

CHAPTER 1

INTRODUCTION

Coordinating Lead Authors

Tom Wirth (USA) and Chengyi Zhang (China)

Lead Authors

Gusti Zakaria Anshari (Indonesia), Kenneth Byrne (Ireland), Elke Hodson (Switzerland/USA), Hans Joosten (EC/WI/FAO), J. Boone Kauffman (IUCN/UNESCO), Leif Klemedtsson (Sweden), Tuija Elina Lapvetelainen † (Finland), Christoph Mueller (Germany), Phillip O'Brien (Ireland) and Mitsuru Osaki (Japan)

Contributing Authors

Tonya Del Sontro (Switzerland), Mark Flugge (USA), Stephen Ogle (USA), Riitta Pipatti (Finland), Rachel Steele (USA), Victoria Thompson (USA) and Kiyoto Tanabe (IPCC TFI TSU)

Review Editors

Fatih Evrendilek (Turkey) and Steen Gyldenkærne (Denmark)

† Ms. Tuija Elina Lapvetelainen, a close colleague, passed away in July 2013. She greatly contributed to the development of Chapter 1.

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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 (CO₂) and nitrous oxide (N₂O) 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 to CO₂ 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 N₂O emissions from soils concluded that there was 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 wet and drained mineral soils in Wetlands and all the other IPCC land-use categories with these soil types that are subject to human activities ('managed'). The *Wetlands Supplement* is organised 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

