the Field Calculator function in QGIS.

**Table 1.** Databases used in mapping the distribution of mangroves and peatlands.

| Name | Description | Version | Source |
|---|---|---|---|
| Global Peatland Database (Greifswald Mire Centre 2022) | Global peatland distribution | 2021_12COP | Global Peatland Database, Greifswald Mire Centre |
| Global Mangrove Watch (GMW) (Bunting et al. 2018) | Mangrove distribution | 2016 | https://data.unep-wcmc.org/datasets/45 |
| OSM Coastlines (OpenStreetMap contributors 2022) | Coastlines | 2022-03-09 | https://osmdata.openstreetmap.de/data/coastlines.html |
| Geoboundaries (Runfola et al. 2020) | Country boundaries | 2020 | https://doi.org/10.1371/journal.pone.0231866 |

## NDC directory search

We searched the UNFCCC NDC directory[2] for activities related to mangroves and peatlands in countries with both mangroves and nearby peatlands (Figure 3) starting with using the keywords mangrove(s), manglare(s), mangle and blue carbon. If positive results were found, we checked whether the respective country has peatlands within 100 km from the coastline. Then we checked whether that country also mentions peatland related activities in its NDC using the following keywords: wetland(s), peatland(s), organic soil(s), histosol(s), bofedale(s), paramos, turbera, tourbe, tourbière(s) and zone humide. We reversed the search starting with peatland keywords to check whether countries with both mangroves and peatlands mention peatland related activities only. The search included only NDC submissions made before 15 April 2022.

[1] For the purpose of this report, we define coastal peatlands here as peatlands within 100 km from the coastline.
[2] https://unfccc.int/NDCREG

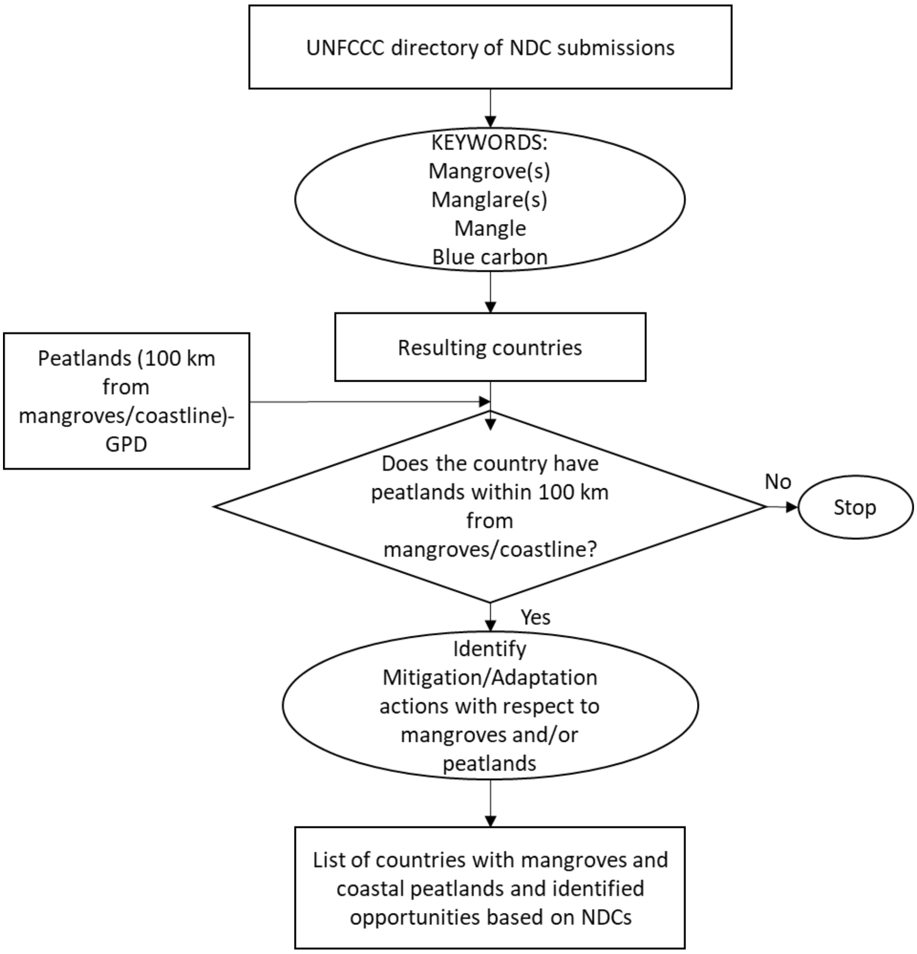


**Figure 3.** Flowchart of the NDC directory search for mangroves and peatlands related activities in countries with both ecosystems within 100 km from each other.

## Expert interviews

Interviews were carried out with experts on peatlands from a global perspective to identify regions of special global relevance for climate change mitigation and/or adaptation (Table 2). A second round of interviews addressed experts on the Caribbean region, which had been selected as most promising, to assess the state-of-the-art knowledge in research and policy and to identify the opportunities and constraints for knowledge, implementation, and policy enhancement.

Each interview started with the expert introducing his/her background and relevant experience. After presenting the project goals, the preliminary results on peatland and mangrove distribution, and the NDC commitments of the country of interest, we asked each expert:

a. What are the mapping, research, or policy efforts needed to conserve and restore peatlands and to ensure that countries can include these ecosystems in their NDCs as well as in their reporting to other related UNFCCC instruments (global, regional and national)?
b. Which countries within specific key regions lack relevant data, technical capacity, or policies and which have indicated a need for assistance with peatland conservation and restoration efforts? How do you see that in view of the data presented on the distribution of peatlands and mangroves (global and regional)?
c. Which knowledge, management options (or key land use practices) and policy plans are currently in place for peatlands in the region/country (regional and national)?
d. What are the priority ecosystem services and climate change mitigation/adaptation measures for the region/country (regional and national)?

e. How can non-governmental organizations, especially environmental and conservation organizations, help countries to progress peatland conservation or restoration, with an emphasis on supporting the inclusion of peatlands into countries' NDCs (regional and national)?
f. Which are the priority regions for technical capacity, implementation and/or policy enhancement? And which interventions are most urgent (regional and national)?

