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Draft Briefing Note on Blue Carbon Ecosystems in the Ramsar Regions: Contributions to Climate Change Mitigation and Nationally Determined Contributions

Blue Carbon Ecosystems in the Ramsar Regions: Contributions to Climate Change Mitigation and Nationally Determined Contributions

This Briefing Note provides a summary of the current state of blue carbon ecosystems (BCEs) located within Ramsar Sites in each Ramsar Region. The available data and information were compiled to make estimates of the carbon these sites sequester and store in a manner consistent with Intergovernmental Panel on Climate Change (IPCC) guidelines. The results of a survey of Contracting Parties is also presented (with 55 responses from Contracting Parties) on their plans to include coastal wetlands in their Nationally Determined Contributions, and the difficulties they face in this process. This data presented in this Briefing Note was drawn from a report completed by Silvestrum Climate Associates that is available on the Ramsar website.

[Relevant Ramsar documents—to be completed by Secretariat]

Summary

This Briefing Note provides a summary of the state of knowledge of BCEs in Ramsar sites within each Ramsar Region using available data and information, to make estimates of their carbon sequestration and storage in a manner consistent with the IPCC Wetlands Supplement (2014). The existing threats to the ecological condition of Ramsar BCEs are also described, as are the results of the Ramsar Secretariat's 'Survey of Contracting Party Needs on Blue Carbon Ecosystems." While Ramsar sites make up only a small percentage of the total coastal wetland extent in each Ramsar Region, the Ramsar Convention's mission of promoting the 'wise use' of wetlands (through the Ramsar wise use guidelines) can be expanded and applied to all BCEs in order to protect the stored and sequestered carbon, and the many other benefits these wetlands provide.

Key Messages

- **Coastal wetlands take up and store significant amounts of carbon from the atmosphere making their conservation and restoration an essential approach to mitigate climate change.** Known as blue carbon ecosystems (BCEs), these are tidally-influenced wetlands (primarily mangrove forests, intertidal marshes, and seagrass beds) where carbon is captured by living organisms and stored in biomass (the total mass of living organism in an area) and sediments. If undisturbed, the carbon stored in sediments is stable and can remain for hundreds or thousands of years. Once disturbed or drained, substantial amounts of carbon can be rapidly released.

- **Ramsar sites that contain BCEs store substantial amounts of carbon, providing climate change mitigation benefits.** Data shows that mangrove forests within Ramsar sites contain total carbon stocks (contained in biomass and soil) ranging from 212.1 to 725.1 t C ha^{-1}, with an average stock of 432.5 (± 121.4) t C ha^{-1}. The available data on carbon storage in intertidal marshes within Ramsar Sites was more limited, with an estimated average of 260 t C ha^{-1}.

- **The change in the spatial extent of mangrove forests in Ramsar Sites followed trends that are seen globally; more than half of the Ramsar Sites with mangrove ecosystems experienced a loss of mangrove area between 1997 and 2016. These sites have lost substantial carbon storage capacity**.

However, nearly 20% of Ramsar Sites showed an increase in mangrove area (over the same period?) and thus are sequestering more carbon, largely in the (above- and below-ground) tree biomass. (The Global Mangrove Watch estimates: 73% of Ramsar Sites have lost area (~110k ha), 18% have gained (~10k ha) and 9% with no change/no data between 1997 and 2016).

- **Accurate global mapping of BCEs remains a significant gap in our understanding of their overall geographic coverage and total extent, particularly for intertidal marshes and seagrass beds**. This data gap was reflected in the existing data available for Ramsar Sites and in a survey of Blue Carbon needs this was identified by Contracting Parties as the most common barrier to protect, restore and sustainably manage BCEs. Using the IPCC Wetlands Supplement guidance[1] depends on having information on wetland area, which is the minimum step required to include blue carbon reporting in Nationally Determined Contributions and allow accurate carbon accounting. The absence of baseline inventory data for the overall extent of BCEs is likely to significantly underestimate their importance in providing climate benefits.

- **There are possibilities for including blue carbon wetlands in Nationally Determined Contributions (NDCs)**. The IPCC recognizes a programmatic role for blue carbon that addresses both climate change mitigation and adaptation benefits. Depending on a country's national definition of "forest," mangroves may be included in its REDD+ program. If not, the carbon contained in the biomass, dead organic matter, and soils of BCEs can be included in national carbon accounting of their NDC. In this way, management actions can be aligned with existing or developing international policy and national commitments to address climate change.

- **While BCEs can be considered 'hot-spots' of carbon storage, they also offer many other ecosystem services and can contribute to ecosystem-based adaptation to climate change.** Beneficial contributions include flood and shoreline protection, water quality protection, support of livelihoods, biodiversity support, and habitat for fish (e.g. nurseries), birds, invertebrates, and mammals, and land-building capacity.

Introduction

Blue carbon refers to the carbon stored and sequestered in coastal wetlands and is defined under the Ramsar Convention as: "the carbon captured by living organisms in coastal (e.g. mangroves, salt (intertidal) marshes and seagrasses) and marine ecosystems and stored in biomass and sediments." [2] The majority of the captured carbon is stored in soils and sediments, resulting in long-term carbon accumulation (Windham-Myers et al. 2019, Chmura et al. 2003). As a result, coastal wetlands are an on-going and powerful carbon sink, with sediment carbon burial rates that are up to 55-times faster than tropical rainforests (McLeod et al. 2011). This carbon uptake helps counterbalance human greenhouse gas emissions, giving blue carbon ecosystems (BCEs) an important role in climate change mitigation.

[1] IPCC 2014, 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (eds). Published: IPCC, Switzerland. Link: https://www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf

[2] The following caveat from Res. XIII.14 is worth noting: "However, not all Contracting Parties endorse this definition or recognize the Ramsar Convention as the competent forum to address mitigation reporting and accounting arrangements."

BCEs also bring other important ecosystem services that contribute to human well-being, such as coastal protection from storms and floods, protection of water quality, biodiversity support, food to support sustainable livelihoods, and as nursery grounds for many species of marine life (thebluecarboninitiative.org).

When BCEs are lost or degraded, the impact on carbon is twofold: one is the lost potential for carbon sequestration (i.e. the annual carbon uptake), while the second is the release of ancient buried carbon that has been stored over the past centuries to millennia (Pendelton et al. 2012). Such impacts may act to convert BCEs from net carbon sinks to a net source of greenhouse gasses (GHGs). This Briefing Note provides a summary of what is known about BCEs in Ramsar sites within each Ramsar Region using available data and information, to make estimates of their carbon sequestration and storage in a manner consistent with the IPCC Wetlands Supplement (2014).

