



IPCC Expert Meeting on HWP, Wetlands and Soil N₂O

19-21 October 2010, Geneva, Switzerland

Task Force on National Greenhouse Gas Inventories

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INTERGOVERNMENTAL PANEL ON
climate change



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IPCC Task Force on National Greenhouse Gas Inventories (TFI)
Technical Support Unit

% Institute for Global Environmental Strategies
2108 -11, Kamiyamaguchi
Hayama, Kanagawa
JAPAN, 240-0115

Fax: (81 46) 855 3808
<http://www.ipcc-nggip.iges.or.jp>

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FOREWORD

We are pleased to present this report, produced in reply to a request from the SBSTA in June 2010, to hold an expert meeting to consider methodological issues related to emissions and removals of greenhouse gases from Harvested Wood Products, Wetlands and N₂O from Soils.

The Task Force Bureau was happy to be able to respond positively to the request from SBSTA, especially given the short time scale to hold the meeting and report on it both to the UNFCCC Workshop on Annex I Reporting Guidelines held 3rd – 4th November in Bonn, Germany, and then to the UNFCCC COP 16 held on 29th November to 10th December in Cancun, Mexico.

We would like to thank all those involved in these meetings, the experts who participated and the Technical Support Unit staff for taking their parts in making this meeting a success despite the short time available to plan, hold and report this meeting.



Thelma Krug

Co-Chair Task Force Bureau



Taka Hiraishi

Co-Chair Task Force Bureau

Executive Summary

The Subsidiary Body on Scientific and Technical Advice (SBSTA) of the United Nations Framework Convention on Climate Change (UNFCCC) has started a work programme to revise their guidelines for the reporting on greenhouse gases by Annex I Parties to the convention with the aim of enabling the use of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for reporting of emissions of the years 2013 onwards, which would be reported in 2015. In their planning their work programme the SBSTA, at its thirty-second meeting in June 2010, invited the IPCC to organize an expert meeting to explore the need and ways to clarify methodological issues related to reporting on harvested wood products, wetlands and nitrous oxide emissions from soils. The SBSTA also invited the IPCC to provide information on the recommendations of this expert meeting for the second workshop of the work programme, and a report of the expert meeting for consideration by the SBSTA at its thirty-third session, with a view to the SBSTA at its thirty-third session considering the need for and scope of an invitation to the IPCC to conduct further work in these areas.

In response the IPCC's Task Force on National Greenhouse Gas Inventories (TFI) held this expert meeting in Geneva on 19-21 October, 2010.

This meeting considered the guidance on harvested wood products, wetlands and nitrous oxide emissions from soils in the light of the recent scientific literature and came to the following conclusions:

The meeting considered the three separate topics, harvested wood products, wetlands and nitrous oxide emissions from soil, and, in general considered that the methodological advice contained in the 2006 IPCC Guidelines still reflects the latest science. In particular, they agreed that there is no N₂O from the biological nitrogen fixation process itself (this was included in earlier guidelines but assumed not to occur in the 2006 IPCC Guidelines). For HWP, it is important that the guidance is followed in its entirety to eliminate potential double- or under-counting of emissions. A few editorial issues were noted for HWP and Soil N₂O and corrigenda addressing these will be issued by the TFI.

These conclusions were summarised in a Co-Chairs Summary (Annex 3) which was presented at the second workshop of the SBSTA work programme to revise their guidelines for the reporting on greenhouse gases by annex I parties to the convention and to COP16 in Cancun, Mexico. The following sections outline the main conclusions. The main proposals for further action are:

- i. **The meeting recommended that the IPCC provide additional methodological guidelines for the rewetting and restoration of peat land; emissions from fires, ditches and waterborne carbon; and constructed wetlands for waste water disposal, to fill gaps in the existing guidelines** (Recommendation 1). This guidance would be additional to the 2006 Guidelines filling gaps for which sufficient information was not available when the guidelines were compiled. While the focus of this work is on the wetland chapter (volume4, chapter 7) of the 2006 IPCC Guidelines it should be remembered that drainage and conversion of wetlands to other land uses is included in other chapters of volume 4 (e.g. forest land, cropland and grassland) and possibly the Waste volume: coherence between these chapters and the Wetland chapter should be maintained.
- ii. **The meeting recommended that an expert meeting be held to assess new EFs measurements for wetlands and develop emission factors from this information to enable more accurate country- and region-specific estimates to be made. The meeting also recommended that the TFI actively collect such data and add it to the EFDB.** (Recommendation 2)
- iii. **The meeting concluded that there should be an expert meeting to discuss all the new science and issues surrounding the development of new guidelines for reservoirs** (Recommendation 3). The participants did not agree that there was now sufficient new information available to produce new and additional guidelines based on the latest literature. They did, however, agree on the need to discuss a range of associated issues, such as the impact of reservoirs on total emissions from

watersheds, allocation of emissions to specific drivers and how emissions may be related to specific reservoir typologies.

- iv. **The participants also noted that the guidance for HWP is complex and proposed the development of FAQ (frequently asked questions) that would guide users to the correct, full implementation of the guidelines** (Recommendation 5). However, the meeting agreed that the methodological guidance in the 2006 IPCC Guidelines is correct, but noted that the entire chapter needs to be considered to ensure there are no inconsistencies with other parts of the guidelines.
- v. **The meeting proposed an expert meeting to assess recent literature on Soil N₂O and consider stratified EF₁ values for the EFDB** (Recommendations 7 & 8). Reviewing recent literature should allow for the development of more regional or country specific emission factors allowing greater stratification by climate, soil, management and leaching.
- vi. **This meeting proposed a joint expert meeting with WG I to explore the gap between the atmospheric N₂O increase and bottom-up estimates of anthropogenic N₂O emissions** (Recommendation 10). Participants noted that increased measurements of currently under represented systems (e.g. large river deltas) may help resolve this issue.

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1. Introduction

The Subsidiary Body on Scientific and Technical Advice (SBSTA) of the United Nations Framework Convention on Climate Change (UNFCCC) has started a work programme to revise their guidelines for the reporting of greenhouse gases by annex 1 parties to the convention¹. The aim is to enable the use of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for reporting of emissions of the years 2013 onwards, which would be reported in 2015.

In their planning their work programme the SBSTA made a specific request to the IPCC at its thirty-second meeting in June 2010:

“The SBSTA invited the IPCC to organize an expert meeting to explore the need and ways to clarify methodological issues related to reporting on harvested wood products, wetlands and nitrous oxide emissions from soils, as specified in annex III. The SBSTA also invited the IPCC to provide information on the recommendations of this expert meeting for the second workshop of the work programme, and a report of the expert meeting for consideration by the SBSTA at its thirty-third session, with a view to the SBSTA at its thirty-third session considering the need for and scope of an invitation to the IPCC to conduct further work in these areas.”

FCCC/SBSTA/2010/L.12, Article 7

Annex III of this document expanded on the requirements (see Box 1, below)

Box 1 UNFCCC request to the IPCC, Annex III of FCCC/SBSTA/2010/L.12

Annex III

Invitations to the Intergovernmental Panel on Climate Change to organize an expert meeting on methodological work related to reporting when using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

The expert meeting referred to in paragraph 7 of this document should explore the need and ways to clarify, improve and provide updated information, as appropriate, related to, inter alia:

- (a) Information in chapter 7 on wetlands, in particular the methodological guidance in those areas for which gaps are identified in table 7.1 of chapter 7 and gaps related to some uses of wetlands which are currently not fully covered, for example the drainage of wetlands, the rewetting of previously drained wetlands or wetland restoration;
- (b) Information in chapter 12 on harvested wood products, in particular definitions, consistency, potential for double counting with other sectors, use of higher tier methods and any new approach that has been proposed;
- (c) Information in chapter 11 relevant to direct and indirect nitrous oxide emissions from soils.

¹ “Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11” FCCC/SBSTA/2006/9 (18 August 2006)

This request was considered by the Task Force Bureau (TFB) of the IPCC's Task Force on National Greenhouse Gas Inventories (TFI). The TFB decided to hold a meeting in Geneva, Switzerland, on 19-21 October 2010 to consider these items. The TFB also decided that for each of the three topics the general aims should be to consider:

- Is the current advice in the 2006 IPCC Guidelines clear or is there a need to issue corrigenda, clarifications or explanations?
- Do more recent scientific and technical developments allow for the development of new advice? For example, the 2006 IPCC Guidelines note that the existing guidance is incomplete for wetlands and so two options being discussed by the UNFCCC are not covered – wetlands restoration and rewetting of peat lands. Can these gaps be filled?
- Any possible future actions

If improvements or further actions are needed, then the meeting should recommend types of actions by the TFI for consideration by the TFB. These actions may include:

- the issuance of corrigenda, Q&A and/or FAQ on the TFI web site;
- additions and improvements to the Emission Factor Database (EFDB);
- expert meetings producing meeting reports (as IPCC Supporting Materials) to explain specific issues,
- a recommendation to initiate formal IPCC consideration of the development of additional guidance by the TFI.

2. Wetlands

2.1 Existing Guidance in the 2006 IPCC Guidelines

As noted in the 2006 IPCC Guidelines the existing guidance is incomplete because of gaps in scientific and technical knowledge at the time the guidelines were completed. The 2006 Guidelines define wetlands as:

“This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed subdivision and natural rivers and lakes as unmanaged subdivisions.”

2006 GL, Vol. 4-1, Ch.7, Page 7.5

2006 Guidelines provide methods for:

- Peatlands cleared and drained for production of peat for energy, horticultural and other uses. The estimation methodology includes emissions from the use of horticultural peat.
- Reservoirs or impoundments, for energy production, irrigation, navigation, or recreation. Includes CO₂ emissions from all lands converted to permanently Flooded Lands. Flooded Lands exclude regulated lakes and rivers unless a substantial increase in water area has occurred.
- Methods for estimating emissions from drained wetlands converted to other lands (forest lands, crop lands, grasslands, settlements) are given in the appropriate land type chapters under “emissions from organic soils”

The impact of wetland drainage is significant globally and so there is a growing interest in impact of rewetting wetlands and restoring peat lands as well as on the impact of draining wetlands for land use conversion.

Table 1 Wetlands Guidance (after Table 7.1 in the 2006 IPCC Guidelines)

Land use category/GHG	Peatlands	Flooded Land
Wetlands Remaining Wetlands		
CO ₂	Section 7.2.1.1	No Guidance ¹
CH ₄	No Guidance ²	Appendix 3
N ₂ O	Section 7.2.1.2	No Guidance ³
Lands Converted to Wetlands		
CO ₂	Section 7.2.2.1	Section 7.3.2.1 and Appendix 2
CH ₄	No Guidance ²	Appendix 3
N ₂ O	Section 7.2.2.2	No Guidance ³
NOTES:		
1. CO ₂ emissions from Flooded land Remaining Flooded land are covered by carbon stock change estimates of land uses and land use change (e.g., soils) upstream of the .Flooded Land		
2. Methane emission from peatlands is negligible after drainage during conversion and peat extraction.		
3. N ₂ O emissions from Flooded Land are included in the estimates of indirect N ₂ O from agricultural or other run-off and waste water.		