Some of the questions were adjusted to fit the experts' profile and expertise. We conducted all interviews via Zoom video calls, and recorded and stored them for further analysis. We used the feedback of the interviewees to select the region/country of interest and noted the recurring themes on policy relevance, knowledge gaps and priority actions using keywords and highlights. The data here represent a targeted sample of experts and are not necessarily representative for all global peat researchers and/or specific stakeholders in the region/country of interest.

## Priority region and country selection

Criteria to select the priority region and priority countries included 1) the presence of both mangroves and coastal peatlands (the latter at least 500 $km^2$) within the country, 2) the inclusion of peatlands in the country's NDC (or their announced upcoming inclusion, as in case of Panama), 3) the inclusion of mangroves (particularly for mitigation action) in the country's NDC, and 4) the priority country selection of the interviewees (in light of country's NDC commitments, political situation and land use trends).

**Table 2.** List of interviewed experts, their affiliation, focal region and expertise.

| Name | Affiliation | Focal area and expertise |
|---|---|---|
| Alexandra Barthelmes | Greifswald Mire Centre, Germany | Global, peatland mapping |
| Dianna Kopansky | UNEP Nairobi, Kenya | Global, international policy and peatlands |
| Faizal Parish | Global Environment Center, Malaysia | Global/Southeast Asia, peatlands science and policy |
| Hannah Morrissette | Smithsonian Environmental Research Center, US | National (Belize), soil organic carbon |
| Jorqe Hoyos-Santillan | University of Magallanes, Chile | Regional (Central and South America), peatland science |
| Julie Loisel | Texas A&M University, US | Regional (Americas, Caribbean), peatland science |
| Maria Nuutinen | FAO Rome, Italy | Global, international peatland policy and land use |

## Land use trends

Data on land use trends were obtained from Hilda+, the global dataset on land use change (Winkler et al. 2022). Hilda+ expresses frequency of change in single and multiple events and presents change of forest, cropland and pastureland in four categories: stable, loss, gain and multiple events of loss and gain. We overlaid the peatland distribution in the selected countries on these spatially explicit data. Finally, we used the "Zonal histogram" tool in QGIS to quantify the trends in the four categories for the peatland area of each country.

# 3. Results and Discussion

## Climate change mitigation relevance of peatlands

In natural peatlands, new plant material is produced faster than dead plant material decomposes. Like pickled vegetables, the plant remains are conserved under water in the absence of oxygen and accumulate as “peat”. Natural peatlands are therefore always wetlands. Not all wetlands are, however, peatlands. Only those wetlands where water saturation is almost continuous accumulate peat, because the decomposition of plant material under oxic (oxygen-rich) conditions is an order of magnitude faster than its accumulation under anoxic (oxygen-free) conditions (Joosten et al. 2022).

By accumulating peat, peatlands store carbon that plants have extracted as $CO_2$ from the atmosphere by photosynthesis and converted into (initially) living and (later) dead plant material: peat. Peatlands often accumulate peat over many thousands of years, leading to layers of peat several meters thick. This persistent accumulation is made possible by positive feedback: the dead plant remains are conserved by water, then obstruct water flow and thereby ensure water saturation and peat accumulation at increasingly higher levels (Temmink et al. 2022; Couwenberg 2021).

As a result of thousands of years of carbon sequestration, peatlands contain a disproportionate amount of carbon compared to other ecosystems. Typically, they hold 1 000-2 000 tonnes of carbon per hectare. Comparatively, forests on mineral soils contain 140-230 tonnes (Temmink et al. 2022). Peatlands cover just 3 percent (i.e. about 450 million ha) of the land area of our planet, yet contain 600 gigatonnes of carbon in their peat. This equates to 30 percent of all carbon in all soils of the world, and almost twice the carbon stock of the world’s total forest biomass on 31 percent of the land (Joosten & Couwenberg 2008; Temmink et al. 2022). Due to this enormous carbon density, it is crucial to include peatlands in the NDCs, even when the area of peatlands in a country might be small.

## Global distribution of mangroves and peatlands

Particularly Central America, north and east South America, Western and Southeast Africa, and Southeast Asia feature substantial areas of coastal peatlands (Figure 4).


**Figure 4.** Mangrove and peatland within 100 km from the coastline (highlighted areas are exaggerated for display) (Sources: Global Peatland Database, Global Mangrove Watch, Openstreetmap).

In total 58 countries and territories (three French territories counted as one: Guadeloupe, French Guiana and Martinique) have both mangroves and coastal peatlands, i.e. peatlands within 100 km from the coastline. On a global scale, differences in size and amount of peatlands for the zone of 100 km from the coastline or from the mangrove edge are not shown. The full results are available in Annex 1.

### *Uncertainties and limitations of the datasets*

Altogether, a robust database was available for most countries and regions. Nevertheless, computation itself was a challenge. Since the standard "clip" operation of QGIS took very long run time and failed for the mangrove area by country, we referred to the GRASS GIS operator "v.overlay" to analyse mangrove area by country instead.

The mangrove data seem to have some gaps. No mangroves are, for example, listed for Togo and Republic of the Congo, although both countries' neighbouring countries do have mangroves. In comparison to the other datasets, the mangrove data are rather old. An updated version of the World Mangrove Watch was expected to be published in July 2022 (pers. comm. Mark Spalding 2022-03-03) but was not available at the time of the analysis.

