CHAPTER 1

INTRODUCTION

Contents

Figures

Tables

Boxes

1 INTRODUCTION

This document describes the supplementary methods and *good practice* guidance for measuring, estimating and reporting of greenhouse gas emissions and removals resulting from land use, land-use change and forestry (LULUCF) activities covered by the Kyoto Protocol for the second commitment period. The document addresses activities under Article 3.3, and forest management and elected activities under Article 3.4. The supplementary methods and *good practice* guidance of this document apply to those Parties listed in Annex B of the Kyoto Protocol that have ratified the Protocol or to other purposes for which the document is agreed relevant. This document does not provide *good practice* guidance for LULUCF projects hosted by Parties listed in Annex B (Article 6 projects) and afforestation / reforestation projects hosted by Parties not listed in Annex B of the Kyoto Protocol (Article 12, Clean Development Mechanism or CDM projects), which are addressed in Section 4.3 of the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (*GPG-LULUCF).*

Under the Kyoto Protocol, Parties are to report emissions by sources and removals by sinks of CO_2 and other specified greenhouse gases resulting from LULUCF activities. These activities include under Article 3.3, afforestation (A), reforestation (R) and deforestation (D) that occurred since 1990; and under Article 3.4, forest management (FM) and any elected human-induced activities which can include: revegetation, cropland management, grazing land management and wetland drainage and rewetting.[1] To ensure compliance with emission-limitation and reduction commitments, in the commitment period Parties are required to report annually, along with their annual reports of greenhouse gas emissions by sources and removals by sinks, supplementary information related to LULUCF under the provisions of the Kyoto Protocol[2]. The annual reporting requirement does not imply a need for annual measurements, but Parties are expected to develop systems that combine measurements, models and other tools that enable them to report on an annual basis.

This supplementary methods and good practice guidance document builds on methods and guidance provided by the *2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines)* and it replaces Chapter 4 (except Section 4.3 on projects) of the *GPG-LULUCF*. The structure and wording of Chapter 4 have been maintained where appropriate for reasons of consistency.

[1] LULUCF related requirements are outlined in Decision 16/CMP.1 and Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/CP/2001/13/Add.1, p.58 and FCCC/KP/CMP/2011/10/Add.1, p.13 respectively:

"Afforestation" is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.

"Reforestation" is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest 31 December 1989.

"Deforestation" is the direct human-induced conversion of forested land to non-forested land.

"Forest management" is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner.

"Cropland management" is the system of practices on land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production.

"Grazing land management" is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced.

"Revegetation" is a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation contained here.

"Wetland drainage and rewetting" is a system of practices for draining and rewetting on land with organic soil that covers a minimum area of 1 hectare. The activity applies to all lands that have been drained since 1990 and to all lands that have been rewetted since 1990 and that are not accounted for under any other activity as defined above, where drainage is the direct human-induced lowing of the soil water table and rewetting is the direct human-induced partial or total reversal of drainage.

[2] See Articles 3.3, 3.4, 3.7, 6 and 12 of the Kyoto Protocol (http://unfccc.int/resource/docs/convkp/kpeng.pdf) and Decision 16/CMP.1 and Decision 2/CMP.7…. ADD ALL OTHER RELEVANT DECISIONS HERE

Relationship between UNFCCC and Kyoto Protocol reporting:

The information to be reported under the Kyoto Protocol is supplementary to the information reported under the United Nations Framework Convention on Climate Change (UNFCCC). Countries do not need to submit two separate inventories but should provide supplementary information under the Kyoto Protocol, within the inventory report.[3]

In practice, national circumstances, and specifically the technical details of the greenhouse gas reporting systems put into place by each country, will determine the sequence in which the reporting information is compiled. For example, it is possible to start with the UNFCCC inventory (with the additional spatial information required for Kyoto Protocol reporting) and expand it to the Kyoto Protocol inventory, or it is possible to use a system that generates the information for both UNFCCC and Kyoto Protocol reporting.

For example when a Party that has elected cropland management under Article 3.4 prepares its UNFCCC inventory for croplands, it is efficient for stratification to reflect the same geographical boundaries (Section 2.2.2). Then, in preparing the supplementary information to be reported under the Kyoto Protocol, the Party would delineate those UNFCCC cropland areas that originated from forests since 1990 (Chapter 5.3, Volume 4, of *2006 IPCC Guidelines*, Land converted to cropland), report these under deforestation according to Article 3.3, and report the remaining croplands under cropland management (Article 3.4).

This document covers supplementary estimation and inventory reporting requirements needed for accounting under the Kyoto Protocol. It does not address the implementation of accounting rules as agreed in relevant decisions[4] of the Conference of the Parties serving as the Meeting of the Parties (CMP) of the Kyoto Protocol (such as caps, annual *vs.* commitment period accounting and other specific provisions related to accounting). Accounting is a policy matter that is excluded from the UNFCCC request to the IPCC to prepare guidance documents. Estimation refers to the way in which inventory estimates are calculated, reporting refers to the presentation of estimates in the tables or other standard formats used to transmit inventory information, and accounting refers to the way the reported information is used to assess compliance with commitments under the Kyoto Protocol.

CMP decisions refer to land in two ways, and these terms are adopted here:

- ***Units of land*** refers to those areas subject to the activities defined under Article 3.3, namely afforestation, reforestation and deforestation, and
- ***Land*** refers to those areas subject to the activities defined under Article 3.4, namely forest management, cropland management, grazing land management, revegetation and wetland drainage and rewetting.

This document uses the terms "**mandatory**" and "**elective**". *Mandatory* refers to activities defined under Article 3.3, namely afforestation, reforestation and deforestation, as wells as forest management and those 3.4 activities that were elected by a country in the previous commitment period. *Elective* refers to those 3.4 activities that can be elected by a country for the commitment period, namely for the second commitment period cropland management, grazing land management, revegetation and wetland drainage and rewetting.

Several complex issues contained in chapter 4 of the *GPG-LULUCF* have been simplified in this document because decision 2/CMP.7 introduced mandatory reporting requirements for forest management and revised the definition of reforestation. This enables further harmonisation of methods used for UNFCCC and KP inventory reporting.

Parties should harmonize UNFCCC and Kyoto Protocol reporting in order to increase transparency, reduce costs and increase accuracy. It is *good practice* to apply the same forest definition for both UNFCCC and Kyoto Protocol reporting. Under the Kyoto Protocol Parties are requested to apply a forest definition that is consistent with that used to submit historical information to FAO and other international bodies, including the UNFCCC. The methods and emission factors used to prepare estimates of carbon stock changes and non-CO_2 emissions are determined by the UNFCCC land-use category.

[3] Article 7, paragraph 1 of the Kyoto Protocol: *Each Party included in Annex I shall incorporate in its annual inventory […] the necessary supplementary information for the purposes of ensuring compliance with Article 3* […].

Article 7, paragraph 2 of the Kyoto Protocol: *Each Party included in Annex I shall incorporate in its national communication, submitted under Article 12 of the Convention, the supplementary information necessary to demonstrate compliance with its commitments under this Protocol.*

[4] CMP decisions relevant for LULUCF accounting for the second commitment period: decision 2/CMP6, decision 2/CMP.7,…

Estimation and reporting of greenhouse gas emissions and removals from activities defined under Article 3.3 and Article 3.4 needs to be in accordance with relevant decisions relating to Articles 5, 7 and 8 of the Kyoto Protocol, and should be consistent with methods set out in volumes 1 and 4 of the *2006 IPCC Guidelines* and in the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*[5], any future elaboration of those guidelines, or parts of them, in accordance with relevant decisions of the Conference of the Parties and the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol. It is *good practice* that methods be applied at the same or higher tier as used for UNFCCC reporting.

1.1 OVERVIEW OF STEPS TO ESTIMATING AND REPORTING SUPPLEMENTARY INFORMATION FOR ACTIVITIES UNDER ARTICLES 3.3, 3.4 AND 6

This section gives an overview of the steps required to measure, estimate and report changes in carbon stocks and emissions and removals of non-CO_2 greenhouse gases for LULUCF activities covered by Articles 3.3, 3.4 and 6 of the Kyoto Protocol. Detailed methods and *good practice* guidance for each individual activity are provided in subsequent Sections of this document.

STEP 1: Define "forest", apply definitions to national circumstances, and establish a hierarchy among elected Article 3.4 activities.

STEP 1.1: Decide the numerical values of parameters to define "forest" for Afforestation and Reforestation (AR) and Deforestation (D) activities under Article 3.3 and for Forest Management (FM) activities under Article 3.4.[6]

Parties that have already selected the parameters of the forest definition in the previous commitment period should consistently apply this definition during subsequent commitment periods. All other Parties need to select the parameters that define forest, i.e., the minimum area (0.05 – 1 ha), the minimum crown closure at maturity (10 – 30%), and the minimum tree height at maturity (2 – 5 m). Areas that meet these minimum criteria are considered forest, as are recently disturbed forests or young forests that are expected to reach these parameter thresholds. The numerical values of those parameters cannot be changed during or between commitment periods. Each Party has to justify in its reporting that such values are consistent with the information that has historically been reported to the Food and Agriculture Organization of the United Nations or other international bodies, and if they differ, explain why and how differing values were chosen.

In addition to the minimum area of forest, it is *good practice* that countries specify the minimum width that they will apply to define forest and units of land subject to ARD activities and lands subject to FM, as explained in Section 2.2.6.1

STEP 1.2: Define natural forest and forest plantation

It is *good practice* that Parties, according to their national circumstances (a) provide their definition of natural forest and planted forest, which should include forest plantations, (b) define when a transition from natural forest to planted forest occurs; and (c) apply these definitions consistently throughout commitment periods.

STEP 1.3: Apply definitions to national circumstances for elected Article 3.4 activities.

Parties that have elected any eligible activity under Article 3.4 in a previous commitment period should report the activity during subsequent commitment periods, consistently applying the activity definition to their national

[5] The IPCC is currently preparing the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (the *2013 IPCC Wetlands Supplement*) in parallel to this document. The *2013 IPCC Wetlands Supplement* provides guidance on estimating emissions and removals on lands with drained and rewetted organic soils in Chapters 2, 3 and 4 and general issues on wetlands are addressed in Chapters 1 and 7. The guidance given here will be updated to reflect the development of the *2013 IPCC Wetlands Supplement* through its review by experts and governments and its approval by the IPCC. The Government and Expert Review of the *2013 IPCC Wetlands Supplement* will be held between 11th February and 7th April, 2013 (see http://www.ipcc-nggip.iges.or.jp/home/wetlands.html).

[6] "Forest" is a minimum area of land of 0.05 – 1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10 – 30 per cent with trees with the potential to reach a minimum height of 2 – 5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10 – 30 per cent or tree height of 2 – 5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest. See paragraph 1(a) of the Annex to decision -16/CMP.1 (Land use, land-use change and forestry).

circumstances as done in a previous commitment period. Parties decide and report which, if any, activities under Article 3.4 they elect. It is *good practice* that Parties document, for each elected activity and for forest management, how the definitions will be applied to national circumstances. Criteria on how to apply definitions should be chosen in such a way as to minimize or avoid overlap and should be consistent with the guidance provided in the decision tree in Figure 1.1 in Section 1.2.

STEP 1.4: Establish a hierarchy among ARD activities, FM activities and elected Article 3.4 activities (Cropland Management (CM), Grazing land Management (GM), Revegetation RV, and Wetland Drainage and Rewetting (WDR)).

It is *good practice* that:

- ARD and FM activities take precedence in the reporting hierarchy over any elected Article 3.4 activity, because they are mandatory activities;
- To increase reporting consistency and transparency, each unit of land subject to an AR or D activity (Article 3.3) be reported under the current Article 3.3 activity, such that the reported activity reflects the current land use, For example, units of land that have been deforested and are currently reforested will be reported under AR;
- Each unit of land converted from forest to non-forest is reported under deforestation (Article 3.3) unless a Party chooses to keep reporting under FM the emissions and removals associated with the harvest and conversion of forest plantations to non-forest land. Parties have this option only if the harvested forest plantation was established or re-established after 1 January 1960 and before 1 January 1990 and if a new forest of at least equivalent area as the harvested forest plantation is established through direct human-induced planting and/or seeding of non-forested land that did not contain forest on 31 December 1989[7]. If such harvest and conversion to non-forest land is reported under FM, then it is also required to identify, monitor and report, including the georeferenced location and year of conversion the harvested land and the newly established plantation as subdivisions of land subject to forest management (see section 2.2.6 and paragraphs 37 to 39 of the Annex to decision 2/CMP.7);
- Each unit of land afforested or reforested, is reported under AR (Article 3.3) unless the unit of land is used to compensate the harvest of forest plantations and conversion to non-forest land, in which case it is reported under FM as explained in the previous paragraph;
- Forest land that is subject to forest management (Article 3.4) is reported under FM.

Where elected activities under Article 3.4 overlap, it is *good practice* that the country specifies a hierarchy among activities prior to the commitment period, rather than deciding on a case-by-case basis. It is *good practice* to apply the specified hierarchy consistently to determine under which activity the land is to be reported. For example, if land could fall into both cropland management and revegetation (such as for new orchards), then the country should report over time that land under one and only one activity according to the established hierarchy.

Agricultural land use at times rotates between cropland and grassland (where grasses are associated with grazing). Where a Party has elected both CM and GM activities, to reduce reporting complexity and to avoid artefacts or inaccuracies in CM and GM reporting associated with rotation of land between cropland and grassland use, a Party may report all land subject to CM and GM under a single activity[8], either CM or GM. Where a Party has elected only one of either CM and GM (Article 3.4), it is *good practice* to keep reporting the land subject to rotation under the elected activity.

Wetland drainage and rewetting, being limited to lands that are not accounted for under any other activity, has the lowest position in the hierarchy among elected activities under Article 3.4.[9]

It is also *good practice* to apply the same hierarchy among elected activities under Article 3.4 across commitment periods.

STEP 2: Identify lands subject to mandatory activities and any newly elected activities under Article 3.4.

[7] The area replanted should be at least equivalent to the area of harvested plantation and should be expected to reach at least the equivalent carbon stock that was contained in the harvested forest plantation at the time of harvest, within the normal harvesting cycle of the harvested forest plantation (see paragraph 37 of the Annex to decision 2/CMP.7)

[8] Reporting requirements and accounting rules for CM and GM are identical

[9] cf. definition of WDR of decision 2/CMP.7, para (1b)

The second step of the inventory assessment is to determine the areas on which the activities have taken place since 1990 (and for which emissions and removals must be estimated). This step builds on the approaches described in Chapter 3, Volume 3 of the *2006 IPCC Guidelines*.

STEP 2.1: Stratify the country into areas of land for which the geographic boundaries will be reported, as well as the area of the units of land subject to Article 3.3 and/or the areas of lands subject to Article 3.4 within these geographic boundaries (see Section 2.2.6). This step can be omitted if Reporting Method 2 (see Section 2.2.2) is used.

STEP 2.2: Compile land-use and land-cover information in 1990 for the mandatory and elected activities.

Using the selected definitions of forest determine forest and non-forest areas in 1990 and update the dataset in subsequent time periods. This can be accomplished with a map that identifies all areas considered forest or with statistical data derived from a national land survey as time-series of a national forest inventory. All forest-related land-use change activities since 1990 can then be determined with reference to either those maps or statistical sets of data (see Section 2.2.2 Reporting methods for lands subject to Article 3.3 and Article 3.4 activities).

STEP 2.3: Identify units of land that, since 1990, are subject to mandatory activities (ARD and FM), and estimate the total area of these units of land and lands within each geographic boundary. Under Reporting Method 2 (Section 2.2.2) the estimation of the area of the units of land and lands will be carried out individually for each unit of land and land.

It is *good practice* to identify the land area subject to FM in each inventory year of the commitment period. A country could interpret the definition of forest management in terms of specified forest management practices, such as fire suppression, harvesting or thinning, undertaken since 1990 (narrow interpretation). Alternatively, a country could interpret the definition of forest management in terms of a broad classification of land subject to a system of forest management practices, without the requirement that a specified forest management practice has occurred on each land (broad interpretation). (For details see Sections 2.2.2 and 2.7).[10]

Parties are required[11] to estimate the area of the units of lands that have been subject to ARD and the area of lands subject to FM within the boundaries mentioned in STEP 2.1 above (for details see Sections 2.2.2, 2.5 and 2.6). Furthermore, each Party is required to estimate and report areas of unit of lands and of lands that fall into categories defined by decision 2/CMP.7: It is therefore *good practice* to identify, for each year in the commitment period:

- units of land and lands affected by disturbances in the commitment period whose associated emissions and subsequent removals have been excluded from accounting;[12]
- lands of forest plantation which have been converted to non-forest land and for which, at least an equivalent area of land has been converted to forest (and other conditions are met); and
- those lands that have been converted to forest to compensate for harvesting of forest plantation.

STEP 2.4: Identify and estimate the area of lands subject to elected activities under Article 3.4 within each geographic boundary. Under Reporting Method 2 (Section 2.2.2) the estimation of areas of land is carried out individually for each land subject to elected Article 3.4 activities.

For cropland management (CM), grazing land management (GM), or revegetation (RV), as is discussed in more depth in Sections 2.9 –2.11, the area under the same activity in 1990 (or the applicable base year) will also have

[10] Possible issues related to unbalanced accounting resulting from selective inclusion of forest management and revegetation are addressed in the IPCC Report on *Definitions and Methodological Options to Inventory and Report Emissions from Direct Human-Induced Degradation of Forests and Devegetation of Other Vegetation Types (IPCC, 2003).*

[11] By decisions of the Conference of the Parties serving as Meeting of the Parties (CMP) of the Kyoto Protocol

[12] Need to think about LUC that occurs in the subsequent CP in cases where emissions were excluded in the preceding CP. *The issue here is that if the disturbance occurs near the end of the CP (and emissions are not accounted) and LUC occurs early in the next CP, then should the disturbance emissions be included in the emissions from LUC? This is the case if the disturbance and deforestation occur in the SAME CP. This can be addressed at the time the deforestation is detected – by asking if the D occurred on land previously affected by a disturbance, and if yes, then did the emissions from the disturbance get excluded from the accounting? This could be represented in a decision tree?*

to be determined, because greenhouse gas emissions and removals on this area in 1990 have to be known to implement accounting rules (see Section 2.9.1).

For wetland drainage and rewetting (WDR), each Party must identify the land area subject to either wetland drainage or rewetting in each inventory year of the commitment period. A country could interpret the definition of wetland drainage and rewetting in terms of specified practices undertaken since 1990 (narrow interpretation). Alternatively, a country could interpret the definition of wetland drainage and rewetting in terms of a broad classification of land subject to a system of drainage and rewetting practices, in 1990 and in the commitment period years, without the requirement that a specified practice is started in 1990 (broad interpretation). (For details see Sections 2.12.1 and 2.12.3).

STEP 2.5: Identify the areas subject to projects under Article 6.

Some units of land subject to Article 3.3 or lands subject to Article 3.4 can also be projects under Article 6 of the Kyoto Protocol. These have to be reported under Article 3.3 or Article 3.4. In addition, these units of land or lands need to be delineated and the greenhouse gas emissions and removals reported separately as part of project reporting (see Section 4.3 of the *GPG-LULUCF*). The relationship between estimation and reporting of activities under Articles 3.3 and 3.4, and projects under Article 6, is discussed in Section 1.3.

STEP 3: Estimate greenhouse gas emissions and removals on units of land and lands identified under Step 2 above.

STEP 3.1: Estimate greenhouse gas emissions and removals for each year of the commitment period, on all areas subject to the mandatory and elected reporting requirements (as identified in steps 2.3 and 2.4) while ensuring that there are no gaps and no double counting.

The estimation of greenhouse gas emissions and removals for an activity begins with the onset of the activity or the beginning of the commitment period, whichever comes later. For further details regarding the beginning of an activity see Section 2.3.2 (Years for which to estimate stock changes and non-CO_2 greenhouse gas emissions).

Table 1.1 provides an overview of the LULUCF activities in the Kyoto Protocol, and the accounting rules. Accounting in the LULUCF sector is done by comparing greenhouse gas emissions and removals during the commitment period with a benchmark under either a base year or a business-as-usual scenario, which could be a scenario in which emissions and removals are assumed to balance to zero.

TABLE 1.1
SUMMARY OF THE LULUCF ACTIVITIES UNDER THE KYOTO PROTOCOL AND THE ASSOCIATED ACCOUNTING RULES

Activities	Benchmark	Cap on Credits[13]
Afforestation, Reforestation (Article 3.3)	Zero	No
Deforestation (Article 3.3)	Zero	No
Forest Management (Article 3.4)	either Business-As-Usual scenario (including zero) or Base Year	Yes
All other activities under Article 3.4	Base Year	No

[13] See paragraph 13 of the Annex to decision 2/CMP.7 (Land use, land-use change and forestry).

1.2 GENERAL RULES FOR CATEGORISATION OF LAND AREAS UNDER ARTICLES3.3 AND 3.4

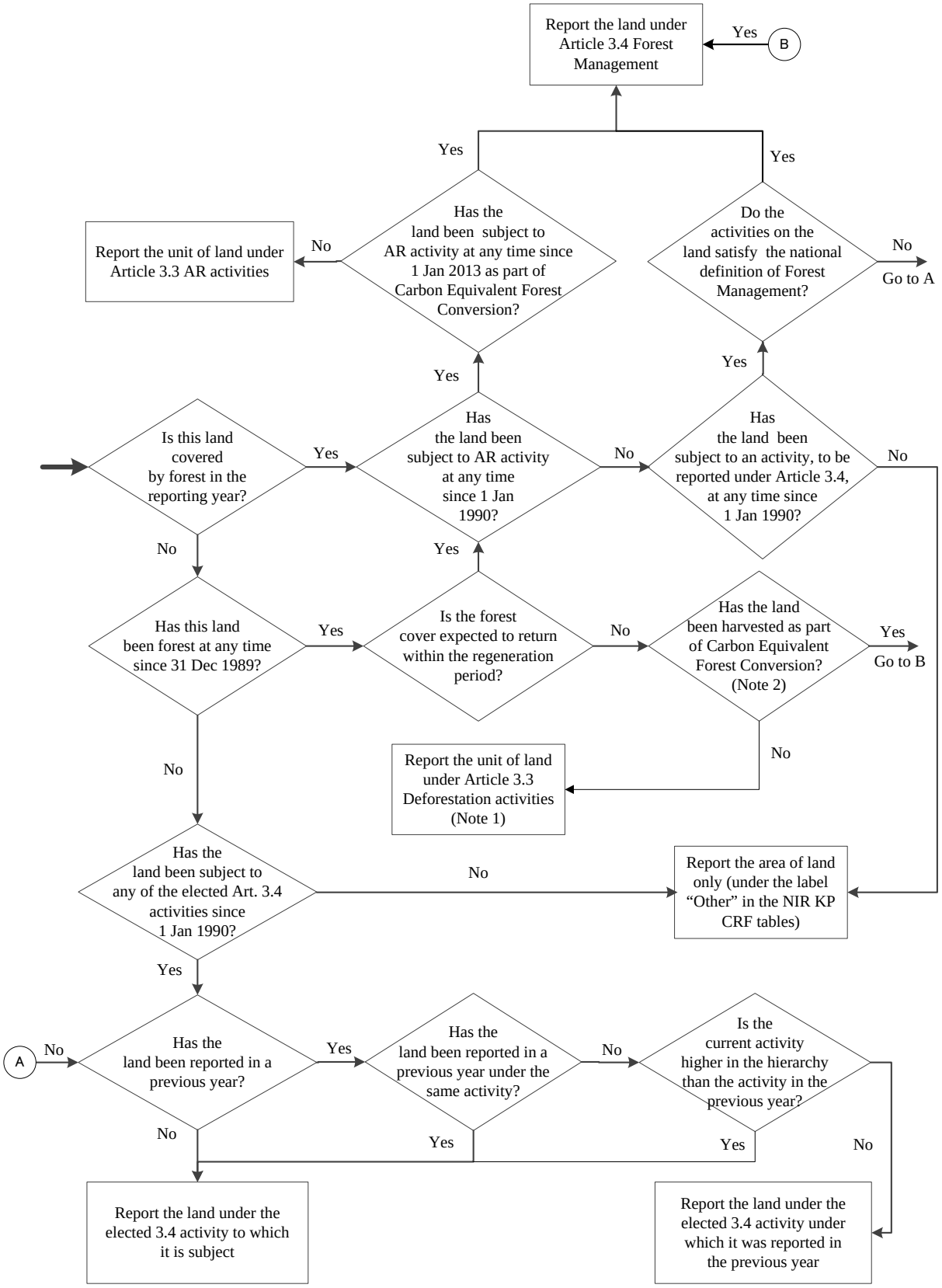
Chapter 3 (Consistent representation of lands) of the *2006 IPCC Guidelines* describes approaches to classifying and representing land areas associated with LULUCF activities. This is the basis for *good practice* guidance concerning identification of all relevant lands, for Kyoto reporting and for avoiding double counting of lands. It is *good practice* to follow the decision tree in Figure 1.1 for each year of the commitment period in order to

- Distinguish between afforestation and reforestation, deforestation, forest management, cropland management, grazing land management, revegetation, and wetland drainage and rewetting activities under Articles 3.3 and 3.4, as well as to remove potential overlaps and gaps between them; and to
- Assign lands to a single activity at any given point in time (i.e., for each year of the second commitment period from 2013 onwards). This is required because of the possible land-use changes which can lead to double counting of units of lands / lands subject to mandatory and elective activities. Additional guidance on how to deal with shifts in land use over time is given in the examples of Box 1.1 at the end of this section.

The decision tree in Figure 1.1 is based on the definitions given in COP/MOP decision 16/CMP.1 and in the annex to 2/CMP.7. It identifies the reporting category for land subject to an activity for a given year X of the second commitment period. The decision tree recognises that a specific piece of land could be reported under different activities over time, subject to certain conditions explained below. The decision tree is to be applied annually during the second commitment period in order to update the allocation of lands to activities, thus taking into account changes in land use that may have occurred. This may be achieved by annual tracking of land or by interpolation between periods. More detailed decision trees to determine whether or not land or a unit of land is subject to specific activities are presented in Sections 2.5 through 2.12.

Where countries that have elected one or more Article 3.4 activity it is necessary to know whether land was previously subject to an Article 3.4 activity, and to determine which elected Article 3.4 activity was most recently applied on the land. If land is subject to more than one Article 3.4 activity over time, it is *good practice* to classify that land under only one Article 3.4 category. Therefore, it is *good practice* for countries to set up a hierarchy among the activities cropland management, grazing land management, and revegetation within the scope of the definitions in the Decision of the Conference of the Parties serving as Meeting of the Parties (CMP) of the Kyoto Protocol – to set up criteria by which lands will be assigned to a single category (see Section 1.1, Overview, STEP 1.4). Wetlands drainage and rewetting can only be reported for land that is not already included in one of the other elected Article 3.4 activities. It is *good practice* to assign land according to specific, pre-determined and consistent rules, rather than on a case-by-case basis.

Figure 1.1 Decision tree for classifying a unit of land under Article 3.3 (ARD) or land under FM, or land under other Article 3.4 (CM, GM, RV and WDR) as of the reporting year of the commitment period. The bold arrow indicates the starting point. Secondary classifications are not shown in the Figure.



Note 1: No matter whether it had been subject to an AR activity before.

Note 2: Additional requirements are defined in paragraph 37 of decision 2/CMP.7.

Abbreviations used in the Figure:

AR	Afforestation / Reforestation	D	Deforestation	FM	Forest Management
CM	Cropland Management	GM	Grazing Land Management	RV	Revegetation
WDR	Wetland drainage and rewetting				

The definitions in Decision 2/CMP.7 specify that

- Forest management can only take place on lands that meet the definition of a forest, with the exception of those non-forest areas originating from the conversion of plantations established after Jan 1, 1960 and before Jan 1 1990 that are compensated by at least an equivalent area of replanted lands, in which case both the non-forest land and the compensating area are included under FM (See Section 2.7.7 for details);
- Grazing land and cropland management can take place both on same lands. Any land should be reported either under grazing land or cropland avoiding any double counting; and
- Wetland drainage and rewetting (WDR) can take place on wetlands and/or organic soils in all land-use categories but can only be reported for land not already subject to mandatory or elected reporting.

In some cases, cropland or grazing land activities occur on lands that also meet the definition of forest. Countries have two options to avoid gaps or overlaps in reporting: 1) It is *good practice* to interpret the definition of forest management such that it covers all managed forests, including those where cropland and grazing land management takes place. As a consequence, all lands subject to grazing or cropland management would necessarily have to be non-forest. 2) Alternatively, it is also *good practice* to use pre-defined criteria other than "forest / non-forest" to determine whether a land area is subject to forest management or grazing land management / cropland management. In that case it is possible that some forest lands are included under cropland or grazing land management. Examples of this second option could include orchards or short-rotation tree crops for the cultivation of Christmas trees or bioenergy. Special attention should be given to avoid overlap or gaps between lands subject to revegetation (if elected) that could qualify under cropland management, grazing land management (if elected).

In addition note that:

- Article 3.3 applies to land that is subject to an afforestation, reforestation or deforestation activity at any time between 1 January 1990 and December 31st of the last year of the commitment period.
- Article 3.4 applies to land that is subject to forest management, or an elected cropland management, grazing land management and wetland draining and rewetting activity during the commitment period[14,15]. Article 3.4 also applies to land subject to revegetation resulting from direct human-induced activities since 1 January 1990.[16] and to forest management and wetland drainage and rewetting when a narrow interpretation of those activities is applied.
- Once a land is reported under Article 3.3 or Article 3.4, all anthropogenic greenhouse gas emissions by sources and removals by sinks on this land must be reported during the first and throughout subsequent and contiguous commitment periods[17], except where the Party chooses not to report a pool that has been shown not to be a source as explained in Section 2.3.1. That is, the total land area included in the reporting of Article 3.3 and 3.4 activities can never decrease.

[14] Conversely, for base year reporting, Article 3.4 applies to land that was subject to an elected cropland management, grazing land management or revegetation activity in the base year.

[15] The reason is that if a land was subject to an Article 3.4 activity between 1 January 1990 and 31 December 2007, but is no longer in the years 2008-2012, it could not be accounted for under the Kyoto Protocol. Carbon reporting of this land during the commitment period would be highly complicated because the land would be under a different land use. Land that left the FM category as a result of deforestation would, of course, be reported under Article 3.3.

[16] As stated in STEP 1.2 above, it is *good practice* to apply the definitions of Article 3.4 activities to national circumstances. In doing so, there may be Article 3.4 activities where an individual practice triggers the land to be reported ("narrowly defined activities"). This is likely to apply to revegetation, also possibly to forest management, and requires to report all lands that are subject to the activity since 1990 (as for AR and D). On the other hand, there will be Article 3.4 activities where the mere classification of the land, without a concrete practice, will suffice for the land to be reported ("broadly defined activities"). This is most likely for cropland and grazing land management – also because there the practices are most likely to occur on an annual basis anyway. Here it is sufficient to report the lands subject to the activity in the reporting year of the commitment period.

[17] Paragraph 19 of the Annex to draft decision -/CMP.1 (Land use, land-use change and forestry), contained in document FCCC/CP/2001/13/Add.1, p.61.

- If certain activities occur during the commitment period, it is under certain circumstances possible that a unit of land or land can be reported under different activities in Article 3.3 and/or Article 3.4 over time during the commitment period. However, for each year it can only be reported under a single activity.

- In order to avoid the reporting of lands or units of land in more than one activity in any year during the commitment period, the following should be applied:

  (i) Units of land subject to activities under Article 3.3 which would otherwise be included in land subject to an Article 3.4 activity (see item (ii) in footnote 12) must be reported separately as lands that are both subject to Article 3.3 and 3.4 activities (secondary classifications are not shown in the decision tree).

  (ii) For lands that are subject to several activities under Article 3.4, it is *good practice* to apply the national criteria that establish the hierarchy among Article 3.4 activities.

- A unit of land subject to land-use changes (LUCs) can move between categories in the following cases:

  – Afforestation/reforestation land that is subsequently deforested is reclassified as deforestation land (Section 2.6 describes specific provisions for units of land subject to afforestation and reforestation activities since 1990).

  – Land under one elected Article 3.4 activity is converted into land under another elected Article 3.4 activity and must be reclassified accordingly.

  – Land under an elected Article 3.4 activity becomes subject to an Article 3.3 activity and must subsequently be reported under the latter. For the second commitment period, land subject to forest management (and established as forest plantation after 1 Jan 1960 and before 1 Jan 1990) that is cleared of forest can be continued to be reported as FM, if certain conditions are met.

- On the other hand, the following transitions are not possible. Note that these restrictions apply to reporting under the Kyoto Protocol (but do of course not affect the actual management that a country applies to its lands):

  – Land cannot transition from FM (Article 3.4) to another elected Article 3.4 activity.

  – Land cannot transition from an elected Article 3.4 activity to another Article 3.4 activity that was not elected.

  – Land cannot leave Article 3.3 reporting[18].

- After the first commitment period land classified as deforested can transition to AR land. This transition among 3.3 categories only affects the 3.3 category in which carbon stock increases are reported but not the reported amount because, in the first commitment period, carbon stock increases were already reported under D for deforested units of land that have been replanted subsequently. Reporting such C stock increases under AR enhances consistency and transparency because it reflects the current land use.[19].

In summary, this means that the area under Article 3.3 (afforestation, reforestation and deforestation lands) will grow from 0 hectares on 1 January 1990 up to a certain value at the end of each commitment period. It is *good practice* that the afforestation, reforestation and deforestation categories contain all areas of land that have been afforested, reforested or deforested at any time since 1 January 1990.

The area of lands under Article 3.4 categories (FM, CM, GM, RV and WDR) can fluctuate because of various land-use changes such as:

- Deforestation can remove land from FM and can add it to an elected Article 3.4 category;
- Afforestation and reforestation can remove land from CM and GM categories;
- Grazing lands can become croplands and vice versa;
- Revegetated lands can become croplands or grazing lands or vice versa; and

[18] It is theoretically possible to that a unit of land that was deforested after Jan 1 1990 could be replanted under the equivalent forest provision. *This would create a conflict between the requirement to always report under 3.3 (Deforestation) and the requirement to report the replanted equivalent forest area under FM. To be discussed.*

[19] Paragraph 1(c) of the Annex to draft decision -/CMP.1 (Land use, land-use change and forestry), contained in document FCCC/CP/2001/13/Add.1, p 58 stated that "For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989". For the second commitment period this constraint does not apply.

- Forest management land areas can increase, for example, as countries expand the road infrastructure to access areas previously in the unmanaged forest category.

[consider moving all examples to an annex]

Box 1.1 provides several examples that summarise the considerations that apply for lands subject to activities under Articles 3.3 and 3.4 of the Kyoto Protocol. For more detailed explanations of the rationale behind the examples in Box 1.1, the reader is referred to the detailed explanations in the remaining sections of this *Supplementary Guidance*.

BOX 1.1
EXAMPLES FOR THE ASSIGNMENT OF UNITS OF LAND TO ARTICLE 3.3 ACTIVITIES AND LANDS TO ARTICLE 3.4 ACTIVITIES OVER TIME

The following examples are intended to show, conceptually and in accordance with the decision tree in Figure 1.1, how different land-use transitions would be categorised in different inventory years of the the Kyoto Protocol. This does not necessarily imply that the land-use transition can be directly measured on an annual basis. Note that for croplands and grazing lands only carbon stock changes are discussed in the examples below. Non-CO_2 greenhouse gas emissions for such lands are reported under the AFOLU Sector of the *2006 IPCC Guidelines* (Chapter 11 Volume 4), independently of which Article 3.4 activities were elected by the Party.

Example 1: A land under forest management is deforested in 1995 and turned into a cropland.

Carbon stock changes and non-CO_2 greenhouse gas emissions on this land are reported under deforestation from 2008 onwards during all commitment periods.

Carbon stock changes on this land will not be reported under cropland management, even if cropland management was elected, because deforestation takes precedence over cropland management. The decision tree in Figure 1.1 therefore assigns this land to deforestation, with cropland management as a secondary classification.

Should trees be re-established on this unit of land after the end of the first commitment period, for example in 2014, the unit of land transitions from one 3.3 category to another (from D to R) to increase transparency and consistency with the observed land cover. Estimates of changes in carbon stock, are based on the methodology for reforestation.

Example 2: A land under forest management is deforested on 1 January 2015 and turned into a cropland.

Carbon stock changes and non-CO_2 greenhouse gas emissions on this land during the second commitment period are reported under deforestation starting in 2015. The methodology for croplands that were previously forest should be used to estimate carbon stock changes. Non-CO_2 greenhouse gas emissions directly resulting from the deforestation should be reported under the Deforestation category. Non-CO_2 greenhouse gas emissions resulting from the agricultural practices should be reported in the AFOLU sector of the national inventory as per the *2006 IPCC Guidelines*. Double counting should be avoided.

Carbon stock changes and non-CO_2 emisisons on this land will not be reported under cropland management, even if cropland management has been elected, because deforestation takes precedence over cropland management. The decision tree in Figure 1.1 therefore assigns this land to deforestation with cropland as a secondary classification.

BOX 1.1 EXAMPLES (CONTINUED)

The following examples illustrate Article 3.3 or 3.4 land use activities are to be reported during the second commitment period (CP2). For each example a correct land use classification is provided in table of this format:

Activity	D	AR	FM	CM	GM	RV	WDR
Status in CP1	M	M	E/NE	E/NE	E/NE	E/NE	N/A
Status in CP2	M	M	M	E/[E/NE]	E/E[NE]	E/[E/NE]	E/NE

Note:

D-Deforestation; AR- Afforestation and Reforestation; FM- Forest Management; CM- Cropland Management; GM:- Grazing Land Management; RV- Revegetation; WDR- Wetland Drainage and Rewetting.

CP1- First Commitment period 2008-2012 inclusive

CP2- Second Commitment period 2013- 2020 inclusive.

M- Mandatory KP reporting; E- Elected by the Party; NE- Not elected by Party. If an activity was elected in CP1 it is automatically also elected in CP2.

Note it may be possible more than one solution is acceptable after the conversion or management change.

Example **X**: A cropland was turned into a grazing land in 2010, FM, CM and GM were elected in CP1.

Activity	D	AR	FM	CM	GM	RV	WDR
Status in CP1	M	M	E	E	E	NE	N/A
Status in CP2	M	M	M	M	M	NE	NE
Answer				X for only 2008 and 2009 of CP1	X for all years 2010 onwards including CP2		
Comments	It is mandatory to continue to report the GM activity elected for CP1 into CP2						

Example X: A cropland was turned into a grazing land in 2015, CM, GM **and** RV were elected in CP2.

Activity	D	AR	FM	CM	GM	RV	WDR
Status in CP1	M	M	NE	NE	NE	NE	N/A
Status in CP2	M	M	M	E	E	E	NE
Answer				X Report for only 2013 and 2014	X Report for all years 2010 onwards	X Report for all years 2010 onwards	
Comments	Two reporting scenarios are possible. The converted land can be reported as Grazing land or Revegetation. However, it may be preferable to report as grazing land as this may be easier to ensure continuity of land identification into the future. The Party is required to provide the definitions of activities which will be classified under each KP Activity when communicating the decision to elect the KP Activity for CP2.						

Example X: A cropland was turned into a grazing land in 2015, FM, CM were elected in CP1and GM is elected in CP2.

Activity	D	AR	FM	CM	GM	RV	WDR
Status in CP1	M	M	E	E	NE	NE	N/A
Status in CP2	M	M	M	M	E	NE	NE
Answer				X for 2008 to 2014	X for period 2015 onwards		
Comments	Continue to report under CM until conversion to GM in CP2.						

Example **X:** A cropland was turned into a grazing land in 2015, FM, GM were elected in CP2 and CM is not elected in CP2.

Activity	D	AR	FM	CM	GM	RV	WDR
Status in CP1	M	M	E	NE	NE	NE	N/A
Status in CP2	M	M	M	NE	E	NE	NE
Answer					X for period 2015 onwards		
Comments	Only report for the period after conversion to GM.						

1.3 RELATIONSHIP BETWEEN ANNEX I PARTIES' NATIONAL INVENTORIES AND ARTICLE 6 LULUCF PROJECTS

Emissions or removals resulting from projects under Article 6 will be part of the host country's annual inventory under the UNFCCC and Kyoto Protocol reporting. The methods for estimating, measuring, monitoring and reporting greenhouse gas emissions and removals resulting from LULUCF project activities are addressed in Section 4.3 of the *GPG-LULUCF* (LULUCF Projects).

When estimating the greenhouse gas emissions and removals of Article 3.3 and 3.4 activities, it is possible to use the information that is reported for, or is meeting the standards of, Article 6 LULUCF projects on these lands (but not *vice versa*). Two options exist for Article 3.3 and Article 3.4 estimation, both of which are considered *good practice*:

Option 1: Carry out Article 3.3 and Article 3.4 assessment without consideration of information reported for Article 6 projects (which are reported separately as outlined in Section 4.3 of the *GPG-LULUCF*). This assumes that a properly designed national system will also automatically include the effects of Article 6 projects. This approach is consistent with the approaches taken in the other emission sectors. For example, an Article 6 project that reduces emissions from fossil fuels is not *individually* considered in the national emissions inventory, but will *implicitly* be included due to the project's impacts in the national statistics for fossil fuels.

Option 2: Consider all changes of carbon stocks as well as greenhouse gas emissions and removals at the project level as a primary data source for Article 3.3 and/or Article 3.4 estimation and reporting, for example by considering projects as a separate stratum. Any Article 3.3 and 3.4 activities that are not projects need to be monitored separately. In this case, the design of the monitoring must ensure that projects are explicitly excluded from the remaining lands under Articles 3.3 and 3.4, to avoid double counting.

One important difference between project and national (Articles 3.3 and 3.4) accounting is that projects have a baseline scenario (i.e., only **additional** carbon stock changes and non-CO_2 greenhouse gas emissions due to the project are accounted), while afforestation, reforestation, deforestation, cropland management, grazing land management and revegetation do not have a baseline scenario. After the first commitment period, Forest Management does have a baseline. Therefore, when using project-level information for reporting under different categories of Articles 3.3 and 3.4, countries must take into account the projects' total contribution to reported overall carbon stock changes and non-CO_2 greenhouse gas emissions and not just the change relative to the projects' baseline scenario.

CHAPTER 2

METHODS FOR ESTIMATION, MEASUREMENT, MONITORING AND REPORTING OF LULUCF ACTIVITIES UNDER ARTICLES 3.3 AND 3.4

Contents

Equations

Figures

613

614 # Tables

Boxes

2 METHODS FOR ESTIMATION, MEASUREMENT, MONITORING AND REPORTING OF LULUCF ACTIVITIES UNDER ARTICLES 3.3 AND 3.4

Chapter 2 of this supplementary guidance provides a description of generic methodological issues concerning all possible land use, land-use change and forestry (LULUCF) activities under Kyoto Protocol Articles 3.3 and 3.4. Section 2.1 deals with the relationship between land-use categories in reporting under the UNFCCC and the Kyoto Protocol, Section 2.2 deals with land areas, Section 2.3 with estimating carbon stock changes and non-CO_2 greenhouse gas emissions, and Section 2.4 with other generic methodological issues. This is followed by specific methodologies for monitoring afforestation and reforestation (treated together), deforestation, forest management, cropland management, grazing land management, revegetation, wetlands drainage and rewetting (Sections 2.5 – 2.12). Readers should refer to both the generic and the specific issues for any one of the activities.

2.1 RELATIONSHIP BETWEEN UNFCCC LAND-USE CATEGORIES AND KYOTO PROTOCOL (ARTICLES 3.3 AND 3.4) LAND-USE CATEGORIES

This section provides an overview of how the activities under Articles 3.3 and 3.4 relate to the land-use categories introduced in Volume 4, Chapter 2 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (*2006 IPCC Guidelines*). The use of these categories for the purposes of reporting on national greenhouse gas emissions and removals under the UNFCCC is elaborated in Chapter 3 of the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (*GPG-LULUCF*).

Land-use systems are classified in Volume 4 of the *2006 IPCC Guidelines* into:

(i) Forest land (managed and unmanaged) (Chapter 4)

(ii) Cropland (Chapter 5)

(iii) Grassland (managed and unmanaged) (Chapter 6)

(iv) Wetlands (managed and unmanaged) (Chapter 7)

(v) Settlements (Chapter 8)

(vi) Other land (Chapter 9)

The relationships between the basic land-use categories (i) to (vi) described in Section 2.2 and the activities of the Kyoto Protocol (Articles 3.3 and 3.4) are summarised in Table 2.1.1. Land subject to Kyoto Protocol activities should be identified as a subcategory of one of these six main categories. There are no reporting requirements for unmanaged land categories.

Using categories (i) to (vi) as a basis for estimating the effects of Articles 3.3 and 3.4 activities helps meet *good practice* requirements and will be consistent with the national land categorization used for preparing LUCF greenhouse gas inventories under the Convention. For example: Forest Land could be partitioned into: a) Forest Land under Article 3.3; b) Forest Land under Article 3.4, c) Other managed Forest Land (only if the definition of "managed forests" differs from the definition of "lands subject to forest management"); and d) Unmanaged Forest Land. More information on the relationship between "managed forests" and "forest management" can be found in Section 2.7, Figure 2.7.1.

Many of the methods described in subsequent sections of this Chapter build on methodologies that appear in Chapters 1 and Section 2.1 to 2.4 of this supplementary guidance or in Volume 4, Chapter 2 of the *2006 IPCC Guidelines*. For continuity and clarity, cross-references to these descriptions appear periodically in Boxes. Direct references to the reporting tables in Chapter 3 of the *GPG-LULUCF* is not possible because for Kyoto Protocol reporting additional spatial stratification is required that cannot be inferred from those Reporting Tables, and for

735 the second Commitment Period, additional reporting categories have been introduced. *[cross reference the*
736 *reporting tables in the Supplementary Guidance if we include them]*

737

TABLE 2.1.1
SUMMARY OF THE LULUCF ACTIVITIES UNDER THE KYOTO PROTOCOL AND THE ASSOCIATED ACCOUNTING RULES

Transitions from the "initial" to the "final" land category indicate which management activities may have occurred on that land. Bold font indicates mandatory reporting categories; regular font indicates elective categories where the classification depends on the election of Article 3.4 activities by a country. Management activities cannot create "unmanaged land" and therefore unmanaged categories are not included in the final columns.

Final / Initial	Managed Forest land	Cropland	Managed Grassland	Wetland	Settlements	Other land
Managed Forest land	**FM**	**D**	**D**	**D**	**D**	**D**
Unmanaged Forest land**	**FM**	**D**	**D**	**D**	**D**	**D**
Cropland	**A/R***	CM, RV, WDR***	GM, RV, WDR***	RV, WDR***	RV	
Managed Grassland	**A/R***	CM, RV, WDR***	GM, RV, WDR***	GM, RV, WDR***	RV	
Unmanaged Grassland**	**A/R***	CM, RV, WDR***	GM, RV, WDR***	GM, RV, WDR***	RV	
Wetland	**A/R***	CM, RV, WDR***	GM, RV, WDR***	GM, RV, WDR***	RV, WDR***	
Settlements	**A/R***	CM, RV, WDR***	GM, RV, WDR***	GM, RV, WDR***	RV	
Other land	**A/R***	CM, RV	GM, RV	RV	RV	

Notes

A/R: Afforestation / Reforestation, D: Deforestation, FM: Forest Management, CM: Cropland Management, GM: Grazing Land Management, RV: Revegetation, WDR: Wetland Drainage and Rewetting.

* A/R takes precedence over FM, and therefore the land is subject to FM, but not reported in the FM category.

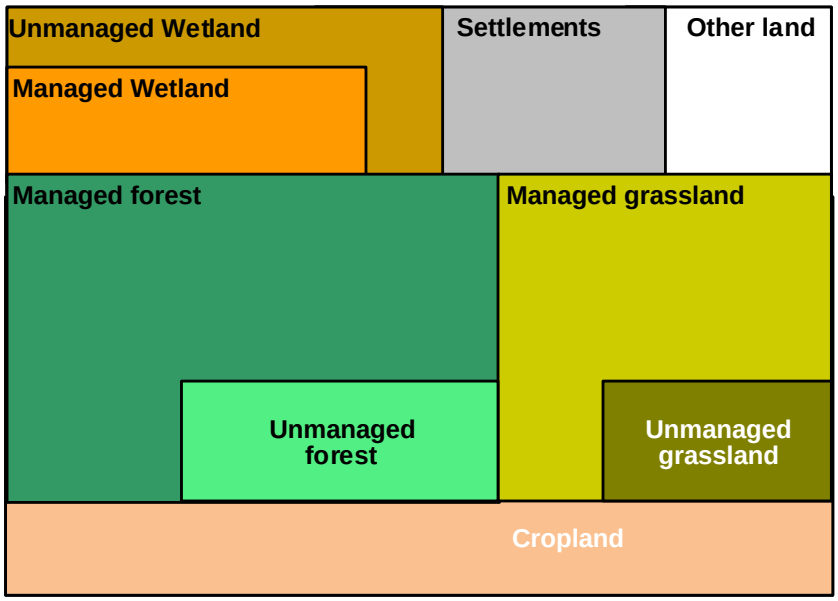
** D takes precedence over cropland/grassland categories.

*** WDR only applies when none of the other elective activities under Article 3.4 have been elected by the country.

738

739 Figures 2.1.1 and 2.1.2 exemplify the relationship between these land-use categories reported in national
740 inventories under the UNFCCC and those under Articles 3.3 and 3.4 of the Kyoto Protocol in any single
741 reporting year. The outer rectangle represents the boundaries of a hypothetical country. Figure 2.1.1 shows the
742 reporting categories for the UNFCCC national inventory according to Chapter 3 of the *GPG-LULUCF*, and
743 Figure 2.1.2 includes additional categories resulting from reporting requirements under the Kyoto Protocol.
744

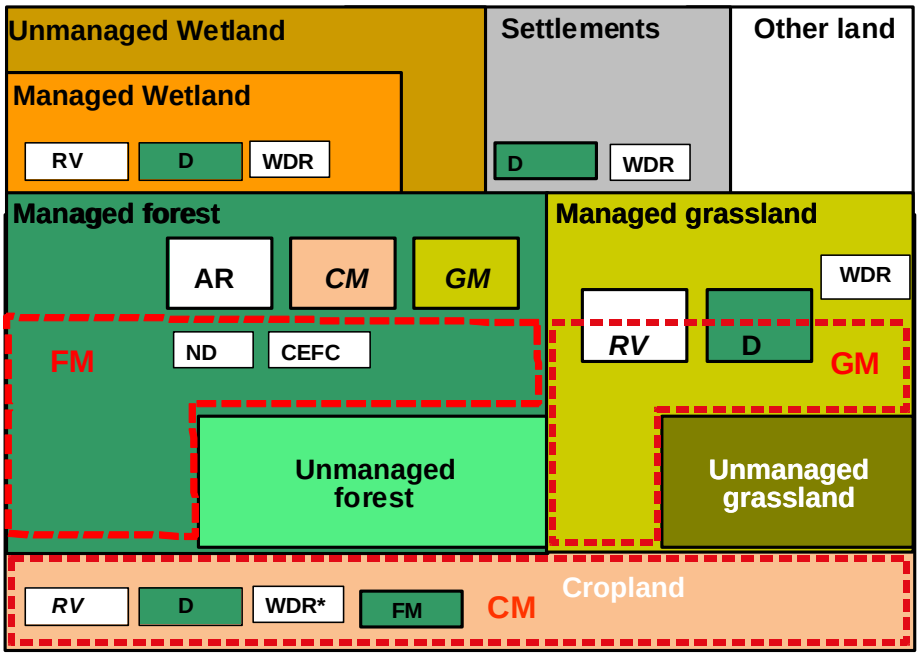
745 **Figure 2.1.1 Land classification in the national inventories under the UNFCCC for a**
746 **hypothetical country in year X of the commitment period**[1]



747

748

749 **Figure 2.1.2 Land classification for Kyoto Protocol reporting for a hypothetical country**
750 **in year X of the commitment period. This classification corresponds to the**
751 **"final" status in Table 2.1.1**



752

753 * WDR on cropland can only occur if CM is not elected, otherwise the associated emissions have to be reported
754 under CM.

755 In Figure 2.1.2, dashed lines delineate areas subject to Forest Management (FM), and two of the elective
756 activities under Article 3.4, cropland management (CM) and grazing land management (GM). Revegetation can
757 occur on various land categories. Wetland drainage and rewetting can only occur on lands that are not already in
758 one of the other Article 3.4 categories. The area subject to forest management can be smaller than the area of
759 managed forest under UNFCCC reporting because (i) countries could use different thresholds for defining

[1] Unmanaged forests and unmanaged grasslands are not reported in UNFCCC inventories.

forests for the Kyoto Protocol and UNFCCC reporting, (ii) Article 3.4 requires that the management activity took place since 1990. For further discussion of this possible definitional difference see Figure 2.7.1 and accompanying text in Section 2.7.2 (Choice of Methods for identifying lands subject to forest management). Emissions and removals on unmanaged forests that remain unmanaged are not included in the UNFCCC or the Kyoto Protocol reporting. However, should a deforestation event occur in unmanaged forests, the associated emissions would be reported as deforestation event under Article 3.3. Lands for which emissions from natural disturbances are not reported (see Section 2.3.9.6 for additional requirements) need to be identified separately for both FM and AR lands ("ND" in Figure 2.1.2). Lands that are used to establish an equivalent forest area to compensate for harvesting of plantations established after Jan 1, 1960 and before Jan 1st 1990, that are re-established in a different location are shown in Figure 2.2 as "CEFC", which includes both the land area that was cleared and may now be in a different land use and the non-forest land on which the plantation was re-established (see Section 2.7.7 for additional requirements).

For Kyoto reporting lands subject to cropland management as described in Decision 16/CMP.1 are identical to Cropland/arable/tillage lands in UNFCCC reporting.

Grazing land management usually occurs on lands classified as grasslands in the UNFCCC inventory. However, grazing land management can also occur in managed forests, and not all grasslands are necessarily grazing lands. Unmanaged grasslands will be excluded from both the UNFCCC and the Kyoto Protocol reporting.

Afforested and reforested (A/R) lands are always managed forests. Carbon stock changes and non-CO2 greenhouse gas emissions are to be reported under Article 3.3 only.

Deforested lands are usually managed (thus, there is no "D" box in the unmanaged grasslands).

2.2 GENERIC METHODOLOGIES FOR AREA IDENTIFICATION, STRATIFICATION AND REPORTING

2.2.1 Reporting requirements

Decisions 16/CMP.1 and 2/CMP.7 state that areas of land subject to Article 3.3 and 3.4 activities must be identifiable[2], adequately reported[3] and tracked in the future.[4] Section 2.2.2 discusses two land reporting methods that can be applied to all Article 3.3 and 3.4 activities. Section 2.2.4 discusses how these reporting methods can draw on the three approaches presented in Chapter 3, Volume 4 of the *2006 IPCC Guidelines* Section 2.2.5 provides a decision tree for selecting one of the two reporting methods, and Section 2.2.6 includes a more

[2] Paragraph 20 of the Annex to the Decision 16/CMP.1 (Land use, land-use change and forestry), contained in document FCCC/CP/2001/13/Add.1, p.61: *National inventory systems under Article 5.1 shall ensure that areas of land subject to land use, land-use change and forestry activities under Article 3, paragraphs 3 and 4 are identifiable, and information about these areas should be provided by each Party included in Annex I in their national inventories in accordance with Article 7. Such information will be reviewed in accordance with Article 8.*

[3] Paragraph 6 of the Annex of the Decision 15/CMP.1 (Article 7):

General information to be reported for activities under Article 3, paragraph 3, and any elected activities under Article 3, paragraph 4, shall include: […]

(b)The geographical location of the boundaries of the areas that encompass:

(i) Units of land subject to activities under Article 3, paragraph 3;

(ii) Units of land subject to activities under Article 3, paragraph 3, which would otherwise be included in land subject to elected activities under Article 3, paragraph 4, under the provisions of paragraph 8 of the annex to decision -/CMP.1 (Land use, land-use change and forestry); and

(iii) Land subject to elected activities under Article 3, paragraph 4. […]

(c)The spatial assessment unit used for determining the area of accounting for afforestation, reforestation and deforestation.

[4] Paragraph 19 of the Annex to the Decision 16/CMP.1 (Land use, land-use change and forestry): *Once land is accounted for under Article 3, paragraphs 3 and 4, all anthropogenic greenhouse gas emissions by sources from and removals by sinks on this land must be accounted for throughout subsequent and contiguous commitment periods.*

790 detailed discussion of how lands subject to Articles 3.3 and 3.4 can be identified, so that the requirements of
791 either reporting method can be satisfied.

792 2.2.2 Reporting Methods for Lands subject to Article 3.3
793 and Article 3.4 activities

794 To meet the reporting requirements set out in Decision 15/CMP1, general information to be reported on activities
795 under Articles 3.3 and 3.4 must include the geographical boundaries of areas encompassing units of land subject
796 to afforestation and reforestation, deforestation, and lands subject to elected activities among forest management,
797 cropland management, grazing land management, revegetation and wetland drainage and rewetting activities. To
798 achieve this a Party may choose one of two methods (Figure 2.2.1):

799 **Reporting Method 1** entails delineating areas that include multiple land units subject to Article 3.3 and 3.4
800 activities by using legal, administrative, or ecosystem boundaries. This stratification is based on sampling
801 techniques, administrative data, or grids on images produced by remote sensing techniques. The identified
802 geographic boundaries must be georeferenced. See Section 2.2.3 for additional reporting requirements arising
803 from Decision 2/CMP.7.

804 **Reporting Method 2** is based on the spatially explicit and complete geographical identification of all units of
805 land subject to Article 3.3 activities and all lands subject to Article 3.4 activities.

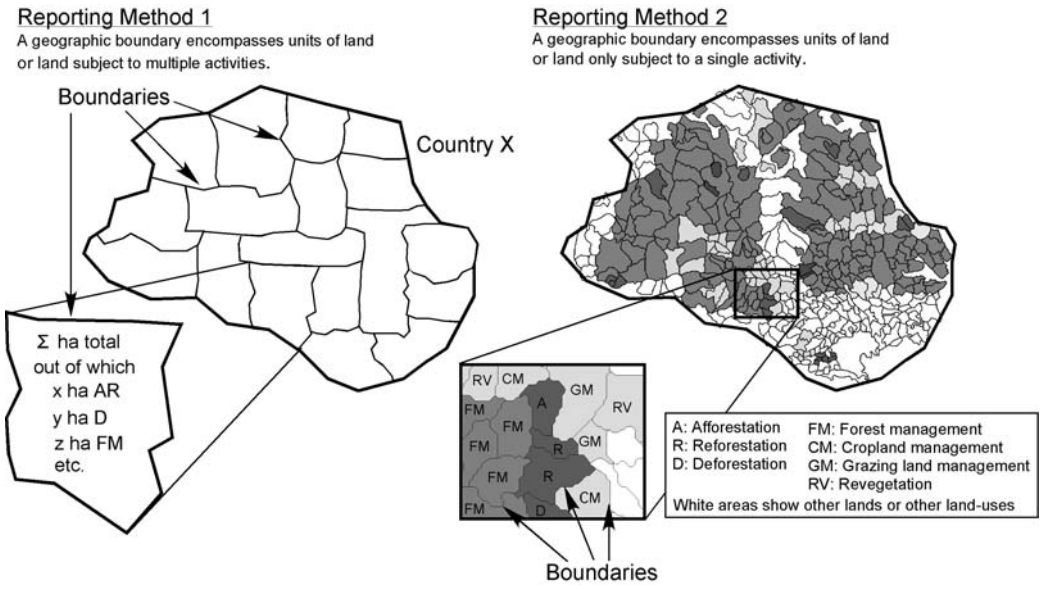
806 To implement Reporting Method 1, it is good practice to stratify the entire country and to define and report the
807 geographic boundaries of these areas of land. Criteria for stratification of the country could include statistical
808 considerations for the sampling intensity or sampling approaches, considerations of the type and amount of land-
809 use change activities (Article 3.3) and elected activities (Articles 3.4), as well as ecological or administrative
810 considerations. Within each resulting geographic boundary the units of land subject to Article 3.3 activities and
811 the lands subject to any Article 3.4 activities (if elected) must then be quantified using the approaches described
812 in Chapter 2 (Section 2.3 Representing land areas) of the *GPG-LULUCF*, in accordance with the guidance in
813 Section 2.2.3, as well as the methods in Sections 2.2.5 (generic methods) and 2.5 to 2.12 (activity-specific
814 methods).

815 To implement Reporting Method 2, a Party should identify and report the spatial location of all lands and units
816 of land based on a complete mapping of all areas within its national boundaries. This is described in Chapter 3 of
817 the *2006 IPCC Guidelines* as the wall-to-wall mapping version of Approach 3 (see also Section 2.2.4.3). This
818 reporting method uniquely identifies lands and units of land and enables activities to be reported without the risk
819 of double counting. To put this reporting method fully into practice requires large-scale data collection and
820 analysis, and the preparation of summary statistics to ensure that reporting is transparent yet concise.

821 [Consider adding a short paragraph on published national examples implementing RM1 (e.g. Canada, Stinson et
822 al. 2011, other published examples?) or RM2 (e.g. Australia, papers by Gary Richards or Rob Waterworth other
823 examples?) in CP1.]

824

Figure 2.2.1 Two reporting methods for land subject to Articles 3.3 and 3.4 activities



With either reporting method, once land is reported as being subject to activities specified under the Kyoto Protocol, it should be traceable for the first and subsequent commitment periods. Therefore, if a Party chooses Reporting Method 1, it is *good practice* to record the information needed to identify the sample locations and the units of land or lands identified in the samples, and to use the same sample locations for any future monitoring. This ensures that changes in the status of land covered by sample plots (Reporting Method 1) or in the entire country (Reporting Method 2) can be tracked and monitored from 1990 to the end of the commitment period.

The geographic boundaries resulting from the stratification of the country should be reported using printed maps or digital maps, as described in Section 2.4.4.1 (Reporting).

For Reporting Method 1, depending on the size of the country and the ecological and climate variability within the country, it is *good practice* to select the number of geographic areas for which the geographic boundaries of land are defined with the goals to reduce heterogeneity and to increase reporting transparency. Thus, unless the country is relatively small it is *good practice* to define the boundaries of more than one geographic area and for relatively large countries it is *good practice* to limit the number of geographic areas to maintain transparency.

2.2.3 Reporting Methods for Lands subject to Special Accounting Provisions

Decision 2/CMP.7 introduced additional reporting requirements for (1) the georeferenced locations of forest areas subject to natural disturbances for which emissions and subsequent removals are excluded from the accounting[5] and (2) the georeferenced locations of forest plantations converted to other land uses for which a carbon equivalent forest was established on non-forest land[6].

Georeferenced locations of areas affected by natural disturbances are required to track whether or not these areas have been converted to non-forest land uses (deforestation) in the years after the natural disturbance. Countries can meet this requirement either by monitoring post-disturbance land-use change on disturbed areas for which emissions were excluded from the accounting or by demonstrating for all units of forest land subject to deforestation that these are not lands previously affected by natural disturbances for which emissions were excluded from the accounting. If land-use change does occur then the emissions from the natural disturbance also have to be reported and accounted.

Decision 2/CMP.7 also states that countries need to demonstrate that emissions associated with salvage logging of these areas were not excluded from the accounting. It is good practice to report and account emissions from all salvage logging, which includes emissions associated with salvage logging on lands affected by natural disturbances for which emissions were excluded from the accounting. If salvage logging does occur, then only

[5] Decision 2/CMP.7 – Paragraph 34 (a) establishes the requirement to report the georeferenced location of these areas.

[6] Decision 2/CMP.7 – Paragraphs 37 – 39 outline all requirements that must be met for this provision.

857 those emissions are reported and accounted, but not the emissions from the prior natural disturbance. See
858 Section 2.3.9 for additional requirements associated with the natural disturbance provision.

859 Decision 2/CMP.7 requires that the georeferenced locations are reported for cases where plantations are
860 harvested and converted to non-forest land and subsequently non-forest land in another location is planted to
861 establish a carbon equivalent forest. The georeferenced locations of both the converted plantation and the newly
862 established plantation are to be reported. The associated emissions are reported under Forest Management
863 (Article 3.4). See Section 2.7.7 for additional requirements associated with the establishment of carbon-
864 equivalent forests.

865 These new reporting requirements imply that Reporting Method 1 can only meet the reporting requirements for
866 the second commitment period if additional, georeferenced information about specific land areas within the
867 geographic boundaries is provided.

868

869

870 2.2.4 Relationship between Approaches in Chapter 3, 871 Volume 4 of the 2006 IPCC Guidelines and Reporting 872 methods in Section 2.2.2

873 Chapter 3, Volume 4 of the *2006 IPCC Guidelines* (Consistent representation of lands) describes three
874 approaches to representing land area. The detailed reporting requirements of Articles 3.3 and 3.4 of the Kyoto
875 Protocol as elaborated in Chapter 3 are met by the two reporting methods given in this chapter, and underpinned
876 by the approaches described in Chapter 3. This section, summarised in Table 2.2.1, discusses which of the three
877 3 approaches are suitable for identifying units of land subject to Article 3.3 activities or lands subject to selected
878 activities under Article 3.4. Note that even the most data-intensive Approach 3 outlined in Chapter 3 can only be
879 sufficient without supplemental information if the spatial resolution at which land-use changes are tracked is
880 consistent with the size parameter selected by a country to define forest, i.e., polygon sizes of 0.05 to 1 ha or
881 grids of 20 to 100 m (see STEP 1.1 in Section 1.1). Land cover and land-use mapping using, for example, 1 km^2
882 (100 ha) pixel resolution does not meet the Protocol's requirements and supplemental information will be
883 required.