[Body]

The conservation, restoration and wise use of wetlands to maintain ongoing carbon sequestration and storage functions and to halt and reverse emissions from degraded or destroyed sites are effective climate mitigation strategies (BN #10, Crooks et al. 2019). The high carbon content (carbon per unit area) in BCEs led the Intergovernmental Panel on Climate Change (IPCC) to develop guidelines for national inventories of their greenhouse gas emissions and removals. These guidelines form the basis for national assessment and reporting of BCEs in NDCs under the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC). As of 2018, 58 countries thus far have recognized BCEs under their NDC commitments to reduce greenhouse gas emissions (Crooks et al. 2019). In this effort, accurate carbon accounting for wetlands is vital to identify and raise understanding of the importance of protecting and restoring wetlands or wetland-dominated landscapes that hold disproportionately large carbon stocks.

It is estimated that up to one billion tons of carbon dioxide are released each year from degraded BCEs, an amount that is equal to nearly 20% of the global emissions from deforestation (Pendelton et al. 2012). Thus, the loss and degradation of BCEs are contributing significantly to global climate change. Current estimates are that about one third of the area covered by these ecosystems has already been lost, and they continue to face ongoing threats.

Ramsar Blue Carbon Ecosystems

Only Ramsar Sites that are tidally influenced can contain BCEs. The total number of Ramsar BCEs were identified using the Ramsar Site Information Sheets (RSIS) database (note that some recent updates to the RSIS may not be included in this analysis). The result was a compilation of 780 Ramsar Sites that include at least one BCE, with many of the sites containing multiple BCEs (Table 1; Figure 1). In total, 324 sites are found to include tidal forested wetlands, of which 301 contain mangroves. Intertidal marshes are found in 547 sites and shrub-dominated wetlands are found in 70 sites. Seagrass beds are found in 271 sites.

Table 1. The number and type of blue carbon ecosystems within each Ramsar Region. Note that some Ramsar sites have multiple BCEs so the total BCEs are greater than the total Ramsar Sites that contain them. Mangrove forests are a subset of intertidal forested wetlands.

Ramsar Region	Total # Ramsar sites	Intertidal Forested Wetlands	Mangrove forests	Intertidal Marshes	Shrub-dominated wetlands	Seagrass beds
Africa	116	65	61	61	13	41
Asia	93	64	62	38	6	29
Europe	337	26	20	286	27	103
Latin America & the Caribbean	87	74	72	52	9	36
North America	110	72	69	83	7	42
Oceania	37	23	17	27	8	20
Total	**780**	**324**	**301**	**547**	**70**	**271**

Mangrove Forest Extent

Globally, mangrove forests occur in 121 countries located throughout the tropics and subtropics and 70 Ramsar Contracting Parties have Ramsar sites containing mangroves. Historically, human activities have caused the loss of an estimated 30 percent of the original global mangrove area, with current loss rates estimated at ~1 to 3 percent per year (Lovelock et al. 2019). To estimate mangrove area, carbon storage, and the changes over time, the Global Mangrove Watch (GMW) dataset generated by Bunting et al. (2018) was used. Mangrove extent in the 1997, 2007, and 2016 datasets were compared to calculate changes in mangrove area on roughly a decadal basis (Table 2). Forty-five of the Ramsar Sites do not have GMW data associated with them[3] and thus are not included in the analysis.

Mangrove area in Ramsar sites decreased between 1997 and 2016 (Table 2). Losses were steady in all Ramsar Regions with the exception of Europe, which showed a 14 percent increase over this time period (largely due to one site whose area increased by 55 percent). The greatest mangrove losses were seen in Latin America and the Caribbean, which has the greatest regional extent, and the largest percent change was in North America, with a loss of 8 percent. In total, over 158,000 ha were lost from the combined Ramsar Regions during this period.

[3] No reason for omission was provided in Bunting et al. (2018).

Table 2. Total mangrove area (ha) in Ramsar Sites in 1997, 2007 and 2016 from the Global Mangrove Watch dataset and changes in area over time in each Ramsar Region. Negative values represent mangrove loss and positive values represent mangrove gain.

Region	1997 area (ha)	2007 area (ha)	2016 area (ha)	1997 to 2007 change (ha)	2007 to 2016 change (ha)	1997 to 2016 change (ha)	% Change 1997 to 2016
Africa	693,010	686,445	661,711	-6,565	-24,734	-31,299	-5%
Asia	873,946	861,697	858,409	-12,249	-3,288	-15,537	-2%
Europe	37,418	39,938	42,702	2,520	2,764	5,284	14%
Latin America and the Caribbean	1,325,005	1,292,607	1,273,923	-32,398	-18,684	-51,082	-4%
North America	834,240	816,189	770,767	-18,051	-45,422	-63,473	-8%
Oceania	157,677	157,055	155,554	-622	-1,501	-2,123	-1%
Total	**3,921,296**	**3,853,931**	**3,763,066**	**-67,365**	**-90,865**	**-158,230**	-4%

Intertidal Marsh Wetlands

Tidal marshes are the dominant BCE in the temperate zone, although they also occur in some upper tidal locations in the tropics. Human use and conversion of tidal marshes has been going on for hundreds or thousands of years, making estimates of their original extent difficult (Lovelock et al. 2019). And, unlike mangrove ecosystems, tidal marsh wetlands have not been systematically mapped globally or over time, making estimates of their extent and associated carbon uptake and storage difficult.

Because of the lack of data, changes in intertidal marsh extent over time could not be determined. Data were available for only 42 percent of sites (230 out of 547 sites). For sites that had been mapped, the Ord River Floodplain in Australia has the greatest mapped area (143,741 ha) and North Uist Machair and Islands in the United Kingdom and Guangdong Nanpeng Archipelago Wetlands in China have less than a hectare mapped. The average mapped area for tidal marshes was large, at 2,494 ha.

Table 3. Total intertidal marsh area in Ramsar Sites where geospatial data were available and the total estimated area of seagrass beds in Ramsar Sites where data were available for each Ramsar Region. Due to limited data availability these numbers are underestimates of the totals for each region.

Region	Mapped intertidal marsh area (ha)	Estimated seagrass meadow area (ha)
Africa	713	No data

Asia	37,104	3,208,000[1]
Europe	287,773	894,000[2]
Latin America and the Caribbean	6,152	No data
North America	10,294	2,431,500[3]
Oceania	251,470	9,641,800[4]
Total	**593,506**	**161,753,010**

Source: Green and Short 2003; [3] Pacific coast of North America, Western North Atlantic Coast of USA, Mid-Atlantic coast of USA, Gulf of Mexico, East coast of Florida, Mexico; [1] Thailand, Peninsular Malaysia, Indonesia, Philippines, Viet Nam, Japan, Republic of Korea; [2] Scandinavia, Western Europe, Western Mediterranean, Euro-Asian Seas; [4] Western Australia, Eastern Australia, New Zealand

Seagrass Beds

Seagrass beds have suffered huge losses of area globally, largely as a result of declining water quality (Forqurean et al. 2012). Although the uncertainty in estimates of the global area of seagrasses is high, estimates show that seagrass loss rates are increasing, from an estimated average of 0.9% per year before 1940 to 7% loss per year since 1990 (Waycott et al 2009 in McLeod et al. 2011, UNEP 2020). A major complication in acquiring data on seagrass extent results from the difficulty of mapping these ecosystems. For instance, remote-sensing techniques used to map wetlands at a large scale are often not able to accurately penetrate water where seagrass beds occur. As a result, there is no comprehensive global dataset on seagrass bed extent or the change in extent over time. Recent advances in remote sensing have allowed for changes in seagrass coverage over large areas to be mapped in optically shallow waters; however, other methods are typically needed to map deeper waters and areas with optically similar substrate (Oreska et al. 2019).

