CHAPTER 1

INTRODUCTION

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1 INTRODUCTION

1.1 BACKGROUND

The *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (*2006 IPCC Guidelines*) acknowledged that the methodological guidance for the land-use category Wetlands in Volume 4 (Agriculture, Forestry and Other Land Use—AFOLU), Chapter 7 (Wetlands) is incomplete and limited to estimating emissions of carbon dioxide (CO_2) and nitrous oxide (N_2O) from *peatlands cleared and drained for production of peat for energy, horticultural and other uses* (Section 7.2, Chapter 7 in Volume 4 of the *2006 IPCC Guidelines*), and CO_2 emissions from land converted to flooded land such as *reservoirs for production of hydroelectricity, irrigation and navigation* (Section 7.2, Chapter 7 in Volume 4 of the *2006 IPCC Guidelines*). In October 2010, an IPCC expert meeting on harvested wood products, wetlands, and N_2O emissions from soils concluded that there is sufficient new scientific information available to provide additional methodological guidance and fill gaps in the existing *2006 IPCC Guidelines* for the rewetting and restoration of peatlands; emissions from fires, ditches, and waterborne carbon; and constructed wetlands for waste water disposal (IPCC, 2011). In December 2010, the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the United Nations Framework Convention on Climate Change (UNFCCC) invited the IPCC *to undertake further methodological work on wetlands, focusing on the rewetting and restoration of peatland, with the objective of filling in the gaps in the 2006 IPCC Guidelines in these areas*.

In response to the invitation of SBSTA, this *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*: *Wetlands - Methodological Guidance on Lands with Wet and Drained Soils, and Constructed Wetlands for Wastewater Treatment* - (*Wetlands Supplement*) provides new and supplementary guidance on estimating and reporting greenhouse gas emissions and removals from lands with organic soils and with wet mineral soils in Wetlands and other land-use categories with these soil types that are subject to human activities ('managed'). The *Wetlands Supplement* is organized into the following chapters:

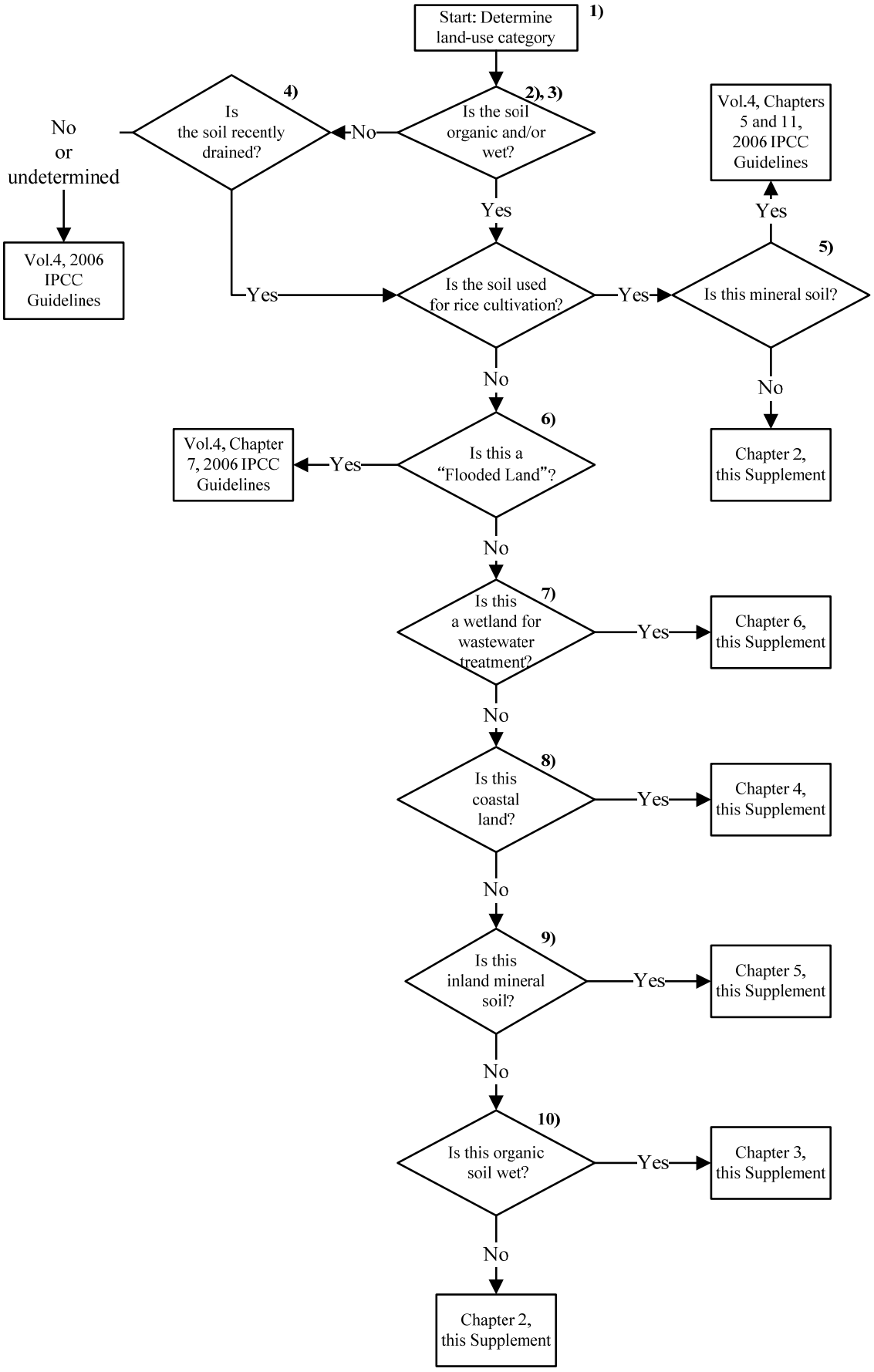
- Chapter 2: Drained Inland Organic Soils
- Chapter 3: Rewetted Organic Soils
- Chapter 4: Coastal Wetlands
- Chapter 5: Inland Wetland Mineral Soils
- Chapter 6: Constructed Wetlands for Wastewater Treatment
- Chapter 7: Cross-Cutting Issues and Reporting

1.2 GUIDANCE FOR USING THIS SUPPLEMENT

This introductory chapter provides guidance on how to use this *Wetlands Supplement* in conjunction with the existing *2006 IPCC Guidelines* when preparing a greenhouse gas inventory that includes land with organic or wet mineral soils across all IPCC land-use categories. The decision tree (Figure 1.1) can be used by inventory compilers as a guide to the relevant chapters within this *Wetlands Supplement* and/or the *2006 IPCC Guidelines*. The numbers located near the "start" box and the diamonds in the decision tree refer to the guidance notes below. The notes explain and illustrate the terms used in the decision tree and in this document (see also the glossary).