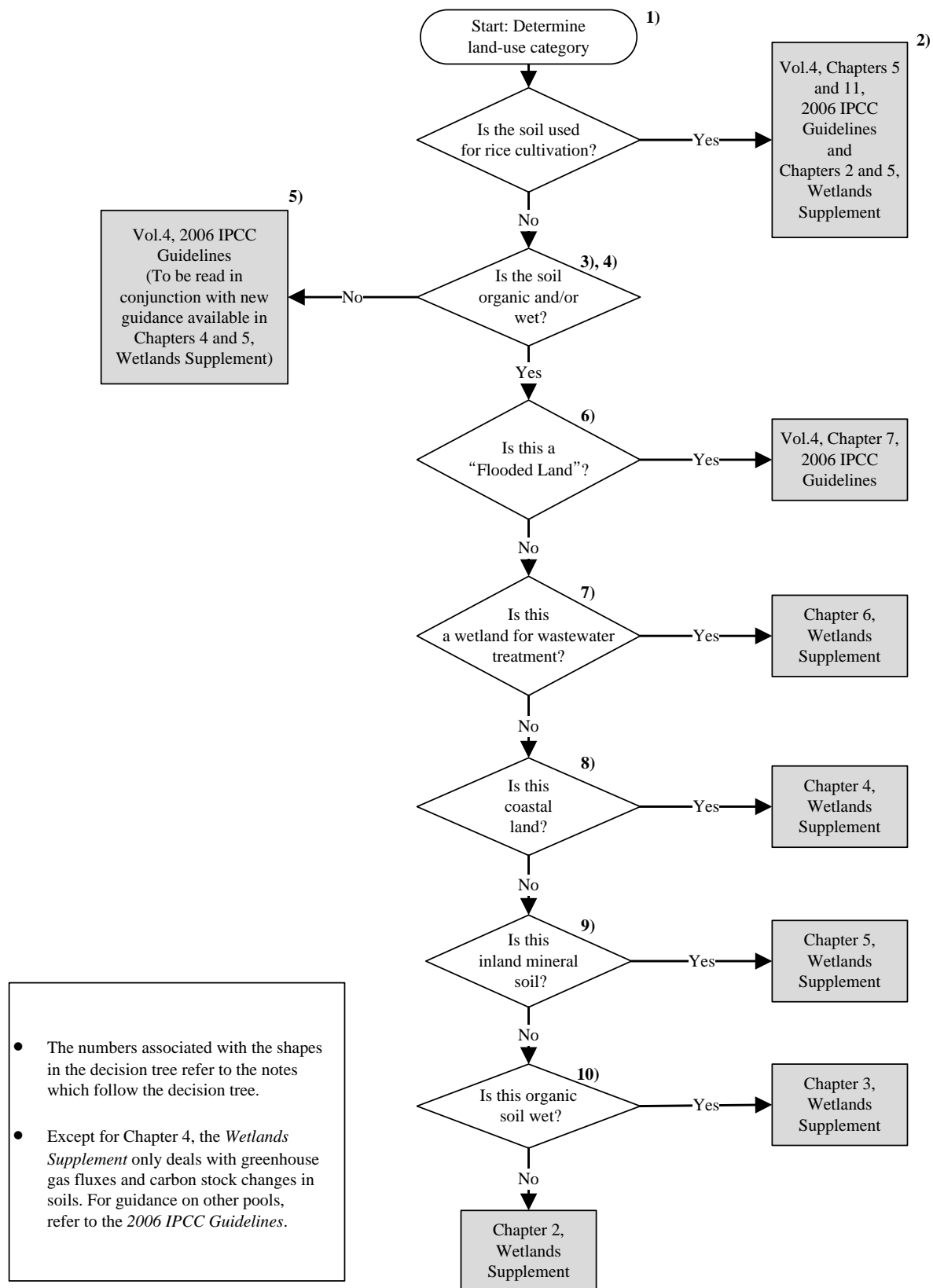
1.2 GUIDANCE FOR USING THIS SUPPLEMENT

This introductory chapter provides guidance on the way to use the *Wetlands Supplement* in conjunction with the existing *2006 IPCC Guidelines*, for the preparation of a greenhouse gas inventory that includes lands with organic soils and wet and drained mineral soils across all the IPCC land-use categories.

Inventory compilers can use the decision tree (Figure 1.1) 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 listed below, which explain and illustrate the terms used in the decision tree and within 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 any other context. For example, except for the use of the term 'Wetlands' in the name of this supplement, this guidance uses the term 'Wetlands' (with a capital 'W' and always plural) solely to refer to the IPCC land-use category Wetlands. The term 'wetland' or 'wetlands' (with a lowercase 'w' and singular or plural) is used to refer to land with wet soil as defined in note 4 below. Other articulations of the concept of 'wetland' are possible, for example 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 applicability of the methodological guidance.

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 organic soils, and wet and drained mineral soils (see notes 2, 3, and 4 for the definition of these terms) across all the 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 land representation¹, land-use conversions should also be identified (e.g. Forest Land converted to Cropland, Cropland converted to Settlements).

In comparison with 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 soils and wet and drained mineral soils (including drained 'wetland mineral soils' (see Note 4 below) subject to rewetting; inland wetland mineral soils subject to long-term cultivation; inland dry mineral soils that have been wetted; coastal drained mineral soils subject to rewetting and coastal mineral soils subject to other management practices²). The *Wetlands Supplement* differentiates between coastal land and 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 addressed in the *Wetlands Supplement*

	Forest Land	Crop-land	Grass-land	Wet-lands	Settle-ments	Other Land
	inland coastal	inland coastal	inland coastal	inland coastal	inland coastal	inland coastal
mineral soil	mineral drained	mineral drained	mineral drained	mineral drained	mineral drained	mineral drained
	mineral wet	mineral wet	mineral wet	mineral wet	mineral wet	mineral wet
organic soil	organic drained	organic drained	organic drained	organic drained	organic drained	organic drained
	organic wet	organic wet	organic wet	organic wet	organic wet	organic wet

Notes on Figure 1.2: Guidance for all the soils shown in this figure is included in the *Wetlands Supplement*. Guidance for 'mineral dry' soils except for those drained for long-term cultivation and drained coastal wetlands (see Note 5) 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 to use - in addition to the dry mineral soils covered by the *2006 IPCC Guidelines* - a division into four soil subcategories³; all with a coastal and inland subdivision where appropriate (see Figure 1.2 above):

- 1) drained mineral soil
- 2) wet mineral soil
- 3) wet organic soil
- 4) drained organic soil.

