INTERNATIONAL PARTNERSHIP FOR BLUE CARBON

Wetlands exchange—Lessons Learned

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Contents

Introduction

Coastal wetlands ecosystems are important for the wide range of ecosystem services they provide, including support of fisheries, water quality improvement, coastal protection, and their capacity for climate change mitigation. Mangroves, tidal marshes, and seagrass have high levels of carbon stocks, particularly in their soils, which when disturbed, converted or degraded can lead to CO_2 emissions. Conversely, conservation and restoration can lead to avoided greenhouse gas (GHG) emissions and increased carbon sequestration within these ecosystems.

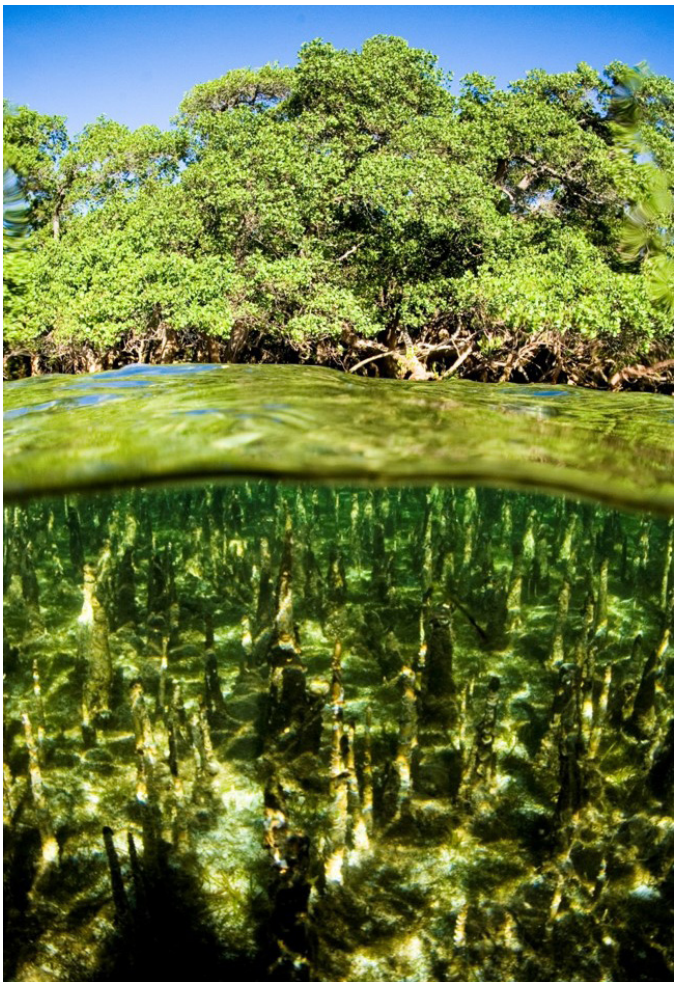

Photo by Baie D'Ambodi-Vahibe, Northeast Madagascar

The *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (from here-after called the *Wetlands Supplement*) provides guidance to countries on reporting for emissions associated with changes in the land-use of coastal wetlands, including both their conversion and degradation, as well as their restoration. The *Wetlands Supplement* is important as it provides technical advice for measuring, reporting, and verifying GHG emissions from coastal wetlands. The guidance within the *Wetlands Supplement* is an important innovation as it supports countries to account for GHG emissions associated with coastal wetlands and activities that were not previously included in the *2006 Guidelines*. The *Wetlands Supplement* therefore is an underpinning document that: 1) increases the range of options for reducing national GHG emissions, 2) provides a means of better understanding the ecosystems involved, and 3) facilitates a way to report the GHG benefits of improved management of coastal wetlands, for multiple reasons and under various policies. The *Wetlands Supplement* is relevant to policy frameworks including REDD+ and Ramsar, and to carbon offset markets. While reporting under the *Wetlands Supplement* is voluntary, improved management of coastal wetlands can contribute to countries' efforts to reduce GHG emissions under the UNFCCC Paris Agreement.

Few countries have implemented the Chapter 4 Coastal Wetlands guidance from the *Wetlands Supplement* indicating there is a need to 1) discover impediments to adopting the new guidance within the *Wetlands Supplement*; 2) document the process of including coastal wetlands within national GHG reports in those countries which have made progress to adopting the *Wetlands Supplement* in order to better understand how the *Wetlands Supplement* can be used, and 3) develop solutions and share knowledge to facilitate enhanced adoption of the *Wetlands Supplement*. This document describes the outcomes of a workshop held by the International Partnership for Blue Carbon and University of Queensland in Brisbane, Australia, July 2018 that addressed these three topics. Government representatives from Australia, Cambodia, Fiji, Malaysia, Mexico, Papua New Guinea, Thailand, United Arab Emirates and the United States joined scientists, non-government organisations to share information at the event.