The global distribution of seagrass beds has been estimated with models (Jayathilake and Costello 2018) and UNEP-WCMC and Short (2018) collated all current seagrass spatial data; however, the data are incomplete, which precludes them from being used in this analysis. Using the World Atlas of Seagrasses (Green and Short 2003), estimates of seagrass extent were compiled for some sites in the Ramsar Regions where data were available (Table 3), although this is by no means comprehensive for the regions listed.

Estimates of Carbon Stocks and Carbon Sequestration Rates

Globally, all blue carbon ecosystems (not just those in Ramsar sites) account for nearly 50 percent of carbon burial in marine sediments, despite taking up less than 2% of the ocean area (Duarte 2005). This represents a high concentration of carbon and provides a strong case for the inclusion of BCEs in climate mitigation planning and NDCs. This carbon is taken up from the atmosphere, stored in plant biomass before it moves to long-term storage in the sediments (Crooks et al. 2019, Troxler et al. 2019).

Mangrove Forest Carbon Stocks

Mangroves are carbon-rich ecosystems that contain high carbon concentrations (carbon per unit area), making their conservation critical to prevent the loss of stored carbon and enable continued sequestration. Estimates of the carbon stocks held in mangrove biomass in the Ramsar Regions were made using modeled global values from Hutchinson et al. (2014). For sites that did not have data, the value from the closest Ramsar Site was used as a proxy. Much of the carbon stored in mangrove ecosystems is found in the soil. Mangrove soil carbon stocks were derived from the Global Mangrove Watch. For sites that did not have data, the value from the closest Ramsar Site was used. Calculations were made using only the top one meter of soil, which is likely to underestimate carbon stocks in many locations (Kauffman et al. 2020) however there is no method currently available to model soil depth.

Ramsar sites with mangroves hold a mean of 331.5 (± 108.4) t C ha^{-1}, ranging from a low of 264.9 t C ha^{-1} in North America to a high of 401.2 t C ha^{-1} in Latin America and the Caribbean and similarly 410.52 t C ha^{-1} in Europe (Table 4; Figure 2**)**. Soil carbon in Ramsar Sites varied between 122 and 579 t C ha^{-1} (sites Estero el Chorro in Mexico and the Sembilang National Park in Indonesia, respectively). Sembilang National Park also had the highest total carbon stock (tree biomass plus soil; 725.13 t C ha^{-1}) and Basse Vallée de l'Ouémé, Lagune de Porto-Novo, Lac Nokoué in Benin had the lowest (126.87 t C ha^{-1}), which is likely driven by differences in climate and hydrogeomorphic settings across Sites. If the available data are summed, the Ramsar mangrove BCEs for which data are available hold an estimated total 1,610 teragrams (i.e. x10^{12}g) of carbon.

Carbon Emissions and Removals in Mangrove Forests with Habitat Area Change

Estimates of total mangrove carbon losses (when carbon is released to the atmosphere) and removals (when carbon is taken up from the atmosphere) were made for Ramsar Sites over the 20-year period between 1997 and 2016 (Table 4; for details of this analysis, see Blue Carbon Report, Ramsar website). This could only be done for mangroves as the other BCEs lack time series data. The majority of mangrove forests in Ramsar Sites have lost area over time and so are likely to have lost carbon. However, nearly 25% of Sites have had increases in mangrove habitat and are sequestering increasing amounts of carbon, largely in the tree biomass.

Table 4. Mean mangrove soil and biomass carbon (above- plus below- ground; t C per hectare) in Ramsar Sites by Ramsar Region. Also shown is the total amount of carbon lost by region from mangroves due to the loss of mangrove area over the period 1997-2016 (negative values indicate carbon lost).

Ramsar Region	**Mean Soil C (t C ha^{-1})**	**Mean Biomass C (above- + below-ground: t C ha^{-1})**	**Mean Total C stock (soil + biomass: t C ha^{-1})**	**Total C loss 1997 – 2016 (tonnes)**
Africa	291.71	107.80	399.51	-13,771,376
Asia	318.63	107.81	426.44	-4,969,476

Europe	410.52	109.02	522.84	1,920,048
Latin America and the Caribbean	401.25	115.78	514.81	-26,397,205
North America	264.90	88.63	353.53	-27,847,040
Oceania	303.19	75.02	378.22	-806,475
Average	**331.70**	**100.68**	**432.56**	

Intertidal wetlands

Data is limited on the carbon sequestered and stored by intertidal wetlands. For example, there are no estimates for above- and below-ground biomass at the global level for intertidal wetlands. However, a recent study of a diverse selection of estuarine and palustrine emergent wetlands, showed a narrow range (0.97 – 2.67 t C ha^{-1}) of biomass production values, which likely apply across global scales due to the diversity of species and wetland types used in these estimates (Byrd et al. 2019). The IPCC Wetlands Supplement provides Tier 2 (country-level) estimates to relate above-ground biomass to below-ground biomass.

There is also no global spatial dataset for intertidal wetland soil carbon stocks. To estimate soil C per Ramsar Region, the IPCC Wetland supplement Tier 1 (global) values were used (these can be used to 1 m depth based on soil type (e.g. mineral or organic soil; Table 5). Carbon storage (total) in intertidal wetlands in the Ramsar Regions ranged from 183,620 tonnes (Africa) to 74,159,600 tonnes (Europe). Oceania has a total of 251,470 ha of intertidal marsh that stores nearly 65,000,000 tonnes of C (or ~65 teragrams; Table 3).

Table 5. Intertidal marsh carbon (above- plus below- ground biomass; t C per hectare) in Ramsar Sites by Ramsar Region.