In the case of dry mineral soil, the guidance in the Forest Land, Cropland or Grassland Chapters in the *2006 IPCC Guidelines* should be used as appropriate. Chapter 4 of the *Wetlands Supplement* provides new guidance for drained coastal mineral soils, and Chapter 5 presents new guidance for drained inland wetland mineral soils

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

² Other management activities on coastal wetland mineral soils covered in the Supplement include extraction, revegetation and aquaculture.

³ The guidance for rice cultivation provided in Chapters 2 and 5 of the *Wetlands Supplement* should be used in conjunction with Chapters 5 and 11 in Volume 4 of the *2006 IPCC Guidelines*.

(see Note 4 below) that have been continuously managed for > 20 years to cultivate predominantly annual crops. In all other cases, the decision tree should be used (see Figure 1.1 above) to identify the appropriate guidance chapter within this *Wetlands Supplement* or within 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' inventory compilers are required to differentiate between 'managed' and '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 the case of coastal wetlands, guidance is provided to estimate and report anthropogenic emissions and removals from specific management activities.

Note 2: Is the soil used for rice cultivation?

Guidance on rice cultivation is provided in Chapters 2 and 5 of the *Wetlands Supplement*, and Chapters 5 and 11 in Volume 4 of the *2006 IPCC Guidelines*.

Note 3: 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.

There are no IPCC definitions for peat and peatland. Definitions of peatland and peat soil differ between countries in relation to the thickness of the peat layer required to be determined as a peatland or a peat soil. In addition, the definition of peat varies among countries and disciplines, especially with respect to the minimum percentage of organic matter the material is required 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 4: 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, adapted to anaerobic conditions, particularly soil microbes and rooted plants, control the quality and quantity of the net annual greenhouse gas emissions and removals. Every soil that is not a wet soil is in this supplement classified as a dry soil.

Drainage is the process of artificial lowering of the soil water table. In this supplement, the term is used to describe the act of changing a soil from wet into dry. A drained soil is a soil that has formerly 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, therefore a dry organic soil is always also a drained organic soil.

Rewetting is the process of changing a drained soil into a wet soil. A rewetted soil is a soil that has formerly been a drained soil but as a result of human intervention has become a wet soil. Similarly, wetting is the process of changing an originally dry soil into a wet soil as a result of human intervention, as in wetland creation. Restoration (adjective restored) is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. In the case of drained former wetlands, restoration always has to include rewetting.

With respect to inland wet mineral soils the *Wetlands Supplement* only provides Tier 1 guidance for 'wetland mineral soils' and mineral soils that have been wetted by human intervention for the purpose of wetland creation.

'Wetland mineral soils' include the 'wetland soils' as defined in footnote 6 to Table 2.3, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines* as *Soils with restricted drainage leading to periodic flooding and anaerobic conditions (in WRB classification Gleysols; in USDA classification Aquic suborders)*. Sandy soils (as defined by footnote 3 to Table 2.3, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*) that are wet are not included.

Chapter 3 of the *Wetlands Supplement* covers organic soils that are rewetted and wet organic soils that are subject to other management practices such as paludicultures. Chapter 4 covers coastal wetland soils that are subject to rewetting (after drainage) and to other management practices such as extraction, revegetation and aquaculture. Chapter 5 covers rewetting of drained inland wetland mineral soils and wetting of originally dry mineral soils.

Note 5: New guidance for drained coastal mineral soils and 'inland wetland mineral soils'

Dry mineral soils in inland lands that are subject to management activities other than rewetting or wetting respectively are covered in Volume 4, *2006 IPCC Guidelines*. Chapter 4 of the *Wetlands Supplement* provides new guidance for drained coastal mineral soils, and Chapter 5 presents new guidance on 'inland wetland mineral soils' (see Note 4 above) that have been continuously cultivated (by default for > 20 years) with predominantly annual crops. Tier 1 methods for both mineral and organic soils do not differentiate between recently and long-time drained soils.'

Drained mineral soils may have a high organic matter content that gives them different greenhouse gas emission characteristics from those of mineral soils that have never been wet, or which were originally wet, but have been in a dry state for a long time. These differences fade with time after drainage, but so long as they persist, the soil is described in this supplement as being 'drained'.