The terms are for the purpose of this document and their definitions are not intended to pre-empt other definitions of these terms in other contexts. For example: Except for in the name of this supplement, this guidance uses the term 'Wetlands' (with capital 'W' and always plural) solely when referring to the IPCC land-use category Wetlands. The terms 'wetland' or 'wetlands' (with lowercase 'w' and singular or plural) are used to refer to land with wet soil as defined in note 3 below. Other articulations of the 'wetland' concept are possible e.g. that used by the Ramsar Convention (www.ramsar.org/cda/en/ramsar-documents-texts-convention-on/main/ramsar/1-31-38%5E20671_4000_0__) but this does not affect the methodological guidance provided.

Figure 1.1 Decision tree for finding the appropriate guidance chapter within the *Wetlands Supplement* or the *2006 IPCC Guidelines*

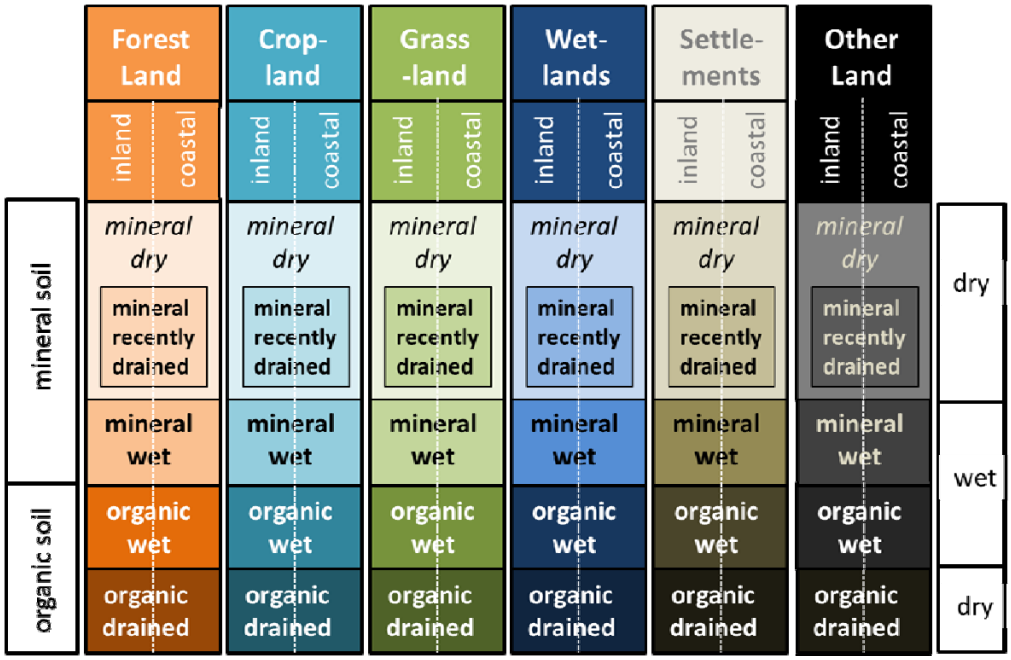


Note 1: Determine land-use category

The *Wetlands Supplement* covers land with wet and dry organic soils and wet and recently drained mineral soils (see notes 2, 3, and 4 for the definition of these terms) across all IPCC land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements, and Other Land, see Figure 1.2). The *Wetlands Supplement* is consistent with Chapter 3 (Consistent Representation of Lands) in Volume 4 of the *2006 IPCC Guidelines* in that it does not change the assignment of land to a category. If using Approach two or three for the land representation [1], land-use conversions (e.g., Forest Land converted to Cropland, Cropland converted to Settlements) should also be identified.

Compared to the *2006 IPCC Guidelines* the *Wetlands Supplement* identifies relevant subcategories (see Figure 1.2 below) and specifies emission factors for all land-use categories with organic, wet mineral or recently drained mineral soils. The *Wetlands Supplement* also differentiates coastal land from inland land, because water salinity and dynamics (e.g., tides) may, for the same land-use category, modify emission factors compared to inland land.

Figure 1.2 Soil based subcategories that are being addressed in the *Wetlands Supplement*



Notes on Figure 1.2: Guidance for all the soils shown in this figure is included the Supplement except for the 'mineral dry' soils that are not 'recently drained' (see note 4). Guidance for 'mineral dry' soils that are not 'recently drained' is provided in the *2006 IPCC Guidelines*.

It is *good practice* to subdivide each land use/conversion category into subcategories with similar characteristics. The *Wetlands Supplement* proposes a division into four soil subcategories; all with a coastal and inland subdivision where appropriate (see Figure 1.2 above):

1) dry mineral soil (with the subdivision 'recently drained')

2) wet mineral soil

3) wet organic soil

4) drained (dry) organic soil.

In the case where dry (but not recently drained, see note 4) mineral soil remains dry mineral soil, use the guidance in the *2006 IPCC Guidelines* on soil carbon estimation in the Forest Land, Cropland or Grassland Chapters as appropriate. In all other cases (including the case of 'recently drained mineral soil', i.e. a dry mineral soil that has recently originated from a wet mineral soil, and the case of the conversion of a dry mineral soil to a wet mineral soil), use the decision tree (see Figure 1.1 above) to identify the appropriate guidance chapter within this *Wetlands Supplement* or the *2006 IPCC Guidelines*

The *2006 IPCC Guidelines* are used for estimating and reporting anthropogenic greenhouse gas emissions and removals only. With respect to 'land' this requires inventory compilers to differentiate between 'managed' and

[1] Cf. Section 3.3.1, Chapter 3 in Volume 4 of the *2006 IPCC Guidelines*

'unmanaged' land for all land-use categories besides Cropland and Settlements, which are inherently managed land. The *Wetlands Supplement* continues to apply the Managed Land Proxy (see Section 1.3 of this supplement) to estimate anthropogenic greenhouse gases. In case of coastal wetlands, guidance is provided to estimate and report countries' emissions and removals from specific management activities.