Ramsar Region	**Number of Sites**	**Total Area in Region (ha)**	**Total C held in all sites (tonnes)**
Africa	2	710	183,620
Asia	13	37,100	9,561,700
Europe	185	287,770	74,159,600
Latin America and the Caribbean	7	6,150	1,585,330

North America	6	10,290	2,652,720
Oceania	25	251,470	64,804,160

Seagrass Beds

Like intertidal wetlands, there is no global dataset for seagrass meadow biomass or underlying soil stocks, making estimates of carbon storage in these BCEs difficult. However, using existing literature, Fourqurean et al. (2012) assembled a dataset of total plant and soil carbon stocks at 946 distinct seagrass beds across the globe that can be applied to Ramsar Sites once seagrass areas are known. Where site-level above-ground biomass data is available, the IPCC Wetlands Supplement includes Tier 2 (region-level) conversions to below-ground biomass. The IPCC Wetland supplement also presents Tier 1 (global) values for seagrass soil carbon stored to 1 m that can be used. When area estimates become available for additional Ramsar Sites containing seagrass beds, these IPCC conversions can be applied to estimate soil carbon stocks

Soil Carbon Sequestration Rates in Ramsar Site BCEs

Soil carbon sequestration represents the capacity of BCEs to take up carbon dioxide from the atmosphere and store in soils over the long-term, with rates typically higher in mangroves and intertidal marshes compared to seagrass beds (Table 6; Hiraishi et al. 2014). For Ramsar Sites where data are available on the extent of mangroves and/or intertidal marshes, the IPCC's mean carbon burial rate for each ecosystem was used to estimate soil carbon sequestration rates.

Table 6. Rates of carbon burial in BCEs.

Ecosystem	**Carbon burial rate (t C ha^{-1} yr^{-1})**			**N**
	Mean	**95% CI**	**Range**	
Mangroves	1.62	1.3 - 2.0	0.10 – 2.2	69
Intertidal marshes	0.91	0.7 - 1.1	0.05 – 4.65	69
Seagrass beds	0.43	0.2 - 0.7	0.09 – 1.12	6

Source: Table 4.12 in Hiraishi et al. 2014; N = sample size.

Greenhouse Gas Emissions from Blue Carbon Ecosystem Soils

When BCEs are disturbed or converted to other land uses, they release stored carbon back to the atmosphere. In total, the three major GHGs, carbon dioxide (CO_2), methane (CH_4) and to a lesser extent nitrous oxide (N_2O, primarily from aquaculture), are released (Hu et al. 2012). In tidal wetland ecosystems where the salinity is greater than 18 Practical Salinity Units (PSU), methane emissions are considered negligible. In estimating emissions from Ramsar sites, all mangroves and salt marshes are assumed to have salinities greater than 18 PSU; therefore, no methane emissions will occur. When salinities are less than 18 PSU, methane emissions can be quite variable; however, the IPCC Wetland Supplement provides a default emissions value of 193.7 kg CH_4 ha^{-1} yr^{-1}, which is equal to 29.84 t CO_2e ha^{-1} yr^{-1} (i.e. carbon dioxide equivalents; Hiraishi et al. 2014) (Figure 4). As data on the extent of brackish and freshwater wetlands become more refined, the IPCC default value can be applied.

Blue Carbon and Nationally Determined Contributions

The Paris Agreement (Decision I/CP.21) established Nationally Determined Contributions as a means for countries to address climate change. Under this Agreement, Parties are required to prepare and communicate successive NDCs, then establish measures required to achieve those carbon reduction goals. Coastal BCEs may be included in NDCs. However, there are critical elements, such as mapping of wetland extent and determining carbon content of biomass, dead organic matter, and soils, that will be required to support effective contributions (Stocktake Report 2017). Implementation of the Paris Agreement began in 2020, and every five years from that time, Parties will be requested to resubmit their NDCs with revised and more ambitious targets (Anisha et al. 2020).

To address the lack of wetland specific information, the IPCC released the 2013 Wetlands Supplement; IPCC 2014). The Supplement covers inland wetlands on organic and mineral soils, coastal wetlands (mangroves, tidal marshes, and seagrass beds), and wetlands constructed for wastewater treatment, and provides emission factors and guidance to use with particular land-use scenarios. For example, emission factors are provided for drained mangroves, which can become a significant source of methane and carbon dioxide. The IPCC also developed an approach to account for new sources and sinks of blue carbon, for example, forest management in mangroves may include removal of wood (carbon loss), or replanting of mangroves on rewetted or saturated soils (carbon uptake) (summarized from Troxler et al. 2019).

If wetlands are to be included in the NDCs, the following considerations are important (from Beasley et al. 2019).

- **Determine the extent and geographic scope of BCEs.**
    - Identifying the extent of coastal wetlands is the first step in using the IPCC Wetlands Supplement, which only requires information on the area of BCEs. Habitat extent data is combined with proxies to calculate the potential for carbon uptake and storage.
- **Establish specific mitigation targets and goals for blue coastal ecosystems.**
    - Targets for coastal ecosystems can include GHG methods similar to those used for forests to recognize forest protection, conservation, or avoided emissions.
    - If mangroves are specified in the National Forest Definition, they may be a part of the country's REDD+ program and can be included in the preparation of NDCs.
- **Adaptation.**
    - BCEs may be included in the adaptation section of a country's NDC or in associated National Adaptation Plans (NAP) and/or Adaptation Communications (AC). Given the

high adaptation value provided by coastal wetlands, such as flood protection, and water and food security, BCEs are well suited for this approach.

Threat Assessment in Ramsar Blue Carbon Ecosystems

The Ramsar Convention emphasizes the conservation and wise use of wetlands, and the restoration of degraded ones, all of which depend on an understanding of the drivers that threaten their existence. Many anthropogenic threats and climatic change impacts have the potential to negatively impact coastal ecosystems, especially since most human communities globally live along or near coastal waters. A threat assessment was conducted using RSIS data submitted by Contracting Parties related to threats that are either within or near Ramsar Sites. One notable omission from the list of potential threats is sea level rise.

Threats to Ramsar Sites varied across ecosystems and Regions. In intertidal forested wetlands and mangroves, biological resource use tended to be the dominant threat, followed by pollution and natural system modifications (Figure 5). Notably, shrub-dominated wetlands in the Oceania Region were reported to be most threatened by climate change and severe weather, and seagrass beds have a greater prevalence of threats from pollution, resource use, and natural system modification.

Survey of the Needs of Contracting Parties with Respect to Blue Carbon Ecosystems

Including coastal wetlands as part of NDCs is critical to ensure that Parties are fully assessing and valuing the contribution to mitigate (and adapt to) the impacts of climate change. This will aid in meeting the goals of the Paris Agreement and further protect, restore, and sustainability manage BCEs. Building the capacity to include blue carbon in NDCs requires country specific information on the extent and types of coastal wetlands. To evaluate this capacity, fifty-five Contracting Parties participated in a survey to determine their requirements and needs in managing coastal wetlands.