Table 1, from the 2006 IPCC Guidelines, indicates the coverage of the IPCC guidelines. However some of the areas where no guidance is given are assumed to be negligible or included elsewhere. Table 2 includes this

information and gives a clearer overview of the state of the guidance. This shows that there are significant gaps in the guidance for flooded lands (reservoirs). Guidance in an Appendix is provided “for the future development of methodological guidance” in areas where guidance could not be provided at the times the guidelines were written.

Table 2 IPCC Guidance for wetlands based on Table 1 and its assumptions

Land use category/GHG	Peatlands	Flooded Land
Wetlands Remaining Wetlands		
CO ₂	Section 7.2.1.1	Included Elsewhere ¹
CH ₄	Negligible ²	Appendix 3
N ₂ O	Section 7.2.1.2	Included Elsewhere ³
Lands Converted to Wetlands		
CO ₂	Section 7.2.2.1	Section 7.3.2.1 and Appendix 2
CH ₄	Negligible ²	Appendix 3
N ₂ O	Section 7.2.2.2	Included Elsewhere ³
NOTES:		
1	CO ₂ emissions from Flooded land Remaining Flooded land are covered by carbon stock change estimates of land uses and land use change (e.g., soils) upstream of the .Flooded Land	
2	Methane emission from peatlands is negligible after drainage during conversion and peat extraction.	
3	N ₂ O emissions from Flooded Land are included in the estimates of indirect N ₂ O from agricultural or other runoff, and waste water.	

However, even within wetlands there are gaps. Specifically rewetting and restoration are not covered. Some specific types of wetlands are not covered:

- Aquaculture
- Ponds
- Irrigated land (if cultivated)
- Salt exploitation sites
- Water storage areas
- Excavations (partly)
- Wastewater treatment areas (including constructed wetlands)
- Canals and drainage channels, ditches.

While a few specific areas are covered:

- Wetlands already converted or being converted to:
 - Cropland, including “bogs” for cranberry and other ericaceous fruits
 - Managed Grassland
 - Managed forested wetlands, including drained or un-drained, according to national definitions
 - Rice cultivation

2.2 Presentations

2.2.1 Introduction

Simon Eggleston (TFI TSU) presented the *tasks of the breakout group (BOG) on wetlands* during the workshop plenary, and in more detail at the start of the work of the BOG.

Simon Eggleston reviewed the invitation to the IPCC and the existing wetlands guidance as discussed above. He asked the group to consider how the request for additional information by SBSTA could be addressed, by

- issuance of corrigenda to the 2006 IPCC Guidelines
- provision of Q&A/FAQ on the TFI website
- provision of EFs and parameters to the IPCC EFDB
- holding additional expert meetings, or
- recommending the initiation of formal IPCC consideration of the development of additional guidance by the TFI.

Finally, he asked the group to consider whether additional guidance can be given on:

- wetland restoration
- rewetting of peatlands
- wetland drainage
- wetlands used for wastewater treatment
- any other wetland sector.

In responding to the questions, the BOG was to consider also the impact of possible new guidance on the time series.

2.2.2 *Status and recent developments in knowledge*

During its work, the BOG listened to five presentations on status and recent developments in the knowledge related to wetlands, with the focus on wetland types that are peatlands or reservoirs. The presentations are attached to this report.

The TFI TSU had also prepared a list of recent publications as background material for the work.

Alain Tremblay (Canada) gave a presentation ***GHG emissions from reservoirs where is the truth?*** Prepared by **Joel Goldenfum** (International Hydropower Association, IHA).

The presentation introduced the concept of so-called net emissions as the difference between scenarios with and without the reservoir, with the intention to factor out emissions that are not attributed to the reservoir. This can be estimated by the difference between pre- and post-reservoir emissions from the portion of the river basin influenced by the reservoir. Emphasis was raised to the different focus of the IPCC and UNESCO/IHA Guidelines on the same problem of estimating GHG emissions from freshwater reservoirs: while IPCC National GHG Inventories are interested in the factors governing emissions and removals for estimating Anthropogenic (direct and indirect) or Natural causes, the UNESCO/IHA Guidelines intend to assess the change in GHG emissions caused by the creation of a reservoir.

Information on emissions from reservoirs in Switzerland, Canada and Brazil was presented to exemplify the complexity of the processes involved, stressing the importance of external organic load to the reservoir, the risk of double counting and the variations in emissions due to reservoir characteristics, such as age and the topography of the reservoirs: large shallow sites showed significantly higher emissions than smaller and deeper reservoirs; older reservoirs emit less than young reservoirs..

Information was also given on a joint UNESCO/IHA project on GHG status of Freshwater Reservoirs. The project has developed GHG Measurement Guidelines for Freshwater Reservoirs to promote scientifically rigorous measurements of emissions for use in the estimation of emissions from freshwater reservoirs. The project aims further to contribute to the development of predictive modelling tools to assess the GHG status of unmonitored reservoirs and potential new reservoir sites.

In his presentation ***Emissions from peat soils***, **John Couwenberg** (Wetlands International and University of Greifswald, Germany) summarized data on CO₂, CH₄ and N₂O emissions from boreal, temperate and tropical peatlands based on a recent review.

Peatlands cover an area of about 400 million ha, which corresponds to ~3% of the global land surface. The total amount of carbon stored in the world's peatlands amounts to about 450 billion tonnes, which makes peatlands

the most dense terrestrial carbon reservoir. In a natural state, peatlands are wetlands. Water saturation hampers the decomposition of dead plant material that, as a result, accumulates in the form of peat. Conventional land use on peat soils involves drainage, resulting in aeration and subsequent decomposition of the stored peat. Land management options currently covered in the IPCC Guidelines (drained soils reported under forest land, cropland, grassland, and peatlands used for peat extraction) are thus associated with considerable CO₂ emissions to the atmosphere.

On a global scale ~40 million ha of peat soils are drained and their carbon stock is degrading. Total emissions from peatland degradation and peat fires (see also below) are estimated at ~2 billion tonnes of CO₂ eq per year, which corresponds to ~6% of total anthropogenic GHG emissions or ~25% of emissions from the AFOLU sector (IPCC AR4). With their small areal extent and large impact, degrading peat soils constitute a hotspot of greenhouse gas emissions.

There is a wide variety of site conditions that influences GHG fluxes from peat soils, including the general climatic and landscape setting of the peatland, the botanical composition of the peat, peat thickness, spatial heterogeneity of microsites, land use and former land use, the vegetation cover and various abiotic conditions like temperature, water level, water level fluctuations, nutrient status and pH. Various studies have shown that besides climate the main driver for GHG fluxes is the water level. Although quantitative differences are apparent, the general relationships described below apply across climate zones.

The annual fluxes of CO₂ and CH₄ mainly depend on the water level. At high water levels at or near the surface, CO₂ fluxes are near zero or negative (net sequestration); lower water levels are associated with an increase in emissions until a plateau is reached.

Methane fluxes from drained sites are negligible (except from ditches). At high mean annual water levels (above ~20 cm below the surface), high emissions are observed. Low fluxes at high water levels are found at sites where plants with coarse aerenchymous tissue (so called shunt species) are not present. For those sites where shunt species are present, the number of aerenchymous leaves is a better proxy for annual CH₄ emissions than the mean water level. There are only a limited number of measurements available for flooded sites. Emission of methane from flooded sites may be linked to fresh plant materials in inflowing water.

Nitrous oxide emissions are restricted to drained nutrient rich (or fertilized) peat soils. Fluxes depend on site parameters that vary strongly both spatially and temporally. As a result N₂O fluxes are erratic and a broadly applicable, simple proxies like mean annual water level fail to capture the variation. However, when water levels are high (less than 20cm below the surface), N₂O fluxes are near zero.

In conclusion, a broad differentiation can be made between drained and un-drained (rewetted) peat soils. CO₂ and N₂O emissions are high in the drained situation; CH₄ emissions are highest in the wet situation. Evidence suggests that aggregate fluxes of CO₂ and N₂O (addressed in CO₂eq) in the drained situation are in general larger than CH₄ emissions in the wet situation, which makes peatland rewetting a viable climate mitigation measure.

Dominique Blain's (Canada) presentation on **Science Advances and Estimation of Wetland Emissions** addressed factors affecting the carbon balance in pristine, drained, rewetted and restored peatlands based on recent studies in Canada and elsewhere.

In pristine peatlands gross primary productivity (GPP, CO₂ uptake) exceeds soil respiration (CO₂ emissions), which results in a net C sequestration. Methane emissions impacts the carbon balance, but are in terms of carbon relatively small (in CO₂eq the importance is more significant). Also dissolved organic carbon (DOC) is lost to waterways affecting the carbon balance; the amounts vary from 5 to 70 per cent of the net ecosystem productivity. The fate of the DOC is not known, but a large proportion is assumed to be emitted to the atmosphere. In the long term pristine peatlands have accumulated large amounts of carbon.

Drainage of peatlands reduces GPP and increases soil respiration turning these lands into CO₂ sources. Methane emissions become insignificant. The intensity of drainage and land-use determine the emissions. Rewetting of the drained areas reduces the soil respiration, but does not necessarily lead to the restoration of a functional acrotelm (living moss layer) and of GPP. The acrotelm will regulate water level and prevents severe fluctuations that enhance CO₂ emissions. Hence rewetted peatlands may remain a net C source, although the level of emissions is reduced. These lands turn to sinks only when the functional acrotelm is re-established (restoration). The methane emissions increase through the rewetting.

Dominique Blain concluded that there is much new information available on the carbon balances in unmanaged and managed peatlands. She also highlighted the importance of the interactions between climate, vegetation and hydrology as factors to be taken into account in development of guidance for estimation of emissions associated with rewetting/restoration of peatlands.

Matthias Drösler (Germany) presented results from recent project collecting data on greenhouse gas budgets and EFs for European (EU) and German peatlands. The projects cover both drained and rewetted/restored peatlands. The results of the projects will be published in 2011.

Drained agricultural land showed the highest emissions, whereas rewetted/restored bogs were net GHG sinks. In drained forest land the emission level was lower than in rewetted/restored fens. The German studies showed also that the intensity of grassland management had a significant impact on the emissions.

In rewetted/restored fen the CO₂ emissions were significantly reduced compared to drained lands, but CH₄ emissions were significant. On average the rewetted/restored fens had lower net greenhouse gas emissions than drained agricultural land. The water table level was the main factor impacting emissions after rewetting. In flooded lands the CH₄ emissions were significantly higher than in land where the water table was regulated near or at surface level.

The results of the EU and German studies can be used in the development of default EFs for temperate regions, and also for the methodology development for rewetting/restoration of peatlands.

The presentations showed that much new scientific information since the completion of the 2006 IPCC GLs has become available for peatlands (drained and rewetted/restored) in boreal, temperate and tropical climate zones. The information provides a good basis for methodology development for rewetting/restoration as well as for compilation and provision of new data on EFs for drained lands to the IPCC Emission Factor Database (EFDB).