Wetlands Supplement Overview

The *Wetlands Supplement* was scoped following recommendations from the Subsidiary Body for Scientific and Technological Advice of the UNFCCC in 2010 and 2011 when gaps in the *2006 Guidelines* were identified. Although peatlands and activities in peatlands were considered in the *2006 Guidelines* Wetlands chapter, guidance for GHG emissions for many types of wetlands were not considered. To include emissions associated with these other types of wetlands a seven Chapter Wetlands Supplement was developed, which included an Introduction (Chapter 1), guidance for emissions from Drained Inland Organic Soils (Chapter 2), Rewetted Organic Soils (Chapter 3), Coastal Wetlands (Chapter 4), Inland Wetland Mineral Soils (Chapter 5), Constructed Wetlands for Wastewater Treatment (Chapter 6) and Cross-cutting Issues and Reporting (Chapter 7).

Chapter 4 Coastal Wetlands provides guidelines for accounting for GHG emissions from mangroves, seagrass and tidal marshes that are consistent with the *2006 Guidelines*. Carbon pools considered were above- and below-ground biomass, dead wood and litter, soil carbon, and harvested wood products for mangroves. Tier 1 GHG emissions factors (emissions and removals) for a range of activities where there was sufficient science were developed (Table 1). For CO_2 emissions and removals the *Wetlands Supplement* considers forest management practices for mangroves (e.g. harvested wood products), extraction (e.g. dredging or excavation for aquaculture), drainage (e.g. conversion to agriculture), and rewetting, revegetation and wetland creation (e.g. for restoration). For nitrous oxide (N_2O) an emission factor for aquaculture is provided, while a Tier 1 emission factor for methane (CH_4) is provided for rewetted soils following a change in hydrology (Table 1). For the biomass carbon pools, but not other carbon pools, the Tier 1 emission factors are disaggregated into three climatic zones (tropical, subtropical, and temperate).

Table 1. Greenhouse gas emission and removals considered in the *Wetlands Supplement*, including activities covered and the ecosystems that are included.

Activity	Sub-activity	Vegetation types affected
Activities related to CO_2 emissions and removals		
Forest management practices	Planting, thinning, harvest, wood removal, fuelwood removal, charcoal production	mangrove
Extraction	Excavation to enable port, harbour & marine construction and filling or dredging to facilitate raising the elevation of the land	mangrove, tidal marsh, seagrass meadow
	Aquaculture—construction	mangrove, tidal marsh
	Salt production—construction	mangrove, tidal marsh
Drainage	Agriculture, forestry, mosquito control	mangrove, tidal marsh
Rewetting, revegetation & creation	Conversion from drained to saturated soils by restoring hydrology & re-establishment of vegetation	mangrove, tidal marsh
	re-establishment of vegetation on undrained	seagrass meadow
Activities related to non-CO_2 emissions and removals		
Aquaculture (use)	N_2O emissions from aquaculture use	mangrove, tidal marsh, seagrass meadow
Rewetted soils	CH_4 emissions from change to natural vegetation following modifcations to restore hydrology	mangrove, tidal marsh

In addition to the provided Tier 1 emission and removal factors, recommendations on the development of Tier 2 and 3 emission and removal factors are also provided. For example, at Tier 2, disaggregating emission factors based on climatic regions is suggested as "*good practice*", or at Tier 3, determining emission factors based on field measurements and statistical or process-based models. Guidance on the availability of activity data is also provided.

Blue Carbon Science Developments

The science associated with blue carbon has progressed rapidly since the *Wetlands Supplement* was published. New studies have encompassed a range of spatial scales (global to local) which could be appropriate for developing Tier 2 and Tier 3 emission and removal factors. Additionally, new information and resources are available for acquiring activity data at a range of scales. At the July 2018 workshop **representatives from most nations indicated obtaining reliable activity data was a key limitation to implementing the *Wetlands Supplement***. Below, a list of some developments (although not exhaustive) is provided to indicate the depth of developments in the field.