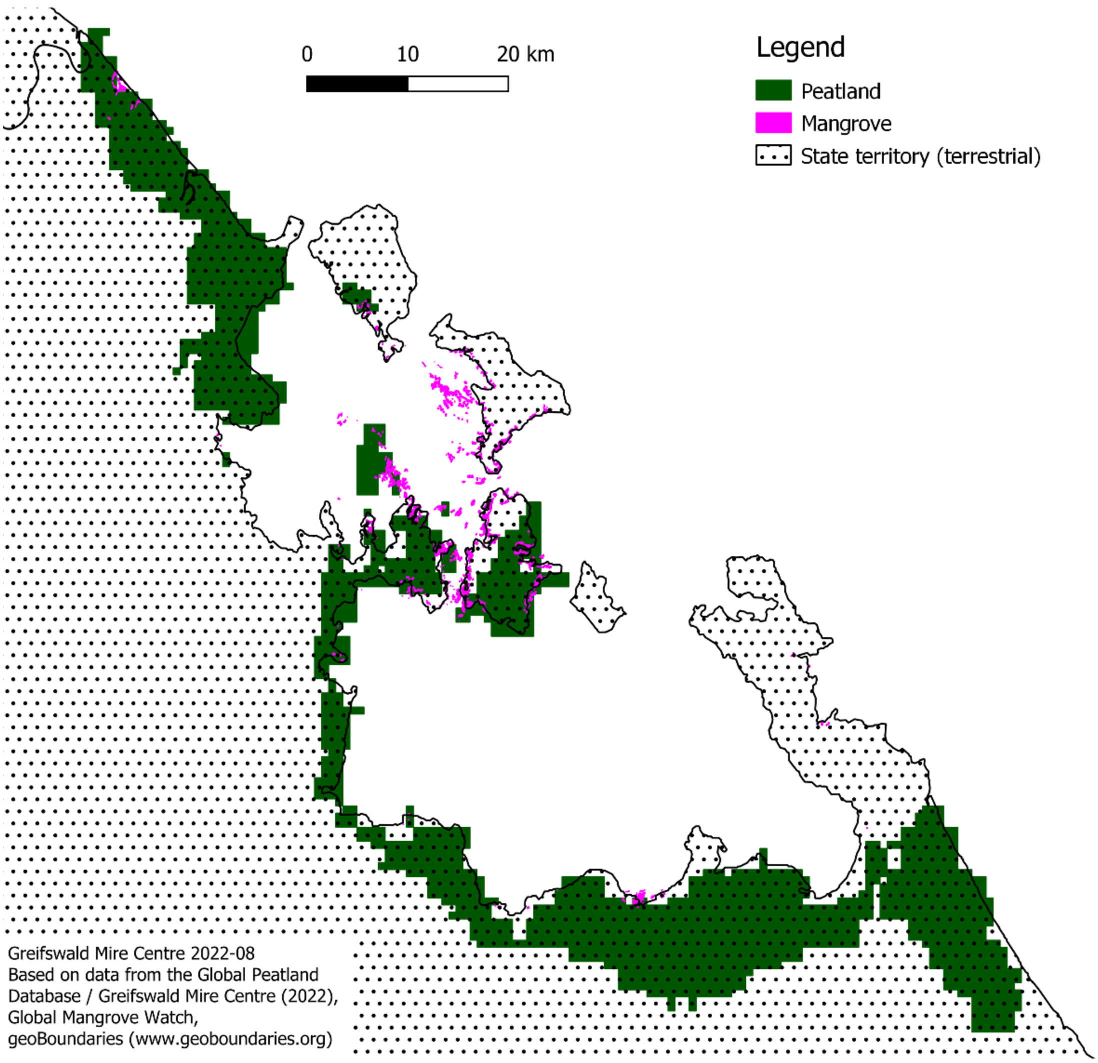


**Figure 5.** Peatland, mangrove and terrestrial state territory in North-West Panama.

The peatland map offers a good overview of the peatland distribution worldwide. However, as the map is based on various, partly outdated data sources and only few peatland occurrences have been verified by field campaigns, the presented peatland distribution should be considered as "probable" pending further ground-truthing. This also applies to peatland distribution and status in regions with intense human activity such as drainage and agriculture.

One unexpected major constraint were the country boundaries, including the boundaries between land and sea. Especially in mangroves and coastal wetlands it is not always clear where the boundary is to be drawn. The available datasets on countries' boundaries draw lines between land and sea, with consequences for the analysis. The data have, due to their global character, a comparatively coarse resolution and may cut across and therewith cut-off some mangrove and peatland area, for example in northwest Panama (Figure 5). In this example, the peatland and mangrove area outside the dotted area was omitted in the calculations as only the dotted, terrestrial state territory (according to the data) was counted. Other data sources for country boundaries, e.g. OSM, are inconsistent and do not provide a better alternative. As a result, the mangrove and peatland area might be larger than calculated for some countries. For an in-depth analysis of single countries, better options have to be used.

## Peatlands and mangroves in NDCs

Wetlands – including peatlands and mangroves – have been recognized as an important part of NDCs (Anisha et al. 2020; Herr & Landis 2016). Despite the general preeminence of peatland carbon stocks, NDCs show a severe underrepresentation of peatlands compared to mangroves (and other blue carbon systems). Among the 58 countries and territories with both ecosystems present, only eight countries have mentioned actions related to peatlands while 35 countries bring up actions related to mangroves (Figure 6). All eight countries with actions on peatlands also have mitigation actions on mangroves. Of the 35 countries with actions on mangroves, twelve have specific mitigation actions on mangrove, while the rest have adaptation actions. The 35 countries cover all tropical regions: from Southeast Asia, west and east Africa to Central and South America. Of the eight countries with actions on peatlands, only four have mitigation actions namely: Costa Rica, Indonesia, Malaysia and Myanmar.