Faizal Parish (Wetlands International) presented ***Emission data from peatland fires in South East Asia***. Progress has been made in documenting spatial distribution of peatland fires and developing methodologies to assess carbon losses. In South East Asia, using a combination of satellite, LIDAR and ground assessments, it has been shown that more than 2 million ha of peatland have been affected by fire in the last decade with average annual emissions of 90 TgC/year and up to 480 TgC/year in extreme droughts. It was noted that fires and related emissions can be significantly reduced through rewetting, better water management or rehabilitation of degraded sites and enhanced fire prevention and control measures.

2.3 Conclusions and recommendations

2.3.1 Drainage and rewetting or restoration of peatlands

The BOG reaffirmed that the 2006 IPCC Guidelines include limited guidelines for estimation of emissions and removals from activities associated with wetland management. CO₂ and N₂O emissions from peat extraction (drainage of the lands for peat extraction and subsequent production of peat for energy, horticultural and other uses) and CO₂ emissions from conversion of land to flooded land are addressed in Chapter 7 Wetlands in the 2006 IPCC Guidelines. An alternative method to estimate the CO₂ emissions from flooding as well as a method for CH₄ emissions is given in the Appendix 2 and 3, respectively. Emissions from drained soils (addressed as organic soils) in forest land, cropland and grassland are addressed in the respective chapters of the Guidelines.

The BOG concluded that since the completion of the 2006 IPCC Guidelines sufficient new science has become available that make it possible to provide guidance to fill methodological gaps for rewetting and restoration of peat lands as well as for collection, assessment and provision of new EF data to IPCC EFDB.

The group also noted that there are also other sources of emissions related to wetlands for which more information is now available.

- **Ditches:** CH₄ emissions from drained peatlands are not zero as ditches in drained peatlands, and also waterborne carbon in some cases, are sources of CH₄ emissions. The relative importance of the methane flux from ditches needs further study.
- **Waterborne Carbon:** The group highlighted waterborne carbon losses as a potential additional source of greenhouse gas emissions from drained and un-drained organic soils. Waterborne carbon comprises several components:
 - **Dissolved Organic Carbon (DOC)** is usually the largest component of water borne carbon fluxes from peatlands. DOC flux is well-studied, also because of the impact of associated water colour problems on the water supply industry. Export from temperate peatlands ranges between ~50 and ~500 kg DOC ha⁻¹ yr⁻¹; fluxes from tropical peatlands may be considerably larger. The aerobic zone of drained peat soils is a significant source of DOC. Current evidence suggests that drainage of peat soils leads to considerable increase in DOC losses. A portion of the DOC is transported downstream and most of it is believed to be decomposed and lost to the atmosphere as CO₂, or CH₄ in some circumstances.
 - **Dissolved Inorganic Carbon (DIC)** is the least studied component of the carbon flux and is a relatively small component of the overall flux. Degassing of dissolved CO₂ from waters draining peat soils may be a more important pathway of carbon loss than downstream DIC transport.
 - **Particulate Organic Carbon (POC)** fluxes are largely associated with physical erosion of the peat surface and controlled by vegetation cover. In severely eroding peatlands, fluvial POC losses may be the largest single component of carbon mass budgets. POC may be buried in anoxic conditions in lakes or reservoirs, but may also be rapidly oxidised in the fluvial system.
- **Constructed wetlands for wastewater treatment:** Some studies on emissions from constructed wetlands for wastewater treatment have been published. The group was however not able to assess whether these would be sufficient for development of new guidance.
- **Peatland Fires.** The BOG noted that in the 2006 IPCC Guidelines a generic methodology for estimation of emissions from fires is given in Chapter 2. One default value for fuel biomass consumption is given to cover all types of fires on peatlands. The group concluded that the generic methodology is applicable to peatland fires, but EF data should be further developed to take into account more recent data on different peatland fire types and the influence of drainage depth.

Recommendation 1

The meeting recommends that new guidance be developed for wetlands to address the identified gaps (rewetting of peatlands, wetland restoration). If possible guidance should include constructed wetlands for wastewater treatment. It also noted that the relevant guidance is not confined to Chapter 7 Wetlands and coherence with the guidance on estimation of emissions from drained land (organic soils) under forest land, cropland and grassland should be addressed.

The development of the guidance should:

- Cover all relevant gases (CO₂, CH₄ and N₂O);
- Take into account water level (e.g., flooded and rewetted), climatic zone (e.g., boreal, temperate and tropical), vegetation, and nutrient status;
- Develop default EFs for ditches and waterborne carbon, or alternatively include these emissions in an overall EF for the lands in question;
- Be applicable to the range of relevant circumstances; and
- Be practical.

For constructed wetlands for wastewater treatment consideration should:

- Address possible double counting with wastewater treatment;
- Include restoration of coastal wetlands, (e.g., salt marshes and mangroves);
- Consider if any additional guidance is needed for fires.

Recommendation 2

The meeting recommends that the IPCC TFI organise an expert meeting to assess the new data on emissions from drainage (all gases and land uses after drainage) and also for rewetting and/or restoration of peatland for collection of new EFs to the IPCC EFDB for use in nationally specific higher tier methods. Peatland fires, particularly, fuel biomass consumption, should be included.

2.3.2 *Flooded lands*

The BOG discussed new available information in scientific literature in regards to emissions downstream of dams (“degassing” at the dam and emissions of CO₂ and CH₄ along the river course), CH₄ bubbling emissions, N₂O emissions, and information on the surface area of small and large reservoirs that might allow the development of more representative EFs for different regions of the world. Also on the impact of the typology of the reservoirs on emissions as well as the different current measuring GHG activities taking place on reservoirs in the world such as those in Brazil, China, Malaysia, United States, Laos, Norway, Iceland and Canada. One of the major concerns that was discussed was the contribution of the input of organic matter from other anthropogenic activities in the upstream watershed (e.g., input of organic matter from agriculture, forestry or wastewater treatment) leading to GHG emissions at the surface of the reservoir and how they should be attributed and/or allocated to other activities, as they might represent a double counting.

Recommendation 3

The IPCC TFI should organize an expert meeting to discuss all the new science and issues surrounding estimating greenhouse gas emissions from reservoirs that need to be clarified before improved and more complete methodological guidance for flooded land can be produced. The meeting should consider, inter alia:

- Integration of the new information available with Chapter 7.3 Flooded land, the Appendix 2 Possible Approach for Estimating CO₂ Emissions from Lands Converted to Permanently Flooded Land: Basis for Future Methodological Development and Appendix 3 CH₄ Emissions from Flooded Land: Basis for Future Methodological Development in the 2006 IPCC Guidelines;
- Possibilities for further guidance to reduce the uncertainties in the estimation of surface area of reservoirs;
- Whether the emissions can be attributed to other human activities and, if so, under which sectors/categories the greenhouse gas (CO₂, CH₄ and N₂O) emissions from the reservoir should be reported (e.g. agriculture, forestry or wastewater treatment);
- How reservoirs impact emissions and removals from the entire watershed.

2.4 Wetlands Group Participants

Pipatti, Riitta (Finland), Co-chair
Washington, Zhakata (Zimbabwe) Co-chair,
Drösler, Matthias (Germany), Rapporteur

Blain, Dominique (Canada)
Couwenberg, John (Wetlands International and
University of Greifswald, Germany)
Eggleston, Simon (TFI TSU)
Evans, Christopher (UK)
Fukuda, Maya (TFI TSU)
Guerin, Frederic (France)
Herold, Anke (Germany)
Heath, Linda (USA), Global Environmental Facility

Klemedtsson, Leif (Sweden)
Krug, Thelma (TFI cochair)
Parish, Faizal (Wetlands International)
Penman, Jim (UK), TFB member
Pinguelli, Luiz (Brazil)
Sirin, Andrey (Russian Federation)
Towprayoon, Sirintornthep (Thailand)
Tremblay, Alain (Canada)
Yagi, Kazuyuki (Japan)

3. Harvested Wood Products

3.1 Presentations

Nalin Srivastava (TFI TSU) gave a presentation on, “**Harvested Wood Products in the 2006 IPCC Guidelines**” to provide some background to the BOG deliberations.

Nalin Srivastava discussed the guidance on HWP contained in the 2006 IPCC Guidelines and the issues to be addressed in light of the UNFCCC request. He described the various elements of guidance on HWP including:

- Alternate approaches to reporting and accounting for the HWP contribution to the Agriculture Forestry and Other Land Use (AFOLU) sector;
- The five variables needed to use any of these approaches;
- Guidance on different methodological tiers for the five variables for estimating and reporting the HWP contribution;
- Guidance on reporting “zero” HWP contribution and the assumptions behind this.

He further discussed the UNFCCC request and the questions that need to be addressed in the meeting:

- Are there any errors for which corrigenda should be issued and how they should be addressed, e.g., the issue of “insignificant” HWP contribution (p. 12.8, Chapter 12)?
- Are there any inconsistencies in the existing guidance and if so, how these should be addressed, e.g., issues relating to consistency with AFOLU and potential double-counting with Energy and Waste sectors?
- Can any clarifications be given to make the existing chapter easier to understand such as the use of higher tier methods, stock methods and detailed country data?
- Are there any new accounting approaches being proposed for which additional material should be provided?

3.1.1 Status and recent developments in knowledge

There were two more presentations by experts on the recent advancements in the scientific knowledge on HWP and the developments in international climate negotiations related to HWP.

Sebastian Rüter (Germany) gave a presentation titled, “**2006 IPCC Guidance on estimating net emissions from HWP**” that dealt with the different reporting and accounting approaches in the 2006 IPCC Guidelines, the new accounting approaches being proposed in the UNFCCC negotiations and the additional guidance that would be needed to report the HWP contribution using them.

The presentation described the various methods that are commonly used for estimating the HWP pool over time, such as direct inventories and flow data methods. The inventory based methods use direct inventories of HWP e.g., building statistics. The flow data methods use the inflow (e.g., from direct estimation or data on trade and removals) and outflow (using direct estimation or different decay curves) data from the HWP pool to estimate the changes in the HWP pool. The presentation also dealt with the guidance in the 2006 IPCC Guidelines on HWP on topics such as decision tree for selecting a methodological tier, when to report zero HWP contribution (IPCC default approach), the conceptual framework and data requirements for the flow data method using service(half) life (IPCC tier 1 method).

The presentation also went into the various previously proposed accounting approaches and the new proposal for HWP accounting in the UNFCCC negotiations.

The presenter concluded that the 2006 IPCC Guidelines, Chapter 12 on HWP does not contain sufficient information on accounting for HWP according to the proposals under negotiation in the UNFCCC. It does not provide methodological guidance on tier 3 methods especially with regard to ensuring comparability of reporting amongst countries. Additional guidance on deriving country specific data, e.g., on half life assumptions, should be provided. Some typographical and minor errors in Chapter 12, 2006 IPCC Guidelines on HWP should be corrected; potential double-counting with the Waste sector also needs to be addressed.

