IPCC Expert Meeting on HWP, Wetlands and Soil N_2O

19-21 October 2010, Geneva, Switzerland

Task Force on National Greenhouse Gas Inventories

INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

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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 N_2O 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, 2010 in Bonn, Germany, and then to the UNFCCC COP 16 held on 29th November to 10th December, 2010 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	Taka Hiraishi
Co-Chair Task Force Bureau	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 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 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 N_2O 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 N_2O 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 IPCC 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.

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 N_2O and consider stratified EF_1 values for the EFDB (Recommendation 7). 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 N_2O increase and bottom-up estimates of anthropogenic N_2O emissions (Recommendation 10). Participants noted that increased measurements of currently under represented systems (e.g. large river deltas) may help resolve this issue.

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 I Parties to the Convention[1]. The aim is to enable the use of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for reporting of GHG emissions and removals of the years 2013 onwards, which would be reported in 2015.

In 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 FAQs 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 IPCC 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*

The 2006 IPCC 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 CO_2 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 the 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_2O	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_2O	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. *CH_4 emission from peatlands is negligible after drainage during conversion and peat extraction.*
3. *N_2O emissions from Flooded Land are included in the estimates of indirect N_2O 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_2O	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_2O	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 CH_4 emission from peatlands is negligible after drainage during conversion and peat extraction.

3 N_2O emissions from Flooded Land are included in the estimates of indirect N_2O 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/FAQs 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 could 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 the status and recent developments in the knowledge related to wetlands, with the focus on wetland types that are peatlands or reservoirs. The presentations are available on the TFI website (http://www.ipcc-nggip.iges.or.jp/presentation/presentation.html).

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 typography of the reservoirs: large shallow sites showed significantly higher emissions than smaller and deeper reservoirs; older reservoirs emit less than younger 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 CO_2, CH_4 and N_2O 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 CO_2 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 CO_2 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 CO_2 and CH_4 mainly depend on the water level. At high water levels at or near the surface, CO_2 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 CH_4 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 N_2O 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), N_2O fluxes are near zero.

In conclusion, a broad differentiation can be made between drained and un-drained (rewetted) peat soils. CO_2 and N_2O emissions are high in the drained situation; CH_4 emissions are highest in the wet situation. Evidence suggests that aggregate fluxes of CO_2 and N_2O (addressed in CO_2eq) in the drained situation are in general larger than CH_4 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, CO_2 uptake) exceeds soil respiration (CO_2 emissions), which results in a net C sequestration. Methane emissions impacts the carbon balance, but are in terms of carbon relatively small (in CO_2eq 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 CO_2 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 CO_2 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 the development of guidance for estimation of emissions and removals associated with rewetting/restoration of peatlands.

Matthias Drösler (Germany) presented results from a 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 CO_2 emissions were significantly reduced compared to drained lands, but CH_4 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 CH_4 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 Guidelines 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 (Global Environment Centre) presented *Peatlands, fires and emissions*. 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. CO_2 and N_2O emissions from peat extraction (drainage of the lands for peat extraction and subsequent production of peat for energy, horticultural and other uses) and CO_2 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 CO_2 emissions from flooding as well as a method for CH_4 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 makes 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: CH_4 emissions from drained peatlands are not zero as ditches in drained peatlands, and also waterborne carbon in some cases, are sources of CH_4 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 CO_2, or CH_4 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 CO_2 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 (CO_2, CH_4 and N_2O);
- 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 CO_2 and CH_4 along the river course), CH_4 bubbling emissions, N_2O 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 CO_2 Emissions from Lands Converted to Permanently Flooded Land: Basis for Future Methodological Development and Appendix 3 CH_4 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 (CO_2, CH_4 and N_2O) 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

Riitta PIPATTI, Co-chair (Finland)
Zhakata WASHINGTON, Co-chair, (Zimbabwe)
Matthias DRÖSLER, Rapporteur, (Germany)

Dominique BLAIN (Canada)
John COUWENBERG (Wetlands International and University of Greifswald, Germany)
Simon EGGLESTON (TFI TSU)
Christopher EVANS (UK)
Maya FUKUDA (TFI TSU)
Frederic GUERIN (France)
Anke HEROLD (Germany)
Linda HEATH (USA, Global Environmental Facility)
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Faizal PARISH (Global Environment centre)
Jim PENMAN (UK, TFB member)
Luiz Pinguelli ROSA (Brazil)
Andrey SIRIN (Russian Federation)
Sirintornthep TOWPRAYOON (Thailand)
Alain TREMBLAY (Canada)
Kazuyuki YAGI (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); and 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 latest proposals currently 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 oxidisation 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 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 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: The 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 IPCC 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 (Tanzania)
Leonard BROWN, Co-chair (New Zealand)
Sebastian RUETER, Rapporteur (Germany)

Annette Louise COWIE (Australia)

Fabiano XIMENES (Australia)