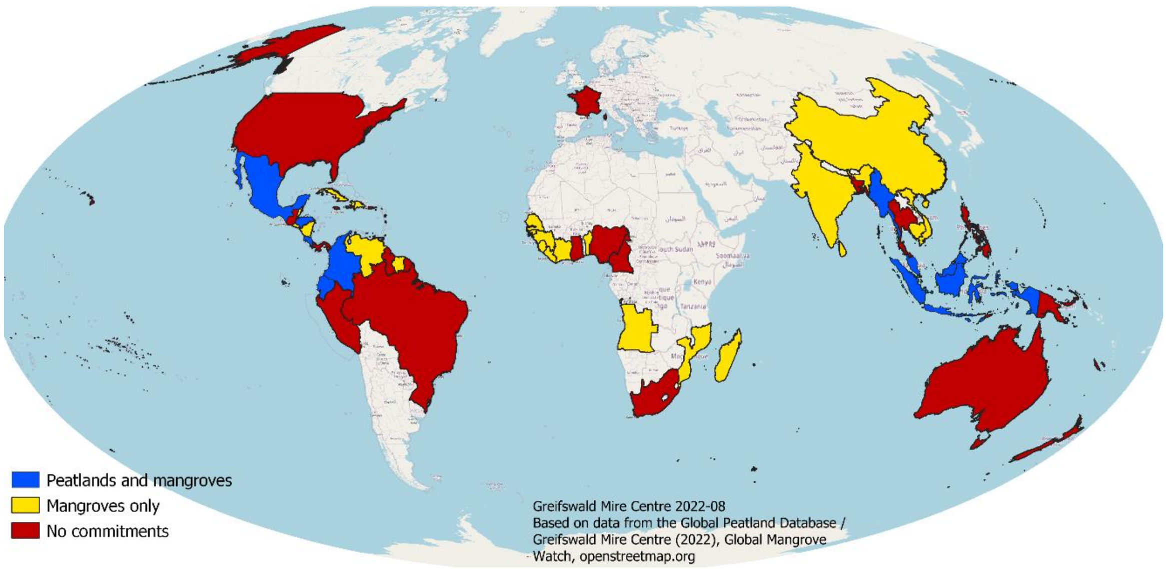


**Figure 6.** NDC commitments in countries with mangroves and peatlands within 100 km from the coastline. Blue: countries with NDC activities on both peatlands and mangroves. Yellow: countries with NDC activities on mangroves only. Red: countries with commitments on neither mangroves nor peatlands.

All countries with peatlands near the Caribbean coastline have made commitments on mangroves, except Guatemala and Panama[3], whereas four have mentioned peatlands in their NDCs: Colombia, Costa Rica, Honduras, and Mexico. Costa Rica is the only country in the region with mitigation actions on peatlands, while the other three include peatlands as part of their adaptation plans, particularly focusing on water supply.

The aim of this report is to identify opportunities for organizations interested in NBS to engage with peatlands, particularly in countries with mangrove-oriented climate mitigation activities in their NDCs. In Central America, several countries have already included adaptation actions on peatlands. But, unlike Southeast Asian countries where mitigation actions are in place due to more knowledge and resources made available in the past decade, more needs to be done in Central America. Therefore, **priority countries based on the political commitments made in their NDCs are Belize, Colombia, Costa Rica, Nicaragua, Honduras, Mexico, and Panama.** Other countries in the region are important in terms of the extent of their peatland area, e.g. Cuba, but lack mitigation activities on either mangroves or peatlands.

## Central American coastal peatlands

### *Distribution of mangroves and peatlands in Central America*

Taking a closer look at Central America, mangroves occur on both the Pacific and the Caribbean coast, whereas coastal peatlands are mainly restricted to the Caribbean coast (Figure 7). In South America, vast probable peatland areas near the coastline stretch from Venezuela to the Amazon Delta. Additionally, such likely peatland areas exist in Colombia and southeast Brazil. Coastal peatlands have been reported from Central America and the Caribbean (Page et al. 2011), but their definition varies and is mainly based on altitude, i.e. reflecting lowland as opposed to mountain peatlands. Such a binary definition may not be suited to demonstrate peatland diversity, which may vary across regions and sites, for instance due to regional and local climatic and hydrogeological conditions.

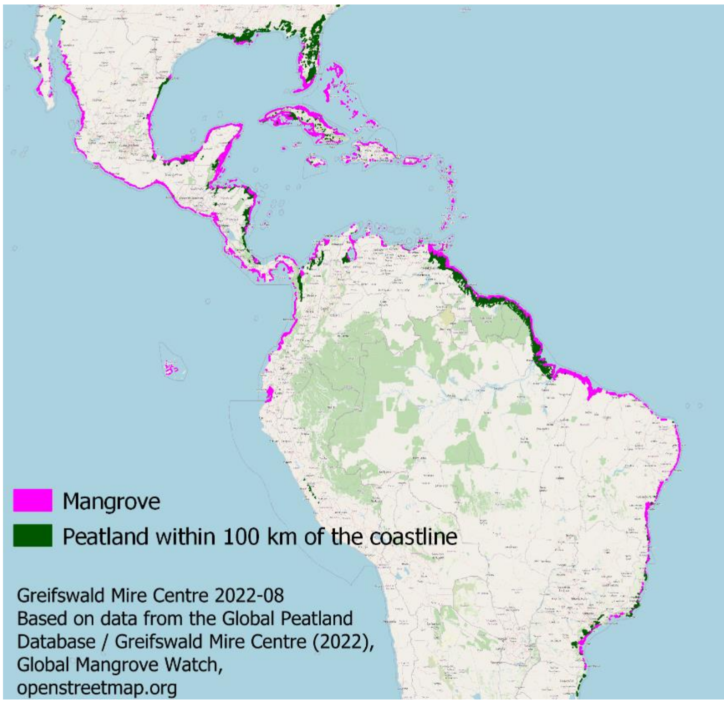


**Figure 7.** Mangrove and peatland within 100 km of the coastline in America (area exaggerated for display).

[3] Panama has at the Bonn Climate Conference June 2022 indicated its intention to include peatlands in the NDC submission for UNFCCC COP 27 in Egypt.