In his presentation titled, "***The 2006 IPCC Guidance on Harvested Wood Products and Some Possible Refinements***", **Gregg Marland** (USA) discussed the various refinements that could be incorporated in the methodologies on HWP in the 2006 IPCC Guidelines.

Gregg Marland recommended two basic refinements: i) dealing separately with various approaches proposed to date; and, ii) providing a more accurate description of the rate of oxidation of the products. On the second point, he proposed a gamma distribution decay function to better represent the probabilistic nature of the decay of products. He explained that HWP follow a distributed decay function with the probability of decay or replacement of the HWP depending on the age of the product. He presented the gamma parameters for the various wood products based on his research.

3.2 Review of existing guidance

The group reviewed the HWP chapter in the 2006 IPCC Guidelines, paying particular attention to the topics identified in the SBSTA request: definitions, consistency, potential for double counting with other sectors, use of higher tier methods and if they are consistent with any new accounting approach that has been proposed.

In general the group confirmed that the existing guidance is correct and complete but emphasised that it needs to be implemented in its entirety to ensure that complete estimates are made without any double counting or omissions. However the group did note there were some editorial issues with the text which should be corrected.

Recommendation 4

The expert group identified that there were some editorial issues in the guidance for HWP and that a corrigendum should be issued. These are:

- Page 12.8, para 12.2.1: "The term 'insignificant' in this context means that the annual change in carbon in HWP stocks, using one of the measures of carbon change above, is of a comparable size to a key category." The experts concluded that the term "is of a comparable size to a key category" should be replaced with "less than the size of any key category".
- Table 12.5, footnote 2 the last term in the equation should be " $-CP_{EX}$ "
- Table 12.5, footnote 3 the last term in the equation should be " $-CP_{EX}$ "
- Page 12.11: Equation 12.2, wrong usage of "produced". The experts concluded that the term "produced" was incorrect and should be replaced by "placed in use".

The experts discussed possible inconsistencies between the HWP, the waste sector and the energy sector and concluded that although there was the possibility for inconsistency, this situation would only

arise from incomplete application of the guidelines. If there is a concern regarding consistency with the Waste sector estimates please see section 12.2.1.5 and 12.4 item 3. Additional clarification, particularly on QA/QC, may be provided in the form of FAQ.

The experts discussed the HWP guidance and noted how a general knowledge of all the material in the guidance was required because in some cases, the information relevant to a particular topic could be found in different sections. A way to aid in developing understanding of the methods and data requirements is to use the spreadsheet provided with the 2006 IPCC Guidance that provides default parameters and indicates how to obtain default data from the UN FAO forest sector database.

Experts also noted that not all of the five variables may be required for all the reporting approaches; however they are required to make valid comparisons with estimates across all countries reporting using other approaches.

Recommendation 5

The experts concluded that an FAQ could be developed by the TSU to aid inventory compilers with advice on common issues. The experts also identified some specific issues where more advice would be beneficial to inventory compilers:

- How to derive country specific service life data e.g.,
 - Using market information on the fate of products for calibration
 - Using information on housing stocks
- Examples of the use of tier 3 methodologies
- Guidance on calibration and verification for tier 3 methodologies, e.g.:
 - Comparing flow estimates with a stock inventory estimates, e.g., comparing estimates of housing stocks derived from use of carbon in housing with separate housing stock estimates
 - Comparing using different decay curves
 - Comparing HWP estimates of discards to SWDS to Waste sector activity data on discards
 - Use of alternative decay curves for tier 3 e.g., Gamma curve or lognormal curve instead of the exponential decay curve
- Clarification on the use of eq. 12.3: eq. 12.3 assumes that round wood exports are being used in the same proportion in the solid wood and paper products in the importing countries as domestically; this estimate could be improved if the countries have more detailed data.
- Clarification on correlation of HWP in the SWDS with the Waste sector categories, e.g., garden and park waste
- Eq. 12.5, the first sentence from the following paragraph: “The carbon release variables are defined in Section 12.1”. The experts noted that most of the definitions for Eq. 12.5 were in table 12.1. The experts considered that it should be specified in the FAQ that most of the variables are in table 12.1, within section 12.1.
- Section 12.2.1.1: The line “The decay of HWP is assumed to be of first order” needs to be clarified. In the context of this chapter, decay is considered as all loss of carbon from a pool and does not just mean biological decay.

The experts noted that the current default values in the guidelines are applicable to make tier 1 estimates for the accounting approaches included in the Annex to the HWP Guidelines. The experts also considered the guidance and information required for the two additional approaches being discussed:

- A. *Estimates of HWP contribution restricted to domestically produced and consumed HWP commonly known as “Stock Change of Domestic Origin (SCAD) approach”.*
- B. *Estimates of HWP contribution of domestically produced with partitioning of exports to individual countries known as “Production Approach with Partitioning of Exports”*

These approaches are not entirely new and build upon the approaches already discussed in the 2006 Guidelines. However, the experts noted that these approaches have been suggested for accounting purposes and may not meet the requirements for convention reporting e.g. to neither over nor underestimate to the extent possible. Associated with these approaches may be a restriction on origin of the HWP that can be included in the calculation

The experts considered to what degree the existing guidance could be used to estimate and report the HWP contribution for each proposal and what additional methods and data would be required to make estimates for these new approaches.

Stock Change of Domestic Origin (SCAD) approach (proposed by Cowie et al., 2006 & taking into account FCCC/ KP/AWG/2010/CRP.3)

- Existing guidance could be used provided there is a modification of eq. 12.3 so that only HWP that is domestically produced and consumed are included.
- In order to restrict HWP to particular harvest/land sources additional data would be needed on the amount and types of HWP (e.g., solidwood and paper products) from those sources.

Production Approach with Partitioning of Exports (taking into account FCCC/ KP/ AWG/2010/CRP.3)

- Existing guidance could be used provided there is a modification of eq. 12.3 to estimate the HWP contribution from domestically produced and consumed HWP (this is one component of the estimate necessary).
- For exported HWP it is also necessary to make estimates of HWP contribution separately for exports to each importing country in the case it is included. Implementing this approach would require consistent information across countries on parameters and decay functions, e.g.:
 - Common aggregates of HWP e.g., using FAO product categories
 - Common form of decay function for all countries for each aggregate of HWP e.g., First Order Decay (FOD), eq. 12.1
 - Half or service life for each country and aggregate
 - Guidance may be needed on how to develop country-specific data
 - Countries using tier 3 methods could be asked to translate their methods in to a common decay curve and half lives for other countries to use in tracking the disposition and fate of their exports.

The experts suggested that development of additional methodological guidance that would build upon the existing guidance in the 2006 IPCC Guidelines may be needed to make estimates for the two approaches.

3.3 HWP Group Participants

Emmanuel MPETA- Co-chair
Leonard BROWN- Co-chair
Sebastian RUETER- Rapporteur

Annette Louise COWIE (Australia)

Fabiano XIMENES (Australia)

Advance copy: subject to final edit

Seiji HASHIMOTO (Japan)
Mario TONOSAKI (Japan)
Nikolay SMIRNOV (Russian Federation)
Rehab HASSAN (Sudan)
Robert William MATTHEWS (UK)

Gregg MARLAND (USA)
Kenneth SKOG (USA)
Daniel MARTINO (Uruguay)
Carol GROSSMAN (Australia)
Nalin SRIVASTAVA (TFI TSU)

4. Soil N₂O

4.1 Presentations

Jamsranjav Baasansuren (IPCC TFI TSU) introduced the guidance given in the 2006 IPCC Guidelines on estimating N₂O emissions from soil. She elaborated on the changes relative to 1996 IPCC Guidelines with regard to emission factors (EF) and parameters and highlighted the questions to be considered in the BOG including:

- If 2006 Guidelines methods and default factors still reflect the latest science;
- Can new methods or default emission factors be provided;
- Are there any improvements to existing guidance that can be provided; and
- Are there any EFs that should be entered into the EFDB.

Beata Eموke Madari (Brazil) presented on **Soil management and nitrous oxide (N₂O) emissions**. N₂O emissions from soil (Rhodic Ferralsol) under different management practices (zero tillage versus conventional tillage) and nitrogen sources (mineral N, bovine excreta). Static chambers and manual vacuum pump (-80 kPa) were used to measure N₂O. Results of N₂O (g N-N₂O ha⁻¹) from the two different crop rotations under zero and conventional tillage showed that zero tillage did not promote higher N₂O emissions compared to conventional tillage. Linear correlations between averages of N₂O and NH₃ fluxes and C and N content in microbial biomass were found. In this study N₂O emissions from different mineral N sources (urea, ammonium nitrate, ammonium sulphate etc.) were different, and urine was a major source of direct and indirect N₂O emission from bovine excreta. In conditions of extensive pasture grazing rarely more than 60% of the N is excreted in the urine that would lead to an emission factor (EF) of 0.5-0.7%. In addition, the field measurements in Brazil revealed lower EF (0.28%) for N₂O emissions from N inputs compared to IPCC default EF1 (1%).

Philippe Rochette (Canada) gave a presentation on **Soil N₂O Emissions: Possible refinements to the 2006 IPCC Guidelines**. The presentation summarized the information on recent literature and findings related to direct and indirect emissions of N₂O from soil. It was highlighted that regional variation exists even within a country for EF₁ and noted that IPCC EF₁ might be biased towards the wet climate. Climate and soil properties are important factors that affect the soil N₂O emissions, for example, in Canada, the emissions on clay soils are double those on sandy soils. The presentation indicated the increasing number of data and information available for soil N₂O and suggested to revisit the literature. However, few studies addressed the organic N sources and indirect emissions of N₂O.

Xiaoyuan Yan (China) presented on **Estimating N₂O emission from Chinese croplands by statistical modeling**. The N₂O emissions from uplands in China were simulated based on field data considering the effect of different organic amendments, crop types and rainfall. The field measurements showed that fresh manure tends to emit more N₂O. Annual mean temperature, water regime and type of organic amendment were considered for simulating N₂O emissions from rice paddy. Simulated N₂O emissions showed that fertilizer induced EFs for China are slightly lower (0.82% and 0.26% for uplands and rice paddy, respectively) than the default value in the 2006 IPCC Guidelines. It was noted that background emission constitutes a significant proportion of the total emissions.

Keith Smith (UK) presented on **N₂O emission factors: top-down vs bottom-up assessments**. For thousands of years the N₂O concentration in Earth's atmosphere was constant. In last 30 years, a linear

increase of N₂O concentration in the atmosphere has been observed and the recent increase in concentration indicates excess of global emissions over the N₂O sinks. However, default values do not account for the observed atmospheric increase. He noted that the ranges of default EFs are logarithmic: e.g., EF1 = 1% (range 0.3-3.0%), and possibly tropical/irrigated systems are skewed to the high end.

4.2 Summary

The group concluded that the current advice in the 2006 IPCC Guidelines is clear and correct. However it recommended some corrigenda should be issued to resolve a few editorial issues. The overall methodology and the sources of Nitrogen input for calculating direct and indirect N₂O emissions are in accordance with the current status of science. The group noted that, due to limited measurements available when the 2006 IPCC Guidelines were finalised, emission factors were based on measurements for temperate climate zones.