Note 2: Is the soil organic?

An organic soil is a soil with a high concentration of organic matter (see below). Every soil that is not an organic soil is classified as a mineral soil, following the *2006 IPCC Guidelines* (Annex 3A.5, Chapter 3 in Volume 4). The *Wetlands Supplement* follows the definition of organic soils in the *2006 IPCC Guidelines* (Annex 3A.5 , Chapter 3 in Volume 4):

Organic soils are identified on the basis of criteria 1 and 2, or 1 and 3 listed below (FAO 1998):
1. Thickness of organic horizon greater than or equal to 10 cm. A horizon of less than 20 cm must have 12 percent or more organic carbon when mixed to a depth of 20 cm.
2. Soils that are never saturated with water for more than a few days must contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).
3. Soils are subject to water saturation episodes and has either:
a. At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soil has no clay; or
b. At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soil has 60% or more clay; or
c. An intermediate proportional amount of organic carbon for intermediate amounts of clay.

The *2006 IPCC Guidelines* largely follow the definition of Histosols by the Food and Agriculture Organization (FAO), but have omitted the thickness criterion from the FAO definition to allow for often historically determined, country-specific definitions of organic soils.

For peat and peatland, no IPCC definitions exist. Definitions of peatland and peat soil differ between countries with respect to how thick the peat layer must be to call something a peatland or a peat soil. Also the definition of peat varies among countries and disciplines, especially with respect to the minimum percentage of organic matter the material has to contain (Joosten and Clarke, 2002). In the *Wetlands Supplement* the concept of peatland is considered to be included in '(land with) organic soil'.

It is *good practice* that, when a country uses another definition of organic soil in accordance with its national circumstances, the concept of organic soil (and its possible subdivisions) applied is clearly defined and that the definition is applied consistently both across the entire national land area and over time.

Note 3: Is the soil wet?

A wet soil is a soil that is inundated or saturated by water for all or part of the year to the extent that biota, particularly soil microbes and rooted plants, adapted to anaerobic conditions control the net annual greenhouse gas emissions and removals**.** Every soil that is not a wet soil is classified as a dry soil (see also note 4).

With respect to soil wetness, for the tier 1 approach this *Wetlands Supplement* differentiates only between wet soil and dry soil. Dry soils generally do not emit methane, but do emit nitrous oxide, whereas wet soils generally do not emit nitrous oxide, but do emit methane. As methane, carbon dioxide and nitrous oxide emissions can vary with water table depth (see Chapters 2 and 3 of this *Wetland Supplement*), it is *good practice* to differentiate more finely amongst water level classes in higher tiers. It should also be noted that flooded (paddy) rice (even on earlier drained land) is considered to be wet soil.

A wetland is an area of land with a wet soil. It is *good practice* that – when a country uses another concept of wetland in accordance with its national circumstances – the definition of wetland (and its possible subdivisions) applied is clearly defined and applied consistently both across the entire national land area and over time.

Rewetting is the process of changing a drained soil (see note 4) into a wet soil. A rewetted soil is a soil that formerly has been a drained soil but as a result of human intervention has become a wet soil.

Restoration (adjective restored) is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. In case of drained former wetlands, restoration always has to include rewetting.

Note 4: Is the soil recently drained?

Drainage is the process of changing a wet soil (see note 3) into a dry soil (see note 3). A drained soil is a soil that formerly has been a wet soil but as a result of human intervention has become a dry soil. All organic soils are assumed to have originally been wet, so that a dry organic soil always is also a drained organic soil.

Recently drained mineral soils may have a 'memory' of the former wet soil conditions (i.e. a high organic content) that may make their greenhouse gas emission characteristics different from mineral soils that always

have been dry. These differences fade out with progressing time after drainage due to the loss of carbon from the aerobic part of the soil. As long as these differences in emission exist, the soil is considered to be 'recently drained'.

Tier 1 does not distinguish such transition period for organic soils, that is, it does not differentiate between recently and long-time drained organic soils. In organic soils the amount of carbon in the aerobic part of the soil does not substantially decrease as long as the soil remains both 'drained' and 'organic'.

Note 5: Soil under rice cultivation

It is *good practice* to separate rice cultivation on mineral soils from that on organic soils. For cultivation on mineral soils the emissions are determined using the *2006 IPCC Guidelines*. For cultivation on tropical organic soils emission factors for CO_2, methane (CH_4) and N_2O are presented in Chapter 2 of the *Wetlands Supplement*.

Note 6: Is this a 'Flooded Land'?

Flooded Land is defined in the *2006 IPCC Guidelines* as *water bodies where human activities have caused changes in the amount of surface area covered by water, typically through water level regulation. Examples of Flooded Land include reservoirs for the production of hydroelectricity, irrigation, and navigation. Regulated lakes and rivers that do not have substantial changes in water area in comparison with the pre-flooded ecosystem are not considered as Flooded Lands. Some rice paddies are cultivated through flooding of land, but because of the unique characteristics of rice cultivation, rice paddies are addressed in Chapter 5 (Cropland) of the Guidelines* (Section 7.3, Chapter 7 in Volume 4 of the *2006 IPCC Guidelines*).

This *Wetlands Supplement* does not include additional guidance for Flooded Land. Estimating emissions from this category of land use is discussed in Section 7.3, Chapter 7, Volume 4 of the *2006 IPCC Guidelines*. Reservoirs constructed as wetlands for wastewater treatment are covered in Chapter 6 of the *Wetlands Supplement*.

Note 7: Is this a wetland for wastewater treatment?

A wetland for wastewater treatment is a wetland that is used for or influenced by waste water treatment. Chapter 6 of the *Wetlands Supplement* provides guidance for wetlands for wastewater treatment, both for wetlands that are constructed for that purpose (constructed wetlands for wastewater treatment) and for natural wetlands that are used for or influenced by wastewater treatment. The emissions are reported under the Waste Sector. Other constructed (i.e., man-made, engineered or artificial wetland creation) wetlands are included in Chapter 5 of the *Wetlands Supplement.*

Note 8: Is this coastal land?