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 of 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 such a 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 artificially created) 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* for a country to clearly define the concept of 'coastal land' and its sea- and landward limits in accordance with its national circumstances, and to apply that definition consistently across the entire national land area and over time. All land that is not coastal is inland.

A coastal wetland is a wetland (see Note 4) at or near the coast that is influenced by brackish/saline water and/or astronomical tides. Coastal wetland may occur on both organic and mineral soils. Brackish/saline water is water that normally contains more than 0.5 or more parts per thousand (ppt) of dissolved salts. Every mineral soil wetland that is neither a coastal wetland, a Flooded Land (see Note 6) nor a constructed wetland for waste water treatment (see Note 7) is classified as inland wetland (cf. Chapter 5).

Note 9: Is this inland mineral soil?

Inland mineral soil is all mineral soil (see Note 3) that is not on coastal land (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 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 and 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 within this *Wetlands Supplement*.

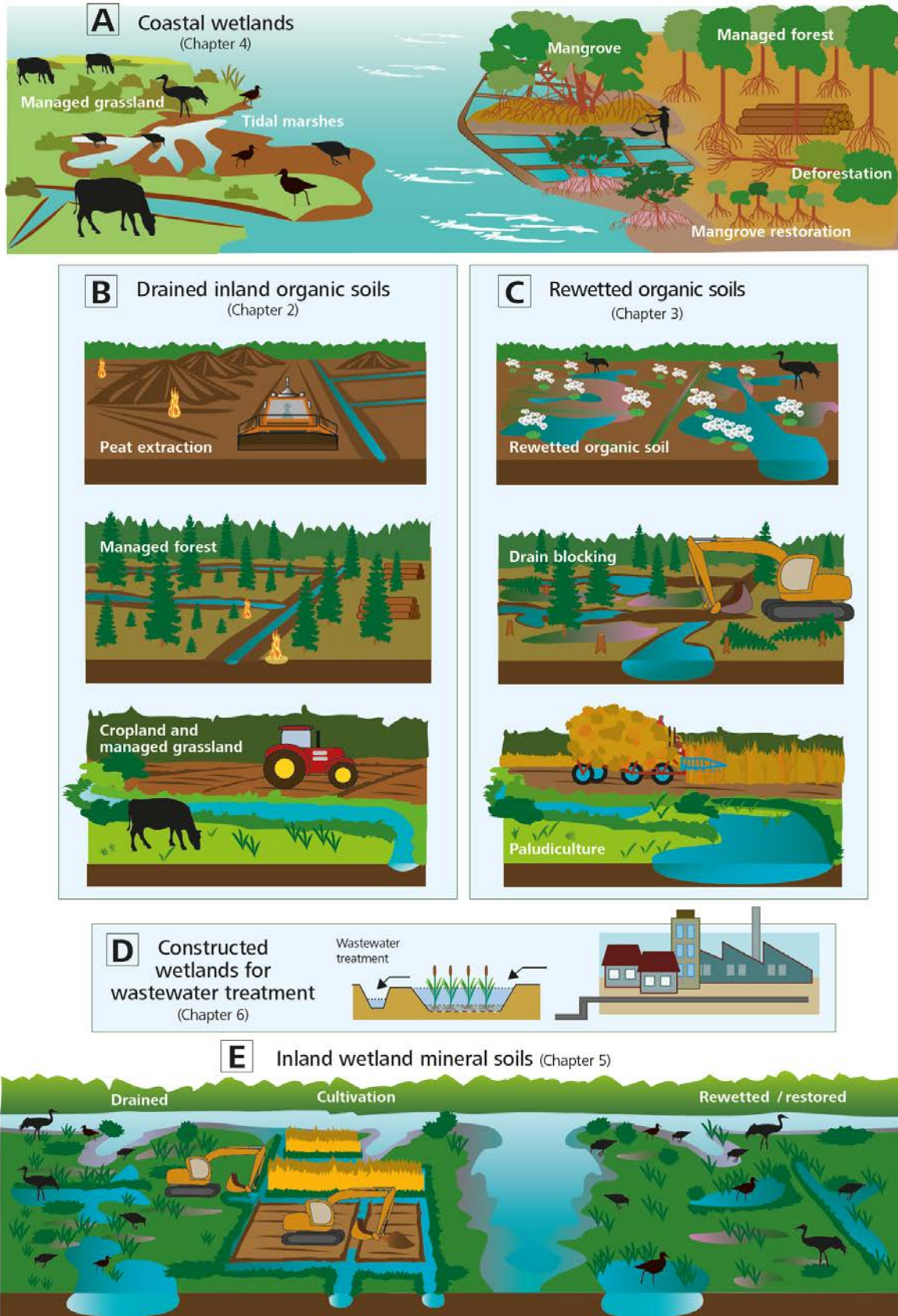
Draining inland organic soils lowers the water table and increases the oxygen content of the soil, thus increasing CO₂ emissions. Methane (CH₄) emissions from drained inland organic soils are generally negligible because the soil carbon is then preferentially oxidized to CO₂. However, methanogenesis may take place in drainage ditches with a higher water table causing significant emissions of CH₄ to the atmosphere. Drained organic soils can also emit significant amounts of N₂O from nitrogen in the organic matter or nitrogen added by fertilization. Losses 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 CO₂ emissions, rapidly decreases N₂O emissions to almost zero, and increases CH₄ 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 CO₂ emissions are greatly reduced or even become negative, causing the wetlands to function as a net remover of greenhouse gases from the atmosphere (Chapter 3 of this supplement). CO₂ emissions from coastal wetlands can be significant, especially during the construction phase of aquaculture and salt production/extraction. CH₄ and N₂O 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 CH₄ emissions (Chapter 5 of this supplement). Constructed and semi-natural wetlands used for wastewater treatment emit CH₄ and N₂O (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), this *Wetlands Supplement* provides guidance to estimate and report countries' emissions and removals from specific management activities such as aquaculture, salt production, and dredging. See Figure 1.3 below for some typical management practices on wetlands.