More than 1000 field studies for soil N₂O research have been published in peer reviewed papers since the finalization of the 2006 IPCC Guidelines. While the group does not believe this would invalidate the default values in the guidelines, this new evidence should be exploited to refine the methodologies and allow some stratification e.g., by climate type and soil type, N sources and management. Models could aid by deriving regional emission factors for Tier 1 and Tier 2 approaches.

Additional assistance to users of the guidelines should be provided, for example, links to additional data sources should be included, e.g., for guidance for estimating releases of NH₃ and soil properties.

Some direct and indirect sources of N₂O emission may be missing due to lack of scientific knowledge (e.g., N₂O from managed forest soils, small-scale hotspots on farms, permanent grass-legume pastures). The group recommends these as priority areas for further research and synthesis.

The 2006 IPCC Guidelines removed the process of biological nitrogen fixation as a direct source of N₂O (this was included as a source in earlier guidelines). Additional scientific evidence, available since the publication of the 2006 IPCC Guidelines supports the assumption that there are no emissions from the process of biological nitrogen fixation itself (Carter and Ambus 2006, Fernández Luqueño et al. 2009, Yang and Cai 2005, Zhong et al. 2009).

The group confirmed the usefulness of the approach that “anthropogenic N₂O” equals all N₂O emissions from all managed land, including Forest Land (page 11.5).

The BOG noted as a generic issue that the observed atmospheric N₂O increase is not matched by bottom-up estimates of anthropogenic N₂O emissions (Crutzen et al. 2008, Davidson 2009). The different approaches used in these papers and the earlier bottom-up approaches (e.g. Nevison 2000) are not easily reconciled but the most recent papers raise concerns that the anthropogenic N₂O emissions may be underestimated.

Recommendation 6

The group recommended issuing four corrigenda:

- A. Page 11.5, last bullet: “removal of biological nitrogen fixation as a direct source of N₂O because of the lack of evidence of significant emissions arising from the fixation process.” was formulated in an unclear manner. Recommendation: rephrase the sentence to “removal of biological nitrogen fixation as a direct source of N₂O because of the evidence that no significant emissions arise from the fixation process”.
- B. Page 11.15: Equation 11.7A Alternative approach to estimate F_{CR} (using Table 11.2): This equation should be equivalent to equation 11.6. However there is a units mismatch. AG_{DM(T)} calculated from Table 11.2 is in Mg/ha while F_{CR} is defined as being in kg/ha. Also root biomass N is underestimated in Equation 11.7A compared to Equation 11.6 because root biomass is multiplied with aboveground residue biomass AG_{DM(T)} instead of total aboveground biomass AG_{DM(T)} * 1000 + Crop_(T). Recommendation: Revise equation 11.7A.
- C. Page 11.17, Table 11.2: Crop_(T) as used in Table 11.2 is in Mg/ha but units are not clearly stated, while Crop_(T) as used in the text on page 11.14 is kg/ha. Recommendation: The correct equation on the top of Table 11.2 is:
$$AG_{DM(T)} \text{ (Mg/ha)} = (\text{Crop}_{(T)}/1000) * \text{slope}_{(T)} + \text{intercept}_{(T)}$$
- D. Page 11.19: N mineralisation associated with loss of soil organic matter resulting from change of land use or management on mineral soils is only included in the leaching/runoff component of indirect N₂O emission. Recommendation: insert link to footnote “²⁰” after “(F_{SOM}).”

4.3 Review of parameters used to estimate Soil N₂O Emissions

4.3.1 EF₁ for direct N₂O emissions from N input

EF₁² is based on 50% of presently available literature. While literature for EF₁ is biased to papers from Temperate Europe and North America many new papers from all other regions and climate zones, in particular from China and other parts of Asia, and South America have appeared since 2005. Recent evidence presented at the experts meeting suggests that the EF₁ may be too high for croplands in many world regions.

Nitrogen input to soil is an important driver of N₂O emissions, but the observed correlation between N fertilizer input and annual N₂O emissions is often weak because it is masked by other N sources and soil and climate factors. The science is mature enough to derive regionally stratified values for the EF₁ that account for climate and soil type.

² EF₁ is the emission factor for emissions of N₂O (expressed as mass of N) per N additions from mineral fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon

Scientific evidence from the reviewed literature and recent work discussed at the meeting supports the important role of regional climate (in particular of the gradients from arid to humid and from oceanic to continental), soil type and texture, and often also crop type, the form of nitrogen (in particular properties of organic fertilizers) and water management for EF₁.

Successful examples showed that statistical and process-based models can help in estimating local EFs and to stratify agricultural systems by establishing typical relations between driving factors and N₂O emissions but the inclusion of management practices for large-scale estimates remains difficult.

Countries are increasingly developing higher Tier methods based on national measured data combined with statistical or process-based models.

Recommendation 7

The participants recommend holding an expert meeting to discuss the implications of recent literature for a possible further stratification of EF₁ and the possible use of models to derive regional EF₁ for Tier 1 approaches.

The participants recommend providing additional technical advice for aggregating measured data to national estimates in the Q&A section of the TFI website (Annex 2).

4.3.2 EF₂³ for direct N₂O emissions from drained organic soils

There is new evidence available that allows a further stratification and update of the EF₂.

Recommendation 8

The EF₂ should be updated jointly with the emission factors for CO₂ and eventually CH₄ from drained organic soils (cf. recommendations by Wetlands BOG).

4.3.3 Indirect N₂O methodology - Atmospheric deposition

There is additional guidance and data available to stratify Fra_{C_{GAS}F}⁴ and Fra_{C_{GAS}M}⁵ by N source and manure management type, maybe also by temperature or climate zone. Information on manure management systems could be taken from the calculations in the livestock sector. The EF₄⁶ is in line with the EF₁, which is scientifically plausible. There is too little new scientific evidence to review the EF₄. An area based approach based on direct measurement of N₂O emissions from managed and unmanaged soils could be a useful and transparent alternative to the present methodology for N₂O related to atmospheric N deposition.

³ EF₂ is the emission factors for emissions of N₂O (as mass of N) per unit area of organic soils.

⁴ Fra_{C_{GAS}F} = fraction of synthetic fertiliser N that volatilises as NH₃ and NO_x, kg N volatilised per kg of N applied

⁵ Fra_{C_{GAS}M} = fraction of applied organic N fertiliser materials and of urine and dung N deposited by grazing animals that volatilises as NH₃ and NO_x, kg N volatilised per kg of N applied or deposited

⁶ EF₄ = emission factor for N₂O emissions from atmospheric deposition of N on soils and water surfaces, [kg N₂O volatilised expressed as N per kg N deposited as NH₃ or NO_x]

4.3.4 Indirect N₂O methodology -N leaching and runoff

The 2006 IPCC Guidelines only consider two extreme situations for nitrogen leaching – either completely humid conditions with a $Frac_{LEACH}$ ⁷ of 0.3 or zero. This was considered too coarse to reflect the situation in many semiarid or seasonally arid regions. The methodology uses soil water holding capacity as input, which may be difficult to obtain for some regions. The revised value of the EF_5 ⁸ is confirmed for those environments where there is recent scientific evidence but the scientific basis for the EF_5 , in particular for tropical environments where scientific evidence is not available, remains weak.

Recommendation 9

Q&A should be developed for the TFI website providing additional technical advice on:

- Stratifying $Frac_{GASF}$ and $Frac_{GASM}$, including matching the EMEP/EEA air pollutant emission inventory guidebook 2009⁹ and an eventual adaptation of the emission factors for NH₃ to tropical conditions.
- Exploring the possibility to further stratify $Frac_{LEACH}$ by using climate indices, e.g. P/PE (ratio between precipitation and potential evapotranspiration).
- Calculating soil water holding capacity, including a table with default values consistent with the soil types used in the Guidelines and with rooting depth.
- Adding the dry matter fraction of additional crop types, e.g., sugar cane, in the Q&A section of the TFI website

4.3.5 Understudied issues, regions and gaps

The group noted that there are a number of potential sources of N₂O that have not been adequately researched and this may lead to the methods in the 2006 Guidelines being incomplete or underestimating N₂O emissions. These areas include:

- **Systems with organic fertilizers:** Less than 10% of the published field studies include organic fertilizers. The relation between organic amendment properties (e.g. fraction between mineral and organic N, C/N ratio, quality of organic carbon) and N₂O emissions needs to be further explored because of possible strong effects on N₂O emissions and a significant potential for N₂O mitigation by changes in land management.
- **Pastures and perennial legumes:** there is emerging evidence that permanent pastures have higher N₂O emissions than unmanaged land. These additional N₂O emissions from managed permanent grasslands and perennial legumes are not considered in the 2006 IPCC Guidelines for unfertilized pastures, which are relevant in many tropical, dry temperate and wet cold climate regions, and in improved pastures without legumes and grass-legume pastures. However, existing data is incomplete.
- **EF_{3PRP}:** there is emerging evidence that urine is associated with much higher N₂O emissions than faeces. The ratio of nitrogen excreted as urine and faeces depends on grazing and mowing intensity,

⁷ $Frac_{LEACH-(H)}$ = fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N per kg of N additions

⁸ EF_5 = emission factor for N₂O emissions from N leaching and runoff, kg N₂O expressed as N per kg N leached and runoff

⁹ <http://www.eea.europa.eu/publications/emepeeaemissioninventoryguidebook2009/>

feed quality and animal type. The EF_{3PRP} in the 2006 IPCC Guidelines seems to be representative of urine only and may overestimate N_2O emissions from excreta from extensive grazing systems.

- **N_2O from managed forest and coppice:** the participants noted that the 2006 IPCC Guidelines do not consider direct N_2O emissions from managed forest and coppice except for N_2O from soil organic matter and organic soils although, according to page 11.5, all N_2O from managed land is considered anthropogenic. Measurements of N_2O emissions from managed forest soils suggest that N_2O emissions can be significant. A review of available literature and further measurements should support the elaboration of area-based EFs for managed forests and EFs for specific management activities including fertilization, liming, clear cutting, and renewal of coppice systems.
- **Small-scale features and hotspots on farms:** extreme hotspots on particular farm places have recently been reported, Matthews et al. (2010). Although these features can have a very small extent they accounted for an additional emission is +15% at farm level. The omission of these small-scale features in the 2006 IPCC Guidelines leads to a systematic underestimation of N_2O emissions from farms, in particular from farms with animals. Further measurements are needed to corroborate the results and better quantify the relevance of such hotspots.
- **Agricultural regions with high seasonality of rainfall:** dominance of emission peaks in annual N_2O emissions – particularly difficult to measure and quantify, and generalize.

4.4 Comparing top-down and bottom-up global N_2O budgets

Using a global top-down approach (based on measured concentrations and overall nitrogen inputs), taking account of the steady increase in the N_2O concentration in the atmosphere (corresponding to 3.9 Tg N_2O -N/yr), Crutzen et al (2008) estimated that 3–5 per cent of all new reactive N input into terrestrial systems is converted to N_2O . This N_2O conversion range (or emission factor) was based on data compiled by Prather et al (2001) and Galloway et al (2004). New nitrogen input includes fertilizer nitrogen produced by the Haber-Bosch process, nitrogen oxides emitted as a result of fossil fuel combustion, and biological nitrogen fixation (BNF). Based on data from the same sources, Crutzen et al also showed that this emission factor was similar to that for terrestrial ecosystems in preindustrial times, when the nitrogen inputs were from natural sources: mainly BNF, plus NO_x from lightning.