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 N_2O

4.1 Presentations

Jamsranjav Baasansuren (IPCC TFI TSU) introduced the guidance given in the 2006 IPCC Guidelines on estimating N_2O emissions from soil. She elaborated on the changes relative to Revised 1996 IPCC Guidelines with regard to emission factors (EF) and parameters and highlighted the questions to be considered in the BOG including:

- If methods and default factors in the 2006 IPCC Guidelines 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 Emoke Madari (Brazil) presented on *Soil management and nitrous oxide (N_2O) emissions.* N_2O emissions from soil (Rhodic Ferralsol) under different management practices (zero tillage versus conventional tillage) and nitrogen sources (mineral N, bovine excreta) were measured using static chambers and a manual vacuum pump (-80 kPa). Results of N_2O (g N–N2O ha^{-1}) from the two different crop rotations under zero and conventional tillage showed that zero tillage did not promote higher N_2O emissions compared to conventional tillage. Linear correlations between averages of N_2O and NH_3 fluxes and C and N content in microbial biomass were found. In this study N_2O emissions from different mineral N sources (urea, ammonium nitrate, ammonium sulphate etc.) were different, and urine was a major source of direct and indirect N_2O 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 N_2O 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 N_2O from soil. It was highlighted that regional variation exists even within a country for EF_1 and noted that IPCC EF_1 might be biased towards the wet climate. Climate and soil properties are important factors that affect the soil N_2O 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 N_2O and suggested to revisit the literature. However, few studies addressed the organic N sources and indirect emissions of N_2O.

Xiaoyuan Yan (China) presented on *Estimating N_2O emission from Chinese croplands by statistical modeling*. The N_2O 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 N_2O. Annual mean temperature, water regime and type of organic amendment were considered for simulating N_2O emissions from rice paddy. Simulated N_2O 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 *N_2O emission factors: top-down vs bottom-up assessments*. For thousands of years the N_2O concentration in Earth's atmosphere was constant. In last 30 years, a linear increase of N_2O concentration in the atmosphere has been observed and the recent increase in concentration indicates excess of global emissions over the N_2O 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 N_2O 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 N_2O 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 NH_3 and soil properties.

Some direct and indirect sources of N_2O emission may be missing due to lack of scientific knowledge (e.g., N_2O 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 N_2O (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 N_2O” equals all N_2O emissions from all managed land, including Forest Land (page 11.5).

The BOG noted as a generic issue that the observed atmospheric N_2O increase is not matched by bottom-up estimates of anthropogenic N_2O 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 N_2O 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 N_2O 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 N_2O 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. to:

EQUATION 11.7A (REVISED)

ALTERNATIVE APPROACH TO ESTIMATE F_{CR} (USING TABLE 11.2)

$$F_{CR} = \sum_T \left\{ \begin{array}{l} \left(Area_{(T)} - Areaburnt_{(T)} \bullet CF\right) \bullet Frac_{Renew(T)} \bullet \\ \left[AG_{DM(T)} \bullet 1000 \bullet N_{AG(T)} \bullet \left(1 - Frac_{Remove(T)}\right) + \left(AG_{DM(T)} \bullet 1000 + Crop_{(T)}\right) \bullet R_{BG\ BIO(T)} \bullet N_{BG(T)} \right] \end{array} \right\}$$

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:
$AG_{DM(T)}$ (Mg/ha) = ($Crop_{(T)}$ /1000) * $slope_{(T)}$ + $intercept_{(T)}$

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 N_2O emission. Recommendation: insert link to footnote "[20]" after "(F_{SOM})."

4.3 Review of parameters used to estimate Soil N_2O Emissions

4.3.1 EF_1 for direct N_2O emissions from N input

EF_1[2] is based on 50% of presently available literature. While literature for EF_1 is biased to papers from Temperate Europe and North America, many new papers from all other regions and climate zones, in

[2] EF_1 is the emission factor for emissions of N_2O (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

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 EF_1 may be too high for croplands in many world regions.

Nitrogen input to soil is an important driver of N_2O emissions, but the observed correlation between N fertilizer input and annual N_2O 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 EF_1 that account for climate and soil type.

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 EF_1.

Successful examples showed that statistical and process-based models can help to estimate local EFs and to stratify agricultural systems by establishing typical relations between driving factors and N_2O 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 EF_1 and the possible use of models to derive regional EF_1 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 EF_2[3] for direct N_2O emissions from drained organic soils

There is new evidence available that allows a further stratification and update of the EF_2.

Recommendation 8

The EF_2 should be updated jointly with the emission factors for CO_2 and eventually CH_4 from drained organic soils (see recommendation 2).

4.3.3 Indirect N_2O methodology - Atmospheric deposition

There is additional guidance and data available to stratify $Frac_{GASF}$[4] and $Frac_{GASM}$[5] by N source and manure management type, maybe also by temperature or climate zone. Information on manure

[3] EF_2 is the emission factors for emissions of N_2O (as mass of N) per unit area of organic soils.