Figure 1.3 Typical management practices on organic and wet soils



(Figure by Riikka Turunen, Statistics Finland)

1.4 COHERENCE AND COMPATIBILITY WITH 2006 IPCC GUIDELINES

This section provides an overview of the links 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 topics of additional guidance in this supplement. Section 1.4.2, highlights guidance in this supplement that was not previously included in the *2006 IPCC Guidelines*, and which 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 AND CO₂ EMISSIONS AND REMOVALS 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 CO₂ emissions from drained organic soils an area-based annual emission factor differentiated by climate region and land use is applied. The *Wetlands Supplement* provides additional guidance for both organic and mineral soils (subdivided into wet and drained) and the information with respect to organic soils is expanded to include activities on wet (undrained, rewetted) 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 provides CO₂ emission factors for drained organic soils, is updated in Table 2.1 in the *Wetlands Supplement*.

CH₄ EMISSIONS FROM MANAGED SOILS

Section 2.3.3.1, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines* assumes that CH₄ emissions due to the drainage of organic soils are negligible. The *Wetlands Supplement* provides guidance on estimating CH₄ emissions from drained organic soils and drainage ditches, including default emission factors in Tables 2.3 and 2.4 in Chapter 2, respectively.

The *2006 IPCC Guidelines* do not provide guidance on estimating CH₄ emissions from mineral soils except for in relation to 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

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 5.

DIRECT AND INDIRECT N₂O EMISSIONS FROM MANAGED SOILS

Methodologies are provided in Section 11.2, Chapter 11 in Volume 4 of the *2006 IPCC Guidelines*, for the estimation of both direct and indirect N₂O emissions from managed soils. Generic equations are presented for application to all land areas in aggregate or to specific land-use categories if the activity data are available. N₂O emissions from drained organic soils are estimated using an area-based annual emission factor differentiated by climate region. The *2006 IPCC Guidelines* caution the risk of double counting indirect N₂O emissions that are reported elsewhere, e.g. under Agriculture (Chapter 11, Volume 4). This caution is reiterated here in relation to the use of the additional information about N₂O emissions.

Certain Tier 1 N₂O emission factors provided in Tables 11.1 (direct emissions), Chapter 11 in Volume 4 of the *2006 IPCC Guidelines* are updated in Table 2.5, Chapter 2 in the *Wetlands Supplement*.