1. Emission and Removal Factors

Some of the new science available for development of Tier 2 CO_2 emission and removal factors have included bioregional values of forest biomass (Hutchinson et al. 2014), new biomass factors for temperate mangroves (Ewers Lewis et al. 2018), country-level soil carbon assessment for mangroves (Atwood et al. 2017) and tidal marshes (Ouyang and Lee 2014), a global mangrove soil carbon map at 30 x 30 m resolution (Sanderman et al. 2018), and soil carbon assessments based on coastal geomorphological classifications (Rovai et al. 2018). Some countries have studies that support disaggregation into different vegetation or geomorphic categories e.g. in Mexico (Adame et al. 2013) and Australia (Macreadie et al. 2017).

In some regions and countries, data that could underpin estimates of emissions have been provided for particular activities (Lovelock et al. 2017). These include clearing of mangroves for aquaculture in the Dominican Republic (Kauffman et al. 2014), for cattle grazing in Brazil (Kauffman et al. 2016), and for timber and charcoal in Malaysia (Adame et al. 2018). For tidal marshes, grazing (Yu and Chmura 2010) can impact carbon emissions. For seagrass, damage by boat anchors (Serrano et al. 2016) has also been considered. New research demonstrates the potential for substantial avoided methane emissions in impounded wetlands or other tidal marshes that are not flooded by saline water by restoring tidal inundation (Kroeger et al. 2017). Data of CO_2 removals due to restoration is also increasing (e.g. Osland et al. 2012; Salmo et al. 2013; Adame et al. 2018).

Photo by Sarah Hoyt, Salt marshes in Duxbury, Massachusetts USA

Photo by Corryanti Soetadji-Sambodo

2. Activity Data

Activity data, for example on mangrove deforestation, was reported to be some of the most difficult to obtain for countries who had limited capacity to collect data in-country. For country-level, Tier 2, changes in mangrove cover (since the *2013 Wetlands Supplement* was published) has been assessed by a range of researchers (e.g. Richards and Friess 2016; Hamilton and Casey 2016). Global remotely sensed products that provide change in cover for seagrass and tidal marsh ecosystems are not available, although distribution maps of the habitat are now available (**http://data.unep-wcmc.org/**).

Easy to access, spatially explicit remote sensing data provides opportunities to collect activity data, but these should be verified using locally sourced information to attribute change in aerial cover to known activities, complying with the good practice accounting rules for *Land Use and Land Use Change and Forestry* (LULUCF, 2000, 2003) and *2006 IPCC Guidelines*. New remote sensing products are becoming available, particularly for mangroves (e.g. Global Mangrove Watch, **https://www.globalforestwatch.org/map/3/15.00/27.00/ALL/grayscale/mangrove_watch?tab=analysis-tab&dont_analyze=true** , Thomas et al. 2017), and the Global Water Explorer (https://global-surface-water.appspot.com/, Pekel et al. 2016). Expert advice offered was "make sure to understand what global products are mapping, and that they are consistent with and calibrated to your national needs and local conditions".

Summary of approaches and common findings

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One of the key messages from the variety of approaches to implement the *Wetlands Supplement* was the strategy of incorporating components of the guidance where data availability was high. For example, the team from the USA has reported on N_2O emissions from aquaculture, calculated from aquaculture yield data that was available from the government fisheries records, while Australia has focused on sites or activities where data was available (e.g. dredging of seagrass habitats).

Allocating coastal wetlands to land categories: The USA, Australia, and United Arab Emirates (UAE) have all made progress to adopt components of the *Wetlands Supplement*. They have taken different approaches **based on whether coastal wetlands are considered "managed lands"**. The USA has taken a simple approach of considering all coastal wetlands as "managed lands" thereby reducing the need for detailed spatial reporting and analysis in order to calculate GHG emissions. By contrast, Australia has considered a subset of the total area of coastal wetlands, those which have undergone some "activity" (e.g. clearing of mangroves, capital dredging of seagrass), as managed coastal wetlands, necessitating detailed spatial data for the calculation of GHG emissions from activities within coastal wetlands. UAE has included coastal wetlands in their managed forested land category.

The approach chosen by countries is consistent with pre-existing definitions and understandings of managed lands by individual countries as well as the data resources available. In Australia and UAE, GHG emissions from some mangroves meet the definition of a forest (i.e. for Australia > 2m tall and 30 per cent canopy cover) and are reported within forest category of the GHG accounts.