884 This section describes three Approaches that may be used to represent areas of land use using the categories as
885 defined and explained in more detail in Chapter 3 of *2006 IPCC Guidelines*. Approach 1 identifies the total
886 change in area for each individual land-use category within a country, but does not provide information on the
887 nature and area of conversions between land uses. Approach 2 introduces tracking of land-use conversions
888 between categories (but is not spatially explicit). Approach 3 is characterized by spatially-explicit observations
889 of land-use categories and land-use conversions.

890

891 2.2.4.1 APPROACH 1: TOTAL LAND-USE AREA, NO DATA 892 ON CONVERSIONS BETWEEN LAND USES

893 Approach 1 in Chapter 3 of the *2006 IPCC Guidelines* provides information that is not spatially explicit and it
894 only reports the net changes in the areas of different land-use categories. Hence, this approach does not meet the
895 land identification requirements of Decisions 16/CMP.1 and 2/CMP.7. National inventory databases are often
896 compiled from detailed spatial inventories that can be based, for example, on sampling approaches that involve a
897 grid or sample plot system. In countries where this is the case, it may be possible to re-compile the detailed
898 inventory information for the geographical boundaries, which have resulted from the stratification of the country,
899 to meet the reporting requirements of the Kyoto Protocol. This means that Approach 1 can only be applied to
900 Reporting Method 1 if additional spatial data at the required spatial resolution are available as a result of re-
901 compiling the inventory information or from other sources, and if additional information is available to quantify
902 the gross land-use transitions (rather than the net changes in land-use categories).

903 2.2.4.2 APPROACH 2: TOTAL LAND-USE AREA, 904 INCLUDING CHANGES BETWEEN CATEGORIES

905 Approach 2 focuses on land-use transitions and provides an assessment of both the net losses or gains in the area
906 of specific land-use categories and what these conversions represent (i.e., changes both from and to a category).
907 The final result of this Approach can be presented as a nonspatially-explicit land-use conversion matrix. Thus,
908 Approach 2 differs from Approach 1 in that it includes information on conversions between categories, but is
909 still only tracking those changes without spatially-explicit location data. Hence, additional spatial information at
910 the required spatial resolution is necessary to meet the reporting requirements of Decisions 16/CMP.1 and
911 2/CMP.7. This approach can therefore only be used to identify units of land or land subject to activities under
912 Articles 3.3 and 3.4 if additional spatial data are available. As with Approach 1, it may be possible to apply
913 Approach 2 to Reporting Method 1 if additional spatial data at the required spatial resolution become available
914 from re-compiling the inventory information.

2.2.4.3 APPROACH 3: SPATIALLY-EXPLICIT LAND-USE CONVERSION DATA

Approach 3 is characterized by spatially-explicit observations of land-use categories and land-use conversions, often tracking patterns at specific point locations and/or using gridded map products, such as derived from remote sensing imagery. The data may be obtained by various sampling, wall-to-wall mapping techniques, or combination of the two methods. This approach is applicable to Reporting Methods 1 and 2 above, as long as the spatial resolution is fine enough to represent the minimum forest area as defined by the Party under Decisions 2/CMP.6, 16/CMP.1 and 2/CMP.7

TABLE 2.2.1
RELATIONSHIP BETWEEN APPROACHES IN CHAPTER 3 OF 2006 IPCC GUIDELINES AND REPORTING METHODS IN THIS REPORT

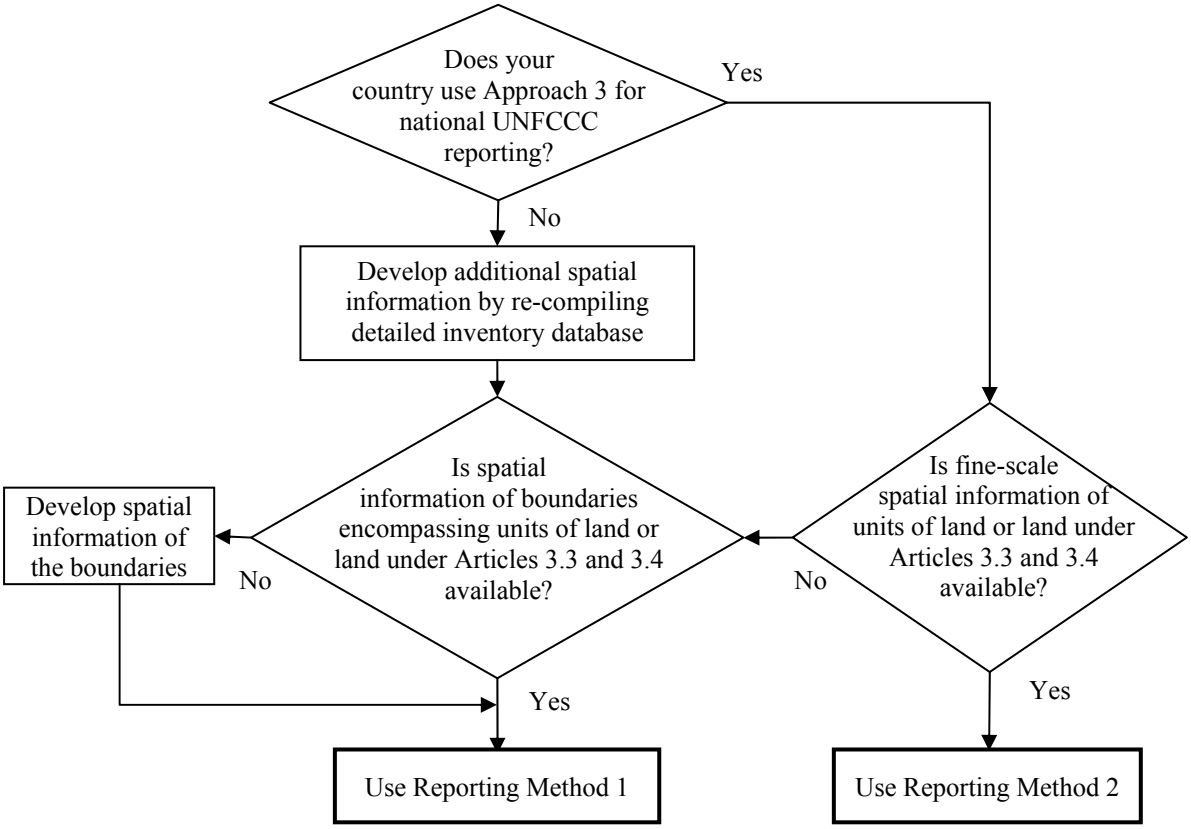
Chapter 3 Approaches	Reporting Method 1 (Broad area identification)	Reporting Method 2 (Complete identification)
Approach 1 Total land-use area, no data on conversions between land uses	Can only be used if additional spatial information is available by re-compiling inventories.	Not applicable
Approach 2 Total land-use area, including changes between categories	Can only be used if additional spatial information is available by re-compiling inventories.	Not applicable
Approach 3 Spatially explicit land-use conversion data	*Good practice* if resolution is fine enough to represent minimum forest area. Involves aggregating data within the reported geographic boundaries.	*Good practice* if resolution is fine enough to represent minimum forest area.

2.2.5 Choice of Reporting Method

It is *good practice* to choose an appropriate reporting method using the decision tree in Figure 2.2.2. National circumstances may enable a Party to use a combination of both reporting methods. In such a case, it is *good practice* to first stratify the entire country and then to quantify and report the area of units of land and land using Reporting Method 1. Within those geographical boundaries where complete spatial identification of lands and units of land is possible, Reporting Method 2 can then be applied.

As outlined in section 2.2.3, additional georeferenced information is required for areas subject to natural disturbances for which emissions and subsequent removals are excluded from the accounting as well as for the locations of forest plantations converted to other land uses for which a carbon equivalent forest was established on non-forest land lands. For either Reporting Method, this additional information would have to be reported using maps or tables containing the relevant information. *[If this is covered in more detail in the reporting tables we can cross-reference to that section.]*

936 **Figure 2.2.2 Decision tree for choosing a reporting method for land subject to activities**
937 **under Articles 3.3 and 3.4.**



938

939 When using Method 1 it is usually *good practice* to use the same geographical boundaries for all activities. This
940 will greatly facilitate the identification, quantification, and reporting of land-use changes. However, national
941 circumstances may provide justification for different choices of geographic boundaries for different activities.
942 For example, different geographic boundaries may be chosen to reduce the variance of estimates for one activity
943 within a given boundary. When a Party uses more than one set of geographic boundaries (i.e., more than one
944 stratification system is used), lands or units of land subject to Article 3.3 or 3.4 activities that moved from one
945 category to another must be appropriately assigned to the correct geographical boundary. This might require
946 proportional allocation of the units of land to each stratification system in use.

947

948 2.2.6 How to identify lands (units of land) in general

949 2.2.6.1 SPATIAL CONFIGURATION OF FORESTS AND 950 AFFORESTATION, REFORESTATION OR 951 DEFORESTATION EVENTS

952 Each Annex I Party to the Kyoto Protocol has chosen country-specific parameters within the definition of forest
953 as an integral part of their Kyoto Protocol reporting. This required selecting values for the following three
954 parameters: the size of the minimum area of land that can constitute a forest, ranging between 0.05 and 1 ha, and
955 parameters for crown cover (10 – 30%) and tree height at maturity (2 – 5 m). The parameter for the minimum
956 area of land that constitutes a forest effectively also specifies the minimum area on which
957 afforestation/reforestation, deforestation, or conversion of natural forests to planted forests events occur. Thus a
958 country that selects, for example 0.5 ha as the minimum area of forest land, must also identify all deforestation
959 and conversion of natural forests to planted forests events that occur on lands that are 0.5 ha or larger. The
960 identification of units of land on which land-use changes occur, such as deforestation, requires the detection of a
961 reduction in forest cover from above to below the country-specific threshold of forest, accompanied by a change
962 in land-use.

The CMP decisions do not specify the shape of areas, neither for forest, nor for those areas on which afforestation, reforestation or deforestation events occur. Square areas that meet the 0.05 to 1 ha range would be 22.36 m to 100 m (1 ha) on each side. But a rectangle that is 10 m wide and 1,000 m long is also 1 ha in area, as is a 5 m wide and 2,000 m long rectangle. Therefore, a treed shelterbelt or any other strip of trees that exceeds these sizes could be considered a forest. But if such "linear forests" are included in a Party's definition of forest, it is *good practice* to also consider as non-forest any areas being cleared from trees by "linear deforestation events", such as roads, transmission right-of-ways, or pipeline corridors. When such corridors have resulted from cuts since 1990, they should be treated as deforestation events under Article 3.3.

For example, if a country selects 1 ha as the minimum area of forests, afforestation, reforestation, deforestation, or conversion of natural forests to planted forests events, and further specifies that these areas are square, then a 20 m wide corridor cut through a forest with 100% canopy closure, will reduce canopy closure to 80%. This is higher than the range of canopy closures (10 – 30%) that could be selected by a Party. Therefore the residual area is defined as forest, and even when this corridor through the forest is cut since 1990, it would not constitute a deforestation event. If this "only" 20 m wide corridor is part of a long corridor, which stretches for many kilometers, such as a transmission right-of-way or a pipeline corridor, the total corridor area is much greater than 1 ha. Therefore the definitional criteria applied to specify the shape of the forests and of the areas subject to afforestation, reforestation, deforestation, or conversion of natural forests to planted forests events can have a large impact on the amount of land reported under Article 3.3.

It is therefore *good practice* for countries to include, within their report on the choice of forest definitions, a description of the definitional criteria which are used to identify forests and areas on which afforestation, reforestation, deforestation, or conversion of natural forests to planted forests events occur. It is also *good practice* to apply these criteria consistently to the identification of deforestation, conversion of natural forests to planted forests, afforestation or reforestation events that have occurred since 1990. For instance, these criteria can simply be defined as the minimum width that will be accepted for a forest and an area subject to an afforestation, reforestation, deforestation or conversion of natural forests to planted forests event. Then the minimum length of the area follows from the combination of width and the chosen parameter for minimum area which can constitute a forest. For example, if the size were defined as 1 ha, with a minimum width of 20 m, then a rectangle of minimum width has to be at least 500 m long to meet the 1 ha size requirement.

It is *good practice* to report the impacts of "linear deforestation events" narrower than the selected minimum width criterion on carbon stock changes in the FM land category. Similarly, it is *good practice* to report the carbon stock changes in shelterbelts that are narrower than the selected minimum width criterion and are therefore not forest, if these shelterbelts are within lands subject to cropland management, grazing land management, or revegetation activities, where the Party has elected the respective Article 3.4 activity.

2.2.6.2 SOURCES OF DATA FOR IDENTIFYING LANDS AND OTHER NEW REPORTING REQUIREMENTS

The needs for the reporting of lands subject to activities under Articles 3.3 and 3.4 and other reporting requirements have been outlined in the previous sections. The data and information available to a country to meet these needs will depend largely on national circumstances, including the investments made into the appropriate measurement, reporting and verification systems. These include the land and forest inventory systems already in place and the additional measures a country chooses to implement to meet the reporting requirements. The data and the acquisition methods must ensure that they are reliable, well documented methodologically, at an appropriate scale, and from reputable sources.

In very general terms there are three major options and their combinations that can be taken to meet the information needs:

- To use information from existing land-use and forest inventory systems.
- To implement a monitoring and measurement system to obtain information on land-use conversions, forest management, natural disturbances and other relevant activity data.
- To implement a system by which land management activities are reported to government agencies, e.g. an incentive program could be established that encourages land managers to report afforestation activities that are difficult to detect through remote sensing. To ensure integrity, such a system should include verification and auditing procedures.

It is likely that in most countries the existing land use and inventory systems are inadequate to meet all the land reporting requirements of the Kyoto Protocol, and that, with varying degrees of incremental efforts, additional information will need to be obtained through monitoring or in-country reporting systems. The optimum approach to obtaining the required data may involve combinations of the three options. For example, national

forest inventory systems with 5 to 10-year periodic remeasurement intervals may not be adequate to meet the reporting needs on annual area disturbed by wildfires, and the associated non-CO_2 emissions. Data from fire monitoring systems could be used to augment the information obtained from forest inventories. Or a country could determine that it would be most efficient to combine an activity reporting system to identify units of land subject to afforestation/reforestation (which are difficult to detect using remote sensing), and a monitoring system to identify units of land subject to deforestation (which are more readily detected).

With the rapid development of remote sensing technology and the, for certain sensors freely available data, remotely sensed data are increasingly contributing to land-use and forest inventory systems, monitoring and measurement systems and activity reporting systems. Considerable efforts, infrastructure and expertise are required to process the large volumes of remote sensing data and to derive estimates of carbon stock changes and non-CO_2 greenhouse gas emissions and removals from the remotely sensed data on land cover and land-use changes.

[Consider expanding this section with references to literature such as GOFC-GOLD source book, GEO-FCT and GFOI, descriptions of models and other tools available to conduct such analyses].

USE OF EXISTING INVENTORIES

Countries that maintain detailed forest and other land-use inventories or collect annual or periodic spatial land statistics may be able to identify lands affected by Article 3.3 and 3.4 activities since 1990 from their inventories. This, however, will only be possible if the national inventory and data collection systems meet stringent technical requirements. The systems must be able to define the land use and forest area in 1990, have an update cycle that is sufficiently short to capture land-use change events between relevant periods (1990-2007, 2008-2012, and 2013-2020) and be of sufficient spatial resolution to identify events of the size of the minimum forest area chosen by the country, i.e., 1 ha or smaller. Also, the sample plots within a "boundary" need to be georeferenced and used repeatedly during future monitoring. If the latter is not possible, e.g., because monitoring procedures were changed, it is *good practice* to develop computational procedures, which allow conversion of data between the sampling schemes or, at least to have a method, which allows to map the data from a previous to a successor sampling scheme (see also Sections 2.4.1 Developing a consistent time series and 2.4.2 Recalculation).

If countries use Approach 3 to carry out inventories, with spatially explicit and complete geographical information of land use and land-use change, the inventories will be sufficient to meet the reporting requirements provided that the minimum grid or mapped polygon meets the area criterion selected to define forest. Forest inventories in large countries often do not record polygons (i.e. the minimum mapping unit) less than, for example, 3 ha in size. The requirement to identify afforestation, reforestation, deforestation or natural forests to planted forests activities at a resolution of 0.05 to 1 hectares can be met, however, with additional statistical analyses to establish the area subject to afforestation, reforestation, deforestation or conversion of natural forests to planted forests events that occurred in units less than 3 ha in size. One possible approach could be to determine the size-class distributions of afforestation/reforestation and of deforestation events in the country, using a statistical sampling approach. The proportion of the area of afforestation/reforestation and of deforestation events that is between 0.05 – 1 ha and the minimum mapping unit in the inventory (in this example 3 ha) can then be applied to estimate the area of afforestation/reforestation and deforestation events from the 3-ha resolution inventory. For example, if the 3-ha resolution inventory shows that there have been 1,000 ha of afforestation/reforestation events in units of 3 ha or larger, and the sample-based size-class distribution of afforestation/reforestation events shows that on average 5% of the afforestation/reforestation events is in areas of size between 0.05 – 1 ha and 3 ha, then the 1,000 ha represent 95% of the total afforestation/reforestation area (and the total is estimated to be 1,000 • 100/95 = 1,052.6 ha). It is good practice to document the statistical validity of the sample-based size-class distribution, and its regional and temporal variation. Note that this approach to augmenting existing inventory information also has implications for the determination of carbon stock changes: since these 5% of the area are not geographically referenced, only statistical methods such as regional averages can be used to determine their carbon stock changes and trace their fate, once they are included under Article 3.3 or 3.4, over time. An alternative approach would be to collect the data regarding afforestation, reforestation, deforestation or conversion of natural forests to planted forests in areas of size between 0.05 – 1 ha and 3 ha through activity reporting but countries would need to ensure completeness and collect georeferenced information (see below).

Additional monitoring and data compilation may be required to meet the reporting requirements for land-use changes, conversion of natural forests to planted forests, wetland drainage and rewetting, and activities such as salvage logging and land-use conversion of lands affected by natural disturbances for which the emissions were not included in the accounting.

Countries that choose an inventory-based approach for the identification of units of land subject to afforestation/reforestation activities can face the challenge that non-forest areas are not normally included in the forest inventory. In this case, countries must ensure that their inventory system detects land-use transitions from non-forest to forest and expands the forest inventory into the newly created forest area. Some countries monitor changes from non-forest to forest by means of remote sensing of lands not previously covered by the forest inventory or by maintaining inventory plots on non-forest land.

MONITORING AND MEASUREMENT OF ACTIVITIES

To meet the reporting requirements of Articles 3.3 and 3.4, countries may have to develop and implement a monitoring system for the identification and recording of land use and land-use change. Such a monitoring system could combine a base map (or other sources of spatial information) on forest area and land use on 31 December 1989 with spatial data on land-use and forest area in subsequent years. Changes in land-use and forest area can then be inferred from a time series of spatial data. This may require interpolation, for example where a base map has been derived from composite satellite images obtained over several years, as is often the case where cloud cover, sensor failures, or other technical reasons make it impossible to obtain complete national coverage for a single point in time.

Some events, such as the conversion of natural forest to planted forest, or logging following natural disturbances, are rarely spatially and temporally explicitly documented in inventories. The monitoring of these events is important, and the monitoring time interval should be short enough to capture relevant changes. Remote sensing monitoring can be useful, especially in large or remote areas, due to its potentially high temporal resolution and cost-effectiveness. However, remote sensing data and their results need to be validated against in-situ data to reduce uncertainties.

In many countries repeated complete (wall-to-wall) coverage of the entire country is not feasible on an annual basis. When implementing temporal and spatial sampling strategies, it is *good practice* to ensure that the sampling methods are statistically sound, well-documented and transparent, and that estimates of uncertainty are provided (Section 2.4.3 Uncertainty assessment). Appropriate pre-stratification of the country for which sample estimates will be developed may reduce the uncertainty.

Recent advances, such as the release of the complete Landsat archives, developments of new image processing algorithms, and vast increases in computing power may enable the production of annual land-cover change products at national, continental and global scales. However, given that land-use change often occurs on only a small fraction of the areas affected by land-cover change and that considerable additional efforts may be required to ascertain whether a land-cover change represents a land-use change, monitoring land-use change to meet the reporting requirements of the Kyoto Protocol will require investments into appropriate monitoring programs. Moreover, special requirements such as the reporting of conversion of natural forests to planted forests will require additional in-situ data, for example to determine whether cover loss occurred in ‘natural forests’ and whether the regenerated forest is the result of planting. These and other special requirements can be met through activity reporting (see below).

Where the monitoring system generates georeferenced data for natural disturbance events, this information can also be used to track subsequent events with reporting obligations, such as salvage logging of disturbed areas or the conversion to non-forest land of disturbed areas for which emissions were not accounted.

ACTIVITY REPORTING

Identification of lands that are subject to activities under Articles 3.3 and 3.4 can be achieved through the implementation of an activity reporting system. For example, since afforestation events are often difficult to detect through remote sensing and often occur outside the area of existing forest inventories, a country may choose to identify these lands through an activity reporting system that encourages land managers who afforested non-forest land to report such activities to the appropriate national agency. Instead of trying to detect afforestation events from inventory or monitoring systems, countries can request that those individuals or agencies that afforest or reforest areas report on their activities.

Activity reporting may also be most efficient where information about land use is required that may not be readily determined from remote sensing, such as cropland management, or grazing land management. Activity reporting may also be important for the attribution of the some land cover change, including revegetation, and to identify where observed conversions to and from forest are linked through the provision of carbon equivalent forest conversions. Reporting systems can usefully include spatial databases that facilitate the compilation of the pertinent activity information. It is *good practice* to include the location and the area of the activity, and

information relevant to the estimation of carbon stock changes, such as site preparation methods, tree species planted, and the actual as well as the expected volume growth function for the land.

Activity reporting may be necessary for the identification of afforestation, reforestation, deforestation or conversion of natural forests to planted forests in areas of size below the inventory minimum unit. Coupled with high resolution remote sensed images, activity reporting can provide geo-referenced information and detailed description of land cover change for small areas and sample plots.

It is *good practice* for Parties that rely on activity reporting systems, to put into place methods for internal auditing and verification to ensure that activities are neither over- nor underreported. Administrative information on programmes or subsidies for afforestation activities alone may not include information on plantation establishment success. Spatially explicit information, i.e., either the delineation of the units of land, or references to a country's national map grid coordinates (e.g., UTM, Universal Transverse Mercator) or legal description of the units of land subject to an activity, are required for the domestic audit and verification procedures applied to a reporting system.

2.3 GENERIC METHODOLOGICAL ISSUES FOR ESTIMATING CARBON STOCK CHANGES AND NON-CO_2 GREENHOUSE GAS EMISSIONS

Once the areas subject to activities under Articles 3.3, and 3.4 have been determined, the carbon stock changes and non-CO_2 greenhouse gas emissions on these areas must be estimated following the methods outlined in the *2006 IPCC Guidelines*, the *2013 IPCC Wetlands Supplement*[7] and this Supplementary Guidance.

Coverage of activities under Articles 3.3 and 3.4 requires an estimation of all carbon stock changes, and emissions and removals of non-CO_2 greenhouse gases from all lands subject to the included activities and for all pools with discretionary omission of those that are not a source of carbon, with higher-tier methods used for key categories. The greenhouse gas fluxes will be estimated regardless of their cause, such as growth, harvest, decomposition, natural disturbance, establishment of equivalent forest. In the case of natural disturbances, the fluxes need to be estimated and reported[8] but countries can elect to exclude these emissions and subsequent removals from the accounting in years where the emissions from disturbances are above the background level plus the margin (See Section 2.3.9.6 for details). The carbon stock changes, and emissions and removals of non-CO_2 greenhouse gases of lands considered as 'carbon equivalent forest conversion' need to be accounted and reported in forest management.

The methodology used to estimate carbon stock changes and greenhouse gas emissions and removals for any particular year depends on the land use in the current and in prior years, because shifts in categories or land uses can occur over time. Therefore the methodologies may vary between units of land or land within one Article 3.3 or Article 3.4 category.[9] The methodology used to calculate greenhouse gas emissions or removals associated with a unit of land or land at a given year should correspond to the actual land use on that land in that year, supplemented by additional methodologies to account for past land uses and changes in land use, where appropriate. If the land use in the current year does not correspond to an Article 3.3 activity or an elected Article 3.4 activity, and if a reporting requirement was not established through land use or land-use change in prior years, then the emissions and removals for that land are not reported under the Kyoto Protocol.

The generic methods of estimating the carbon stock changes, for all pools to be reported (see below), are described in Chapter 2 of the *2006 IPCC guidelines*. This section provides supplementary guidance applicable to

[7] The IPCC is currently preparing the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (the *2013 IPCC Wetlands Supplement*) in parallel to this document. The *2013 IPCC Wetlands Supplement* provides guidance on estimating emissions and removals on lands with drained and rewetted organic soils in Chapters 2, 3 and 4 and general issues on wetlands are addressed in Chapters 1 and 7. The guidance given here will be updated to reflect the development of the *2013 IPCC Wetlands Supplement* through its review by experts and governments and its approval by the IPCC. The Government and Expert Review of the *2013 IPCC Wetlands Supplement* will be held between 11th February and 7th April, 2013 (see http://www.ipcc-nggip.iges.or.jp/home/wetlands.html).

[8] Decision 2/CMP.7, Annex definition E paragraph 33

[9] For example, two units of land may both be in the cropland management category. However, one of them may have resulted from grassland conversion into cropland, the other from continuing cropland management, so that the greenhouse gas assessment methods need to take account of differing values of soil carbon resulting from their different management histories.

all activities under Articles 3.3 and 3.4. Guidance for specific activities can be found in Sections 2.5 to 2.12. Methodological updates for mineral and organic soils that are recently published *[or forthcoming]* include:

Mineral Soils

The inventory calculations are based on land area and lands that are stratified by climate regions and default soils types as shown in Table 2.3, Chapter 2, Volume 4, *2006 IPCC Guidelines*. This table presents default reference (under native vegetation) soil organic C stocks for mineral soils (tonnes C ha^{-1} in 0-30 cm depth). Countries following Tier 2 method may also refer to data provided in Batjes (2011). It is *good practice* whenever possible to verify values by comparison with results from field measurements.

Organic soils

The 2013 IPCC Wetlands supplement contains updated and new methodological guidance for greenhouse gas emissions and removals from drained and rewetted peatlands, organic soils, as well as from specific human-induced changes in coastal, inland mineral soil, and constructed wetlands.

2.3.1 Pools to be reported

The *2006 IPCC Guidelines* provide methodologies for the estimation of the carbon stocks and stock changes in five carbon pools: above and belowground biomass, dead wood, litter and soil organic carbon. (Table 1.1, Chapter 1, Volume 4, *2006 IPCC Guidelines*). Decision 2/CMP.7 introduced the additional requirement to report and account for the storage of carbon in harvested wood products (see Section 2.3.8). Decreases in one pool may be offset by increases in another pool, e.g., biomass pools decline after a disturbance but litter and dead wood pools can increase. Thus the change in a single pool can be greater than the net change in the sum of the pools.

Once the individual pools have been estimated and reported for a specific area, the sum of the carbon stock increases or decreases in the five pools and HWP is calculated. Any net decrease in carbon stocks is converted to the equivalent CO_2 emission in the reporting tables (see Section 2.4.4) and any net increase is reported as the equivalent CO_2 removal. Carbon stock changes are converted to CO_2 emissions and removals by multiplying the net carbon stock change by 44/12 (the stochiometric ratio of CO_2 and C) and by converting the sign: a decrease in carbon stocks (negative sign) leads to an emission to the atmosphere (positive sign) and vice versa. Chapter 1 in Volume 4 in *2006 IPCC Guidelines* provides clear definitions of carbon pools (see Table 1.1). If national circumstances require modifications to those definitions, rationale and documentation should be provided for these modifications and on the criteria used to distinguish between carbon pools. It is *good practice* to provide such information on both the individual pools included in the reporting, and on the total carbon stock change of the five pools.

Decision 16/CMP.1 specifies that a Party may choose not to account for a given pool in a commitment period, if transparent and verifiable information is provided that the pool is not a source.[10] *Good practice* in providing verifiable information, which demonstrates that excluded pools, if any, are not a net source of greenhouse gases, can be achieved by:

- Representative and verifiable sampling and analysis to show that the pool has not decreased. It is *good practice* under this approach to measure the pool at enough sites, within regions, to provide statistical confidence, and to document the sampling and research methods;
- Reasoning based on sound knowledge of likely system responses. For instance, if cropland is converted to forest land by afforestation or reforestation, the dead wood pool cannot decrease, because there is typically no deadwood in a cropland (if it does not contain trees, e.g., if it does not contain any shelterbelts, was no orchard, and was no other agroforestry system);
- Surveys of peer-reviewed literature for the activity, ecosystem type, region and pool in question (for example, showing that in the climatic situation and with the soil types of the region, afforestation or reforestation of cropland leads to increases in soil organic carbon stocks); or
- Combined methods.

[10] See paragraph 21 in the Annex to the decision 16/CMP.1 (Land use, land-use change and forestry), contained in document FCCC/KP/CMP/2005/8/Add.3, p.3.

It is *good practice* to report, wherever it is applicable, levels of confidence in estimates that led to the exclusion of a pool, and how this level of confidence was established (see also Section 2.4.3 Uncertainty Assessment).

[Check if relevant information in the discussion of FM reference levels on included pools should also be covered in this section. Also still need to address issues arising from combination of pools and issues related to 'insignificant pools'.]

2.3.2 Years for which to estimate carbon stock changes and non-CO_2 greenhouse gas emissions

CMP decisions specify that the carbon stock changes for each unit of land subject to an Article 3.3 activity, and for lands subject to forest management and other elected activities under Article 3.4 be reported for each year of the commitment period[11], beginning with the start of the commitment period, or with the start of the activity, whichever is later. Decision 2/CMP.7 also requires that each area that was subject to reported activities during the first commitment period has to be reported during subsequent commitment periods and the associated emissions and removals estimated, even if the area is no longer subject to any Article 3.3 or 3.4 activity.

This means that if the activity started in 2014, then the carbon stock changes and greenhouse gas emissions should be reported for each of the remaining years of the commitment period. If the activity started after 1990 but before 1 January 2013, then reporting of the carbon stock changes and greenhouse gas emissions for the commitment period should cover each year of the commitment period, 1 January 2013 to 31 December of the last year of the commitment period. Where differences occur between the sum of the annual reports and the report for the entire commitment period, these should be addressed and reconciled at the end of the commitment period (see Sections 2.3.3, 2.4.1.1 and Chapter 5 of the *GPG-LULUCF*).

In summary, the area and associated carbon stocks changes and non-CO_2 emissions to be reported by Parties, each year, under each activity are:

- For afforestation/reforestation, deforestation and for forest management and wetland drainage and rewetting, when a "narrow" approach on the implementation of their definition is applied, the area to be reported under the activity is the cumulative area of units of land and lands subject to the activity since 1990; although for each unit of land and land carbon stocks changes and non-CO_2 emissions have to be reported only since the year of the onset of the activity or the start of the second commitment period - i.e. 1 January 2013 -, whichever comes later.

BOX 2.3.1
EXAMPLE

A Party had three deforestation events reported between 1990 and the last year of the second commitment period:

· the first occurred in 2005, i.e. before the start of the first commitment period - and it was 1,000 ha large,

· the second in 2010, i.e. during the first commitment period, and it was 2,000 ha large,

· the third in 2015, i.e. during the second commitment period, and it was 4,000 ha large.

This Party will report during the second commitment period:

· for the first two years, i.e. 2013 and 2014, the total area deforested until that date, i.e. 1,000 + 2,000 = 3,000 ha, and carbon stock changes and non-CO2 emissions that occurred on those units of land since the start of the second commitment period, i.e. 1 January 2013.

· for the remaining years of the second commitment period, the total area deforested until that date, i.e. 1,000 + 2,000 + 4,000 = 7,000 ha, and carbon stock changes and non-CO2 emissions that occurred since the start of the second commitment period, i.e. 1 January 2013, on the 3,000 ha plus carbon stock changes and non-CO2 emissions that occurred since 2015 on the 4,000 ha.

- For cropland management, grazing land management, revegetation and for forest management and wetland drainage and rewetting, when a "broad" approach on the implementation of their definition is applied, the area to be reported under the activity is the cumulative area of lands reported under the activity since the start of the first commitment period i.e. 1 January 2008; although for each land carbon stock changes and

[11] See paragraph 5 in the Annex to the draft decision -/CMP.1 (Article 7), contained in document FCCC/CP/2001/13/Add.3, p. 22.

non-CO_2 emissions have to be reported only since the year of the onset of the activity or the start of the second commitment period,i.e. 1 January 2013, whichever comes later.

BOX 2.3.2
EXAMPLE

A Party is reporting the entire national forest area as subject to FM. While there is no deforestation the area subject to FM is continuously increasing during the three first years of the second commitment period due to natural forest expansion, adding annually 1,000 ha year-1. The area reported subject to FM activity at the beginning of the second commitment period, i.e. 1 January 2013, is equal to 1,000,000 ha.

This Party will report during each year of the second commitment period an additional 1,000 ha of area subject to FM, so that at the end of:

· 2013 the area reported will be equal to 1,001,000 ha and associated carbon stocks changes and non-CO_2 emissions, since the beginning of the year, will be reported;

· 2014 the area reported will be equal to 1,002,000 ha: an initial area, 1,001,000 ha, subject to FM since 2013 and 1,500 ha of new forest area subject to FM for the first time in this year. For the initial area associated carbon stocks changes and non-CO_2 emissions, since 2013, will be reported. For the new area associated carbon stocks changes and non-CO_2 emissions, since the beginning of the year, will be reported;

· 2015 the area reported will be equal to 1,003,000 ha: an initial area, 1,001,000 ha, subject to FM since 2013, an additional area of 1,000 ha subject to FM for the first time in 2014 and a new forest area subject to FM for the first time in this year. For the initial area associated carbon stocks changes and non-CO_2 emissions, since 2013, will be reported. For the area added in 2014 associated carbon stocks changes and non-CO_2 emissions, since 2014, will be reported. For the new area associated carbon stocks changes and non-CO_2 emissions, since the beginning of the year, will be reported;

For each following year the Party will report lands and associated carbon stock changes and non-CO_2 emissions since the year in which have been reported under FM for the first time.

According to the hierarchical order adopted, countries must avoid any double counting of units of land and lands, and associated carbon stocks changes and non-CO_2 emissions, consequently the area of units of land and lands that during the first and/or the second commitment period experience a change of activity under which they have to be reported has to be subtracted from the cumulative area of the activity under which they were reported previously and added to the cumulative area of the activity to which they have been moved, and the associated carbon stocks changes and non-CO_2 emissions will be accordingly reported under the new activity.

Each activity (afforestation, reforestation, deforestation, forest management, cropland management, grazing land management, revegetation and wetland drainage and rewetting) may consist of a suite of practices and may begin with one or several of these. For instance, an afforestation programme may begin with planning, land purchase, producing propagation material etc. Operations like site preparation can also precede the planting or seeding (as a result of which the land actually becomes a "forest"). Some of these operations do not affect carbon stocks (e.g. planning), while others like site preparation may result in significant carbon, nitrous oxide or methane emissions. It is *good practice* to interpret the beginning of an activity as the start of *in situ* carbon stock change and/or non-CO_2 emissions due to any of the suite of the operations. For example, if an afforestation activity includes site preparation, then it is *good practice* to include carbon stock changes caused by site preparation. In order to do that, one can either a) measure the carbon stocks on the site prior to the start of any operations related to the activity (in case carbon stock changes are estimated using multiple stock measurements), or b) make sure that the estimate of the stock change includes an estimate of the emissions resulting from these initial operations.

2.3.3 Correct implementation of C stock change estimation methods when areas are changing

The carbon stock change method outlined by the *GPG-LULUCF* and the *2006 IPCC Guidelines* requires that the area for which carbon stock changes are estimated is constant over the assessment period. If the forest area is changing, for example as a result of deforestation, afforestation, or both, then carbon stock changes can occur as

a result of the transfer of land between UNFCCC or Kyoto Protocol reporting categories (see Figure 11 in Kurz et al. 2009 for an example). Several possible approaches can be implemented to address this issue.

To ensure that actual carbon stock changes are reported, and not artefacts resulting from changes in area over time, it is *good practice* to implement the calculations of annual carbon stock changes in the following sequence: for each activity, for each unit of land or land, the annual carbon stock change should first be calculated for the year of interest, and these stock changes should then be summed for all areas subject to the activity. The inverse sequence, i.e., first summing up the carbon stocks across all areas at times t_1 and t_2 and then calculating the difference in carbon stocks, can result in errors if the total area at times t_1 and t_2 is not the same; it is therefore *good practice* that area of each unit of land or land used in the calculation at times t_1 and t_2 is identical If the area subject to an activity increases from the beginning to the end of the reported year then the reported carbon stocks reflect the transfer of area (and the associated carbon stocks) into the land category; similary, carbon stocks will decrease, if area is removed from a land category[12]. The issue is of particular concern when areas outside the reporting system enter into the reporting system, such as unmanaged land areas, or areas subject to activities not elected by a country. For example the C stock increase in AR lands afforested on a land category not included in the reporting will yield an apparent increase in soil C stocks but this C was transferred from the other land category and does not contribute to C removals from the atmosphere.

It is therefore *good practice* to conduct all calculations of annual carbon stock changes and greenhouse gas emissions for the area at the end of the inventory year - i.e. the area at time t_2 in the equation 2.5 of Chapter 2, Volume 4, *2006 IPCC Guidelines*- and to use this approach consistently through time.

[12] Because of the obligation to keep reporting any area subject to any Article 3.3 or Article 3.4 activity at any point in time during commitment periods, a decrease of the area reported under an activity may only happen as a consequence of a transfer of area to another activity, e.g. decrease of area reported under forest management because of deforestation.

BOX 2.3.3
EXAMPLE

During a year of the commitment period the area of land reported under FM varies because new forest land is added to the FM area and because of deforestation activities:

	At the start of the year	At the end of the year
area of forest lands that was subject to FM in the previous year	1,000,000 ha	990,000 ha
area of lands subject to FM converted to non-forest land	0 ha	10,000 ha
area of **new** forest lands subject to FM	0 ha	10,000 ha
Total area subject to FM	1,000,000 ha	1,000,000 ha

The carbon stocks measured at times t_1 and t_2 in those lands are:

	At the beginning of the year	At the end of the year
average per hectare living biomass carbon stock of forest lands subject to FM	100 tC ha^{-1}	105 tC ha^{-1}
average per hectare living biomass carbon stock of **new** forest lands subject to FM	80 tC ha^{-1}	84 tC ha^{-1}
average per hectare living biomass carbon stock in deforested lands	100 tC ha^{-1}	20 tC ha^{-1}

A correct procedure will calculate stock changes in the three land categories:

- forest lands that were subject to FM since the beginning of the year,
- forest lands were the FM activity started during the year,
- forest lands subject to FM that were deforested and converted to cropland in the year.

Then, the sum of stock changes calculated for the two types of lands subject to FM will be reported under the FM activity, while the change in stock calculated for deforested land will be reported under D (Article 3.3).

A. Total stock-change in area subject to FM that was subject to FM in the previous year	990,000 ha * (105 – 100) tC ha^{-1} = 4,950,000 tC
B. Total stock-change in area subject to FM for the first time in this year	10,000 ha * (84 – 80) tC ha^{-1} = 40,000 tC
C. Total stock-change in deforested areas	10,000 ha * (20 – 100) tC ha^{-1} = -80,000 tC
Total stock-change in areas subject to FM (A+B)	4,950,000 + 40,000 = 4,990,000 tC
Stock change reported in FLCL under UNFCCC and in D under Article 3.3 (C)	-80,000 t C

It would be incorrect to calculate the total aboveground biomass carbon stock on total land subject to FM at times t_1 and t_2 and then subtract C_1 from C_2 e.g.

C_1 Total stock in land subject to FM at the beginning of the year	1,000,000 ha * 100 tC ha^{-1} = 100,000,000 tC
C_2 Total stock in land subject to FM at the end of the year	990,000 ha * 105 tC ha^{-1} + 10,000 ha * 84 tC ha^{-1} = 103,950,000 + 840,000 = 104,790,000 tC
C_2 - C_1 – yields the incorrect result	104,790,000 – 100,000,000 = 4,790,000 tC

Countries that use the IPCC default method need to ensure that, when land-use change events occur, the subsequent fluxes are reported in the new land-use category. Tier 3 models that carry the land-category as an attribute for reporting categories need to ensure that the land-category attribute is updated to reflect the subsequent land-use change prior to implementing any C stock impacts from the land-use change event (see Box 1 in Kurz et al. (2009) as an example of a Tier 3 modelling approach that implements the required land-use change prior to simulating any carbon stock changes associated with land-use changes).

2.3.4 Reporting and measurement intervals

The CMP decisions specify that all emissions by sources and removals by sinks caused by Article 3.3, forest management and elected Article 3.4 activities be reported annually.[13] A number of methods are available to obtain annual estimates and the annual reporting requirement does not imply that annual field measurements are necessary. This would be neither feasible nor cost-effective. In fact, although more frequent measurement will generally decrease uncertainties, the opposite can also happen because of short-term variability, as discussed in Section 2.3.9 (Interannual variability). Carbon stock changes for pools with high uncertainties, e.g., soil organic carbon, are usually not detectable on an annual or short-term basis. Broadly speaking, when countries are developing and selecting methods to meet their reporting requirements, they should seek a balance which is affordable, make best use of data that are already available, allow stock changes to be verified consistently with the approaches set out in Chapter 6, Volume 1, of the *2006 IPCC Guidelines* (Section 6.10 Verification), and not make inventories susceptible to the impacts of annual fluctuations in weather. Although Section 2.3.9 suggests that field data collection on a five-year cycle may represent a reasonable compromise, the re-measurement interval also depends on the pool and the magnitude of the expected changes relative to the spatial variability in the pool and the uncertainties involved in pool size assessments. For example, changes in soil carbon can often only be detected over longer time periods. Data already available annually, such as planting or harvest statistics, may be combined with measurements conducted over longer time periods – which are less affected by annual fluctuations – or with data based on a five-year running mean.

2.3.5 Time Averaging of Interannual Variability

The two primary sources of interannual variability in greenhouse gas emissions and removals in the LULUCF sector are natural disturbances (such as fire, insects, windthrow, and ice storms) and climate variability (e.g., temperature, precipitation, drought, and extreme events). Natural disturbances have large impacts per hectare in the areas where they occur, while climate variability typically causes small changes per hectare but can affect large areas (Kurz 2010, Richards 2010). The second source of interannual variability is the rate of human activities, including forest harvesting, land use, and land-use change. The methodology used to calculate reported emissions and removals affects the extent to which these sources of variability are captured in the reporting. Moreover, the impacts of natural disturbances and climate variability can obscure trends in the impacts of human activities. The provision in decision 2/CMP.7 that enables countries to exclude from the accounting

[13] Note that although annual reporting is required, countries have the option to account either annually or over the entire commitment period (cf. paragraph 8(d) in the Annex to draft decision -/CMP.1 (Modalities for the accounting of assigned amounts), contained in document FCCC/CP/2001/13/Add.2, p.59).

emissions from natural disturbances (see Section 2.3.9) removes some of the variability from indirect-human and natural factors.

Higher Tier methods are more strongly affected by interannual variability in non-anthropogenic drivers of greenhouse gas emissions and removals. This is because IPCC default data (including those contained in the Emissions Factor Database[14]) have been calculated by averaging data collected over time and space to estimate representative global, regional, and ecological factors. By averaging out time and space variability Tier 1 methods that use these IPCC factors do not reflect interannual variability from natural and indirect-human induced factors. In contrast, Tier 3 methods that use process models to calculate net primary production (NPP) and heterotrophic respiration (Rh) as a function of environmental variability can report the highest interannual variability in emissions and removals as a result of climate variability. Forest inventory-based modelling approaches that implement the IPCC default approach (stock gain and loss) and that use empirical yield tables, which are not affected by climate variability, report lower interannual variability in greenhouse gas emissions and removals but are affected by interannual variability in natural disturbances and human activity. Estimates of greenhouse gas emissions and removals derived from the stock change method (calculating the difference in C stocks estimated from forest inventories at two points in time) report the average annual net balance over the period between the first and second forest inventory. This approach averages interannual variability and also without additional information is not able to attribute observed emissions and removals to the drivers such as natural disturbances, environmental change or human activities.

It is *good practice* at Tier 3 to assess and document clearly the extent to which non-human factors influence the time series of reported annual greenhouse gas emissions and removals in the LULUCF sector. Measures to reduce the reported impacts of environmental variability include time-averaging of weather data over 5 or 10-year periods.

National reporting of greenhouse gas emissions and removals serves as the basis for assessing progress towards reducing emissions and the associated dangerous anthropogenic interference with the global climate system. However, because LULUCF inventories do not necessarily include all land areas which may include large tracts of unmanaged land (forests, grasslands and wetlands) and may not represent environmental variation or long-term trends, it is generally understood that they are not necessarily an accurate representation of the contribution of national terrestrial systems to the atmosphere. Reducing interannual variability of natural and indirect-factors improves the ability to assess the trends in emissions and removals from changes in human activities but reduces the accuracy with which these inventories report actual annual emissions to the atmosphere.

Methods used to reduce interannual variability also can help isolate the impacts of changes in human activities relative to a business-as-usual baseline. This can be achieved by calculating two time series of emissions and removal in which only the rate of human activities differ. For example, using Tier 3 models that are responsive to climate variability, two time series can be calculated *ex post*: first, the baseline emissions (with actual climate data, actual natural disturbance rates and business-as-usual human land use and land-use change and forest management data); and second the actual emissions (with actual climate data, actual natural disturbance rates but actual human land use, land-use change and forestry data). The difference between these two time series reports the impacts of changes in human activities because the impacts of interannual variability in climate and natural disturbances are the same in both scenarios and cancel each other out when calculating the difference between scenarios (Kurz 2010).

Reference levels and the provision to exclude emissions from natural disturbances introduced for Forest Management in Decision 2/CMP.7 can affect the extent to which interannual variability is reflected in the reported estimates of greenhouse gas emissions and removals. Countries that elect to exclude emissions from natural disturbances will reduce the interannual variability in reported emissions.

The impact of the use of reference levels on interannual variability will depend on the methods used to caluclate the reference level and the actual reported emissions. Countries could introduce large bias due to interannual variability in reported emissions if they use a reference level that was calculated with methods that are not responsive to environmental variability or with average climate parameters, but then calculate actual emissions with methods that are responsive to environmental variability or with actual climate parameters,. It is therefore *good practice* to use consistent methods to calculate both the reference level and the actual emissions. For example, if a technical adjustment to the reference level calculations using Tier 3 methods used the same interannual variability in climate parameters that are used in the calculation of the actual emissions, then the impacts of such interannual variability would cancel out in the difference between the two time series.

[Still need to check the above for consistency with the reference level discussion in the FM section, and need to further consolidate with Section 2.3.10]

[14] Emissions Factor data base: http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

1454

1455 2.3.6 Choice of method

1456 It is *good practice* to estimate carbon stock changes and non-CO_2 greenhouse gas emissions from Articles 3.3 or
1457 Article 3.4 activities using the methods set out in Volume 4 of the *2006 IPCC Guidelines.* For each unit of land
1458 under Article 3.3 or land under Article 3.4, it is *good practice* to use the same tier or a higher tier for estimating
1459 stock changes and greenhouse gas emissions as the one that was used for the corresponding land use in the
1460 UNFCCC inventory, following the guidance on methodological choice and identification of key categories
1461 included in Chapter 4, Volume 1, of the *2006 IPCC Guidelines*.

1462 Whenever a category is identified as key in the UNFCCC inventory, the associated activity under the Kyoto
1463 Protocol it is *good practice* to consider it as key in reporting under the Kyoto Protocol[15]. In the identification and
1464 documentation of key categories under the Kyoto Protocol it is also *good practice* to include a qualitative
1465 assessment, because there is not always an unambiguous correspondence between the UNFCCC categories and
1466 Kyoto Protocol activities. A country may also undertake Approach 2 (see Section 4.3.2 of Volume 1 of the *2006*
1467 *IPCC Guidelines*) to identify the key categories of their inventory including the Kyoto Protocol activities. The
1468 results of this assessment will in most circumstances result in fewer LULUCF key categories.

1469 Table 2.3.1 can be used to establish the relationship between land categories and Kyoto Protocol activities for
1470 purposes of identifying key categories under Articles 3.3 and 3.4 of the Kyoto Protocol.

1471

[15] This applies also when there only are partial overlaps with the UNFCCC inventory

1472

TABLE 2.3.1
RELATIONSHIP BETWEEN KYOTO PROTOCOL ACTIVITIES AND IPCC LAND CATEGORIES FOR LULUCF

1	2	3
Land categories of the *2006 IPCC Guidelines*	**Kyoto Protocol activities**	**Key category if item in Column 1 was identified as key in the analysis of the UNFCCC inventory[a]**
FOREST LAND		
Forest land remaining forest land (managed)	FM	
Land converted to forest land (managed)	AR	
CROPLAND		
Cropland remaining cropland	CM, RV, WDR	
Land converted into cropland	D[b], RV, CM, WDR	
GRASSLAND		
Grassland remaining grassland (managed)	GM, RV, WDR	
Land converted to grassland (managed)	D[b], RV , GM, WDR	
WETLANDS		
Wetlands remaining wetlands (managed)	RV, WDR	
Land converted to wetlands	D[b], RV, WDR	
SETTLEMENTS		
Settlements remaining settlements	RV	
Land converted to settlements	D[b], RV	
OTHER LAND[a c]		
Other land remaining other land	WDR	
Land converted to other land	D[b], WDR	

[a] Article 3.4 activities only when elected (except FM, which is mandatory)

[b] D only if Forest Land was the original land category

[c] Theoretically revegetation can occur in both subcategories.

FM: forest management, AR: afforestation and reforestation, CM: cropland management, D: deforestation, RV: revegetation,
GM: grazing land management, WDR: wetland drainage and rewetting

1473

1474 The left column lists the land categories of the *2006 IPCC Guidelines* that may have been used in the key
1475 category analysis of the UNFCCC inventory[16]. If any of these are identified as key, the Kyoto Protocol activities
1476 in the corresponding right column should initially be considered key. However, as in some cases several Kyoto
1477 Protocol activities potentially can be key, it is *good practice* to examine qualitatively which of the possible
1478 activities actually are key and when doing the assessment indicate so in Column 3 of a copy of Table 2.3.1. For
1479 example, if land converted to grassland was identified as key, this can involve deforestation, revegetation,
1480 grassland management, wetland drainage and rewetting, or land-use changes not covered by the Kyoto Protocol.
1481 The land area affected by revegetation or wetland drainage and rewetting may be much smaller than the land
1482 area of the land category in which it occurs. If this is the case, and if revegetation is identified as potentially key
1483 according to Table 2.3.1, then countries may separately assess the importance of greenhouse gas emissions and
1484 removals in revegetation compared to the other category (or categories). It is *good practice* to explain and
1485 document which of the potential key categories are finally identified as key for Kyoto Protocol reporting.

[16] If the analysis was based on the IPCC source/sink categories (1996) the transformation will be less precise. The mapping is shown in Chapter 3, Section 3.1. of *GPG-LULUCF*.

In addition, it is *good practice* to take into account the following considerations in the key category determination for estimates prepared under Articles 3.3 and 3.4 of the Kyoto Protocol:

- As shown in Table 2.3.1, several activities under the Kyoto Protocol can occur in more than one land category of the UNFCCC inventory. In such cases, it is *good practice* to consider the total emissions and removals from the activity for purposes of the key category analysis. When this approach is needed, an activity is considered key if the emissions or removals from the sum are greater than the emissions from the smallest category that is identified as key in the UNFCCC inventory (including LULUCF).
- If, when using the quantitative methods, a category is not identified as key for the present year but it is anticipated to increase strongly in the future, it is *good practice* to identify it as key. This could, for example, occur with a large-scale afforestation program producing only small sinks in initial years, but with the expectation of larger yields later.
- In some cases, it is possible that the emissions or removals from an activity under the Kyoto Protocol could exceed the emissions or removals of the associated category in the UNFCCC inventory. In such a case it is *good practice* to identify the Kyoto Protocol activity as key if its emissions/removals exceed the emissions of the smallest category that is identified as key in the UNFCCC inventory (including LULUCF).

It is *good practice* to determine for each key category, where relevant (see Table 4.1 in Volume 1 of the *2006 IPCC Guidelines*), whether any subcategories are particularly significant. Usually, for this purpose, the subcategories are ranked according to their contribution to the aggregate key category. Those subcategories that contribute together more than 60 percent to the key category are considered particularly significant. For example, if cropland management has been elected and is identified as key, it is *good practice* to identify which pools and subcategories are significant. It may be appropriate to focus efforts towards methodological improvements of these most significant subcategories.

Tier 1 as elaborated in Chapter 4 of the *2006 IPCC Guidelines* assumes that the net change in the carbon stock for litter (forest floor), dead wood and soil organic carbon pools is zero. However, paragraph 26 of 2/CMP.7 specifies that all changes be accounted in the following carbon pools: above-ground biomass, below-ground biomass, litter, dead wood, soil organic carbon and harvested wood products. With the exception of harvested wood products, a Party may choose not to account for a given pool in a commitment period, if transparent and verifiable information is provided that demonstrates that the pool is not a source. Therefore Tier 1 can only be applied if the litter, dead wood and soil organic carbon pools can be shown not to be a source using the methods outlined in Section 2.3.1. Tier 1 can also only be applied if forest management is not considered a key category, which can only be the case if "forests remaining forests" in Chapter 4 of the *2006 IPCC Guidelines* are not a key category.

2.3.7 Factoring out indirect, natural and pre-1990 effects

CMP decisions specify that information be provided whether or not anthropogenic greenhouse gas emissions by sources and removals by sinks from activities under Articles 3.3 and 3.4 factor out removals from elevated carbon dioxide concentrations above pre-industrial levels, indirect nitrogen deposition, and the dynamic effects of age structure resulting from activities prior to 1 January 1990.[17] In addition to the requirement to report whether or not these effects are factored out, those Parties that choose factoring out should also report the methods they used. For the purpose of accounting under the Kyoto Protocol "factoring out" has been addressed through a so-called net-net approach where net change in GHG emissions and removals are accounted by comparing GHG emissions and removals during the commitment period with a benchmark under either a base year or a business-as-usual scenario, which could also be a scenario in which emissions and removals are assumed to balance to zero.

2.3.8 Reference Levels

Decision 2/CMP.6 requests from each Annex I Party to submit information on Forest Management Reference Levels (FMRLs) and provides guidelines for the submission and review of information on FMRLs. Technically the FMRL is a level of greenhouse gases emissions and removals against which the net emissions and removals reported for forest management during the second commitment period will be compared for accounting purposes.

[17] See paragraph 7 in the Annex to draft decision -/CMP.1 (Article 7), contained in document FCCC/CP/2001/13/Add.3, p. 23.

It is *good practice* to construct FMRLs taking into account historical data from greenhouse gas (GHG) inventory submissions, age-class structure and the need to exclude removals from accounting in line with decision 16/CMP.1, paragraph 1. It is also *good practice* to take into account forest management activities which were already undertaken, projected forest management activities under a 'business as usual' scenario, and continuity with the treatment of forest management in the first commitment period where relevant. Finally, it is *good practice* to include pools and gases consistently in the construction of the FMRLs. Details of the methodology for determining FMRLs can be found in Section 2.7.5 of this document.

Decision 2/CMP.7 paragraph 14 requests methodological consistency between the FMRL and reporting for forest management during the second commitment period when accounting for forest management. According to paragraph 15 of that decision a technical correction shall be applied if the reported data on forest management or forest land remaining forest land used to establish the reference level are subject to recalculations. The standard method for ensuring consistency of time series is to recalculate the estimates using the same method for all inventory years. Thus, to ensure methodological consistency of the accounting of forest management, a technical correction may be needed to ensure that the same method and data are used for the construction of the FMRL and the reporting during the commitment period, or at least to remove the impact of any methodological inconsistency when accounting. Section 2.7.6 of this document describes how to detect the need for a technical correction, as well as when and how to apply a technical correction.

2.3.9 Disturbances[18]

The effect of disturbances in terms of emissions and removals is included in the discussion of generic methods set out in Chapter 2, Volume 4 of the *2006 IPCC Guidelines*. Examples of disturbance include fire, wind-throw, droughts, flooding, ice storms, geological events, pests and pathogens. Disturbances can be either natural, as in the case of volcanic eruptions; or human-induced, as in the case of some types of fires. In many instances the proximate cause of the disturbance may be unknown.

Under the UNFCCC, and in the first commitment period under the Kyoto Protocol, the effect of disturbances on managed land is included in reporting, irrespective of whether the disturbances are natural or human-induced. Emissions from disturbance on unmanaged lands are not included in reporting so long as these lands continue to be unmanaged. Decision 2/CMP.7 introduced a modification to this approach by which under certain conditions the effect of natural disturbances that occur on managed land may be excluded from accounting under the Kyoto Protocol during the second commitment period. This section addresses the consequences of this.

The size, intensity and frequency of the natural disturbance may depend significantly on the type of disturbance. While fire, wind and ice storms usually kill or directly damage vegetation, drought can reduce tree productivity (net primary production, or NPP) and CO_2 removals, and increase the vulnerability to other types of disturbance. For example, drought-related tree mortality increases forest flammability (for examples see Martin et al., 2010; Perry et al., 2011; Xaio and Zhuang, 2007). Insect outbreaks, which may be the major agent of natural disturbance in some regions, may be rather periodic, but the frequency and size is often erratic, and influenced by multiple factors (Fleming et al., 2002; McCullough, 2000; Rouault et al., 2006).

The impacts of natural disturbances of interest here include those that cause direct releases of carbon and non-CO_2 greenhouse gases to the atmosphere (e.g., from fires); those that redistribute carbon between ecosystem carbon pools (e.g., live biomass transferred to dead wood and litter); those that result in post-disturbance emissions (e.g., through the decay of residual biomass after a disturbance); and/or post-disturbance removals. In addition, there are some types of natural disturbance that change the structure and dynamics of the ecosystem in a way that influences greenhouse gas dynamics of the different pools. For instance, decay dynamics and carbon stock changes in both the soil and litter pools may change when mineral soil and litter are mixed as a result of a disturbance (e.g., wind-throw).

2.3.9.1 DEFINITIONAL ISSUES

For reporting and accounting under the second commitment period of the Kyoto Protocol, Decision 2/CMP.7[19] provides the following definition of natural disturbances:

"Natural Disturbances are non-anthropogenic events or non-anthropogenic circumstances. For the purposes of this decision, these events or circumstances are those that cause significant emissions in forests and are beyond

[18] References in this section are to paragraphs of Annex to Decision 2/CMP.7, unless indicated otherwise.

[19] Paragraph 1 (a) in the Annex to Decision 2/CMP.7 contained in the document FCCC/KP/CMP/10/2011/Add.1

the control of, and not materially influenced by, a Party. These may include wildfires, insect and disease infestations, extreme weather events and/or geological disturbances, beyond the control of, and not materially influenced by, a Party. These exclude harvesting and prescribed burning."

The list of examples provided in the Decision may be understood as follows:

- **Wildfires**: wildfires affect the ecological functioning of many forests. Wildfires can also have undesirable environmental, social and economic impacts. Fire regimes can have significant impacts on forest carbon stocks across considerable spatial and temporal scales (King et al. 2011). Recent studies on wildfires and forest include: Hirsch and Fuglem (2006); Williams and Bradstock (2008); Swetnam and Anderson (2008); Girardin et al. (2010).

- **Insect and disease infestations**: diseases and pest insects can play a role in ecological processes and substantially affect large-scale regional greenhouse gas balances (Kurz et al. 2008, Hicke et al. 2012). Outbreaks of forest diseases and pest insects can also have significant negative economic, social and environmental impacts on forested lands. Recent studies on insect and disease infestations on forest include: Canadian Council of Forest Ministers (2012a, 2012b and 2012c); Raffa et al. (2008); Bentz et al. (2010).

- **Extreme weather events**: extreme weather events include droughts, floods, snow, avalanches, ice, and strong winds. In some regions, extreme snow cover on forest canopies can damage forest stands due to heavy weights of wet snow accumulated on evergreen conifer tree canopies (Kato 2008). Other recent studies on extreme weather events and forests include: Linder et al. (2010); Yamashita et al. (2002); Allen et al. (2010); Kramer et al. (2008); Bebi et al. (2009); Phillips et al. (2009).

- **Geological disturbances**: geological disturbances include, volcanic eruptions, landslides, and earthquakes. Recent studies on geological disturbances and forest include: Kamijo and Hashiba (2003).

Decision 2/CMP.7 requires Annex I Parties intending to apply the provisions for natural disturbance to forest management under Article 3 paragraph 4, and/or to afforestation and reforestation under Article 3 paragraph 3 of the Kyoto Protocol to provide transparent information on, inter alia, "that the occurrences were beyond the control of, and not materially influenced by, the Party in the commitment period, by demonstrating practicable efforts to prevent, manage or control the occurrences that led to the application of the provisions contained in paragraph 33" of the Decision.

The demonstration of practicable efforts could include, but will not necessarily be limited to:

- Minimise the probability of the disturbance occurring, by modifying factors related to the occurrence or propagation of the disturbance. Actions taken in this regard may develop their full function only after an initial impact, e.g. thinning to increase stand stability against storm damages, prescriptive burning to reduce the amount of combustible material, introduction of firebreaks to make the spread of fire less likely;

- Manage the disturbance during its occurrence. This may be facilitated by the implementation of monitoring programs and early warning systems, integrated coordination with the fire squads, etc.

Depending on national circumstances, examples of transparent and verifiable information that demonstrates these efforts could include but will not necessarily be limited to:

- A national level policy statement, such as a national forest policy or fire management policy, which defines a national strategy for managing the types of natural disturbance which led the party to apply the provision for natural disturbance[20];

- Information which shows that the Party took practicable efforts to manage or control the individual disturbances included under the natural disturbance provision (for example, expenditure on the fire suppression effort and/or the incident management plans for the disturbance);

- Sub-national management plans or policy statements, which define a management strategy for managing the types of natural disturbance, which led the party to apply the provision for natural disturbance.

It is *good practice* to demonstrate that the implementation of the strategy has occurred or is in the process of being implemented when a country indicates its intention to apply the disturbance provision.

The disturbance provision recognizes that in some instances it may not be practicable to prevent, manage or control the disturbance. For example, it is unlikely that practicable efforts could be taken to prevent, manage or control volcanic eruptions that impact upon forests. Where such events or circumstances are included by a Party

[20] Paragraph 33 in the Annex to Decision 2/CMP.7 contained in the document FCCC/KP/CMP/2011/Add.1

under the natural disturbance provision, it is *good practice* to provide transparent and verifiable information that no practical action could be taken to prevent, manage or control the occurrences of the event or circumstance.

2.3.9.2 CHOICE OF METHODS FOR IDENTIFYING LAND SUBJECT TO NATURAL DISTURBANCE

Annex I Parties that choose to apply the natural disturbance provision outlined in Decision 2/CMP.7 need to be able to meet requirements set out in paragraph 34, (a) to (f) of the Annex to the Decision.

This includes "showing that all lands subject to paragraphs 33(a) and 33(b) are identified, including their georeferenced location, year and types of disturbances" (paragraph 34 (a)), and subsequent monitoring to identify any subsequent salvage logging or land-use change following a disturbance event or circumstance (paragraphs 34 (c) and (f)), and to be able to reflect the treatment of emissions and removals on these lands in LULUCF accounting for subsequent commitment periods (paragraph 36 of the Annex to the Decision).

This section provides guidance and provides examples to help Parties in their choice of approach for identifying lands subject to natural disturbance. It has linkages with Section 2.2 that addresses the area identification, stratification and reporting.

For lands subject to Articles 3.3 and 3.4, Section 2.2.2 outlines Reporting Method 1 and Reporting Method 2 (RM1 and RM2 respectively). These are reporting methods, and as discussed in Section 2.2.4 are not the same as the underlying methods used to identify land areas for greenhouse gas inventory purposes, though there are linkages between them. RM1 entails delineating areas that include multiple land units, assessing the respective contribution of relevant activities to the total emissions from these lands, and is often associated with the application of statistical sampling approaches to land identification. RM2 is based on the spatially explicit and complete geographical identification of all units of land subject to a single activity (or condition) and entails wall-to-wall mapping. Similarly, identification of lands subject to natural disturbance can be undertaken with statistical sampling approaches or via wall-to-wall mapping, which is frequently associated with the application of remote sensing techniques. Combinations of different sampling approaches may also be used in support of either reporting method.

Estimation of area requires that the:

i. Proportion of area affected by a disturbance is assessed accurately if RM1 is used and that each area affected by disturbances can be identified as being disturbed when RM2 is used, and

ii. Final determination of methods and algorithms used for disturbance and disturbance type detection are suitable for the identification and capture of disturbances affecting the minimum area as used in the Parties' e.g. forest definition as used in reporting under the Kyoto Protocol and that the respective area or areas of land can be identified in subsequent years. General guidance on this topic is provided in Chapter 3, Volume 4 of the *2006 IPCC Guidelines* and Fuller et al. (2003) discuss possible problems commonly occurring in this field.

Statistical sampling schemes do not delineate disturbed areas directly, but assess total disturbed area by way of the representativeness of affected sample plots (see general guidance on sampling and area estimation in Chapter 3, Volume 4 of the *2006 IPCC Guidelines*). Localisation of disturbance events is performed on a per-plot basis. Such sampling networks may be based e.g. on National Forest Inventory sampling grids, but capturing the effects of natural disturbances may require intensifications in space and/or time in comparison to the regular inventories, so that the uncertainty with which disturbance related emissions and removals can be estimated, expressed in percentage terms, is comparable with the uncertainty in estimating Art 3.3 and 3.4 forest related emissions overall.