Peatlands near mangroves are present in all countries of the Caribbean. However, only six countries, with NDC mitigation actions mentioned for either peatlands or mangroves, have more than 500 km² of peatland area within 100 km from the coastline, namely Belize, Colombia, Honduras, Mexico, Nicaragua, and Panama (Figure 8). Furthermore, the peatland areas within 100 km from the coastline in all Caribbean countries are larger than the mangrove areas. The largest concentration of Caribbean coastal peatlands is within the tropical rainforest ecological zone (GEZ FAO 2012), while some are in the tropical moist deciduous forest and dry tropical forest zones, particularly in Yucatan (Mexico) and Colombia (Figure 9).

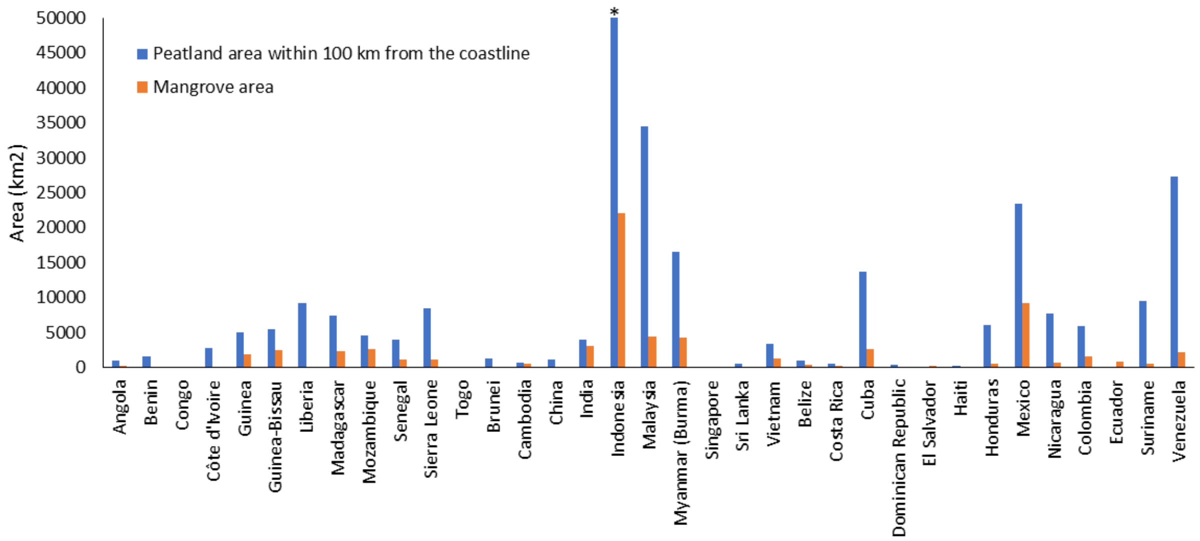


**Figure 8.** Mangrove and peatland area within 100 km from the coastline, in countries with NDCs actions on mangroves. * Indonesia's peatland area within 100 km from the coastline is 366,767 km².

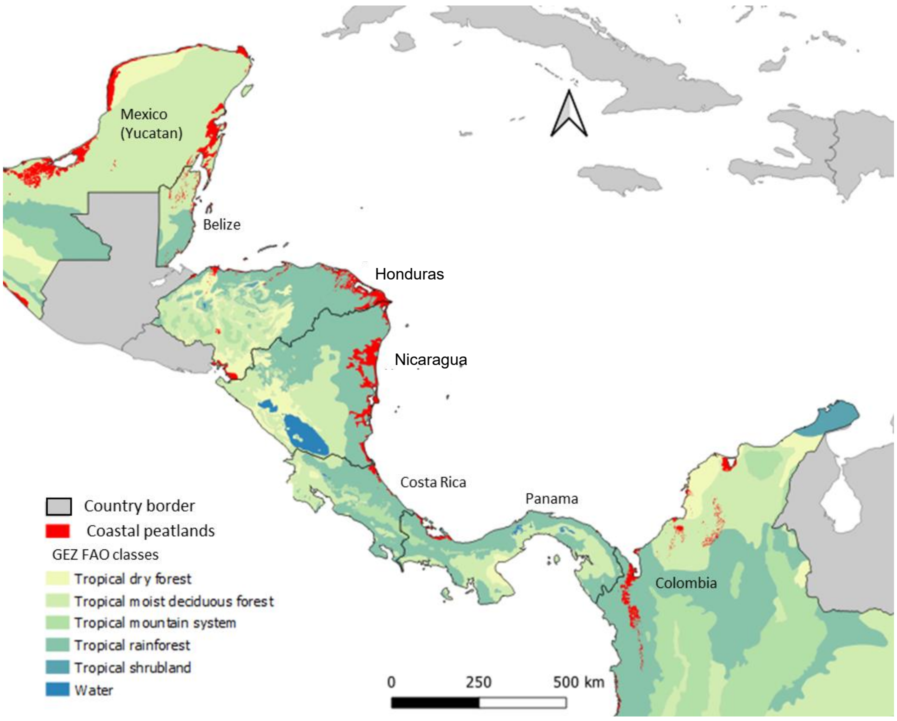


**Figure 9.** Coastal peatlands, 100 km from the coastline, in the selected Caribbean countries overlaying the global ecological zones (GEZ) of FAO (2012).