The IPCC bottom-up approach (based on identifying and estimating each source sector) provides a default EF_1 for direct emissions of 1%. The defaults for N loss by volatilization (10% of fertilizer N, 20% of manure N), combined with the EF_4 (1%) for N_2O from this N once re-deposited, are equivalent to another 0.1-0.2% of the N applied to the field. Similarly, the default leaching fraction of 30%, combined with the indirect EF_5 (0.75%), adds a further 0.23%. Thus in total the default fraction of applied N that is emitted as N_2O adds up to 1.33-1.43%. This is only one-third of the mean emission factor of 4% obtained via the Crutzen et al approach.

The top down method of Crutzen et al (2008) considered only new reactive N input and found that 3-5% of the new reactive N is emitted as N_2O . However, this is an accumulated emission factor as some new reactive N can be recycled several times in a year. Del Grosso et al (2008), made another comparison between the IPCC 2006 method and the top down method. Using IPCC 2006 method, he estimated 5.8 Tg N_2O -N from agricultural system, which is close to the middle of the range (4.2– 7.0 Tg) based on the top-down approach. This implies that on sufficiently large scales, the top-down and bottom-up approaches used to calculate N_2O emissions from agricultural systems may yield similar estimates.

In addition to the gaps noted above, these differences may, in part, be due to the fact that the environments studied up to now (on which the guidelines methods and parameters are necessarily based)

are not globally representative. Unstudied areas include hot countries; big slow-moving rivers; major deltas, in particular tropical rivers with high organic carbon load; estuaries and anoxic high-nitrogen offshore zones to which the leached nitrogen is finally transported; all of which are potentially significant sources of N₂O. There is a need for new methods (e.g. aircraft/balloon/satellite-based) to target these regions, and to make measurements at the necessary regional scale to determine their emissions.

Recommendation 10

An expert meeting with land, ocean and atmospheric scientists should explore the gap between top-down and bottom-up global N₂O budgets; identify possible reasons of this mismatch; identify potential additional sources and sinks of N₂O; and explore ways to improve methodologies.

Encouragement should be given for measurement programmes to be strengthened for these understudied regions and issues.

4.5 Soil N₂O Group Participants

Annette Freibauer, Co-Chair
Mamadou Khouma, Co-Chair
Leandro Buendia, Rapporteur

Marta ALFARO (Chile)
Amnat CHIDTHAISONG (Thailand)
Rui DU (China)
Leonidas Osvaldo GIRARDIN (Argentina)
Taka Hiraishi (TFI Co-chair)
Baasansuren Jamsranjav (TFI TSU)
Jurgen KERN (Germany)
Sadeddin KHERFAN (Syria)
Sonoko Dorothea KIMURA (Japan)

Beata Eموke MADARI (Brazil)
Zhijian MU (China)
Astrid OLSSON (UNFCCC)
Philippe ROCHETTE (Canada)
Keith A. SMITH (United Kingdom)
Miguel Angel TABOADA (Argentina)
Jaak TRUU (Estonia)
Xiaoyuan YAN (China)
Lingxi ZHOU (China)

5. Conclusions and Recommendations

In June 2010, SBSTA 32, as part of its work programme to revise their reporting guidelines for Greenhouse Gas Emissions and removals from Annex I parties to allow the use of the 2006 IPCC Guidelines, invited the IPCC to hold an Expert Meeting to “explore the need and ways to clarify methodological issues related to reporting on harvested wood products, wetlands and nitrous oxide emissions from soils” (FCCC/SBSTA/2010/L.12). In response, the IPCC Task Force on National Greenhouse Gas Inventories held this meeting in Geneva on the 19th-21st October.

The meeting considered the three separate topics, harvested wood products, wetlands and nitrous oxide emissions from soil, and, in general considered that the methodological advice contained in the 2006 IPCC Guidelines still reflects the latest science. A few editorial issues were noted for HWP and Soil N₂O and corrigenda addressing these will be issued by the TFI.

These conclusions were summarised in a Co-Chairs Summary (Annex 3) which was presented at the second workshop of the SBSTA work programme to revise their guidelines for the reporting on greenhouse gases by annex I parties to the convention and to COP16 in Cancun, Mexico. The following sections outline the main conclusions.

5.1 Wetlands

- i. **The meeting recommended that the IPCC provide additional methodological guidelines for the rewetting and restoration of peat land; emissions from fires, ditches and waterborne carbon; and constructed wetlands for waste water disposal, to fill gaps in the existing guidelines (Recommendation 1).** This guidance would be additional to the 2006 Guidelines filling gaps for which sufficient information was not available when the guidelines were compiled. While the focus of this work is on the wetland chapter (volume 4, chapter 7) of the 2006 IPCC Guidelines it should be remembered that drainage and conversion of wetlands to other land uses is included in other chapters of volume 4 (e.g. forest land, cropland and grassland) and possibly the waste volume: coherence between these chapters and the wetland chapter should be maintained. The development of the guidance should:
 - Cover all relevant gases (CO₂, CH₄ and N₂O);
 - Take into account water level (e.g. flooded and rewetted), climatic zone e.g. boreal, temperate and tropical, vegetation, and nutrient status;
 - Develop default EFs for ditches and waterborne carbon, or alternatively include these emissions in an overall EF for the lands in question
 - Be applicable to the range of relevant circumstances, and
 - Be practical.
 - For constructed wetlands for wastewater treatment consideration should include:
 - Possible double counting with wastewater treatment;
 - Restoration of coastal wetlands, e.g. salt marshes and mangroves
 - Consider if any additional guidance is needed for fires.
- ii. **The meeting recommended that an expert meeting be held to assess new EFs measurements and develop emission factors from this information to enable more accurate country- and**

region-specific estimates to be made. The meeting also recommended that the TFI actively collect such data and add it to the EFDB. (Recommendation 2)

- iii. **The meeting concluded that there should be an expert meeting to discuss all the new science and issues surrounding the development of new guidelines for reservoirs** (Recommendation 3). The participants did not agree that there was now sufficient new information available to produce new and additional guidelines based on the latest literature. They did, however, agree on the need to discuss a range of associated issues, such as the impact of reservoirs on total emissions from watersheds, allocation of emissions to specific drivers and how emissions may be related to specific reservoir typologies.

5.2 Harvested Wood Products

- iv. **The participants also noted that the guidance is complex and proposed the development of FAQ (frequently asked questions) that would guide users to the correct, full implementation of the guidelines** (Recommendation 5). The meeting agreed that the methodological guidance in the 2006 IPCC Guidelines is correct, but noted that the entire chapter needs to be considered to ensure there are no inconsistencies with other parts of the guidelines.
- v. The participants noted that to produce estimates for HWP according to the approaches currently being discussed in the UNFCCC AWG-KP negotiations (FCCC/KP/AWG/2010/CRP.3) may require some modification to the existing guidelines (particularly equation 12.3).

5.3 Soil N₂O

- vi. The participants agreed that the methods in the 2006 IPCC Guidelines reflect the latest scientific literature, but the emission factors were based mainly on information from temperate regions (most importantly for EF₁ but this is also true for all emission factors for soil N₂O emissions). In particular they agreed that there is no N₂O from the biological nitrogen fixation process itself (this was included in earlier guidelines but removed from the 2006 IPCC Guidelines).
- vii. **The meeting proposed an expert meeting to assess recent literature and consider stratified EF₁ values for the EFDB** (Recommendations 7 & 8). Reviewing recent literature should allow for the development of more regional or country specific emission factors allowing greater stratification by climate, soil, management and leaching.
- viii. **This meeting proposed a joint expert meeting with WG I to explore the gap between the atmospheric N₂O increase and bottom-up estimates of anthropogenic N₂O emissions** (Recommendation 10). Participants noted that increased measurements of currently under represented systems (e.g. large river deltas) may help resolve this issue.

Annex 1. List of Participants

Argentina

Leonidas Osvaldo GIRARDIN
Fundación Bariloche
Piedras 482 2H - Buenos Aires, 1070
Argentina
Tel & Fax: +54 11 4331 2021
logirardin@fundacionbariloche.org.ar
logirardin@gmail.com

Miguel Angel TABOADA
INTA, CIRN, Instituto de Suelos
Los Reseros y Las Cabañas (S/N),
Hurlingham, Provincia de Buenos Aires,
B1686 Argentina
Tel: +54 11 4621 3207
Fax: +54 11 4481 1688
mtaboada@cnia.inta.gov.ar
mtaboada@agro.uba.ar

Australia

Annette Louise COWIE
University of New England
Primary Industries Innovation Centre
UNE Armidale, 2351 Australia
Tel: +61 4 03071044
Fax: +61 2 67733238
Annette.cowie@une.edu.au

Carol GROSSMAN
Australian Government Department of
Climate Change and Energy Efficiency
GPO Box 854, Canberra ACT, 2601
Australia
Tel: +61 2 6159 7186
Fax: +61 2 6159 7013
Carol.Grossman@climatechange.gov.au

Fabiano XIMENES
Industry and Investment NSW
121-131 Oratava Avenue, West Pennant Hills,
New South Wales, 2125 Australia
Tel: +61 2 9872 0143
Fax: +61 2 9871 6941
fabianox@sf.nsw.gov.au

Brazil

Thelma KRUG (TFI Co-chair)
INPE-Instituto Nacional de Pesquisas Espaciais
Av. Dos Astronautas, 1758 - Jardim da Granja,
SJC Campos - SP, 12227-010 Brazil
Tel: +55 12 3208 6005
Fax: +55 12 3941 2077
thelmakrug@dir.inpe.br
thelma@dir.iai.int

Beata Eموke MADARI
Brazilian Agricultural Research Corporation, National
Rice and Beans Research Center (Embrapa Rice
and Beans)
Rodovia GO-462, km 12, Santo Antônio de
Goiás-GO, 75375-000 Brazil
Tel: +55 62 3533 2181 / 2119
Fax: +55 62 3533 2206
madari@cnpaf.embrapa.br

Luiz Pinguelli ROSA
COPPE/UFRJ
Rua Moniz de Aragão s/n,
Prédio CGTEC - Cidade Universitária,
Ilha do Fundão - Rio de Janeiro,
21941-972 Brasil
Tel: +55 21 36223477
Fax: +55 21 36223463
lpr@adc.coppe.ufrj.br

Canada

Dominique BLAIN
Environment Canada
200 boul Sacré-Coeur, Gatineau (Qc),
K1A 0H3 Canada
Tel: +1 819 994 0888
Fax: +1 819 953 3006
Dominique.Blain@ec.gc.ca