Coastal land is land at or near the coast. It is *good practice* that a country clearly defines the concept of 'coastal land' and its sea- and landward limits in accordance with its national circumstances and applies that definition consistently both across the entire national land area and over time. All land that is not coastal is inland.

The types of land of interest here include coastal wetland (with both primary wet soil and rewetted soil, see note 3) and recently drained former coastal wetland (see note 4).

A coastal wetland is a wetland (see note 3) on coastal land that is influenced by saline or brackish water and/or astronomic tides. Coastal wetland may occur on both organic and mineral soils. Brackish/saline water is water that normally contains more than 5 or more parts per thousand (ppt) of dissolved salts. Every mineral soil wetland that is neither a coastal wetland (see note 8), nor a Flooded Land (see note 6) nor a constructed wetland (see note 7) for waste water treatment is classified as inland wetland (cf. Chapter 5).

Note 9: Is this inland mineral soil?

Inland mineral soil is all mineral soil (see note 2) that is not on coastal land (see note 8). The types of land of interest that are likely to be identified include inland mineral soil wetland (with both primary wet soils and rewetted soils, see note 3) and recently drained former inland mineral soil wetland (see note 4).

An inland mineral soil wetland is every wetland (see note 3) on mineral soil (see note 2) that is neither a coastal wetland (see note 8), nor a Flooded Land (see note 6) nor a constructed wetland for wastewater treatment (see note 7). Inland mineral soil wetlands may have brackish/saline water (see note 8).

Note 10: Is this organic soil wet?

Chapter 3 of the *Wetlands Supplement* focuses on rewetted organic soils and peatlands. While Chapter 3 of the *Wetlands Supplement* does not provide Tier 1 methods for management practices such as paludicultures, these are discussed in the general discussion and in the higher tier sections of that chapter. Chapter 2 of the *Wetlands Supplement* covers drained (dry) organic soils.

BOX 1.1
GREENHOUSE GAS EMISSIONS AND REMOVALS OF MANAGED ORGANIC AND WET SOILS

Lands with organic and wet soils are crucial in maintaining the Earth's carbon balance as they contain soils with high organic carbon content (Mitra *et al.*, 2005; Joosten and Couwenberg, 2008; Donato *et al.*, 2011). Human activities on wetlands (e.g., drainage, agriculture, forestry, peat extraction, aquaculture) and their effects (e.g., oxidation of soil organic matter) may significantly affect the carbon and nitrogen balance and, thus, the greenhouse gas emissions and removals from these lands. The actual magnitude of human-induced emissions and removals from lands with organic or wet soils depends on numerous variables, including soil type, type of land use/conversion, wetland type, wetland size, management practice, vegetation composition, water table depth, growing season length, salinity, precipitation, and temperature and is discussed in greater detail in this *Wetlands Supplement*.

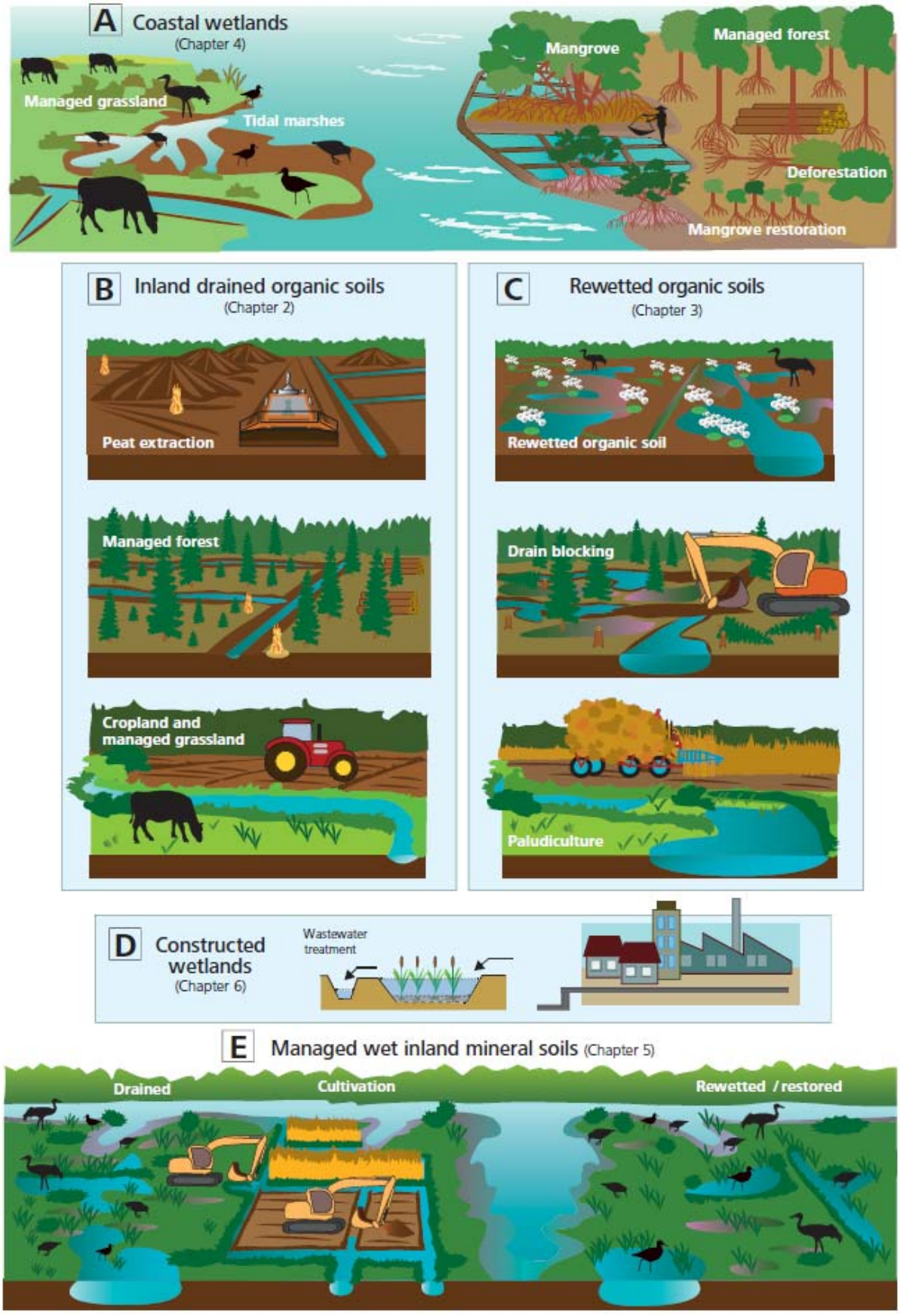
Draining inland organic soils lowers the water table and increases the oxygen content of the soil, thus increasing CO_2 emissions. CH_4 emissions from drained inland organic soils are generally negligible because the soil carbon is then preferentially oxidized to CO_2. However, methanogenesis may take place in drainage ditches with a higher water table causing significant sources of CH_4 to the atmosphere. Drained organic soils can also emit significant amounts of N_2O from nitrogen in the organic matter or nitrogen added by fertilization. Removals of particulate and dissolved organic carbon in drainage waters from organic soil are also included in this *Wetlands Supplement* (Chapter 2). Rewetting inland organic soils raises the water table again, decreases CO_2 emissions, rapidly decreases N_2O emissions to close to zero, and increases CH_4 emissions compared to the drained state as the oxygen level in the soil drops and methanogenesis starts again. Rewetting can also restore wetlands to a state where net emissions are greatly reduced or even become negative and the wetlands function as a net remover of greenhouse gases from the atmosphere (Chapter 3 of this supplement). CO_2 emissions from coastal wetlands can be significant especially during the construction phase of aquaculture and salt production/extraction. CH_4 and N_2O emissions from coastal wetlands are not significant except when the wetlands are enriched with nutrients from agricultural run-off or sewage (Chapter 4 of this supplement). Restoring and creating wetlands on mineral soils, similar to rewetting organic soils, creates anoxic conditions and increases CH_4 emissions (Chapter 5 of this supplement). Constructed and semi-natural wetlands used for wastewater treatment emit CH_4 and N_2O (Chapter 6 of this supplement).