When using remotely sensed data to detect changes in land use/land cover triggered by the occurrence of natural disturbances, a Party needs to identify the appropriate temporal, spatial, and spectral resolution of the data and to assess the need for complementary ancillary and/or ground data. The identification and assessment are specific to types of individual natural disturbance events or circumstances a country intends to consider. In addition, the timing of the analysis of the data is also relevant to, and may influence the uncertainty of the estimates. For instance, if the analysis of the data occurs shortly after the occurrence of a discrete disturbance event or circumstance, the estimate of the change on the ground is likely to have a reasonably high degree of certainty. Otherwise, the data may be confounded with land-use change, with annual phenological and climatic differences, and other factors that differ between the pre- and post-disturbance. It is therefore *good practice* to define the baseline conditions prior to the change that is captured, for instance, the variability in some types of remotely sensed data in the spectral response during wet and dry years so as to identify real changes due to natural disturbances and not to seasonal events. Other factors that need to be considered when using remotely sensed data relate to the magnitude of the change and the type of disturbance. Some types of disturbance may not be

identified with data of moderate spatial resolution, e.g., identification of areas affected by pest infestation, which may be related to the per cent cover of the damaged crowns.

Wall-to-wall mapping and statistical sampling schemes both have advantages and challenges. For example, wall-to-wall approaches based on remote sensing may not be able to distinguish clear-cut harvest from salvage logging, while systematic sampling grids of existing forest inventories may not have an acceptable sample size and sampling error or return interval in order to identify the affected area with an acceptable level of uncertainty or assign the year of disturbance. For both wall-to-wall mapping and statistical sampling techniques existing national approaches for land identification may need amendments and improvements in order to fulfil the requirement for identification of lands subject to natural disturbance including their georeferenced location, year and types of disturbances.

The choice of approach for land identification applied by a Party will depend on national conditions in land under forest management and/or A/R, the inventories already in place, and the type and magnitude of the disturbance(s) to be assessed (see Box 2.3.4 for further examples). It is therefore *good practice* for Parties to present information justifying the suitability of the inventory technique used to identify lands due to natural disturbance and on how the provisions concerning salvage logging and land-use change following such disturbances are monitored. It may also be possible to achieve the desired outcomes by other means, e.g. by amending an existing inventory scheme tailored to detect deforestation events in a way that it also assesses whether land-use change has occurred on previously disturbed lands, or by incorporating the detection of salvage logging in harvest records.

BOX 2.3.4

EXAMPLES OF APPROACHES FOR IDENTIFYING LANDS AFFECTED BY NATURAL DISTURBANCE

It is assumed that the wall-to-wall technique uses remote sensing.

Example 1: Repeated point-based inventory system

A Party conducts a forest inventory with permanent sample plots in a regular design and estimates both emissions and land-use changes based on the sample plots.

Inventory system requirements: design-based inference based on a permanent sample plot inventory with regular measurement intervals. Measurements must be able to allow the estimation of the parameters of interest such as disturbance type and year of occurrence.

Estimation method: the area affected by a disturbance and the respective emissions are estimated as the number of affected plots multiplied by the area and the area-specific emissions represented by a plot. The error associated with the estimate can be calculated by applying standard sampling theory (provided inChapter 2, Volume 1 of the *2006 IPCC Guidelines*). In case the area-specific emissions vary then the estimation can be done by establishing strata of different emission intensities within which the emission intensity is about the same.

The potential challenges: the potential challenges of this approach include a large percentage sampling error associated with rare disturbance events unless the sampling grid is intensified. If these affect only small areas they may not meet the criteria for exclusion. For larger rare events (rare in time, not necessarily rare in space), where the sampling error needs to be reduced in order to meet the criteria for exclusion, additional sampling points may be established in the areas of concern. When the regular inventory return interval is not sufficient to assign a year (e.g. for wind-throw), additional field visits or other data/methods may be required. Similarly, field visits may be needed in order to monitor the absence of subsequent land-use changes or salvage logging (within a single commitment period) on sites where the emissions and removals are excluded from accounting.

Example 2: Direct estimation of land areas (wall-to-wall mapping based system)

Example: A Party uses remote sensing data or a complete cadastral land register for land use and land-use change estimation.

Requirements: This approach requires full coverage remotely sensed data with an appropriate resolution combined with appropriate classification algorithms and estimators or a complete cadastral land register containing land-use information. Classification algorithms and estimators have to be developed and validated by field observations in case remotely sensed data are used or a system to track changes in land-use or the conditions on each cadastral land unit has to be implemented. For fire monitoring, an alternate approach is to use a two-stage process: first detect and record hot spots (using coarse resolution satellites), and second use higher resolution remote sensing products from satellites or aircraft to map the extent of the burned area.

Estimation method: The total area affected by a disturbance is the sum of areas classified as affected by the respective disturbance or disturbance type. Emissions from a disturbance type are also added up for the total area concerned.

The potential challenges: All classification and mapping algorithms based on remote sensing data will have an associated error. For some disturbance types this error is low (e.g. forest fires), while for others it may be high, e.g. disturbances that cause dispersed single tree mortality over large areas, such as Ash dieback[21]. Another challenge is the validation of algorithms and the decision on acceptable levels of errors.

Example 3: Repeated point-based inventory system combined with remote sensing

Example: a Party conducts a forest inventory with permanent sample plots in a regular design and uses remote sensing data for stratification (or a similar small-area estimation method).

[21] *Chalara fraxinea*, a fungus affecting ash trees in Europe

Inventory system requirements: design-based inference based on permanent sample plot inventory with regular measurement intervals and full coverage by remotely sensed data with an appropriate resolution combined with appropriate classification algorithms.

Estimation method: The area affected by a disturbance is estimated on the basis of remote sensing-based strata, while the actual affected area is a stratified estimate based on the sample plots that fall within the disturbance strata from the remote sensing data. The strength of this method is that it potentially allows for an accurate estimation of both emission and affected areas with lower levels of errors than in either example 1 or 2 above.

The potential challenges: The potential challenge of this approach is that it requires very extensive and cost intensive systems that require both thorough remote sensing and ground-based inventory systems.

Example 4: Remote sensing and additional field inventory

Example: A Party uses remote sensing data for land use and land-use change estimation and additional measurements for some disturbances, e.g. identification of defoliator-caused tree death.

Requirements: This approach requires full coverage by remotely sensed data with an appropriate resolution combined with appropriate classification algorithms and estimators. Classification algorithms and estimators will need to be validated with field observations. Field inventories must be suitable to capture the information needed on the disturbance type in question.

Estimation method: The total area affected by a disturbance is the sum of areas classified as affected by the disturbance. Total emissions are calculated in a similar fashion.

The potential challenges: All classification and mapping algorithms based on remote sensing data will have an associated error. For some disturbance types these errors are low (e.g. forest fires) while for others it may be high. Another challenge is the validation of the algorithms and decision on acceptable levels of errors.

2.3.9.3 GENERAL GUIDANCE ON ESTIMATION OF CARBON STOCK CHANGES FROM NATURAL DISTURBANCES

The methods to estimate carbon stock changes in the relevant pools under the Kyoto Protocol are given in the *2006 IPCC Guidelines* and are elaborated in Chapter 4, Volume 4 for above and below-ground biomass, dead wood, litter, and soil organic matter.

With respect to natural disturbance, projected reference level accounting rules are applied as stated in Decision 2/CMP.7, therefore, information on carbon stock changes due to natural disturbances may be required for constructing a background level (see Section 2.3.9.7 below).

Land subject to natural disturbance is land that has already been identified as land under forest management or afforestation and reforestation. The estimation of carbon stock changes due to natural disturbance should therefore be consistent with or complement the Tier level and method applied for each of the pools under the respective activities. There are particular considerations in relation to the estimation of carbon stock changes where a country applies the provision for natural disturbance and also for the selection of Tier levels for forest management and afforestation and reforestation:

- Under Tier 1, the assumption is that the net carbon stock change in dead wood and litter is zero. Decision 2/CMP.7 specifies that the carbon stock change in all pools must be accounted for unless the pool can be shown to not be a source. Although lands affected by disturbance may be excluded from accounting in the second commitment period, they need to be reflected in the accounting of subsequent commitment periods and as natural disturbances may transfer significant amounts of carbon to the dead wood and litter pool, which will then decay, it becomes less likely that a Party could subsequently show that these pools are not a source;
- Countries experiencing significant changes in disturbance regimes in their forests (which would be the case if major disturbance events occur) are encouraged to develop domestic data to quantify the impacts from these changes using Tier 2 or 3 methodologies (Section 2.2.1, Volume 4 of the *2006 IPCC Guidelines*);
- It is *good practice* to apply Tier 2 or 3 to estimate carbon stock changes from natural disturbance for forest management where the 'Forest land remaining Forest land' category under the UNFCCC is a key category

and similarly for afforestation and reforestation if the 'Land converted to Forest land' category under the UNFCCC is a key category (Chapter 4, Volume 1of the *2006 IPCC Guidelines*);

- For natural disturbances that occur during the commitment period, reporting (and potential exclusion) of units of land as being subject to natural disturbances should begin at the beginning of the year in which the natural disturbance commences. Carbon stock changes during the commitment period associated with the disturbance and post disturbance carbon stock changes are subsequently included under land subject to natural disturbances, provided all the conditionalities are met;
- Where salvage logging occurs on land subject to natural disturbance, the carbon stock change due to salvage logging must be separately reported (cf. paragraph 34 (f) of Decision 2/CMP.7). For the purposes of the natural disturbance provision, the carbon stock changes due to salvage logging are those that occur as wood removals. The carbon stock change due to wood removals is treated as a loss of carbon from the land in the year the salvage logging occurs, subject to the harvested wood provisions on Decision 2/CMP.7 where wood derived from salvage logging can be shown to enter HWP pools;
- Management activities that are similar to and thus can be confused with natural disturbances (e.g. prescribed burning can be similar to areas affected by wildfire, and clear-cuts can be difficult to distinguish from wind damaged areas after salvage logging) have to be differentiated in the accounting from natural disturbances. Emissions from such management activities should not be accounted under natural disturbances and double accounting has to be avoided.

Consistent with Tier 2 and 3 methods, it is *good practice* to reflect the effect of different natural disturbances on carbon stocks under the respective conditions. Methodologies should represent the effect of the particular natural disturbance event or circumstance on the carbon stocks on the land affected by natural disturbance. The effects which should be considered include: direct release of carbon and non-CO_2 greenhouse gases to the atmosphere (e.g., during wildfires); the transfer of carbon between pools (e.g., transfer of living biomass to the dead wood and litter pools due to wind-throw); particular post-disturbance emissions dynamics (e.g., through the decay of dead wood and litter post disturbance, and changes in post disturbance decay rates); changes in post disturbance stand dynamics that affect the growth rate of the forest (e.g., early rapid growth in young trees that regenerate after a stand replacing fire). These effects will require appropriate stratification to adequately represent the disturbance types, ecosystems and affected parts of ecosystems, and land use history; and appropriate estimation of emission factors, decomposition rates and other factors and functions involved that are representative of the disturbance event.

It is *good practice* to provide transparent information on how the emissions from natural disturbances have been estimated during the commitment period. This includes but is not limited to the use of disturbance matrices[22] (Section 2.3.1.1, Volume 4 of the *2006 IPCC Guidelines*). For each disturbance type, disturbance matrices define the impact of the event on the proportion of each carbon pool that is transferred to another pool, released to the atmosphere, or removed from forest in salvage logging and entering the carbon pool of harvested wood products.

REMOVALS

Removals on lands previously disturbed can be estimated using the methodologies for forest land, reforestation or regeneration, taking account of the conditions found following the disturbance. For example, if a disturbance results in the loss of all old, large trees but leaves younger age classes intact, estimation methodology for forest management may well be appropriate. In case a disturbance results in bare ground without vegetation cover left and without seed-bank (e.g. after landslides or extreme flooding), it is *good practice* to apply methods oriented towards revegetation assessments rather than to use methods oriented towards reforestation or forest management that are less suited to capture the specific situations of a disturbed site. In cases like this, it is also *good practice* to show how the lands still fulfils the forest land definition set by the Party.

GUIDANCE ON MONITORING LANDS AFFECTED BY NATURAL DISTURBANCE

Forest lands that have been designated as affected by natural disturbance should be monitored over the commitment period using methods consistent with those used for identifying emissions from these areas. This will be done to:

- estimate changes in carbon stocks including the effect of rehabilitation;
- provide data to input to national statistics on disturbance over time to include the local disturbance type, area, strength etc. and ensure continuity and consistency;

[22] A description of disturbance matrices and their use in greenhouse gas accounting can be found Kurz, et al (2009).

- estimate changes in the vegetation health/density after the disturbance;
- identify lands where the land-use is changed after a natural disturbance from forest to any other land-use and that are therefore to be considered "deforestation" lands;
- identify lands where salvage logging has occurred, and its extent

2.3.9.4 SPECIFIC GUIDANCE ON ESTIMATION OF CARBON STOCK CHANGES FROM NATURAL DISTURBANCES

Estimation of the effects of natural disturbances requires the consideration of specifics such as:

- Attribution to individual years, (natural disturbances may be extended over several successive years or one disturbance after another);
- The legacy effects that can continue over several years;
- Effects that can be very variable over space and time, making it hard to distinguish natural disturbances from other events.

It is *good practice* to estimate carbon stock changes from natural disturbance in a manner consistent with the other forest management and afforestation and reforestation estimates for reporting under the Kyoto Protocol, and in a way that legacy effects and spatial incidence from natural disturbances can be identified and integrated into estimates for future years, so that accounting can reflect them correctly. This can be achieved by ensuring that the stratification, activity data, the emissions and removals factors and other parameters used for estimates of carbon stock changes in years beyond the date of occurrence reflect the spatial and time incidence of the natural disturbance.

The incidence of natural disturbances varies both spatially and temporally. Spatial variability refers to the distribution, intensity and the size of the areas affected by disturbances: the impact of a disturbance (e.g., a strong wind and/or insect attack) could be concentrated in a large and continuous forest area; or spread across small-discontinued areas; with either homogeneous or heterogeneous intensity. It is *good practice* to stratify the impacted forest area in terms of disturbances types and damaged intensity, and account for carbon stock changes for different strata.

Temporal variability refers to the occurrence of natural disturbances over time and the extension of post-disturbance effects over time. Direct releases of carbon to the atmosphere (e.g., during fires) or transfers of carbon out of the ecosystem (e.g., during harvest or landslides) are assumed to occur and be accounted for in the year of the disturbance. However, when natural disturbances redistribute all or a part of carbon among carbon pools, it is *good practice* to estimate these legacy emissions, while avoiding double counting. For example, if a large amount of live biomass damaged during disturbances is transferred to dead wood and litter (i.e. the dead organic matter, or DOM pool), post-disturbance emissions from DOM through the decay process will extend over a period of time, and need to be accounted for and attributed to individual years following the natural disturbances. In case of disturbances lasting more than one year, it is *good practice* to account for both the direct carbon emissions in the year they occur and legacy emissions in the subsequent years. Parties are encouraged to use higher Tier methods and country-specific factors (as discussed in Section 2.3.2, Volume 4 of the *2006 IPCC Guidelines*) for this purpose.

Disturbances types such as forest fire, windfall and floods in most cases can be clearly attributed to individual years because the disturbing event or circumstance occurs during a short period of time. Other natural disturbances such as droughts, insect infestations and diseases can lead to a continuous decline in vitality and complicate the determination of the year of disturbance. Affected areas that progressively increase over time can also be difficult to attribute to individual years. Examples are wind-throw areas where the initial impact has left stands susceptible to further wind-throw or outbreaks of insect infestations. It is, therefore, *good practice* to use the onset of transfers of carbon from the living biomass to DOM pools as onset of emission release, and to regard the respective year as the year of a specific event. It is also possible to represent an insect infestation as a series of annual disturbance events, for example repeated annual defoliation of forests will lead to cumulative impacts on growth reduction, mortality and subsequent emissions (e.g. Dymond et al. 2010).

Remote sensing or ground-based assessments that focus on the disturbance event can be helpful for addressing spatial variability and attributing carbon stock changes due to natural disturbance to individual years. Since these assessments are resource intensive, and other relevant statistics that record, for example, the salvage cuttings on an annual basis may also be relevant.

Emissions from salvage logging are to be associated in reporting with the disturbance event to assure proper attribution of the emissions associated with the disturbance. Therefore, it is *good practice* to assign harvests to

the year when they take place in case that harvests are a part of forest health measures to prevent the spread of insect or disease infestations, or a part of measures to improve rehabilitation following a disturbance event. Similarly, fellings to create fire breaks during a forest fire should be attributed to the fire disturbance and the year when it occurred.

2.3.9.5 GENERAL GUIDANCE ON ESTIMATION OF NON-CO_2 GREENHOUSE GAS EMISSIONS FROM NATURAL DISTURBANCES

As Section 2.3, Volume 4 of the *2006 IPCC Guidelines* specifies, losses in carbon stocks or pools may in particular cases imply emissions of non-CO_2 greenhouse gases like CO, CH_4, N_2O and NOx. Typically, emissions of these gases occur due to fires, for which the estimation methodology is provided in Section 2.4, Volume 4 of the *2006 IPCC Guidelines*. Here, guidance for both CO_2 and non-CO_2 greenhouse gases is given, which should be applied together with land-use specific enhancements in Chapter 4 (Forest Land), Volume 4 of the *2006 IPCC Guidelines*.

Note that the non-CO_2 greenhouse gases include methane and carbon monoxide whose emissions may also occur due to natural disturbances and that contain carbon. In order to avoid omissions or double counting of the amount of carbon, it is *good practice* to check for complete coverage of CO_2 and non-CO_2 greenhouse gas emissions due to losses in carbon stocks or pools.

Non-CO_2 greenhouse gas emissions are estimated e.g. for all fire situations. If fire in forests contributes significantly to net greenhouse gas emissions, it is *good practice* to apply higher Tiers and that countries develop a more complete and country-specific methodology which includes the dynamics of dead organic matter and improves the estimates of direct and post-fire emissions.

2.3.9.6 GUIDANCE ON THE EXCLUSION OF EMISSIONS DUE TO NATURAL DISTURBANCES FROM ACCOUNTING

If a Party intends to exclude from accounting emissions from natural disturbances that in any single year exceed the forest management background level plus margin if needed, it may do so by excluding the appropriate amount of emissions resulting from one or more natural disturbance types on geo-referenced land, depending on the type of the method used to develop the background level (see Section 2.3.9.7). The amount excluded can be simply a certain portion of all emissions due to natural disturbances, or total emissions from a subset of all events due to natural disturbances in the inventory year on geo-referenced lands subject to one or more natural disturbance types.

Subject to the conditionalities discussed below, a Party may exclude from the accounting for forest management, either annually or at the end of the second commitment period, emissions from natural disturbances that in any single year exceed a level of emissions called the forest management background level, plus a margin where needed (see below in Section 2.3.9.7)[23]. Parallel provisions apply to afforestation and reforestation, taken together. A Party may choose to exclude natural disturbances in forests subject to forest management under Article 3.4, or in forests resulting from afforestation and reforestation under Article 3.3 of the Kyoto Protocol, or both. A prerequisite for developing the background levels and the margin, if needed, is that their application should avoid the expectation of net credits or net debits.

A Party is required to indicate in time in its national inventory greenhouse gas report for 2015 whether it intends to apply the disturbance provision for forest management, and/or for afforestation and reforestation. It is *good practice* for Parties to report in time for its inventory report for 2015 one or more specific types or combined types of natural disturbances it intends to be able to exclude from accounting of emissions from natural disturbances and the combined background level associated with these disturbances.

In developing the amount of emissions to exclude, and in identifying years when emissions can be excluded, it is *good practice* to estimate and report, for all land under forest management and for all land under afforestation and reforestation, emissions from each chosen type or combined types of natural disturbances on all areas affected (estimated and reported separately by areas of land for forest management and units of land for afforestation and reforestation) in the inventory years.

[23] Paragraph 33 (a)

It is *good practice* to provide transparent and verifiable information on how the emissions exceeding the background level and the margin, if needed, have been estimated for each chosen type or combined types of disturbance concerned, how estimating emissions from different types or combined types of disturbances has been achieved, and how this is considered in subsequent years of the commitment period.

CONDITIONALITIES RESTRICTING POSSIBLE EXCLUSION

Even if the background level (plus a margin if needed) are exceeded, emissions from natural disturbances may only be excluded from accounting provided paragraphs 33 (a) and 33 (b) in Decision 2/CMP.7 are met for which country specific information should be provided on:

- How the background level for each chosen type or combined types of disturbances has been estimated, and how the margin has been established[24], if a margin is needed; or
- If the background and margin if needed has not been used, what other methodologies have been applied to avoid the expectation of net credits or net debits during the commitment period.

Furthermore, prior to exclusion from accounting, country specific information should be provided on:

- All lands subject to paragraph 33(a) and (b) of the Decision 2/CMP.7 should be identified, including their geo-referenced location, year and types of disturbances[25];

And in addition information should be provided demonstrating that:

- The occurrences were beyond the control of, and not materially influenced by, the Party in the commitment period[26];
- Efforts have been taken to rehabilitate, where practicable, the land for which emissions are intended to be excluded[27];
- How annual emissions resulting from disturbances and the subsequent removals in those areas have been estimated[28];
- No land-use change has occurred on lands where the Party intends to exclude emissions[29];
- The Party has explained the methods and criteria for identifying any future land-use changes on those land areas during the commitment period[30];
- Emissions associated with salvage logging from areas subject to natural disturbance are estimated and not excluded from accounting[31].

It is *good practice* to report how all of the above criteria are met, based on the guidance in this chapter and any additional reporting guidance to be developed.

2.3.9.7 GUIDANCE ON THE DEVELOPMENT OF THE BACKGROUND LEVEL AND MARGIN

INTRODUCTION TO THE BACKGROUND LEVEL

The background level, and where needed a margin, are used in order to be able to exclude from accounting emissions associated with natural disturbances above the background level plus the margin, where a margin is needed. In developing the background level the main aim is to avoid expectation of net credits or net debits during the commitment period from applying the disturbance provision. Hence, it is *good practice* to ensure consistent treatment of emissions associated with natural disturbance and the forest management reference level

[24] Paragraphs 33 (a), 33 (b), and also footnote 8 to paragraph 33(a)

[25] Paragraph 34(a)

[26] Paragraph 34(d)

[27] Paragraph 34(e)

[28] Paragraph 34(b)

[29] Paragraph 34(c)

[30] Paragraph 34(c)

[31] Paragraph 34(f)

(FMRL). For this, it is *good practice* to establish and report whether emissions from natural disturbances (by disturbance type) are implicitly included in the FMRL or not.

If a Party intends to apply the natural disturbance provision in accordance with Decision 2/CMP.7, country-specific information on a background level of emissions associated with natural disturbance is to be provided in the national greenhouse gas inventory report for 2015. The background level and the margin, where a margin is needed, should be separately developed for forest management, and for afforestation and reforestation (AR), taken together.

Decision 2/CMP.7 allows for different methods to establish the background level. The default method is an iterative process first to exclude statistical outliers from the historical time series of emissions associated with natural disturbances, and then to calculate the mean of the remaining emissions data. Alternative methods involve country-specific approaches.

For both the default and alternative methods, Decision 2/CMP.7 requires that the background levels are constructed using consistent and initially complete time series. For the default method, this series should contain 1990–2009 emissions associated with natural disturbances, whereas for the alternative methods, a consistent and initially complete time series of data including, but not limited to, the period 1990–2009 is required[32]. As Decision 2/CMP.7 requires development of separate background levels for FM and AR, there may be separate time series for FM and for AR.

If a Party does not have a time series of emissions from the disturbance types that it wishes to exclude, if they are not implicitly included in the forest management reference level, then the background level and the margin are zero. If they are implicitly included, for example because a certain level of emissions from fire, wind-throw or pest damage is implicitly estimated in establishing the FMRL then it is *good practice* to establish what the background level is that is implicitly included. The implicit background level needs to be established for a certain type of disturbance, or shown to be zero, for a type of disturbance to be excluded.

The approach for developing the background level and the associated documentation will depend on national circumstances. Guidance on the development of the background level and the margin, if needed, is given by means of the stepwise procedure (Step 1-5) outlined below.

STEPWISE GUIDANCE ON DEVELOPING THE BACKGROUND LEVEL

Step 1: Define the type of disturbances that the country plans to exclude from accounting

It is *good practice* for Parties to define the disturbances that they plan to exclude and are explicitly or implicitly included in the background level. These types of disturbances can be one or more (for example fires, fires and pest outbreaks).

Step 2: Establish a consistent and initially complete time series of data including the period 1990–2009

Having defined the relevant disturbance types in Step 1, it is *good practice* to sum the emissions from all of these disturbances in each year of the historical time series in the period 1990 to 2009, and to construct the background level and the margin, if needed, using this combined time series.

If emission data are missing for one or several years for a disturbance type, it is *good practice* to apply one of the methods described below to fill gaps.

- If the historical time series contains data for most but not every year during the period 1990-2009, data from a number of other years equivalent to the number of years where no data are available, for which information on all disturbance types is available before or after the calibration period and closest to it should be used to fill in gap(s).
- In case the country has data for most but not all years within the period 1990 to 2009, and there are no data available from before or after this period, it is *good practice* to use all data available, and to apply proxy data or additional information, including expert judgment, to develop data for the missing years.
- If the country has data only for a few years for the period of 1990-2009 (e.g. only for the second part of the period), or if there are no historical estimates of emissions and removals associated with natural disturbances, the country may still be able to construct a time series if reliable information, or proxy data, are available, in an appropriate and consistent historical time series that are related to the impacts of natural disturbances on the forest. This information may include defoliation rates, or mortality rates associated with a specific pest

[32] Footnote 7 to paragraph 33(a)

(possibly by age classes) etc. In such cases, an appropriate and transparently demonstrated model is also necessary to develop the level of emissions associated with the occurrence of such defoliations or pests. It may also be possible to use modelling approaches to derive the estimates of historic emissions associated with natural disturbances.

Step 3: Establish whether the disturbances for potential exclusion are included explicitly or implicitly in the background level

- It is *good practice* for steps 1) and 2) to be undertaken by, or coordinated with, the experts and institutions responsible for developing the forest management reference level. In general if the background level of disturbances relevant to a country is not explicitly included in the FMRL it can be assumed to have been implicitly included because otherwise the FMRL will not be representative. The ability of models used to construct FMRLs to reproduce historical forest management emissions and removals, which is a requirement discussed in the Section 2.7.5, is therefore evidence of implicit inclusion in cases where background levels of disturbance have not been explicitly included.

Decision 2/CMP.7 requires separate time series for forest management, and for afforestation and reforestation taken together. If the required historic time series of emissions associated with natural disturbances is not available for one of the above activities, country-specific methods can be applied using emissions from natural disturbances on land under the other activity as a proxy to estimate the missing information provided that it is transparently demonstrated how the emissions in the activities forest management, and afforestation and reforestation are related, and that the method avoids estimating emissions that may not be characteristic of that activity. For example, a country may not have estimates on emissions from natural disturbances on land under afforestation and reforestation and wants to relate them to emissions from natural disturbances on forest management land. In this case, it should be demonstrated for each disturbance type that the emission rates on forest management land are age-independent, or are otherwise independent from the differences in species, size, density etc. that may occur between the forests on afforestation and reforestation land and those on forest management land.

If the land area is significantly changed between the calibration period and the reference period, the historic time series of emissions related to natural disturbances for forest management land and/or afforestation and reforestation land may not represent the same area as in the commitment period. This is most likely for afforestation and reforestation land where area can continuously and substantially increase after 1990. If the area changes, it is *good practice* to correct the background level according to the guidance given under Step 4. An example of an approach for adjusting for changes in land area is illustrated in Box 2.3.5.

BOX 2.3.5:
APPROACH FOR ADJUSTING FOR A CHANGE IN AREA BETWEEN COMMITMENT PERIOD AND HISTORIC DATA

An adjustment for a significantly changed area between the historic time series and the commitment period may be required. The adjustment for each year in the historical time series is done by dividing the annual emission by the area in that year and multiplying the result by the area in the last year of the calibration period:

$$E_{i,a} = (E_i / A_i) \cdot A_l$$

where:

$E_{i,a}$ = adjusted emission for year i

E_i = unadjusted emission for year i

A_i = area of land in the category for year i

A_l = area of land in the category for the last year of the historical dataset

i = 1990 to 2009, or other years for which emissions data are available.

Similar adjustment may be needed during the commitment period if the area under the respective activities considerably changes relative to the area of land in the category in the last year of the historical dataset (see Step 4).

Note that the above approach assumes that the probability of natural disturbances to occur in the various above areas is the same. However, if this is not the case (e.g. if an area highly prone to natural disturbances has been disturbed and excluded, and the remaining areas are not so prone to natural disturbances), the country may apply a different but transparent method to adjust for the different areas.

Emissions from salvage logging and emissions from land subject to land use change following a disturbance are to be accounted for[33]. These emissions are estimated in the commitment period in order to apply the provision but may not be known for the calibration period[34], either because they have not been estimated (no data concerning disturbance-related emissions have been collected) or because they have not been identified and emissions e. g. from salvage logging have been included in FM reporting. In this case, the time series of emissions that can be used to develop the background level may thus include emissions from these sources. Correct accounting can be achieved by (1) separately estimating and including these emissions in both the background level and the actual emissions in the commitment period, and (2) adding emission from salvage logging and emissions from land subject to land use change to the other emissions and removals of FM and AR, respectively, so that they are also accounted for.

In all cases, it is *good practice* to report on how the country has estimated the emission data in the time series.

Step 4: Develop the background level by applying the default or an alternative method

Once the appropriate historic time series has been obtained, the Party can apply the default or an alternative method (see description below) in order to obtain the background level. It is *good practice* that a Party reports whether it applies the default method or an alternative method, and in the second case whether a margin is required. In choosing the method, it is *good practice* that the resulting natural disturbances background level is consistent with the one included (inherently or explicitly) in the forest management reference level already reported, and corrected if necessary as discussed below.

The method to develop the background level and the margin may have a significant effect on the frequency of the years when emissions may be excluded. If the sum of the background level and the margin is high, years when emissions are higher than this sum will be rare, whereas when this sum is low, years with emissions from natural disturbances higher than this sum will occur frequently. Note that in years when emissions are excluded by a Party, the Party must identify land where natural disturbances have occurred, calculate all emissions and

[33] Para 33(c) and (d), respectively

[34] This is due to the high variability of these emissions and the fact that these emissions may be de-linked from the total emissions from natural disturbances.

removals subject to the provisions on natural disturbances, and provide transparent information on a number of other issues related to these emissions as detailed above[35].

The default method

The *default method* involves the application of the following steps:

(1) Calculate the arithmetic mean of the annual emissions for the calibration period.

(2) Calculate the standard deviation (SD) of the mean for the calibration period. As the size of the historical time series is usually small (the number of data points, N, is less than 30), it is *good practice* to apply the following formula:

EQUATION 2.3.1
CALCULATION OF THE STANDARD DEVIATION OF THE MEAN FOR THE CALIBRATION PERIOD

$$SD = \sqrt{\sum_{i=1}^{N} (x_i - X)^2 \Big/ (N-1)}$$

where

x_i = the emission or removal estimate for year i, i= 1, 2…, N where N is the number of data points (years in the calibration period).

X = the average of all x_i.

(3) Check whether any data points are greater than the mean plus twice the SD, or smaller than the mean minus twice the SD. In case there is one or more such data points ("outliers"), remove them from the dataset and the subsequent calculations, and go back to step (1) above using the reduced dataset.

1. In case there are no (or no more) outliers, the background level is equal to the mean calculated in the last step, and the margin is equal twice the SD calculated in the last step.

An example of the application of the default method is found in Box 2.3.6, Example 1.

Alternative methods

Possible alternative methods are country-specific. It is *good practice* that these methods are based on a consistent and initially complete time series of data including the period 1990–2009 (Step 2 above) and that the application of these methods will avoid the expectation of net credits or net debits.

Alternative methods include those that apply different approaches to exclude outliers, and that set the background level that is not equal to the average of the dataset (excluding outliers) during the calibration period. Such levels can e.g. be the lowest historical annual emission, a value between this and the average of the historical dataset (excluding outliers), or a background level of zero. These approaches may require a margin of zero. Setting the background level at a low level (relative to the average of the dataset, excluding outliers) can also be achieved e.g. using a method that is similar to the default method except that outliers are excluded above or below a smaller limit, e.g. when the SD is multiplied by a number that is smaller, or much smaller than the value of 2 as applied in the default method.

It is *good practice* that alternative methods yield a background level and a margin, if needed, that can be used to identify years when excluding emissions related to natural disturbance is possible. It is also *good practice* transparently to describe the method that includes the explanation of the assumptions applied, why a margin is needed or not, and how the margin is developed.

Step 5: Ensuring that the method applied does not lead to expectation of net credits or net debits

In the case of the default method, the margin is twice the standard deviation of the data around the mean. Alternative methods should demonstrate transparently that the applied methodology does not lead to net credits or net debits for either land under FM or land under AR. To do this, it is *good practice* to analyze under what conditions the application of the background level and margin, if needed, are going to yield net zero credits or debits for the country during the commitment period, whether these conditions will be met during the commitment period or not, and modify the background level and the margin if necessary to avoid the expectation of net credit or net debit.

[35] Para 34

In case an area change occurs, it is *good practice* to correct the background level and the margin, if needed, at the end of the commitment period so that they both relate to the mean area during the commitment period (using a methodology consistently with the one discussed in Step 2 above).

In case a Party observes a trend in the historic time series of emissions related to natural disturbance on a unit area basis (i.e. the trend is not due to the trend in the total area but due to other factors), and this trend continues into the commitment period, it is *good practice* to correct the background level at the end of the commitment period to reflect this trend if the trend would lead to a net credit or net debit. This can be the case with the default method. In this case, the average of the emissions during the commitment period will statistically be different from the background level, which is also an average. The trend means that the average changes over time, and this change is what has to be removed.

The expectation of net credits or net debits can be removed for the default method by taking the difference between the background level (corrected, if needed) and the mean of the emissions due to natural disturbances during the commitment period.

With the alternative methods, an expectation of undue net credits or net debits can e.g. be avoided if the background level is set to value that is lower than the mean emissions from natural disturbances during the calibration period or if the background level is set to zero. However, it is *good practice* to demonstrate in these cases that an expectation of net credits and net debits is avoided.

An example of the application of an alternative method is found in Box 2.3.6, Example 2.

Step 6: Considerations when the FMRL is set to an historical level, or zero

For Parties that use a projected reference level (see Section 2.7.5) the application of both the default and alternative methods for the establishment of the background level are possible as set out above.

If emissions from a single historical year or period are used as a forest management reference level, the background level is equal to the level of disturbances in the year, or the average level of disturbances for the years in the period, and the margin is equal to two standard deviations estimated using the formula applied with the default method.

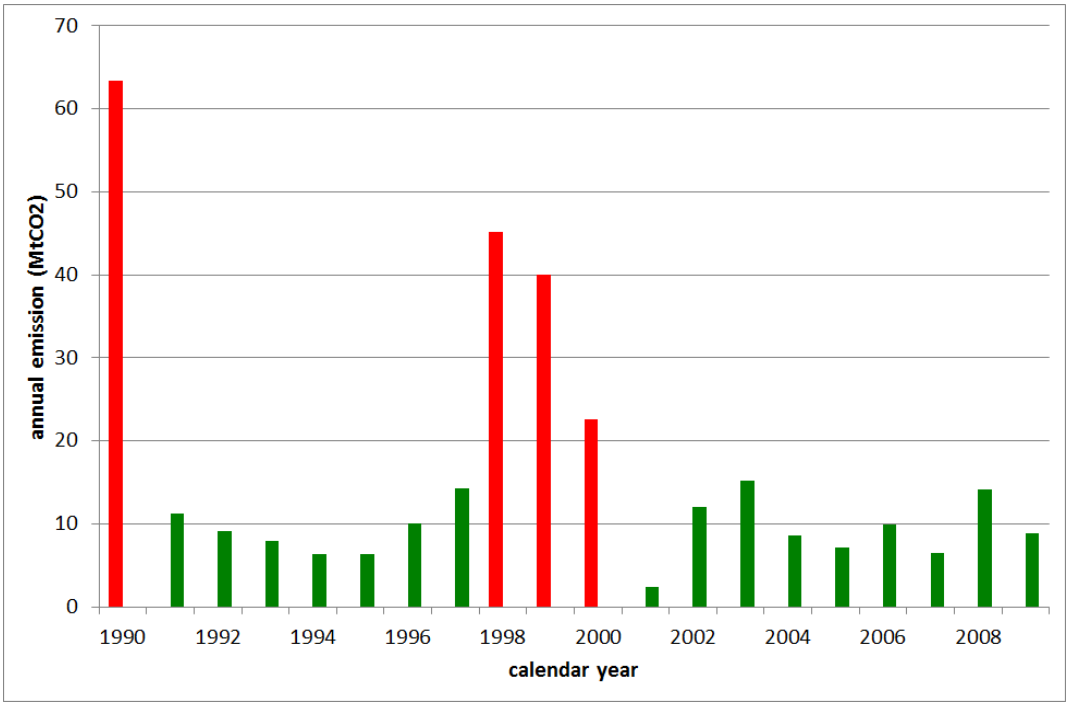
If the FMRL is zero then the background level and margin are zero.

BOX 2.3.6:
EXAMPLES OF APPROACHES FOR THE DEVELOPMENT OF THE BACKGROUND LEVEL

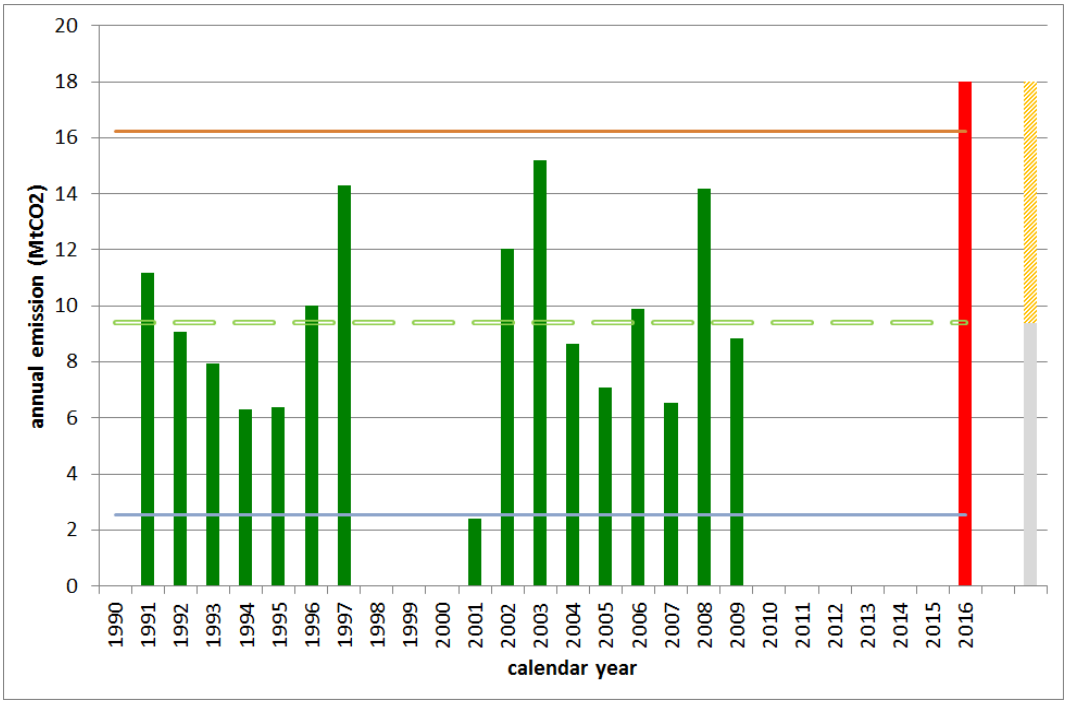
Example 1: Application of the default method

Based on the iterative process described above, the outliers in the time series (i.e. the red bars in Figure a) are identified and removed. The background level is estimated as the mean (i.e. the light green horizontal line in Figure b) of the remaining observations (i.e. the green bars), and the margin is twice the standard deviation of these observations (shown by a line above and another below the background level). In a year during the commitment period when the total emissions from natural disturbances (the red bar in Figure b) exceed the background level plus the margin, emissions above the background level (in yellow) may be excluded, provided that all the other requirements of the exclusion are met.

a)

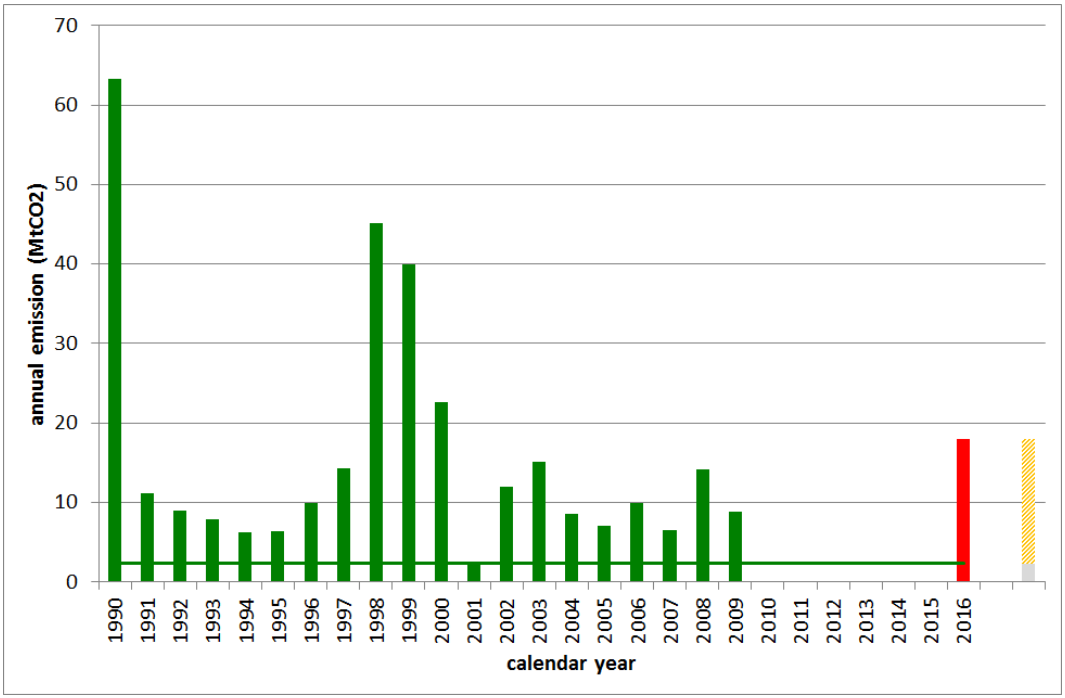


b)



Example 2: An alternative method: minimum level of historical time series will be set as the background level

An alternative method which minimises the risk of overestimating the emissions from natural disturbances during the commitment period to exclude is to identify the minimum expected emissions from natural disturbance for any year in the commitment period. This may be done by identifying the minimum emissions from natural disturbances during the calibration period and setting it as the background level. Because emissions are expected to exceed this level in every year of the commitment period, the margin required to determine the level of emissions at which emissions may be excluded under Decision 2/CMP.7 is equal to zero. When applying such a background level and margin (for a year during the commitment period, for which there is one example year in 2016), emissions during the commitment period may be excluded when they exceed the background level, and the amount that may be excluded (provided that all the other requirements of the exclusion are met) is the emission above the background level (in yellow).



2.3.9.8 GUIDANCE ON THE EXCLUSION OF REMOVALS ON LANDS AFFECTED BY THE NATURAL DISTURBANCE PROVISION

In case a Party excludes from accounting emissions from natural disturbances that in any single year exceed the background level plus margin, where a margin is needed, it should also exclude from accounting any subsequent removals during the commitment period on the affected land. This requires the assessment of the removals (using the guidance given above in Section 2.3.9.3) occurring on lands affected by the disturbance(s) causing the emissions that were excluded from accounting, without regard whether they originate from the re-establishment of young forest vegetation by rehabilitation measures or natural re-growth of vegetation, and to ensure their subsequent exclusion from accounting. Special care has to be taken that the removals are not captured by another assessment system, if for example complementary assessments on the natural disturbance areas are conducted in addition to a national forest inventory.

2.3.9.9 INFORMATION ON EFFORTS TAKEN TO REHABILITATE THE LAND SUBJECT TO NATURAL DISTURBANCES

Once a natural disturbance has occurred, the Party may implement actions to rehabilitate the forest cover in order to restore or secure forest functions and to prevent degradation of forests. Although rehabilitation is different from restoration and revegetation in terms of greenhouse gas reporting, the techniques used may include the

same as used for reforestation and revegetation, e. g. planting, seeding and/or the human-induced promotion of natural seed sources. The rehabilitation effort will depend on the severity of the impact, the likelihood of regeneration and cost-benefit analysis. Common examples of rehabilitation are wind-throw and forest fires. Following wind-throw, usable timber may be removed (salvage logging, see Section 2.3.9.3), the affected areas are cleared by e.g. banking of debris (which affects dead biomass and soil pools) or preparation of planting sites in places, and subsequent planting of crop tree species or seed-bed preparation is conducted, if seed trees are still available on the lands. If seed trees or natural regeneration are available (if the disturbance mainly affected higher age-classes and led to a shift in the age-class distribution), rehabilitation can be restricted to activities that ensure the site is accessible for further management activities following e.g. salvage logging. In case of forest fires, species within ecosystems can respond to fire and fire regimes in different ways (Gill, 1975). For example, some forest species are resilient to even the most severe fires and respond through epicormic resprouting post fire. In such instances efforts to rehabilitate may not be required and it is *good practice*, in these cases, to demonstrate that no other direct human intervention is necessary for rehabilitation.

If efforts have been taken and/or are planned to rehabilitate the areas subject to natural disturbances, it is *good practice* to provide transparent information on:

- Area rehabilitated, or planned to be;
- Time frame for the rehabilitation, i.e. duration of the management activity undertaken if this is not completed in the year of reporting, or time until a specified state ('result', see below) is expected to be reached;
- Description of the efforts taken and/or planned, including where no action is to be taken because the forest ecosystem rehabilitates without human intervention;
- Expected results, these may be e.g. recovering of carbon stocks, tree crown cover, or tree species structure and growth patterns, and ecosystem health conditions, and also any changes in efforts to avoid further disturbances.

If efforts have not been taken and/or are not planned to rehabilitate the areas subject to natural disturbances, it is *good practice* to provide transparent information on the reasons why the rehabilitation is not intended and / or impracticable. Because disturbed lands may be confused with deforested lands or may be subject to subtle land-use change, it is also *good practice* to demonstrate how the attribution of previously disturbed lands is conducted so that deforested areas are distinguished from disturbed lands and that land-use change is detected, if it occurs.

2.3.9.10 GUIDANCE ON THE TREATMENT OF EMISSIONS AND REMOVALS THAT OCCUR ON THE LANDS SUBJECT TO NATURAL DISTURBANCES IN SUBSEQUENT COMMITMENT PERIODS

Emissions and removals from afforestation and reforestation under Article 3.3 or forest management under Article 3.4 of the Kyoto Protocol over the third and subsequent commitment periods are likely to depend on legacy affects associated with natural disturbances that occurred in the earlier commitment periods. For example an event or circumstances may affect the age structure of forests, the carbon stock increases or decreases of dead organic pools and hence emissions and removals associated with them.

It is *good practice* that the annual emissions and removals estimates for years beyond the end of the second commitment period take account of these potential legacy effects.

Therefore, it is *good practice* that these emissions and removals are estimated in a manner consistent with the other forestry estimates in the greenhouse gas inventory, and in a way that legacy effects from natural disturbances can be identified and integrated into estimates for future years, so that accounting in the third and subsequent commitment periods can reflect them. This can be achieved by ensuring that the frequency of data collection, stratification, activity data, the emissions and removals factors and other parameters used for inventory estimates in years beyond the end of the second commitment period reflect the legacy effects of natural disturbance that occurred during the second commitment period.

2.3.10 Interannual variability

Associated with human's activities in the LULUCF sector, the annual rate of net carbon emissions or removals in an ecosystem is strongly influenced by climate variability, management practices, natural disturbance and other factors that alter growth and decomposition rates (e.g., in Griffis *et al.,*2003 ; Li et al., 2011; Yasuda et al., 2012). Consequently, the rate of net greenhouse gas emissions or removals in a given area may vary from year to year, and can shift between a net source and a net sink in successive years.

There are two aspects to interannual variability, and they need to be addressed independently. First, the national statistics on the variation between years in harvest rates, land-use change, or natural disturbances such as the area burned, are usually available, and it is *good practice* to include these in the calculation of carbon stock changes and greenhouse gas emissions and removals in the annual inventory report. Second, the variations in growth and decomposition rates due to seasonal and annual variations in environmental conditions, such as moisture regimes, temperature, or growing season length are much more difficult to quantify.

Because of interannual variability in environmental conditions, extrapolation of from a single year may result in incorrect conclusions about long-term trends. Conversely, interpolation of long-term trends in, e.g. forest growth rates may result in under- or overestimation of the actual growth in a single year. Forest growth functions and yield tables used in countries with forest management planning systems are based on measurements of periodic growth (e.g., over 5 or 10-year re-measurement intervals) and therefore incorporate and average the impacts of past interannual variability of environmental conditions. One approach that meets *good practice* is to use such growth functions to estimate biomass growth rates, because they represent the average growth rates and are therefore influenced little by short-term fluctuations in environmental conditions.

Where empirical growth and yield functions are used to estimate stand growth, it is *good practice* to evaluate the potential influences of interannual variability in environmental conditions, for example through comparisons of predicted and actual growth on a set of regionally distributed permanent sample plots. Where the periodic (e.g., 5-year) increment is consistently under- or over-predicted, the growth estimates should be adjusted accordingly, and the new data considered for incorporation in updated empirical functions. Countries that use process-based models to simulate annual variability in stand growth and other stock changes need to also evaluate these predictions against measurements of periodic stock changes on permanent sample plots and adjust the predictions, and underlying models where necessary.

In addition to greenhouse gas emissions and removals during the commitment period, Decision 15/CP.17 also requires estimation and reporting of greenhouse gas emissions and removals during the base year (1990 in most cases) for those elected activities for which net-net accounting applies (Table 1.1). The impact of this estimate for a single year could be large because it will be compared against the estimates for each year in the commitment period in which this activity occurred. The effects of interannual variability on the base year estimates could therefore be large. The direction and magnitude of the impact depends on how the year 1990 deviated from the long-term climatic averages. Moreover, it may be difficult to confirm the estimate for the base year using direct measurements, unless these were already taken in 1990. Where environmental conditions in the base year (e.g., 1990) caused major deviations in greenhouse gas emissions and removals from their longer-term (e.g., 5-year) averages, it is *good practice* to use longer-term averages of environmental conditions to represent the base year.

The effect of interannual variability may decrease as the geographical area considered increases. For example, the effects of local weather patterns may partially offset each other across a large country, but may be more pronounced in a small country or within a small region of a country. There are, however, climatic processes that can synchronize variations in weather over large regions, such as global climate change or El Niño Southern Oscillation (ENSO) events which typically occur on time scales of 3 to 7 years. Within limits, the longer the measurement or estimation interval the more likely it is that the results will capture the true long-term average value but averages can mask trends. One way of dealing with this issue is not to measure all sampling units annually or periodically but instead measure a subset of plots and to use a sampling technique called sampling with partial replacement to estimate changes in carbon stocks. This method allows the calculation of sampling errors with reduced costs of data collection (Ware and Cunia, 1962; Bokalo et al., 1996). Where non-linear processes are involved, e.g., the sigmoidal accumulation of forest biomass over age, simple linear interpolation for intermediate years will become increasingly unreliable with longer time periods. In general, an averaging period of about five years is likely to reduce the impacts of interannual variation.

The signal of the impact of direct human-induced emissions and removals, or the impact of mitigation measures, may not be discernible when confounded by large interannual variability originating from natural or indirect-human causes. The ability to discern the signal of the mitigation from the noise of the inter-annual variability is important when inventory estimates are used for monitoring the impacts of mitigation measures (IPCC, 2010).

It is *good practice* to document whether the methods selected for the estimation of greenhouse gas emissions and removals are sensitive to interannual variability of environmental conditions during the commitment period, and to report how interannual variation was addressed in the inventory calculations

2.4 OTHER GENERIC METHODOLOGICAL ISSUES

2.4.1 Developing a consistent time series

The units of land and lands subject to Article 3.3 or elected Article 3.4 activities and the management thereon need to be tracked continuously through time, to ensure that all emissions and removals are reported throughout subsequent commitment periods and with no gap between periods. Moreover, the continuity of management greatly influences GHG emissions and removals, and changes in management or land use are often the periods associated with the greatest changes in carbon stocks. For example, it is not sufficient merely to state that 10% of a cropland management area has been under no-till for a specified period. The rate of carbon stock change for the total area depends on whether the same 10% of land has remained under no-till or whether the 10% of no-till occurred on a different portion of the area in different years. It is therefore *good practice* to follow continuously the management of land subject to Article 3.3, FM and elected 3.4 activities. (See also Box 2.4.1)

Assessment of the continuity of management on land could be achieved either by continuously tracking units of land and lands subject to an Article 3.3, FM or an elected Article 3.4 activity from 1990 until the end of the commitment period (see Section 2.7.2 Choice of methods for identifying lands subject to forest management), or by developing statistical sampling techniques that can determine the transition of different types of management on land subject to Article 3.3 or elected 3.4 activities (see Section 5.3 of the *GPG-LULUCF*). An example of how such a scheme could operate is given in Box 2.4.1.

A supplementary condition for developing a consistent time series is to use the same methods for estimating carbon stock change and non-CO_2 greenhouse gas emissions during the whole period and for setting the benchmark value to be used in accounting i.e. either the reference level or the base year value, or to ensure consistency between different methods.

Time series consistency is discussed further in Chapter 5, Volume 1, (Time series consistency and recalculations) of the *2006 IPCC Guidelines*.

BOX 2.4.1
AN EXAMPLE OF CONSISTENCY IN ESTIMATING THE EFFECT OF MANAGEMENT PRACTICES

To estimate changes in soil carbon stocks, whether by Tier 1, 2 or 3 methods, management practices on applicable lands need to be followed continuously over time. Ideally, the management of each land would be tracked explicitly. But such data may not always be available. An alternative approach may be to estimate the *average* history of lands now under a given management. Consider the following example.

Example: Cropland management

Suppose there was a cropland region of 10,000 ha, of which 5,000 are in no-till (NT) in the year 2000, up from 2,000 ha in 1990. The remainder, in each year, is under conventional tillage (CT). In order to simplify this example, suppose also that the land management in the year 1990 was unchanged for a long period before (more than 20 years). The estimated soil carbon stock change is based on a matrix of coefficients; say 0.3 Mg C/ha/yr for land shifting from CT to NT, -0.3 Mg C/ha/yr for a shift from NT to CT. (The carbon stock change is calculated by the amount of soil carbon, the relative carbon stock change[36] factor, over 20 years, for the management activity, and the length of the period, one year. See Chapter 3.3.1.2, and Tables 3.3.3 and 3.3.4 of the *GPG-LULUCF*. Unfortunately, there has been no tracking of management on individual land. However, based on a statistical analysis (e.g., a survey), it is possible to estimate, with reasonable confidence, the following shifts:

CT	→	NT	3,500 ha
CT	→	CT	4,500 ha
NT	→	CT	500 ha
NT	→	NT	1,500 ha

The total carbon gain is therefore:

(3,500 • 0.3 + 4,500 • 0 + 500 • (-0.3) + 1,500 • 0) Mg C/yr = 900 Mg C/yr.

2.4.2 Recalculation of Time Series

This section deals with recalculation of time series, excluding implications for the technical correction of reference levels; which is dealt in section 2.7.6. As inventory capacity and data availability improve, the methods and data used to calculate estimates are updated and refined. Recalculation of historic emissions and removals is *good practice* when new methods are introduced or existing ones refined, when new sources and sinks categories are included, or when data are updated (for example through new measurements during the commitment period or the availability of new information on verification). Recalculations may also be needed if lands are reclassified at a later time (e.g., for lands that have lost forest cover but where a classification as deforested lands was pending and has been resolved, see Section 2.6.1).

The CMP decisions make provisions for recalculation[37], consistent with the UNFCCC reporting guidelines, and mention that previous estimates should be recalculated using the new methods for all years in the time series. Annual greenhouse gas emissions and removals reported for a given year during the commitment period can be recalculated in subsequent reporting years (up to the final year of the commitment period). When recalculating emissions and/or removals, time series consistency must be checked and ensured. It is also *good practice* to report why the new estimates are regarded as more accurate or less uncertain.

One potential problem in recalculating previous estimates is that certain data sets may not be available for the earlier years. There are several ways of overcoming this limitation and they are explained in detail in Chapter 5, Volume 1, of the *2006 IPCC Guidelines*.

[36] "Carbon stock change factor" is in use to refer to carbon emission/removal factors.

[37] See paragraphs 4, 12 (notably 12(d) and12(e)), 13 and 14(e) in the Annex to draft decision -/CMP.1 (Article 5.1), contained in document FCCC/CP/2001/13/Add.3, pp. 5-8.

2.4.3 Uncertainty assessment

Uncertainties should be quantified and all information on anthropogenic greenhouse gas emissions by sources and removals by sinks which result from mandatory and elective activities have to be within levels of confidence as elaborated by any IPCC good practice guidance adopted by the CMP.[38] Because of the importance for many countries of well-designed sampling programmes to reduce uncertainties when preparing LULUCF inventories, specific information on the design of sampling programmes for land areas and biomass stock, as well as the assessment of associated uncertainties should be provided. Generally, the approaches provided in Chapter 3 (*2006 IPCC Guidelines*) and the estimation of sampling error related to the sampling design used for data collection, can be used for assessing uncertainties associated with estimates reported under the UNFCCC and under the Kyoto Protocol LULUCF activities. However, some issues and terms which are specific to the Kyoto Protocol require additional uncertainty assessment, for example the estimation of the areas under LULUCF activities or the need to track activities since 1990. For Kyoto Protocol reporting, uncertainty assessment is particularly important in order to support verification requirements. In addition, to be consistent with *good practice*, the uncertainties in inventory estimates should be reduced as far as practicable. Moreover, while selecting a particular tier to estimate changes in carbon stocks and non-CO_2 greenhouse gas emissions, it is *good practice* to consider the implications of this choice for the management of uncertainties.

2.4.3.1 IDENTIFYING UNCERTAINTIES

In the context of the Kyoto Protocol the following sources of uncertainties are likely to be significant:

- Definitional errors, such as bias and inconsistencies resulting from the interpretation and implementation of the various definitions in the Kyoto Protocol (including the potential mismatch between data available to Parties and their interpretation of the definitions);
- Classification errors, such as land use and land transition classification errors (e.g., forest vs. non-forest classification with possible errors regarding temporarily unstocked forest lands);
- Activity data errors (e.g., distinction between the harvesting-regeneration cycle vs. deforestation or human-inducement of afforestation and reforestation);
- Estimation errors, such as errors in area estimates (e.g., due to incorrect classification of change events i.e., both omission and commission errors in remote sensing (see below for details), or due to differing scales used to identify lands subject to the various activities, e.g., afforestation/reforestation vs. deforestation, or modifications made to the sampling procedures and/or densities during the course of time);
- Identification errors arising while defining the geographical boundaries of areas encompassing lands and units of lands subject to LULUCF activities (although this may not have a direct impact on the uncertainty of the carbon stock change estimates for a given activity);
- Model errors occur whenever models or allometric equations are used to estimate carbon stock changes or non-CO_2 greenhouse gas emissions and removals, which is likely to be the case at higher tiers. It can be very cumbersome to trace the propagation of errors through complex models chained to each other. In general, this may introduce additional uncertainties, except for those cases where simpler models can be used to estimate typical uncertainty ranges that can be combined with central estimates from complex models.
- Sampling errors associated with the number of samples (number and location) within a "geographical boundary". In this case samples do not sufficiently cover the temporal and spatial variability of the estimated parameters. This is particularly critical when reporting land areas that include multiple land units by using legal, administrative, or ecosystem boundaries. This stratification is based on sampling techniques, administrative data, or grids on images produced by remote sensing techniques and the identified geographic boundaries are georeferenced.

[38] This refers to paragraph 6 (d) including footnote 5, and paragraph 9 including footnote 7 in the Annex to Decision 15/CMP.1 (Article 7).

SOME NOTES ON FACTORS AFFECTING UNCERTAINTY

Natural Variability

Natural variability is a result of variations in natural controlling variables, such as annual climate variability, and variability within units of land that are assumed to be homogenous, e.g., the spatial variability of e.g., forest soils within a given unit of land. When sufficient experimental data are available, *good practice* should permit determination of the resulting combined plot-level and up-scaling uncertainties using standard statistical methods such as Generalized Linear Models (e.g., Tate *et al.*, 2003). In some cases, especially for inter-annual or periodical variability, considerable impacts may change the sign of the reported net emissions and removals of an entire country or region. In inventory calculations uncertainty due to natural variability can be reduced by using time average coefficients and by averaging direct measurements over a time period sufficiently long to assess the variability, as discussed in Section 2.3.9 above.

Lack of activity data

In addition to uncertainties in default carbon emission and removal factors, there are often uncertainties associated with missing activity data. Determining retrospectively the inventory for the base year, in most cases 1990, may pose a particular challenge for cropland management, grazing land management, revegetation and wetland drainage and rewetting. It may be possible to establish base year emissions by extrapolating a consistent time series of emissions and removals established for a period over which activity data are available. Alternatively a country-specific methodology may be used if this can be shown to be more reliable in estimating base year carbon stock change. It is good practice to verify that this methodology does not over- or underestimate emissions/removals in the base year. It is *good* practice to also use in the estimation of base year emissions historical data on management practices prior to 1990, if available.

Resolution of remote sensing and ground truth

The objective of using satellite imagery for land cover assessments is often to obtain, for an inventory region, total area estimates, percentages of land-cover classes, or geographical boundaries. Remote sensing is particularly well suited to produce a complete identification of lands and units of land. A source of uncertainty is the selection of imagery of inadequate resolution. In order to capture changes in areas as small as one hectare, the resolution of the imagery must be finer than one hectare. In addition, improper or insufficient ground truthing can result in classification errors.

Positional errors occur where (a) the geometric correction is not done, incomplete or false, (b) the pixel location and location of ground truth plot do not coincide, and (c) there is insufficient accuracy in the definition of the borderlines. For example, when detecting land-use changes by a time series of remotely sensed images, the spatial displacement of pixels from one sampled image to the next will introduce errors. In the case of detection of a transition from forest to non-forest or vice versa, the associated uncertainties will be larger when forests are fragmented.

Classification errors arise from an incorrect identification of the real land cover class. They comprise omission errors, i.e., a population element from a given category is omitted and put erroneously into another class, and commission errors, i.e., classifying wrong categories into a given ground truth category.

The use of remote sensing is discussed further in Vol 4, Chapter 3 of the 2006 Guidelines, especially section 3A.2.4.

2.4.3.2 QUANTIFYING UNCERTAINTIES

Uncertainties associated with carbon stock changes and emissions estimation are to be quantified according to standard statistical methods. Uncertainties can originate from several sources and be combined into an overall uncertainty.

It is *good practice* to derive confidence intervals by applying a quantitative method to existing data. Confidence intervals at given confidence levels provide a minimum basis for a simple quantitative estimate of uncertainty.

Uncertainties for the activities covered by the Kyoto Protocol can be treated in the same way as other uncertainty estimates taking into account that:

- The "since 1990" clause and the use of definitions specific to the Kyoto Protocol are likely to cause systematic errors related to the estimation of the required activity data. The potential for differences between the managed forest area and the area subject to forest management, and also between grassland area and area subject to grazing land management implies that the areas whose uncertainties are being assessed may differ between the Kyoto Protocol activities and the corresponding categories of the *2006 IPCC Guidelines.*

- Activity data can also relate to individual practices or ownership structures, e.g., the fraction of cropland farmers using a given amendment on a particular soil. If the fraction is estimated by survey, the survey design should incorporate an uncertainty estimate depending on the level of inventory data disaggregation, otherwise the uncertainty will have to come from expert judgement.

- For cropland management, grazing land management, wetlands drainage and rewetting and/or revegetation (if elected) uncertainty estimates are needed also for the base year. These are likely to be higher than for estimates in the commitment period, because this information may often be derived only by backward extrapolations or models, rather than by actual inventories in or near the base year. In addition, determination of activities in the base year, where required, may pose difficulties if pre-base year surveys of land use are not available. Where reliable data are not available for 1970 to 1990 (or other applicable time periods), countries can use a country-specific methodology, shown to be reliable, to estimate base year carbon stock change in 1990. It is *good practice* to verify that this methodology does not over- or underestimate emissions/removals in the base year. In most cases, these methods also require historical data on management practices prior to 1990. The associated uncertainties could, in principle, be assessed by formal statistical methods, but more likely by expert judgement which is based on the feasible ranges of backward extrapolation of time trends. If surrogate data (i.e., alternative datasets that can be used as a proxy for missing data) are available, they can be a useful guide for extrapolating the trend in periodic data and subsequently interpolating the same data following the next data collection cycle. If there are no available surrogates or other information, then the only technique available is to extrapolate, with a recalculated interpolation of the estimates when the new observations are available. Thus, it is good practice to attempt to find reliable surrogate data to guide extrapolation and interpolation when the fundamental data used for the inventory estimates are not available annually.