Activity data: Discussion among the group of countries at the workshop suggested that while reference carbon stock data and emissions data were largely available (e.g. in the *Wetlands Supplement* or from the scientific literature) there were significant **challenges in collecting activity data**. It was agreed that while it is better to use local and national datasets, activity data was not always available for a range of reasons. These reasons included: 1) activity data is not collected nationally, 2) if collected by other government agencies they are often not aware of the use of the data and do not provide it in a form that is can be used for compiling GHG inventories. A suggested solution which may assist some nations is to assemble regional databases of activities where countries could extract suitable data for GHG inventories. For example, regional approaches for the Pacific, or South East Asia using existing partnerships e.g. Secretariat of the Pacific Regional Environment Programme (SPREP) or Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) may be appropriate.

Reporting on soils: Countries looked for guidance to making decisions around including soil carbon and to what soil depth emissions should be reported. There are existing guidelines in the *Wetlands Supplement* that recognize default values. For example, emissions/removals from mineral soils can be reported to 30cm for both Tier 1 and Tier 2 (Chapter 5 and consistent for REDD+, GOFC-GOLD 2013). Soil Organic Carbon stocks for mangrove, tidal marsh, and seagrass soils can be reported to 1m for Tier 1 and based on the availability of datasets for Tier 2 (Chapter 4) and data or models for Tier 3.

Gathering national soils data requires considerable investment, although there is some emerging research on optimizing sampling strategies to reduce costs. At Tier 2, the new global soil carbon map could be useful (Sanderman et al. 2018). In Australia, emissions and removals of soil carbon under coastal wetlands are not yet reported in the national accounts because of complexity in incorporating within existing models. For example, inclusion of the mangrove soil carbon pool in GHG accounts requires consideration of mangroves as a subset of forested land within the forest category, with its own emission and removals factors which adds complexity. Provision of suitable common reporting tables may make some of these decisions easier for inventory compilers (see below).

Reporting tables: Various issues with reporting within the existing **reporting tables and mechanisms** were also discussed as an impediment for reporting GHG emissions from coastal wetlands. Countries reported technical difficulties with reporting when using 2006 IPCC software and worksheets as dedicated lines in the spreadsheets are not evident for coastal wetlands. The USA team provided an example of adding lines to common reporting format (CRF) tables (see National Inventory Report website for USA example **https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/submissions/national-inventory-submissions-2017**). Australia incorporated mangroves within their forestry category (e.g. forest to settlement) (see Box on page 8). Development of tables and worksheets to assist in implementing the *Wetlands Supplement* would enhance uptake of the guidance and improve consistency in reporting among nations.

Country Case Studies

United States of America—developing the inventory

- All wetlands are recognized as managed lands, mostly consisting of agricultural to tidal marsh transitions with restoration. Both Vegetated Coastal Wetlands and Unvegetated Open Water Coastal Wetlands were included, although sufficient data on seagrasses were not available (Crooks and Beers 2018).
- Accounting for transitions in land-use due to restoration activities (e.g. rewetting) is included. The reporting table (below) shows areas of cropland, grasslands and other land categories converted to coastal wetlands.
- An interagency working group was created to facilitate effective collaboration between government offices and a consultant team responsible for the accounts.
- Coastal wetlands sequester 8.5 $MMTCO_2$ each year, but erosion releases 1–7 $MMTCO_2$ per year (Crooks and Beers 2018).

TO: / FROM:	Forest land (managed)	Forest land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetlands (managed)	Wetlands (unmanaged)	Settlements	Other land	Total unmanaged land	Initial area
	(kha)										
Forest land (managed)[2]	292493.19	IE	59.75	3960.58	NA	55.71	NA	417.91	75.35	IE	297062.49
Forest land (unmanaged)[2]	IE	8600.58	NO	IE	IE	IE	IE	NO	IE	IE	8600.58
Cropland[2]	165.32	NA	149721.75	16555.31	NA	345.82	NA	2982.16	679.31	NA	170449.68
Grassland (managed)[2]	678.10	NA	12827.06	303120.28	NA	700.08	NA	3653.28	1108.69	IE	322087.49
Grassland (unmanaged)[2]	IE	IE	NO	IE	26935.60	IE	IE	NO	IE	IE	26935.60
Wetlands (managed)[2]	31.47	NA	127.76	199.15	NA	41272.67	IE	26.17	101.76	IE	41758.97
Wetlands (unmanaged)[2]	IE	NA	IE	IE	NA	IE	IE	IE	IE	IE	IE,NA
Settlements[2]	16.57	NA	90.73	114.04	NA	1.31	NA	35848.47	13.03	IE	36084.15
Other land[2]	95.28	IE	212.50	1048.15	IE	98.06	NA	190.11	20809.09	IE	22453.19
Total unmanaged land [3]	IE	IE	NO	IE	IE	IE	IE	NO	IE	46300.25	46300.25
Final area	293479.93	8600.58	163039.56	324997.51	26935.60	42473.64	IE,NA	43118.10	22787.24	46300.25	971732.41
Net change[4]	-3582.56	0.00	-7410.12	2910.02	0.00	714.67	IE,NA	7033.95	334.05	0.00	0.00