Generally, Contracting Parties reported that work is needed to increase the awareness of BCEs on the part of governments, from community through to national levels. Within each Ramsar Region, an average of 70 percent of countries reported low to no awareness of what BCEs are, or what benefits they provide (Figure 6a). Only four countries reported that the awareness of BCEs is high, and the Africa Region showed the highest awareness overall, with 22 (40%) countries reporting moderate to high awareness. This lack of understanding of the benefits of blue carbon and the important co-benefits that BCEs bring is a significant barrier to their inclusion in NDCs. In order to include coastal wetlands as part of NDCs, the first step is to effectively communicate their extent and the benefits they provide. This can be a key incentive to increase the protection of coastal wetlands and help leverage the restoration of degraded sites so that they can be included in, and increasingly contribute to, the NDCs.

The proportion of Contracting Parties in the Ramsar Regions that are already including, or are planning to include, coastal wetlands in their NDCs under the Paris Agreement is highly variable; across Ramsar

Regions, an average of 50% of countries reported that coastal wetlands were not currently included in their NDCs, ranging from a high of 80% of countries in the Africa and Asia Regions, to a low of none (0 percent) in the North America and Oceania Regions. Of the countries that do not currently include blue carbon, more than half indicated that they plan to include BCEs in their NDC in the future (Figure 6b,c).

Building the capacity to include coastal wetlands depends on gathering spatially accurate information on their location and extent in order to implement carbon accounting (Stocktake Report 2017). The IPCC 2013 Wetlands Supplement and the methodological guidance it provides on estimating emissions and removals has significantly advanced the carbon accounting needed to determine the contributions of BCEs in carbon sequestration and storage; however, using this guidance depends on having accurate information on wetland habitat extent, which is the minimum step required to reliably include blue carbon estimates/values in NDCs.

Globally, accurate mapping of BCEs is a significant gap in our understanding of their extent and geographic scope, particularly for tidal marshes and seagrass beds. Contracting Parties clearly identified this gap, with nearly 80% of respondents indicating that coastal wetlands were only partially mapped or had not been mapped at all. Only 8 countries (or an average of 14% across Ramsar Regions) indicated that all BCEs were mapped. The need for comprehensive mapping of coastal BCEs was the most common barrier identified (expressed by over 50 percent) which is limiting their ability to protect, restore, and sustainable manage these ecosystems. The second most common concern (expressed by 25 percent of countries) centered on the need to build the capacity to assess carbon stocks and changes in those stocks within coastal BCEs, including acquiring/finding data to fill existing data gaps.

Conclusions

Blue carbon ecosystems take up and store large amounts of carbon, making their conservation and restoration a valuable part of efforts to mitigate climate change. While Ramsar Sites protect only a small percentage of the total extent of BCEs in the Ramsar Regions, they sequester and store significant amounts of carbon, contributing to climate change mitigation and supporting other valued ecosystem services.

The Ramsar designation provides an important international level of protection for these wetland types, and the Convention provides Contracting Parties with further opportunities to protect BCEs, through either enhanced management, expansion of existing Sites, and/or designating new Sites. Some BCEs may also be captured by other national, regional, or international protected area designations for example, many near coastal ecosystems and islands are protected in formal marine park networks and also as part of inscribed World Heritage properties, such as in Australia and other countries in the Oceania Region.

To meet the goals of the Paris Agreement, the Ramsar mission of promoting the wise use of wetlands can be expanded and applied in order to protect the stored and sequestered carbon, as well as the other benefits these wetlands provide. To this end, Contracting Parties should consider designating BCEs in their jurisdiction to address gaps and contribute to NDCs.

The significant gaps in knowledge of the full geographical coverage and extent of coastal wetlands in the global Ramsar network is a barrier for Contracting Parties to understand the importance of their BCEs and to be managing them effectively. This means that blue carbon is not yet being fully appreciated by all Contracting Parties as an important means to mitigate climate change and its impacts. This data gap is not restricted to Ramsar Sites but rather is an important global knowledge gap that needs to be addressed to achieve multiple benefits for the climate, nature and people. new and emerging.

Improvements in remote sensing techniques supplemented with field surveys are promising to address this glaring gap. Using techniques highlighted in the Coastal Blue Carbon manual (Howard et al. 2014) and Blue Carbon Primer (Oreska et al. 2019), individual or coordinated site-level survey efforts could take place in order to provide a baseline survey in relevant areas. These can then be calibrated against satellite imagery to inform both current distributions and historic. While there are growing efforts to map intertidal marshes, a data gap still exists similar to seagrass beds, which prevents global and national comparisons across Ramsar Sites and also across the Regions. The technology exists which could map intertidal marshes, but to date a coordinated global effort comparable to mapping mangrove ecosystems has not yet occurred.

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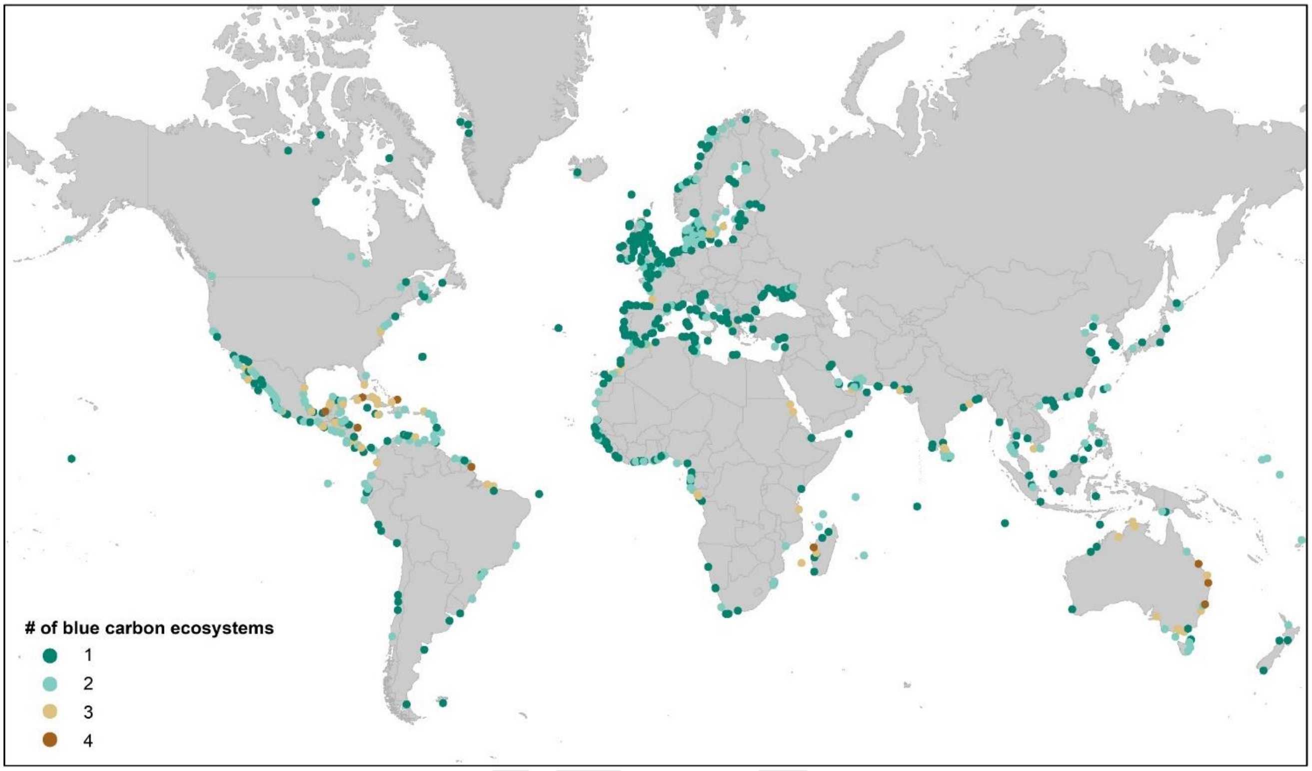