- When remote sensing is employed for classification of land use and detection of land-use change including units of land, the uncertainties could be quantified by verifying classified lands with adequate actual ground truth data or higher resolution imagery. In order to estimate the accuracy of land-use/land-cover maps on a category-by-category basis, a number of sample points on the map and their corresponding real world categories are used to create an error matrix as proposed by Lilles and *et al.* (2008). The diagonal of this matrix shows the probability of correct identification and the off-diagonal elements show the relative probability of misclassification of a land category into one of the other possible categories. The error matrix expresses not only the accuracy of the map but it is also possible to determine which categories are easily confounded with each other. Based on the error matrix, a number of accuracy indices can be derived (Congalton and Green, 2009). It is good practice to present an estimate of the accuracy of the land-use/cover map category-by-category and a error matrix may be employed for this purpose where remote sensing is used. Multi-temporal analysis (analysis of images taken at different times to determine the stability of land-use classification) can also be used to improve classification accuracy, particularly in cases where ground truth data are limited.

Separate annual uncertainty estimates need to be made for each of the mandatory and elective activities, for each reported carbon pool, each greenhouse gas and geographical location. Estimates should be reported using tables generated following the model of Tables 2.4.5 -2.4.8 in Section 2.4.3 (Reporting and Documentation). Separate tables should be reported for the base year in case Cropland Management, Grassland Management, Revegetation or Wetland Drainage and Rewetting are elected. Estimates should be expressed as percent of the area and of the emissions by sources or removals by sinks (or changes in stocks) reported in Tables 2.4.5 – 2.4.8.

Uncertainty associated with areas of lands and units of land need to be estimated. When using Reporting Method 1, it is *good practice* to report a separate estimate of uncertainty for each of the mandatory activities, and each of the elective activities within a given geographical boundary. Under Reporting Method 2, each geographical boundary is subject to a single activity. Therefore there will only be one uncertainty estimate needed for each geographical boundary. However, because Reporting Method 2 can contain very large numbers of polygons it is *good practice* to also provide uncertainty estimates for the summary statistics.

Where uncertainties are difficult to derive, default values for uncertainties are to be used. Guidance on selecting default carbon emission or removal factors for cropland management can be found in Annex 4A.1, Tool for Estimation of Changes in Soil Carbon Stocks associated with Management Changes in Croplands and Grazing Lands based on IPCC Default Data. Since these factors are taken from the *IPCC Guidelines*, no true uncertainty

ranges can be assigned. However, using expert judgement, default uncertainty ranges corresponding to a sampling error of 50% can be assigned, based on an analysis of no-till long-term experiments in Europe in which the 95% confidence interval of the mean annual emission or removal estimate was found to be around ±50% of that mean (Smith *et al*., 1998). For revegetation and wetland drainage and rewetting, default uncertainty ranges cannot be specified at present. It is *good practice* for a Party electing these activities to provide its own estimates of the uncertainty associated with emissions and removals from all pools for the affected lands. Estimates of uncertainties have to be based on national sources or expert judgment reflecting national circumstances. Inventory agencies may also apply national methods for estimating the overall uncertainty, e.g., error propagation methods that avoid the simplifying approximations and in this case, it is *good practice* clearly to document such methods.

Problems may arise when activity data are lacking or are not well-documented. Activity data necessary to apply scaling factors (i.e., data on agricultural practices and organic amendments) may not be available in current databases/statistics. Estimates of the fraction of farmers using a particular practice or amendment should then be based on expert judgement, and so should the range in the estimated fraction. As a default value for the uncertainty in the fraction estimate, ±0.2 is proposed (e.g., the fraction of farmers using organic amendment estimated at 0.4, the uncertainty range being 0.2–0.6). As practical consideration it is assumed that uncertainties of the various input data estimates, either as default values, expert judgement or estimates based of sound statistical sampling can be combined for an overall uncertainty estimates.

2.4.3.3 REDUCING UNCERTAINTIES

Estimating uncertainties in a quantitative manner helps to identify major sources of uncertainties and to pin-point areas of potential improvements in order to reduce uncertainties in future assessments. In particular, for reporting under the Kyoto Protocol it is recommended to make efforts to convey the overall uncertainty estimates to all agencies and/or firms involved in order to encourage improvement, i.e., reduced uncertainties in estimates of future reports. It is also *good practice* to establish institutional means and procedures that are likely to contribute towards reducing uncertainties. For instance, a country may choose on purpose to estimate uncertainties by more than one procedure. This will produce complementary results for the same country and data category, prompting further research on potential sources of inconsistency and ultimately enhancing the robustness of estimates.

Often, uncertainties can be reduced if areas subject to land-use change are estimated directly as a class by themselves within a stratification scheme, rather than as a difference between two overall estimates of land-use areas.

The extra effort required for area identification should help to reduce uncertainties in the assessment of areas subject to Kyoto Protocol activities.

Uncertainties are likely to be reduced by implementing means to make the design, procedure and frequency of data collection more systematic, for example by establishing – whenever possible – long-term, statistically sound monitoring programmes.

2.4.4 Reporting and documentation

2.4.4.1 REPORTING

The anthropogenic greenhouse gas emissions by sources and removals by sinks from land use, land-use change and forestry activities, estimated using the methods described before and in the activity-specific Sections 2.5 – 2.12, must be reported as outlined in relevant decisions[39] of the Conference of the Parties serving as Meeting of the Parties (CMP) of the Kyoto Protocol. Some information on definitions and elected activities must be reported once by the end of 20XX, whereas supplementary information must be reported annually during the second commitment period. The information to be reported is summarised in Tables 2.4.1, but excludes information associated with removal unit (RMU) accounting. It is *good practice* to report all information requested in these tables.

Annual reports under the Kyoto Protocol must include estimates of areas of land subject to activities under Article 3.3, Article 3.4 forest management and any other elected Article 3.4 activities, of emissions by sources

39 CMP decisions relevant for LULUCF accounting for the second commitment period: decision 2/CMP6, decision 2/CMP.7.

and removals by sinks on these areas of land, and the associated uncertainties, using Tables 2.4.5 through 2.4.8. It is *good practice* to include in these reports additional information on methods and approaches used to identify lands and to estimate the emissions and removals.

TABLE 2.4.1
SUPPLEMENTARY INFORMATION TO BE REPORTED FOR THE ANNUAL GREENHOUSE GAS INVENTORY DURING THE SECOND COMMITMENT PERIOD ACCORDING TO RELEVANT DECISIONS OF THE CONFERENCE OF THE PARTIES SERVING AS MEETING OF THE PARTIES (CMP) OF THE KYOTO PROTOCOL. TEXT IN ITALICS INDICATES A DIRECT QUOTE FROM THE RELEVANT PARAGRAPHS IN THE CMP DECISIONS TEXT

Information to be reported	Detailed information	Reference in CMP decisions[40]
Land related information		
Approach for geographical location and identification of units of land and lands	*The geographical location of the boundaries of the areas that encompass:* *(i) Units of land subject to activities under Article 3, paragraph 3;* *(ii) Units of land subject to activities under Article 3, paragraph 3, which would otherwise be included in land subject to elected activities under Article 3, paragraph 4, […];* *(iii) Land subject to elected activities under Article 3, paragraph 4.* *(iv) Land subject to forest management* *(v) Land subject to forest management which would otherwise be included in units of land subject to activities under Article 3, paragraph 3,* *(vi) Lands and unit of lands affected by disturbances whose associated emissions, and following removals, have been excluded from accounting*	6 (b)
Spatial assessment unit	*The spatial assessment unit used for determining the area of accounting for afforestation, reforestation, deforestation and forest management*	6 (c)
Information on methods and approaches to estimate emissions and removals		

[40] Entries in this column refer to relevant paragraphs in the Annex to CMP decisions -/CMP.1 (Article 7), contained in document FCCC/CP/2001/13/Add.3, pp.21-29. The table does not necessarily refer to *all* relevant legal texts.

Description of methodologies used including methods used for calculating the reference level and the associated background level of emissions	The emissions and removals should be estimated using methodologies given in the *IPCC Guidelines* as elaborated by this report, and using the principles as laid out in the decision 16/CMP.1 (Land use, land-use change and forestry). The methodologies used should be reported with information on the reporting method for lands subject to Articles 3.3 and 3.4 (Reporting Method 1, 2 or a combination thereof), the approach(es) used for land identification, and the tier level(s) for estimating the emissions and removals. National approaches, models, parameters and other related information should be described transparently indicating how they improve the accuracy of the reporting. The assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the report and taking into account the principles in paragraph 1, items (a), (b), (d), (g), (h) in the decision 16/CMP.1 (Land use, land-use change and forestry).	see 6 (a) Paragraph 4 of decision 2/CMP.6 Paragraph 33 of Annex to decision 2/CMP.7
Justification when omitting any carbon pool	*Information on which, if any, of the following pools: below-ground biomass, litter, dead wood and/or soil organic carbon were not accounted for, together with verifiable information that demonstrates that these unaccounted pools were not a net source of anthropogenic greenhouse gas emissions. The above-ground biomass pool cannot be excluded from the reporting.*	6 (e)
Information on indirect factors on greenhouse gas emissions and removals	*Information should also be provided which indicates whether or not anthropogenic greenhouse gas emissions by sources and removals by sinks from land use, land-use change and forestry activities under Article 3 paragraph 3, forest management and elected activities under Article 3 paragraph 4 factor out removals from:* *(a) Elevated carbon dioxide concentrations above pre-industrial levels;* *(b) Indirect nitrogen deposition; and* *(c) The dynamic effects of age structure resulting from activities prior to 1 January 1990* (See Section 2.3.7)	7
Changes in data and methods	Any changes in data or methodology: - since the report of the previous year, e.g., in the choice of methods, activity data collection method, activity data, difficulties of detection (e.g., distinction between harvesting and deforestation when estimating the D area), parameters used in the calculations should be reported in a transparent manner. The reporting should include information on whether these changes have been applied also to reporting on previous inventory years to ensure consistency of the time series; - compared to data and methods applied for calculating the reference level and the associated background level of emissions. The reporting should include information on whether these changes have resulted in inconsistencies between reported emissions and removals and the reference level; and in the latter case information on the technical correction applied to minimize or eliminate methodological differences between reference level calculations and emissions reporting.	10

2623

2624

2625

TABLE 2.4.1 (CONTINUED)
SUPPLEMENTARY INFORMATION TO BE REPORTED FOR THE ANNUAL GREENHOUSE GAS INVENTORY DURING THE FIRST COMMITMENT PERIOD ACCORDING TO RELEVANT DECISIONS OF THE CONFERENCE OF THE PARTIES SERVING AS MEETING OF THE PARTIES (CMP) OF THE KYOTO PROTOCOL. TEXT IN ITALICS INDICATES A DIRECT QUOTE FROM THE RELEVANT PARAGRAPHS IN THE DECISIONS TEXT

Information to be reported	Detailed information	Reference in CMP decisions[41]
Other generic methodological issues	Any additional relevant information on methodological issues, such as measurement intervals, interannual variability (see Section 2.3)	
Specific information for activities under Article 3, paragraphs 3 and 4		
Specific information on Article 3.3 activities and Forest Management	*Information that demonstrates that activities under Article 3, paragraph 3, and forest management began on or after 1 January 1990 and before 31 December of the last year of the commitment period, and are directly human-induced*; *Information on how harvesting or forest disturbance that is followed by the re-establishment of a forest is distinguished from deforestation*; Information on how forest plantations are distinguished from natural forests Information on areas that have been converted to forest land to compensate conversion of forest plantations to non-forest land. Needed information consists of identification, including the georeferenced location and year of conversion, of areas and the quantification of expected carbon stocks at the end of harvesting cycle and of actual carbon stocks It is *good practice* to provide information on the size and geographical location of forest areas that have lost forest cover but which cannot be classifed as deforested (and will therefore remain classified as forest with a re-assessment in the next inventory).	8 (a) 8 (b) Paragraphs 37-39 of the Annex to decision 2/CMP.7
Article 3.3 activities and forest management specific information on safeguards when excluding from accounting emissions associated with disturbances	Each Party shall provide transparent information: (a) Showing that all lands subject to disturbances whose associated emissions have been excluded from accounting, are identified, including their georeferenced location, year and types of disturbances; (b) Showing how annual emissions resulting from disturbances and the subsequent removals in those disturbed areas are estimated; and showing that subsequent removals have been excluded from accounting; (c) Showing that no land-use change has occurred on those lands and explaining the methods and criteria for identifying any future land-use changes on those land areas during the commitment period; (d) That demonstrates that disturbances, for which emissions have been excluded from accounting, were beyond the control of, and not materially influenced by, the Party in the commitment period, by demonstrating practicable efforts to prevent, manage or control those occurrences; (e) That demonstrates efforts taken to rehabilitate, where practicable, those lands; (f) Showing that emissions associated with salvage logging were not excluded from accounting.	Paragraph 34 of Annex to decision 2/CMP.7
Elected Article 3.4 activities specific information	*A demonstration that elected activities under Article 3, paragraph 4, have occurred since 1 January 1990 and are human induced*	9 (a)
Information related to the estimates of emissions by sources and removals by sinks (for reporting data, see Tables 2.5-2.6)		

[41] Entries in this column refer to relevant paragraphs in the Annex to Decision 15/CMP.1 (Article 7). The table does not necessarily refer to *all* relevant legal texts.

Estimates for greenhouse gas emissions by sources and removals by sinks	Estimates of greenhouse gas emissions by sources and removals by sinks for human-induced activities under Article 3, paragraphs 3, and forest management and, if any, elected activities under Article 3, paragraph 4, and for all geographical locations reported in the current and previous years, since the beginning of the commitment period or the onset of the activity, whichever comes later. In the latter case the year of the onset of the activity must also be included.	see 6 (d)
	[…] Estimates for Article 3, paragraphs 3 and 4, shall be clearly distinguished from anthropogenic emissions from the sources listed in Annex A to the Kyoto Protocol.[…]	5
Afforestation/ reforestation, deforestation and forest management	Area of natural forests that have been converted to forest plantation Area of forest plantations subject to forest management that have been converted to non-forest land and area of non-forest land converted to forest land to compensate the forest conversion Carbon stocks of forest plantations subject to forest management that have been converted to non-forest land and expected and actual carbon stocks of area of land converted to forest land to compensate the forest conversion	xxx
Forest management	Reference level; Background level of emissions associated with natural disturbances; Margin, where needed, to avoid that the exclusion of emissions from disturbances results in the expectation of net credits or net debits during the commitment period; Amount of emissions associated with disturbances; Amount of removals from lands whose emissions from disturbances have been excluded from accounting; Demonstration that emission are reported for salvage logging on lands whose emissions from disturbances have been excluded from accounting;	xxx
Harvested Wood Products	Information whether the Party has included emissions from harvested wood products originating from forests prior to the start of the second commitment period; and information demonstrating that, where already accounted, emissions from harvested wood products originating from forests during the first commitment period have been excluded.	xxx
Cropland management, grazing land management, revegetation and wetland drainage and rewetting	Anthropogenic greenhouse gas emissions by sources and removals by sinks for **each year of the commitment period** and for the **base year** for each of the elected activities on the geographical locations identified, excluding emissions reported under the Agriculture sector of the *IPCC Guidelines*.	9 (b), and paragraph 9 of the annex to draft decision -/CMP.1 (LULUCF), FCCC/CP/2001/13/Add.1, p.59
Absence of overlap between 3.3 and 3.4 activities	*Information that demonstrates that emissions by sources and removals by sinks resulting from elected Article 3, paragraph 4, activities are not accounted for under forest management or activities under Article 3, paragraph 3*.	9 (c)
Uncertainty of emission and removal estimates	Estimates of emissions and removals *shall be within levels of confidence as elaborated by any IPCC good practice guidance adopted by the CMP and in accordance with relevant decisions of the CMP on land use, land-use change and forestry.*	6(d), footnote 5

It is *good practice* to use coordinates as set out in Sections 2.5 to 2.7 below for the reporting of the geographical location of the boundaries that encompass the units of land subject to activities under Article 3.3 and the lands subject to forest management and elected activities under Article 3.4. This information can be summarised on a map for visual presentation and data sharing. It is also *good practice* to report the land transition matrix below (Table 2.4.3) to demonstrate that the Party has accounted for all areas where afforestation, reforestation, deforestation and forest management and, if elected, Article 3.4 activities have occurred. The diagonal cells of the table indicate the area of lands remaining in the same category (e.g., FM land remaining FM land), while other cells indicate the areas of lands converted to other categories (e.g., cropland converted to afforested land).

It is *good practice* that the total area reported in consecutive inventories is constant and that any change in area is documented and explained.

It is *good practice* to use Tables 2.4.5 – 2.4.8, or future versions of these tables as decided by CMP, to submit annual estimates. For Article 3.3 and 3.4 activities (Tables 2.4.5 to 2.4.8), data must be provided by geographical locations. The CMP decisions also require that, in addition to the data for the actual inventory year, a Party also reports this information for the base year for cropland management, grazing land management, revegetation and wetland drainage and rewetting. No reporting is necessary for those Article 3.4 activities that were not elected by the Party.

When filling in these tables, care should be taken to insert carbon stock changes for each pool with proper signs. Carbon stock changes are to be reported in units of carbon as positive when the carbon stock has increased, and as negative when the carbon stock has decreased. All changes are totalled for each geographic location, and the total values are then multiplied by 44/12 to convert carbon stock changes to CO_2 emissions or removals. This conversion also involves sign change to switch from the ecosystem to the atmospheric perspective: stock changes refer to ecosystem carbon stocks (where increases have a positive sign) while fluxes of CO_2 and non-CO_2 greenhouse gasses refer to exchanges with the atmosphere where emissions are additions to the atmosphere and therefore have a positive sign.

Table 2.4.9 is a summary table of carbon stock changes resulting from activities under Articles 3.3 and 3.4 for the inventory year. It is *good practice* to use the table also for the base year for each Article 3.4 elected activity. This table summarises data of the compilation tables by activity across all carbon pools and across all strata within a country.

In addition to the data in the Tables 2.4.5 through 2.4.9, it is *good practice* to report the underlying assumptions and factors used for the calculation of the carbon stock changes and emissions of CH_4 and N_2O, as well as for the calculation of the uncertainties. Such information can be obtained using the worksheets in Chapter 3 of the *GPG-LULUCF* or from equivalent information supporting the estimates obtained using higher tiers or other methods.

Decision 2/CMP.7 contains a clause for afforestation/reforestation and forest management activities that carbon stock changes and non-CO_2 greenhouse gas emissions resulting from natural disturbances may be excluded from accounting (see Table X.X.X – *not included in First Order Draft*). If this provision is to be used then the areas where such disturbances occurred have to be identified and monitored for subsequent land-use change.[42] If such units of land and/or lands exist for the inventory year, it is *good practice* to distinguish them from other afforestation/reforestation units of land and/or forest management lands and to report them (and the associated carbon stock changes and non-CO_2 greenhouse gas emissions, distinguishing emissions from subsequent removals) separately in Tables 2.4.5 to 2.4.8. Although this is an issue related to accounting, it is mentioned here because inventory data are likely to be needed to implement the provision.

Decision 2/CMP.7 contains a clause that Parties can elect to report carbon stock changes and non-CO_2 greenhouse gas emissions resulting from conversion of forest plantation to non-forest land under forest management together with carbon stock changes and non-CO_2 greenhouse gas emissions resulting from conversion of at least an equivalent area of non-forest land converted to forest land (see Table X.X.X – *not included in First Order Draft*). If this provision is to be used, then all areas subject to this provision have to be identified and their georeferenced locations reported.[43] Although this is an issue related to accounting, it is mentioned here because inventory data are likely to be needed to implement the provision.

Finally, separate annual uncertainty estimates should be reported for each activity under Articles 3.3 and 3.4, for each carbon pool, each greenhouse gas and geographical location. Estimates should be reported using tables generated following the model of Tables 2.4.5 to 2.4.8. Separate tables should be reported for the base year when CM, GM RV and/or WDR are elected. Uncertainty estimates are to be made at the 95% confidence limits expressed as percent of the emissions by sources or removals by sinks (or changes in stocks) reported in Tables 2.4.5 to 2.4.8.

Additional text describing the tables is still required here.

[42] Paragraphs 33, 34 and 35 in the Annex to decision 2/CMP.7 (Land use, land-use change and forestry)

[43] Paragraphs 33, 34 and 35 in the Annex to decision 2/CMP.7 (Land use, land-use change and forestry)

Table 2.4.2a
Summary Table

Activity coverage and other information relating to activities under Article 3.3, forest management and elected activities under Article 3.4

INVENTORY YEAR:

Activity		Change in carbon pool reported[1]					
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	HWP	Soil
Article 3.3 activities	Afforestation and Reforestation						
	Deforestation						
Article 3.4 activities	Forest Management						
	Cropland Management						
	Grazing Land Management						
	Wetland Drainage and Rewetting						
	Revegetation						

Activity		Greenhouse gas sources reported[2]							Net CO_2 emissions/ removals[5][6]	CH_4[7]	N_2O[8]	Net CO2 equivalent emissions/ removals
		Fertilization[3]	Drainage of soils under forest managemen	Disturbance associated with land-use	Liming	Biomass burning[4]						
		N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O	(Gg)			
Article 3.3 activities	Afforestation and Reforestation											
	Deforestation											
Article 3.4 activities	Forest Management											
	Cropland Management											
	Grazing Land Management											
	Wetland Drainage and Rewetting											
	Revegetation											

2686

TABLE 2.4.2B
ADDITIONAL INFORMATION: SELECTION OF PARAMETERS FOR DEFINING "FOREST" UNDER THE KYOTO PROTOCOL

Parameter	Range	Selected value
Minimum land area		
Minimum crown cover		
Minimum height		

2687

TABLE 2.4.2C
ADDITIONAL INFORMATION: BACKGROUND LEVEL OF EMISSIONS ASSOCIATED WITH NATURAL DISTURBANCES AND ITS MARGIN

Activity	Background level	Margin
Afforestation and Reforestation		
Forest Managtement		
Minimum height		

2688

TABLE 2.4.2D
ADDITIONAL INFORMATION: FOREST MANAGEMENT REFERENCE LEVEL

Methodology applied[9]	Value inscribed in decision 2/CMP.7	Technical correction to be applied, as calculated in the reporting year							
		2015	2016	2017	2018	2019	2020	2021	2022

Note

[1] Indicate R (reported), NR (not reported), IE (included elsewhere) or NO (not occurring), for each relevant activity under Article 3.3 or forest management or elected activity under Article 3.4. If changes in a carbon pool are not reported, it must be demonstrated in the NIR that this pool is not a source of greenhouse gases. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

[2] Indicate R (reported), NE (not estimated), IE (included elsewhere) or NO (not occurring) for greenhouse gas sources reported, for each relevant activity under Article 3.3 or forest management or elected activity under Article 3.4. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

[3] N_2O emissions from fertilization for Cropland Management, Grazing Land Management, Revegetation and Wetland Drainage should be reported in the Agriculture sector. If a Party is not able to separate fertilizer applied to Forest Land from Agriculture, it may report all N_2O emissions from fertilization in the Agriculture sector.

[4] If CO_2 emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning; this also includes the carbon component of CH_4. Parties that include CO_2 emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

[5] According to the 2006 IPCC Guidelines, for the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+). Net changes in carbon stocks are converted to CO_2 by multiplying C by 44/12 and by changing the sign for net CO_2 removals to be negative (-) and net CO_2 emissions to be positive (+).

[6] CO_2 emissions from liming, biomass burning and drained organic soils, where applicable, are included in this column.

[7] CH_4 emissions reported here for Cropland Management, Grazing Land Management, Revegetation and Wetland Drainage and Rewetting, if elected, include emissions from biomass burning (with the exception of savannah burning and agricultural residue burning which are reported in the Agriculture sector) and Drainage and Rewetting of organic soils (with the exception of rice cultivation which is reported in the Agriculture sector). Any other CH4 emissions from Agriculture should be reported in the Agriculture sector.

[8] N_2O emissions reported here for Cropland Management, if elected, include only emissions from biomass burning (with the exception of savannah burning and agricultural residue burning which are reported in the Agriculture sector) and N_2O emissions from mineral soils from conversion to Cropland of lands other than Forest Land. Any other N_2O emissions from Agriculture should be reported in the Agriculture sector.

[9]

2692

TABLE 2.4.3A
LAND TRANSITION MATRIX

Areas and changes in areas between the previous and the current inventory year [(1), (2), (3)]

INVENTORY YEAR:

			To current inventory year								
			Article 3.3 activities		Article 3.4 activities					Other[(5)]	Total area at the beginning of the current inventory year[(6)]
			Afforestation and Reforestation	Deforestation	Forest Management	Cropland Management (if elected)	Grazing Land Management (if elected)	Revegetation (if elected)	Wetland Drainage and Rewetting (if elected)		
			(kha)								
From previous inventory year	Article 3.vities	Afforestation and Reforestation									
		Deforestation									
	Article 3.4 activities	Forest Management									
		Cropland Management[(4)] (if elected)									
		Grazing Land Management [(4)] (if elected)									
		Revegetation[(4)] (if elected)									
		Wetland Drainage and Rewetting									
		Other[(5)]									
		Total area at the end of the current inventory year									

2693

2694

2695

TABLE 2.4.3B
ADDITIONAL INFORMATION: AREA OF NATURAL FOREST CONVERTED TO FOREST PLANTATIONS IN THE CURRENT INVENTORY YEAR

GEOGRAPHICAL LOCATION [(3)]	Area of natural forest converted to forest plantations	Area of drained organic soils[(7)]
Identification code	**(kha)**	**(kha)**
Total		

Note

[1] This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the previous year and the current inventory year. For example, the total area of land subject to Forest Management in the year preceding the inventory year, and which was deforested in the inventory year, should be reported in the cell in column of Deforestation and in the row of Forest Management..

[2] Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

[3] In accordance with section 4.2.3.2 of the IPCC good practice guidance for LULUCF, the value of the reported area subject to the various activities under Article 3.3 and 3.4 for the inventory year should be that on 31 December of that year.

[4] Lands subject to Cropland Management, Grazing Land Management, Revegetation or Wetland Drainage and Rewetting which, after 2008, are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under Cropland Management, Grazing Land Management, Revegetation or Wetland Drainage and Rewetting, respectively.

[5] "Other" includes the total area of the country that has not been reported under an Article 3.3 or an elected Article 3.4 activity.

[6] The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country and is constant for all years.

2696

2697

TABLE 2.4.4
SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL

Key categories of emissions and removals	Gas	Criteria used for key category identification			Comments[2]
		Associated category in UNFCCC inventory[1] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory [1], [3] (including LULUCF)	Other	
Specify key categories according to the national level of disaggregation used[1]					

Note

[1] See section XXX of the *2006 IPCC Guidelines* and section XXX of this report

[2] Describe the criteria identifying the category as key.

[3] If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.

2698

2699

2700

Table 2.4.5
Article 3.3 activities: Afforestation and Reforestation[(1), (2)]

INVENTORY YEAR:

GEOGRAPHICAL LOCATION [(3)]	ACTIVITY DATA			
Identification code	**Subdivision[(4)]**	**Year of conversion**	**Area subject to the activity (kha)**	**Area of drained organic soils[(8)] (kha)**
Total for activity AR				
Total	lands impacted by natural disturbances[(12)]	Year[(13)]		
Total		2013		
Total		…		

2701

2702

2703

Table 2.4.5 (Continued)
Article 3.3 activities: Afforestation and Reforestation [(1), (2)]

INVENTORY YEAR:

GEOGRAPHICAL LOCATION [(3)]	CHANGE IN CARBON STOCK [(7)]											Net CO_2 emissions/ removals[(9)]
Identification code	Carbon stock change in above-ground biomass[(5), (6)]			Carbon stock change in below-ground biomass[(5), (6)]			Net carbon stock change in litter [(5)]	Net carbon stock change in dead wood[(5)]	Net carbon stock change in HWP[(11)]	Net carbon stock change in soils[(5)]		
	Gains	Losses	Net change	Gains	Losses	Net change				Mineral soils	Organic soils[(10)]	
	(Gg C)											(Gg CO_2)
Total for activity AR												
Total												
Total												
Total							…					

2704

2705

2706

INFORMATION ITEM UNITS OF LAND OTHERWISE SUBJECT TO FOREST MANAGEMENT[14]		
GEOGRAPHICAL LOCATION [3]	**ACTIVITY DATA**	
Identification code	**Subdivision[4]**	**Area subject to the activity (kha)**
Total for activity AR		

2707

INFORMATION ITEM EMISSIONS ASSOCIATED WITH NATURAL DISTURBANCES[15]							
GEOGRAPHICAL LOCATION [16]	**ACTIVITY DATA**			**EMISSIONS**			
Identification code	**Subdivision[4]**	**Area subject to the activity (kha)**	**Type of natural disturbances[17]**	**CO_2**	**CH_4**	**N_2O**	**Total CO_2 equivalent[18]**
				(Gg)			
Total for activity AR							

2708

Documentation box
Parties should provide detailed explanation on the land use, land-use change and forestry sector in the relevant annex of the NIR: Supplementary information on LULUCF activities under the Kyoto Protocol. Use this documentation box to provide references to relevant sections of the NIR if any additional details are needed to understand the content of this table.

Note

[1] Report here information on anthropogenic change in carbon stock for the inventory year for all geographical locations that encompass units of land subject to Afforestation and Reforestation under Article 3.3.

[2] As both Afforestation and Reforestation under Article 3.3 are subject to the same provisions specified in the annex to decision 16/CMP.1, they can be reported together.

[3] Geographical location refers to the boundaries of the areas that encompass units of land subject to Afforestation and Reforestation.

[4] Activity data may be further subdivided according to climate zone, management system, soil type, vegetation type, tree species, ecological zone, national land classification or other criteria. Complete one row for each subdivision.

[5] The signs for estimates of gains in carbon stocks are positive (+) and of losses in carbon stocks are negative (-).

[6] Carbon stock gains and losses should be listed separately except in cases where, due to the methods used, it is technically impossible to separate information on gains and losses. In that case, net gains should be reported in the "Gains" column and net losses should be reported in the "Losses" column. The notation key IE should be filled in, in the other column.

[7] Note that net change corresponds to increase/decrease of carbon stock (see table 4.2.6a of the IPCC good practice guidance for LULUCF).

[8] This information is needed for the calculation of the net carbon stock changes in soils per area.

[9] According to the 2006 IPCC Guidelines, for the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+). Net changes in carbon stocks are converted to CO2 by multiplying C by 44/12 and changing the sign for net CO2 removals to be negative (-) and for net CO2 emissions to be positive (+).

[10] The value reported here could be an emission and not a carbon stock change.

[11] If the Party reports HWP applying instantaneous oxidation. In this column the notation key IE should be filled in.

[12] Report here information, if applicable, on changes in carbon stocks for the inventory year for all geographical locations that encompass units of land subject to Afforestation and Reforestation under Article 3.3 where natural disturbances occurred in a year of the commitment period and whose associated emissions that exceeded the background level have been excluded from accounting.

[13] Report here information on changes in carbon stocks for the inventory year for all geographical locations that encompass units of land subject to Afforestation and Reforestation under Article 3.3 where natural disturbances occurred in the single year of the commitment period and whose associated emissions that exceeded the background level have been excluded from accounting.

[14] Units of land subject to Afforestation/Reforestation under Article 3.3 otherwise subject to Forest Management. They are implicitly reported under AR. They are reported here for transparency and to fulfil the requirement of paragraph 2 (b) (ii) of the annex II to decision 2/CMP.8.

[15] This table sum up all emissions associated with natural disturbances in the reported year

[16] Geographical location refers to the boundaries of the areas that encompass afforested/reforested units of land that have been subject to natural disturbances.

[17] Here the type of natural disturbances that caused the emissions has to be listed; including, but not limited to, wildfires, insect and disease infestations, extreme weather events and/or geological disturbances.

[18] Here sum all GHG emissions as converted in tons of CO2 equivalent.

2711

Table 2.4.6
Article 3.3 activities: Deforestation[(1)]

INVENTORY YEAR:

GEOGRAPHICAL LOCATION[(2)]	ACTIVITY DATA			
Identification code	**Subdivision[(3)]**	**Year of conversion**	**Area subject to the activity (kha)**	**Area of drained organic soils[(7)] (kha)**
Total for activity D				

GEOGRAPHICAL LOCATION [(3)]	CHANGE IN CARBON STOCK [(6)]											Net CO_2 emissions/ removals[(8)]
Identification code	**Carbon stock change in above-ground biomass[(4), (5)]**			**Carbon stock change in below-ground biomass[(4), (5)]**			**Net carbon stock change in litter [(4)]**	**Net carbon stock change in dead wood[(4)]**	**Net carbon stock change in HWP[(11)]**	**Net carbon stock in soils[(4)]**		
	Gains	**Losses**	**Net change**	**Gains**	**Losses**	**Net change**				**Mineral soils**	**Organic soils[(9)]**	
	(Gg C)											**(Gg CO_2)**
Total for activity D												

2712

2713

2714

INFORMATION ITEM UNITS OF LAND OTHERWISE SUBJECT TO FOREST MANAGEMENT[10]		
GEOGRAPHICAL LOCATION [3]	**ACTIVITY DATA**	
Identification code	**Subdivision[4]**	**Area subject to the activity (kha)**
Total for activity FM		

2715

Documentation box
Parties should provide detailed explanation on the land use, land-use change and forestry sector in the relevant annex of the NIR: Supplementary information on LULUCF activities under the Kyoto Protocol. Use this documentation box to provide references to relevant sections of the NIR if any additional details are needed to understand the content of this table.

2716

Note

[1] Report here information on anthropogenic change in carbon stock for the inventory year for all geographical locations that encompass units of land subject to Deforestation under Article 3.3.

[2] Geographical location refers to the boundaries of the areas that encompass units of land subject to Deforestation.

[3] Activity data may be further subdivided according to climate zone, management system, soil type, vegetation type, tree species, ecological zone, national land classification or other criteria. Complete one row for each subdivision.

[4] The signs for estimates of gains in carbon stocks are positive (+) and of losses in carbon stocks are negative (-).

[5] Carbon stock gains and losses should be listed separately except in cases where, due to the methods used, it is technically impossible to separate information on gains and losses. In that case, net gains should be reported in the "Gains" column and net losses should be reported in the "Losses" column. The notation key IE should be filled in, in the other column.

[6] Note that net change corresponds to increase / decrease of carbon stock (see table 4.2.6a of the IPCC good practice guidance for LULUCF).

[7] This information is needed for the calculation of the net carbon stock changes in soils per area.

[8] According to the 2006 IPCC Guidelines, for the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+). Net changes in carbon stocks are converted to CO2 by multiplying C by 44/12 and changing the sign for net CO2 removals to be negative (-) and for net CO2 emissions to be positive (+).

[9] The value reported here could be an emission and not a carbon stock change.

[10] Units of land subject to Deforestation under Article 3.3 otherwise subject to elected activities under Article 3.4. They are implicitly reported under D. They are reported here for transparency and to fulfil the requirement of paragraph 2 (b) (ii) of the annex II to decision 2/CMP.8.

2717

2718

2719

Table 2.4.7
Article 3.4 activities: Forest Management[(1)]

INVENTORY YEAR:

GEOGRAPHICAL LOCATION [(2)]	ACTIVITY DATA			
Identification code	**Subdivision[(3)]**	**Year**	**Area subject to the activity (kha)**	**Area of drained organic soils[(7)] (kha)**
Total for activity FM				
Total	*afforested/reforested lands under CEFC[(11)]*	Year[(12)]		
Total		2013		
Total		…		
Total	*deforested lands under CEFC[(13)]*	Year[(14)]		
Total		2013		
Total		…		
Total	*lands impacted by natural disturbances[(15)]*	Year[(16)]		
Total		2013		
Total		…		

2720

2721

Table 2.4.7 (Continued)
Article 3.4 activities: Forest Management[1]

INVENTORY YEAR:												
GEOGRAPHICAL LOCATION [3]	**CHANGE IN CARBON STOCK [7]**											**Net CO_2 emissions/ removals[8]**
Identification code	**Carbon stock change in above-ground biomass[4], [5]**			**Carbon stock change in below-ground biomass[4], [5]**			**Net carbon stock change in litter [4]**	**Net carbon stock change in dead wood[4]**	**Net carbon stock change in HWP[10]**	**Net carbon stock change in soils[4]**		
	Gains	**Losses**	**Net change**	**Gains**	**Losses**	**Net change**				**Mineral soils**	**Organic soils[9]**	
	(Gg C)											**(Gg CO_2)**
Total for activity FM												
Total												
Total												
Total												
Total												
Total												
Total												
Total												
Total												
Total												

2724

INFORMATION ITEM CARBON EQUIVALENT FOREST CONVERSION[17]					
GEOGRAPHICAL LOCATION [18]	**ACTIVITY DATA**		**TOTAL CARBON STOCKS[19]**		
Identification code	**Subdivision[4]**	**Area converted (kha)**	**losses[20]**	**net gains[21]**	**level to be achieved[22]**
			(Gg C)		
Total for forest plantation converted to non-forest cover					
Total for equivalent lands converted to forest					

2725

INFORMATION ITEM EMISSIONS ASSOCIATED WITH NATURAL DISTURBANCES[22]							
GEOGRAPHICAL LOCATION [23]	**ACTIVITY DATA**			**EMISSIONS**			
Identification code	**Subdivision[4]**	**Area subject to natural disturbances (kha)**	**Type of natural disturbances[24]**	**CO_2**	**CH_4**	**N_2O**	**Total CO_2 equivalent[25]**
				(Gg)			
Total for activity AR							
Total for activity FM							

2726

Documentation box
Parties should provide detailed explanation on the land use, land-use change and forestry sector in the relevant annex of the NIR: Supplementary information on LULUCF activities under the Kyoto Protocol. Use this documentation box to provide references to relevant sections of the NIR if any additional details are needed to understand the content of this table.

2727

Note

[1] Here information on anthropogenic carbon stock change for the inventory year for all geographical locations that encompass land subject to Forest Management under Article 3.4.

[2] Geographical location refers to the boundaries of the areas that encompass land subject to Forest Management.

[3] Activity data may be further subdivided according to climate zone, management system, soil type, vegetation type, tree species, ecological zone, national land classification or other criteria. Complete one row for each subdivision.

[4] The signs for estimates of gains in carbon stocks are positive (+) and of losses in carbon stocks are negative (-).

[5] Carbon stock gains and losses should be listed separately except in cases where, due to the methods used, it is technically impossible to separate information on gains and losses. In that case, net gains should be reported in the "Gains" column and net losses should be reported in the "Losses" column. The notation key IE should be filled in, in the other column.

[6] Note that net change corresponds to increase / decrease of carbon stock (see table 4.2.6a of the IPCC good practice guidance for LULUCF).

[7] This information is needed for the calculation of the net carbon stock changes in soils per area.

[8] According to the 2006 IPCC Guidelines, for the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+). Net changes in carbon stocks are converted to CO_2 by multiplying C by 44/12 and changing the sign for net CO_2 removals to be negative (-) and for net CO_2 emissions to be positive (+).

[9] The value reported here could be an emission and not a carbon stock change.

[10] If the Party reports HWP applying instantaneous oxidation. In this column the notation key IE should be filled in.

[11] Report here information, if applicable, on changes in carbon stocks for the inventory year for all geographical locations that encompass lands subject to Forest Management under Article 3.4 that have been converted in a year of the commitment period to a "Carbon Equivalent Forest" (see paragraphs 37-39 of the annex to decision 2/CMP.7).

[12] Report here information on changes in carbon stocks for the inventory year for all geographical locations that encompass lands subject to Forest Management under Article 3.4 that have been converted in the single year of the commitment period to a "Carbon Equivalent Forest" (see paragraphs 37-39 of the annex to decision 2/CMP.7

[13] Report here information, if applicable, on changes in carbon stocks for the inventory year for all geographical locations that encompass lands subject to Forest Management under Article 3.4 which forest cover has been harvested in a year of the commitment period and for which, in the same year, another land has been converted to a "Carbon Equivalent Forest" (see paragraphs 37-39 of the annex to decision 2/CMP.7

[14] Report here information on changes in carbon stocks for the inventory year for all geographical locations that encompass lands subject to Forest Management under Article 3.4 which forest cover has been harvested in the single year of the commitment period and for which, in the same year, another land has been converted to a "Carbon Equivalent Forest" (see paragraphs 37-39 of the annex to decision 2/CMP.7

[15] Report here information, if applicable, on changes in carbon stocks for the inventory year for all geographical locations that encompass lands subject to Forest Management under Article 3.4 where natural disturbances occurred in a year of the commitment period and whose associated emissions that exceeded the background level have been excluded from accounting.

[16] Report here information on changes in carbon stocks for the inventory year for all geographical locations that encompass lands subject to Forest Management under Article 3.4 where natural disturbances occurred in the single year of the commitment period and whose associated emissions that exceeded the background level have been excluded from accounting.

[17] Report here information on carbon stocks for the inventory year for all geographical locations that encompass lands subject to the "Carbon Equivalent Forest Conversion" provisions, within Forest Management under Article 3.4 (see paragraphs 37-39 of the annex to decision 2/CMP.7), since the beginning of the second commitment period.

[18] Geographical location refers to the boundaries of the areas that encompass lands subject to the "Carbon Equivalent Forest Conversion" within Forest Manageemnt under Article 3.4 (see paragraphs 37-39 of the annex to decision 2/CMP.7).

[19] Carbon stocks reported under "losses", "net gains" and "level to be achieved" have to be calculated on same carbon pools applying for each carbon pool the same methodological tier.

[20] Report here the total carbon stock losses caused by the forest-cover loss. Net carbon stock losses means the algebric addition of all changes estimated to occur in all reported carbon pools because of the forest-cover removal.

[21] Report here the current total net carbon stocks gains since the forest plantation. Net carbon stock gains means the algebric addition of all carbon stock changes changes occurred in all reported carbon pools since the establishment of the forest.

[22] This table sum up all emissions associated with natural disturbances in the reported year

[23] Geographical location refers to the boundaries of the areas that encompass lands under Forest Management that have been subject to natural disturbances.

[24] Here the type of natural disturbances that caused the emissions has to be listed; including, but not limited to, wildfires, insect and disease infestations, extreme weather events and/or geological disturbances.

[25] Here sum all GHG emissions as converted in tons of CO_2 equivalent.

2729

Table 2.4.8
Elected Article 3.4 activities[(1), (2), (3), (4), (5)]

INVENTORY YEAR:

GEOGRAPHICAL LOCATION[(6)]	ACTIVITY DATA			
Identification code	**Activity[(7)]**	**Subdivision[(8)]**	**Area subject to the activity (kha)**	**Area of drained organic soils[(13)] (kha)**
Total for activity				
…				

GEOGRAPHICAL LOCATION [(3)]	CHANGE IN CARBON STOCK [(11)]											
Identification code	**Carbon stock change in above-ground biomass[(9), (10)]**			**Carbon stock change in below-ground biomass[(9), (10)]**			**Net carbon stock change in litter[(9)]**	**Net carbon stock change in dead wood[(9)]**	**Net carbon stock change in HWP[(15)]**	**Net carbon stock in soils[(9)]**		**Net CO_2 emissions/ removals[(14)]**
	Gains	**Losses**	**Net change**	**Gains**	**Losses**	**Net change**				**Mineral soils**	**Organic soils[(12)]**	
	(Gg C)											**(Gg CO_2)**
Total for activity												
…												

2730
2731

2732

Documentation box

Parties should provide detailed explanation on the land use, land-use change and forestry sector in the relevant annex of the NIR: Supplementary information on LULUCF activities under the Kyoto Protocol. Use this documentation box to provide references to relevant sections of the NIR if any additional details are needed to understand the content of this table.

2733

Note

[1] For each elected activity, this table and all relevant CRF tables should also be reported for the base year.

[2] If Cropland Management has been elected, report here information on anthropogenic carbon stock change for the inventory year for all geographical locations that encompass land subject to Cropland Management under Article 3.4.

[3] If Grazing land Management has been elected, report here information on anthropogenic carbon stock change for the inventory year for all geographical locations that encompass land subject to Grazing land Management under Article 3.4.

[4] If Revegetation has been elected, this table and all relevant CRF tables should also be reported for the base year for Revegetation.

[5] If Wetland Drainage and Rewetting has been elected, report here information on anthropogenic carbon stock change for the inventory year for all geographical locations that encompass land subject to Wetland Drainage and Rewetting under Article 3.4.

[6] Geographical location refers to the boundaries of the areas that encompass land subject to the activity.

[7] Put here the identification acronym of the elected activity i.e. CM for Cropland Management, GM for Grazing land Management, R for Revegetation, WDR for Wetland Drainage and Rewetting

[8] Activity data may be further subdivided according to climate zone, management system, soil type, vegetation type, tree species, ecological zone, national land classification or other criteria. Complete one row for each subdivision.

[9] The signs for estimates of gains in carbon stocks are positive (+) and of losses in carbon stocks are negative (-).

[10] Carbon stock gains and losses should be listed separately except in cases where, due to the methods used, it is technically impossible to separate information on gains and losses. In that case, net gains should be reported in the "Gains" column and net losses should be reported in the "Losses" column. The notation key IE should be filled in, in the other column.

[11] Note that net change corresponds to increase / decrease of carbon stock (see table 4.2.6b of the IPCC good practice guidance for LULUCF).

[12] The value reported here could be an emission and not a carbon stock change.

[13] This information is needed for the calculation of the net carbon stock changes in soils per area.

[14] According to the 2006 IPCC Guidelines, for the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+). Net changes in carbon stocks are converted to CO_2 by multiplying C by 44/12 and changing the sign for net CO_2 removals to be negative (-) and for net CO_2 emissions to be positive (+).

[15] If the Party reports HWP applying instantaneous oxidation. In this column the notation key IE should be filled in.

2734

Table 2.4.9 Direct N2O emissions from N fertilization[(1), (2)] and N2O emissions from disturbance associated with land-use conversion to cropland[(1), (2)]		
Inventory year:		
Identification code of geographical location	**ACTIVITY DATA**	**EMISSIONS**
	Total amount of fertilizer applied (Gg N/year)	**N_2O (Gg)**
A.1 Afforestation/Reforestation[(3)]		
B.1. Forest Management[(4)]		
	Land area converted (kha)	
A.2. Deforestation[(7), (8)]		
B.2. Cropland Management (if elected)[(9), (10)]		

2735

Documentation box
Parties should provide detailed explanation on the land use, land-use change and forestry sector in the relevant annex of the NIR: Supplementary information on LULUCF activities under the Kyoto Protocol. Use this documentation box to provide references to relevant sections of the NIR if any additional details are needed to understand the content of this table.

Note

[1] N_2O emissions from fertilization for Cropland Management, Grazing Land Management, Revegetation and Wetland Drainage and Rewetting should be reported in the Agriculture sector. If a Party is not able to separate fertilizer applied to Forest Land from Agriculture, it may report all N_2O emissions from fertilization in the Agriculture sector. This should be explicitly indicated in the documentation box.

[2] Direct N_2O emissions from fertilization are estimated following section 3.2.1.4.1 of the IPCC good practice guidance for LULUCF based on the amount of fertilizer applied to land under Forest Management. The indirect N_2O emissions from Afforestation and Reforestation and land under Forest Management are estimated as part of the total indirect emissions in the Agriculture sector based on the total amount of fertilizer used in the country. Parties should show that double counting of N_2O emissions from fertilization with Agriculture sector estimates has been avoided.

[3] Methodologies for N_2O emissions from disturbance associated with land-use conversion to Croplands are found in section 3.3.2.3.1.1 of the IPCC good practice guidance for LULUCF. N_2O emissions from fertilization in the preceding land use and new land use should not be reported here. Parties should avoid double counting with N_2O emissions from drainage and from cultivation of organic soils reported in the Agriculture sector under Cultivation of Histosols.

[4] According to the IPCC good practice guidance for LULUCF N_2O emissions from disturbance of soils are only relevant for land conversions to Cropland. N_2O emissions associated with Wetland Drainage are reported in table 9. only.

[5] Geographical location refers to the boundaries of the areas that encompass units of land subject to Afforestation and Reforestation.

[6] Geographical location refers to the boundaries of the areas that encompass land subject to Forest Management.

[7] Geographical location refers to the boundaries of the areas that encompass units of land subject to Deforestation.

[8] N_2O emissions associated with Deforestation followed by the establishment of Cropland shall be reported under Deforestation even if Cropland Management is not elected under Article 3.4.

[9] Geographical location refers to the boundaries of the areas that encompass land subject to Cropland Management, if elected.

[10] This includes N_2O emissions in land subject to Cropland Management from disturbance of mineral soils due to the conversion to Cropland of lands other than Forest Lands. N_2O emissions in land subject to Cropland Management from disturbance of organic soils are included in the Agriculture sector under Cultivation of Histosols

2736

2737

2738

Table 2.4.10 CH_4 and N_2O emissions from drainage and rewetting of soils[1]			
Inventory year:			
Identification code of geographical location[4]	**ACTIVITY DATA**	**EMISSIONS**	
	Area of soils	**N_2O**	**CH_4**
	(kha)	**(Gg)**	
Total drainage			
Forest Management *(organic soils)*			
B.5 Wetland Drainage (if WDR elected)[2]			
Total for organic soils			
Total for mineral soils			
Organic soils			
Mineral soils			
Organic soils			
Mineral soils			
Organic soils			
Mineral soils			
Total Rewetting (if WDR elected) [3]			
Total for organic soils			
Total for mineral soils			
Organic soils			
Mineral soils			
Organic soils			
Mineral soils			
Organic soils			
Mineral soils			

2739

2740

2741

Documentation box
Parties should provide detailed explanation on the land use, land-use change and forestry sector in the relevant annex of the NIR: Supplementary information on LULUCF activities under the Kyoto Protocol. Use this documentation box to provide references to relevant sections of the NIR if any additional details are needed to understand the content of this table.
Note [1] Methodologies for estimating CH_4 and N_2O emissions from drainage and rewetting of soils are addressed in XXX [2] N_2O emissions from drainage of soils do not include Cropland and Grassland soils since those are covered in the Agriculture sector under Cultivation of Histosols. [3] CH_4 and N_2O emissions from Rewetting of soils do not include Rice Cultivation soils since those are covered in the Agriculture sector. [4] Geographical location refers to the boundaries of the areas that encompass land subject to Forest Management or Wetland Drainage (if elected).

2742

2743

2744

Table 2.4.11 Carbon emissions from lime application[1]		
Inventory year:		
Identification code of geographical location	**ACTIVITY DATA**	**EMISSIONS**
	Total amount of lime applied	**Carbon**
	(kha)	**(Gg)**
A.1 Afforestation/Reforestation[2], [9], [10]		
Total for limestone		
Total for dolomite		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
A.2. Deforestation[3], [9], [10]		
Total for limestone		
Total for dolomite		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
B.1. Forest Management[4], [9], [10]		
Total for limestone		
Total for dolomite		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
B.2. Cropland Management (if elected)[5], [9], [10]		
Total for limestone		
Total for dolomite		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
B.3. Grazing Land Management (if elected) [6], [9], [10]		
Total for limestone		
Total for dolomite		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		

2745

2746

2747

Table 2.4.11 (Continued)
Carbon emissions from lime application[(1)]

Inventory year:		
Identification code of geographical location	**ACTIVITY DATA**	**EMISSIONS**
	Total amount of lime applied	**Carbon**
	(kha)	**(Gg)**
B.4. Revegetation (if elected)[(6), (9), (10)]		
Total for limestone		
Total for dolomite		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
B.5. Wetland Drainage and Rewetting (if elected) [(8), (9), (10)]		
Total for limestone		
Total for dolomite		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		
Limestone ($CaCO_3$)		
Dolomite ($CaMg(CO_3)_2$)		

2748

Documentation box

Parties should provide detailed explanation on the land use, land-use change and forestry sector in the relevant annex of the NIR: Supplementary information on LULUCF activities under the Kyoto Protocol. Use this documentation box to provide references to relevant sections of the NIR if any additional details are needed to understand the content of this table.

2749

Note

[1] Carbon emissions from agricultural lime application are addressed in sections 3.3.1.2.1.1 and 3.3.2.2.1.1 of the IPCC good practice guidance for LULUCF.

[2] Geographical location refers to the boundaries of the areas that encompass units of land subject to Afforestation and Reforestation.

[3] Geographical location refers to the boundaries of the areas that encompass units of land subject to Deforestation.

[4] Geographical location refers to the boundaries of the areas that encompass land subject to Forest Management.

[5] Geographical location refers to the boundaries of the areas that encompass land subject to Cropland Management, if elected.

[6] Geographical location refers to the boundaries of the areas that encompass land subject to Grazing Land Management, if elected.

[7] Geographical location refers to the boundaries of the areas that encompass land subject to Revegetation, if elected.

[8] Geographical location refers to the boundaries of the areas that encompass land subject to Wetland Drainage and Rewetting, if elected.

[9] If Parties are not able to separate lime application for different geographical locations, they should include liming for all geographical locations in the total.

[10] A Party may report aggregate estimates for total lime applications when data are not available for limestone and dolomite.

2750

2751

2752

2753

Table 2.4.12
GHG emissions from biomass burning

Inventory year:						
Identification code of geographical location	**ACTIVITY DATA**			**EMISSIONS**		
	Description[8]	**Unit**	**Values**	**CO_2 [9]**	**CH_4 [9]**	**N_2O**
	Area (AB) or biomass burned (BB)	**ha or kg dm**		**(Gg)**		
A.1 Afforestation/Reforestation						
Total for controlled burning						
Total for wildfires						
Controlled burning						
Wildfires						
Controlled burning						
Wildfires						
A.2. Deforestation[2], [10]						
Total for controlled burning						
Total for wildfires						
Controlled burning						
Wildfires						
Controlled burning						
Wildfires						
B.1. Forest Management[3], [10]						
Total for controlled burning						
Total for wildfires						
Controlled burning						
Wildfires						
Controlled burning						
Wildfires						
B.2. Cropland Management (if elected)[4], [10], [11]						
Total for controlled burning						
Total for wildfires						
Controlled burning						
Wildfires						
Controlled burning						
Wildfires						
B.3. Grazing Land Management (if elected) [5], [10], [12]						
Total for controlled burning						
Total for wildfires						
Controlled burning						
Wildfires						
Controlled burning						
Wildfires						

2754

Table 2.4.12 (Continued)
GHG emissions from biomass burning

Inventory year:						
Identification code of geographical location	**ACTIVITY DATA**			**EMISSIONS**		
	Description[8]	**Unit**	**Values**	**CO_2 [9]**	**CH_4 [9]**	**N_2O**
	Area (AB) or biomass burned (BB)	**ha or kg dm**		**(Gg)**		
B.4. Revegetation (if elected) [6], [10], [11], [12]						
Total for controlled burning						
Total for wildfires						
Controlled burning						
Wildfires						
Controlled burning						
Wildfires						
B.5. Wetland Drainage and Rewetting (if elected)[7], [10], [11]						
Total for controlled burning						
Total for wildfires						
Controlled burning						
Wildfires						
Controlled burning						
Wildfires						

2755

Documentation box

Parties should provide detailed explanation on the land use, land-use change and forestry sector in the relevant annex of the NIR: Supplementary information on LULUCF activities under the Kyoto Protocol. Use this documentation box to provide references to relevant sections of the NIR if any additional details are needed to understand the content of this table.

2756

Note

[1] Geographical locations refers to the boundaries of the areas that encompass units of land subject to Afforestation and Reforestation.

[2] Geographical location refers to the boundaries of the areas that encompass units of land subject to Deforestation.

[3] Geographical location refers to the boundaries of the areas that encompass land subject to Forest Management, if elected

[4] Geographical location refers to the boundaries of the areas that encompass land subject to Cropland Management, if elected

[5] Geographical location refers to the boundaries of the areas that encompass land subject to Grazing Land Management, if elected

[6] Geographical location refers to the boundaries of the areas that encompass land subject to Revegetation, if elected

[7] Geographical location refers to the boundaries of the areas that encompass land subject to Wetland Drainage and Rewetting, if elected.

[8] For each activity, activity data should be selected between area burned (AB) or biomass burned (BB). Units will be ha for area burned, and kg dm for biomass burned. The implied emission factor will refer to the selected activity data with an automatic change in the units.

[9] If CO2 emissions from biomass burning are not already included in Tables 4, 5, 6 and 7, they should be reported here. This also includes the carbon component of CH4. This should be clearly documented in the documentation box and in the NIR. Parties that include all carbon stock changes in the carbon stock Tables 4, 5, 6 and 7, should report IE (included elsewhere) in the CO2 column.

[10] Parties should report controlled/prescribed burning and wildfires emissions separately, where appropriate.

[11] Burning of agricultural residues is included in the Agriculture sector.

[12] Greenhouse gas emissions from prescribed savannah burning are reported in the Agriculture sector.

2757

2758

2759 2.4.4.2 DOCUMENTATION

2760 Documentation requirements under the Kyoto Protocol are outlined in the relevant decisions of UNFCCC as part
2761 of the description of the requirements for inventory management[62]. The information required includes all
2762 disaggregated emission factors, activity data, and documentation about how these factors and data have been
2763 generated and aggregated for the preparation of the inventory.

2764 It is *good practice* to document and archive the underlying data and description of, or reference to, methods,
2765 assumptions and parameters used, which are used to produce estimates of emissions by sources and removals by
2766 sinks of greenhouse gases that would allow independent reviewers to follow the process of developing the
2767 reported estimates. Documented data and explanation of methods, and the rational for their selection should be
2768 provided for both steps: the identification of land and the assessment of carbon stock changes and the emissions
2769 of non-CO_2 greenhouse gases.

2770 Documentation should also include information about uncertainty assessment (see also Section 2.4.3 Uncertainty
2771 Assessment), QA/QC procedures, external and internal reviews, verification activities and key category
2772 identification and planned improvements (see *2006 IPCC Guidelines* Volume 1, General Guidance and
2773 Reporting).

2774

2775 ACTIVITIES DEFINITION AND IDENTIFICATION

2776 It is *good practice* to explain how the definitions of Forest Management and of the elected Article 3.4 activities
2777 have been interpreted according to national circumstances. For instance, if only a part of the managed forests
2778 reported in the UNFCCC greenhouse gas inventory is included under forest management in the Kyoto Protocol
2779 reporting, the criteria that are used to distinguish forests under "forest management" from "managed forests"
2780 should be provided. Differences between croplands (or grasslands) in the UNFCCC greenhouse gas inventory
2781 and lands undergoing cropland management (or grazing land management), as well as the difference between the
2782 wetland and other organic land under Kyoto Protocol reporting should also be documented.

2783

2784 DATA DOCUMENTATION

2785 When using Reporting Method 1, the areas encompassed by the geographical boundaries resulting from the
2786 stratification of a country, should be identified by unique serial numbers in the tables. These serial numbers are
2787 to be cross-referenced to a database or other archive (the LULUCF Archive) specifying the locations in terms of
2788 established legal or administrative boundaries, or by means of an existing coordinate system, for example an
2789 established national grid system, the UTM (Universal Transverse Mercator) grid or latitude and longitude. When
2790 using Reporting Method 2, land-area identification should be possible through the databases associated with the
2791 use of this reporting method.

2792 It is *good practice* to ensure that the documentation of estimates of greenhouse gas emissions and removals
2793 include:

2794 • The sources of all data used in the calculations (i.e., complete citations for the statistical database(s) from
2795 which data were collected);

2796 • The information, rationale and assumptions that were used to develop reported data and results, in cases they
2797 were not directly available from databases (for instance if interpolation or extrapolation methods have been
2798 applied) and a comparison to other published emission factors and explanation of any significant differences

2799 • The frequency of data collection; and

2800 • Estimates of the associated uncertainties together with a description of the major sources of the
2801 uncertainties.

2802

[62] Paragraph 16 (a) in the Annex to the draft decision19/CMP.1 (Article 5.1), contained in FCCC/KP/2005/8/Add.3, p.19.

DESCRIPTION OF THE METHODS USED IN LAND IDENTIFICATION AND ESTIMATION OF EMISSIONS AND REMOVALS

It is *good* practice to document the methods with the following information:

- Choice of reporting methods for lands subject to Articles 3.3 and 3.4 (Reporting Method 1 or 2) or a description of the reporting method, if a combination of the two is used;
- Description of the approach used for geographical location and identification of the geographical boundaries, lands, and units of land; references of maps used, if any;
- Choice of tier(s) used for estimating greenhouse gas emissions and removals;
- Methods used for estimating carbon stock changes, non-CO_2 greenhouse gas emissions and magnitudes of the corresponding uncertainties;
- Choice of activity data;
- Identification of key categories
- If Tier 1 is used: all values of default parameters and emission/removal factors used;
- If Tier 2 is used: all values and references of default and national parameters and emission/removal factors used;
- If Tier 3 is used: Parties should, as applicable, report information on: basis and type of model, application and adaptation of the model, main equations/processes, key assumptions, domain of application, how the model parameters were estimated, description of key inputs and outputs, details of calibration and model evaluation, uncertainty and sensitivity analysis, QA/QC procedures adopted and references to peer-reviewed literature, description of the process by which carbon stock changes and emissions or removals are estimated;
- In case of Tier 2 or 3 the documentation should justify the use of specific parameters, factors or models;
- Transparent and verifiable information that demonstrates that the pools not included in the reporting are not sources.

ANALYSIS OF FLUCTUATIONS

It is *good practice* to explain significant fluctuations in reported emissions or removals between years. The reasons for any changes in activity levels and in parameter values from year to year should be documented. If the reason for the changes is an improvement in methods, it is *good practice* to recalculate results for the preceding years by using the new methods, new activity and/or new parameter values (see Chapter 5, Section 5.6 of the *GPG-LULUCF* 'Time series consistency and recalculations')

2.4.5 Quality assurance and quality control

It is *good practice* to implement quality control checks as outlined in Volume 1, Chapter 6 (Quality Assurance and Quality Control) of the *2006 IPCC Guidelines* on category-specific QC Procedures, and expert review of the emission estimates. Additional quality control checks and quality assurance procedures may also be applicable, particularly if higher-tier methods are used to estimate carbon stock changes and non-CO_2 greenhouse gas emissions. A detailed treatment of inventory QA/QC for field measurement is described in Appendix 4A.3 of the *GPG-LULUCF*.

Some important issues are highlighted and summarised below.

When compiling data, it is *good practice* to cross-check estimates of emissions and removals of greenhouse gases against independent estimates. The inventory agency should ensure that estimates undergo quality control by:

- Cross-referencing aggregated production data (e.g., crop yield, tree growth) and reported area statistics with national totals or other sources of national data (e.g., agriculture / forestry statistics);
- Back-calculating national emission/removal factors from aggregated emissions and other data;
- Comparing reported national totals with default values and data from other countries.

It is also *good practice* to verify that the sum of the disaggregated areas used to estimate the various emissions/removals equals the total area under the activity, reported as per guidance in Volume 1, Chapter 6 of *2006 IPCC Guidelines* (using the LU/LUC matrix).

2.4.6 Verification

Good practice guidance for verification is given in Chapter 5, Section 5.7 of the *GPG-LULUCF* (Verification) and Chapter 4, Section 4.3.2.3 of the *2006 IPCC Guidelines* (Choice of Activity Data).

[Consider adding an example for specific LULUCF issues here]

2.5 AFFORESTATION AND REFORESTATION

This section addresses specific methods applicable to afforestation and reforestation activities and should be read in conjunction with the general discussion in Sections 2.2 to 2.4.

2.5.1 Definitional issues and reporting requirements

According to the definitions of the Marrakesh Accord, both afforestation and reforestation refer to direct human-induced conversion of land to forest from another land use. The definitions do not include regrowth of forests following harvest or natural disturbance of forests. This is because these losses of forest cover are only temporary and therefore not considered deforestation: the land remains as forested land. Harvesting followed by re-establishment of forest is considered a forest management activity (Section 2.7). The distinction between afforestation and reforestation is due to the period of time the land has been non-forest. Afforestation occurs on land that has not been forest for at least 50 years prior to the start of the commitment period. Reforestation occurs on land that has been forest more recently, though was non-forest on or at some time since, 31 December 1989. Land that was forest on 1st January 1990 can be identified as reforestation if it was subject to deforestation to non-forest land after this date, and forest re-establishment subsequently occurs.

For the identification of units of land, afforestation and reforestation will be discussed together because the two definitions differ only by the time since the area was last forested, and because the same carbon reporting and accounting rules apply to both activities. When calculating changes in carbon stocks following afforestation and reforestation, the assumptions about the initial size and composition of the litter, dead wood, and soil organic carbon pools should reflect the preceding land-use type and history, rather than the distinction between afforested and reforested sites.

The annual inventory should, at a minimum, identify (for Reporting Method 1 in Section 2.2.2):

- The geographical location of the boundaries of the areas that encompass units of land subject to afforestation/reforestation activities (including those units of land subject to activities under Article 3.3, of the Kyoto Protocol which would otherwise be included in land subject to forest management or elected activities under Article 3.4, of the Kyoto Protocol, because reporting of Article 3.3 activities takes precedence over Article 3.4 activities, see Section 1.1). Land areas previously considered subject to deforestation which are subsequently subject to reforestation should also be included. Lands that would be subject to afforestation/reforestation activity under Article 3.3 but are instead accounted for as forest management activity under the Carbon Equivalent Forest Conversion provision should be identified separately (section 2.7.7). The geographical boundaries which are reported should correspond to strata in the estimation of land areas as described in Chapter 3, Volume 4, *2006 IPCC Guidelines*;
- For each of these areas, or strata, estimates of the area of the units of land affected by afforestation/reforestation activities in the three subcategories, namely those subject to Article 3.3, those subject to Article 3.3 that would otherwise be subject to Article 3.4; and those subject to deforestation that are subsequently subject to reforestation. This is to avoid double counting;
- The year of the start of afforestation/reforestation activities, which will be between 1 January 1990 and the end of the inventory year. Within the boundary of the areas, afforestation/reforestation activities may have started in different years. It is good practice to group afforestation and reforestation units of land by age and to report the area in each age class separately; and
- The area of units of land subject to afforestation/reforestation in each productivity class and species combination to assign growth rate estimates and to support the calculation of carbon stock changes and non-CO_2 greenhouse emissions.