United Arab Emirates—Accounting for mangrove and seagrass change with excavation and restoration

- UAE included mangrove aboveground and belowground biomass in the GHG inventory within the forestry sector of LULUCF and calculated annual removal of about 1 million tonnes of CO_2 by the mangroves using the IPCC 2006 worksheets.
- They manually calculated potential emissions of 62 million tonnes of CO_2 from soils and biomass due to excavation and removal of seagrass and mangroves.
- This work resulted in a forest management policy change to avoid extraction activities because of evidence that removal of mangroves was contributing to GHG emissions.

The Republic of Indonesia

- Indonesia has 22.6% of global mangrove cover (Giri et al. 2011) and has some of the most carbon rich mangroves in the world (Donato et al. 2011, Atwood et al. 2017). Indonesia also has substantial seagrass resources. The mangroves of Indonesia are highly threatened by aquaculture, which could account for a substantial part of Indonesia's LULUCF emissions (Murdiyarso et al. 2015).
- Indonesia includes mangroves within forestry, but currently does not include soil carbon.
- Indonesia plans to include mangroves within REDD+ and needs to have consistency between REDD+ and national inventory reporting.
- There are challenges as emission factors may vary spatially, among provinces and among species.

Australia—Investigating inclusion of a range of activities (extraction)

- Australia has reported coastal wetlands within its GHG inventory, and reported mangroves within its forest category.
- Coastal wetlands are approximately 5% of national carbon stocks in the Forest sector.
- They are examining case studies for a range of activities, e.g. dredging of ports, harbours and marinas maintain navigable passages for boating and shipping and excavation due to canal estate development; and excavation for aquaculture.
- They convened a technical expert panel to provide advice on implementation of *2013 Supplement* for coastal wetlands within national GHG accounts.
- In the future, Australia plans to continue to incorporate new data to improve model values and identify and incorporate new activities to extend activity data coverage.

(From left) Photos by Astra Bonardo, Marunda, North Jakarta and Mutiara C Andani

Lessons Learned

	Key Lessons Learned
Reporting	• IPCC worksheets and reporting tables are not user friendly for implementation for coastal wetlands • Initiating application of the *Wetlands Supplement* is difficult, countries should focus on what is available and improve the account as more information can be incorporated
Technology & Activity Data	• Activity data is difficult to obtain despite increasing availability of global remote sensing products • To access activity data, countries should combine resources, work together with multiple groups and agencies, and use Tier 1 default values and emission factors when country-specific information is not available
Modelling	• Tier 3 models for GHG emissions and removals from coastal wetlands are emerging but not available for all countries and require regional, national and subnational calibration • Many global datasets are available
Policy	• Integration of GHG inventory teams with other government institutions that are responsible for providing data is often an impediment • Inclusion of coastal wetlands within GHG Inventory can alter policy • Non-governmental organizations already implement some of this work with communities, so they need to be integrated into these plans

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Next Steps and Conclusion

A number of recommendations were identified to assist with implementation of the *Wetlands Supplement* Chapter 4, Coastal Wetlands. These included:

- Training workshops to provide technical knowledge in using existing and emerging tools for inventory compilers and linking inventory compilers with scientists and applicable science.
- Training in interpreting remotely sensed data, assessing major drivers influencing coastal wetland inventories and use of models.
- Peer-to-peer exchange and the establishment of technical reference groups.
- The improvement or development of 'guides' to working with IPCC worksheets and tables was a high priority and the development of regional emission factor databases or repositories of information for inventory compilers.
- Increase consideration of mangroves, including remote sensing and analysis, such as by the Global Forest Observations Initiative. This would support better coverage of mangroves under REDD+.
- New research needs include expansion of the range of emission factors and activity data across regions and geomorphic settings, CH_4 emissions across salinity gradients and from impounded water and ditches, and N_2O emissions in wetlands loaded by nutrients.
- This July 2018 workshop demonstrated the value of international communication and collaboration to identify common challenges, discuss solutions, and establish connections and to maintain this critical partnership as the process of creating GHG inventories progresses.

Photo by Wahyu Budiarso

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