Figure 1. The distribution of Ramsar Sites containing blue carbon ecosystems (BCEs) indicating the number of BCEs within each site. Ecosystems include intertidal wetlands, intertidal forested wetlands, seagrass beds and shrub-dominated wetlands (see Silvestrum Report for additional data at ramsar.org).

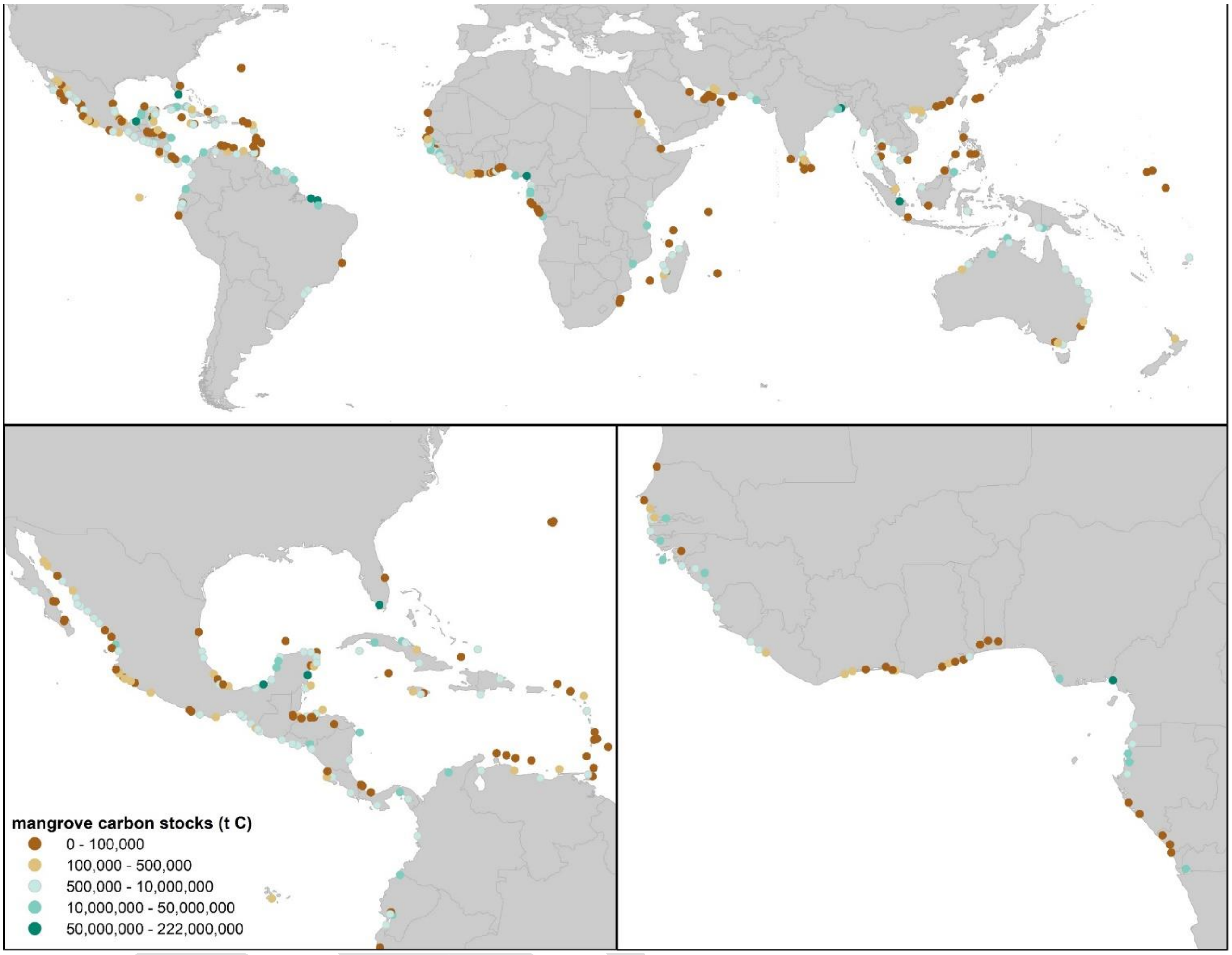

Figure 2. Total carbon stocks in mangrove ecosystems (trees plus soils) in Ramsar Sites (units in t C). Boxes in top map denote insets below.