A more comprehensive system (Reporting Method 2 in Section 2.2.2) identifies each unit of land subject to afforestation/reforestation activities since 1990 (again in the two subcategories – Article 3.3 and Article 3.3 that would otherwise be subject to Article 3.4; note that if areas under the Carbon Equivalent Forest Conversion provision exist, these should be identified separately within the area subject to Article 3.4), using the polygon boundaries, a coordinate system (e.g., the Universal Transverse Mercator (UTM) Grid or Latitude/Longitude), or a legal description (e.g., those used by land-titles offices) of the location of the land subject to afforestation or reforestation activities. Chapter 3, Volume 4 of the *2006 IPCC Guidelines* (Basis for Consistent Representation of Land Areas) discusses in detail the possible approaches for consistent representation of land areas.

2.5.2 Choice of methods for identifying units of land subject to direct human-induced afforestation/ reforestation

Parties need to report on the carbon stock changes and non-CO_2 emissions during the commitment period on areas that have been subject to afforestation and reforestation (AR) activities since 1990. The first step in this process is to make national parameter choices for the forest definition within the ranges allowed by the Marrakesh Accords, namely 0.05 – 1 ha for minimum area, minimum tree crown cover of 10-30% (or equivalent stocking level), minimum height at maturity of 2 to 5 meters and to report on these parameters, in the annual greenhouse gas inventory as set out in Table 2.4.1. As explained in Section 2.2.6.1 it is also good practice to choose a parameter for the minimum width of forest areas. Once the parameters have been chosen, they will allow identification of units of land subject to afforestation and reforestation.

The identification of units of land subject to afforestation / reforestation activities requires the delineation of areas that:

- Meet or exceed the size of the country's minimum area in the applied forest definition (i.e., 0.05 to 1 ha), and
- Did not meet the definition of forest on, or at some point after, 31 December 1989, and
- Do meet the definition of forest at the time of the assessment as the result of direct human-induced activities; and
- Do not meet the criteria for Carbon Equivalent Forest Conversion at the time of the assessment

Note that the definition of forest can be met by young trees that do not yet meet the minimum height or crown cover criteria, provided that they are expected to reach these parameter thresholds at maturity.

It is *good practice* to distinguish those areas that did not meet the crown cover threshold in the definition of forest, for example because of recent harvest or natural disturbances, from those areas that were non-forest on or at some point after 31 December 1989, because only the latter areas are eligible for afforestation and reforestation activities under the Marrakesh Accords. The Marrakesh Accords require that Parties provide information on the criteria used to distinguish harvesting or forest disturbance that is followed by the re-establishment of a forest from deforestation[63]. It is *good practice* to apply the same criteria when evaluating whether a unit of land meets the definition of forest. For example, if a country uses the criterion "time since harvest" to distinguish temporary forest cover loss from deforestation, and specifies that a harvested area will regenerate within X years, then only those areas that have been harvested and that have not regenerated after X years would be eligible for reforestation, as only they would be considered non-forest. Similarly, areas that have been disturbed by wildfire or other natural disturbances and that have not regenerated to forest after X years would be classified as non-forest and would therefore be eligible for reforestation.

As discussed in Section 2.2.2 (Reporting methods for Lands subject to Article 3.3 and 3.4 activities), Parties have the option either to report a complete inventory of all units of land subject to Article 3.3 activities, or to stratify the land into areas, i.e., defining the boundaries of these areas, and to then develop for each area estimates or inventories of the units of land subject to afforestation, reforestation and deforestation activities. Combined approaches are also possible: complete spatial inventories of all units of land can be developed for some strata, while estimates based on sampling approaches are developed for other strata in the country, ensuring consistency in land representation in order to avoid double counting.

A Party's choice of methods for the development of an inventory of afforestation and reforestation activities will depend on the national circumstances. It is *good practice* to use Approach 3 in Chapter 3 Volume 4 of the *2006 IPCC Guidelines* (Consistent Representation of Lands, Section 3.3) for the identification of units of land subject to afforestation and reforestation since 1990. As discussed above, this requires that the spatial resolution of the systems in Approach 3 meets the requirements for the identification of the minimum forest area of 0.05 to 1 ha. The methods available to identify lands subject to afforestation and reforestation activities are discussed in Section 2.9.2. It is *good practice* to provide information on uncertainties in the estimates of the total area of the units of land subject to afforestation and reforestation as discussed in Section 2.4.3 of this volume.

[63] See paragraph 8(b) of the Annex to draft decision -/CMP.1 (Article 7), contained in document FCCC/CP/2001/13/Add.3, p.23.

2958 It is *good practice* to provide information demonstrating that all afforestation and reforestation activities
2959 included in the identified units of lands are direct human-induced [64] . Relevant information includes
2960 documentation which demonstrates that a decision has been taken that aimed at replanting or promoting or
2961 allowing forest regeneration, for example, through laws, policies, regulations, management decisions and
2962 practices. In the absence of such documentation or information, forest regrowth as a consequence of
2963 abandonment does not qualify as direct human induced afforestation or reforestation.

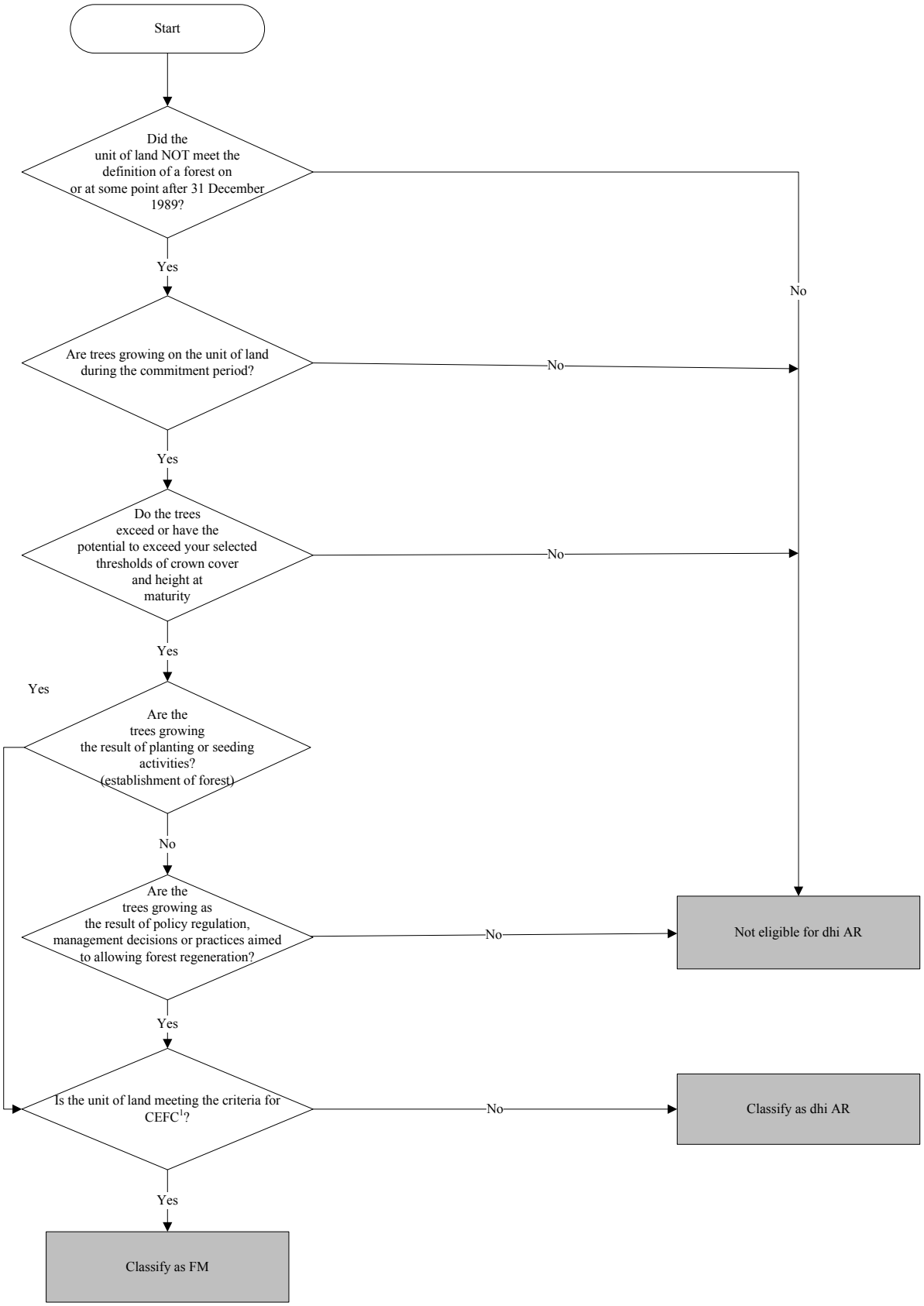
2964 In some cases it may not be clear whether newly established trees will pass the forest threshold. The difference
2965 between afforestation/reforestation activities and revegetation is that, revegetation does not lead to meet (in X
2966 years) the Party's definition of a forest (i.e., the height at maturity or the minimum crown closure). Where it is
2967 uncertain whether the trees on a unit of land will pass the thresholds of the definition of forest, it is *good practice*
2968 not to report these areas as afforested or reforested land, and to await confirmation (at a later time) that these
2969 parameter thresholds have been or will be passed. Prior to meeting the definition of afforestation or reforestation,
2970 the carbon stock changes on these units of land could be reported in the land-use category in which the land was
2971 reported prior to the land-use change, provided that this category is included in the national inventory, e.g., as
2972 cropland or revegetation. This approach is consistent with the treatment of deforestation, i.e., units of land that
2973 have not been confirmed as deforested remain in the forest category – see Section 2.6.2.1. A decision tree for
2974 determining whether an area will qualify for afforestation/reforestation or for revegetation is given in Figure
2975 2.5.1

2976

[64] Decision 16/CMP.1 defines afforestation and reforestation as "... the *direct human-induced* conversion of [non forested] land ... to forested land through planting, seeding and/or the human-induced promotion of natural seed sources." Decision 2/CMP.7 maintained the same definitions.

The *2006 IPCC Guidelines* give the following definition of *Land converted to Forest Land*: **"**Land is converted to Forest Land by afforestation and reforestation, either by natural or artificial regeneration (including plantations). The anthropogenic conversion includes promotion of natural re-growth (e.g., by improving the water balance of soil by drainage), establishment of plantations on non-forest lands or previously unmanaged Forest Land, lands of settlements and industrial sites, abandonment of croplands, pastures or other managed lands, which re-grow to forest." It should be noted that the *2006 IPCC Guidelines*, used for reporting under the UNFCCC, use the term "afforestation and reforestation" with a broad meaning. The reporting under the Kyoto Protocol for the second commitment period follows the rules defined in Decision 2/CMP.7 and any other relevant CMP decision. According to the draft decision -/CMP.8 (Implications of the implementation of decisions 2/CMP.7 to 5/CMP.7 on the previous decisions on methodological issues related to the Kyoto Protocol, including those relating to Articles 5, 7 and 8 of the Kyoto Protocol), Annex II, paragraph 4, page 7, specific information to be reported for activities under Article 3, paragraph 3, shall include information that demonstrates that activities under Article 3, paragraph 3, began on or after 1 January 1990 and before 31 December of the last year of the commitment period, and are *directly human-induced*. The demonstration of direct-human induced afforestation and reforestation is therefore a specific requirement under the Kyoto Protocol, additional to the reporting requirements under the UNFCCC. Due to this difference, some areas that have turned into forest since 1990 in the UNFCCC inventory may not have been converted through direct human- induced activity.

Figure 2.5.1 Decision tree for determining whether a unit of land qualifies for direct human-induced (dhi) Afforestation/Reforestation (AR) or Revegetation (RV)



Note:

1. Equivalent Forest Conversion (CEFC): refer to Section 2.7.7: Carbon Equivalent Forest

Links with methodologies in the *2006 IPCC Guidelines* on reporting of land areas and carbon stock changes and non-CO2 emissions in inventories under the UNFCCC are given in the Box 2.5.1.

BOX 2.5.1

LINKS WITH THE *2006 IPCC GUIDELINES*

Chapter 4 (Forest Land), Section 4.3 (*Land Converted to Forest Land*): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on land converted to Forest Land from different land-uses, through afforestation and reforestation, either by natural or artificial regeneration (including plantations). Note that some areas that have turned into forest since 1990 in the UNFCCC inventory may not have been converted through direct human-induced activity.

2.5.3 Choice of methods for estimating carbon stock changes and non-CO_2 emissions

Estimation of carbon stock changes from afforestation and reforestation activities (including forest establishment accounted for as Article 3.4 forest management under the Carbon Equivalent Forest provision, that would otherwise be accounted for as Article 3.3 afforestation or reforestation) should be consistent with the methods set out in the *2006 IPCC Guidelines* - Chapter 4 (Forest Land), Section 4.3 (*Land converted to Forest Land*), and the equations it contains, and applied at the same or higher tier as used for UNFCCC reporting. Growth characteristics of young trees differ from those of the managed forest as a whole, and special provisions may be needed where the UNFCCC inventory (prepared according to Section 4.3, *Land converted to Forest Land*) is not sufficiently detailed to provide information that applies to young stands.

On areas subject to Article 3.3 activities, gross-net accounting rules are applied and information on carbon stock changes and non-CO_2 emissions in the base year (i.e., 1990) is therefore not required. Only the carbon stock changes and non-CO_2 emissions during each year of the commitment period are estimated and reported.

At Tier 1, biomass growth is determined using the data in *2006 IPCC Guidelines* - Chapter 4, Section 4.3 (*Land Converted to Forest Land*).

Under Tier 2, regional or national growth rates are likely to be available as a function of stand age, species or site quality, but data may be missing for stands between ages 0 years and that reached by the end of the commitment period. Where biomass estimates exist for older age stands, biomass at younger ages can be estimated by interpolating between the known value and biomass zero at age zero using a non-linear growth function fitted to the data that are available for older stands; in some cases, depending on the availability of data other interpolation methods may be applied.

At Tier 3, biomass growth rates should be established directly using measured data, validated growth models, or empirical yield tables for the appropriate combinations of species and site conditions. The estimates of changes in carbon stocks in biomass can be carried out on the basis of finer geographical scale and sub-division to forest type. It is *good practice* to include ground-based field measurements as part of any Tier 3 method, either as a component of a national (or project) forest inventory or of a growth and yield forest monitoring system.

Determination of the size and dynamics of litter, deadwood and soil organic carbon pools prior to the afforestation/reforestation activity may require the use of methods developed for Cropland or other land uses (*2006 IPCC Guidelines* - Chapter 5 and other relevant chapters).

It is *good practice* to estimate emissions and removals of the harvest wood product pool associated with afforestation and reforestation activities using the guidance provided in Section 2.8 (Harvested Wood Products) of this report. It is *good practice* to report carbon stock changes and non-CO_2 emissions (e.g, methane) from organic soils associated with rewetting of drained wetlands under Afforestation and Reforestation activities using the guidance provided in Chapter 2.12 (Wetland drainage and rewetting) of this report.

Links with methodologies in this report and the *2006 IPCC Guidelines* on reporting of carbon stock changes and non-CO_2 emissions in inventories under the UNFCCC are given in Box 2.5.2 below.

Box 2.5.2

LINKS WITH CHAPTERS OF THIS REPORT

Section2.8: Harvested Wood Products

Section 2.12: Wetland drainage and rewetting

LINKS WITH THE *2006 IPCC GUIDELINES*

Section 4.3, Chapter 4 (*Land Converted to Forest Land*)

This section provides methodological guidance on estimation of emissions and removals of greenhouse gases, which occur on lands converted to Forest Land from different land-uses, including Cropland, Grassland, Wetlands, Settlements, and Other land, through afforestation and reforestation, either by natural or artificial regeneration (including plantations).

2.5.3.1 POOLS AFFECTED BY AFFORESTATION/REFORESTATION ACTIVITIES

Afforestation/reforestation activities often involve site preparation (slashing and possibly burning coarse biomass residue, and tilling or ploughing on parts of or the whole area), followed by planting or seeding. These activities may affect not only above and belowground biomass pools, but also soil, as well as deadwood, and litter, if (in the latter instances) land with woody shrub or sparse tree cover was afforested.

The Marrakesh Accords require Parties to estimate carbon stock changes in all five pools (see *2006 IPCC Guidelines* Volume 4, Chapter 1, Table 1.1) during the commitment period unless the Party can demonstrate by transparent and verifiable information that the pool is not a source[65], for which *good practice* guidance is set out in Section 2.3.1. Decision 2/CMP.7[66] further requires Parties to estimate carbon stock changes in the harvested wood product Pools. It is *good practice* to include carbon stock changes and non-CO_2 emissions that result from pre-planting activities, such as site preparation or shrub removals. Land conversions on mineral soils generally either maintain similar levels of belowground biomass carbon storage or create conditions that increase soil carbon stocks, particularly if the land was previously managed for annual crop production (Merino et al. 2004, Post and Kwon, 2000, Schulp et al. 2008). However, under certain circumstances, soil carbon may decline with afforestation of grasslands or wetlands for several years following conversion (Davis and Condron, 2002; Guo and Gifford. 2002; Paul et al., 2003; Tate et al., 2003; Vesterdall et al. 2002), and net losses of carbon after planting and seeding can persist over many years. Therefore, it is *good practice* to ensure that estimates of pre-activity carbon stocks in the area are used to compute stock changes, including for methodologies involving modelling. Since there is no forest on the area prior to the afforestation/reforestation activity, the assessment should be done by methods described in the appropriate sections of the *2006 IPCC Guidelines* - Chapter 4, Section 4.3 (*Land Converted to Forest Land*).

For Article 3.3 afforestation or reforestation activities that begin during the commitment period, reporting for that unit of land should begin at the beginning of the year in which the activity commences[67]. Site preparation and seeding/planting activities should be considered part of the activity, and associated emissions during the commitment period should therefore be included. For forest establishment activity undertaken under the Carbon Equivalent Forest provision, reporting for that unit of land should begin at the beginning of the year in which the corresponding forest land unit is cleared under the same provision.

The methods given in *2006 IPCC Guidelines* – Volume4, Chapter 4, Section 4.3 for estimating non-CO_2 greenhouse gas emissions on lands converted to forest land are applicable for the afforestation and reforestation activities (see *2006 IPCC Guidelines*, Volume4, Chapter 4, Section 4.3.4: Non-CO_2 greenhouse gases emissions from biomass burning).

[65] Paragraph 21 in the Annex to Decision 16/CMP.1 (Land use, land-use change and forestry)

[66] Decision 2/CMP.7

[67] Paragraph 6(d) in the Annex to Decision 15/CMP.1 (Article 7)

2.5.3.2 METHODS TO ADDRESS NATURAL DISTURBANCE

Under the UNFCCC, and in the first commitment period under the Kyoto Protocol, the effect of disturbances on emissions and removals is included in reporting for disturbances, which occur on managed lands, regardless of whether the disturbances are natural or human-induced. Decision 2/CMP.7 introduced a modification of this approach by which under certain conditions the effect of natural disturbances that occur in forests may be excluded from accounting under the Kyoto Protocol for the second commitment period. This provision extends to units of land subject to afforestation and reforestation. The effect of disturbances is included in the discussion of generic methods set out in Chapter 2 of *2006 IPCC Guidelines* and Section 2.3.9 of this volume

Forest lands that have been designated as affected by natural disturbance should be monitored over the commitment period using methods consistent with those used for estimating emissions and removals from these areas. It is *good practice* to keep a complete record of the areas of land that have been subject to natural disturbance provisions, including their geo-referenced location and to check annually for the occurrence of land-use change and salvage logging on each of these land areas using remote sensing or by visiting the land, or these methods in combination. If land-use change has occurred then lands may not be excluded from accounting under the disturbance provision.

2.6 DEFORESTATION

This section addresses specific methods applicable to deforestation activities and should be read in conjunction with the general discussion in Sections 2.2 to 2.4.

2.6.1 Definitional issues and reporting requirements

Under the definitions of the Marrakesh Accords, deforestation refers to direct, human-induced conversion of forest to non-forest land. The definition does not include losses of forest cover due to harvest or natural disturbance events that are followed by natural or human-induced re-establishment of forest. This is because these losses of forest cover are only temporary and therefore not considered deforestation, the land remains as forested land. Harvest followed by re-establishment of forest is considered a forest management activity and reported according to Section 2.7. Natural disturbance followed by re-establishment of forest is not counted as deforestation and disturbance emissions may be excluded from accounting following the methodologies in Section 2.3.9. Human activities (since 1990) such as agricultural practices or the construction of roads or settlements, that prevent forest regeneration by changing land-use on areas where forest cover was removed by a natural disturbance, are considered direct human-induced deforestation. Under the Decision 2/CMP.7, deforestation of some plantation forests in special circumstances may be accounted for as a forest management activity under the Carbon Equivalent Forest Conversion provisions (Section 2.7.7).

The annual inventory should, at a minimum, identify (for Reporting Method 1 in Section 2.2.2):

- The geographical location of the boundaries of the areas that encompass units of land subject to direct human-induced deforestation activities. Areas subject to direct human-induced deforestation that are subject to the Carbon Equivalent Forest Conversion provision (and will therefore be accounted for under forest management) should be identified separately. The geographical boundaries which are reported should correspond to strata in the estimation of land areas as described in Chapter 3, Volume 4 of *2006 IPCC Guidelines*;
- For each of these areas, or strata, an estimate of the area of the units of land affected by direct human-induced deforestation activities, and the area of these units of land that are also subject to elected activities under Article 3.4 (cropland management, grazing land management, revegetation);
- The year of the deforestation activities (1990 or later), which could be estimated through interpolation from a multi-year inventory; and
- The area of units of land subject to direct human-induced deforestation in each of the new land-use categories (Cropland, Grassland, Settlements) to support the calculation of carbon stock changes and non-CO_2 emissions. It is *good practice* to group deforestation units of land by year and to report the deforestation area in each year separately.

Following Decision 2/CMP.7[68] it is mandatory to report and account for conversion of natural forest to planted forest. Reporting should be under forest management rather than Deforestation, because the land remains under the forest definition (Section 2.7).

The more comprehensive system for compiling annual inventory (Reporting Method 2 in Section 2.2.2) identifies each unit of land subject to deforestation since 1990 using the polygon boundaries, a coordinate system (e.g., the Universal Transverse Mercator (UTM) Grid or Latitude/Longitude) at possible finer resolution, or a legal description (e.g., those used by land-titles offices) of the location of the land subject to deforestation activities (note that areas subject to the Carbon Equivalent Forest Conversion provision should be identified separately). Chapter 3, Volume 4 of the *2006 IPCC Guidelines* (Basis for Consistent Representation of Land Areas) discusses in detail the possible approaches for consistent representation of land areas.

Parties will need to use the methods outlined in Chapter 3, Volume 4 of *2006 IPCC Guidelines* (Consistent Representation of Lands), and the guidance in Section 2.2 to ensure that units of land subject to deforestation are adequately identified in land-use change and other inventory databases. The Marrakesh Accords require that areas subject to direct human-induced deforestation since 1990 be reported separately from areas subject to direct human-induced deforestation since 1990 that are also subject to elected activities under Article 3.4. This will ensure that carbon stock changes and non-CO_2 emissions in areas that have been deforested since 1990 (Article 3.3) and that are subject to other elected activities such as cropland management (Article 3.4) are not counted twice. Decision 2/CMP.7 also requires that areas that would be reported as Article 3.3 Deforestation but are instead reported as Article 3.4 forest management under the Carbon Equivalent Forest Conversion provision, be reported separately (Section 2.7.7).

A Party's choice of methods for the development of an inventory of units of land subject to deforestation activities will depend on the national circumstances. For detecting deforestation areas it is *good practice* to use Approach 3 in Section 3.3.1, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*. Section 2.2.2 of this volume provides a general discussion of methods for the reporting on units of land subject to Article 3.3 activities.

2.6.2 Choice of methods for identifying units of land subject to direct human-induced deforestation

Annex B Parties to the Kyoto Protocol must report carbon stock changes and non-CO_2 emissions during the commitment period on land areas that have been subject to direct human-induced deforestation activities since 1990 (after 31 December 1989). The definition of deforestation is given by the Marrakesh Accords[69]. Deforestation for the purposes of the Kyoto Protocol involves the conversion of forest land to non-forest land. The Decision 2/CMP.7 allows the conversion of some planted forest land to non-forest land to be accounted for and reported as forest management if a Carbon Equivalent Forest is established elsewhere (Section 2.7.7). To quantify deforestation, forest must first be defined in terms of potential height, crown cover and minimum area as already described for afforestation and reforestation activities. The same parameter values for the definition of forest must be used for determining the area of land subject to deforestation.

Once a Party has chosen its parameter values for the definition of forests, the boundaries of the forest area can be identified for any point in time. Only areas within these boundaries are potentially subject to deforestation activities. "Treed areas" that do not meet the minimum requirements of the country-specific forest definition can therefore not be deforested.

The identification of units of land subject to deforestation activities requires the delineation of units of land that

[68] Paragraph 5 in the Annex to Decision 2/CMP.7 Annex, Paragraph 5: "Each Party included in Annex I shall report and account for, in accordance with Article 7, all emissions arising from the conversion of natural forests to planted forests". Paragraph 5(d) in Annex II to the Draft decision -/CMP.8 specifies this activity as being reported under Forest Management.

[69] Paragraphs 1(d), 3 and 5, respectively, in the Annex to Decision 16/CMP.1 (Land use, land-use change and forestry):

"Deforestation" is the direct human-induced conversion of forested land to non-forested land.

For the purposes of determining the area of deforestation to come into the accounting system under Article 3, paragraph 3, each Party shall determine the forest area using the same spatial assessment unit as is used for the determination of afforestation and reforestation, but not larger than 1 hectare.

Each Party included in Annex I shall report, in accordance with Article 7, on how harvesting or forest disturbance that is followed by the re-establishment of a forest is distinguished from deforestation. This information will be subject to review in accordance with Article 8.

1. Meet or exceed the size of the country's minimum forest area (i.e., 0.05 to 1 ha), and
2. Have met the definition of forest on or after 31 December 1989, and
3. Have ceased to meet the definition of forest at some time after 1 January 1990 as the result of direct human-induced deforestation; and
4. Do not meet the criteria for Carbon Equivalent Forest Conversion.

Units of land can only be classified as deforested if they have been subject to direct human-induced conversion from forest to non-forest land. Areas in which forest cover was lost as a result of natural disturbances are therefore not considered deforested, even if changed physical conditions delay or prevent regeneration, provided no land-use change has occurred (Section 2.3.9). If, however, the natural disturbance is followed by a non-forest land use, then this will prevent the regeneration of forest, and the disturbance emissions count as deforestation and cannot be excluded from accounting. Forest areas that have been flooded as a result of changed drainage patterns (e.g., road construction or hydroelectric dams) and where the flooding has resulted in a loss of forest cover are considered to be subject to direct human-induced deforestation.

Linkages with methodologies in this report and the *2006 IPCC Guidelines* on reporting of land areas related to deforestation (conversion of forest to other land uses) in inventories under the UNFCCC are given in the Box 2.6.1.

Box 2.6.1

LINKS WITH THE *2006 IPCC GUIDELINES*

Volume 4 **Agriculture, Forestry and Other Land Use**

Chapter 3: Consistent Representation of Land Areas

Chapter 5 (Cropland), Section 5.3 (*Land Converted to Cropland*): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on *Land Converted to Cropland* from different land-uses.

Chapter 6 (Grassland), Section 6.3 (*Land Converted to Grassland*): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on *Land Converted to Grassland* from different land-uses.

Chapter 7 (Wetlands), Section 7.3.2 (*Land Converted to Flooded land*): methodological guidance on annual estimation of emissions and removals of CO_2, which occur on *Land Converted to Flooded land* from different land-uses.

Chapter 8 (Settlements), Section 8.3 (Land Converted to Settlements): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on *Land Converted to Settlements* from different land-uses.

Chapter 9 (Other Land), Section 9.3 (Land Converted to Other land): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on *Land Converted to Other land* from different land-uses.

2.6.2.1 DISCRIMINATING BETWEEN DEFORESTATION AND TEMPORARY LOSS OF FOREST COVER

Parties must report on how they distinguish between deforestation and areas that remain forests but where tree cover has been removed temporarily[70], notably areas that have been harvested or have been subject to other human disturbance but for which it is expected that a forest will be replanted or regenerated naturally. It is *good practice* to develop and report criteria by which temporary removal or loss of tree cover can be distinguished from deforestation. For example, a Party could define the expected time periods (years) between removal of tree cover and successful natural regeneration or planting. The length of these time periods could vary by region, biome, species and site conditions. In the absence of land-use change, such as conversion to Cropland or construction of settlements, areas without tree cover are considered "forest" provided that the time since forest cover loss is shorter than the number of years within which tree establishment is expected. After that time period,

[70] Paragraph 8(b) in the Annex to Decision 15/CMP.1 (Article 7).

lands that were forest on or after 31 December 1989, that since then have lost forest cover due to direct human-induced actions and that failed to regenerate are identified as deforested and the carbon stock changes and non-CO_2 emissions for this land are to be recalculated and added to those of other deforested areas. There is an exception under the Carbon Equivalent Forest provision which allows the carbon stock changes and non-CO_2 emissions from some plantation conversion to non-forest to be reported under forest management if a Carbon Equivalent Forest is established elsewhere (see Section 2.7.7).

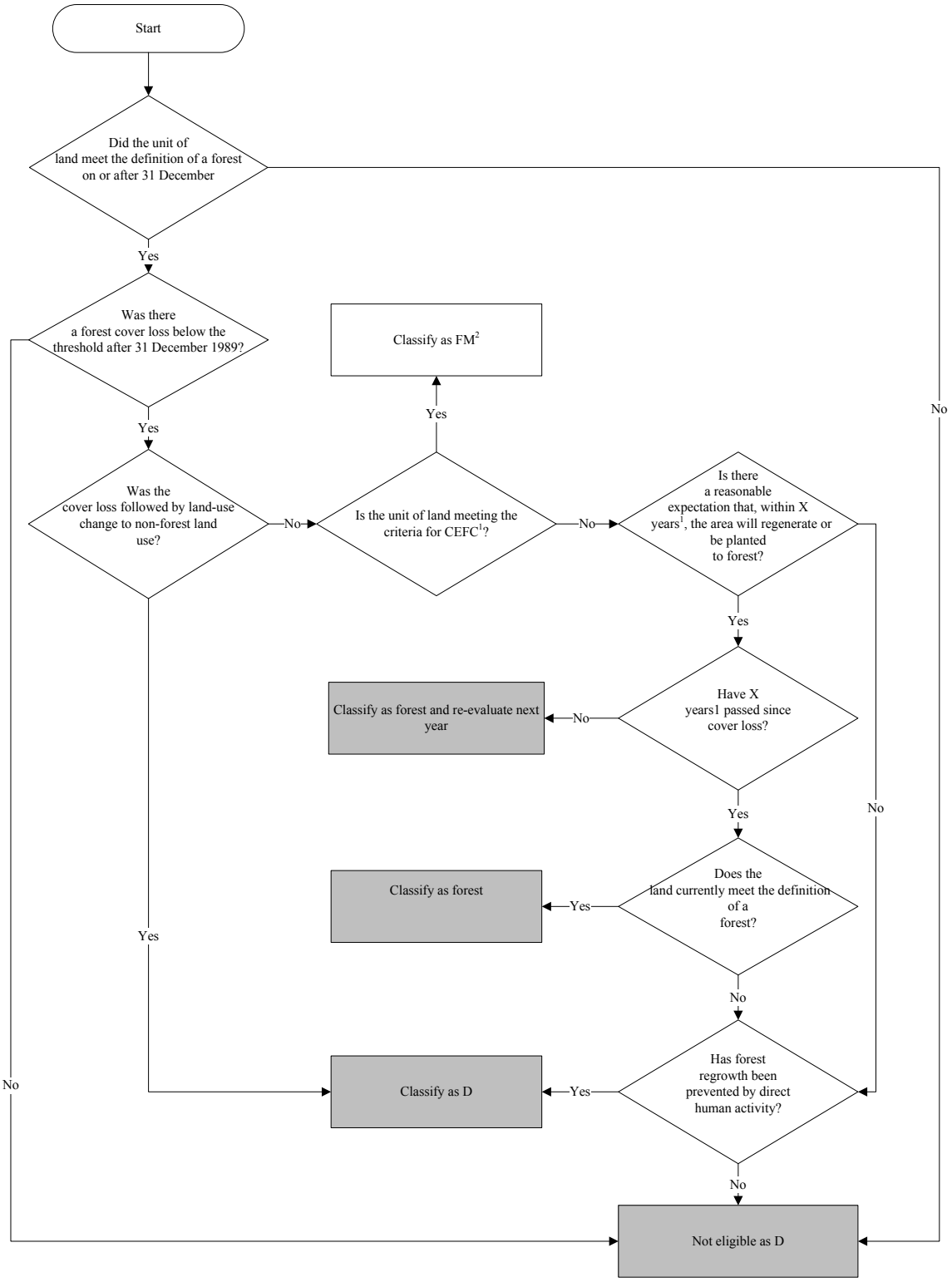
Although the loss of forest cover is often readily identified, e.g., through change detection using remote sensing images, the classification of this area as deforested is more challenging. It involves assessing the unit of land on which the forest cover loss has occurred, as well as the surrounding area, and typically requires data from multiple sources to supplement the information that can be obtained from remote sensing. In some cases a new land use can be determined from remote sensing images, for example where it is possible to identify agricultural crops or infrastructure such as houses or industrial buildings. Information about actual or planned land-use changes and actual or planned forest regeneration activities can be used to distinguish deforestation from temporary loss in forest cover. Where such information is missing or unavailable, only the passage of time will tell whether or not the cover loss is temporary. In the absence of land-use change or infrastructure development, and until the time for regeneration has elapsed, these units of land remain classified as forest. Note that this is consistent with the approach suggested for afforestation and reforestation, i.e., units of land that have not been confirmed as afforested/reforested remain classified as non-forest land. A Party may also choose a more conservative approach. It could calculate, based on regional averages or other data, the proportion of the lands without forest cover that is expected not to regenerate to forest and assign this proportion of the area to lands subject to deforestation.

Regardless of the approach selected, it is *good practice* for Parties to identify and track the units of land with loss of forest cover that are not yet classified as deforested, and to report on their area and status in the annual supplementary information (see Table 2.4.1 in Section 2.4.4.1) It is also *good practice* to confirm that, on these units of land, regeneration did occur within the expected time period. Units of land for which, at the end of a commitment period, no direct information was available to distinguish deforestation from other causes of cover loss, could be reassessed annually or at a minimum prior to the end of the next commitment period. If regeneration did not occur or if other land-use activities are observed, then these units of land should be reclassified as deforested and the carbon stock changes and non-CO_2 emissions recalculated accordingly (see also Chapter 5, Volume1, *2006 IPCC Guidelines*: Time Series Consistency).

The task of distinguishing temporary forest cover loss and deforestation can be supported by information on harvested areas and areas subject to natural disturbances. In many countries, information on harvest cut blocks and on natural disturbance events is more readily available than information on deforestation events. Such information can be used to distinguish direct human-induced deforestation from temporary cover loss (e.g., harvest) or non-human induced disturbances (e.g., wildfire or insect outbreak). Attribution of the cause of forest cover loss to the remaining areas would be made easier and would support the identification and verification of units of land subject to deforestation.

A decision tree for determining of whether a unit of land is subject to direct human-induced deforestation is given in Figure 2.6.1

Figure 2.6.1 Decision tree for determining whether a unit of land is subject to direct human-induced (dhi) Deforestation (D)



Note:

1. Refer to country-specific criteria for distinguishing harvesting from deforestation
2. Carbon Equivalent Forest Conversion (CEFC): refer to Section 2.7.7: Carbon Equivalent Forest

3261

3262 2.6.3 Choice of methods for estimating carbon stock
3263 changes and non-CO_2 emissions

3264 The Marrakesh Accords specify that all carbon stock changes and non-CO_2 emissions during the commitment
3265 period on units of land subject to direct human-induced deforestation since 1990 must be reported[71]. Where
3266 deforestation occurred between 1990 and the beginning of the commitment period, changes in the carbon pools
3267 after the deforestation event need to be estimated for each inventory year of the commitment period. Post-
3268 disturbance losses during the commitment period will result primarily from the continuing decay of deadwood,
3269 litter, below ground biomass and soil carbon remaining on the site after the deforestation event. These losses can
3270 be offset by increases in biomass pools.

3271 If the deforestation occurs during the commitment period, biomass carbon stocks will decrease but, depending on
3272 deforestation practices, some of this biomass may be added to litter, deadwood and harvested wood product
3273 pools. Their increase can initially partly offset biomass carbon losses and delay emissions. In subsequent years,
3274 carbon is likely to be released from litter, deadwood and harvested wood product pools through decay or burning.

3275 It is *good practice* to report carbon stock changes and non-CO_2 emissions (e.g, methane) from organic soils
3276 associated with rewetting of drained wetlands under deforestation activities using the guidance provided in
3277 Section 2.12 (Wetland drainage and rewetting) of this report.

3278 On areas subject to Article 3.3 activities, gross-net accounting rules are applied[72] and information on carbon
3279 stock changes and non-CO_2 emissions in the base year (i.e., 1990) is therefore not required. Only the carbon
3280 stock changes and non-CO_2 emissions during each year of the commitment period are estimated and reported.

3281 For the estimation of carbon stock changes, it is *good practice* to use the same or a higher tier than is used for
3282 estimating emissions from forest conversion in *2006 IPCC Guidelines* Chapters 5,6,7,8,9, Volume 4
3283 (Conversion from Forest Land to any other land-use category).

3284 Carbon stock changes on lands subject to deforestation activities during the commitment period can be estimated
3285 by determining the carbon stocks in all pools prior to and after the deforestation event. Alternatively, the stock
3286 changes can be estimated from the carbon transfers out of the forest, e.g., the amount harvested (Chapter 2,
3287 Volume 4, *2006 IPCC Guidelines*) or the fuel consumed in the case of burning. For deforestation events that
3288 occur prior to the commitment period, knowledge of pre-deforestation carbon stocks will also be useful for the
3289 estimation of post-disturbance carbon dynamics. For example, estimates of emissions from decay of litter,
3290 deadwood, and soil organic carbon pools can be derived from data on pool sizes and decay rates. Information
3291 about pre-deforestation carbon stocks can be obtained from forest inventories, aerial photographs, satellite data,
3292 by comparison with adjacent remaining forests, or can be reconstructed from stumps where these are remaining
3293 on the site. Information on the time since deforestation, on the current vegetation and on management practices
3294 on that site is required for the estimation of carbon stock changes and non-CO_2 greenhouse gas emissions.
3295 Carbon stock changes and non-CO_2 emissions on planted forest land that is converted to non-forest land under
3296 the Carbon Equivalent Forest Conversion provision should be estimated using the same approach as for Article
3297 3.3 deforestation lands, although they will be reported under forest management.

3298 Harvested wood products derived from deforestation activity are accounted for as an instantaneous emission at
3299 the time of deforestation, unless a Carbon Equivalent Forest is established in which case the land is reported
3300 under the forest management activity and harvested wood products are accounted for according to the
3301 methodology described in Section 2.8.

3302 Where units of land subject to deforestation become land under other categories such as Cropland or Grassland,
3303 the established methodologies described in relevant sections of the *2006 IPCC Guidelines* should be used to
3304 estimate carbon stocks changes. Several of these categories may contain little or no carbon, or the change in
3305 carbon may be very small. Box 2.6.2 summarises links with methodologies on estimation of carbon stock
3306 changes and non-CO_2 emissions in this report and with the *2006 IPCC Guidelines*.

3307

[71] Pools which are not a source can be excluded from accounting, though this is unlikely in the case of deforestation

[72] Except for Parties that fall under the provisions of the last sentence of Article 3.7.

BOX 2.6.2

LINKS WITH OTHER CHAPTERS OF THIS REPORT

Chapter 2.8 Harvested Wood Products

Chapter 2.12 Wetland drainage and rewetting

LINKS WITH THE *2006 IPCC GUIDELINES* (VOLUME 4, Agriculture, Forestry and Other Land Use)

Chapter 5 (Cropland), Section 5.3 (*Land Converted to Cropland*): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on *Land Converted to Cropland* from different land-uses.

Chapter 6 (Grassland), Section 6.3 (*Land Converted to Grassland*): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on *Land Converted to Grassland* from different land-uses.

Chapter 7 (Wetlands), Section 7.3.2 (*Land Converted to Flooded land*): methodological guidance on annual estimation of emissions and removals of CO_2, which occur on *Land Converted to Flooded land* from different land-uses.

Chapter 8 (Settlements), Section 8.3 (*Land Converted to Settlements*): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on *Land Converted to Settlements* from different land-uses.

Chapter 9 (Other land), Section 9.3 (*Land Converted to Other land*): methodological guidance on annual estimation of emissions and removals of greenhouse gases, which occur on *Land Converted to Other land* from different land-uses.

2.7 FOREST MANAGEMENT

According to Decision 2/CMP.7 (Land use, land-use change and forestry), accounting of emissions and removals from forest management under the Kyoto Protocol during the second commitment period is mandatory[73] , and based on a reference level[74] .

This section addresses definitional issues and specific methods for identification of areas subject to forest management and calculation of carbon stock changes and non-CO_2 emissions for those areas (Sections 2.7.1, 2.7.2, 2.7.3).

This section also addresses the new elements introduced by Decision 2/CMP.7, including:

- Reporting of emissions arising from the conversion of natural forests to planted forest (within Section 2.7.1).
- Methodological requirements related to the forest management reference level (Section 2.7.5).
- Performance of technical corrections for accounting purposes (see Section 2.7.6).
- Reporting and accounting of lands under the Carbon Equivalent Forest Conversion provision (i.e., lands under forest management that would otherwise be accounted as Article 3.3 lands, Section 2.7.7).

The treatment of harvested wood products related to forest management, according to Decision 2/CMP.7, is discussed briefly in this section and in more detail in Section 2.8.

This section should be read in conjunction with the general discussion in Sections 2.2 to 2.4.

2.7.1 Definitional issues and reporting requirements

Under the Marrakesh Accords, "Forest Management" is defined as "*a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner*". It includes both natural forests and plantations meeting the forest definition in the Marrakesh Accords with the parameter values for forests that have been selected and reported by the Party. Decision 2/CMP.7 maintains the same definition of forest management as in the Marrakesh Accords[75] .

There are two conceivable approaches that countries could choose to interpret the definition of forest management. In the narrow approach, a country would define a system of specific practices that could include stand-level forest management activities, such as site preparation, planting, thinning, fertilization, and harvesting, as well as landscape-level activities such as fire suppression and protection against insects, undertaken since 1990. In this approach the area subject to forest management might increase over time as the specific practices are implemented on new areas. In the broad approach, a country would define a system of forest management practices (without the requirement that a specified forest management practice has occurred on each land), and identify the area that is subject to this system of practices during the inventory year of the commitment period.

According to Decision 2/CMP.7, Parties are required to report and account for all emissions and removals arising from the conversion of natural forests to planted forests after 31 December 2012. In this context, "conversion" does not involve a land-use change but refers to the replacement of natural forest after harvesting with planted forests. Following Section 1.1, it is *good practice* that Parties, according to their national circumstances, provide their definition of natural forest and planted forest, which should include forest plantations (as defined in the *2006 IPCC Guidelines*), define when a transition from natural forest to planted forest occurs, and apply these definitions consistently throughout the commitment periods. It is *good practice* that emissions and removals on lands subject to conversion from natural forest to planted forest are reported and accounted within forest management.

According to Decision 2/CMP.7, Parties applying the Carbon Equivalent Forest Conversion provision described in Section 2.7.7 need to report these lands separately from other forest management lands. These lands will include both forest and non-forest lands but are accounted for as forest management.

[73] See paragraph 7 in the Annex to Decision 2/CMP.7, contained in document FCCC/KP/CMP/2011/10/Add.1, p.14.

[74] See paragraph 12 in the Annex to Decision 2/CMP.7, contained in document FCCC/KP/CMP/2011/10/Add.1, p.14.

[75] See paragraphs 20 and 21 of the Annex to Decision 2/CMP.7, contained in document FCCC/KP/CMP/2011/10/Add.1, p.16.

Section 2.2 (Generic Methodologies for Area Identification, Stratification and Reporting) explains that the geographical location of the boundaries of the areas containing land subject to forest management activities need to be defined and reported. Two reporting methods are outlined in Section 2.2.2.

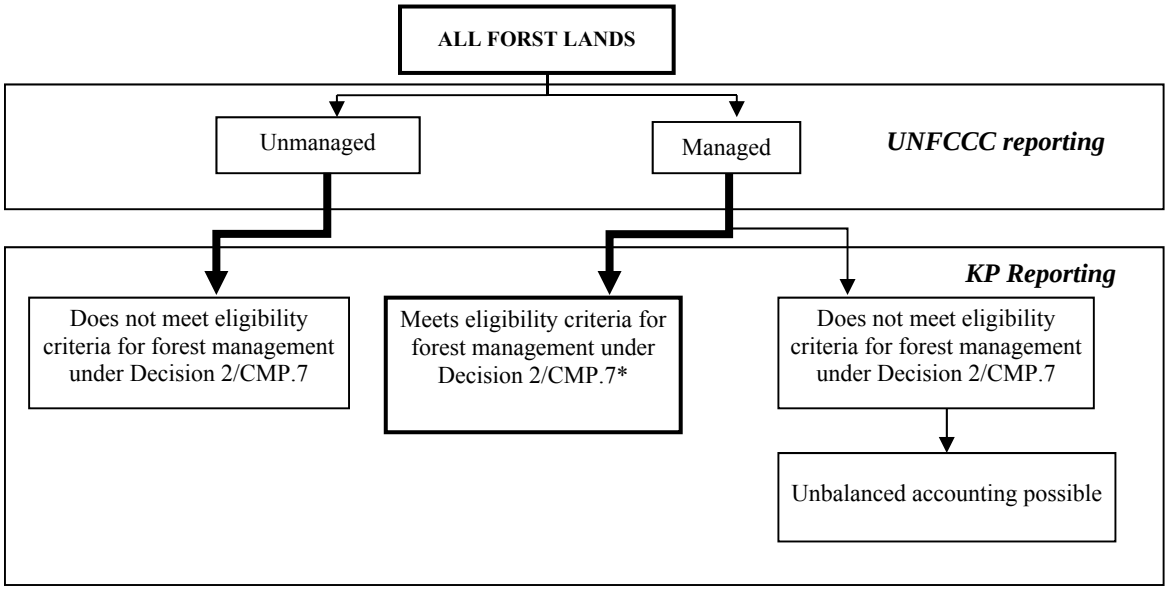
In Reporting Method 1 a boundary may encompass multiple forest management lands and other kinds of land use such as agriculture or unmanaged forests. Any estimates of carbon stock changes resulting from forest management are for the forest management lands only. In Reporting Method 2, a Party identifies the geographic boundaries of all lands subject to forest management throughout the country. Reporting Method 1 or 2 are used for reporting the carbon stock changes and non-CO_2 emissions in the aboveground biomass, belowground biomass, deadwood, litter, and soil organic carbon. Accounting for the harvested wood products pool is at the national level. For both reporting methods, forest management lands include also non-forest land accounted for under forest management through the Carbon Equivalent Forest Conversion provision.

The Marrakesh Accords also specify that lands subject to forest management (Article 3.4) that are also subject to Article 3.3 activities (in this case only afforestation and reforestation) be reported separately from those lands that are subject to forest management only.

2.7.2 Choice of methods for identifying lands subject to Forest Management

Land subject to "Forest Management" as defined by the Marrakesh Accords and by Decision 2/CMP.7 is not necessarily the same area as "managed forests" in the context of the *2006 IPCC Guidelines* used for UNFCCC reporting. The latter includes all forests under direct human influence, including forests that may not meet the requirements of the Marrakesh Accords. Most of the forest area that is subject to forest management under Article 3.4 of the Kyoto Protocol would also be included in the area of "managed forests" of a Party. The relationships are summarized in Figure 2.7.1.

Figure 2.7.1 Relationship between different forest categories. Some of these lands may also be subject to activities under Article 3.3 (afforestation or reforestation) as outlined in Figure 1.1. Thick arrows indicate where the majority of the area included in a particular category for UNFCCC reporting is likely to be included for Kyoto Protocol reporting. See Sections 2.7 and 2.7.1 for further explanation.



* Some non-forest land can also meet the eligibility criteria of Decision 2/CMP.7 for accounting as forest management, under the Carbon Equivalent Forest Conversion provision (see Section 2.7.7).

It is *good practice* for each Party to provide documentation of how it applies the definition of forest management under Decision 2/CMP.7 in a consistent way, and how it distinguishes areas subject to forest management from other areas. Examples of country-specific decisions include the treatment of tree orchards or grazing lands with tree cover. It is *good practice* to base the assignment of land to activities using criteria of predominant land use, following the guidance in Section 1.2.

Figure 2.7.1 outlines the relationship between different forest categories. For UNFCCC reporting, countries have subdivided their forest area into managed forests (those that are included in the reporting) and unmanaged forest (not included). The managed forests could further be subdivided into those areas that meet the eligibility criteria for forest management activities under Decision 2/CMP.7 and those (if any) that do not.

Since most countries have in place policies to manage forests sustainably, and/or use *practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner*[76] , the total area of managed forest in a country will often be the same as the area subject to forest management. It is *good practice* to define the national criteria for the identification of land subject to forest management such that there is good agreement between the area of managed forest (as reported under the UNFCCC) and the area of forest subject to forest management. Where differences occur between the two, these should be explained and the extent of the differences should be documented. In particular, where areas that are considered managed forest are excluded from the area subject to forest management, the reason for the exclusion should be provided, to avoid the perception of unbalanced accounting (Figure 2.7.1). Unbalanced accounting can occur if areas that are considered a source are preferentially excluded and areas considered a sink are included in the national reporting. The IPCC Report on *Definitions and Methodological Options to Inventory Emissions from Direct Human-Induced Degradation of Forests and Devegetation of Other Vegetation Types* further addresses the issue of unbalanced accounting. The inclusion of non-forested areas within forest management accounting under the Carbon Equivalent Forest

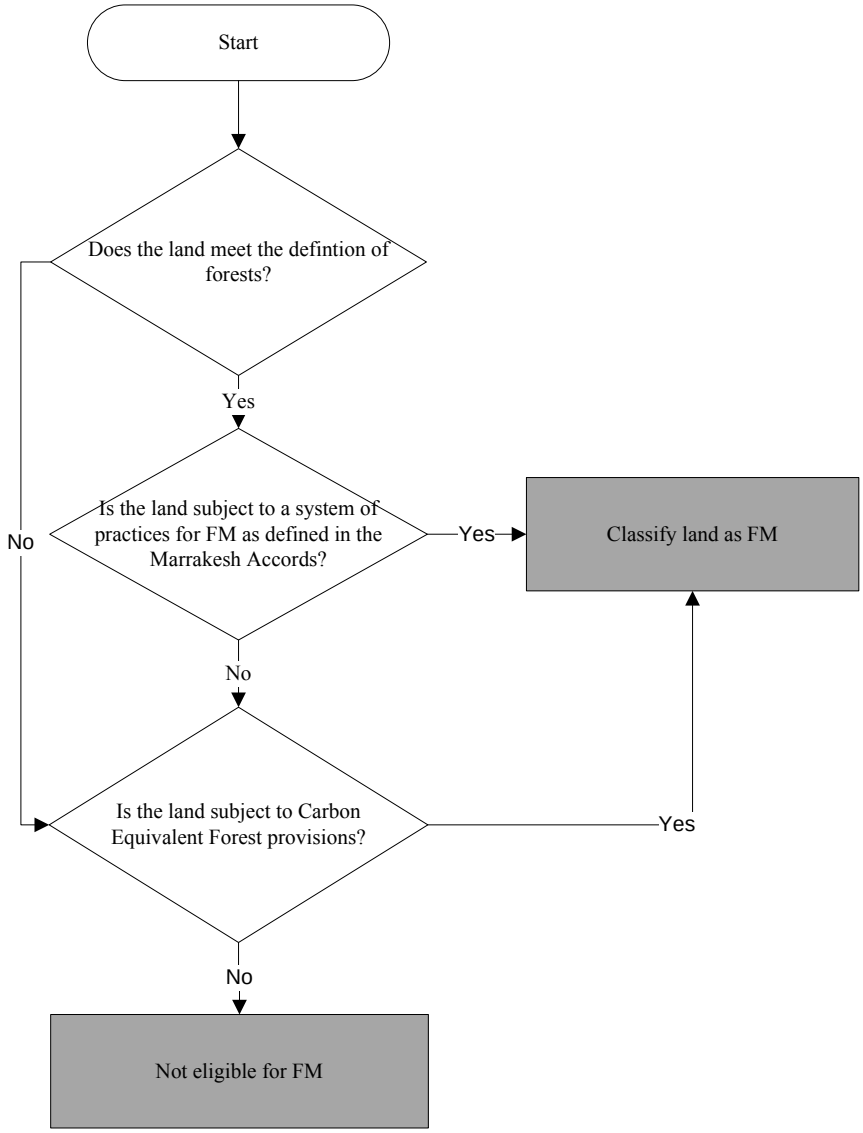
[76] See paragraph 1(f) in the Annex to Decision 16/CMP.1 (Land use, land-use change and forestry).

Conversion provision can also lead to differences between the reported area of managed forest and the area under forest management – all such areas must be clearly identified (see Section 2.7.7).

Figure 2.7.2 gives the decision tree for determining whether land qualifies as subject to forest management. Land that is classified as subject to forest management must meet the country's criteria for forest. It is possible that more than one direct human activity impacts the land. In such cases, the land has to be reported under forest management, if not already reported under afforestation/reforestation.

3438 **Figure 2.7.2 Decision tree for determining whether land qualifies as being subject to**
3439 **Forest Management. This decision tree applies to lands which are not eligible**
3440 **for direct human-induced AR (see Figure 2.5.1)**

3441



3442

3443

It is *good practice* to develop clear criteria for the assignment of lands to Article 3.4 activities based on the predominant land use and the hierarchy among activities, according to the guidance in Section 1.2 on land categorization, and to apply these criteria consistently across space and time. For example, lands that are predominantly managed for grazing could be included under grazing land management even if tree cover exceeds the threshold for forest definition, provided that the predominant land use is not forest. Similarly, fruit orchards can meet the definition of forest, but be reported under cropland management if the forest land use is not predominant. Whether land is classified under forest management, or grazing land management/cropland management or wetland drainage and rewetting has implications for the accounting rules that apply.

It is *good practice* for each Party to describe its application of the definition of forest management and to delineate boundaries of the areas that encompass land subject to forest management in the inventory year of the commitment period. In most cases, this will be based on information contained in forest inventories including criteria such as administrative, zoning (e.g., protected areas or parks) or ownership boundaries, since the difference between managed and unmanaged forests or, possibly, between managed forest meeting the Marrakesh Accords definition of forest management and managed forest not doing so, may be difficult or impossible to detect by remote sensing or other forms of observation. Lands subject to afforestation and reforestation activities that also qualify as forest management lands must be identified separately from those areas meeting only the criteria of Article 3.3 or those only subject to forest management under Article 3.4. Identification of these areas reduces the possibility of double counting.

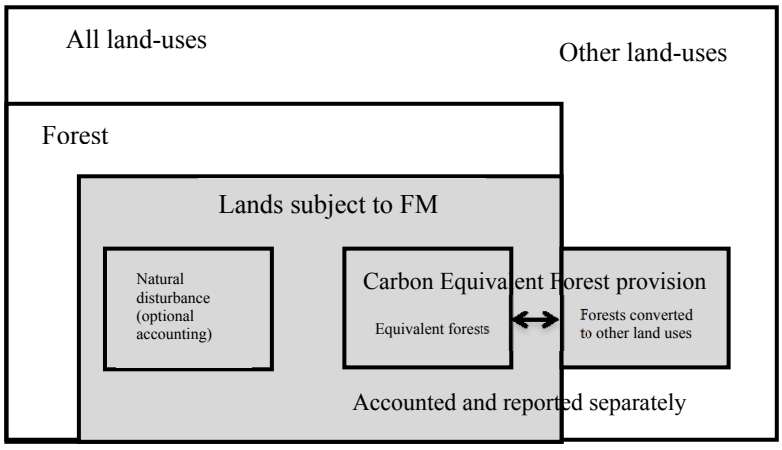
It is *good practice* for each Party to provide information to show that where a transition from natural forest to planted forest has occurred based on their national definitions, reporting and accounting of emissions and removals has been captured within forest management.

According to Decision 2/CMP.7, the carbon stock changes and non-CO_2 emissions on lands subject to forest management under Article 3.4 can be excluded from accounting if they are subject to natural disturbance (See Section 2.3.9).

The area of land subject to forest management can increase or decrease over time. For example, if a country expands its road infrastructure into previously unmanaged forests and initiates harvesting activities, the area of land subject to forest management is increasing and the associated carbon stock changes need to be estimated accordingly. On the other hand, deforestation decreases the area under forest management. Where changes in area occur over time, it is essential that the methods for carbon stock change calculation are applied in the sequence outlined in Section 2.3.3. Failure to use the correct computational methods may result in an apparent but incorrect increase in carbon stocks that is the result of the area change.

Once an area has been included in the carbon stock change reporting under the Kyoto Protocol it cannot be removed, but it can change the reporting category (as outlined in Section 1.2). Units of land that are deforested are, however, subject to the rules of Article 3.3 and future carbon stock changes must be reported. Thus, while the area reported under Article 3.4 would be decreasing, the area reported under Article 3.3 would be increasing by the same amount.

Figure 2.7.3 Relationship among forest lands, lands subject to FM, lands subject to natural disturbance and Carbon Equivalent Forests.



Forest land that is converted to non-forest under the Carbon Equivalent Forest provision (see Section 2.7.7. is reported under Article 3.4, as is the compensating non-forest land converted to forest land. This means that the

area reported under forest management may increase without an increase in forested land. It is *good practice* that lands subject to the Carbon Equivalent Forest provision are identified separately with the boundaries delineated. All lands under the Carbon Equivalent Forest provision are subject to forest management, and these lands include newly planted equivalent forests and forests converted into other land uses. Figure 2.7.3 shows relationships of lands subject to forest management.

Box 2.7.1 summarises links with methodologies in this report and with the *2006 IPCC Guidelines* for the identification of land areas.

BOX 2.7.1

LINKS WITH CHAPTER 3 OR 4 OF THE *2006 IPCC GUIDELINES*

Volume 4 Agriculture Forestry and Other Land Use

Chapter 3 Consistent Representation of Lands

Chapter 4 Section 4.2 (*Forest Land Remaining Forest Land*)

2.7.3 Choice of methods for estimating carbon stock changes and non-CO_2 emissions

The methods to estimate carbon stock changes in the various pools within forest management lands follow those in the *2006 IPCC Guidelines*, as elaborated in Volume 4, Chapter 4, for above- and belowground biomass, dead wood, litter and soil organic carbon. For harvested wood products, estimation methods in line with Decision 2/CMP.7 are provided in Section 2.8 of this report.

On areas subject to forest management activities, the reference level accounting rule is applied for the second commitment period, i.e. for each Party the accounting is based on the comparison between the net emissions and removals reported for forest management during the commitment period and the forest management reference level inscribed in the appendix to the Decision 2/CMP.7 (see Section 2.7.5). In certain cases, it is *good practice* to apply Technical Corrections for accounting purposes (see Section 2.7.6).

The tier structure described in the *2006 IPCC Guidelines* should be applied as follows:

- Tier 1 can only be applied if forest management is not considered a *key category*, or if the pool is "not significant", according to the guidance in Section 2.3.6 (Choice of method). Tier 1 as elaborated in Volume 4, Chapter 4 assumes that the net change in the carbon stocks for litter (forest floor), dead wood and soil organic carbon (SOC) pools is zero, but Decision 2/CMP.7 specifies that above- and belowground biomass, litter, dead wood, and SOC should all be accounted unless the country chooses not to report changes in a pool demonstrating it is not a net-source. Therefore Tier 1 can only be applied if the litter, dead wood and SOC pools can be shown not to be a net-source using the methods outlined in the Section 2.3.1 (Pools to be reported). It is important to note that, once a pool has been included in the forest management reference level, for consistency reasons it is *good practice* to report this pool during the commitment period, irrespective of the pool being a sink or a source (see Section 2.7.5.2 on methodological consistency). For the harvested wood products, specific guidance is provided in Section 2.8.
- It is *good practice* to apply Tier 2 and 3 methods if forest management is a *key category* and if the pool is "significant", according to the guidance in Section 2.3.6. With the exception of the pools already included in the forest management reference level, a country may decide to exclude those pools that can be shown not to be a net-source, using the methods described in Section 2.3.1.

In most cases, the information requirements for Kyoto Protocol reporting exceed the information contained in the national UNFCCC inventory. The conditions that need to be met to ensure that the information contained in the national UNFCCC inventory satisfies the requirements for Kyoto Protocol reporting include:

1. The areas subject to forest management are the same as the areas of the managed forest (Figure 2.7.1), (or where these are not the same the area and carbon stock changes of the areas subject to forest management are known), and
2. The area and carbon stock changes of the managed forest within the geographic boundaries of each of the strata used in a country are known, and
3. The area of the managed forest that was the result of direct human-induced afforestation or reforestation since 1990 is known, along with the carbon stock changes on this area.

4. There has been no Carbon Equivalent Forest conversion, so there are no non-forest lands accounted for within forest management but not within managed forests under the UNFCCC reporting.

5. There have been no areas subject to natural disturbance for which emissions and subsequent uptake have been excluded from accounting.

6. Harvested wood products may be accounted for on the basis of instantaneous oxidation, or a country-specific approach has been used for convention reporting that is compatible with the requirements for accounting as defined in Decision 2/CMP.7 (e.g. harvested wood products from deforestation and imports are excluded).

Furthermore, to meet the Kyoto Protocol reporting requirements, national accounting systems should be able to identify and track all forest areas (with geo-referenced and/or statistical techniques, as specified in Section 2.2), whether these are classified as managed forest (UNFCCC) or subject to Articles 3.3 and/or 3.4 of the Kyoto Protocol, and whether they have been subject to natural disturbances or to the Carbon Equivalent Forest accounting provisions. Such systems can then be used to calculate and report the net carbon stock changes in all relevant categories for both UNFCCC and Kyoto Protocol reporting. Such a comprehensive approach would also ensure consistency among the methods used for calculating and reporting carbon stock changes, because the same forest and land-use change inventories would be the basis for the computations used in both UNFCCC and Kyoto Protocol reporting.

Box 2.7.2 summarises links with methodologies in this report and with the *2006 IPCC Guidelines* to estimate carbon stock changes and non-CO_2 emissions.

BOX 2.7.2

LINKS WITH THE *2006 IPCC GUIDELINES*

Chapter 4 Section 4.2 (*Forest Land Remaining Forest Land*)

The area subject to forest management may not be the same as the area of *Forest Land Remaining Forest Land* and estimates may have to be adjusted accordingly.

2.7.4 Methods to address natural disturbance

The identification of areas subject to forest management, and especially the calculation of carbon stock changes and non-CO_2 emissions for these areas, can be influenced by the presence of natural disturbances, i.e. non-anthropogenic events or non-anthropogenic circumstances that cause significant emissions in forests and are beyond the control of, and not materially influenced by a Party. Emissions from forest management can be influenced by natural disturbances in two ways: 1) through emissions from natural disturbances occurring in the commitment period and; 2) through an inconsistency between the treatment of natural disturbances in the reporting of forest management emissions in the commitment period and the forest management reference level. Methods for addressing natural disturbances in case 1) are provided by Section 2.3.9 Disturbances. Guidance to address inconsistencies in the treatment of natural disturbances in reported data and the forest management reference level are presented in Sections 2.7.5 and 2.7.6.

2.7.5 Forest Management Reference Levels

According to Decision 2/CMP/7[77], for the second commitment period of the Kyoto Protocol, accountable carbon stock changes and non-CO_2 emissions resulting from forest management under Article 3, paragraph 4, equal carbon stock changes and non-CO_2 emissions in the commitment period, less the duration of the commitment period in years times the Forest Management Reference Level (FMRL) inscribed in the Appendix to the decision. In practice, the FMRL is a value of annual net emissions and removals from forest management, against which the net emissions and removals reported for forest management during the second commitment period, will be compared to for accounting purposes.

This section addresses methodological issues related to the FMRL, including: (i) approaches and methods used and the elements taken into consideration by Parties for the construction of their FMRL, (ii) a description of how to demonstrate methodological consistency between the FMRL and reporting for forest management during the commitment period, and (iii) a description of how and when to perform technical corrections for accounting

[77] Decision 2/CMP.7 in document FCCC/KP/CMP/2011/10/Add.1.

purposes, if necessary to ensure consistency, or to exclude from the accounting any impact due to inconsistencies. This section should be read in conjunction with the general guidance on forest management in Sections 2.7.1 to 2.7.4.

2.7.5.1 APPROACHES, METHODS AND ELEMENTS CONSIDERED IN THE CONSTRUCTION OF FMRLS

Decision 2/CMP.6 requested each Annex I Party to submit information on how the country's FMRL was constructed and provided guidelines for the submission of such information. The objectives of the submissions were: (a) to provide information consistent with the general reporting principles set out by the Convention and elaborated by the IPCC on how the elements contained in footnote 1 in paragraph 4 of decision 2/CMP.6[78] were taken into account by Parties in the construction of FMRLs, and to provide any additional relevant information; (b) to document the information that was used by Parties in FMRLs in a comprehensive and transparent way; and (c) to provide transparent, complete, consistent, comparable and accurate methodological information used at the time of the construction of the FMRL.