1.3 APPLICATION OF THE MANAGED LAND PROXY TO WETLANDS

The Managed Land Proxy is used in the *2006 IPCC Guidelines* and *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (*GPG-LULUCF*) as a pragmatic way to estimate anthropogenic emissions and removals because detailed factoring out of natural emissions or removals is impractical at the country level. According to the *2006 IPCC Guidelines* (Section 3.2, Chapter 3 in Volume 4), *managed land is land where human interventions and practices have been applied to perform production, ecological or social functions*, and all emissions and removals from managed land are to be reported regardless of whether they are anthropogenic or non-anthropogenic.

The Managed Land Proxy continues to be applied in the *Wetlands Supplement*. For coastal wetlands (Chapter 4 of this supplement), where non-anthropogenic emissions and removals are often significantly greater than the anthropogenic fluxes, this *Wetlands Supplement* provides guidance to estimate and report countries' emissions and removals from specific management activities (e.g., aquaculture, salt production, dredging). See Figure 1.3 below for some typical management practices on wetlands.

272 **Figure 1.3 Typical management practices on organic and wet soils**



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1.4 COHERENCE AND COMPATIBILITY WITH 2006 IPCC GUIDELINES

This section provides an overview of the linkages between the *2006 IPCC Guidelines* and the information presented in this *Wetlands Supplement*. Section 1.4.1 presents an outline of the activities in the *2006 IPCC Guidelines* that are the topic of additional guidance in this supplement. Section 1.4.2, highlights the guidance in this supplement that was not previously included in the *2006 IPCC Guidelines* and may need to be considered by inventory compilers.

1.4.1 Guidance on activities in the 2006 IPCC Guidelines that are also covered in the Wetlands Supplement

CARBON STOCK CHANGES IN MINERAL AND ORGANIC SOILS

The *2006 IPCC Guidelines* provide guidance for estimating carbon stock changes in mineral soils and drained organic soils within the land use categories Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land. In Section 2.3.3, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*, complete guidance is provided at the Tier 1 level, with additional guidance for Tiers 2 and 3. For mineral soils, the default method is based on changes in soil carbon stocks over a finite period of time. The change is computed based on the carbon stock after the management change relative to the carbon stock in a reference condition. To estimate CO_2 emissions from drained organic soils an area-based annual emission factor is applied that is differentiated by climate region and land use. The *Wetlands Supplement* provides additional guidance for both organic and wet mineral soils that may need to be considered. Mineral soils are sub-divided into dry mineral soils (not subject of the *Wetlands Supplement*), wet mineral soils and recently drained mineral soils. The information with respect to organic soils is expanded to include activities on wet (undrained, rewetted or restored) organic soils. The information in Table 4.6 in Chapter 4 (Forest Land), Table 5.6 in Chapter 5 (Cropland), and Table 6.3 in Chapter 6 (Grassland) in Volume 4 of the *2006 IPCC Guidelines*, which provide CO_2 emission factors for drained organic soils, is updated in Table 2.1 in the *Wetlands Supplement*.

CH_4 EMISSIONS FROM MANAGED SOILS

Section 2.3.3.1, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines* assumes CH_4 emissions due to the drainage of organic soils are negligible. The *Wetlands Supplement* provides guidance on estimating CH_4 emission from drained organic soils and drainage ditches, including default emission factors in Table 2.3 and 2.4 in Chapter 2, respectively.

The *2006 IPCC Guidelines* do not provide guidance on estimating CH_4 emissions from mineral soils except for rice cultivation. The *Wetlands Supplement* provides guidance on this potential source in Table 5.4 in Chapter 5, based upon a review of the available scientific literature.

BIOMASS AND DEAD ORGANIC MATTER CARBON STOCK CHANGES

The generic methodologies for estimating above-ground and below-ground biomass carbon stock changes for all land-use categories are available in Section 2.3.1, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*. Guidance to estimate the dead organic matter pool is provided in Section 2.3.2, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*. More specific guidance by land-use categories can be found in Volume 4 of the *2006 IPCC Guidelines* under the specific land-use category Chapters: 4 (Forest Land), 5 (Cropland), 6 (Grassland), 7 (Wetlands), 8 (Settlements), and 9 (Other Land). The *Wetlands Supplement* provides additional guidance for these carbon pools with respect to coastal wetlands in Section 4.2, Chapter 4.