### *Physical properties and key ecosystem services*

Vegetation cover in peatlands is highly diverse and may include various mangrove species (e.g. *Rhizophora mangle*), *Raphia taedigera* palm (Figure 10), mixed woody species (including *Campnosperma panamensis* and *Symphonia globulifera*) and herbaceous species (including *Cladium* sp. and *Eleocharis* sp.) (Figure 11) (Phillips et al. 1997). Available literature indicates that peatlands in the Caribbean can be either ombrotrophic or minerotrophic, i.e. solely rainwater-fed or also surface- and/or groundwater fed (Peters & Tegetmeyer 2019). The ombrotrophic peatlands are domed, acid and nutrient poor. The minerotrophic ones are fed by water that has been in contact with the mineral substrate and consequently less acid and more nutrient rich (Cohen et al. 1995).

**Figure 10.** *Raphia taedigera* peatland in Costa Rica (source: Peters & Tegetmeyer 2019).

Although not much systematic information on peat depth distribution, carbon stocks and peat hydrological properties is available, some data do exist. In Costa Rica, peat depths of up to 15 meters have been reported in Medio Queso (Obando et al. 1995). Thick peat deposits have also been found in coastal peatlands in Nicaragua and Mexico (Page et al. 2011, Sjögersten et al. 2021). The largest deposits have been reported from Panama, the best studied example being the 80 $km^2$ ombrotrophic, domed Changuinola deposit in Bocas del Toro on the Caribbean coast (Upton et al. 2018). Many mangrove areas also have peat deposits (Cahoon et al. 2003; Wooller et al. 2007), for example a recent ground-truthing in Belize reported peat depths ranging between 0.5 to 3 meters (pers. comm. Hannah Morrissette).


**Figure 11.** a) Landscape impression of open grassland site dominated by *Eleocharis* spp. with patches of *Acoelorrhaphe wrightii* palms (Honduras); b) Peat core from Laguna Karatá, Nicaragua (Source: Peters & Tegetmeyer 2019).

### *Land use trends*

Many peatlands in Central America and the Caribbean have been drained for agriculture, although the extent of this conversion is unknown. For example, the expansion of banana plantations across coastal Central America reaches back to the early 20th century and locally has already led to the total disappearance of the former organic soils. In the San San - Pond Sak wetland (Panama), which has substantial peat deposits, ditches have been constructed to facilitate the transport of goods, e.g. timber (Aronson et al. 2014). Other peatland areas in the region have been drained for cattle grazing and smallholder crop production (Peters & Tegetmeyer 2019). Substantial work was undertaken in the 1980s and 1990s in the region as a prelude to peat extraction for fuel (Bord na Mona 1984; Cohen et al. 1995), but this has not led to any substantial extraction. Logging has been reported from peatland areas in Costa Rica, but not as extensive as in other regions (e.g. Southeast Asia) (Webb & Peralta 1998).

Data from the Hilda+ project are quite limited for peatlands in the countries of interest, possibly because of the project's focus on forested landscapes. Despite the small number of data points, the dataset indicates a loss in forest cover and an increase in pasture- and cropland area, most notably in Mexico, Nicaragua, Colombia, and Belize (Figure 12). Pastureland encroachment appears to be a predominant driver and takes about 10 fold the area of cropland encroachment. Panama and Costa Rica show the least land use change. Most land use change has happened only once, while in Colombia and Mexico land use appears to change more frequently, i.e. deforestation and reforestation or deforestation and conversion to cropland or pasture land.

The available data from the Global Peatland Emissions Database show similar patterns (GMC Global Peatland Database 2022). Mexico has the largest area of drained peatland followed by Colombia and Honduras. Costa Rica, Nicaragua, and Panama have the smallest area of drained peatland. The proportion of drained area in all six countries is still quite low, but this might change in the future.

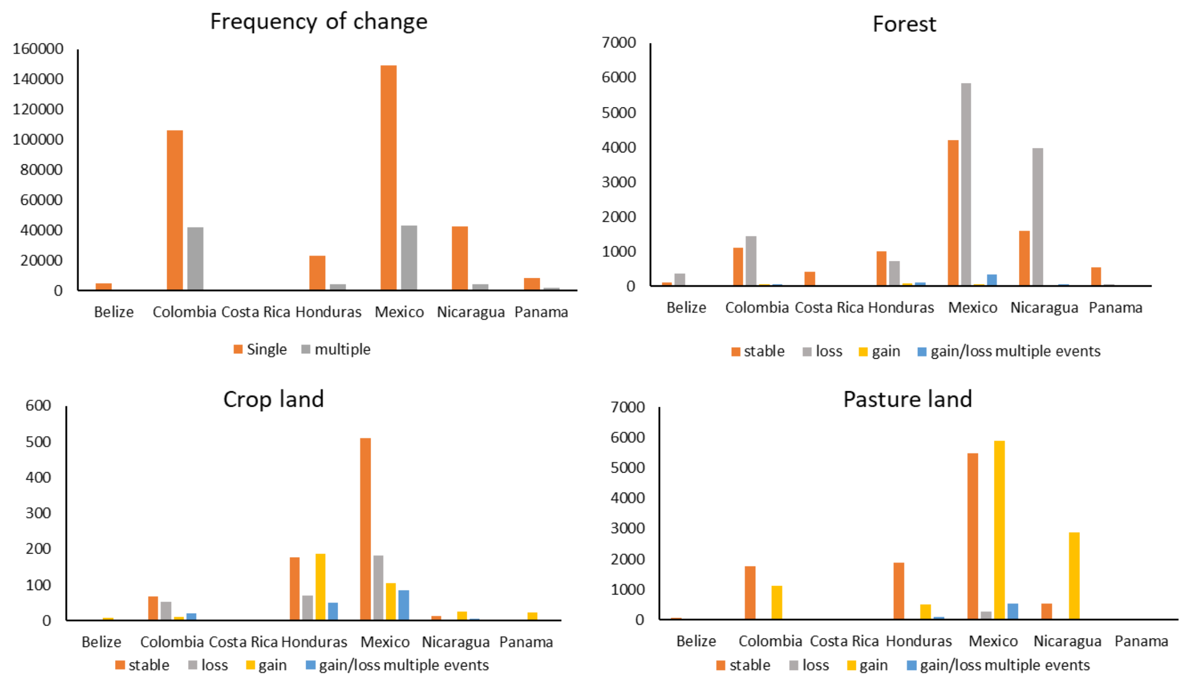


**Figure 12.** Land use (in ha) on peatlands, within 100 km from the coastline, in the selected countries for the period from 1960 to 2019 as derived from Hilda+ data (Winkler et al. 2020).