The information provided by the Parties on how the FMRL was constructed provides the basis for assessing the methodological consistency between the FMRL and the reporting of forest management during the second commitment period. This section summarizes the approaches and methods used and the elements considered in the construction of the FMRL, based on the FMRL submissions made by Parties and the synthesis report of the technical assessments provided by the UNFCCC Secretariat[79].

APPROACHES AND METHODS USED TO CONSTRUCT FMRLS

The FMRL submissions included a description of the approaches, methods and models used in the construction of the FMRLs, including assumptions used and referring, where relevant, to the latest available NIR. Based on the submissions on FMRL made by Parties, the following general approaches used to set FMRLs may be recognized (see Box 2.7.3 for more details):

1. FMRLs based on modelled projections under a business as usual scenario.
2. FMRLs based on the average of or the linear extrapolation of historical data from GHG inventories, assumed as proxy for a business-as-usual scenario.
3. FMRLs based on a single year (1990).
4. FMRL set as zero.

[78] These elements are: (a) removals or emissions from forest management as shown in greenhouse gas inventories and relevant historical data; (b) age-class structure; (c) forest management activities already undertaken; (d) projected forest management activities under a 'business as usual' scenario; (e) continuity with the treatment of forest management in the first commitment period; (f) the need to exclude removals from accounting in accordance with decision 16/CMP.1, paragraph 1. Points (c), (d) and (e) above were applied where relevant. The FMRLs also took into account the need for consistency with the inclusion of carbon pools and the provisions for addressing natural disturbances.

[79] Synthesis report of the technical assessments of the forest management reference level submissions. Note by the secretariat. FCCC/KP/AWG/2011/INF.2, http://unfccc.int/bodies/awg-kp/items/5896.php

BOX 2.7.3
APPROACHES USED FOR CONSTRUCTING FOREST MANAGEMENT REFERENCE LEVELS

Based on the UNFCCC's synthesis report of the technical assessments of the FMRL submissions, it emerges that out of the 38 Parties submitting FMRLs, 17 used country-specific projections, 14 used a common approach for projections, one proposed a historical average, two proposed an extrapolation of historical data, three proposed historical FMRLs based on a single year, and one proposed an FMRL of zero. Below are summarized the different approaches used, aggregated into the four groups:

1) FMRLs based on modelled projections under a 'business-as-usual' scenario

Model-based projections using country-specific methodology. Most of the country-specific approaches used data from national forest inventory (NFI) as a source information for future forest resources, combined with projections of future harvest demand from partial equilibrium models or scenario analysis.

Model-based projections using a common methodological approach. Several EU countries followed a common approach developed by Joint Research Centre (JRC) of the European Commission, in collaboration with modelling groups from the International Institute for Applied Systems Analysis (IIASA) and the European Forest Institute (EFI). Two models projected annual estimates of emissions and removals for forest management until 2020 for the living biomass carbon pool. To calculate the FMRL, the average of models' results for the time series 2000–2020 were "calibrated" ex-post using historical GHG data from each country for the period 2000–2008. This was achieved by shifting the projection up or down to achieve the same average as the historical data for the calibration period.

2) FMRLs based on the elaboration of historical data from GHG inventories, assumed as proxy for a 'business-as-usual' scenario

Average of historical data. One Party for its revised FMRL used the average removals under the Forest land Remaining Forest Land category, as reported in the 2011 GHG inventory for the period 1990–2009.

Extrapolation from a historical time series trend. Two Parties used a linear extrapolation of net emissions historical data (1990–2008) to construct the FMRLs.

3) Historical FMRL based on the single year 1990

Three Parties proposed the use of a historical FMRL based on 1990 data.

4) FMRL equal to zero

One Party used the narrow approach for forest management, and set its FMRL equal to zero, which is equivalent to gross–net accounting.

ELEMENTS CONSIDERED IN THE CONSTRUCTION OF FMRLS

Pools and gases

Decision 2/CMP.6 requested Parties to identify pools and gases which have been included in the FMRL, to explain the reasons for omitting a pool from the FMRL construction (i.e. including evidence for the pool not being a source), and to explain consistency between the pools and gases included in the FMRL and those included in the reporting of forest management or *Forest Land Remaining Forest Land*.

Furthermore, Decision 2/CMP.7 specified that for the second commitment period Party shall account for all changes in above-ground biomass, below-ground biomass, litter, deadwood, soil organic carbon and harvested wood products (see Section 2.3.1 for additional information and methodological guidance).

Area under forest management

The FMRL submissions contain information on the forest management area used in the construction of the FMRL with the aim of showing consistency with the reporting of forest management or *Forest land Remaining Forest Land*. Parties also explained how the area used in the construction of the FMRL relates to the area accounted for as subject to deforestation and afforestation or reforestation activities. In the case of modelled projections, consistency between FMRL area and area under Article 3.4 activities means that the future deforestation is taken into account by projecting a decreasing FM area in the second commitment period[80] , and that the expected future afforestation and reforestation should not affect the evolution of FM area considered for FMRL. In some cases, an increase in the future FM area was included in FMRL due to new forest area (e.g., previously unmanaged) assumed to enter the FM definition.

Historical data from greenhouse gas inventory

Parties were also requested to include in the FMRL submissions information on the relationship between forest management and *Forest Land Remaining Forest Land* as shown in GHG inventories and relevant historical data, including information provided under Article 3.3, and, if applicable, Article 3.4. The purpose of this information is to show the consistency between the proposed FMRLs and historical data as reported in each Party's GHG inventory and NIR. The historical data came from the 2010 GHG inventory, unless otherwise specified. In case of modelled projections, the consistency with historical data can be shown by the fact that the model used for constructing the projected FMRL reproduces historical data forest management or *Forest land Remaining Forest Land* from the GHG inventory.

Forest characteristics and related management

The FMRL submissions included information on forest characteristics, including age-class structure, increments, rotation lengths, and other relevant information, including information on forest management activities already undertaken and assumed under business as usual. In many cases information included the forest types, the soil types, the growing stock, the tree species composition and the detailed silvicultural practices (including the regeneration modality, the type and frequency of cuttings, etc.). In the case of models used for projected FMRLs, other information included the assumptions on future silvicultural practices, on key drivers (i.e. harvest rates), on the expected evolution of key forest characteristics (age structure, increment), with the aim to describe transparently the forest management activities foreseen under the business as usual scenario and to demonstrate their feasibility.

Historical and assumed harvesting rates

Harvest rate is a major driver of emissions and removals from forest management. The FMRL submissions included the time series of historical harvesting rates and the predicted future harvest rates. In the case of modelled projections, it is particularly important that the information showing that the historical harvest used by the models is consistent with data used in the GHG inventory or, in case harvest is not used in GHG inventories (i.e., if the stock-difference method is used), that the historical harvest used by the models is consistent with official country statistics.

For projected FMRLs, countries provided information on the assumptions about the future harvesting rates, based on business-as-usual scenarios (i.e. considering domestic policies adopted and implemented no later than December 2009). Some Parties used averages of historical harvest rates as a proxy of business-as-usual scenario, while other Parties predicted future harvest based on macroeconomic scenarios or based on the continuation of current forest management activities. For transparency purposes, any information on the assumptions made on the disaggregation of future harvest, by type of wood use (i.e. industrial wood/wood for energy use) and/or by assortment types (as feedstock for HWP production, cf. Section 2.8.1), was useful to demonstrate consistency between the biomass losses due to assumed future harvest rates and the biomass used for HWP estimates.

Harvested wood products

Many Parties presented in their FMRL submissions values related to the contribution of HWP, assuming either instantaneous oxidation, or a first-order decay function with default half-lives (see Section 2.8.5).

Since the final agreement on HWP, included in the Decision 2/CMP.7, was reached after the FMRL submissions, it is essential to consider the need for a Technical Correction for accounting purposes in order to reflect the Decision 2/CMP.7. See Section 2.8 for detailed information and *good practice* guidance on HWP.

[80] Some Party did not consider the impact of future deforestation rate on the evolution of the FM area, assuming this has a conservative impact on the FMRL value.

Natural disturbances

Decision 2/CMP.6 also requested Parties to consider including in the construction of their FMRLs information on disturbances in the context of *force majeure* (as defined in decision 2/CMP.6). Most Parties did not consider disturbances explicitly in the construction of their FMRLs, often noting the low frequency of such events. In some cases, the average impact of past disturbances is incorporated in the FMRL through the methodologies used. In other cases, the impact of natural disturbances on FMRL was expressed as a range of possible disturbances scenarios or as a constant background level of natural disturbances.

Since the final agreement on natural disturbances, included in the Decision 2/CMP.7, was reached after the FMRL submissions, a Technical Correction for accounting purposes may be needed if a country intends to apply the provision on natural disturbances for the second commitment period. See Section 2.3.9 for detailed information and *good practice* guidance on natural disturbances.

Factoring out

Decision 2/CMP.6 required Parties to consider in their FMRL submissions factoring out in accordance with paragraph 1(h) (i) and 1(h) (ii) of decision 16/CMP.1 (i.e. to factor out the removals from elevated carbon dioxide concentrations above pre-industrial level, indirect nitrogen deposition, and the dynamic effects of age class structure resulting from activities and practices before the reference year 1990). Parties did not explicitly consider factoring out in their FMRLs. In the case of historical FMRLs, it is noted that, given the present state of scientific knowledge, the effects of elevated CO_2 concentrations and indirect nitrogen deposition are considered to be approximately the same in the FMRL and in the commitment period estimates, and therefore they can be assumed to be factored out. The dynamic age-class effects will remain over any given commitment period but may eventually be removed from accounting by being cancelled out over successive commitment periods. For projected FMRLs, it is generally assumed that there is no effect from elevated CO_2. Furthermore, the use of a projected FMRL means that removals resulting from elevated CO_2 concentrations above the pre-industrial level and indirect nitrogen deposition will be factored out when subtracting the FMRL from net emissions or removals that occur during the commitment period. Similarly, the dynamic effects of differing age-class structures across the forests resulting from past activities and practices and natural disturbances are included in both the construction of the FMRL and the estimation of net emissions during the reporting period.

Continuity with the treatment of forest management in the first commitment period

This is not a relevant element for most approaches used to calculate the FMRL. For one country, the continuity with the treatment of forest management in the first commitment period means that the same narrow approach with gross–net accounting will continues, and therefore FMRL was set as zero. In this case, the narrow approach accounts for emissions and removals only from forest land where these activities, including thinning, are implemented or where any additional activity is to be implemented to enhance sustainable forest management in the future. In doing this, the narrow approach provides continuity with the first commitment period.

Policies included

Following Decision 2/CMP.6, Parties were requested to include in their FMRL submissions a description of the domestic policies adopted and implemented no later than December 2009 and explain how these polices have been considered in the construction of the FMRL. Parties were also requested to confirm that the construction of the FMRL includes neither assumptions about changes to domestic policies adopted and implemented after December 2009, nor includes new domestic policies. The aim of this information is also to document the feasibility of the policies and the assumptions included in the FMRL, in relation to the country-specific circumstances. A few Parties also clarified the effects of policies related to biofuel or the use of biomass as a renewable source in the calculation of their FMRLs.

Parties proposing historical FMRLs based on 1990 do not take into account policies and measures since that year.

Other relevant information

Decision 2/CMP.7 introduced some new elements and some refinements as compared to the text in Decision 2/CMP.6, on which the FMRL submissions were based on.

The new elements and refinements include:

- The emissions arising from the conversion of natural forests to planted forest (see Section 2.7.1)
- The Carbon Equivalent Forest Conversions (see Section 2.7.7)
- The final agreement on the accounting of harvested wood products removed from areas under forest management (see Section 2.3.8)

- The final agreement on the possible exclusion of emissions associated with natural disturbances (see Section 2.3.9).

To fulfil the requirement under point (a), it is *good practice* to provide additional information according to the Section 2.7.1. Whenever any of points (b), (c) or (d) is applied, it is essential to consider the need for Technical Correction when accounting (see Section 2.7.6).

2.7.5.2 METHODOLOGICAL CONSISTENCY BETWEEN FMRL AND REPORTING FOR FOREST MANAGEMENT DURING THE COMMITMENT PERIOD

According to Decision 2/CMP.7, when accounting for forest management, Parties shall demonstrate methodological consistency between the FMRL[81] and reporting for forest management during the second commitment period, and shall apply technical correction, if necessary, to ensure consistency. This section discusses general issues and *good practice* guidance related to methodological consistency. Technical corrections are addressed in the following section.

Consistency is one of the key principles in the estimation of greenhouse gases inventories. In the UNFCCC reporting guidelines consistency means that an inventory should be internally consistent in all its elements with inventories of other years, i.e. it refers to the need of time-series consistency of an inventory. An inventory is consistent if the same methodologies are used for all years and if consistent data sets are used for estimating carbon stock changes and non-CO_2 emissions during the whole period. Under certain circumstances[82] , an inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner, and if potential inconsistencies are minimized in accordance with the guidance provided in the *2006 IPCC Guidelines* (Volume 1, Chapter 5) and with *GPG-LULUCF* (Chapter 5).

The *2006 IPCC Guidelines* describe common situations in which time series consistency may not be achieved, including: (i) recalculations due to *methodological changes and refinements*, and (ii) *adding new categories*. A methodological change is a switch to a different tier (or to a different method, e.g. from stock-change to gain-loss, or from inventory-based to process-based method) from the one previously used for reporting, often driven by the development of new and different data sets. A methodological refinement occurs when an inventory compiler uses the same tier to estimate emissions but applies it using a different data source or a different level of aggregation. Both methodological changes and refinements over time are an essential part of improving inventory quality. The adding of new categories includes also the addition of new carbon pools and gases.

In the context of FMRL, the following distinction needs to be made:

1. *Methodological elements used in the construction of FMRL* (as reported in the FMRL submission), including:
   (i) The historical data (i.e. pre-2010[83]) used to establish the FMRL (e.g. area, harvest, increment, age structure, forest characteristics and management, emissions and removals etc.).
   (ii) Other methodological elements, including: pools and gases, the treatment of harvested wood products, the treatment of natural disturbances, the treatment of Carbon Equivalent Forest Conversions, factoring out.
2. *Policy assumptions under business-as-usual scenarios* (for projected FMRL only, as reported in the FMRL submission), including economic assumptions or responses and assumptions on the evolution (after the FMRL submission) of forest management, of the forest area, of forest characteristics, and harvesting rates.

During the commitment period, it is essential to ensure consistency between the methodological elements (see 1 above) used in the construction of FMRL and those used in the reporting of forest management. It is *good practice* to consider all the specific elements highlighted in paragraphs 14 and 15 of the Annex to Decision 2/CMP.7, and the list of criteria and elements included in Table 2.7.1 to address any inconsistency through a Technical Correction (see following section).

[81] As inscribed in the appendix of decision 2.CMP.7.

[82] Referred to in paragraphs 16 to 18 of the UNFCCC reporting guidelines (decision … CMP.7)

[83] Depending of the country, the FMRL may have been constructed using historical data up to 2008 or 2009.

By contrast, a deviation in policy assumptions (see 2 above) from those assumed in constructing the FMRL, including differences in economic assumptions or responses (e.g. harvesting decisions), do *not* represent methodological inconsistencies, and thus should not be considered for technical corrections.

A common situation of inconsistency is the change, after the FMRL has been set, of one or more of the methodological elements used in the construction of FMRL when reporting forest management during the commitment period. For instance, a methodological change or refinement may lead to the recalculation of historical data (pre-2010) used to establish FMRL, or the treatment of HWP or natural disturbances may change in the commitment period as compared to the FMRL. These changes would introduce inconsistencies. Other possible cases of inconsistency between the FMRL and reporting for forest management during the commitment period are possible. For this reason, for the purpose of demonstrating that the accounting of emissions and removals during the commitment period is not affected by methodological or time-series inconsistency, additional information and/or checks may be needed, depending on the approach and method used to set FMRL.

For projected FMRLs, it is *good practice* to provide information on the main factors generating the accounted quantity (i.e., the difference in net emissions and removals between reporting of forest management during the second commitment period and the FMRL); for instance, given that harvest rate is *generally* the main driver of the forest sink in the short term, it is *good practice* to show that a higher (or lower) sink during the second commitment period, as compared to what was assumed in the business-as-usual scenario, is quantitatively consistent with the observed lower (or higher) harvest rate, and/or to provide evidence that other major factors are involved. The aim of this information is to show that the accounted quantity in the second commitment period can be explained in terms of deviations in policy assumptions or responses to them (e.g. harvest rate) as compared to what was assumed in the FMRL.. The aim is not to provide the basis for a technical correction. In addition, it is *good practice* to show that a model used for constructing a projected FMRL reproduces the historical data of forest management or *Forest land Remaining Forest Land* as reported in FMRL submission. It is also *good practice* that the documentation of the model follows the criteria listed in the Annex 1 of the IPCC expert meeting report on the use of models in Greenhouse Gas Inventories (IPCC, 2010), including information on model selection and development, on model calibration and evaluation, on input data used, on uncertainties, on model implementation and on the evaluation of model results.

Furthermore, for any of the approaches used to set FMRL, once a pool has been included in the FMRL inscribed in the Appendix to Decision 2/CMP.7, for consistency reasons it is *good practice* to report this pool during the commitment period, irrespective of the pool being a sink or a source (i.e. a pool that has been included in FMRL cannot be omitted when reporting forest management during the commitment period by referring to the "not a net-source" provision).

2.7.6 Technical Corrections for accounting purposes

Estimation of the FMRL typically relies upon numerous data inputs, assumptions, and models brought together in a consistent and transparent way. For accounting of forest management, what counts is the difference between the FMRL and forest management emissions and removals occurring in the second commitment period. Therefore, it is important to ensure that the FMRL and the reporting of forest management during the commitment period are as methodologically consistent as possible (see Section 2.7.5.2).

If the reported data on forest management or *Forest land Remaining Forest Land* used to establish the reference level are subject to recalculations, or if other methodological inconsistency exists between the FMRL and the forest management reporting during the respective commitment period, to ensure consistency, Parties are requested to apply a technical correction. The Technical Correction ensures methodological consistency between the FMRL and the reporting of forest management during the commitment period, or at least it removes the impact of any methodological inconsistency when accounting.

Essentially, the Technical Correction is a value of net emissions and removals, which is added *at the time of accounting* to the original FMRL (contained in Decision 2/CMP.7) to ensure that accounted emissions and removals will not reflect the impact of methodological inconsistencies. The Technical Correction is defined as (in Mt CO_2eq/year):

EQUATION 2.7.1
TECHNICAL CORRECTION

$$Technical\_Correction = FMRL_{corr} - FMRL$$

Where:

Technical Correction= Value of net emissions and removals, which is added *at the time of accounting* to the original FMRL (contained in Decision 2/CMP.7) to ensure that accounted emissions and removals will not reflect the impact of methodological inconsistencies

FMRL = Forest Management Reference Level inscribed in the appendix of Decision 2/CMP.7

$FMRL_{corr}$ = Forest Management Reference Level recalculated for the purpose of calculating the Technical Correction.

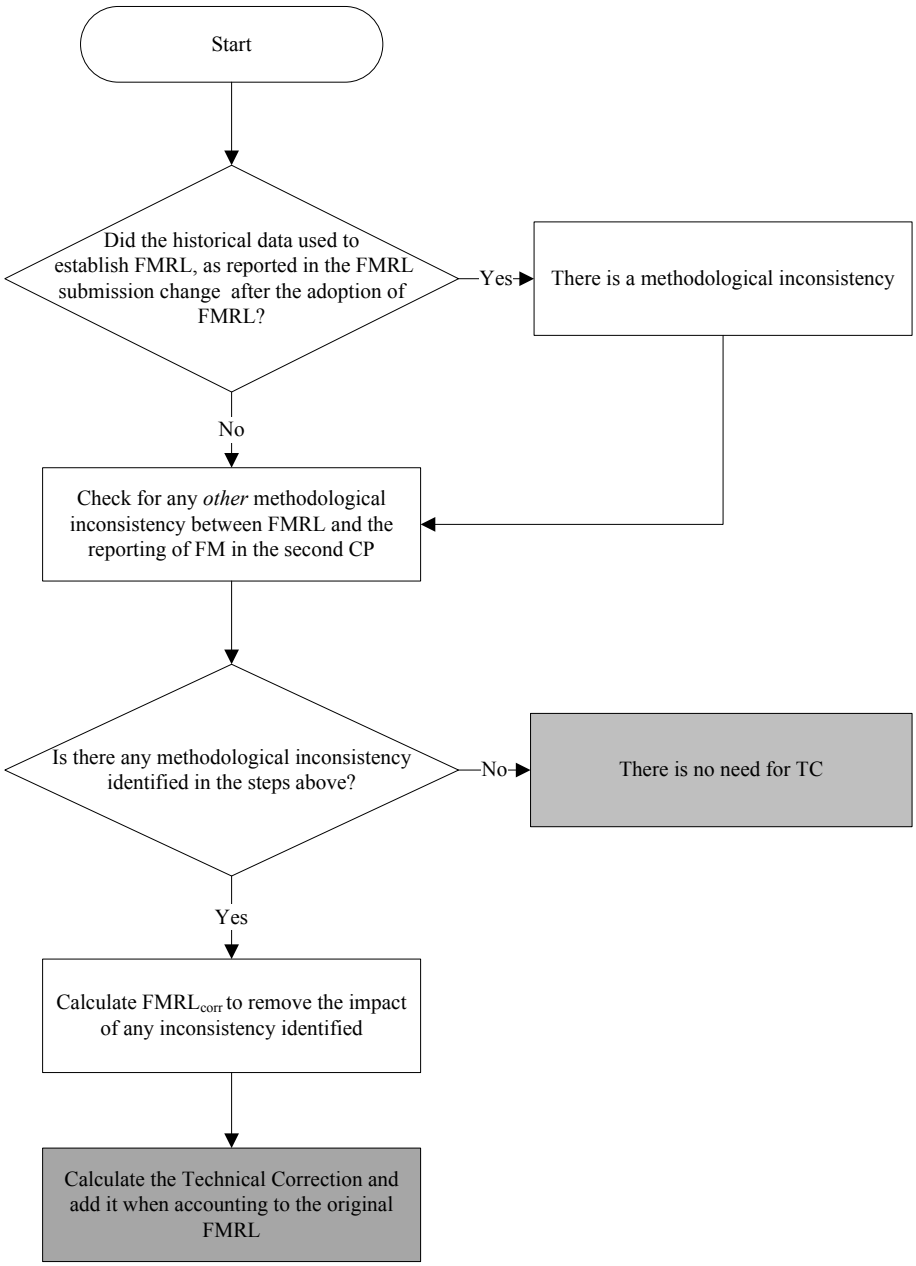
FMRL itself is not changed through a technical correction. However, in the case the need for Technical Correction is identified, i.e. if a methodological inconsistency is found at any time during the commitment period, the $FMRL_{corr}$ represents the recalculated reference level which does not contain impacts of any methodological inconsistencies.

This section describes how to detect the need for technical correction, how to calculate $FMRL_{corr}$, and when to apply the technical correction.

2.7.6.1 HOW TO DETECT THE NEED FOR TECHNICAL CORRECTIONS

Figure 2.7.4 provides a general decision tree on how to identify the need for technical correction. Table 2.7.1 provides the specific criteria and the elements to be checked to detect a possible methodological inconsistency and the consequent need for technical correction.

3890 **Figure 2.7.4 Decision tree for identifying the need for Technical Correction during the**
3891 **second commitment period.**



3892
3893

If a methodological inconsistency is identified between FMRL and reporting of forest management during the commitment period, technical corrections are for the purpose of removing the impact of this methodological inconsistency when accounting. The need for Technical Correction may arise *only* if one of the following conditions are met:

1. The historical data (i.e., pre-2010) used to establish the FMRL, as reported in the FMRL submission, change after the adoption of FMRL.

2. Any other methodological inconsistency exists between the FMRL and reported data during the respective commitment period (see Table 2.7.1 for a full list of criteria and elements to be checked).

Technical corrections can neither be triggered by changes in policy assumptions or responses to them, nor by changes in the approach or model used to set FMRL.

Common cases where it is *good practice* to apply a Technical Correction for accounting purposes may include:

- Errors have been identified in the previous inventory data, models, or methods that affect the data used to establish the FMRL.

- Available historical input data used to establish FMRL have changed. For example, forest inventory data may be compiled only once in a five or ten year period. In the case new historic (pre-2010) forest inventory data (e.g. new area, age structure, carbon stock, net removals, harvest or increment rates) become available that could not be used for the construction of the FMRL, Technical Correction could allow the inclusion of such new information.

- Methodological change or refinements are implemented in the reporting of forest management (i.e. moving to a different tier), which lead to recalculation of reported historical data (pre-2010) of forest management or *Forest land Remaining Forest Land* used. In the future, new methods may be developed that take advantage of new datasets, and modelling tools, new technologies or improved scientific understanding. For example, remote-sensing technology and site-specific modelling is making it feasible to estimate historic emissions from land clearing activities more accurately than by using simple aggregate emission factor and activity data. The development of new or refined inventory methods for reporting is part of the broader process of continuous improvement, which countries are encouraged to follow.

- In the case of FMRLs based only on the elaboration of historical data from GHG inventories (average of past data, linear extrapolation) or FMRL based on the single year 1990, any recalculation of the time series used to establish the FMRL will trigger a technical correction.

- New pools or GHG sources are included in the reporting for forest management. For instance, if a pool not reported earlier (and therefore not included in the FMRL) because of being a sink, becomes a source in the future, it is *good practice* to include this pool both in the reporting of forest management and in a new $FMRL_{corr}$.

- The FMRL and the reporting of forest management in the respective commitment period are not consistent with respect to:

  (i) The treatment of harvested wood products agreed in Decision 2/CMP.7. Since the final agreement on HWP was reached after the FMRL submissions, a Technical Correction related to HWP is expected to be a common case.

  (ii) The treatment of natural disturbances agreed in Decision 2/CMP.7, e.g. if the calculation of the background level of natural disturbances indicates that one or more events need to be excluded, it is *good practice* to remove these events should be removed from historical emissions andto calculate $FMRL_{corr}$ should be calculated.

  (iii) The treatment of Carbon Equivalent Forest Conversions.

Other kinds of methodological inconsistency may exist between the FMRL and the forest management reporting during the commitment period. For example, if a model used for constructing a projected FMRL does not reproduce the historical data (before the FMRL submission) of forest management or *Forest land Remaining Forest Land*, this is a likely sign of inconsistency. In this case, it is *good practice* either to provide additional evidence demonstrating consistency or to apply a technical correction.

3943

TABLE 2.7.1
CRITERIA TO DETECT THE NEED FOR TECHNICAL CORRECTION

Criteria		Comment /action
1. **Any of the methodological element used to establish the FMRL, as reported in the FMRL submission, changed after the adoption of FMRL**		
Element	**Change**	
a) Pools and gases	New pools or gases[84]	Calculate $FMRL_{corr}$ by including the new pools or gases
b) Area under forest management	Different historical area pre-2010	Calculate $FMRL_{corr}$ using the new area
c) Historical data from greenhouse gas inventory	Different historical data pre-2010 for FL-FL or FM, due to recalculation.	Calculate $FMRL_{corr}$ using the new data
d) Forest characteristics and related management[85]	Different historical data and information on management pre-2010	Calculate $FMRL_{corr}$ using the new data and information
e) Historical Harvesting rates	Different historical data pre-2010	Calculate $FMRL_{corr}$ using the new harvesting rates
f) Harvested wood products	Different data and/or methods	Calculate a FMRLcorr by applying the same data and/or method
g) Natural disturbances	Different data and/or method	Calculate a $FMRL_{corr}$ by applying the same data and/or method
Other relevant information		
h) Carbon Equivalent Forest Conversion	Different treatment	Calculate a $FMRL_{corr}$ by applying the same treatment of CEFC
2. Other possible methodological inconsistencies, e.g. the FMRL model does not reproduce historical data (pre-2010) of FM or FL-FL		If needed, calculate a $FMRL_{corr}$, e.g., by applying IPCC methods to ensure time-series consistency.

3944

3945 Table 2.7.1 provides general guidance on the cases for which methodological consistency is affected and
3946 Technical Correction needs to be applied. By contrast, policy assumptions occur without affecting
3947 methodological consistency. In particular, the evolution of specific elements *after* the FMRL submission (i.e.
3948 forest management area, forest characteristics and related management, harvesting rates) represent a deviation
3949 from the policy assumptions described in the FMRL submission. These deviations do not imply a
3950 methodological inconsistency, and therefore do not trigger technical corrections.

3951

3952 2.7.6.2 HOW TO PERFORM AND DOCUMENT THE CALCULATION OF 3953 $FMRL_{CORR}$

3954 If the need for Technical Correction is determined, it is *good practice* to calculate $FMRL_{corr}$. Several methods
3955 may be considered to address methodological inconsistencies and to calculate $FMRL_{corr}$, depending on the
3956 approach used to construct FMRL, the cause of the inconsistency and the data that are available to perform the

[84] Note that, when accounting, it is not possible to exclude a pool or gas already included in the FMRL

[85] This includes, among others: age-class structure, increment, species composition, rotation lengths, management practices, etc.

recalculations. Irrespective of the method used, it is *good practice* to provide information that the method used avoids the expectation of net credits linked to any methodological inconsistency between $FMRL_{corr}$ and reporting for forest management during the commitment period.

In the case of projected FMRLs, $FMRL_{corr}$ may be calculated by, inter alia, a new model projection using new historical data or applying a different treatment of a specific element (e.g., HWP, natural disturbances). When new projections are made, it is essential to keep all the policy assumptions under the business-as-usual scenario unchanged.

If the need for a Technical Correction due to a methodological inconsistency has been identified, but a new model run cannot be performed, the time-series consistency may be ensured by using one of the methods described by *2006 IPCC Guidelines*, including the overlap between models results and data for forest management of *Forest land Remaining Forest Land* reported for the historical period (before the FMRL submission). In this case, consistency would be ensured *ex-post*, i.e. adjusting existing model results to the historical reported data.

In the case of FMRL based on elaboration of historical data only (average of past data, linear extrapolation) or on the single year 1990, any recalculation of the time series will automatically produce $FMRL_{corr}$. It is essential that the criteria to calculate $FMRL_{corr}$ are the same as those used for setting FMRL, i.e. if the FMRL is calculated as a linear extrapolation of any historical period trend, the same period should be used for FMRLcorr in case a recalculation of historical time series occurs.

Irrespective of the method applied to calculate $FMRL_{corr}$, it is *good practice* to accompany any Technical Correction with transparent information on:

- Rationale for calculating $FMRL_{corr}$ (description of which criteria in Table 2.7. 1 has been met)
- Methods used to calculate $FMRL_{corr}$. In case a model is used, it is *good practice* to document the implementation of the model according to the criteria listed in the Annex 1 of the IPCC Expert Meeting Report on the Use of Models in GHG Inventories (IPCC, 2010).
- Results, i.e. the $FMRL_{corr}$
- Discussion of the differences between $FMRL_{corr}$ and FMRL. For this purpose, it is *good practice* to report acomparison of recalculated estimates with previous estimates, e.g. as shown in Table 2.7. 2 and whenever possible also as a graphical plot showing the temporal dynamics of the estimates underlying $FMRL_{corr}$ and FMRL.

TABLE 2.7.2
EXAMPLE OF DOCUMENTATION DOCUMENTATIONWHEN PERFORMING A TECHNICAL CORRECTION

	Emissions and Removals (Gg)
FMRL	-10000
$FMRL_{corr}$	-10500
Difference in per cent =100●[($FMRL_{corr}$–FMRL)/FMRL]	10%
Technical Correction= $FMRL_{corr}$ - FMRL	-500
FM reported during the commitment period	-12000
Accounted Quantity = FMRL - reported FM + Technical Correction	1500

2.7.6.3 WHEN TO APPLY TECHNICAL CORRECTION

It is essential to apply Technical Correction when accounting, i.e. annually or at end of the commitment period, depending on the choice made by the Party.

For most Parties, it is expected that in most years there will be the need to calculate $FMRL_{corr}$, e.g., due to change in reporting methods or new data which cause a recalculation of historical data used to construct FMRL. Therefore, also for not accounting years, for transparency purposes whenever it is possible it is *good practice* to assess annually the need for technical correction, i.e. to check the criteria set in Table 2.7.1, to calculate $FMRL_{corr}$ and to report such information in the annual national inventory report.

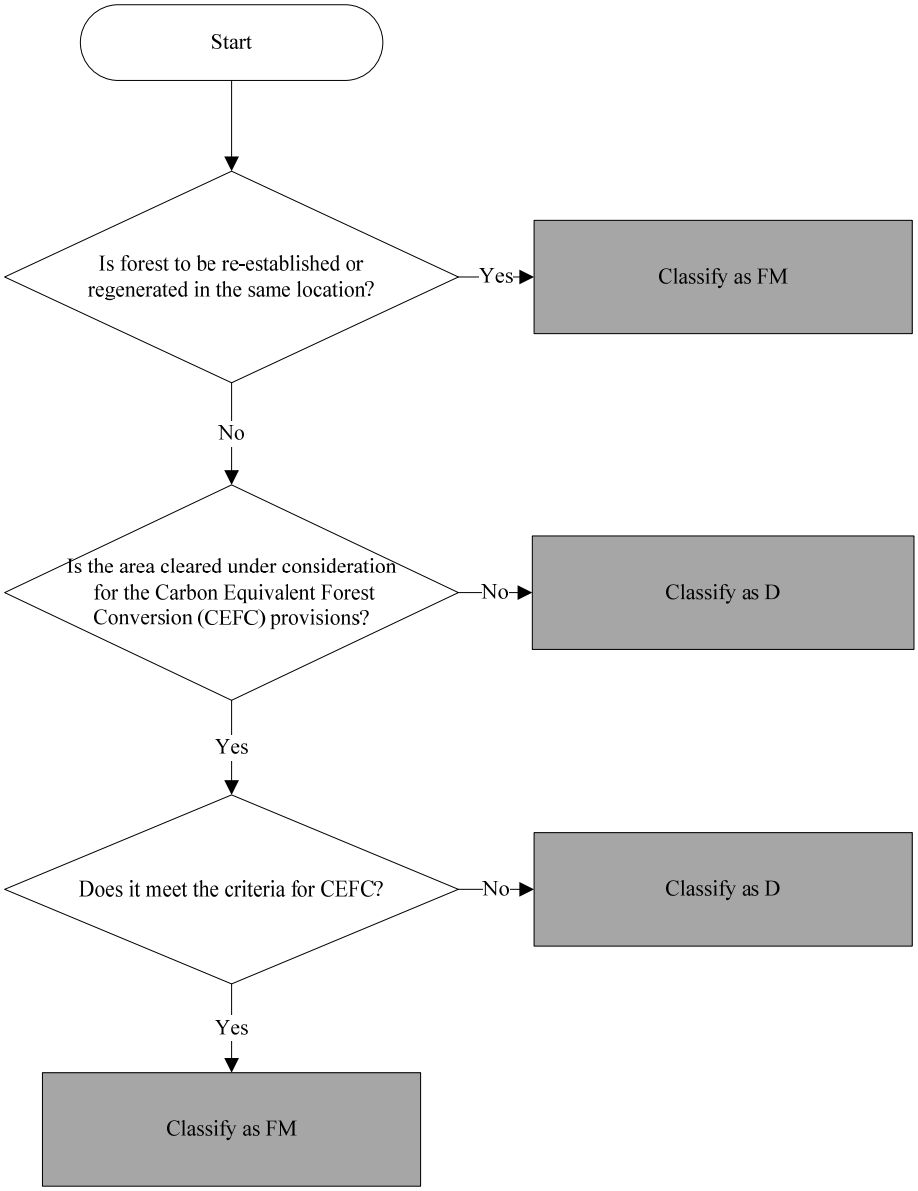
2.7.7 Carbon Equivalent Forests

2.7.7.1 DEFINITIONAL ISSUES AND REPORTING REQUIREMENTS

Under Decision 2/CMP.7, Parties may account for emissions by sources and removals by sinks resulting from the harvest and conversion of some forest plantations to non-forest land, provided that certain conditions are met. The main condition is that a forest of at least the same area and carbon stock potential must be created on non-forest land. Carbon Equivalent Forest Conversion (CEFC) is the activity of converting plantation forest to non-forest while simultaneously establishing a "carbon equivalent forest" on non-forest land elsewhere. The CEFC provision allows what would otherwise be Article 3.3 Deforestation and Afforestation/Reforestation activity to be accounted for as Article 3.4 Forest Management instead.

CEFC requires two land components – the existing forest land to be cleared (CEF-d) and the non-forest land on which a Carbon Equivalent Forest is to be established (CEF-ar). Both components must meet the criteria for CEFC in order to be accounted for under forest management. Figures 2.7.5 and 2.7.6 provide decision trees for categorising forest clearance and establishment activities.

4011 **Figure 2.7.5 CEFC decision tree for forest clearance**

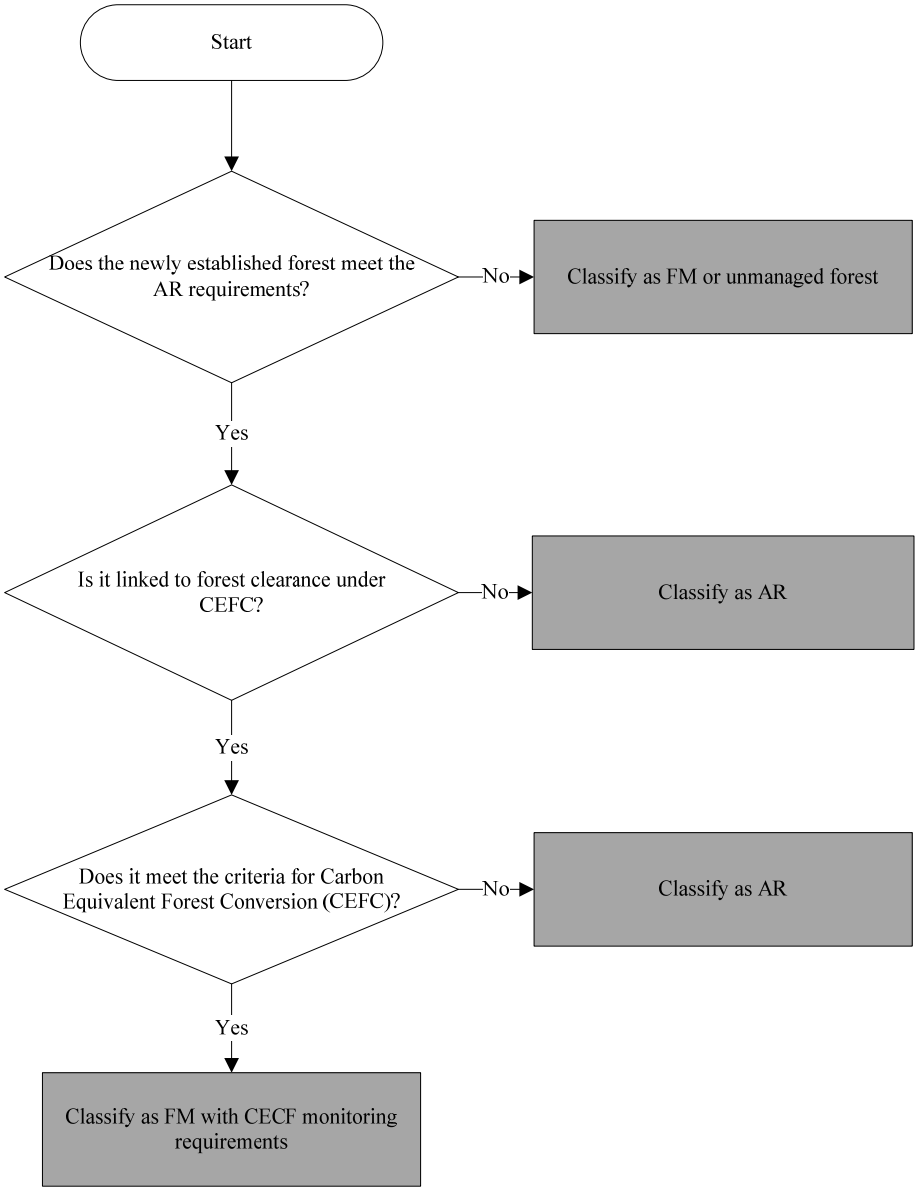


4012

4013

4014

4015 **Figure 2.7.6 CEFC decision tree for forest establishment**



4016

4017

4018

It is *good practice* for Parties to identify, monitor and report all lands and associated carbon pools subject to the CEFC provision, including the geo-referenced location and year of conversion. It is *good practice* to use a reporting method that is consistent with the method used for Article 3.3 activities.

If Reporting Method 1 is used, the Party must identify:

- The geographical location of the boundaries of the areas that encompass units of land subject to the CEFC provision. The geographical boundaries which are reported should correspond to strata in the estimation of land areas as described in Section 2.2.2;
- For each of these areas, or strata, estimates of the area of the units of subject to CEFC in the two subcategories, namely those that would have been subject to Article 3.3 Deforestation, and Article 3.3 Afforestation/Reforestation.

If Reporting Method 2 is used, the Party must identify each unit of land subject to the CEFC provision using the polygon boundaries, a coordinate system (e.g., the Universal Transverse Mercator (UTM) Grid or Latitude/Longitude) at possible finer resolution, or a legal description (e.g., those used by land-titles offices) of the location of the land subject to the CEFC provision.

For both reporting methods the Party must provide:

- The year of the start of CEFC activities, which will be between 1 January 2013 and the end of the inventory year. The year of forest land conversion to non-forest under the CEFC provision is taken as the year in which land use change is confirmed. Within the boundary of the areas activities may have started in different years. It is *good practice* to group units of land by age and to report the area in each age class separately; and
- The area of units of land subject to CEFC activity in each productivity class and species combination (where relevant) to support the calculation of carbon stock changes and non-CO2 emissions;
- Documentation that demonstrates the link between each unit of forest land cleared and the corresponding land established in plantation forest under the CEFC provision. It is *good practice* for Parties to provide, according to their national circumstances, the definition of plantation forest that is used in the application of the CEFC provision. This definition should be consistent throughout the time series and the inventory.

2.7.7.2 CHOICE OF METHODS FOR IDENTIFYING LANDS SUBJECT TO CARBON EQUIVALENT FOREST CONVERSION

For eligibility under the CEFC provision, conditions apply to both the land converted from plantation forest to non-forest (CEF-d land) and the corresponding land converted from non-forest to forest (CEF-ar land). According to Decision 2/CMP.7 the forest to be cleared must meet the following criteria:

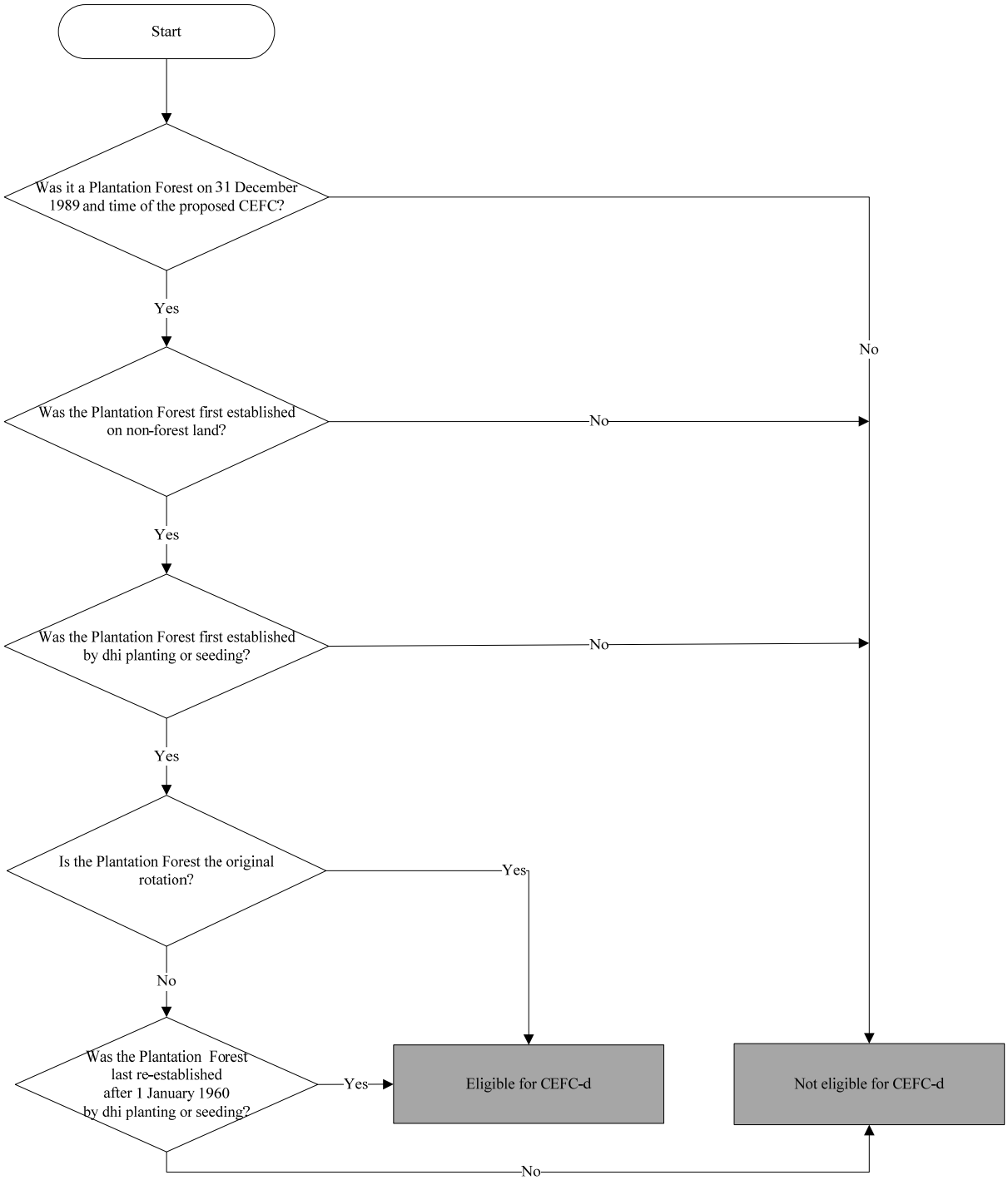
- Must be plantation forest at time of conversion, meeting or exceeding the thresholds for the country's definition of forest as well as their specific definition of plantation forest.
- Must have been plantation forest on 31 December 1989
- Must have been first established by direct-human induced planting or seeding
- Must have been first established onto non-forest land. If this non-forest land was previously forested, it is *good practice* to apply the same criteria used to distinguish harvesting or forest disturbance that is followed by the re-establishment of a forest from deforestation. For example, normal practice in a country may be to re-establish forests three years after harvesting. A plantation that was first established on land that had remained non-forest for five years would then be eligible under the CEFC provision.
- Must still be the original forest established, or, if re-established, this must have last occurred through direct human induced planting and/or seeding after 1 January 1960.

It is *good practice* to apply the same methods described in Section 2.6.2 for identifying units of land subject to direct human-induced deforestation, to also identify units of land cleared of forest which are to be accounted for under the CEFC provision, since only land that qualifies as Article 3.3 D land will qualify as CEF-d land.

The decision tree for determining eligibility for forest land to be converted to non-forest land under the CEFC provision is shown in Figure 2.7.7.

4068 **Figure 2.7.7 Decision tree for determining the eligibility of land to be deforested under**
4069 **CEFC provision (CEF-d land)**

4070



4071

4072

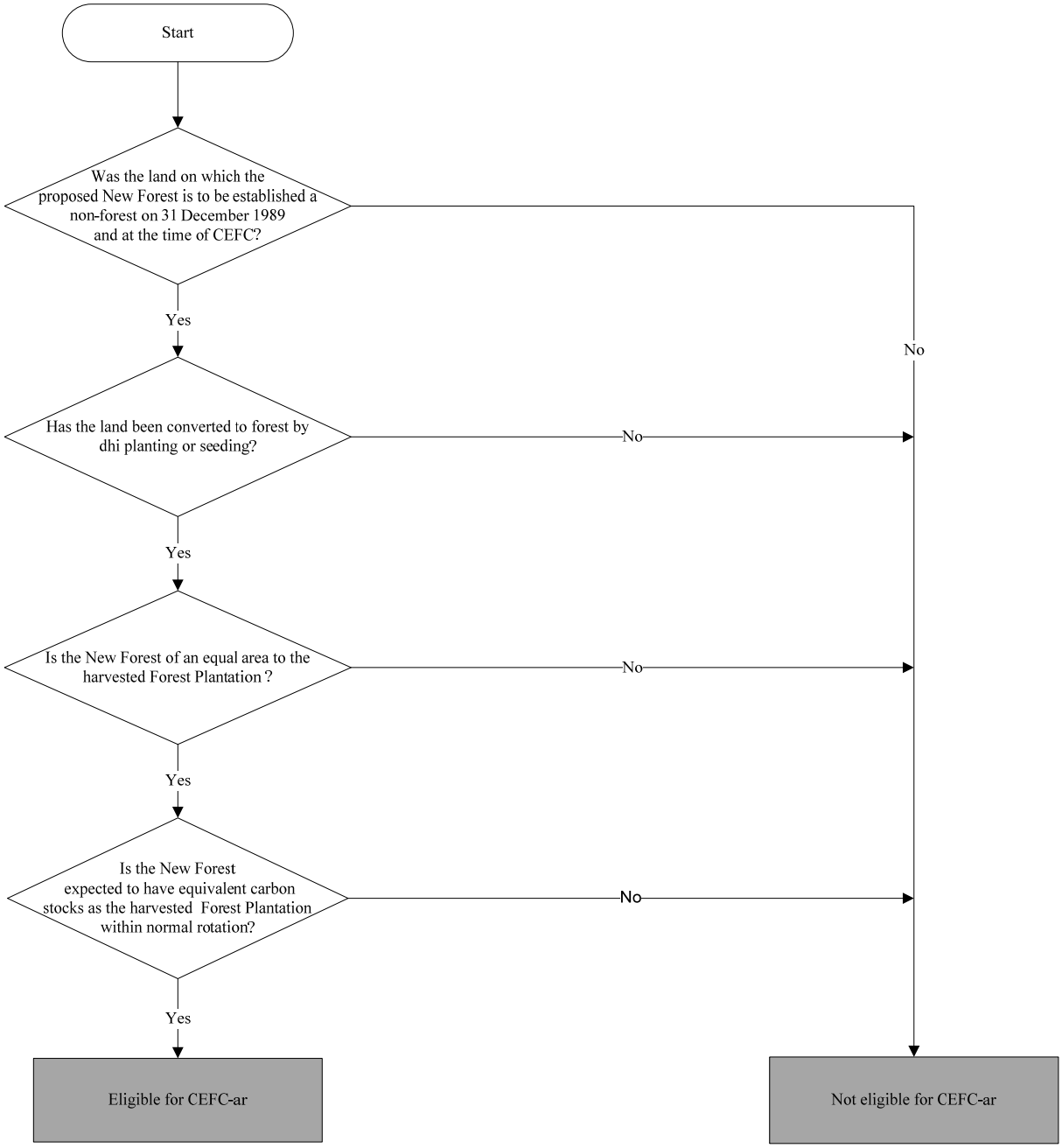
The land on which a Carbon Equivalent Forest is to be established (CEF-ar land) must meet the following criteria:

- Must be non-forest at the time of conversion.
- Must have been non-forest on 31 December 1989
- Must be converted to forest land through direct human-induced planting and/or seeding
- The forest established must be at least equal in area to the forest converted to non-forest
- The forest established must reach at least the equivalent carbon stock that was contained in the harvested forest plantation at the time of harvest, within the normal harvesting cycle of the harvested forest plantation, and if not, a forest management accounting debit would be generated under Article 3.4.

It is *good practice* to apply the methods described in Section 2.5.2 for identifying units of land subject to direct human-induced afforestation and reforestation also for identifying units of land established in forest which are to be accounted for under the CEFC provision, since only land that qualifies as Article 3.3 AR land will qualify as CEF-ar land.

The decision tree for determining eligibility for non-forest land to be converted to forest land under the CEFC provision is shown in Figure 2.7.8

Figure 2.7.8 Decision tree for determining eligibility of land to be afforested under CEFC provision (CEF-ar land)



All lands and associated carbon pools subject to the CEFC provision can be accounted for as forest management under Article 3.4. This includes any harvested wood products resulting from the conversion of forest to non-forest land.

It is *good practice* to provide documentation that CEF-ar lands included in the identified units of land are forests established by direct human-induced planting and seeding. Where it is uncertain whether the trees on a unit of land will pass the thresholds of the definition of forest, it is *good practice* not to report these areas as forest management lands under the CEFC provision, and to await confirmation (at a later time) that these parameter thresholds have been or will be passed.

DISCRIMINATING BETWEEN ARD LAND AND CARBON EQUIVALENT FORESTCONVERSION LAND

It is *good practice* that areas subject to the CEFC provision are reported separately from areas subject to direct human induced deforestation and afforestation/reforestation. Until forest establishment on CEF-ar land has been confirmed, the clearance of plantation forest on the CEF-d land should be reported as Article 3.3 Deforestation. After confirmation that a forest has been established, both the CEF-d and CEF-ar land should be reported as Article 3.4 Forest Management lands. Documentation should be provided to demonstrate that all the requirements for the CEFC provision have been met.

If non-forest land established in forest under the CEFC provision is subsequently deforested (before or after achieving carbon stock equivalence) the land should be reclassified as Article 3.3 Deforestation land and reported accordingly.

DISCRIMINATING BETWEEN CM, GM AND RV LAND AND CARBON EQUIVALENT FORESTCONVERSION LAND

It is *good practice* that areas subject to the CEFC provision are reported under forest management which has priority over elected activities under Article 3.4. This means that there may be land units that are subject to elective article 3.4 activities (e.g. cropland management) but are reported under forest management. These lands should be identified and reported separately from other forest management lands. Methodologies appropriate to the actual land use should be applied, such that emissions and removals are neither under- nor over-estimated.

2.7.7.3 CHOICE OF METHODS FOR ESTIMATING CARBON STOCK CHANGES AND NON-CO_2 EMISSIONS

It is *good practice* too apply the same methods for estimating carbon stock changes and non-CO_2 emissions on CEFC lands asas are applied on FM land. The same or a higher tier should be used. In addition, forest land converted to non-forest under the CEFC provision may be subject to management that results in anthropogenic greenhouse gas emissions over-and-above what would have been expected if the forest had been re-established. It is *good practice* to capture these emissions and stock changes by applying the methods for the appropriate land use (e.g. cropland or grazing land).

Accounting for forest management is based on a reference level approach. If a modelled projection is used to establish the FMRL, then the expectation that an equivalent carbon stock will be achieved through the CEFC provision must be included within FMRL. This will require a Technical Correction for accounting purpose so that the impact of the establishment of a Carbon Equivalent Forest on non-forest land is considered in the accounting. This ensures that if carbon equivalence is not achieved, a forest management debit will be generated based on deviation from the reference level. Similarly, net credits will be generated if carbon equivalence is surpassed e.g. if the CEF-ar land has a higher productivity than the CEF-d land which would lead to exceeding the FMRL. The expectation of future carbon stock should be established in a way that is consistent with the approach used for other forest management lands in the reference level. It is *good practice* that transparent documentation is provided that defines the normal rotation length of the cleared forest plantation and shows how the expectation that carbon stock will be equivalent has been met.

If forest land established under the CEFC provision is affected by natural disturbance, the emissions and subsequent uptake on that land can be excluded from accounting in accordance with the natural disturbance provisions in Section 2.3.9. The natural disturbance accounting provision applies to emissions from forests, so cannot be used for natural disturbances affecting non-forest CEF-d land that is accounted for under forest management using the CEFC provision.

2.8 HARVESTED WOOD PRODUCTS (HWP)

This chapter provides *good practice* guidance for estimating annual changes in carbon stocks and CO_2 emissions/removals (hereinafter referred to as *HWP contribution*) from the harvested wood products (HWP) pool to be accounted for in accordance with decision 2/CMP.7.[86] It gives guidance for selecting the adequate data and methods for estimating the carbon stock and the carbon stock changes in the HWP in line with the defined system boundaries of the accounting approach agreed upon in decision 2/CMP.7.

To date various accounting approaches have been proposed to estimate and report *HWP contribution*. They differ in the reference to the atmosphere and/or the treatment of HWP trade, due to different interpretations of some key terms relevant for the reporting framework (Winjum*, et al.* 1998, Cowie*, et al.* 2006).

This is also reflected in Chapter 12 of the *2006 IPCC Guidelines* which states that the guidance given "does not prefer any of these approaches and does not attempt to prejudge whether these, or any other approach, should be used to account" for the *HWP contribution* (IPCC 2006). Hence, it suggests calculating different variables that are needed to estimate the *HWP contribution* according to the different approaches (see Table 12.1, IPCC 2006).

One of the implications of the decision 2/CMP.7 is that accounting of HWP shall be confined to products in use where the wood in the products came from domestic harvest, i.e. trees harvested in the reporting country.[87] In principle, this follows the approach to base estimates of *HWP contribution* on changes in the pool (i.e. stock-changes) reflected by variable 2A in Table 12.1 in *2006 IPCC Guidelines*. But contrary to the estimation method proposed there, decision 2/CMP.7 limits the extent of HWP which can be included in the estimates and defines constraints for accounting of *HWP contribution* by Parties.

2.8.1 Initial steps to estimate HWP contribution

In order to estimate the *HWP contribution* and account for the changes in the HWP pool in line with decision 2/CMP.7, it is *good practice* to follow the decision tree (Figure 2.8.1) and the steps described hereinafter, which give guidance on choosing the adequate tier method for the estimation.

The following steps are to be taken for selecting the adequate tier method corresponding to the national circumstances.

STEP 1: Check availability of transparent and verifiable activity data on HWP

According to decision 2/CMP.7 Parties shall account for HWP on the basis of the change in the HWP pool during the second and subsequent commitment periods, provided that transparent and verifiable activity data for the three HWP categories sawn wood, wood panels and paper are available.[88]

STEP 1.1: In order to verify whether your country complies with this mandatory requirement, check databases of international organizations, such as the public database of the Food and Agricultural Organization of the United Nations (FAO)[89] for the availability of production and trade statistics on the defined HWP categories. Detailed guidance is given in Section 2.8.1.1.

STEP 1.2: In case your country complies with this requirement, check whether other activity data (i.e. country-specific) are available which fulfil the requirement to be "transparent and verifiable". Further guidance is given in Section 2.8.4.1.

STEP 1.3: If available country-specific activity data do not follow the classification of forest products as outlined in Section 2.8.1.1, determine whether HWP activity data represent information on the material use of wood in service and cross-check the information with guidance given in Section 2.8.2.

STEP 2: Check whether HWP categories to be used in the calculation originate from forests that are accounted for by your country and allocate HWP to the particular forest land use category

[86] References to paragraphs in this chapter refer to the Annex of decision 2/CMP.7 to be found in document FCCC/KP/CMP/2011/10/Add.1, unless indicated otherwise

[87] Cf. paragraphs 27 and 32

[88] Cf. paragraph 29

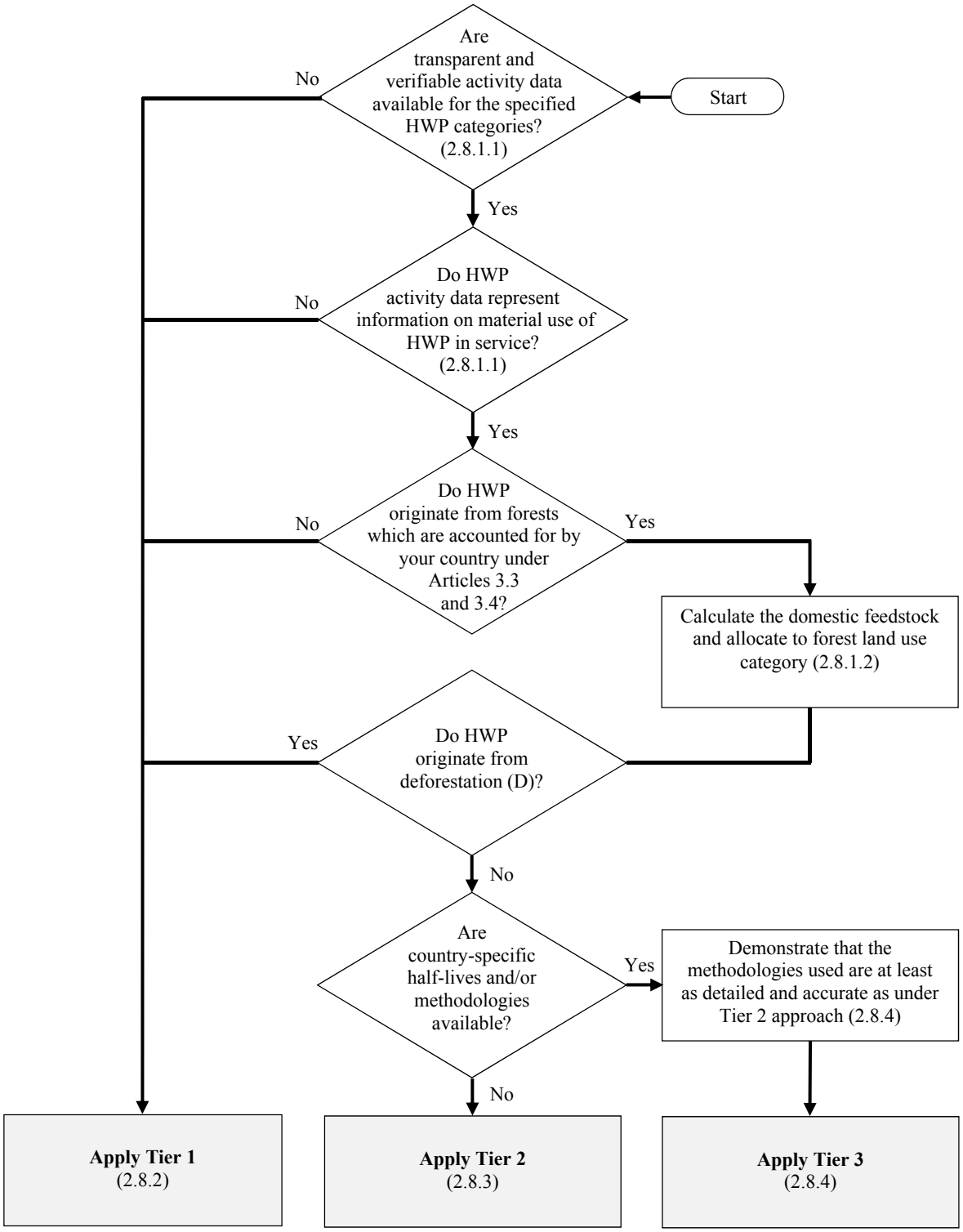
[89] http://faostat.fao.org/site/630/Default.aspx

Decision 2/CMP.7 limits the mandatory accounting to HWP originating from forests which are accounted for by that Party under Article 3, paragraphs 3 and 4. Imported HWP, irrespective of their origin, are excluded[90]. As reflected in the decision tree (Figure 2.8.1), the decision 2/CMP.7 specifies the methods to be used for the estimation depending on the purpose of use as well as the origin of HWP.[91]

[90] Cf. paragraph 27

[91] Cf. paragraphs 28, 29, 31 and 32

Figure 2.8.1 Decision tree for selection of a correct tier method for estimating HWP carbon stock change



Detailed guidance on how to implement the following steps is given in Section 2.8.1.2.

STEP 2.1: Estimate the share of HWP originating from forests within your country. The default assumption is that domestic industrial roundwood represents the feedstock for the subsequent processing of the semi-finished product categories sawnwood and wood panels. Domestic wood pulp is the feedstock for paper production.

STEP 2.2: Estimate the share of HWP originating from afforestation, reforestation and deforestation (ARD) under Article 3 paragraph 3 and forest management (FM) under Article 3 paragraph 4, as the methods for estimating the *HWP contribution* will differ according to the provisions outlined in the decision tree for tier selection (Figure 2.8.1).

STEP 2.3: The share of HWP activity data entering the accounting framework is obtained by allocating HWP which originate from domestic harvest (STEP 2.1) to the relevant forest land use category (STEP 2.2).

STEP 3: Check availability of country-specific information and estimate carbon stock in HWP and its annual change

Depending on the results of STEPS 1 and 2, as well as the availability of country-specific half-lives and/or country-specific methodologies, which again have to comply with specific requirements[92], the estimation of *HWP contribution* follows different tier methods.

Tier 1 method specifies the assumption of instantaneous oxidation that is to be used under certain circumstances and for specific parts of the HWP pool. The combination of HWP activity data following the international classification system of semi-finished wood products (Figure 2.8.2) with default conversion factors and default half-lives constitutes Tier 2. Under a Tier 3 method, more accurate country-specific information is to be applied. This includes activity data and/or emission factors (i.e. service life information of HWP), which is intended to improve the accuracy of the estimates.

STEP 3.1: In case HWP originate from deforestation within your country use Tier 1 method (Section 2.8.2).

STEP 3.2: Check whether country-specific HWP activity data following the international classification system outlined in Section 2.8.1.1 together with specific conversion factors are available for your country following guidance given in Section 2.8.4.1. If this is the case, allocate HWP activity data in line with STEPS 2 and apply Tier 3 (Section 2.8.4).

STEP 3.3: Check whether country-specific half-life values for the three HWP categories and/or its disaggregates (See Section 2.8.1.1) can be obtained following the guidance given in Section 2.8.4.2. If this is the case, apply Tier 3 (Section 2.8.4).