Philippe ROCHETTE
Agriculture and Agri-Food Canada
2560, Hochelaga Blvd, Quebec City, QC,
G1V 2S3 Canada
Tel: +1 418 210 5042
Fax: +1 418 648 2402
rochettep@agr.gc.ca
philippe.rochette@agr.gc.ca

Alain TREMBLAY
Hydro-Quebec
75 Boul Rene Levesque, Montreal,
H2Z 1A4 Canada
Tel: +1 514 289 2211 ext:4416
Fax: +1 514 289 5038
Tremblay.alain@hydro.qc.ca

Chile

Marta ALFARO
Instituto de Investigaciones Agropecuarias
(INIA)
Ruta 5 Norte, KM 8, Osorno, 24-O
Chile
Tel: +56 64 450420, ext. 737
Fax: +56 64 237746
malfaro@inia.cl

China

Rui DU
College of Resources and Environment of Chinese
Academy of Sciences
No.19 (A) Yuquanlu road, Shijingshan district,
Beijing, 100049 China
Tel: +86 10 88256543
Fax: +86 10 88256415
ruidu@mail.iap.ac.cn
ruidu2000@yahoo.com

Zhijian MU
College of Resources and Environment,
Southwest University
No.2 Tianshenglu, Beibei, Chongqing
400716 China
Tel: +86 23 68250484
Fax: +86 23 68250444
muzj@swu.edu.cn
muzj01@gmail.com

Xiaoyuan YAN
Institute of Soil Science, Chinese Academy
of Sciences
71# East Beijing Road, Nanjing, 210008
China
Tel: +86 25 8688 1530
Fax: +86 25 8688 1000
yanxy@issas.ac.cn

Lingxi ZHOU
Chinese Academy of Meteorological Sciences
(CAMS),
China Meteorological Administration (CMA)
CAMS, 46 Zhongguancun Nandajie,
Beijing, 100081 China
Tel: +86 10 58995279
Fax: +86 10 62176414
zhoulx@cams.cma.gov.cn
zhoulx2007@gmail.com

Estonia

Jaak TRUU
University of Tartu
46 Vanemuise Str., Tartu, 5101
Estonia
Tel: +372 7 376 038
Fax: +372 7 420 286
jaak.truu@ut.ee

Finland

Riitta PIPATTI
Statistics Finland
P.O. Box 6A, FI-00022 Tilastokeskus
00022 Finland
Tel: +358 50 500 5247
Fax: +358 9 1734 3429
Riitta.Pipatti@stat.fi

France

Frederic Pierre Christian Axel GUERIN
Institut de Recherche pour le Développement
(IRD)
Laboratoire des Mécanismes et transferts
en Géologie (LMTG)
14, Avenue Edouard Belin, F-31400
Toulouse France
Tel: +33 5 61332648
Fax: +33 5 61332560
Frederic.guerin@lmtg.obs-mip.fr

Germany

Sebastian RUETER
Johann Heinrich von Thuenen-Institute (vTI)
Leuschnerstrasse 91c, Hamburg, 21029
Germany
Tel: +49 40 73962 619
Fax: +49 40 73962 699
sebastian.rueter@vti.bund.de

Matthias DRÖSLER

Munich University of Technology(TUM)
Chair of Restoration Ecology,
Emil Ramann Str. 6, Freising, 85354
Germany
Tel: +49 8161 713715
Fax: +49 8161 714143
droesler@wzw.tum.de

Annette FREIBAUER

Federal Research Institute for Rural Areas, Forestry
and Fisheries (VTI)
Institute of Agricultural Climate Research (AK)
Bundesallee 50, Braunschweig, 38116
Germany
Tel: +49 531 5962634
Fax: +49 531 5962699
annette.freibauer@vti.bund.de

Anke HEROLD

Oeko-Institut e.V.
Schicklerstr. 5-7, D 10179 Berlin, 10179
Germany
Tel: +49 30 405085 386
Fax: +49 30 405085 388
a.herold@oeko.de

Jurgen KERN

Leibniz Institute for Agricultural Engineering
Potsdam-Bornim
14469 Potsdam, Max-Eyth-Allee 100, 14469
Germany
Tel: +49 331 5699 123
Fax: +49 331 5699 849
jkern@atb-potsdam.de

Japan

Seiji HASHIMOTO
National Institute for Environmental Studies
(NIES)
16-2 Onogawa, Tsukuba, 305-8506 Japan
Tel: +81 29 850 2842
Fax: +81 29 850 2917
hashimoto.seiji@nies.go.jp

Taka HIRAIISHI (TFI Co-chair)

C/o Institute for Global Environmental
Strategies (IGES)
2108-11 Kamiyamaguchi Hayama, Kanagawa,
240-0115 Japan
Tel: +81 46 855 3758
Fax: +81 46 855 3808
hiraishi@iges.or.jp

Sonoko Dorothea KIMURA
Tokyo University of Agriculture and Technology
Saiwaicho 3-5-8, Fuchu, Tokyo, 183-8509
Japan
Tel & Fax: +81 42 367 5952
skimura@cc.tuat.ac.jp

Mario TONOSAKI
Forestry and Forest Products Research Institute
1 Matsunosato, Tsukuba-city, Ibaraki,
305-8687 Japan
Tel: +81 29 829 8299
Fax: +81 29 874 3720
tonosaki@ffpri.affrc.go.jp

Kazuyuki YAGI
National Institute for Agro-Environmental Sciences
3-1-3 Kannondai, Tsukuba, 305-8604
Japan
Tel: +81 29 838 8430
Fax: +81 29 838 8199
kyagi@affrc.go.jp

New Zealand

Leonard BROWN
Ministry for the Environment
23 Kate Sheppard Place, Wellington 6143
New Zealand
Tel: +64 4 439 7504
Fax: +64 4 439 7706
Len.Brown@mfe.govt.nz

Philippines

Leandro BUENDIA
Freelance Consultant
2113A Pula St., College Ville, Barangay Putho-
Tuntingin, Los Banos, Laguna
4030 Philippines
Tel: +63 49 536 3380
leandro.buendia@gmail.com

Russia

Andrey Arturovich SIRIN
Institute of Forest Science Russian Academy
of Sciences
Sovetskaya 21, Uspenskoye, Moscow Region,
143030 Russia
Tel: +7 495 6345257 / 916 5430838
Fax: +7 495 9306777 / 495 6345257
sirin@proc.ru

Nikolay SMIRNOV
IGCE of ROSHYDROMET and RAS
Moscow, Glebovskaya str., 20B,
107258 Russia
Tel: +7 499 169 2198
Fax: +7 499 160 0831
Smns-80@rambler.ru

Senegal

Mamadou KHOUMA
International Development Consulting (IDEV)
B.P. 50037 Dakar R.P. Senegal
Tel: +221 77 632 13 88
Fax: +221 33 855 95 92
khoumamamadou@yahoo.fr

Sudan

Rehab HASSAN
Higher Council for Environment and
Natural Resources
Gama'a Street, P.O.BOX 10488, Khartoum,
1111 Sudan
Tel: +249 9 12377973
Fax: +249 183 787617
rehabkhatmi@hotmail.com

Sweden

Leif KLEMETSSON
University of Gothenburg
Department of Plant and Environmental
Sciences
Carl Skottbergs gata 22B, P.O Box 461,
SE 405 30 Gothenburg Sweden
Tel: +46 31 786 26 32
leif.klemetsson@dpes.gu.se

Syria

Sadeddin KHERFAN
Arab University of Science & Technology
Hama - Tal Kartel, P.O. Box 74, 033
Syria
Tel: +963 944 458468
Fax: +963 33 884903
skherfan@yahoo.com

Tanzania

Emmanuel Jonathan MPETA
Tanzania Meteorological Agency
Ubungo Plaza, Morogoro Road,
P.O. BOX 3056, Dar es Salaam
Tanzania
Tel: +255 22 2460706/8
Fax: +255 22 2460735
empeta@meteo.go.tz
empeta@yahoo.co.uk

Thailand

Amnat CHIDTHAISONG
The Joint Graduate School of Energy and
Environment,
King Mongkut's University of Technology Thonburi
126 Pracha Uthit Rd., Bangmod, Tungkru,
Bangkok 10141 Thailand
Tel: +66 2 4708309/10
Fax: +66 2 8729805
amnat_c@jgsee.kmutt.ac.th

Sirintornthep TOWPRAYOON
The Joint Graduate School of Energy and
Environment,
King Mongkut's University of Technology Thonburi
126 Prachauthit Rd., Bangmod, Tungkru, Bangkok,
10140 Thailand
Tel: +662 4708309 ext:4126
Fax: +662 8739805
sirin@jgsee.kmutt.ac.th

United Kingdom

Christopher EVANS
Centre for Ecology and Hydrology
Environment Centre Wales, Deiniol Road, Bangor
LL57 2UW United Kingdom
Tel: +44 1248 374500
Fax: +44 1248 355363
cev@ceh.ac.uk

Robert William MATTHEWS
Forest Research
Alice Holt Lodge, Farnham, Surrey,
GU10 4LH United Kingdom
Tel: +44 1420 526235
Fax: +44 1420 23450
robert.matthews@forestry.gsi.gov.uk

Jim PENMAN
UK Dept of Energy and Climate Change
3 Whitehall Place, London SW1A 2AW
United Kingdom
Tel: +44 7717 541289
Jim.penman@decc.gsi.gov.uk

Keith A. SMITH
University of Edinburgh
Woodlands One, Pomeroy Villas, Totnes, Devon
TQ9 5BE United Kingdom
Tel: +44 1803 865013
keith.smith@ed.ac.uk

Uruguay

Daniel L. MARTINO
Carbosur
Misiones 1372/304, Montevideo,
11.000 Uruguay
Tel: +598 2915 3514
Fax: +598 2915 4124
daniel.martino@carbosur.com.uy

USA

Linda S. HEATH
Global Environmental Facility
1818 H St NW, MSN G6-602, Washington, DC
20433 USA
Tel: +1 202 473 6730
Fax: +1 202 522 2720
lheath@thegef.org

Gregg MARLAND
Oak Ridge National Laboratory
Environmental Sciences Division
Oak Ridge, Tennessee 37831-6301 USA
Tel: +1 865 241 4850
Fax: +1 865 574 2232
marlandgh@ornl.gov

Kenneth SKOG
USDA Forest Service
Forest Products Laboratory
One Gifford Pinchot Drive, Madison,
WI 53726 USA
Tel: +1 608 231 9360
Fax: +1 608 231 9508
kskog@fs.fed.us

Zimbabwe

Washington ZHAKATA
Climate Change Office, Ministry of
Environment and Natural Resources Management
P. BAG 7753, Causeway, Harare
Zimbabwe
Tel: +263 4 701681/3
Fax: +263 4 702758
climate@ecoweb.co.zw
washingtonzhakata@hotmail.com

UNFCCC

Astrid OLSSON
UNFCCC secretariat
P.O. Box 260 124, D-53153 Bonn
Germany
Tel: +49 228 815 14 50
Fax: +49 228 815 19 99
AOlsson@unfccc.int