*Knowledge gaps and technical capacity*

The distribution of peatlands in Central America and the Caribbean is poorly known. Studies have hitherto focused on the Caribbean coasts of Panama, Costa Rica, and Nicaragua, although small deposits have been reported more widely across the Caribbean (Bord na Mona 1984; Cohen et al. 1995; Page et al. 2011). In contrast to other regions, few recent re-assessments of peatland extent, depth, or carbon storage have taken place. Up-to-date data on peatland distribution and peat depth are sparse. Interviewed experts have reiterated the need for baseline studies on peatland distribution and properties as the first and foremost action to be carried out at the regional level, e.g. by establishing research networks (pers. comm. Julie Loisel and Jorqe Hoyos-Santillan).

Despite adaptation-focused peatland NDCs, empirical evidence on the role of peatlands in climate change adaptation, particularly for maintaining fresh water supply, is missing for the Caribbean. Most literature extrapolates from other regions where landscape context, peat hydrological properties and self-regulation mechanisms of peatlands may differ from those from the Caribbean. Therefore, ecohydrological studies need to be carried out to better understand the hydrological factors conditioning peatland ecology as well as the interactions between the peatlands and the upstream and downstream parts of their catchment.

In most cases, the Hilda+ land use change data covered 5 % or less of the peatlands of the area, the rest have “no data”. This demonstrates the need for better inventory, monitoring, verification and reporting capacities and methodologies to detect hotspots of greenhouse gas (GHG) emissions and biodiversity. GHG emission measurements are not available for the individual land use types in the region.

According to the interviewed regional experts, the technical and political willingness and the financial capacities are often incompatible. They indicated that while technical capacity in Mexico for peat mapping, carbon stock taking and GHG measurement is present, the political willingness might be low. Meanwhile, the situation in countries like Belize and Panama is quite the opposite. The political interest in conservation and restoration of mangroves and peatlands for climate change mitigation and adaptation is high, but the financial and technical capacities are limited (pers. comm. Jorqe Hoyos-Santillan).

# 4. Conclusions and Recommendations

Here, we identify opportunities for organizations interested in Nature-Based-Solutions (NBS) to engage with peatlands, particularly in countries that already have mangrove-oriented climate mitigation activities included in their NDCs. There is a general openness in the countries we studied closer to include peatlands in their NDCs, but lacking data availability and capacity hinder the broader uptake and the concrete implementation of measures. The openness provides many opportunities for impactful progress for organizations who want to engage. Therefore, we describe priority actions for countries with peatlands near the Caribbean coast and a high potential for peatland projects, namely Belize, Colombia, Costa Rica, Honduras, Nicaragua, Mexico, and Panama.

1. Peatland mapping, with a strong emphasis on ground-truthing, is the most urgent action needed to build a solid data base for implementation. The Greifswald Mire Centre (GMC) has developed a straightforward peatland mapping methodology, overlaying various kinds of cartographic and satellite-based earth observation data within a GIS to produce peatland probability maps (c.f. FAO 2020; Joosten et al. 2022). These probability maps are available for most countries in the Caribbean region (see Peters & Tegetmeyer 2019). Informed by these probability maps, systematic peat coring in ground-truthing missions must confirm or modify the actual peatland

distribution. Simultaneously, additional information (e.g. on land use, vegetation, water levels, peatland condition and threats, peat depth and carbon stock) should be gathered. Conducting such missions requires much time and local knowledge especially in remote and difficult to access areas. Teams (of around 10 persons) composed of researchers from local universities, research institutions or agencies should be formed, trained in ground-truthing by experienced peatland specialists, and equipped with appropriate field research gear like coring devices. Training should happen in regular theoretical and practical field courses and curricula for such training courses have to be developed. Potential implementing institutions in the region could be CONABIO in Mexico, URACCAN Puerto Cabezas in Nicaragua, UNA Heredia or SINAC in Costa Rica, or the Smithsonian Tropical Research Centre in Panama. Peatland specialist support to conduct trainings could come from Texas A&M University or GMC. A long-term platform to sustain capacities and repeat trainings could be the Ramsar regional center CREHO in Panama, which serves as a knowledge hub for wetlands in the region. Lacking technical and financial resources and research capacity could be supplied by international organizations.

2. The systematic inclusion of climate change mitigation in NDCs requires land use monitoring and the measurement, verification, and reporting (MRV) of GHG emissions using adequate technologies and methodologies. Peatland MRVs need to be adapted to the specific regional geographical and climatic conditions e.g. by using regionally appropriate land use types and tailored (tier 2 or tier 3) emission factors. To develop such schemes, national or regional working groups of wet- and peatland, soil, land use, and GHG experts, complemented by members of the field mapping teams mentioned above, need to be established. These working groups should preferably function within international networks to share the financial burden, while stimulating collaborative action and be supported by international organizations to provide technical assistance for capacity building and knowledge transfer.