STEP 3.4: Check whether other country-specific methods are available that meet the requirements as specified in Section 2.8.1.1 and 2.8.4. If this is the case, allocate HWP activity data in line with STEP 2 and apply Tier 3 (Section 2.8.4).

STEP 3.5: In case your country will not make use of a Tier 3 method as outlined for the STEPS 3.2 to 3.4, allocate HWP activity data in line with STEP 2 and apply Tier 2. Detailed guidance on Tier 2 is given in Section 2.8.3.

2.8.1.1 AVAILABILITY OF TRANSPARENT AND VERIFIABLE ACTIVITY DATA

A key prerequisite for Parties to consider the HWP contribution in their accounting is the availability of "transparent and verifiable activity data" for the three specified HWP categories "paper, […] wood panels, and […] sawnwood" (cf. STEP 1).[93] This section gives guidance on when available data is to be considered transparent and verifiable for estimating the HWP contribution.

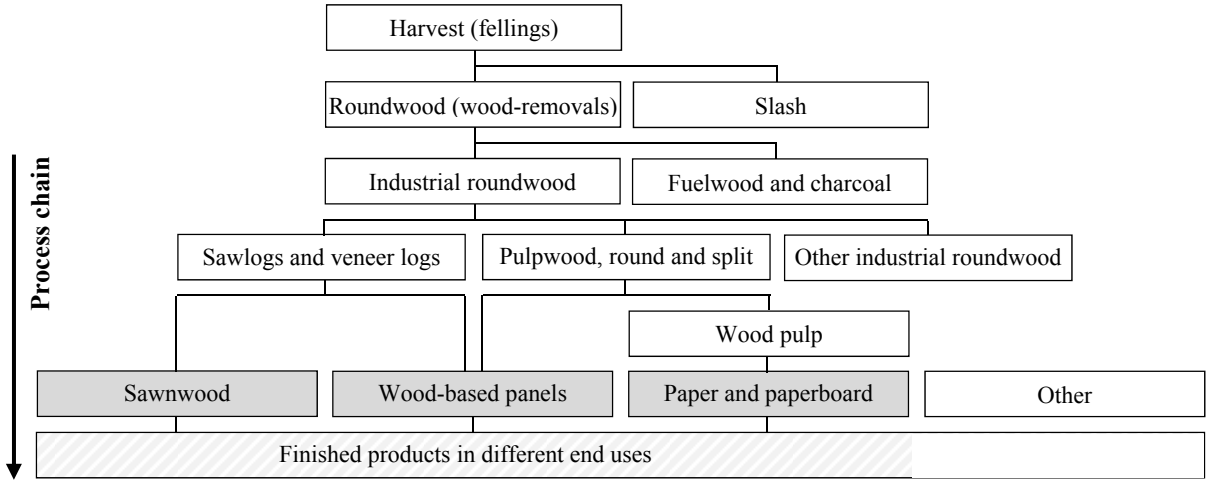
Whereas the term "harvested wood products" is based on a concept containing the two separate elements "forest harvesting" and "wood products" (Brown, et al. 1998, FCCC/TP/2003/7), the named categories refer to the definitions of semi-finished wood products of the international classification system of forestry products (cf. FAO 2009). It is thus good practice to assume that the three HWP categories named in 2/CMP.7 accord with these commodities. "Removals" (i.e. roundwood) are a subset of "forest harvesting" of biomass (i.e. fellings) at the beginning of the forest-wood chain. Following the forestry products definitions of the Food and Agriculture Organization (FAO), Figure 2.8.2 furthermore shows the relevance of the aggregate commodity "industrial

[92] Cf. paragraph 30

[93] Paragraph 29

roundwood". Its subcategories provide the feedstock for the subsequent processing of the three named semi-finished HWP commodities along the value chain (cf. FAO 2012). The international classification system for forestry products can be related to the Harmonized Commodity Description and Coding System (HS) of tariff nomenclature provided by World Customs Organization (WCO).[94]

Figure 2.8.2 Forest-wood chain based on simplified classification of wood products based on FAO forestry products definitions[4]



In the following, definitions of product commodities, which are relevant for the application of the guidance on estimating *HWP contribution* in line with decision 2/CMP.7, are listed (cf. Figure 2.8.2). They are drawn from the definitions of the Joint Forest Sector Questionnaire as established by the Intersecretariat Working Group on Forest Sector Statistics[95] and form the basis for the forest products statistics e.g. provided by FAO (2009).[96] Datasets for these aggregate product categories are freely and easily accessible, are updated on at least an annual basis with a 6-month or one year reporting lag, and time series are available for most countries worldwide.[97]

SAWNWOOD (2/CMP.7 refers to this as "sawnwood")**:** "Wood that has been produced from both domestic and imported roundwood, either by sawing lengthways or by a profile-chipping process and that exceeds 6 mm in thickness. It includes planks, beams, joists, boards, rafters, scantlings, laths, boxboards and "lumber", etc., in the following forms: unplaned, planed, end-jointed, etc. It excludes sleepers, wooden flooring, mouldings (sawnwood continuously shaped along any of its edges or faces, like tongued, grooved, rebated, V-jointed, beaded, moulded, rounded or the like) and sawnwood produced by resawing previously sawn pieces. It is reported in cubic metres solid volume."[96]

WOOD-BASED PANELS (2/CMP.7 refers to this as "wood panels")**:** "This product category is an aggregate comprising veneer sheets, plywood, particle board, and fibreboard. It is reported in cubic metres solid volume."[96]

For the definitions of these subcategories please see FAO 2009. [96]

PAPER AND PAPERBOARD (2/CMP.7 refers to this as "paper")**:** "The paper and paperboard category is an aggregate category. In the production and trade statistics, it represents the sum of graphic papers; sanitary and household papers; packaging materials and other paper and paperboard. It excludes manufactured paper products such as boxes, cartons, books and magazines, etc. It is reported in metric tonnes."[96]

By definition, these three aggregate commodities on semi-finished wood products represent information on the material use of HWP and equal the default categories mentioned in decision 2/CMP.7. Additionally, all datasets are reported in cubic metres solid volume or metric tonnes, which is information that enables countries to convert the data given into carbon units. Commodities which are excluded from the definitions above (e.g. V-

[94] http://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-online.aspx (2012/11/26)

[95] Comprising the Forestry Department of FAO, the Economic Commission for Europe (ECE), the Statistical Office of the European Communities (EUROSTAT) and the International Tropical Timber Organization (ITTO)

[96] http://www.fao.org/forestry/62283/en/

[97] http://faostat.fao.org/site/630/default.aspx

jointed sawnwood) might be the result of subsequent processing and therefore fall under the definition of finished wood products (see below). For further clarification on the mass flows along the forest wood processing chain and definitions of the relevant commodities, countries are strongly encouraged to consult e.g. FAO 2009. This is especially important to avoid potential double counting. The inclusion of the commodity pulp under the HWP category paper, for example, would result in double counting, as pulp by definition constitutes the feedstock for the production of paper and paperboard, cf. Figure 2.8.2).

In order to implement STEP 2, further information on commodities representing the processing stages of forest harvesting eventually used as feedstock for the production of the above listed semi-finished HWP categories (cf. Figure 2.8.1) is needed. Further definitions of major feedstock commodities that are used as a default to estimate the carbon in the above listed semi-finished HWP commodities entering the accounting framework are provided below. Please note that some possible feedstock commodities are not included due to difficulties in determining sources and multiple uses, e.g. wood chips used in wood-based panel production as some chips come from industry co-products, others could be recycled products and others go to energy use.

According to the 2006 *IPCC Guidelines*, "**WOOD-REMOVALS** are generally a subset of fellings".

ROUNDWOOD: "All roundwood felled or otherwise harvested and removed. It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period, calendar year or forest year. It includes all wood removed with or without bark, including wood removed in its round form, or split, roughly squared or in other form (e.g. branches, roots, stumps and burls (where these are harvested) and wood that is roughly shaped or pointed. It is an aggregate comprising wood fuel, including wood for charcoal and industrial roundwood (wood in the rough). It is reported in cubic metres solid volume underbark (i.e. excluding bark)."[96]

INDUSTRIAL ROUNDWOOD (WOOD IN THE ROUGH): "All roundwood except wood fuel. In production, it is an aggregate comprising sawlogs and veneer logs; pulpwood, round and split; and other industrial roundwood. It is reported in cubic metres solid volume underbark (i.e. excluding bark). The customs classification systems used by most countries do not allow the division of Industrial Roundwood trade statistics into the different end-use categories that have long been recognized in production statistics (i.e. sawlogs and veneer logs, pulpwood and other industrial roundwood). Thus, these components do not appear in trade. It excludes: telephone poles."[96]

WOOD PULP: "Fibrous material prepared from pulpwood, wood chips, particles or residues by mechanical and/or chemical process for further manufacture into paper, paperboard, fibreboard or other cellulose products. It is an aggregate comprising mechanical wood pulp; semi-chemical wood pulp; chemical wood pulp; and dissolving wood pulp."[96]

Production data on finished wood products processed from the three semi-finished product categories (see Figure 2.8.2) are not included in international databases. However, the HS nomenclature also includes some commodities for finished HWP (e.g. furniture, builders' joinery and carpentry of wood). Accordingly, information on such commodities could be available in national production and trade statistics (See Section 2.8.4.1).

In consequence, *good practice* in providing transparent and verifiable activity data for HWP, which qualifies for the provision of decision 2/CMP.7 to account for *HWP contribution* on the basis of changes in the HWP pool, is achieved by the availability of data in public available databases of international organizations (e.g. FAO) for the three aggregate HWP commodities sawnwood, wood-based panels and paper and paperboard. It is *good practice* to report on uncertainties and, wherever it is applicable, levels of confidence related to these datasets (see Section 2.8.6)

Countries, for which data on finished wood product categories derived from the default HWP categories are available, are encouraged to use these data following the guidance given in Section 2.8.4.

2.8.1.2 ALLOCATION OF HWP TO DOMESTIC FOREST ACTIVITIES UNDER ARTICLE 3, PARAGRAPHS 3 AND 4

According to 2/CMP.7, accounting for the *HWP contribution* shall only consider carbon in HWP from forests which are accounted for by the particular Party under Article 3, paragraphs 3 and 4. Carbon in imported HWP shall be excluded.[98] As the accounting framework furthermore differentiates between activities under Article 3 paragraph 3 and activities under Article 3 paragraph 4, it is *good practice* to allocate the carbon in HWP to these particular activities. Also within Article 3 paragraph 3, HWP from deforestation is treated differently from HWP for afforestation and reforestation activities (see Section 2.8.3.1).

[98] Cf. paragraph 27

In the following, guidance is given on how to implement STEP 2 (See 2.8.1) for estimating *HWP contribution* originating from forests that are accounted for by your country under particular forest land use category.

Implementation of STEP 2.1

Firstly, the share of carbon in HWP coming from domestic forests is to be estimated. For this purpose, the domestic consumption (computed from data on the production + imports – exports) of industrial roundwood (IRW_{CONS}) (see Section 2.8.1.1) is assumed to equal the feedstock being used for the subsequent processing of the semi-finished HWP categories sawnwood and wood-based panels within your country (i.e. domestic production, cf. Figure 2.8.1) (Rüter 2011, Johannsen*, et al.* 2011). Furthermore, it is assumed that the domestic consumption of wood pulp being produced from pulpwood serves as feedstock for the semi-finished HWP commodity paper and paperboard. However, commodities other than industrial roundwood and/or wood pulp serve as feedstock for the production of HWP and the fraction of domestic feedstock in reality differs within the different product categories (Rüter and Diederichs 2012). For example, substantial amounts of industrial wood residues including wood chips are being used for producing particle board (Wilson 2010).

Provided detailed and representative information on the composition of feedstock and the associated wood flows is available for these domestically produced HWP commodities, countries are encouraged to use this country-specific information to estimate the fraction of feedstock from domestic harvest for HWP production and apply Tier 3 (see Section 2.8.4.1).

If no country-specific estimates are available to determine the processing of feedstock coming only from domestic origin (e.g. track and trace systems), it is *good practice* to apply Equation 2.8.1 for estimating the annual fraction of the feedstock coming from domestic harvest $f_{IRW}(i)$ for the HWP categories sawnwood and wood-based panels.

EQUATION 2.8.1
ESTIMATION OF ANNUAL FRACTION OF FEEDSTOCK FOR HWP PRODUCTION ORIGINATING FROM DOMESTIC HARVEST

$$f_{IRW}(i) = \left(\frac{IRW_P(i) - IRW_{EX}(i)}{IRW_P(i) + IRW_{IM}(i) - IRW_{EX}(i)}\right)$$

Where:

$f_{IRW}(i)$ = share of industrial roundwood for the domestic production of HWP originating from domestic forests in year *i*.

$IRW_P(i)$ = production of industrial roundwood in year *i*, Gg C yr^{-1}

$IRW_{IM}(i)$ = import of industrial roundwood in year *i*, Gg C yr^{-1}

$IRW_{EX}(i)$ = export of industrial roundwood in year *i*, Gg C yr^{-1}

In consideration of the HWP process chain and countries that produce paper from traded pulp and in order to provide more reliable figures, it is likewise *good practice* to apply Equation 2.8.2 to estimate the annual fraction of domestically produced wood pulp as feedstock originating from domestic harvest for the production of the HWP category paper and paperboard ($f_{PULP}(i)$).

EQUATION 2.8.2
ESTIMATION OF ANNUAL FRACTION OF DOMESTICALLY PRODUCED WOOD PULP AS FEEDSTOCK FOR PAPER AND PAPERBOARD PRODUCTION

$$f_{PULP}(i) = \left(\frac{PULP_P(i) - PULP_{EX}(i)}{PULP_P(i) + PULP_{IM}(i) - PULP_{EX}(i)}\right)$$

Where:

$f_{PULP}(i)$ = share of domestically produced pulp for the domestic production of paper and paperboard in year *i*.

$PULP_P(i)$ = production of wood pulp in year *i*, Gg C yr^{-1}

$PULP_{IM}(i)$ = import of wood pulp in year *i*, Gg C yr^{-1}

$PULP_{EX}(i)$ = export of wood pulp in year *i*, Gg C yr^{-1}

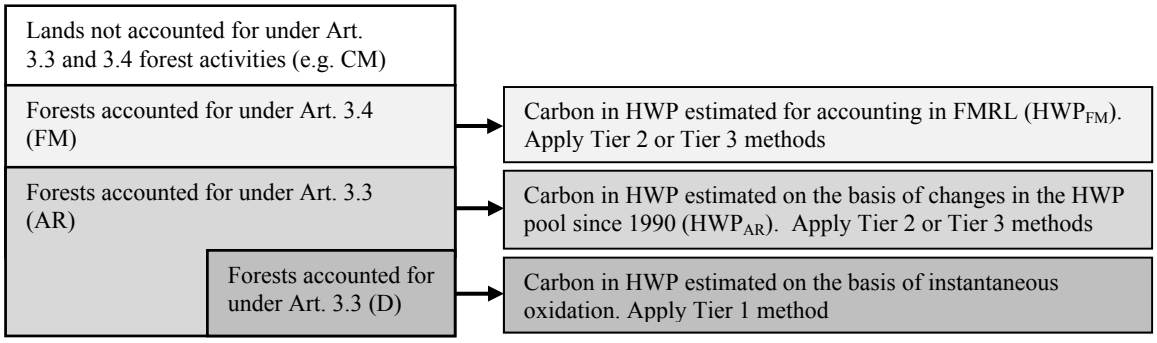
As result, the feedstock factor $f_{IRW}(i)$ is then to be applied for the aggregate commodities sawnwood and wood-based panels in Equation 2.8.4 below. For estimating the *HWP contribution* of the aggregate commodity paper and paperboard, both feedstock factors $f_{IRW}(i)$ and $f_{PULP}(i)$ apply.

Implementation of STEP 2.2

For estimating the *HWP contribution* in line with decision 2/CMP.7, it is *good practice* to allocate the carbon in HWP to the particular forest activities under Article 3, paragraphs 3 and 4 (see Figure 2.8.1). Under Article 3 paragraph 3, the *HWP contribution* originating from forest activities afforestation (A), reforestation (R) and deforestation (D) is estimated since the base year 1990. The *HWP contribution* from HWP originating from forest management (FM) under Article 3 paragraph 4 is accounted for in the second commitment period on the basis of a forest management reference level (FMRL)[99] (See Section 2.7.5).

Provided transparent and verifiable activity data are available (see Section 2.8.1.1), it is *good practice* to apply Tier 2 or Tier 3 methods for the particular fractions of HWP derived from domestic forests accounted for under FM and AR activities (HWP_{FM} and HWP_{AR}) in line with the provisions set out in decision 2/CMP.7 (See Figure 2.8.3).[100] In both cases, guidance on estimation methods is provided in Sections 2.8.3 and 2.8.4. For HWP originating from D activities it is likewise *good practice* to apply Tier 1 method (Section 2.8.2).

Figure 2.8.3 Allocation of carbon in harvest associated with ARD and FM activities



In case no country-specific approaches are available to allocate domestic harvest or to track and trace carbon in harvest from the area subject to ARD and/or FM, the estimates shall be based on the harvest volumes associated with the particular activity.

Most countries only report harvest from forests as industrial roundwood to the statistics and the uncertainties associated with feedstock for HWP production originating from lands other than forests are generally expected to be low. However, due to the definition of roundwood (see Section 2.8.1.1), it may be the case that the specified HWP categories are produced from industrial roundwood (or domestic feedstock), which originates from land not accounted for under activities related to forests under Article 3, paragraphs 3 and 4 (cf. Figure 2.8.2).[101] In the Kyoto-Protocol accounting framework, activities on lands which are not covered by the country-specific forest definition and which could provide industrial roundwood to the markets (e.g. short-rotation plantations), could instead be accounted for under the activity cropland management on a voluntary basis[102] (e.g. as perennial crops including trees, see Section 4.2.8.2). Following the guidance given in Sections 4.2.8.1 and 4.2.8.2 of the *GPG-LULUCF* countries are encouraged to provide information on how lands that could potentially be the source of harvested woody biomass have been included in their accounting. It is furthermore *good practice* to demonstrate that no significant amounts of biomass not originating from forests[103] have been used as feedstock

[99] Paragraph 12 and 14

[100] Paragraph 16, 29 and 30

[101] Cf. Paragraph 27: „ […] harvested wood products removed from forests which are accounted for by a Party under Article 3, paragraphs 3 and 4 […]"

[102] Paragraph 6

[103] See Footnote 6 in Section 4.1 of *GPG-LULUCF* for the definition of "forest" given in the Marrakesh Accords

for the production of the HWP default commodities. In case Parties did not elect cropland management, further information on the origin of industrial roundwood can be obtained from the *2006 IPCC Guidelines* under Chapter 5.

For estimating the annual fraction of HWP derived from the specific forest activity ($f_j(i)$), Equation 2.8.3 is to be applied as a default.

EQUATION 2.8.3
ESTIMATION OF ANNUAL FRACTION OF FEEDSTOCK FOR HWP ORIGINATING FROM FOREST ACTIVITIES UNDER ARTICLE 3, PARAGRAPHS 3 AND 4

$$f_j(i) = \left(\frac{harvest_j(i)}{harvest_{Total}(i)}\right)$$

Where:

$f_j(i)$ = share of harvest originating from the particular activity *j* in year *i*.

j = activity *FM, AR* or *D* in year *i*.

For estimating harvest fractions associated with the particular activity *j* related to forests under Article 3, paragraphs 3 and 4, it is *good practice* to apply information, which identifies the provision of wood from the forest associated with the particular activity. This could be derived e.g. from national forest inventories or other information on fellings (cf. Figure 2.8.2). Further guidance on relevant information is provided in Sections 2.5.3, 2.6.1.2 and 2.7.2.1. The identified fraction of the total harvest should then be attributed to HWP by application of Equation 2.8.4.

As the annual fraction of feedstock for HWP originating from forest activities under Article 3, paragraphs 3 and 4 ($f_j(i)$) can only be estimated from information available from the first and second commitment periods, it is a conservative approach and thereby in line with *good practice* to assume that all harvested wood prior to the start of the first commitment period is derived from managed forests (i.e. forest management).

Implementation of STEP 2.3

In order to finally obtain the annual fractions of HWP entering the accounting framework from domestic harvest associated with the particular activity *j* (ARD and FM), the results of STEP 2.1 (i.e. Equations 2.8.1 and 2.8.2) and STEP 2.2 (i.e. Equation 2.8.3) are, as a default, to be combined with the annual production of the HWP commodity categories (HWP_P) as specified in Section 2.8.1.1 (i.e. sawnwood, wood-based panels, paper and paperboard). For this purpose, it is *good practice* to apply Equation 2.8.4, in case no country-specific track and trace systems are available.

EQUATION 2.8.4
ESTIMATION OF ANNUAL HWP AMOUNTS BEING PRODUCED FROM DOMESTIC HARVEST RELATED TO ACTIVITIES UNDER ARTICLE 3, PARAGRAPHS 3 AND 4

$$HWP_j(i) = HWP_P(i) \bullet f_{DP}(i) \bullet f_j(i)$$

with: $f_{DP}(i) = f_{IRW}(i)$ for HWP categories 'sawnwood' and 'wood-based panels'; and
$(f_{IRW}(i) \bullet f_{PULP}(i))$ for HWP category 'paper and paperboard'

Where:

$f_{DP}(i)$ = share of domestic feedstock for the production of particular HWP category originating from domestic forests in year *i*

$HWP_j(i)$ = HWP amounts being produced from domestic harvest associated with activity j in year *i*, in m³ or m.t. yr^{-1}

$HWP_P(i)$ = production of the particular HWP commodities (i.e. sawnwood, wood-based panels and paper and paperboard, or their sub-categories, see Section 2.8.1.1) in year *i*, in m³ or m.t. yr^{-1}

Note that Equation 2.8.4 must be applied separately to each of the defined HWP commodities (HWP_p) and separately to HWP related to activities under Article 3, paragraphs 3 and 4 (HWP_j).

The estimates associated with the particular land use category (ARD and FM) also apply in case countries provide estimates for sub-categories of the three HWP default categories (see Section 2.8.3.1), or for country-specific activity data e.g. on assemblies composed of a combination of products, such as in wooden buildings. Further guidance on how to estimate fraction of HWP originating from forests being accounted for under Article 3, paragraphs 3 and 4 using country-specific activity data is provided in Section 2.8.4.1.

As emissions by sources (i.e. harvest) from A and R activities will be higher than the subsequent removals of carbon on the land associated with these activities, it is a conservative approach and complies with *good practice* to assume that HWP entering the accounting framework originating from A and R are derived from FM.

2.8.2 Tier 1: "Instantaneous oxidation"

The estimation method presented in this section is to be applied by countries as the default method to estimate the *HWP Contribution*.[104] It is based on the assumption that the annual carbon release from the HWP pool is the same as the annual carbon inflow to the pool. In consequence, this method corresponds to an estimate of no change in HWP carbon stocks. It equals the assumption that all carbon in biomass harvested is oxidised in the removal year and is equivalent to reporting no net-emissions from HWP, as the annual change in carbon stock in HWP is zero (cf. IPCC 1997, IPCC 2006).

According to *GPG-LULUCF*, in the first commitment period, the storage of carbon in HWP was not included in the reporting since, as result of this recommended default assumption, it was not listed as a pool covered by the Marrakesh Accords.[105] Following this decision, the mere presence of carbon stocks is excluded from the accounting. Countries following the *good practice* guidance as described in *GPG-LULUCF* and applying instantaneous oxidation, did thus not account for emissions from HWP in the first commitment period.[106]

Decision 2/CMP.7 establishes mandatory accounting of all changes in the HWP pool.[107] Prerequisite for accounting HWP on the basis of delayed emissions, however, is the availability of transparent and verifiable HWP activity data (see Section 2.8.1.1). In consequence, it is *good practice* to apply the Tier 1 method as outlined in this section (i.e. reporting no net-emissions from HWP) in case no transparent and verifiable activity data for the default HWP categories are available.[108]

Furthermore, defined fractions of HWP are to be accounted on the basis of instantaneous oxidation (see Figure 2.8.1):

- HWP resulting from D activities under Article 3 paragraph 3 (see Section 2.8.1.2);[109]
- HWP in solid waste disposal sites;[110]
- Harvested wood being used for energy purposes.[110]
- HWP originating from activities other than activities under Article 3, paragraphs 3 and 4.

Following the guidance given in Section 2.8.1.2, the fraction of HWP originating from domestic forests being accounted for under the activities AR and FM can be derived. Thereby, the fraction of HWP resulting from D is implicitly excluded from further estimation of *HWP contribution* and assumed to be treated on the basis of instantaneous oxidation. However, in case it is assumed that HWP entering the accounting framework originating from A and R are derived from FM, it is *good practice* to separately calculate the estimates for HWP_D by means of Equation 2.8.3. The amounts for HWP_D are subsequently subtracted from HWP activity data (HWP_j) that are used to estimate *HWP contribution* following the guidance in Sections 2.8.3 and 2.8.4.

[104] Paragraph 28

[105] Decision 11/CMP.7

[106] Cf. Paragraph 16

[107] Paragraph 26

[108] Cf. Paragraph 29

[109] Paragraph 31

[110] Paragraph 32

By estimating *HWP contribution* on the basis of methodologies as outlined in Sections 2.8.3 and 2.8.4, only *HWP contribution* of HWP in use is estimated. HWP in solid waste disposal sites and wood harvested for energy are thus implicitly treated on the basis of instantaneous oxidation. Estimates that are based on the three default commodities are per definition not derived from wood that harvested for energy purposes. Where carbon dioxide emissions from HWP in solid waste disposal sites are separately accounted for, it is *good practice* to include them on the basis of instantaneous oxidation (i.e. reporting no net-emissions from HWP).

2.8.3 Tier 2: First order decay

Provided transparent and verifiable activity data are available for the three default HWP categories sawnwood, wood-based panels and paper and paperboard, as defined in Section 2.8.1.1, and no country-specific information qualifying to apply a Tier 3 method is available (cf. Section 2.8.4), Parties shall obtain estimates on the *HWP contribution* by application of the Tier 2 method as outlined in this section.

In line with the decision 2/CMP.7, it is *good practice* to estimate the change in carbon stocks separately for each of the HWP fractions associated with the particular forest activity (HWP_j) as specified in Section 2.8.1.2. For this purpose, the first-order decay (FOD) function as presented in Equation 2.8.5, which is a flux data method that corresponds to Equation 12.1 of the *2006 IPCC Guidelines*, is to be applied:

EQUATION 2.8.5
ESTIMATION OF CARBON STOCKS AND ANNUAL CARBON STOCK CHANGES IN HWP POOL OF THE REPORTING COUNTRY

$$C(i+1) = e^{-k} \bullet C(i) + \left[\frac{(1-e^{-k})}{k}\right] \bullet Inflow(i)$$

$$\Delta C(i) = C(i+1) - C(i)$$

Source: IPCC 2006

Where:

i = year

C (i) = the carbon stock in the particular HWP category at the beginning of year i, Gg C

k = decay constant of first-order decay for HWP category given in units yr^{-1} (k = ln(2)/HL, where HL is half-life of the HWP pool in years (see Section 2.8.3.2).

Inflow (i) = the inflow to the particular HWP category (HWP_j) during year i, Gg C yr^{-1}

$\Delta C(i)$ = carbon stock change of the HWP category during year i, Gg C yr^{-1}

It is *good practice* to apply Equation 2.8.5 with activity data for semi-finished wood products that have been dedicated to the particular forest activity (HWP_j) (see Section 2.8.1). In combination with semi-finished wood product commodities, this FOD implicitly includes finished HWP in the pool estimates, and it is assumed that immediate losses of the HWP pool due to final processing along the processing chain (cf. Figure 2.8.1) are described realistically by the exponential decay pattern (Pingoud and Wagner 2006). Emissions from wood processing residues used for energy purposes along the process chain are also well described by FOD.

Whereas Equation 12.1 contained in the *2006 IPCC Guidelines* suggests to start with i = 1900, the application of FOD in the context of the decision 2/CMP.7 necessitates a differentiated approach to enable HWP accounting associated with the different forest activities (see Section 2.8.1.2).

In order to produce an estimate of the existing HWP carbon pool by means of Equation 2.8.5, and based on the subsequent changes of this pool to produce an estimate of the *HWP contribution*, the historical wood use (i.e. the accumulation of the historic *Inflow* to the HWP pool) has to be included. This procedure is needed as this also includes the historic and current discard from the HWP pool, which is also termed "inherited emissions" (IPCC 2006). This is reflected in decision 2/CMP.7, which states that "emissions that occur during the second commitment period from harvested wood products removed from forests prior to the start of the second commitment period shall also be accounted for."[111] The term "emissions" from HWP (which are defined as a

[111] Paragraph 16

4547 pool[112]) thus refers to the "decay" from that pool, which is the discarding of wood and paper products from end
4548 uses described e.g. by FOD (i.e. Equation 2.8.5). Discarding, thus, does not mean that the products' carbon is
4549 oxidized, but describes the release of HWP from the HWP pool in use (or in service) from where the products
4550 are potentially recycled, burned, composted or transferred to solid waste disposal.[113] The discard from the pool
4551 of HWP in use (comprising wood products in service), therefore depends on the historic level of Inflow (see
4552 Section 2.8.1) and the particular service life and/or half-life of the HWP commodities (cf. Sections 2.8.3.2 and
4553 2.8.4.2).

4554 In order to account for *HWP contribution* from A and R activities, estimates are to be based on activity data
4555 since the base year 1990. It is thus *good practice* to include inherit emissions from the pool that has been
4556 established from HWP_{AR} since 1990. This is implemented by the use of Equation 2.8.5 starting with i = 1990.

4557 For HWP from FM activities, however, the inclusion of inherited emissions in the estimates of the HWP carbon
4558 pool depends on the Party's accounting approach for FM. In case the FM reference level (FMRL) is based on a
4559 projection which represents a 'business as usual scenario' (See Sections 2.7.5.1 and 2.8.5), Parties may exclude
4560 inherited emissions from before the start of the second commitment period in their estimates.[114] In this case, the
4561 estimation by means of Equation 2.8.5 starts with i = 2013. If the Party's FMRL is not based on a projection
4562 representing a 'business as usual scenario', it is thus *good practice* to include inherit emissions from the pool.

4563 As reflected also by Equation 2.8.4 ($HWP_j(i)$), it is thus *good practice* to separately estimate and report by the
4564 above procedure the annual *HWP contribution* for:

4565 • HWP from AR activities (HWP_{AR}) and for HWP from FM activities (HWP_{FM})

4566 • HWP for each of the particular commodities (i.e. sawnwood, wood-based panels, paper and paperboard or
4567 their subcategories)

4568 The availability of activity data series (i.e. $Inflow(i)$) varies. For most countries e.g. the FAO statistics provide
4569 data on the HWP commodity categories since 1961. [115] However, for some countries activity data are available
4570 only since their independence or foundation (e.g. in 1991). Further guidance on the activity data to be used for
4571 Tier 2 method is provided in Section 2.8.3.1.

4572 As a default proxy in the Tier 2 method it is assumed that the HWP pools are in steady state at the initial time t_0
4573 from which the activity data start. This means that as a proxy $\Delta C(t_0)$ is assumed to be equal to 0. The steady state
4574 carbon stock $C(t_0)$ for each HWP commodity category is approximated based on the average of $Inflow(i)$ during
4575 the first 5 years of which statistics data are available. By substituting $C(t_0)$ in Equation 2.8.6, the $C(i)$ and $\Delta C(i)$
4576 in the sequential time instants can be calculated.

4577

4578 **EQUATION 2.8.6**
4579 **APPROXIMATION OF THE CARBON STOCKS IN HWP POOLS AT INITIAL TIME, I.E. SINCE WHEN**
4580 **ACTIVITY DATA ARE AVAILABLE**
4581

$$C(t_0) = k \bullet Inflow_{average}$$

4582

4583 where $Inflow_{average} = \left(\sum_{i=t_0}^{t_4} Inflow(i)\right)/5$

4584

4585 This corresponds to the approach to calculate missing activity data since the year 1900 on HWP_{FM} carbon pool
4586 inflow from the average of the first five years for which activity data are given for the country (cf. Rüter 2011),
4587 which many countries have chosen to estimate the *HWP contribution* to the FMRL.[116] Further estimation
4588 methods for calculating the carbon inflow to the HWP_{FM} pool (*Inflow(i)*) back to the year 1900 are provided by
4589 the *2006 IPCC Guidelines* (i.e. on the basis of estimated annual rates of increase for industrial roundwood
4590 production that are based, inter alia, on the annual per cent change of population growth). If inherited emissions

[112] Cf. Paragraph 26

[113] For more information see IPCC FAQ, Q4-29 (http://www.ipcc-nggip.iges.or.jp/faq/faq.html)

[114] Paragraph 16

[115] http://faostat.fao.org/site/630/default.aspx

[116] See submissions by Parties on FMRL as requested by decision 2/CMP.6 (http://unfccc.int/bodies/awg-kp/items/5896.php)

from the HWP_{FM} pool are to be considered as described above and the inclusion of HWP in the countries' FMRL is not based on a projection representing a 'business as usual scenario' (see Section 2.7.5 and 2.8.5), it is *good practice* to demonstrate that the approach chosen to include inherited emissions in the estimates of the HWP_{FM} carbon pool reflects best the countries' circumstances.

The carbon stock change in all the HWP pools of the commodities associated with the particular activities is obtained by summing the stock changes ΔC of each commodity category. The carbon stock change is then converted into Gg CO_2 yr^{-1} by multiplying with 44/12.

Under the Tier 2 method, Equation 2.8.5 is equally applied for domestically consumed as well as for exported HWP together with the same half-life parameters (See Section 2.8.3.2). Therefore, it complies with *good practice* not to differentiate between domestic consumption and exports in the reporting of *HWP contribution*. In order to increase transparency and facilitate potential changes in the methodology used to estimate *HWP contribution* (e.g. by application of country-specific half-lives following the guidance provided in Section 2.8.4), however, Parties are encouraged to report separately for domestically consumed and exported HWP.

2.8.3.1 ACTIVITY DATA

Activity data include the carbon stock of the HWP pool at the beginning of each year (C(i)) and the inflow to the HWP pool during each year (*Inflow* (*i*)) for each HWP category. In order to apply Equation 2.8.4, it is *good practic*e to determine C(*i*) and *Inflow* (*i*).

For this purpose, Tier 2 uses forest products data from FAO or other international organizations (e.g. UNECE) for semi-finished HWP commodities as set out in Section 2.8.1.1. As a default, the annual *Inflow*(*i*) to the HWP pool comprises of the three default HWP commodity categories, i.e. sawnwood, wood-based panels, paper and paperboard), separated by the particular activity ($HWP_j(i)$, see Section 2.8.1.2).

In order to estimate carbon amounts in HWP, default conversion factors are provided in Table 2.8.1. In fact, the conversion factors for the HWP default commodities (i.e. aggregates) very much depend on composition of countries' production amounts of the particular subcategories (e.g. particle board). If Parties have disaggregated data on subcategories of semi-finished wood products as listed in Table 2.8.1, it is thus *good practice* to apply Equation 2.8.5 to the disaggregated subcategories.

TABLE 2.8.1
DEFAULT CONVERSION FACTORS FOR THE DEFAULT HWP CATEGORIES AND THEIR SUBCATEGORIES

HWP categories	Air dry density [Mg m^{-3}]	Carbon fraction (per oven dry matters)	C conversion factor (per air dry density) [Mg C m^{-3}]	Source
Sawn wood (*aggregate*)	[..] [*footnote*]	…	…	1
Coniferous sawnwood	[..] [*footnote*]	0.5	…	2
Non-coniferous sawnwood	[..] [*footnote*]	0.5	…	2
Wood-based panels (*aggregate*)	[..] [*footnote*]	…	…	3
Veneer sheets	0,59	…	…	4
Plywood	0,48	…	…	4
Particle board	0.633	0.424	0.269	5
Hardboard (HDF)	0.85	0.394	0.335	5
Medium-density fibreboard (MDF)	0.738	0.4	0.295	5
Fibreboard compressed	0.794	0.396	0.315	6
Other board (Insulating board, LDF)	0,270	…		7
Paper and paperboard (*aggregate*)*	0.9	0.5	0.45	8

* reported per tonne

[1] [*Will be calculated on the basis of the weighted average from coniferous and non-coniferous sawnwood production volumes of the countries as listed in Appendix of the Annex of decision 2/CMP.7*]

[2] [*Will be calculated on the basis of the weighted average of density (odm) from tree species distribution of the countries as listed in Appendix of the Annex of decision 2/CMP.7*]

[3] [*Will be calculated on the basis of the weighted average of included subcategories from the production volumes of the countries as listed in Appendix of the Annex of decision 2/CMP.7*]

[4] Haynes et al 1990, Tables B-6 and B-7, IPCC 2003, Appendix 3a.1

[5] Rüter and Diederichs 2012 (including Oriented Strand Board, OSB)

[6] 50% of HDF and 50% of MDF

[7] Rüter 2011

[8] IPCC 2006

In order to reduce uncertainties associated with assumptions on the conversion factors of activity data (i.e. data on semi-finished wood product commodities derived from statistics) (See Section 2.8.6), Parties are encouraged to use country-specific activity data comprising further items of the HWP subcategories as listed in Table 2.8.1. More information can be obtained in Section 2.8.4.1.

2.8.3.2 EMISSION FACTORS

The rate at which carbon in the default HWP categories is removed from the HWP pool in service in a given year is specified by a constant decay rate (k) is expressed as half-life in years. The *2006 IPCC Guidelines* define the half-life as "the number of years it takes to lose one-half of the material currently in the pool". As the half-life in the context of 2/CMP.7 refers to HWP in use (cf. Section 2.8.1.1), the half-life to be applied is a function the (estimated) service life (ESL) of the particular HWP commodities (with HL = ESL* ln(2), cf. Section 2.8.4.2).

When applying the Tier 2 method, decision 2/CMP.7 requires countries to use the default half-lives of the three HWP categories as specified in Table 2.8.2. The same half-lives apply for the particular subcategories of the aggregate HWP categories as specified in Table 2.8.1.

TABLE 2.8.2
TIER 2 DEFAULT HALF-LIVES[117] OF HWP CATEGORIES

HWP categories[118]	Default half-lives (years)
Paper	2
Wood panels	25
Sawn wood	35

In order to reduce uncertainties associated with the assumptions on the half-lives of the HWP commodities (See Section 2.8.6) Parties are encouraged to use country-specific half-lives, both for the domestic use of HWP categories, as well as country-specific half-lives as being applied by the importing country for the exported HWP categories. Further guidance on how to use and obtain country-specific half-life information for the relevant HWP categories can be obtained in Section 2.8.4.2.

2.8.4 Tier 3: Country-specific methods

This section provides *good practice* guidance on the use of country-specific methods to estimate the HWP carbon pool and its changes in order to estimate the overall *HWP contribution*. These methods shall be applied by Parties in line with requirements as outlined in Section 2.8.1 and the decision 2/CMP.7 covering the 3 semi-finished HWP categories.[119] It complies with *good practice* to apply country-specific methods provided that verifiable and transparent activity data are available and that the methodologies used are at least as detailed or accurate as those described under Tier 2. *Good practice* thus includes a verification of the Tier 3 methods used,

[117] See footnote of paragraph 29 of decision 2/CMP.7: Half-lives are based on Table 3a.1.3 of the *GPG-LULUCF*.

[118] HWP categories as defined in paragraph 29 of decision 2/CMP.7 refer to the commodities sawnwood, wood-based panels, paper and paperboard, acc. to the international classification system for forestry products (See guidance in Section 2.8.1.1)

[119] Use of Tier 3 methods does not apply to exported wood in circumstances where the importing country uses Tier 3 methods and the exporting country uses Tier 2 methods. This would lead to inconsistencies in the accounting. An example of this situation would be exported sawnwood accounted for under a Tier 2 method, which is then processed into floor boards by the importing country, which applies a Tier 3 method with half-lives for HWP subcategories.

e.g. by comparing the results derived using the Tier 2 method (See Section 2.8.3), and by providing all relevant information in a transparent and verifiable way to demonstrate how *HWP contribution* has been estimated. More information on how to verify Tier 3 methods can be found in IPCC FAQs on HWP.[120]

Two key Tier 3 methodological pathways allow for estimating changes in the HWP carbon pool in line with the requirements as outlined in decision 2/CMP.7 comprising (i) flux data methods, and (ii) combinations of stock inventory and flux data methods.

FLUX DATA METHODS

In flux data methods HWP carbon pool and its changes are basically calculated from the difference of the production (i.e. carbon inflow to the HWP pool) and decay/discard rate. There are comprehensive international activity databases on production and trade of HWP (See Section 2.8.1.1), whereas information on the discard from the HWP pool is incomplete. Using this discard information (e.g. from waste statistics) to calculate the above difference would lead to overestimation of HWP carbon pool and its changes. Thus practicable flux data methods that comply with *good practice* rest on service life information of HWP. They are based on the use of decay functions and dynamic models assuring the continuity of mass so that all HWP carbon coming into the pool will be discarded in the long run.

Following alternatives under a Tier 3 method could be used:

- The Tier 2 FOD function (See Equation 2.8.5) is a special case of flux data methods and could also be applied under Tier 3 with:
  - (i) Default half-lives in combination with country-specific activity data for disaggregated commodity items of the three HWP commodities that follow the HS classification system (see 2.8.4.1)
  - (ii) Country-specific half-lives to be based on national information on service life of the default HWP commodities or their sub-categories (See below and Section 2.8.4.2).
- Other country- or product-specific decay functions could be applied. Examples of different decay functions include logarithmic decay (e.g. Karjalainen, et al. 1994), retention curves (e.g. Skog and Nicholson 1998) and distribution functions (e.g. Marland, et al. 2010). They could be used with in combination with:
  - (i) Default half-lives (See Table 2.8.2), or country specific half-lives as specified in Section 2.8.4.2
  - (ii) Country-specific activity data (See Section 2.8.4.1).

If country-specific half-lives or decay functions are used, it is *good practice* to separate HWP pools for the reporting country and for the export markets in order to separately estimate and report its *HWP contribution*. Likewise it is good practice to separate the HWP pools for the reporting country and for the export markets in case

Furthermore, is complies with *good practice* to separately estimate and report HWP contribution of the HWP pool for the domestic market (i.e. reporting Party) and for export markets, in case:

- Country-specific half-lives or decay functions, and/or
- Country-specific activity data (i.e. other than specified in Section 2.8.3.1) are used.

In case HWP pools of both semi-finished and finished products are included in Tier 3 calculation models it is *good practice* to ensure that overlapping of the HWP pools must be eliminated to avoid any double-counting of HWP carbon stock changes.

COMBINED HWP STOCK INVENTORY AND FLUX DATA METHODS

HWP stock inventory methods use data of the HWP carbon pool itself for two or preferably more separate points in time to estimate changes in the pool. Its application is basically relevant for HWP pools in the reporting country alone (See Section 2.8.4.1) and could be used to estimate the annual change in carbon stock of some specific finished HWP pools (cf. Figure 2.8.2) such as buildings. Examples of such inventories are reported in Gjesdal*, et al.* (1996) for Norway, in Pingoud*, et al.* (2001) and Statistics Finland (2011) for Finland.

In case of inventory methods, no procedure for adding up wood use data from historical data is needed to estimate the existing HWP stock or annual change in stock, which is an advantage compared to the flux methods (IPCC 2006). However, a fundamental problem in the application of inventory methods alone for the present accounting purpose is the estimation of that part of the HWP carbon stock originated from domestic forests and

[120] http://www.ipcc-nggip.iges.or.jp/faq/faq.html

being thus accountable for (See Section 2.8.1). Furthermore, in line with decision 2/CMP.7, imported HWP must be excluded from the estimated HWP pool increasing the uncertainties.[121]

Since inventory data are never available for all finished HWP and neither for export markets, it is thus *good practice* to apply inventory methods only in combination with flux data methods.

In case a Party applies inventory methods for specific HWP end uses (e.g. the housing sector), it is thus *good practice* to estimate HWP contribution for the remaining fraction of the 3 HWP default commodities in combination with the flux-data method under Tier 2 or 3. For this purpose, the three HWP categories being used in the housing sector must be factored out from the flux-data calculation to avoid double-counting and to meet the requirements of 2/CMP.7.

Inventory methods are looking backwards so it is not possible to do any projections by them (cf. Section 2.8.5). Flux data models could, however, be calibrated to the inventories and used for projective purposes (See Section 2.8.4.2). Through the calibration procedure more realistic country-specific half-lives could be estimated and used in a Tier 3 level flux-data model (Statistics Finland 2011).

2.8.4.1 COUNTRY-SPECIFIC ACTIVITY DATA

Section 2.8.1.1 introduces the international classification system of forestry products following the HS nomenclature, which is also relevant for activity data used for a Tier 3 method. Whereas data for semi-finished HWP can be obtained from national statistics as well as from international databases, HWP activity data other than outlined in Section 2.8.3.1 (See Table 2.8.1) are available from national sources only. In the case of Parties using country-specific activity data as described in this section, it is *good practice* to disclose the source of data and provide in a transparent and verifiable manner additional information for items that make up subcategories and/or final products being produced from the three default HWP categories as defined in decision 2/CMP.7[122] (cf. Figure 2.8.2).

Country-specific HWP activity data to be used for Tier 3 could be:

1. Item data following the international HS nomenclature and classification system

These data could be available from country-specific statistics containing further disaggregated items of the subcategories as specified in Table 2.8.2. Examples would be coated particle board, fibreboard with specific density or surface, or coniferous sawnwood made from specific tree species (e.g. larch). Introducing disaggregated item data using appropriate carbon conversion factors e.g. based on information on wood densities can contribute to considerably improve the accuracy of the HWP estimations. Further information could be obtained e.g. in Forest Products Laboratory 2010.

In some cases, the aggregated datasets for the specified HWP categories available from national statistics are different from available databases of international organizations (e.g. FAO or UNECE). In order to reduce uncertainties associated with the use of these datasets (see Section 2.8.6) and in order to provide country-specific activity data in a transparent and verifiable way, Parties are encouraged to explain the differences between data used from national sources from these provided in international databases.

2. Finished HWP not containing components with different service lives

These types of activity data refer to finished HWP that do not contain components with different potential half-lives. They are made up from at least one of the (default) semi-finished HWP categories (See Figure 2.8.2). This group of products comprise e.g. doors, flooring systems, books or furniture, which could also be obtained from national production statistics (e.g. furniture production statistics).

3. Data on buildings with different wooden construction components with different renovation intervals

These types of products rather represent a market segment where finished products are used. Wooden houses are composed of different construction components with different renovation intervals, e.g. long lived roof construction made of beams, wall systems, and comparatively short-lived wooden flooring systems. Country-specific activity data for buildings could again be derived from the production statistics (e.g. Building Construction Starts statistics) or from inventories and surveys.

[121] Paragraph 27

[122] Paragraph 30

Some of the above mentioned activity data might be available from annual statistics being applicable for flux data methods. Others might be available only at the start and the end of the commitment period for the use in combined HWP stock inventory and flux data methods.

In order to allocate the carbon in HWP to the particular forest activities under Article 3, paragraphs 3 and 4 (see 2.8.1.2) Parties could still apply the relevant equations as suggested in Section 2.8.1 for the use in Tier 3 methods. Nevertheless, Parties are encouraged to estimate carbon in HWP originating from domestic forests using more country-specific information, including e.g. detailed data on the use of timber assortments for the subsequent processing of HWP categories. Provided country-specific approaches are available for this purpose, it is *good practice* to demonstrate and report how the allocation has been done to meet the requirements as set out in decision 2/CMP.7.

When using country-specific activity data, information on carbon conversion factors (cf. Table 2.8.1) may not be readily available. Especially HWP activity data representing finished commodities (See Figure 2.8.2) or market segments of wood use (e.g. wooden building components, see Table 2.8.3 in Section 2.8.4.2) often include mixes of wood and other materials. In this case, specific conversion factors could be obtained from statistics or from life cycle inventory (LCI) information, which forms the basis for life cycle assessment (LCA) according to ISO 14040:2006 and 14044:2006. Information on the average amount of wood content per unit could be provided e.g. per square meter of floor space (Tsunetsugu and Tonosaki 2010). Examples of representative LCI information are reported in Rüter and Diederichs (2012) for Germany.

When using such specific conversion factors, it is *good practice* to demonstrate and report how conversion factors have been derived and provide information on the representativeness of associated data as regards time, technology and geographical scale (see e.g. European Union 2010).

2.8.4.2 COUNTRY-SPECIFIC EMISSION FACTORS

This section gives guidance on the concept of service life and half-life information to estimate the *HWP contribution* on the basis of flux data methods.

In general, national values for service- or half-life could be derived for the three default HWP categories and their subcategories (See Section 2.8.1.1). But also other HWP categories could be established and combined with the respective service life information. However, in order to ensure that the methodology used is at least as accurate as the one described in Section 2.8.3, Parties are encouraged to make those HWP categories broad enough to capture significant carbon volumes contributing to the HWP pool. As a guide, the volumes of HWP categories are deemed significant if they represent at least 5% of the total HWP production.

Potential data providers and sources for national service life information are national and industry agencies, technical literature and direct consultations (i.e. surveys of experts, industry and the general public). It is important to note that service- and half-life values representing the material use of wood can differ notably among and within countries depending on factors such as construction practices, culture, fashion, and climate. Thus, in case country-specific information is used, a national quality control system is encouraged in order to provide data which is as transparent and verifiable as possible.

Several approaches can be used to derive country-specific service- and half-life values based on transparent and verifiable data:

- Following ISO 15686 standard series approach in combination with obsolescence on national level (See Box 2.8.1),
- A combination of production and trade statistics data with building stock inventory information, and/or
- National surveys on the final market use of wood.

In the following, ways on improving service life estimates based on the ISO 15686 series are shown, and an example of HWP half-life calculation for HWP categories is given based on its estimated service life in combination with an obsolescence factor and information on its market share.

In order to adequately apply flux data methods based on information on country-specific HWP service life (i.e. time carbon is held in HWP pool in use before they are disposed or recycled), apart from the concept of half-life (See Section 2.8.3.2), following terms and concepts are to be differentiated:

- ISO 15686-1 (2011) defines the reference service life (RSL) as the service life of a product, component, assembly or system which is known to be expected under a particular set, i.e. a reference set of in-use conditions;.

- The estimated service life (ESL) on the other hand is the service life that a wooden or wood based component would be expected to have in a set of specific in-use conditions. It is determined from RSL data after taking into account any differences from the reference in-use conditions (ISO 15686-1:2011);
- The factor method is used to calculate the ESL. It is a modification of RSL by seven factors to take account of the specific in-use conditions (ISO 15686-8:2008); and
- Obsolescence arises (according to ISO 15686-1:2011) when a facility no longer can be adapted to satisfy changing requirements. Obsolescence tends to result from unexpected changes, often unrelated to the construction, and includes:
    - (i) Functional obsolescence: function no longer required.
    - (ii) Technological obsolescence: new alternatives can offer better performance, change the pattern of use.
    - (iii) Economic obsolescence: Fully functional but less efficient, more expensive than alternatives. This includes also replacement due to changing fashion or taste.

ISO 2011 states that estimates of obsolescence should be based on the designer's and clients experience, and, if possible, documented feedback from practice. In order to estimate the carbon storage of HWP in use and its impact on emissions/removals by means of flux data methods using country-specific service life information, it is thus *good practice* to take into account obsolescence and to distinguish replacement of HWP in use due to e.g. a defective performance from obsolescence (cf. ISO 2011).

For example:

In northern Europe a wooden decking can last for 50 years or more given proper construction and choice of material. But the same decking is likely to be replaced already after 20 years (or less) e.g. due to aesthetical reasons. Hence, for calculating country-specific ESL or half-life values an obsolescence factor is needed to use in Tier 3 estimates of *HWP contribution* the time actually spent in the HWP carbon pool, not the potential full service life of a wooden component given by ESL.

In this guidance document the ESL is applied for estimates on national level and not for a specific case as suggested in the ISO 15686 standard series. To include the effect of obsolescence:

- Either an additional factor (O) is included, with
    - (i) Obsolescence = 1 when there is considered to be no significant effect of obsolescence compared to RSL
    - (ii) Obsolescence is given a value < 1 based on the intensity of obsolescence
    - (iii) Obsolescence can never be larger than 1.
- Or a decay function to be assigned that uses the service life data to estimate the decay profile (based on products leaving the pool, not only biological decay and not a biological decay profile) or the actual time path that products take to go out-of-use.[123]

An example of how to derive national service life estimates by means of the factor method is given in the box 2.8.1 below.

[123] For more information see IPCC FAQ, Q4-29 (http://www.ipcc-nggip.iges.or.jp/faq/faq.html)

BOX 2.8.1
EXAMPLE ON THE CALCULATION OF NATIONAL ESL BY MEANS OF FACTOR METHOD

A theoretical example with wooden claddings in Norway is given based on the ISO 15686-8, but elevated from the case specific level given in the standard to a national level. The factor classes and the factor method are described e.g. in ISO 15686-8: 2008. Non relevant factors are excluded from the equation. The RSL is based on accelerated field trials and failure was defined when the mean decay rating reached 2 (on a scale from 0–4 where 0 is no decay and 4 is failure).

National estimated service life ESL = 55(RSL)*1(A)*1(B)*1(C)*1.2(E)*1(F)*0.9(G) = 59.4 years

A=Quality of components, B= Design level, C= Work execution level, E= Outdoor environment, F= Usage conditions, G= Maintenance level.

Factor D 'indoor environment' is excluded because it is not relevant. It is good practice to include factors that do not deviate from the RSL even if they do not contribute in changing the RSL since they are given the value 1. The reasoning for choice of factors needs to be given based on the same principle as given in ISO (2008).

Another example on how to derive country-specific half-life values (here for the three aggregate HWP categories, see Section 2.8.1.1) as a function of information on market share of the use of wood (see above), ESL and obsolescence is given in Table 2.8.3.

The use of composed HWP categories in different markets, such as in the construction sector, can be divided further into different segments (e.g. wall systems, flooring, and roof construction). These different segments comprise different service lives and obsolescence factors. Hence, Parties are encouraged to allocate the contribution of the different HWP categories or subcategories (e.g. coniferous sawnwood) to markets and their segments in order to receive improved service life estimates for the particular HWP categories.

4852

4853

TABLE 2.8.3
EXAMPLE ON HOW TO DERIVE COUNTRY-SPECIFIC HALF-LIFE FOR HWP CATEGORIES AS A FUNCTION OF INFORMATION ON MARKET SHARE, ESTIMATED SERVICE LIFE (ESL) AND OBSOLESCENCE

HWP categories (*here: aggregates*)	Markets*	Market share of HWP category	National estimated service life (ESL), years	National obsolescence factor (O)	Adjusted ESL of HWP category (=ESL*O)* market share adjustment	Half-life (=Adjusted ESL* ln(2))
Sawn wood	construction	60%	70	0.9	41.0	28.4
	furniture	10%	45	0.6		
	packaging	30%	6	0.3		
	paper	0%	-	-		
Wood-based panels	construction	50%	60	0.7	30.5	21.2
	furniture	45%	35	0.6		
	packaging	5%	6	0.3		
	paper	0%	-	-		
Paper and paperboard	construction	0%	-	-	1.5	1
	furniture	0%	-	-		
	packaging	50%	3	0.3		
	paper	50%	10	0.2		

4854 **HALF-LIFE DATA TO BE USED FOR EXPORTED HWP**

4855 In case of exported HWP, country-specific data refers to country-specific half-lives and HWP usage in the
4856 importing country.[124] Hence, it is necessary to quantify export activity data within the three HWP categories
4857 and/or sub categories. In addition, national half-lives must be obtained from the countries the HWP are exported
4858 to. It is thus *good practice* to ensure that the same activity data (HWP categories) both in the exporting and
4859 importing country are being used. Otherwise the default values (Tier 2) should be used. When verifiable and
4860 transparent activity data are available, the categories should be broad enough to capture significant volumes
4861 contributing to the pool. The amount of exported and domestic wood should be separately reported.

4862

4863 2.8.5 Consideration of the HWP pool in FMRLs

4864 In this section, guidance is given on the relation of HWP originating from FM as described in Section 2.8.1 and
4865 its consideration in the forest management reference level (FMRL) as outlined in the decisions 2/CMP.6[125],
4866 2/CMP.7 and -/CMP.8. Guidance on the FMRL is provided in Section 2.7.5.

4867 **APPROACHES AND METHODS FOR CONSIDERATION OF HWP IN FMRL**

4868 Decision 2/CMP.6 requested Parties to *inter alia* submit descriptions of how HWP were considered in the
4869 construction of the FMRL.[126] In line with the different approaches and methods used by Parties to construct the
4870 FMRL as listed in Section 2.7.5.1, two general approaches on how to treat HWP in FMRL can be differentiated:

4871 1. Instantaneous oxidation

[124] Paragraph 30, Footnote 6

[125] Paragraph 4 and paragraph 2 and 9 of Appendix II

[126] See submissions by Parties on FMRL as requested by decision 2/CMP.6 (http://unfccc.int/5896.php) and document FCCC/KP/AWG/2011/Inf.2

In this case, Parties only presented values for a FMRL which do not contain estimates on the *HWP contribution*.[127] Similar to the treatment of HWP in the first commitment period as described in *GPG-LULUCF*, as result of the assumption of instantaneous oxidation, the storage of carbon in the HWP pool is not included (cf. Section 2.8.2). This approach equates the HWP Tier 1 estimation method as described in Section 2.8.2 and was chosen by Parties following the FMRL approach 3) and 4) as described in Box 2.7.5.1.

2. Inclusion of the HWP pool on the basis of modeled projections under a 'business as usual' scenario

In this case, Parties presented values for the FMRL that include estimates of the *HWP contribution* based on changes in the HWP pool.[128] This approach was chosen by Parties following the FMRL approaches 1) and 2) as described in Box 2.7.5.1. Many countries derived the values for the projected *HWP contribution* by means of FOD as specified in Section 2.8.3 for the Tier 2 HWP estimation method (Equation 2.8.5) applying default half-lives as listed in Table 2.8.3 for the HWP categories sawnwood, wood panels and paper (cf. Section 2.8.1.1).[129] However, different approaches had been used as regards the consideration of HWP originating from forests prior to the start of the second commitment period[130], as indicated in the application of HWP activity data (i) since 1900, or (ii) since 1990.

Besides these two basically different methodological approaches in the treatment of HWP in the FMRL, further distinction between Parties' estimates on the *HWP contribution* to the FMRL can be recognized for (i) the applied models that have been used (including activity data, carbon conversion factors, etc.), and (ii) the applied underlying assumptions as regards the projected HWP contribution and/or its relation to particular projected harvest rates of Parties.

An example of how estimates of the *HWP contribution* in the FMRL could be derived is listed in Box 2.8.2.

[127] See FMRL values in column '*Reference level*' in the table of the Appendix of the Annex of decision 2/CMP.7

[128] See FMRL values in column '*Applying first-order decay function for HWP*' in the table of the Appendix of the Annex of decision 2/CMP.7

[129] Paragraph 27 of Chapter II, Annex I in document FCCC/KP/AWG/2010/18/Add.1.

[130] Cf. paragraph 15 sexies, Ibid.

BOX 2.8.2
EXAMPLE ON THE ESTIMATION OF HWP CONTRIBUTION AS PRESENTED IN PARTIES' FMRL

The following example is intended to show, how estimates of the projected *HWP contribution* based on changes in the HWP pool could be derived that are consistent with the assumed harvesting rates following a 'business as usual' scenario in case no country-specific information on assumed future production of HWP and/or 'track and trace' models were available (cf. Rüter 2011).

In line with the guidelines for the submission and review of information on FMRL contained in the Appendix II of decision 2/CMP.6, Parties had been requested to provide information on historic and assumed harvesting rates following a 'business as usual' scenario for forest management.

STEP 1: Calculation of the rates of change of the projected harvest as compared to the last five years' average of the historic harvest, for which up-to-date data were available.

Numeric example:

(i) Average historic harvest for the years 2005-2009: 50 Million m³

(ii) Projected harvest (in Million m³): in 2013=52, in 2014=53, in 2015=55 …

(iii) Rates of change as compared to historic average: in 2013=4%, in 2014=6%, in 2015=10%

STEP 2: Application of these annual change rates to the same five year average of historic carbon inflow to the HWP pool, which has been calculated from HWP production (cf. Section 2.8.3), in order to project the future carbon inflow to the HWP pool.

Numeric example:

(i) Production of sawnwood for the years 2005-2009: 10 Million m³

(ii) Projected production of sawnwood (in Million m³): in 2013=10.4, in 2014=10.6, in 2015=11 …

As a result, it is assumed that the same average proportion of harvested timber being used as feedstock for the subsequent production of HWP in the chosen historic five year period will also apply in the projection period.

A five year average was chosen, in order to reduce the uncertainties associated with because the proportions of harvested timber being used for HWP production can vary considerably from year to year. A similar approach had been proposed by Kangas and Baudin (2003). In case of substantially varying time series, they suggest to use a 'fixed constant' as the projection that is an average over the last five years.

METHODOLOGICAL CONSISTENCY BETWEEN HWP IN THE FMRL AND THE REPORTING DURING THE SECOND COMMITMENT PERIOD

General guidance on methodological consistency in relation to the FMRL is provided in Section 2.7.5.2.

In line with decision 2/CMP.7, it is *good practice* to demonstrate methodological consistency between the treatment of HWP in the reference level and the reporting for forest management (FM) during the second commitment period.[131]

Provided that Parties comply with the requirements as outlined in Section 2.8.1.1 to estimate *HWP contribution* on the basis of changes in the HWP pool following a Tier 2 or Tier 3 method (See Sections 2.8.3 or 2.8.4), methodological consistency between the treatment of HWP in the FMRL and the reporting as explained in Section 2.7.5.2 can be demonstrated by providing following information in the annual greenhouse gas inventory in accordance with Article 5, paragraph 2, of the Kyoto Protocol, which shall be submitted starting with the annual inventory for the first year of the second commitment period[132]:

- Time series of HWP_{FM} separately for the included HWP categories (HWP_P), including historic information as appropriate (See Sections 2.8.3, 2.8.4 and below), in order to also demonstrate that

[131] Paragraph 14

[132] This information includes methodological elements as used in the estimation of HWP contribution to the FMRL and the reporting during the second commitment period as defined in Annex II of Decision -/CMP.8

(i) the method(s) to be used for estimating HWP contribution following the different tiers have been applied consistently (See Sections 2.8.2, 2.8.3 and 2.8.4);

(ii) the method to determine the fraction of HWP originating from FM has been applied consistently (See Section 2.8.1.2);

(iii) the same HWP categories (HWPP) have been applied (See Sections 2.8.1.1, 2.8.3.1 and 2.8.4.1);

(iv) the same carbon conversion factors have been used (See Sections 2.8.3.1 and 2.8.4.1)

- Emission factors (i.e. service- or half-life information) associated with the particular HWP categories (HWP_P) ;
- The annual *HWP contribution* (i.e. emissions/removals) from HWP originating from FM;

In case the FMRL has been based on a projection (See Section 2.7.5.1) is furthermore *good practice* to provide separate information whether the historic pool (i.e. emissions from HWP originating from forests prior to the start of second commitment period, see detailed description in Section 2.8.3) has been included in the estimates.

Since the final agreement on HWP, included in the decision 2/CMP.7, was reached after the FMRL submissions, a technical correction for accounting purposes as described in Section 2.7.6 might be needed in the estimation of the *HWP contribution* to the FMRL to reflect the changes in the applied methodological elements as described above and in the relevant Sections 2.8.1, 2.8.2, 2.8.3 and 2.8.4.

Further general guidance on the detection for the need for, the procedures of performance and documentation of, and the timing of the application of a technical correction is provided in the relevant Section 2.7.6.

2.8.6 Uncertainty assessment

This section provides information on potential sources of uncertainty associated with the estimates of the *HWP contribution*. The uncertainties can be divided into uncertainties associated with the methods as well as parameter uncertainties.

METHOD UNCERTAINTIES

In the Tier 2 flux data method the basic model uncertainties are related to the assumption of FOD (Equation 2.8.5). A model is always a simplification of real world inducing method based uncertainties associated with Tier 2. The reason for using decay models — instead of just counting the inflow minus outflow from the HWP pools — is that there are no extensive and reliable statistics on the real discard flows (unlike on the inflows of semi-finished products), but some knowledge on the service life of wood products. FOD decay is assumed to be a good proxy for the decay of semi-finished products and other type of distributions could be used to describe the true decay process. However, the real world is even more complex. The service life and decay pattern of wood products are not just a technical issue, but are also related to socio-economic factors (See Section 2.8.4.2). For instance, the demand for wood products is likely to grow in economic booms resulting simultaneously in increasing replacement of old HWP with new ones. Thus also discards of HWP correlate with their increasing consumption. This is not reflected in the FOD pattern, where the discard rate is a constant fraction of the HWP pools in use over time. As a result of FOD the annual change of carbon stock in HWP is steered too strongly by the instantaneous production rate of HWP of domestic origin.

In the Tier 2 method another uncertainty is associated with initialisation of the FOD model. Due to lack of long historical data series on semi-finished HWP – for some countries series only since early 1990s – the initial stocks of the HWP categories ($C(t_0)$) are approximated by assuming that the stock change was zero at initial time. This proxy slightly overestimates the inherited emissions within the second commitment period from the long-lived HWP categories sawnwood (with half-life of 35 years) and wood based panels in case their stock in reality was growing at initial time, particularly when the calculation in Equation 2.8.5 is started just from the early 1990s. Depending on the accounting of HWP under Article 3 paragraph 4, this could thus potentially increase the uncertainties of the *HWP contribution* provided especially from products with high half-life values. In case the accounting approach for FM is based on a projected FMRL, however, this source of uncertainty is of no relevance and consequence for the accounting of the *HWP contribution*.