Wetlands International

John COUWENBERG
University of Greifswald / DUENE eV,
Institute of Botany and Landscape Ecology
Grimmer Str. 88, D-17487 Germany
Tel: +49 3834 864177
Fax: +49 3834 864114
couw@gmx.net

Faizal PARISH
Global Environment Centre
2nd Floor Wisma Hing, 78 Jalan SS2/72, Petaling
Jaya, Selangor, 47300 Malaysia
Tel: +60 12 32 7350
Fax: +60 3 7957 7003
fparish@gec.org.my

IPCC TSU

C/o Institute for Global Environmental
Strategies (IGES)
2108-11 Kamiyamaguchi, Hayama, Kanagawa,
240-0115 Japan

Simon EGGLESTON
Tel: +81 46 855 3751
Fax: +81 46 855 3808
eggleston@iges.or.jp

Nalin SRIVASTAVA
Tel: +81 46 855 3754
Fax: +81 46 855 3808
srivastava@iges.or.jp

Jamsranjav BAASANSUREN
Tel: +81 46 855 3757
Fax: +81 46 855 3808
baasansuren@iges.or.jp

Maya FUKUDA
Tel: +81 46 855 3753
Fax: +81 46 855 3808
m-fukuda@iges.or.jp

Advance copy: subject to final edit

Eriko NAKAMURA
Tel: +81 46 855 3750
Fax: +81 46 855 3808
nakamura@iges.or.jp

Annex 2. Meeting Agenda

Tuesday 19th October

9:00-10:00	Registration		
10:00 –	Meeting Opening – Co-Chairs		
11:00	Welcome – IPCC Secretariat		
	Introduction – Meeting Background, Aims, Outputs – TSU		
Groups	Wetlands	HWP	Soil N₂O
	<p>Presentations:</p> <ul style="list-style-type: none"> Wetlands in the 2006 IPCC Guidelines (Simon Eggleston, TSU) GHG emissions from reservoirs – where is the truth ? (Alain Tremblay, IHA) Emissions from peat soils (John Couwenberg, Wetlands International and University of Greifswald) Science advances and estimation of wetland emissions (Dominique Blain, Canada) Peatland GHG-fluxes (Matthias Drösler, Germany) Peatlands, fires and emissions (Faizal Parish, Wetlands International) 	<p>Presentations:</p> <ul style="list-style-type: none"> Harvested Wood Products in the 2006 IPCC Guidelines (Nalin Srivastava, TSU) 2006 IPCC Guidance on estimating net-emissions from HWP (Sebastian Rüter, Germany) The 2006 IPCC Guidance on Harvested Wood Products and some possible refinements (Gregg Marland, USA) 	<p>Presentations:</p> <ul style="list-style-type: none"> Soil N₂O emissions in the 2006 IPCC Guidelines (Jamsranjav Baasansuren, TSU) Soil management and nitrous oxide (N₂O) emissions (Beáta Emőke Madari, Brazil) Soil N₂O Emissions: Possible refinements to the 2006 IPCC Guidelines. (Philippe Rochette, Canada) Estimating N₂O emission from Chinese croplands by statistical modeling (Xiaoyuan Yan, China) N₂O emission factors: top-down vs bottom-up assessments (Keith Smith, UK)
11:00-13:00			
LUNCH			
13:00 –			
14:00			
14:00 –	<p>Breakout group discussion</p> <ul style="list-style-type: none"> Can additional guidance be given on: <ol style="list-style-type: none"> Wetland Restoration Re-wetting Peat lands Wetlands Drainage Wetlands used for wastewater treatment Any other wetland sector Can guidance in the 2006 guidelines be updated? Are there more information for EFs, defaults or for EFDB? 	<p>Breakout group discussion:</p> <ul style="list-style-type: none"> Are there any errors for which corrigenda should be issued? Are there any inconsistencies in the existing guidance? If so, how should these be addressed? Can any clarifications be given to make the existing chapter easier to understand? Are there any new accounting approaches being proposed for which additional material should be provided? 	<p>Breakout group discussion:</p> <ul style="list-style-type: none"> Can new methods or default emission factors be provided? Are there any improvements to existing guidance that can be provided? Are there any emission factors that should be entered into the EFDB?
17:00			

Wednesday 20th October

Groups	Wetlands	HWP	Soil N₂O
09:00 - 13:00	Breakout group discussions continue		
Lunch 13:00-14:00			
14:00 –			
17:00			

Thursday 21st October

Groups	Wetlands	HWP	Soil N₂O
09:00 - 12:00	Breakout group discussions continue		
12:00 - 13:00	Plenary – each Breakout Group to present conclusions		
13:00 – 14:00	LUNCH		
14:00 – 17:00	Breakout group discussions continue (if needed)		

Annex 3. Co-Chairs Summary

IPCC Expert Meeting on HWP, Wetlands and Soil N₂O

WMO Geneva, 19-21 October 2010

Co-Chairs Summary

- In June 2010, SBSTA 32, as part of its work programme to revise their reporting guidelines for Greenhouse Gas Emissions and removals from Annex I parties to allow the use of the 2006 IPCC Guidelines, invited the IPCC to hold an Expert Meeting to “*explore the need and ways to clarify methodological issues related to reporting on harvested wood products, wetlands and nitrous oxide emissions from soils*” (FCCC/SBSTA/2010/L.12). In response, the IPCC Task Force on National Greenhouse Gas Inventories held this meeting in Geneva on the 19th-21st October.
- The meeting considered the three separate topics, harvested wood products, wetlands and nitrous oxide emissions from soil, and, in general considered that the methodological advice contained in the 2006 IPCC Guidelines still reflects the latest science. A few editorial issues were noted for HWP and Soil N₂O and corrigenda addressing these will be issued by the TFI.
- A meeting report will be produced that describes the discussions and conclusions in more detail and also highlights areas where additional scientific research could contribute to future improvements in estimates of greenhouse gas fluxes.

Wetlands

- The Wetland chapter (volume 4, chapter 7) of the 2006 IPCC Guidelines identifies gaps which could not be filled at the time the 2006 IPCC Guidelines were compiled. These include rewetting of peat lands and wetland restoration (conversion of land to wetlands, and wetlands remaining wetlands), and CO₂ and CH₄ emissions from reservoirs (flooded land remaining flooded lands, and lands converted to flooded lands). It should be remembered that drainage and conversion of wetlands to other land uses is included in other chapters of volume 4 (e.g. forest land, cropland and grassland): coherence between these chapters and the wetland chapter should be maintained.
- Since the 2006 IPCC Guidelines were completed much new scientific information is now available about various wetlands that enable emissions and removals to be estimated from wetland restoration and rewetting especially for peat lands. ***The meeting recommended that the IPCC provide additional methodological guidelines for the rewetting and restoration of peat land; emissions from fires, ditches and waterborne carbon; and constructed wetlands for waste water disposal, to fill gaps in the existing guidelines.***
- The meeting also noted that there are now a large number of new EFs measurements and other information available across climate zones for wetlands and drainage addressed in other land use chapters. ***The meeting recommended that an expert meeting be held to assess these data and develop emission factors from this information to enable more accurate country- and region-specific estimates to be made. The meeting also recommended that the TFI actively collect such data and add it to the EFDB.***
- For reservoirs (flooded lands), in the 2006 Guidelines there is only a method for the estimation of CO₂ from the conversion of land to flooded lands. Methods for CH₄ are in appendices “for the development of future methodological guidance” as is a different approach for CO₂ from land converted to flooded lands. The meeting discussed whether there was now sufficient new information available to produce

new and additional guidelines based on these appendices and the latest literature. The participants discussed a range of associated issues, such as the impact of reservoirs on total emissions from watersheds, allocation of emissions to specific drivers and how emissions may be related to specific reservoir typologies. **The meeting concluded that there should be an expert meeting to discuss all the new science and issues surrounding the development of new guidelines for reservoirs.**

Harvested Wood Products

- The meeting agreed that the methodological guidance in the 2006 IPCC Guidelines is correct, but noted that the entire chapter needs to be considered to ensure there are no inconsistencies with other parts of the guidelines. **The participants also noted that the guidance is complex and proposed the development of FAQ (frequently asked questions) that would guide users to the correct, full implementation of the guidelines.**
- The participants noted that to produce estimates for HWP according to the approaches currently being discussed in the UNFCCC AWG-KP negotiations (FCCC/KP/AWG/2010/CRP.3) may require some modification to the existing guidelines (particularly equation 12.3).

Soil N₂O

- The participants agreed that the methods in the 2006 IPCC Guidelines reflect the latest scientific literature, but the emission factors¹⁰ were based mainly on information from temperate regions.
- They agreed that there is no N₂O from the biological nitrogen fixation process itself (this was included in earlier guidelines but removed from the 2006 IPCC Guidelines).
- There has been a lot of work published on N₂O emissions from soils since the 2006 IPCC Guidelines were published and this should allow for the development of more regional or country specific emission factors. This would allow greater stratification by climate, soil, management and leaching. **The meeting proposed an expert meeting to assess recent literature and consider stratified EF1 values for the EFDB.**
- The meeting also noted that the atmospheric N₂O increase is not matched by bottom-up estimates of anthropogenic N₂O emissions but the reasons for this are unclear. Increased measurements of currently under represented systems (e.g. large river deltas) may help resolve this issue. **This meeting proposed a joint expert meeting with WG I to explore this gap.**

TFI Co-Chairs, Geneva,
21st October 2010

¹⁰ Most importantly for EF1 but this also applies to all emission factors for soil N₂O emissions

Annex 4. Bibliography

This bibliography contains references used or available to the participants and is not intended to be an exhaustive review of the available literature.

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Annex 5. Presentations

The presentation given during the meeting are all available on our website (<http://www.ipcc-nggip.iges.or.jp/presentation/presentation.html>). They are:

Wetlands:

Wetlands in the 2006 IPCC Guidelines, (Simon Eggleston, TSU)

GHG emissions from reservoirs – where is the truth ? (Alain Tremblay, IHA)

Emissions from peat soils (John Couwenberg, Wetlands International and University of Greifswald)

Science advances and estimation of wetland emissions (Dominique Blain, Canada)

Peatland GHG-fluxes (Matthias Drösler, Germany)

Peatlands, fires and emissions (Faizal Parish, Wetlands International)

Harvested Wood Products

Harvested Wood Products in the 2006 IPCC Guidelines (Nalin Srivastava, TSU)

2006 IPCC Guidance on estimating net-emissions from HWP (Sebastian Rüter, Germany)

The 2006 IPCC Guidance on Harvested Wood Products and some possible refinements (Gregg Marland, USA)

Soil N₂O

Soil N₂O emissions in the 2006 IPCC Guidelines (Jamsranjav Baasansuren, TSU)

Soil management and nitrous oxide (N₂O) emissions (Beáta Emőke Madari, Brazil)

Soil N₂O Emissions: Possible refinements to the 2006 IPCC Guidelines. (Philippe Rochette, Canada)

Estimating N₂O emission from Chinese croplands by statistical modeling (Xiaoyuan Yan, China)

N₂O emission factors: top-down vs bottom-up assessments (Keith Smith, UK)