The *Wetlands Supplement* does not provide additional guidance for these pools in Chapters 2, 3 and 6. The *Wetlands Supplement* provides new emission factors for carbon stock changes in biomass, dead organic matter and for soils for those associated with activities that occur in coastal wetlands (Section 4.2, Chapter 4). New stock change factors are provided for inland wet mineral soils (Section 5.3, Chapter 5).

DIRECT AND INDIRECT N_2O EMISSIONS FROM MANAGED SOILS

In Section 11.2, Chapter 11 in Volume 4 of the *2006 IPCC Guidelines*, methodologies are provided to estimate both direct and indirect N_2O emissions from managed soils. Generic equations are presented that can be applied to all land areas in aggregate or to specific land-use categories if activity data are available. N_2O emissions from drained organic soils are estimated using an area-based annual emission factor differentiated by climate region. The *2006 IPCC Guidelines* cautions of the risk of double counting of indirect N_2O emissions that are reported elsewhere, e.g. under Agriculture (Chapter 11, Volume 4) or under Industry (Section 7.3, Chapter 7 in Volume 1). This caution is reiterated here with regard to the use of the additional information about N_2O emissions,

Certain Tier 1 N_2O emission factors provided in Tables 11.1 (direct emissions), Chapter 11 in Volume 4 of the *2006 IPCC Guidelines* are updated Table 2.5, Chapter 2 in the *Wetlands Supplement*.

NON-CO_2 EMISSIONS FROM BIOMASS BURNING

Generic guidance for non-CO_2 emissions due to burning of live and dead biomass on managed lands (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land) is provided under Section 2.4, Chapter 2, Volume 4 of the *2006 IPCC Guidelines*. The existing guidance does not include burning of peat and other organic soils, which is a large emission source for some countries. The *Wetlands Supplement* addresses CO_2, CH_4 and carbon monoxide (CO) emissions associated with burning of organic soils.

RICE CULTIVATION

CH_4 emissions from rice cultivation are included in Section 5.5, Chapter 5 in Volume 4 of the *2006 IPCC Guidelines*. Soil carbon stock changes are accounted for using guidance as described above in Section 2.3.3, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*. Chapter 2 of the *Wetlands Supplement* provides emission factors for CO_2, CH_4 and N_2O for rice cultivation on tropical drained organic soils.

WETLANDS

In the Wetlands chapter of the *2006 IPCC Guidelines* (Chapter 7 in Volume 4), methodologies are provided to estimate greenhouse gas emissions and removals from peatlands cleared and drained for extracting peat for energy, horticulture and other uses (Section 7.2, Chapter 7 in Volume 4 of the *2006 IPCC Guidelines*). Emissions from the use of horticultural peat are accounted for in Chapter 7 in Volume 4 of the *2006 IPCC Guidelines*, while emissions from peat used for energy generation are estimated under the Energy Sector (Volume 2 of the *2006 IPCC Guidelines*). In the *2006 IPCC Guidelines*, guidance for peat extraction that does not include drainage is not provided; this remains the case in this *Wetlands Supplement*.

The *2006 IPCC Guidelines* (Volume 4, Chapter 7) provide guidance for estimating CO_2 emissions from reservoirs or impoundments used for hydroelectricity production, irrigation, navigation, or recreation (Section 7.3). This guidance, however, is restricted to CO_2 emissions from land converted to flooded land, i.e., where human activities have caused an increase in area covered by water. Regulated lakes and rivers that do not have substantial changes in water area in comparison with the pre-flooded ecosystem are not considered flooded land. No additional guidance relative to that in the *2006 IPCC Guidelines* (Chapter 7 in Volume 4) is provided in this *Wetlands Supplement* for cases where the management of reservoirs or impoundments for water supply fulfil the definition of Flooded Land.

WASTEWATER TREATMENT

Chapter 6 in Volume 5 of the *2006 IPCC Guidelines* (wastewater treatment and discharge) provides a methodology to estimate CH_4 and N_2O emissions from domestic and industrial wastewater treatment. CO_2 emissions from wastewater are not considered in the *IPCC Guidelines* and should not be included in national total emissions because of their biogenic origin. The *Wetlands Supplement* provides guidance on CH_4 and N_2O emissions associated with constructed and natural wetlands used for wastewater treatment.

1.4.2 Supplementary guidance in this report

Figure 1.3 shows schematic representations of typical generic management practices that are covered in each of the chapters of the *Wetlands Supplement*. The illustrations are not intended to be comprehensive; rather they are a visual guide to the landscapes and ecosystem types that are to be considered when using this supplement.

CHAPTER 2—DRAINED INLAND ORGANIC SOILS

Chapter 2 in the *Wetlands Supplement* provides an updated summary of emission factors and supplementary guidance to Volume 4 of the *2006 IPCC Guidelines* on estimating greenhouse gas emissions and removals from drained inland organic soils for all land-use categories: Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land, (see Figure 1.3, Frame B in this chapter).

Additional Tier 1 guidance is provided to include the impact of drainage depth (water-table level) on the emission of CO_2, CH_4 and N_2O. New emission factors to estimate the release of CH_4 from drainage ditches are also provided.

Chapter 2 in the *Wetlands Supplement* also identifies additional pathways by which carbon is lost from the soil: namely carbon loss as Dissolved Organic Carbon (DOC), as Particulate Organic Carbon (POC), and as Dissolved Inorganic Carbon (DIC). Guidance is provided to estimate these carbon losses separately from the direct emissions. The loss of carbon from managed organic soils via DOC can be estimated using the Tier 1 methodology and the emission factors provided. Chapter 2 does not provide Tier 1 methodologies for emissions associated with POC or DIC. However, Annex 2A.1, Chapter 2 in the *Wetlands Supplement* sets out the basis for future methodological development for estimating CO_2 emissions associated with waterborne carbon loss from POC. Fire on drained organic soils causes not only on-site CO_2, CH_4, and N_2O emissions directly from the burning, but also has a high potential to increase off-site carbon loss from waterborne organic matter. Chapter 2 in the *Wetlands Supplement* provides supplementary methodological guidance to estimate CO_2, CH_4 and CO emissions.