NON-CO₂ EMISSIONS FROM BIOMASS BURNING

Generic guidance for non-CO₂ emissions from the 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 the burning of peat and other organic soils, which is a large emission source for some countries. The *Wetlands Supplement* addresses CO₂, CH₄ and carbon monoxide (CO) emissions associated with the burning of organic soils.

RICE CULTIVATION

CH₄ 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 CO₂, CH₄ and N₂O for rice cultivation on tropical drained organic soils.

WETLANDS

Methodologies are provided in the Wetlands chapter of the *2006 IPCC Guidelines* (Chapter 7 in Volume 4) 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 the *Wetlands Supplement*. CO₂ emissions from land converted to flooded land such as reservoirs for production of hydroelectricity, irrigation and navigation are provided in Section 7.2, Chapter 7 in Volume 4 of the *2006 IPCC Guidelines*; no further guidance is provided for flooded lands in the *Wetlands Supplement*.

WASTEWATER TREATMENT

Chapter 6 in Volume 5 of the *2006 IPCC Guidelines* (wastewater treatment and discharge) provides a methodology to estimate CH₄ and N₂O emissions from domestic and industrial wastewater treatment. CO₂ emissions from wastewater are not considered in the *IPCC Guidelines* and should not be included in the national total emissions because of their biogenic origin. The *Wetlands Supplement* provides guidance on CH₄ and N₂O 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 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 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* for use in the estimation of greenhouse gas emissions and removals from drained inland organic soils in 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 emissions of CO₂, CH₄ and N₂O. New emission factors to estimate the release of CH₄ 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, however, 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 the future methodological development for estimating CO₂ emissions associated with waterborne carbon loss from POC. Fire on drained organic soils causes not only on-site CO₂, CH₄, and N₂O emissions directly from 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 CO₂, CH₄ and CO emissions from fires on drained organic soils.

CHAPTER 3—REWETTED ORGANIC SOILS

Chapter 3 in the *Wetlands Supplement* provides new guidance and emission factors for organic soils that have been drained for forestry, crop production, grazing, peat extraction or other purposes, and have subsequently 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. the restoration of damaged vegetation cover), in the majority of cases restoration will include rewetting.

Chapter 3 provides Tier 1 guidance for assessing greenhouse gas (CO₂, CH₄ and N₂O) 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 emissions and removals of greenhouse gases (CO₂, CH₄ and N₂O) associated with specific activities on managed coastal wetlands that 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, revegetation and creation, and forest management practice in mangroves.

CHAPTER 5—INLAND WETLAND MINERAL SOILS

Chapter 5 in the *Wetlands Supplement* provides guidance for managed inland wetland mineral soils, including drained soils subject to rewetting and those under long term cultivation; and any other mineral soils that have been wetted by human intervention (e.g. inundation for the purpose of wetland creation) not included in Chapter 4 (coastal wetlands) or Chapter 6 (constructed wetlands for wastewater treatment) in the *Wetlands Supplement* (see Figure 1.3, Frame E in this chapter). The chapter provides methodologies for estimating greenhouse gas emissions and removals, delivers 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 wetland mineral soils. It also gives guidance that is 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 CH₄ emissions for mineral soils in any land-use category that have been rewetted or inundated for the purpose of wetland creation.

Chapter 5 in the *Wetlands Supplement* does not provide guidance on the application of the methodology given in Chapter 11 in Volume 4 of the *2006 IPCC Guidelines*, for estimating N₂O 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 updated and new defaults for SOC_{REF} and SOC stock change factors. However the chapter suggests a future development on the issue.

CHAPTER 6—CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT

Chapter 6 in the *Wetlands Supplement* provides guidance on estimating CH₄ and N₂O 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* in relation to 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, N₂O emissions from wetlands managed for the filtration of non-point source agricultural effluents, such as fertilizers, are included in indirect N₂O 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*. Inventory compilers are encouraged to consider the guidance given 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 summarises 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 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 N₂O emissions from wetlands that result from non-point source agricultural effluents already addressed as indirect emissions from soil amendments (e.g. nitrogen fertilizers) within Chapter 11 in Volume 4 of the *2006 IPCC Guidelines*. Double-counting can be avoided by considering only those management practices that result in direct N₂O emissions.