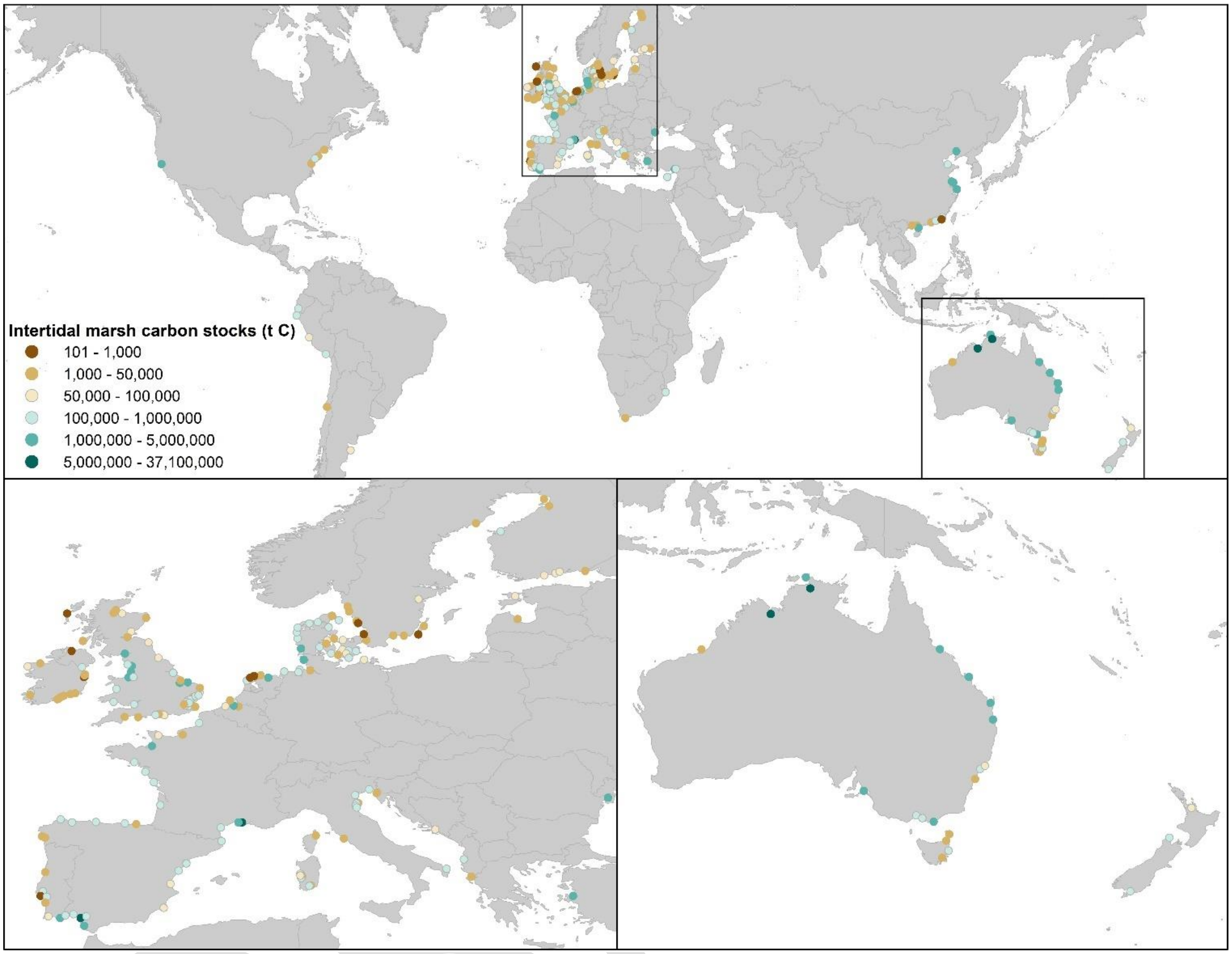

Figure 3. Total carbon stocks in intertidal marsh ecosystems in Ramsar Sites (units in t C). Boxes in top map denote insets below.

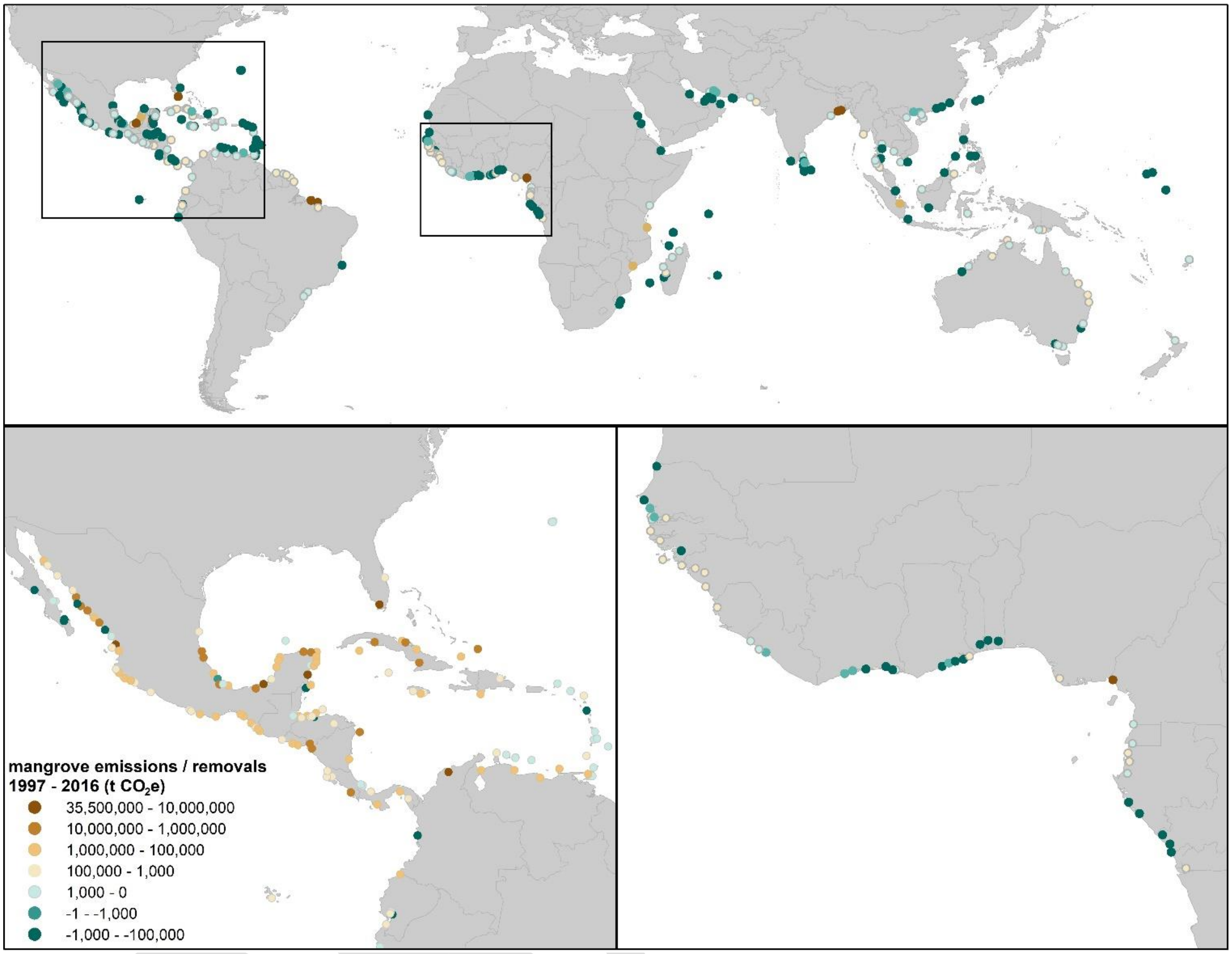

Figure 4. Emissions and removals from mangrove area change between 1997 and 2016 in Ramsar Sites (units in t CO_2e). Emissions are positive values and removals are negative values. Boxes in top map denote insets below.