[4] $Frac_{GASF}$ = fraction of synthetic fertiliser N that volatilises as NH_3 and NO_x, kg N volatilised per kg of N applied

[5] $Frac_{GASM}$ = fraction of applied organic N fertiliser materials and of urine and dung N deposited by grazing animals that volatilises as NH_3 and NO_x, kg N volatilised per kg of N applied or deposited

management systems could be taken from the calculations in the livestock sector. The EF_4[6] is in line with the EF_1, which is scientifically plausible. There is too little new scientific evidence to review the EF_4. An area based approach based on direct measurement of N_2O emissions from managed and unmanaged soils could be a useful and transparent alternative to the present methodology for N_2O related to atmospheric N deposition.

4.3.4 Indirect N_2O 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 2009[9] and an eventual adaptation of the emission factors for NH_3 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 N_2O that have not been adequately researched and this may lead to the methods in the 2006 Guidelines being incomplete or underestimating N_2O 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 N_2O emissions needs to be further explored

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[6] EF_4 = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [kg N_2O volatilised expressed as N per kg N deposited as NH_3 or NO_x]

[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 N_2O emissions from N leaching and runoff, kg N_2O expressed as N per kg N leached and runoff

[9] http://www.eea.europa.eu/publications/emepeeaemissioninventoryguidebook2009/

because of possible strong effects on N_2O emissions and a significant potential for N_2O mitigation by changes in land management.

- Pastures and perennial legumes: There is emerging evidence that permanent pastures have higher N_2O emissions than unmanaged land. These additional N_2O 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 N_2O emissions than faeces. The ratio of nitrogen excreted as urine and faeces depends on grazing and mowing intensity, 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 of +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 (2008) 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 (2008) 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 comparision between the IPCC 2006 method and the top down method. Using IPCC 2006 method, they 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 N_2O. 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 N_2O budgets; identify possible reasons of this mismatch; identify potential additional sources and sinks of N_2O; 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 N_2O Group Particpants

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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 N_2O 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 if 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 IPCC 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 (CO_2, CH_4 and N_2O);
   - 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 N_2O

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 EF_1 but this is also true for all emission factors for soil N_2O emissions). In particular they agreed that there is no N_2O 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 EF_1 values for the EFDB (Recommendations 7). 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 N_2O increase and bottom-up estimates of anthropogenic N_2O 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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Annex 2. Meeting Agenda

Tuesday 19th October

9:00-10:00	Registration		
10:00 – 11:00	Meeting Opening – Co-Chairs		
	Welcome – IPCC Secretariat		
	Introduction – Meeting Background, Aims, Outputs – TSU		
Groups	Wetlands	HWP	Soil N_2O
11:00-13:00 LUNCH 13:00 – 14:00	*Presentations*: • 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)	*Presentations*: • 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)	*Presentations:* • Soil N_2O emissions in the 2006 IPCC Guidelines (Jamsranjav Baasansuren, TSU) • Soil management and nitrous oxide (N_2O) emissions (Beáta Emőke Madari, Brazil) • Soil N2O Emissions: Possible refinements to the 2006 IPCC Guidelines. (Philippe Rochette, Canada) • Estimating N_2O emission from Chinese croplands by statistical modeling (Xiaoyuan Yan, China) • N_2O emission factors: top-down vs bottom-up assessments (Keith Smith, UK)
14:00 – 17:00	Breakout group discussion - Can additional guidance be given on: 1. Wetland Restoration 2. Re-wetting Peat lands 3. Wetlands Drainage 4. Wetlands used for wastewater treatment 5. Any other wetland sector - Can guidance in the 2006 IPCC Guidelines be updated? - Are there more information for EFs, defaults or for EFDB?	Breakout group discussion: - 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?	Breakout group discussion: - 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?

Wednesday 20th October

Groups	Wetlands	HWP	Soil N_2O
09:00 -13:00 Lunch 13:00-14:00 14:00 – 17:00	Breakout group discussions continue		

Thursday 21st October

Groups	Wetlands	HWP	Soil N_2O
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 N_2O

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 N_2O 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 (volume4, 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 CO_2 and CH_4 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 CO_2 from the conversion of land to flooded lands. Methods for CH_4 are in appendices "for the development of future methodological guidance" as is a different approach for CO_2 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 N_2O

- The participants agreed that the methods in the 2006 IPCC Guidelines reflect the latest scientific literature, but the emission factors[10] were based mainly on information from temperate regions.

- They agreed that there is no N_2O 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 N_2O 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 N_2O increase is not matched by bottom-up estimates of anthropogenic N_2O 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 N_2O 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.

<u>Wetlands</u>

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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, Global Environment Centre)

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 N_2O

Soil N_2O emissions in the 2006 IPCC Guidelines (Jamsranjav Baasansuren, TSU)
Soil management and nitrous oxide (N_2O) emissions (Beáta Emőke Madari, Brazil)
Soil N_2O Emissions: Possible refinements to the 2006 IPCC Guidelines. (Philippe Rochette, Canada)
Estimating N_2O emission from Chinese croplands by statistical modeling (Xiaoyuan Yan, China)
N_2O emission factors: top-down vs bottom-up assessments (Keith Smith, UK)