CHAPTER 3—REWETTED INLAND ORGANIC SOILS

Chapter 3 in the *Wetlands Supplement* provides new guidance and emission factors for organic soils that had been drained for forestry, crop production, grazing, peat extraction or other purposes, and subsequently have been rewetted to re-establish water saturation (see Figure 1.3, Frame C in this chapter). Rewetting may have several objectives such as emission reduction, restoration for nature conservation or enabling other management practices on saturated organic soils (paludicultures). While restoration may take place on undrained sites (e.g., restoration of damaged vegetation cover), in the majority of cases restoration will include rewetting.

Chapter 3 provides Tier 1 guidance for assessing the greenhouse gas (CO_2, CH_4 and N_2O) emissions and removals from rewetted organic soils by climate region and general guidance for utilizing higher tier methodologies.

CHAPTER 4—COASTAL WETLANDS

Chapter 4 in the *Wetlands Supplement* provides guidance on estimating emission and removals of greenhouse gases (CO_2, CH_4 and N_2O) associated with specific activities on managed coastal wetlands, which may or may not result in a land use change. Coastal wetlands are wetlands near the coast that are influenced by tidal and/or saline or brackish water. They may consist of mangrove, tidal marsh and seagrass vegetation and can have organic and mineral soils (see Figure 1.3, Frame A in this chapter). Management practices included in the guidance are aquaculture, salt production, extraction, drainage, rewetting and revegetation, and forest management activities in mangroves.

CHAPTER 5—INLAND WETLAND MINERAL SOILS

Chapter 5 in the *Wetlands Supplement* provides guidance for inland managed lands with wet mineral soils not included in Chapter 4 (coastal wetlands) or Chapter 6 (constructed wetlands for wastewater treatment) in the *Wetlands Supplement*, and for recently drained inland mineral soils. The chapter provides methodologies for estimating greenhouse gas emissions and removals, gives updated default reference values for soil organic carbon stocks and offers a default stock change factor for land use for long term cultivation of croplands on inland wet mineral soils. It also gives guidance not contained in the *2006 IPCC Guidelines*, including a default stock change factor for land use for rewetted croplands, and methodologies and emission factors for CH_4 emissions for mineral soils in any land-use category that have been rewetted or have been inundated for the purpose of wetland creation.

Chapter 5 in the *Wetlands Supplement* does not provide guidance on the application of the methodology from Chapter 11 in Volume 4 of the *2006 IPCC Guidelines*, for estimating N_2O emissions associated with loss of soil carbon as a result of changes in land use and/or management on inland wetland mineral soils based on estimates

of the loss of soil carbon in relation to the updated and new defaults for SOC_{REF} and SOC stock change factors. But the Chapter suggest a future development on the issue.

CHAPTER 6—CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT

Chapter 6 in the *Wetlands Supplement* provides guidance on estimating CH_4 and N_2O emissions from constructed wetlands and semi-natural treatment wetlands used for wastewater treatment (see Figure 1.3, Frame D in this Chapter). The guidance supplements Chapter 6 in Volume 5 of the *2006 IPCC Guidelines* on wastewater treatment. Default emission factors for different types of constructed wetlands, e.g., those with surface, subsurface vertical or subsurface horizontal flows, are provided for the Tier 1 method. The types of wastewater include domestic, industrial wastewater, collected runoff from agricultural land and leachate from landfill. To avoid double-counting, N_2O emissions from wetlands managed for the filtration of non-point source agricultural effluents such as fertilizers are included in indirect N_2O emissions from managed soils (Chapter 11 in Volume 4 of the *2006 IPCC Guidelines*) as part of the leaching/ runoff and volatilization components of indirect emissions, and are not considered within this Supplement. No specific guidance for estimating potential changes in carbon pools associated with constructed wetlands for wastewater treatment is presented in Chapter 6 in the *Wetlands Supplement*. The inventory compiler is encouraged to consider guidance in the *2006 IPCC Guidelines* and in the *Wetlands Supplement* for possible approaches to reporting these carbon pools.

CHAPTER 7—CROSS-CUTTING ISSUES AND REPORTING

Chapter 7 in the *Wetlands Supplement* provides guidance on reporting and cross-cutting issues, including uncertainties, key category analysis, completeness, time series consistency, quality control, and quality assurance. The chapter summarizes the *good practice* guidance on these cross-cutting issues found in Volume 1 of the *2006 IPCC Guidelines* and addresses the cross-cutting issues specific to Chapters 2 to 6 of this *Wetlands Supplement.* Worksheets that can be used for estimating the emissions and removals for each category using the Tier 1 guidance, and revised background tables are included in the annex of the chapter.

OVERVIEW OF GENERAL CONSIDERATIONS IN USING THE WETLANDS SUPPLEMENT AND THE 2006 IPCC GUIDELINES

It is *good practice* for countries to avoid double-counting emissions that have already been estimated elsewhere in the greenhouse gas inventory. This is especially relevant because lands with organic soils or with wet soils can be included under various land categories.

In particular, there is a risk that using the guidance provided in Chapters 4 and 6 of the *Wetlands Supplement* could result in double-accounting of N_2O emissions from wetlands that result from non-point source agricultural effluents that are already addressed as indirect emissions from soil amendments (e.g., nitrogen fertilizers) within Chapter 11 in Volume 4 of the *2006 IPCC Guidelines*. This risk can be avoided by using as activity data only N that is originates directly as a result of the activities discussed here.

Chapter 2 of this supplement provides guidance on waterborne carbon (DOC, DIC and PIC), However, waterborne carbon may already be included in a country's emission estimates if the country uses a methodology in which soil carbon stock changes are measured in situ (e.g., soil sampling associated with forest inventories).

Table 1.1 below provides guidance on which chapters of this *Wetlands Supplement* are relevant when the inventory compiler is considering particular combinations of land use and soil type and soil condition. Where no guidance is provided in this *Wetlands Supplement* the table is blank. Table 1.1 does not provide guidance for the *2006 IPCC Guidelines*. For example, Grasslands on wet mineral soils in Table 1.1 refers to Chapter 5 of this *Wetlands Supplement*. However in many cases this *Wetlands Supplement* only provides additional guidance on a subset of the particular land use, soil type, and soil condition combinations listed in Table 1.1. To estimate total greenhouse gas emissions from organic and wet soils correctly, this *Wetlands Supplement* should be referenced together with the *2006 IPCC Guidelines*.