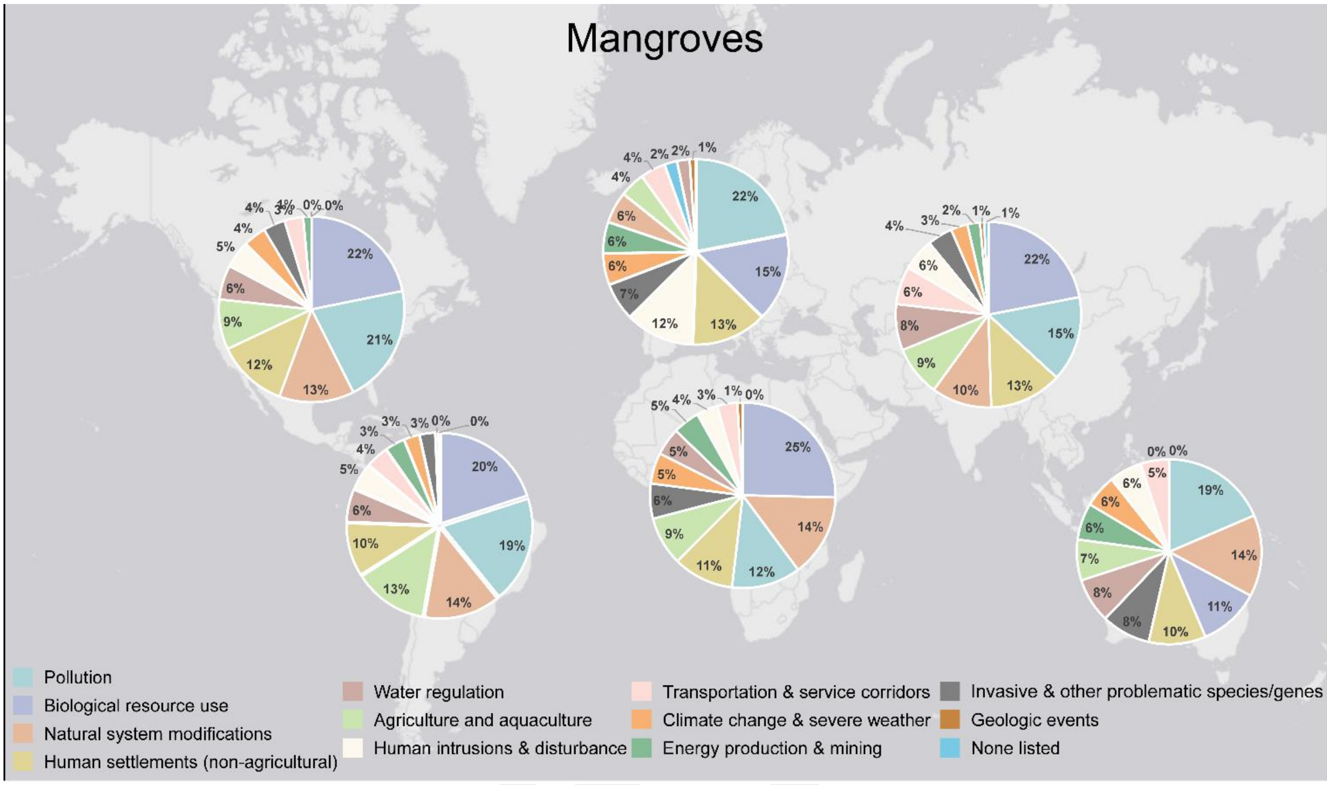

Figure 5. Percentage of Ramsar Sites that listed a given threat to mangrove ecosystems in the Ramsar Site Information Service across Ramsar Regions.

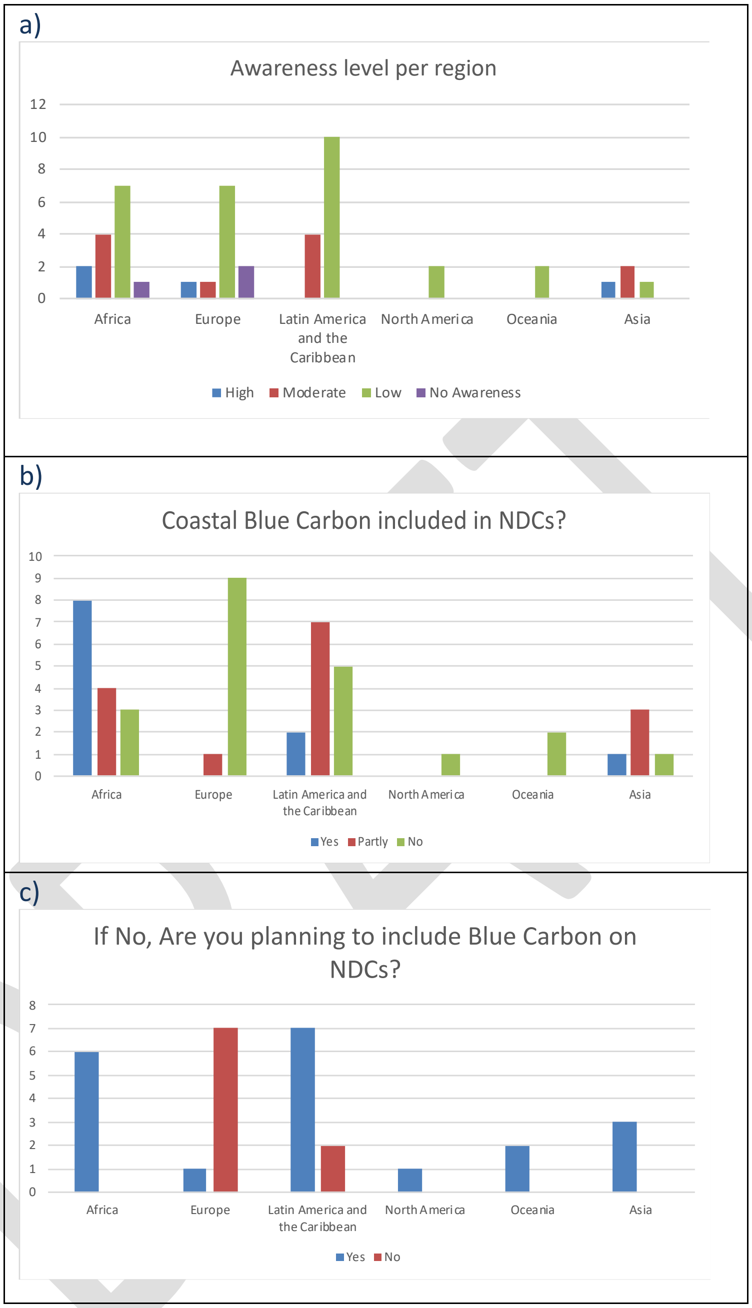

Figure 6. Responses of Contracting Parties who responded to Ramsar Secretariat's 'Survey on Managing Blue Carbon Ecosystems' grouped by Ramsar Region on questions a) What is the level of awareness, including in government, provincial and community levels of what coastal blue carbon ecosystems are, and their importance; b) Does your country include coastal blue carbon ecosystems in your Nationally Determined Contributions to implement the Paris Agreement?, and c) If no, are you considering including coastal blue carbon ecosystems in future pledges under your Nationally Determined Contributions?