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

Table 1.1 below provides guidance for inventory compilers on which chapters of this *Wetlands Supplement* are relevant when considering methods for particular combinations of land use, soil type and soil condition. Where no guidance is provided in this *Wetlands Supplement*, the table is blank. To estimate total greenhouse gas emissions from organic and wet soils correctly, this *Wetlands Supplement* should be used together with the *2006 IPCC Guidelines*.

TABLE 1.1
LOOK-UP TABLE FOR WETLANDS SUPPLEMENT BY LAND-USE CATEGORIES, SOIL TYPE AND CONDITION 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	Refer to the 2006 IPCC Guidelines											
		CH ₄												
		N ₂ O												
	Mineral Drained ⁴	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 ₂ O		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 ₂ O	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 ₂ O	3	4	3	4	3	4	3	4	3	4	3	4
	Organic Drained	CO ₂	2	4	2	4	2	4	2	4	2	4	2	4
		CH ₄	2		2		2		2		2		2	
		N ₂ O	2		2		2		2		2		2	
	Constructed and Natural Wetlands for Wastewater treatment	The emission sources discussed in the <i>Wetlands Supplement</i> 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 <i>Wetlands Supplement</i> 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 <i>Wetlands Supplement</i> provides a discussion and guidance on carbon loss from organic soils through water pathways. This information is relevant to all land-use categories.												

⁴ Here 'Mineral Drained' refers to drained inland wetland mineral soils that are subject to rewetting and drained coastal wetland mineral soils.

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 from 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 on 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 offers open source geospatial data. Wetlands International is the only global non-governmental organisation (NGO) that focuses on wetland best practices, restoration and conservation. It has regional offices in all continents and has compiled a variety of data on wetlands and organic soils.

Online Resources	Description
The Ramsar Convention on Wetlands http://www.ramsar.org	The Convention on Wetlands of International Importance (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 consisted 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 World Conservation Monitoring Centre (UNEP-WCMC) http://www.unep-wcmc.org/datasets-tools--reports_15.html	This site provides a set of metadata related to conservation in general. It also contains several atlases of wetlands, e.g. the World Mangrove Atlas and the 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.

References

- Donato, D.C., Kauffman, J.B., Murdiyarso, D., Kurnianto, S., Stidham, M. & Kanninen, M. (2011) Mangroves among the most carbon-rich forests in the tropics. *Nature Geosciences* **4**: 293-297. http://mangroveactionproject.org/files/resources/Donato.etal_2011_NatureGeo_MangroveCarbonStorage.pdf
- IPCC (2006) *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.
- IPCC (2011) *IPCC Expert Meeting on HWP, Wetlands and Soil N₂O*. Geneva, Switzerland: eds: Eggleston, H.S., Srivastava, N., Tanabe, K., Baasansuren, J. and Fukuda, M. IGES, Japan 2011.
- Joosten, H. & Clarke, D. (2002) *Wise use of mires and peatlands – Background and principles including a framework for decision-making*. International Mire Conservation Group / International Peat Society, 304 p. http://www.peatociety.org/sites/default/files/files/WUMP_Wise_Use_of_Mires_and_Peatlands_book.pdf
- Joosten, H. & Couwenberg, J. (2008) Peatlands and carbon. In: Parish, F., Sirin, A., Charman, D., Joosten, H., Minaeva, T. and Silviu, M. (eds). *Assessment on peatlands, biodiversity and climate change*. Global Environment Centre, Kuala Lumpur and Wetlands International Wageningen, pp. 99-117.
- Mitra, S., Wassmann, R. & Vlek, L.G. (2005) An appraisal of global wetland area and its organic carbon stock. *Current Science* **88**: 25–35.
- The Ramsar Convention on Wetlands. The Convention on Wetlands text, as amended in 1982 and 1987. http://www.ramsar.org/cda/en/ramsar-documents-texts-convention-on/main/ramsar/1-31-38%5E20671_4000_0