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TABLE 1.1
LOOK-UP TABLE FOR *WETLANDS SUPPLEMENT* CROSS-REFERENCED TO LAND-USE CATEGORIES, SOIL TYPE AND CONDITION (WET, RECENTLY DRAINED, DRY), AND INLAND OR COASTAL LOCATION

Soil Type		Gas	Forest land		Cropland		Grassland		Wetlands		Settlements		Other Land		
			Inland	Coastal	Inland	Coastal	Inland	Coastal	Inland	Coastal	Inland	Coastal	Inland	Coastal	
Mineral	Mineral Dry	CO_2													Dry
		CH_4													
		N_2O													
	Mineral Recently Drained	CO_2	5	4	5	4	5	4	5	4	5	4	5	4	Wet
		CH_4	5	4	5	4	5	4	5	4	5	4	5	4	
		N_2O		4		4		4		4		4		4	
	Mineral Wet	CO_2	5	4	5	4	5	4	5	4	5	4	5	4	
		CH_4	5	4	5	4	5	4	5	4	5	4	5	4	
		N_2O	5	4	5	4	5	4	5	4	5	4	5	4	
Organic	Organic wet	CO_2	3	4	3	4	3	4	3	4	3	4	3	4	
		CH_4	3	4	3	4	3	4	3	4	3	4	3	4	
		N_2O	3	4	3	4	3	4	3	4	3	4	3	4	
	Organic Dry (Drained)	CO_2	2	4	2	4	2	4	2	4	2	4	2	4	Dry
		CH_4	2		2		2		2		2		2		
		N_2O	2		2		2		2		2		2		
	Constructed and Natural Wetlands for Wastewater treatment	The emission sources discussed in the *Wetlands Supplement* Chapter 6 provide guidance for the Waste Sector and do not impact on estimates of emissions and removals within AFOLU. However, the area of constructed wetlands should be reported as Wetlands, Settlements, or other land-use categories as appropriate and the impact on biomass, soil carbon and other pools may be considered. Care is required to avoid double-counting of emissions.												
	Emissions due to burning of organic soils	Chapter 2 in the *Wetlands Supplement* provides guidance for estimation of greenhouse gas emissions due to burning of organic soils. This guidance can be applied across all land use categories as appropriate where burning is reported as occurring.													
	DOC, DIC, PIC, POC	Chapter 2 in the *Wetlands Supplement* provides a discussion and some guidance on carbon loss from organic soils through water pathways. The information is relevant to all land use categories.													

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1.5 RELEVANT DATABASES FOR WETLANDS AND ORGANIC SOILS

To generate estimates of emissions and removals from wetlands and organic soils, inventory compilers will need to gather activity data and secondary data, such as soil type (organic or mineral), climate zone, wetland type, size, water table level, vegetation composition, and management practices. Guidance on data collection is provided in Chapter 2 in Volume 1 of the *2006 IPCC Guidelines*. It is *good practice* to focus these efforts on collecting data needed to improve estimates of *key categories*, which will vary by country depending on which emission sources are the largest, have the largest potential to change or have the greatest uncertainty. Chapters 2-6 of the *Wetlands Supplement* provide specific guidance on assembling the necessary activity data for implementation of the Tier 1 methodology as well as general guidance on activity data that may be necessary for implementation of higher tiers. Chapter 7 in the *Wetlands Supplement* provides general guidance for producing consistent times series when activity data are not available for all years.

Inventory compilers may be able to collect activity data from in-country natural resource agencies or national experts. To supplement in-country data, or if in-country data are not readily available, inventory compilers may use internationally available data. Table 1.2 below presents a list of online resources that may prove useful to inventory compilers in obtaining activity data for estimating greenhouse gas emissions and removals from the wetlands and organic soils included in this *Wetlands Supplement*. The most notable wetlands dataset is the Ramsar database of the Ramsar Convention. For most 'wetlands of international importance,' the Ramsar database provides relevant characteristics, including wetland type, area, elevation, persistence of water, salinity, soil type, land use inside and adjacent to the wetland, and vegetation types. In addition, the FAO provides a variety of metadata sets, including forestry, agriculture, and carbon emissions at a country scale. The United Nations Environment Programme (UNEP) in collaboration with the World Conservation Monitoring Centre (WCMC) has a collection of wetland atlases and offer open source geospatial data. Wetlands International is the only global NGO that focuses on wetland best practices, restoration and conservation. This organization has regional offices in all continents and has compiled a variety of data on wetlands and organic soils.

TABLE 1.2
GLOBAL AND REGIONAL ON-LINE RESOURCES THAT PROVIDE METADATA SETS FOR DEVELOPING AN INVENTORY OF GREENHOUSE GAS EMISSIONS AND REMOVALS FROM WETLANDS AND ORGANIC SOILS

Online Resources	Description
The Ramsar Convention on Wetlands http://www.ramsar.org	The Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. In 2013, this convention consists of 167 Contracting Parties, 2,122 wetlands of International Importance, and 205,366,160 hectares of wetlands designated as Ramsar sites
FAOSTAT http://faostat3.fao.org/home/index.html	A large time series and cross section of data relating to hunger, commodity prices, foods, forestry, agriculture, and emissions for 245 countries and territories and 35 regional areas, from 1961 to the most recent year
United Nations Environment Programme and Word Conservation Monitoring Centre (UNEP-WCMC) http://www.unep-wcmc.org/datasets-tools--reports_15.html	This site provides a set of metadata on conservation in general. It also contains several atlases of wetlands, e.g. World Mangrove Atlas, and World Atlas of Seagrass
GeoNetwork Open Source Geographic data sharing for everyone http://geonetwork.grid.unep.ch/geonetwork/srv/en/main.home	This site is managed by UNEP. It contains geographic metadata that can be freely requested
Wetlands International http://www.wetlands.org/	Wetlands International is the only global not-for-profit organisation dedicated to the conservation and restoration of wetlands. This NGO also has several regional metadatasets, e.g. South Asia Wetlands, Australia Wetlands, etc.

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