3. Climate change adaptation requires the recognition of ecosystem services relevant for local communities and international sustainability goals (SDGs) and the identification of the most important ones, which then could be integrated into NDCs. Water-regulation adaptive capacity is probably the most important ecosystem service considering the climate context and political interests of the region. The water-regulation capacity of peatlands needs to be quantified using empirical evidence to identify and prioritize areas for conservation and restoration. The lack of data, knowledge and capacity on these fields in the countries of the region needs to be addressed by the national or regional working group described under 2). Capacities could be built continuously within courses hosted by the Ramsar regional center CREHO with technical and financial support from international organizations to develop suitable curricula with input from international experts.

4. Biodiversity conservation requires more knowledge on peatland-dependent species, especially the highly adapted and rare regional peatland endemics, and their habitats in the Caribbean biodiversity hotspot. Peatlands are difficult to access, so specially equipped and trained field teams of specialists for various taxonomic groups (plants, birds, mammals, insect and spider groups) should be formed. These teams could plan and conduct field research together with the peat ground-truthing teams from recommendation 1).

5. Pilot sites to study and demonstrate peatland value may best be situated in catchments with also mangroves to adopt a balanced and integrated landscape approach to climate change mitigation and adaptation. Pilot projects can best be started in areas with existing work on mangroves to draw from local expertise on stakeholder engagement and field experience. Local NGOs, protected area management, agencies and other key stakeholders should be involved right from the start in the planning and implementation of such pilot projects. Regional and national

expertise on peatlands should be consulted to integrate existing efforts, for instance regarding mapping. Implementation of pilot sites will benefit from stable and open political conditions like in Belize, Costa Rica, Panama or Mexico. Additionally, countries with clear political strategies or programs to conserve and restore wetlands, peatlands and mangroves, e.g. in their NDCs or national biodiversity plans, should be favoured. Ongoing work of international organizations in the countries with reliable and well-established partnerships and trustable track record, like The Pew Charitable Trusts' work in Belize or the Smithsonian Institute in Panama, is a strong asset. Peters & Tegetmeyer (2019) have listed recommendations for pilot sites in some countries of the region that could operate as lighthouses within a larger program covering also work on recommendations 1-4.

Ideally, all listed measures and actions would be implemented as components of a broader program for peatlands in the Caribbean region to leverage maximum synergies between activities for climate change mitigation and adaptation, biodiversity, water security and local livelihoods.

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# Annex 1

List of countries with mangroves and peatlands and their respective spatial distribution

| **Country** | **Mangrove area ($km^2$)** | **Peatland area within 100 km from mangroves ($km^2$)** | **Peatland area within 100 km from the coastline ($km^2$)** |
|---|---|---|---|
| Angola | 337 | 971 | 971 |
| Benin | 1 | 1251 | 1566 |
| Congo (Republic of the) | 0 | 154 | 154 |
| Côte d'Ivoire | 54 | 2857 | 2857 |
| Guinea | 1969 | 4994 | 4980 |
| Guinea-Bissau | 2506 | 5514 | 5500 |
| Liberia | 188 | 9239 | 9186 |
| Gambia, The | 596 | 1538 | 954 |
| Madagascar | 2308 | 1630 | 7397 |
| Mozambique | 2719 | 3127 | 4652 |
| Senegal | 1222 | 4120 | 4040 |
| Sierra Leone | 1222 | 9175 | 8483 |
| Togo | 0 | 123 | 123 |
| Nigeria | 6824 | 25111 | 21955 |
| Ghana | 195 | 481 | 481 |
| Cameroon | 1773 | 937 | 936 |
| South Africa | 25 | 496 | 499 |
| Bangladesh | 3956 | 4017 | 3779 |
| Brunei | 105 | 1386 | 1386 |
| Cambodia | 532 | 0 | 726 |
| China | 64 | 317 | 1236 |
| Philippines | 1892 | 4381 | 4386 |
| India | 3062 | 1216 | 4013 |
| Indonesia* | 22019 | 366767 | 364702 |
| Malaysia | 4465 | 34494 | 34558 |
| Myanmar (Burma) | 4360 | 16423 | 16498 |
| Singapore | 4 | 1 | 1 |
| Sri Lanka | 154 | 538 | 538 |
| Vietnam | 1246 | 3299 | 3333 |

| | | | |
|---|---|---|---|
| Thailand | 1962 | 2229 | 2210 |
| Timor Leste | 9 | 12 | 12 |
| Laos | 0 | 177 | 0 |
| Papua New Guinea | 3861 | 49244 | 51715 |
| Palau | 51 | 4 | 4 |
| New Zealand | 166 | 241 | 1046 |
| Australia | 8209 | 158 | 12447 |
| Jamaica | 90 | 326 | 326 |
| Puerto Rico, American Virgin Islands (USA) | 66 | 157 | 157 |
| Panama | 1402 | 811 | 811 |
| Belize | 355 | 1084 | 1084 |
| Costa Rica | 339 | 67 | 578 |
| Cuba | 2679 | 13717 | 13717 |
| Dominican Republic | 176 | 439 | 439 |
| El Salvador | 321 | 2 | 2 |
| Haiti | 126 | 328 | 328 |
| Honduras | 547 | 5992 | 6047 |
| Mexico | 9181 | 22237 | 23386 |
| Nicaragua | 713 | 7783 | 7785 |
| Guatemala | 237 | 39 | 39 |
| French territories (Guadeloupe, Martinique, French Guiana) | 436 | 3170 | 3417 |
| Guyana | 245 | 10909 | 10900 |
| Brazil | 8206 | 23404 | 21835 |
| Colombia | 1564 | 6386 | 6016 |
| Ecuador | 869 | 7 | 7 |
| Peru | 22 | 3 | 144 |
| Suriname | 633 | 9536 | 9531 |
| Venezuela | 2155 | 27317 | 27288 |
| Trinidad and Tobago | 51 | 169 | 169 |