Another model uncertainty is related to the number of HWP categories in the model. In the simplest Tier 2 method there are three HWP sub-pools for the main categories: sawnwood, wood-based panels and paper and paperboard, each of which follows the FOD pattern but with different half-lives. The uncertainty could basically be lowered by introducing disintegrated sub-pools (e.g. for sawnwood) with differing half-lives based on their

end-use (cf. Table 2.8.3) or based on subcategories (e.g. wood-based panels disintegrated to particle board, fibreboard etc., cf. Table 2.8.1).

In Tier 3, direct inventories of HWP in service (e.g. in the construction sector) could also be used to reduce the uncertainties associated with the flux data based method of Tier 2. The advantage of direct inventories is that no idealised models with uncertain assumptions on decay pattern are needed and whose verification and validation could be questioned. The inventory method could in principle provide more robust and less uncertain estimates for the carbon stock changes of the included HWP pools. Sequential direct inventories could also be applied to calibrating of the flux-data models and their half-life parameters (see Box 2.8.1) and thus reducing their uncertainties. However, the limitation of the method is that the statistics, if available, contains only some major pools such as the housing sector of the reporting country: but there is no information e.g. on the use of wood for furniture or packaging. For the use of HWP in export markets inventory methods are inapplicably either. Thus it must always be combined with flux data methods inducing double-counting risks of semi-finished and final products. Furthermore, it is applicable only in those few countries from which relevant and sequential statistics are available.

UNCERTAINTIES OF ACTIVITY DATA

Uncertainties related to activity data on HWP from international databases (e.g. FAO) and associated uncertainties of the estimates of the level of *HWP contribution* could arise due to:

- Lack of time series: some Annex I countries were founded in the early 1990s and thus older activity data might not be available (see above).
- Definitional uncertainties (i.e. data provided do not conform to what has been requested). Removals data e.g. tend in fact to be only commercial forestry operations or planned cuts, sawnwood production is being provided in nominal, not solid m3, and pulp is only market (commercially sold) pulp.
- The scope of data collection, as not all information is collected, particularly in the informal sector and from small operators. This tends to affect especially the sawmilling industries, as limits to collect statistical data might be linked to business volume or number of employees.
- Double counting (e.g. final products counted in semi-finished commodities, such as cut paper being added to paper in rolls).
- Reporting errors in providing correct data that is numbers are put into the wrong category or incorrectly processed by reporter or collecting agency.
- Uncertainties associated with aggregate HWP commodities (e.g. wood-based panels): in general, the sum of the subcategories accords with the value for the aggregate commodities, but some categories may underreport because of missing subcategories (e.g. missing data on veneer sheets result in an underestimate for wood-based panels).

Concerning data on the feedstock of production of semi-finished HWP categories (i.e. industrial roundwood and wood pulp), uncertainty could be caused by unreported sources, by-product use or trade data.

Also the semi-finished HWP categories (i.e. sawnwood, wood-based panels and paper and paperboard) are subject to the above mentioned conditions. An overall estimate of these factors results in an estimated deviation of the reported values between -25% to +5%.

All of these sources of uncertainty together tend to result in an under-reporting of HWP commodity data in international databases, that is actual figures are usually higher. As this is particularly the case in roundwood (i.e. wood-removals, see Figure 2.8.2) the allocation of the HWP categories to forest activities as described in Section 2.8.1.2 should be fairly conservative.

Further uncertainties associated with activity data are caused by conversion factors. The provided conversion factors (See Table 2.8.1) are highly generalized and reflect global averages which are not correct for species and specific items.

In order to reduce uncertainties around conversion factors for carbon, Parties are encouraged to use sub-categories under Tier 2 (See Section 2.8.3.2) or use a Tier 3 approach where they can make use of commodity specific conversion factors linked e.g. to various wood species of the particular items (See Section 2.8.4.2).

Aside from reviewing the data to check if it fits with a general understanding of the forest products supply in a country, it is most useful for reducing the uncertainties relating to activity data to cross-check if the amount of domestic production of HWP categories balances with the available supply of wood. Other validation methods could include a review of trade unit values and determination of per capita apparent consumption.

UNCERTAINTIES ASSOCIATED WITH EMISSION FACTORS (SERVICE- AND HALF-LIFE ESTIMATES)

The half-life parameters are in general the most uncertain part of the Tier 2 calculation method. There is not much hard scientific evidence behind the default values given in Table 2.8.2[133]. Nor do they present a conservative estimate that would rather lead to underestimation than overestimation of the carbon stock changes in HWP. For decreasing uncertainty countries are strongly encouraged to adjust the Tier 2 half-life parameters by calibrating the FOD model either a) with direct inventories of HWP in use, or b) with market information as shown in Table 2.8.3. The application of stock inventory information, however, due to the lack of appropriate statistics is hardly practicable in most countries. Furthermore, it does not cover export markets of the reporting country. Two specific calibration studies (Pingoud*, et al.* 2001, Statistics Finland 2011) indicate that the true half-life of sawnwood and wood-based panels in Finland is likely to be much shorter than the default half-lives (Table 2.8.2). Thus, in this particular case the use of default half-lives would substantially overestimate the HWP pool in use. The results of this kind of case studies could possibly be generalised to obtain better estimates for default half-lives.

Even though the uncertainty associated with Tier 2 estimates using default data could be high, working through such estimates can be the first step in identifying ways to improve them. Initial improvements can be made using country specific data with country-specific half-lives instead of the default half-lives in Tier 3.

To decrease uncertainties in Tier 3 Parties are encouraged to use direct inventories of HWP in use, to develop more realistic decay patterns for HWP and use of more sub-pools in case transparent information is available. However, the model calibration procedure to direct HWP inventories requires in practice a model with very few adjustable parameters.

2.8.7 Quality assurance/Quality control

Detailed steps to improve estimates of HWP activity data are already described in detail for Tiers 2 and 3 methods in Sections 2.8.3 and 2.8.4, and also in Section 2.8.6 (as it relates to uncertainties). These steps include the use of country-specific data and half-lives for Tier 2 methods (Sections 2.8.3.1.and 2.8.3.2) and the application of potential steps to derive improved Tier 3 estimates (Sections 2.8.4.1. and 2.8.4.2). Therefore, this section does not provide a separate, detailed sub-section on Quality assurance and Quality control.

[133] Paragraph 29

2.9 CROPLAND MANAGEMENT

2.9.1 Definitional issues and reporting requirements

"Cropland management" is the system of practices on land on which agricultural crops are grown and on land that is set-aside or temporarily not being used for crop production.[134] Cropland management includes all lands under annual and perennial crops, and all fallow lands set at rest for one or several years before being cultivated again.

It is *good practice* to include, in land subject to cropland management, all the lands in the 'Cropland' category of Section 3.2 of the *2006 IPCC Guidelines*, namely cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category. It is also *good practice* for countries to specify how land subject to cropland management is distinguished from other land management categories using the guidelines provided in Section 3.3 of Volume 4 of the *2006 IPCC Guidelines*.

Perennial crops can include orchards, vineyards and plantations such as cocoa, coffee, tea and bananas. If perennial cropped lands meet the threshold criteria for forests (see Footnote 6 in Section 4.1 for the definition of "forest" given in the Marrakesh Accords), it is *good practice* to include them under cropland management or forest management, but not under both. Rice paddies are also included under cropland, but associated methane emissions are reported under *Methane Emissions from Rice cultivation* in section 5.5 of the *2006 IPCC Guidelines.* Treed areas such as orchards or shelterbelts that were established after 1990 and meet the definition of a forest can qualify as afforestation/reforestation, and if they do, should be included under those categories (see Section 4.1.2 General rules for categorization of land areas under Articles 3.3. and 3.4). Cropland that is temporarily used for grazing can also be included under cropland management. Countries are encouraged to develop consistent criteria for defining set aside lands and their allocation among activities.

The aim of the accounting exercise is to identify and report trends and systematic changes in the carbon stocks resulting from changes in cropland management over time. The premise is that changes in soil C stocks result from changes in cropland management that influence the rates of either additions to, or losses of, soil carbon. However, cropland management is not the only driver of changes in carbon stocks. Natural effects, such as weather, wild fire, abnormal flooding or prolonged drought can also influence the rate of carbon gains and losses in cropland, and if their effects are large enough, can mask the carbon trend or signal resulting from cropland management practices, as elements of cropland management activities. Countries are encouraged to use higher tier methods (Tier 2 or Tier 3) to develop emissions coefficients or models to represent the effects of management practices rather than those of inter-annual variability and natural disturbances on carbon stocks. More information about higher tier methods is provided in Section 2.9.3.

The main processes involved in estimating emissions and removals are, first, to subdivide the total cropland area into strata that represent consistent classes of land types, biophysical characteristics and management practices for the base year and each of the years in the commitment period (see section 2.9.2 and examples in Table 5.5 of the *2006 IPCC Guidelines*). Broad sets of practices under cropland management that affect carbon stocks include tillage practices, rotations and cover crops, fertility management, plant residue management, erosion control and irrigation management (IPCC, 2000 Special Report on LULUCF, p.184). The second main process is to estimate how management practices and changes in management practices influence emissions and removals over time, using methods discussed in Section 2.9.3. The steps for using the proposed methodology for estimating carbon emissions and removals are outlined in Box 2.9.1.

Countries should aim for consistency and completeness in estimation of emissions and removals across activities. For example, greenhouse gas estimation methodologies for cropland management practices occurring on land that was deforested should be consistent with methods used for the surrounding cropland management practices, even though they are accounted under Article 3.3 of the Kyoto Protocol and not under Cropland Management.

Box 2.9.1 provides steps for estimating emissions and removals from cropland.

[134] Paragraph 1(g) in the Annex to Decision 16/CMP.1 (Land use, land-use change and forestry)

BOX 2.9.1
STEPS FOR ESTIMATING EMISSIONS AND REMOVALS FROM CROPLAND MANAGEMENT

STEP 1. Define cropland management and apply the definition in a consistent manner over time, including in the base year. Crops such as vineyards and orchards that meet the definition of forest can be included under cropland management or under forest management, but not under both. It is important to apply the definitions consistently over time, even though data and information from the past may be of lower quality.

STEP 2. Identify the land under cropland management using the approaches described in Section 3.3 of the *2006 IPCC Guidelines* and the appropriate sections in this KP Supplement.

STEP 3. Distinguish between the two subcategories of cropland management: mineral soils and organic soils.

STEP 4. Select the appropriate tier and methodology for estimating emissions and removals, based on key category and significant source analysis (*2006 IPCC Guidelines,* Volume 1, section 4.2) and subject to available data. For mineral soils, this includes methodologies for monitoring land management activities and change.

STEP 5. Stratify by climate. For mineral soils also stratify by other biophysical characteristics of the land and cropland management practices (see section 2.9.2).

STEP 6. For each stratum, estimate the cropland management emissions/removals for the base year and the commitment year using Tier 1, Tier 2 or Tier 3 methods (see section 2.9.3). Total emissions are the sum of net emissions or removals from mineral soils plus organic soils.

2.9.1.1 BASE YEAR

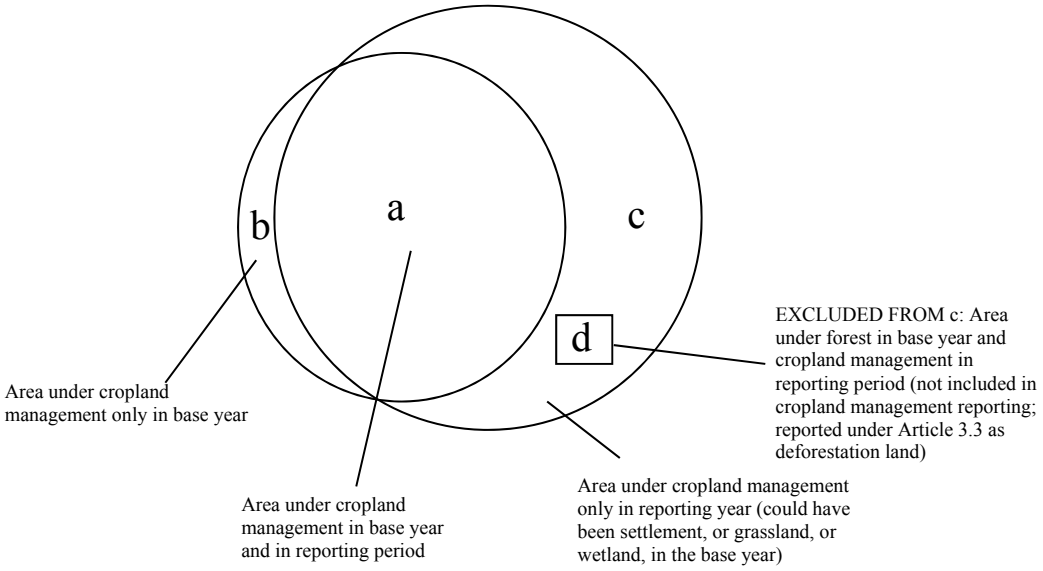
Under Article 3.4 of the Kyoto Protocol, emissions and removals resulting from cropland management are estimated using a net-net accounting approach (as are grazing land management, revegetation and wetland drainage and rewetting).[135] Net-net accounting requires that greenhouse gas emissions and removals are estimated for the base year and each year of the commitment period. This entails determining the total area under cropland management for the base year and for each year of the commitment period and calculating the carbon stock change for those areas. Guidance for estimating the corresponding non-CO_2 greenhouse gas emissions from cropland for 1990 are covered in Chapters 10 and 11 of Volume 4 of the *2006 IPCC Guidelines* (see the text on non-CO_2 gases in this section and Box 4.1.1, Examples 1 and 2 in Section 4.1.2).

If the area under cropland management changes significantly between the base year and the commitment period, this may lead to estimates on moving land basis (that is, subtraction of stock changes on a land base that changes in size over time (see Box 2.9.2)).

[135] Net-net accounting refers to the provisions of paragraph 10 of the Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/Add.1.

BOX 2.9.2
AN EXAMPLE OF CROPLAND MANAGEMENT AREAS IN 1990 AND IN THE COMMITMENT PERIOD (NET-NET ACCOUNTING)

In this example the area under cropland management in the reporting year during the commitment period is larger than in the base year. Some of the area was under cropland management in both the base year and during the reporting period (a). Some of the area under cropland management in the base year is no longer under cropland management in the reporting year (b). There are also areas under cropland management in the reporting year that were not under cropland management in the base year (c). Area (d) is under cropland management, but was subject to deforestation which takes precedence. Under the Kyoto Protocol, the emissions and removals in areas (a) + (b) in the base year are compared to emissions and removals in areas (a) + (c) – (d) in the reporting year.



This approach avoids having to track the carbon stock changes arising from activities not covered by the Marrakesh Accords. Like other alternatives, it may have policy implications. For example, a simple change in area without a change in stock change per unit area could yield a credit or debit without there being an actual change in carbon flux to or from the atmosphere.

For most Parties with commitments under the Kyoto Protocol, the base year is 1990. Under the provisions of Article 4.6 of the UNFCCC, however, Parties with economies in transition (EITs) are granted some flexibility on the level of historical emissions chosen as a reference. As a consequence five EITs have a base year or period between 1985 and 1990 and hence need to assess the CO_2 and other greenhouse gas emissions and removals for those years. Historical data on land-use and management practices in 1990 (or the appropriate year(s)) and in years prior to 1990 are needed to establish the 1990 base year net emissions/removals of soil carbon from cropland management. The Tier 1 method described in the *2006 IPCC Guidelines* (Section 5.3.3 Soil carbon), for mineral soils assumes that a change in land-use/land management has an impact on carbon emissions and removals for a duration of 20 years; hence, in this approach and if a change in management has taken place since 1970, the net carbon stock change in 1990 has to be calculated taking this change into account. If area and activity data are available for 1970 to 1990, the net carbon stock change during the 1990 base year can be established using the default carbon emission and removal factors. For organic soils, the inventory time period is treated the same a long-term cropped organic soils, with Tier 1 emission factors provided in Table 5.6 of the 2006 IPCC Guidelines.

The duration of impact may be shorter or longer than 20 years. If data on the duration of impact are available, it is *good practice* to use the appropriate time period, based on country-specific data and measurements (see Tier 2 and Tier 3 approaches in Section 2.9.3).

If area and activity data are not available for 1970 to 1990, countries can establish the 1990 carbon stock using the most appropriate of the following options, in a manner consistent with guidance provided in *2006 IPCC Guidelines*, Volume 1, Section 5.3.1 (Issues with data availability). It is *good practice* to use a long time period (e,g., 20 years) as close to 1990 as possible. The net carbon stock change for 1990 could be estimated:

- if data are available for the time series between 1990 and 2010, based on the trend in carbon stock for the time series between 2010 and 1990;
- if data for the time series between 1970 and 1990 or 1990 and 2010 are incomplete, using the available data to extrapolate a trend through 1990.

The results of accounting on a net-net basis depend not just on changes in land management activities, but also partly on where the base year and commitment period years fall within the temporal dynamics of carbon sequestration processes. As noted above, carbon stock change resulting from land use and land management changes on mineral soil tends to persist for about 20 years, after which the cropland carbon levels approach a new equilibrium carbon stock. The rate of carbon sequestration in cropland following a change in management in which carbon additions increase or carbon losses decline tends to be high in the first decades and then decline over time, as illustrated in Figure 4.2.12. This will be reflected in net sinks and sources in the accounting.

2.9.2 Choice of methods for identifying lands subject to cropland management activities

General guidance on consistent representation of lands is provided in Chapter 3 of the *2006 IPCC Guidelines* with additional guidance about identification of lands subject to cropland management provided in Sections 1.1, 1.2, 2.1, and 2.2 of this report.

Under the Marrakesh Accords (Decision 15/CMP.1, Annex, paragraph 6), the geographical location of the boundaries of the area that encompass land subject to cropland management needs to be reported annually, along with the total land areas subject to this activity. The geographical location of boundaries may include a spatially explicit specification of each land subject to cropland management, but does not have to. Instead, the boundaries of larger areas encompassing smaller lands subject to cropland management may be provided, along with estimates of the area subject to cropland management in each of the larger areas. In either case, the land subject to cropland management and the management thereon need to be tracked through time because the continuity and duration of management practices and changes affects carbon emissions and removals.

If a Party estimates a change in cropland carbon pools resulting from a change in management practice using default emissions or removal factors that assume continuity of the practice, such as the values provided in Table 5.5 of *2006 IPCC Guidelines*, it is *good practice* to demonstrate that the land has remained continuously under the practice. This could be achieved by tracking each land subject to cropland management from 1990 until the end of the commitment period (e.g. see Section 2.9.1 Definitional issues and reporting requirements). Alternatively, countries could develop statistical sampling techniques, consistent with the advice in *2006 IPCC Guidelines* Annex 3A.3, which allow the management transitions on cropland management land to be determined (see also Section 2.4.1 Developing a consistent time series).

If it is not demonstrated that a management practice occurs continuously on the same land, a Party may use statistical sampling techniques to estimate the duration and proportion of the management practice of interest. In this case, country-specific emission and removal factors (Tier 2) or modelling (Tier 3) approaches can be developed to represent the duration and proportion of the practice over the time series. More information about statistical sampling methods is provided in the *2006 IPCC Guidelines*, for example in Annex 3A.3.3 Sampling Design.

At the national level, it is *good practice* to identify criteria that could be relevant to subdivision for the purpose of stratification when setting up a sampling strategy. Stratification criteria may include relatively static biophysical characteristics, such as climate and soil type, as well as management practices that tend to be more dynamic drivers of change in emissions and removals from the carbon pools. Guidance on stratifying land to match data needs for estimating emissions and removals is provided in Section 3.3.2 of the *2006 IPCC Guidelines*.

Management factors that may be useful in establishing a national stratification include:

- Degree of soil disturbance (e.g. tillage frequency and intensity)
- Level of input of crop biomass or organic carbon (e.g. plant litter, roots, manure, other amendments)
- Frequency of fallow practices
- Inclusion of woody biomass in the cropping system (e.g. shelterbelts, orchards, other perennial plantations)
- Temporary use for livestock grazing
- Lands converted to croplands since 1990 (land-use change) that are not in any other land-use category.

For all resulting subcategories under cropland management, the areas derived from the conversion of forests (i.e., deforestation) since 1990 need to be tracked separately as these will be reported as units of lands subject to deforestation under Article 3.3 of the Kyoto Protocol. At higher tiers further subdivision of the cropland management area may be necessary.

Methods to identify croplands with adequate disaggregation may include:

- National land-use and management statistics: in most countries, the agricultural land base including croplands is surveyed regularly, providing data on distribution of different land uses, crops, tillage practice and other aspects of management, often at sub-national regional level. These statistics may originate, in part, from remote sensing methods.
- Inventory data from a statistically based, plot-sampling system: land-use and management activities are monitored at specific permanent sample plots that are revisited on a regular basis.

Links to related methods for cropland area are given in Box 2.9.3 below:

Box 2.9.3

LINKS WITH CHAPTER 2 OR 3 OF *THIS REPORT*

Section 2.3.2 (Three Approaches): Croplands that remain croplands or any conversion that leads to croplands in Chapter 2 (except forests to croplands).

LINKS WITH THE *IPCC GUIDELINES*

Section 3.3.1 (Three Approaches), Volume 4, *2006 IPCC Guidelines*.

2.9.3 Choice of methods for estimating carbon stock changes and non-CO_2 greenhouse gas emissions

For croplands, the *2006 IPCC Guidelines* identify two ways of assessing sources or sinks of CO_2 from agricultural soils:

- Net changes in organic carbon stocks associated with changes in land use and management on mineral soil (Chapter 5)
- Emissions of CO_2 from cultivated organic soils (Chapter 5)

Total annual emissions and removals of CO_2 are calculated by summing emissions and removals from the two subcategories (mineral and organic soils) using methods outlined in Chapter 5 and Equation 2.24 of the *2006 IPCC Guidelines*.

In most croplands, the main soil carbon flux associated with changes in land-use and management for cropland management activities is from changes in soil organic carbon in soils. Crop biomass carbon from herbaceous and annual crops is assumed to cycle annually (biomass gains are assumed to equal biomass losses in a single year) and is not estimated. Carbon stock changes associated with perennial crop biomass (e.g., trees, shelterbelts and orchards) is estimated for the aboveground and belowground biomass, litter and dead wood pools using guidance provided in the afforestation/reforestation or forest management sections (see Table 2.9.1).

If cropland management is a key category, the inventory compiler should determine if certain subcategories, such as mineral soil or organic soil or aboveground biomass, are particularly significant. The *2006 IPCC Guidelines* (Volume 1, section 4.2) suggests ranking subcategories according to their contribution to the aggregate key category. Those subcategories that collectively contribute more than 60 percent to the key category should be treated as significant. It may be appropriate to focus efforts towards methodological improvements of these most significant subcategories.

5291

TABLE 2.9.1
SECTIONS WHERE METHODOLOGIES CAN BE FOUND FOR ESTIMATING DIFFERENT CARBON POOLS ASSOCIATED WITH CROPLAND MANAGEMENT ACTIVITIES

Pools to be estimated	Section where methodologies can be found
Aboveground biomass	Section 2.5 (Afforestation and Reforestation) and Section 2.7 (Forest Management)
Belowground biomass	Section 2.5 (Afforestation and Reforestation) and Section 2.7 (Forest Management)
Litter and dead wood	Section 2.5 (Afforestation and Reforestation) and Section 2.7 (Forest Management)
Soil C	Section 2.9.3 (here)
Non-CO_2	*2006 IPCC Guidelines, Chapter 11* and Section 2.9.3.4

5292

5293 The Marrakesh Accords specify that a Party may choose not to account for a particular pool if it can verifiably
5294 demonstrate that the pool is not a source. Requirements for reporting excluded pools and documenting that a
5295 pool is not a source can be found in Section 2.3.1 (Pools to be Reported).It is possible that countries will use
5296 different tiers to prepare estimates for individual subcategories of soil C (e.g., soil organic C stocks changes in
5297 mineral soils and organic soils). Since different methods may yield different estimates with different levels of
5298 uncertainty, it is *good practice* to use the same tier and methodology for estimating carbon emissions and
5299 removals from each subcategory and pool for the full time series, for example, in 1990 and during the
5300 commitment period.

5301 Methods for estimating cropland carbon emissions and removals for the base year and the commitment period
5302 are provided in Chapter 3 and the *2006 IPCC Guidelines*, as outlined in Box 2.9.4. The following sections of this
5303 report highlight aspects of these methods specific to the Kyoto Protocol.

5304 Box 2.9.4

5305 **LINKS WITH CHAPTER 2 OR 3 OF THIS REPORT**

5306 Section 3.3.1.1 Change in carbon stocks in living biomass

5307 Section 3.3.1.2 Change in carbon stocks in soils

5308 **LINKS WITH THE *2006 IPCC Guidelines***

5309 Section 5.2.1 Biomass

5310 Section 5.2.2 Dead Organic Matter

5311 Section 5.2.3 Soil Carbon

5312 Section 5.2.4 Greenhouse Gas Emissions from Biomass Burning

5313 Section 5.3 Land Converted to Cropland

5314 Section 5.5 Methane Emissions from Rice Cultivation

5315 2.9.3.1 MINERAL SOILS

5316 Methods for estimating mineral soil carbon stock changes resulting from changes in cropland management fall
5317 into one of three methodological tiers described in Volume 4, Sections 1.3.2 and 1.3.3 of *2006 IPCC Guidelines*.

5318 METHODS FOR ESTIMATING CARBON STOCK CHANGES IN MINERAL 5319 SOILS

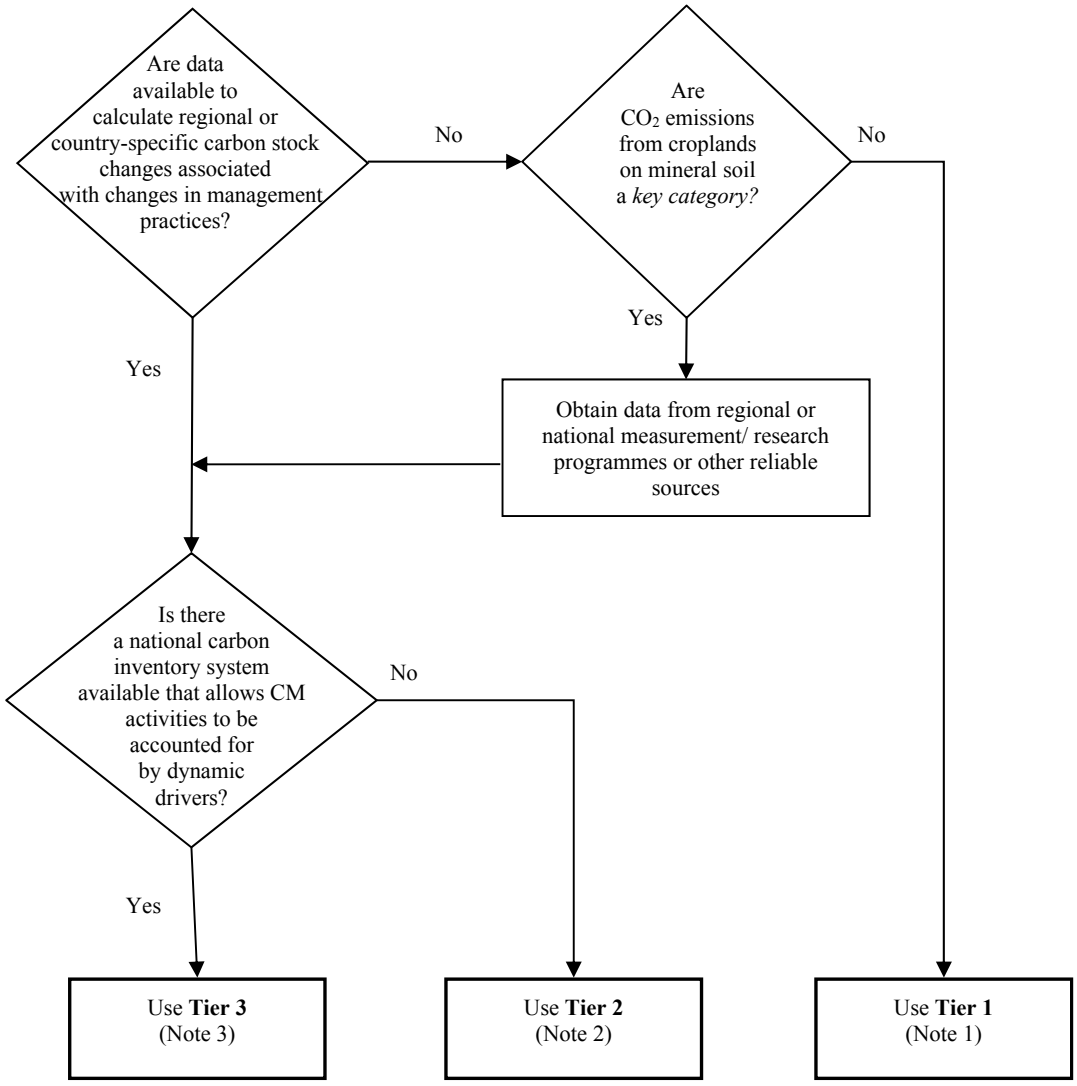
5320 The decision tree in Figure 2.9.1 should be used to decide which tier to use for estimating carbon stock changes
5321 associated with changes in cropland management under the Kyoto Protocol. It is *good practice* to use Tier 2 or
5322 Tier 3 methods 3 for reporting carbon stock changes from mineral soils if cropland management is a key
5323 category.

5324 Tier 1

5325 The Tier 1 method for estimating carbon stock changes in mineral soils is described in *2006 IPCC Guidelines*
5326 Volume 4, Sections 2.3.3.1 (Tier 1 Approach: Default Method) and 5.2.3 (Soil carbon): default soil carbon
5327 factors, which assume continuous practice for a 20-year period are provided in Table 5.5; default reference soil
5328 organic carbon stocks for mineral soils are given in Table 2.3.

Section 5.2.3.4 of *2006 IPCC Guidelines* Volume 4 outlines the steps for estimating average annual rates of carbon stock change of cropland mineral soils using the default reference carbon stocks (Tables 2.3), carbon stock change factors (Table 5.5) and Equation 2.25 of the guidelines. The Tier 1 method can be used to estimate carbon flux resulting from changes in land-use, cropland management or the level of carbon input across a range of temperature and moisture regimes and soil types.

5335 **Figure 2.9.1 Decision tree for selecting the appropriate tier for estimating carbon stock**
5336 **changes in mineral soils under cropland for Kyoto Protocol reporting (see**
5337 **also Figure 3.1.1)**



Note 1: Use the matrix/database of default values.

Note 2: Use regionally specific parameters, soil data and duration of impact.

Note 3: Use more sophisticated modelling techniques, often linked to geographical databases.

5338

5339

Since the Tier 1 default methods assume continuity of practice on the land subject to the cropland management, it is *good practice* to follow continuously the land subject to cropland management from the base year through the commitment period. Methods for continuously tracking land are described in Section 2.9.2.

CALCULATION OF CARBON STOCK CHANGE RESULTING FROM CROPLAND MANAGEMENT

The carbon stock change estimated using Equation 2.25 from *2006 IPCC Guidelines* Volume 4 can be used to calculate a yearly emission/removal of carbon resulting from cropland management activities (a carbon stock change factor) by multiplying the carbon stock change factor by the cropland area to which the management change has been applied as follows:

EQUATION 2.9.1
ANNUAL SOIL CARBON EMISSIONS/REMOVALS FROM CROPLAND MANAGEMENT

$$\Delta C_{CM\ SOC} = CSF \bullet A$$

Where:

$\Delta C_{CM\ SOC}$ = annual change in carbon stock in soil organic carbon, Mg C yr^{-1} (= $\Delta C_{Mineral}$ in Eq. 2.25)

CSF = carbon stock change factor, Mg C ha^{-1} yr^{-1}

A = area, ha

For net-net accounting, the calculation shown in Equation 2.9.1 has to be performed for the base year and each year of the commitment period. For discussion of how to estimate the cropland management area, see Section 1.2 (General rules for categorization of lands areas under Articles 3.3 and 3.4).

Tier 2

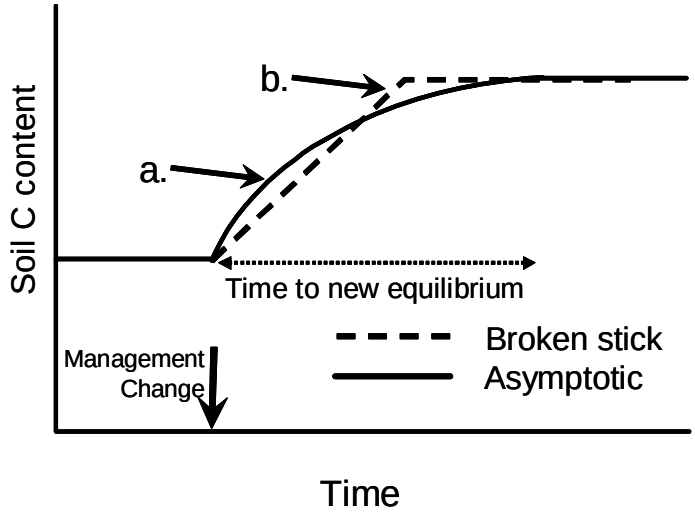
The Tier 2 method also uses the methodology described in Volume 4, Chapter 5 of the *2006 IPCC Guidelines*, but now the default factors are replaced with more reliable country- or region-specific values. It is *good practice* to obtain region- or country-specific emissions factors from literature values, long-term experiments or the local application of well-calibrated, well-documented soil carbon models. Region-specific data for soil carbon content (such as that available from national soil inventories) can also be used.

To ensure that regionally-specific carbon stock change factors are better than default factors at representing actual carbon stock change in a given region, rigorous criteria must be applied to demonstrate that the more specific factors do not lead to under- or overestimation of the soil carbon change. Regional or country-specific factors should be based on verified soil carbon model estimates or measurements that are conducted frequently enough and over a long enough time period and with sufficient spatial density to reflect variability of the underlying biochemical processes, and documented in accessible publications.

For Tier 2 approaches, it is *good practice* to replace the 20-year default with a value that reflects national or regional information about the duration of changes in cropland management on soil carbon emissions and removals.

An asymptotic model can also be fitted to data of soil carbon stock changes. (Figure 2.9.2). Using this method, the higher carbon factors applied immediately after a land-use or management change gradually diminish, so that stock changes are not underestimated soon after a change (“a” on Figure 2.9.2), or overestimated as the soil approaches the new equilibrium (“b” on Figure 2.9.2).

Figure 2.9.2 **Schematic representation of a change in soil carbon stocks after a carbon-sequestering management change is imposed represented by a broken-stick model of stock change (as used in the *IPCC Guidelines* where the time to a new equilibrium is 20 Years) and by an asymptotic curve (for definitions of**



At Tier 2, default factors (e.g., input factors) associated with a different land-use or land-management change can be replaced by more detailed relationships between the intensity of a practice (e.g., the amount of an organic amendment applied to the soil) and a change in the yearly soil carbon emissions/removals. For example, in Europe, Smith *et al.* (2000) have developed such relationships (e.g., average yearly soil carbon stock change (tonnes C ha^{-1}) = 0.0145 x amount of animal manure (tonnes dry matter ha^{-1} yr^{-1}) added; recalculated from data in Smith *et al.*, 1997; $R^2 = 0.3658$, n = 17, $p < 0.01$). Similar relationships could be derived from long-term data for different soil types in different climatic regions. Alternatively, well-calibrated and well-evaluated models of soil carbon change (e.g., CENTURY (Parton *et al.*, 1987), RothC (Coleman and Jenkinson, 1996)) could be used to generate either stock change factors, or the intensity relationships described above, for different soils in different climatic regions.

Rigorous criteria must be applied so that any carbon stock change is not under- or overestimated. It is good practice that stock change factors be based on experiments sampled according to the principles set out in Section 5.3 of *GPG-LULUCF*, and to use the experimental values if they are more appropriate than the default values to the region and management practice. Factors based on models should only be used after the model has been tested against experiments such as those described above and any model should be widely evaluated, well-documented and archived. It is good practice to provide confidence limits and/or uncertainty estimates associated with regional, country-specific or local stock change factors.

Tier 3

Tier 3 methods generally encompass a range of methodologies, more elaborate than Tier 2 and usually based on sophisticated modeling techniques, often linked to geographical databases. Tier 3 methods that can be used for the national UNFCCC inventory (as described in *2006 IPCC Guidelines* Chapter 5 (Cropland), Section 5.3.3.1 (Choice of method) and taking into account the generic guidance for Tier 3 methods in Chapter 2, Secion 2.5 (Additional generic guidance for Tier 3 methods)) are also likely to be used for cropland management accounting under the Kyoto Protocol. Compared with the static matrix used at Tiers 1 and 2, Tier 3 can represent the management history of a land that facilitates calculation of soil carbon changes resulting from multiple changes in management practices over time. Tier 3 (like Tier 2) methods can also take into account longer duration to reach equilibrium than 20 years. Current computing power makes it possible to link spatially disaggregated (stratified) land data to management practice data. The analytical system can track carbon stock changes over time by linking equations describing the rate of change in soil carbon under specific management practices with carbon contents, initialised at some point and cross-checked periodically. Tier 3 methods can also be based on repeated statistical sampling consistent with the principles set out in Annex 3A.3 (Sampling) of *2006 IPCC Guidelines.* The sampling protocol should be of sufficient density to capture the soil types, climatic regions and management practices.

CHOICE OF CARBON STOCK CHANGE FACTORS FOR MINERAL SOILS

The carbon emission/removal factors used at each tier are described briefly in the following sections.

Tier 1

At Tier 1, average yearly carbon stock changes in mineral soils are calculated from default values by dividing the 20-year stock change by 20, as set out in Chapter 2, Equation 2.25 of *2006 IPCC Guidelines* Volume 4. Default reference (under native vegetation) soil organic C stocks (SOC_{REF}) for mineral soils, full details of default relative stock change factors for land use (F_{LU}), input (F_I) and management (F_{MG}) factors (over 20 years) can be found in Table 2.3 (for SOC_{REF}) and table 5.5 (for F_{LU}, F_I and F_{MG}) of the *2006 IPCC Guidelines* Volume 4 respectively, respectively. Management practice is assumed to influence stocks to a depth of 30 cm. For a summary of the steps and a sample calculation, see Section 3.3.1.2.1.1, Choice of method (mineral soils), of *GPG-LULUCF*.

Tier 2

At Tier 2, some or all of the default values for carbon stock change (Tier 1) are replaced by values shown to be more reliable. These new values may be based on literature values, measured changes in carbon stocks, on simple carbon models, or a combination of these. (See 'Choice of management data for mineral soils' below for some examples). It is *good practice* to derive relative stock change factor values for a higher resolution classification of management, climate and soil types if there are significant differences in the stock change factors among more disaggregated categories based on an empirical analysis. Reference soil organic C stocks (SOC_{REF}) can also be derived from country-specific data in a Tier 2 approach. Additional guidance is provided in Chapter 2, Section 2.3.3.1 of *2006 IPCC Guidelines* Volume 4.

Tier 3

For mineral soils, Tier 3 carbon stock change factors are country-derived, and may be calculated using complex models. The carbon models used for Tier 3 are generally more complex than those in Tier 2, taking into account soil (e.g., clay content, chemical composition, parent material), climate (e.g., precipitation, temperature, evapotranspiration), and management factors (e.g., tillage, carbon inputs, fertility amendments, cropping system). *Good practice* requires that the models be calibrated using measurements at benchmark sites, and that model and assumptions used are described transparently.

In all cases, rigorous criteria must be applied so that any change in carbon stocks is neither under- nor overestimated; models used to estimate carbon stock changes should be well-documented and should be evaluated using reliable experimental data for conditions and practices to which the models are applied. It is *good practice* to provide estimates of confidence limits or uncertainty according to the description in section 5.2.3.5 and 5.3.3.5 of *2006 IPCC Guidelines*. Default carbon stock change factors may also be replaced by values generated as part of national/regional carbon accounting systems (see Section 2.7.3 Choice of methods for estimating carbon stock changes and non-CO2 emissions subject to Forest Management, of *this report*).

CHOICE OF MANAGEMENT DATA FOR MINERAL SOILS

Area data on land uses and practices need to be available in accordance with Approach 2 or Approach 3 as described in Section 3.3.1 of *2006 IPCC Guidelines* and guidance given in Section 2.2.4, of *this report*. The data on management required for each of three tiers are outlined briefly here.

Tier 1

Using the *2006 IPCC Guidelines* Volume 4, impacts of land-use or land management change are assumed, by default, to have an impact for 20 years. If area and activity data are available for 20 years prior to the base year, a net carbon removal/emission for the base-year can be established using the default carbon stock change factors described above. The land-use changes and management practices at Tier 1 are the same as those given in the *2006 IPCC Guidelines*: differing cultivation, differing tillage, and differing input levels. Within these specific land-use or land-management changes, activities are defined semi-quantitatively, e.g., low, medium, high without manure, and high with manure input levels, full, reduced and no-till systems. Land-use or management systems are not subdivided into finer levels of detail than this. Areas may be obtained from international data sets (e.g., FAO), though some of these sources lack the spatial explicitness needed for reporting and may only be helpful for cross-checking data. If area and activity data are available for 1970 and 1990, a 1990 baseline net carbon stock change can be established using the default carbon stock change factors described above and the area and activity data for 1970 and 1990.

If area and activity data are not available for 1970 and 1990, countries can derive the area and activity data using the most appropriate of the following options, in a manner consistent with guidance provided in Chapter 5 (Section 5.3.1, Issues with data availability), Volume 1 of *2006 IPCC Guidelines*. It is *good practice* to use a long time period (e,g. 20 years) as close to 1990 as possible.

- if the area and activity data are available for the time series between 1990 and 2010, by calculating the trend in area and activity data using the time series between 1990 and 2010;
- if the area and activity data for the time series between 1970 and 1990 or 1990 and 2010 are incomplete, using the available data to extrapolate a trend through 1990.

Tier 2

Tier 2 approaches are likely to involve a more detailed stratification of management systems than in Tier 1 if sufficient data are available. This can include further subdivisions of annual cropping input categories (i.e., low, medium, high, and high with amendment), rice cultivation, perennial cropping systems, and set-asides. It is *good practice* to further subdivide default classes based on empirical data that demonstrates significant differences in soil organic C storage among the proposed categories. In addition, Tier 2 approaches can involve a finer stratification of climate regions and soil types. Tier 2 methods may require area descriptions of higher resolution than those in Tier 1. In any case, rigorous criteria must be applied so that emissions in the base year and removals in the inventory year are not overestimated, emissions in inventory year and removals in the base year are not underestimated. This criterion may result in a conservative estimate of net soil carbon stock change.

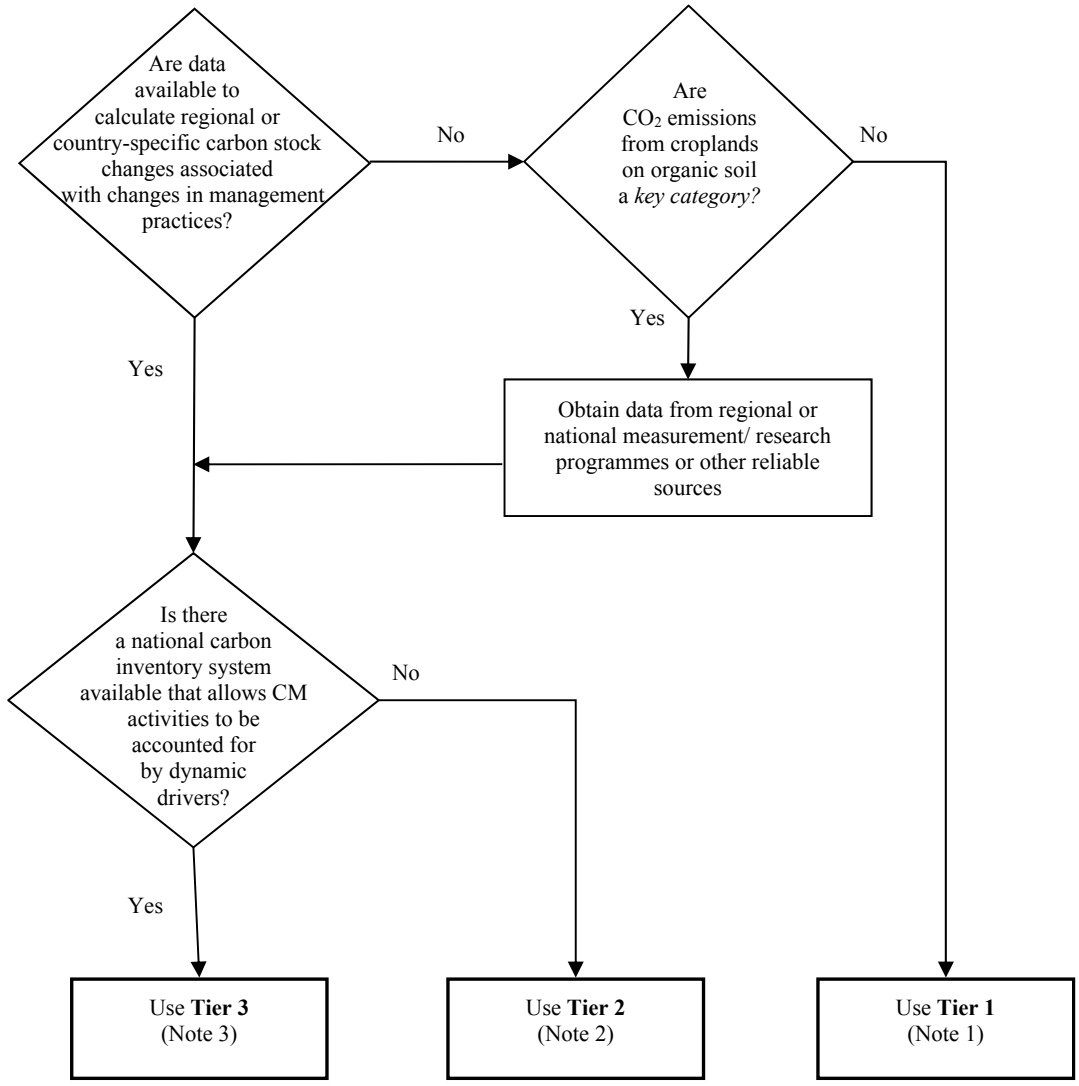
Tier 3

Management data used in the more complex Tier 3 methodologies need to be consistent with the level of detail required by the model. It is good practice to use management data at a spatial resolution appropriate for the model, and to have, or be able to estimate reliably, quantitative measures of the management factors required by the model.

2.9.3.2 CARBON STOCK CHANGES IN ORGANIC SOILS

For carbon stock changes in organic soils, the following decision tree (Figure 2.9.3) should be used to decide which tier to use for reporting under the Kyoto Protocol.

5496 **Figure 2.9.3 Decision tree for selecting the tier at which to report carbon stock changes in**
5497 **organic soils under the Kyoto Protocol**



Note 1: Use the matrix/database of default values.

Note 2: Use regionally specific parameters, soil data and duration of impact.

Note 3: Use more sophisticated modelling techniques, often linked to geographical databases.

5498

5499

METHODS FOR ESTIMATING CO2 EMISSIONS/REMOVALS FROM ORGANIC SOILS

When organic soils are converted to or managed for agriculture, they are typically drained, tilled and fertilized, resulting in on-site CO_2 emissions to the atmosphere as well as to waterborne carbon losses that lead to off-site CO_2 emissions. Countries may use methods of different tier level for on-site and off-site CO_2 emissions from organic soils. The rate of CO_2 release will depend on, inter alia, climate, the degree of drainage, depth of the peat layer, nutrient status and practices such as fertilisation and liming. Oxidation of organic soils results in land subsidence and CO_2 emissions will continue until the organic soil layer is depleted or until further lowering of the drainage base is not feasible. In addition to on-site and off-site CO_2 emissions, drainage will result in CH_4 emissions from ditches (see Section 2.9.3.3). Drained organic soils under Cropland management can be (partially) rewetted while remaining under Cropland management. Guidance on (partially) rewetted organic soils can be found in Chapter 2.12 on Wetland drainage and rewetting. For all tier levels it is *good practice* to follow the methods for on- and off-site CO_2 emissions set out in Chapter 2 of the *2013 IPCC Wetlands Supplement*.[136]

Tier 2

If more reliable country- or region-specific data is available on CO_2 emissions from organic soils it is *good practice* to use these instead of Tier 1 defaults. Any data used should be shown to be more reliable and representative for the national conditions than defaults. It is *good practice* to use a finer classification for climate and management practices, in particular drainage classes, if there are significant differences in measured carbon loss rates among the proposed classes.

Tier 3

A Tier 3 approach may involve estimation of CO_2 and non-CO_2 greenhouse gas emissions in an integrated way. However, the non-CO_2 emissions should be reported in the Agriculture sector, and double counting and omission should be avoided. It is *good practice* to use models that are calibrated using measurements at benchmark sites, and to describe models and assumptions used transparently.

CHOICE OF CARBON EMISSION/REMOVAL FACTORS FOR ORGANIC SOILS

For all tier levels it is *good practice* to follow the guidance on emission/removal factors on-site and off-site CO_2 emissions set out in Chapter 2 of the *2013 IPCC Wetlands Supplement*.

Tier 2

For organic soils, it is *good practice* to replace the default values identified in Chapter 2 of the *2013 IPCC Wetlands Supplement* with country- or region-specific factors. It is *good practice* to use country- or region-specific emission/removal factors derived from measurements or experiments within the region that are well-designed and with adequate sampling and coverage. It is *good practice* to provide confidence limits and/or uncertainty estimates associated with any country- or region-specific emission/removal factors.

Tier 3

For organic soils, CO_2 and non-CO_2 greenhouse gas emissions or emissions/removals may be estimated using a model or measurement based approach. Time-dependent emission/removal factors capture more accurately the effects of land-use and management changes. Dynamic models should capture the influence of (changes in) land use and management practices, particularly the effect of variable drainage levels. Before such models are applied they should be thoroughly tested and evaluated country- or region-specific field data.

CHOICE OF MANAGEMENT DATA FOR ORGANIC SOILS

The same considerations apply as for management data for cropland management activities on mineral soils, as described earlier in Section 2.9.3.

[136] The IPCC is currently preparing the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (the *2013 IPCC Wetlands Supplement*) in parallel to this document. The *2013 IPCC Wetlands Supplement* provides guidance on estimating emissions and removals on lands with drained and rewetted organic soils in Chapters 2, 3 and 4 and general issues on wetlands are addressed in Chapters 1 and 7. The guidance given here will be updated to reflect the development of the *2013 IPCC Wetlands Supplement* through its review by experts and governments and its approval by the IPCC. The second Government and Expert Review of the *2013 IPCC Wetlands Supplement* will be held between 11th February and 7th April, 2013 (see http://www.ipcc-nggip.iges.or.jp/home/wetlands.html).

Area data on land uses and management practices need to be available in accordance with Approach 2 or Approach 3 (Section 2.2.2), and guidance given in Section 2.2.4. The data on management required for each of the three tiers are outlined briefly here.

Tier 1

Drainage of organic soils results in immediate and ongoing emissions that are not restricted to a 20 year time period, but are determined by subsidence rates, thickness of the peat and technical possibilities of deepening of the drainage base in subsiding land. Net carbon emission/removal from the soil in the base year can be established based on data from the base year only. The land-use changes and management practices at Tier 1 are the same as those for mineral soils.

Tier 2

It is *good practice* to disaggregate data on management practices by drainage depth, nutrient status of the organic soil, land use intensity, and peatland type if appropriate emissions factors for on-site and off-site CO_2 emissions/removals are available. In many instances standard drainage depths are used in management practices and disaggregation is not useful in improving accuracy of the emission/removal estimates. Where significant variation in drainage depth exists for different management practices, and where appropriate emissions factors exist, it is *good practice* to improve the accuracy of an inventory by separating out drainage classes. Tier 2 methods may require area descriptions of higher resolution than those in Tier 1. It is good practice to apply rigorous criteria so that any change in emissions or removals is neither under- nor overestimated.

Tier 3

Management data used in the more complex Tier 3 methodologies need to be consistent with the level of detail required by the model. It is *good practice* to use management data at a spatial resolution appropriate for the model, and to have, or be able to estimate reliably, quantitative measures of the management factors required by the model.

2.9.3.3 CO_2 EMISSIONS FROM LIMING

Supplementary data provided for the Kyoto Protocol includes CO_2 emissions from liming of croplands only if cropland management is elected.

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g., limestone ($CaCO_3$), or dolomite ($CaMg(CO_3)_2$) leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3^-$), which evolves into CO_2 and water (H_2O). CO_2 emission rate will vary according to soil conditions and the compound applied. Repeat applications are made every few years but can be averaged out over time and the average annual rate is the basis for inventory calculations.

METHODS FOR ESTIMATING CO_2 EMISSIONS FROM LIMING

Methods for estimating CO_2 emissions from liming, using Tier 1, 2 or 3 approaches, are provided in the *2006 IPCC Guidelines*, Volume 4, Chapter 11. A decision tree is provided in Figure 11.4 to assist inventory compilers with selection of the appropriate tier to estimate CO_2 emissions from liming.

Tier 1

The Tier 1 method for estimating CO_2 emissions from liming is identical to that described as equation 11.12 in Chapter 11 of *2006 IPCC Guidelines,* Volume 4.

Tier 2

A Tier 2 method for liming uses country-specific data to derive emission factors in place of the default coefficients described in Chapter 11 (Section 11.3.1) of *2006 IPCC Guidelines,* Volume 4 for CO_2 emissions from liming, where these are shown to be more reliable.

Tier 3

Tier 3 methods use more sophisticated models or measurement procedures. If sufficient data and understanding of inorganic carbon transformation for specific climate-soil conditions are available, specific emission factors could be derived. It is *good practice* to use such methods if they have been well-documented and evaluated.

CHOICE OF CARBON EMISSION FACTORS FOR LIMING

Tier 1

Default emission factors (EF) are 0.12 for limestone and 0.13 for dolomite as defined in Chapter 11 of *2006 IPCC Guidelines,* Volume 4.

5595 **Tier 2**

5596 Derivation of emission factors using country-specific data could entail differentiation of sources with variable
5597 compositions of lime and account for the proportion of carbonate-C from liming that is emitted to the
5598 atmosphere as CO_2. Country-specific emission factors can be derived if there are sufficient data and
5599 understanding of inorganic carbon transformations, in addition to knowledge about transport of aqueous Ca, Mg,
5600 and inorganic C. It is good practice to document the source of information and method used for deriving country-
5601 specific values in the reporting process.

5602 **Tier 3**

5603 Tier 3 approaches are based on estimating variable emissions from year to year, which depends on a variety of
5604 site-specific characteristics and environmental drivers.

5605 **CHOICE OF ACTIVITY DATA FOR LIMING**

5606 **Tier 1**

5607 If soil application statistics for carbonate lime are available, use the statistics data and default emission factors
5608 recommended by *2006 IPCC Guidelines* in Chapter 11 of Volume 4 to estimate CO_2 emissions from liming. If
5609 there are no statistics for soil application of carbonate lime, the amount of carbonate lime applied to soil can be
5610 estimated based on annual sales of carbonate lime or lime availability on an annual basis according to the
5611 description in Chapter 11, volume 4 of *2006 IPCC Guidelines*. It is *good practice* to average data records over
5612 three years (current year and two most recent) if emissions are not computed on an annual basis for reporting
5613 purposes.

5614 **Tier 2**

5615 Tier 2 may incorporate information on the purity of carbonate limes as well as site-level and hydrological
5616 characteristics to estimate the proportion of carbonate-C in lime application that is emitted to the atmosphere.

5617 **Tier 3**

5618 For Tier 3 model-based and/or direct measurement-based inventories, it is likely that more detailed activity data
5619 are needed, relative to Tier 1 or 2 methods, but the exact requirements will be dependent on the model or
5620 measurement design.

5621 2.9.3.4 NON-CO_2 GREENHOUSE GASES

5622 Most N_2O and CH_4 emissions from cropland management, as listed below, are accounted under the Agriculture
5623 sector and are therefore not accounted under the LULUCF sector. The same list applies to grazing land
5624 management, revegetation and wetlands drainage and rewetting. These include:

5625 • Direct N_2O emissions from agricultural soils due to

5626 (iii) Use of synthetic fertilisers,

5627 (iv) Use of animal excreta as fertiliser,

5628 (v)Biological nitrogen fixation due to cultivation of legumes and other nitrogen fixing crops,

5629 (vi) Crop residue and sewage sludge application,

5630 (vii) Cultivation of soils with high organic content,

5631 (viii) N in mineral soils that is mineralised,

5632 (ix) Urine and dung N deposited by grazing animals on pasture, range and paddock

5633 • Indirect N_2O emissions from nitrogen used in agriculture, including emissions from

5634 (x) Volatilisation and subsequent atmospheric deposition of NH_3 and NO_x (originating from the
5635 application of fertilisers and manures),

5636 (xi) Nitrogen leaching and runoff

5637 • CH_4 emissions from rice cultivation;

5638 • CH_4 emissions from ditches in organic soils

5639 • Non-CO_2 emissions from burning of vegetation;

5640 • CH_4 from enteric fermentation;

- CH_4 and N_2O emissions from manure management.

Parties that do not elect cropland management under Article 3.4, nevertheless report the N_2O and CH_4 emissions listed above as emissions from sources listed in the Annex A to the Kyoto Protocol. Parties that elect cropland management should also report these emissions in the agriculture sector and not include them under Article 3.4137. The exception is CH4 emissions from drainage ditches in organic soils. The *2013 IPCC Wetlands Supplement* of the *2006 IPCC Guidelines*: Wetlands provides updated methodologies for drained and wet organic soils. Further guidance on non-CO_2 emissions related to land management on organic soils is given in Chapter 2.12 on Wetland drainage and rewetting.

Non-CO_2 emissions/removals on deforested lands converted to cropland (Article 3.3) which are not reported under Agriculture need to be reported separately from those under cropland management (Article 3.4). If non-CO_2 emissions/removals on deforested land cannot be determined directly, they may be estimated as a fraction of total non-CO_2 emissions/removals from cropland, corresponding to the area of total cropland on deforested land. For example, if 10% of the cropland area is on deforested land, then 10% of total cropland non-CO_2 emissions/removals would be ascribed to lands that have been subject to deforestation since 1990.

Some management practices adopted to increase soil carbon may also influence the emissions of non-CO_2 gases. Many of these effects are included in Chapter 5 and Chapter 11 of the *2006 IPCC Guidelines*, Volume 4, but there may be other effects on non-CO_2 gases not considered (see examples presented in Box 2.9.5).

-

[137] According to the Marrakesh Accords estimates of emissions from sources and removals by sinks from for Article 3.3 and 3.4 activities are to be clearly distinguished from anthropogenic emissions from the sources listed in Annex A to the Kyoto Protocol (cf. paragraph 5 in the Annex to Decision 16/CMP.1 (Article 7), contained in document FCCC/CP/2001/13/Add.3, p.22).

BOX 2.9.5
EXAMPLES OF POSSIBLE INFLUENCES OF CARBON STOCK CHANGES ON EMISSIONS OF NON-CO_2 GASES

Example 1: Influence of reduced tillage on N_2O emission.

Adoption of reduced or no-tillage often increases soil carbon in croplands. However, at the same time it may also alter N_2O emissions, through effects on porosity (and the fraction of the porosity occupied by water) (Ball *et al.*, 2008), N and C cycling (Six *et al.*, 2004; Drury *et al.*, 2006; Ahmad *et al.*, 2009; Six *et al.*, 2004), temperature (Singurindy *et al.*, 2009), and other factors (Lee et al., 2009). The observations are inconclusive, with some studies showing higher N_2O emission under no-till than under tilled systems (Six *et al.*, 2004; Liu *et al.*, 2006; Ball *et al.*, 2008; Rochette *et al.*, 2008; Ahmad *et al.*, 2009; Suddick *et al.*, 2011), and others showing little effect or lower N_2O emissions (Venterea *et al.*, 2005; Helgason *et al.*, 2005; Elder and Lal, 2008; Gregorich *et al.*, 2008; Petersen *et al.*, 2008; Chirinda *et al.*, 2010; Bhatia *et al*., 2010). The available data suggest that this variable response depends on interactive effects of soil and climate, and that wetter environments with poorer aeration, in which N_2O emissions generally tend to be highest, are also associated with higher emissions under no-till than under conventional tillage (Ball *et al.*, 2008).

Example 2: Links between organic matter turnover and N_2O emission.

Organic matter in soil is continually decomposing, resulting in the release of ammonia, and of nitrate. A portion of this 'available' N may be converted to N_2O. Consequently, practices that increase the rate of organic matter decomposition may stimulate N_2O emissions (Millar *et al.*, 2004; Rochette and Janzen 2005; Ruser *et al.*, 2006; Chantigny *et al.*, 2007; Thomsen *et al.*, 2010). In contrast, re-planting grasslands and reducing 'fallow' frequency may reduce N_2O emissions (Millar *et al.*, 2004). The significance and magnitude of these effects, however, are not well-understood and it may not be possible to quantify them reliably at this stage.

Example 3: Effect of cropland management on CH_4 oxidation.

Some practices that enhance soil carbon in croplands may also influence the rate of CH_4 oxidation in soils, negatively or positively (Wegener *et al.*, 2008; Ussiri *et al.*, 2009; Oremland, 2010; Nielsen *et al.*, 2012). Often these effects are smaller than those on N_2O when expressed in units of CO_2-equivalence.

The effects on non-CO_2 emissions of these and other management practices may be included in higher tier methods for cropland. Where estimated, they should still be reported with cropland, to avoid double counting. Examples of how these effects could be estimated include:

- Direct measurement of the non-CO_2 greenhouse gases at representative sites;
- Estimation of emission rates based on literature values taking into account management, soil and climate.

2.10 GRAZING LAND MANAGEMENT

2.10.1 Definitional issues and reporting requirements

'Grazing land management' is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced (Footnote: Paragraph 1(h) in the Annex to Decision 16/CMP.1 (Land use, land-use change and forestry).Lands under grazing land management are predominantly used for production of herbaceous perennial vegetation (introduced or indigenous) for harvest by grazing, cutting, or both. In order to ensure a comprehensive coverage, it is *good practice* to include all of the following management activities in the grazing land management category: grazing, burning, cutting for forage or bedding material as well as fertilizing/manuring, liming, irrigation, reseeding, and application of organic amendments or agrochemicals to control productivity. Note that not all grasslands are necessarily included under grazing land management.

Given the potential overlap with other activities, it is *good practice* for countries to specify what types of lands are included under other activities under Article 3.3 (afforestation/reforestation) and Article 3.4 (forest management, revegetation – if elected, cropland management – if elected). This will enhance the comparability of reporting across countries and ensure there is no double-counting of greenhouse gas emissions/removals.

Where treed lands meet the definition of a forest land and the trees have been established since 1990, the lands are included under the afforestation/reforestation category. Forest lands that are only temporarily used for grazing shall be included under forest land management. Lands that meet the definition of forest land can be included under GM, if grazing is the most important activity and the land is not included under forest land management, based on the criteria established by the country.

Permanent grasslands, pastures, rangelands or savannahs on which trees and shrubs are grown are included under grazing land management if growing of forage crops or grazing is the most important activity on the area. Protected lands, such as those subject to permanent cover programmes are also included under grazing land management, if they are also used for livestock production.

Lands that are only temporarily used for grazing, as part of a cropping rotation, would normally be included under cropland management (see Section 2.9 cropland management of this report). If Cropland Management is not elected, such land can be included under grazing land management, subject to national criteria consistently applied. If grazing land management is elected with Cropland Management, it is *good practice* to include all cropland (see Section 2.2 Land-use categories of the *GPG-LULUCF*) under Cropland Management and grassland (see Section 2.2 Land-use categories of the *GPG-LULUCF*) used for livestock production under Grassland Management. The criteria used to distinguish between land under cropland management and grazing land managemnt needs to be explicitly stated and applied consistently based on national definition.

If GM is elected with RV (see Section 2.11 Revegetation of this report), the criteria used to distinguish between land under RV and GM needs to be explicitly stated and applied consistently based on national definition. It is *good practice* to include revegetated land that is used predominantly for production of livestock under GM.

The aim of the accounting exercise is to identify and report trends in the carbon stocks resulting from grazing land management over time. The methodology for estimating CO_2 emissions/removals is based on the premise that changes in carbon stocks over time occur following changes in management that influence the rates of either carbon additions to, or carbon losses from soil. If no change in management practices occurs, the carbon stocks are assumed to be at equilibrium, and hence the change in carbon stocks is deemed zero. Countries are encouraged to use methods that show systematic changes in the carbon pools rather than inter-annual variability and short-term temporal dynamics. Another factor that may mask the carbon trend or signal is the occurrence of natural disturbances on grassland.

It is *good practice* to have information sharing between national systems for national inventory and accounting of KP activities to have consistency among data. Information sharing for ensuring consistency include: grazing animals consistent with those under agricultural sector for enteric fermentation and PRP N_2O, mass balance of organic soil amendment application on lands under grazing land management and other lands, and land areas.

To use the proposed methodology for determining carbon stock change on those lands, the total grazing land area needs to be subdivided into areas under various sets of management practices (which may overlap both in time and space) for the base year and each of the years in the commitment period, such as those provided in Table 6.2 of the *2006 IPCC Guideline*. Broad families of practices under grazing land management that affect carbon stocks include stocking rate, fertility management, irrigation management, species composition and fire management (*2000 IPCC Special report on LULUCF*). The carbon stock change factors depend on both the current and previous management. Some areas may be emitting CO_2, others may be sequestering carbon, others may be in equilibrium and this may change if management changes. Further detail can be found in Chapter 3 of the *GPG-LULUCF* and Chapter 6 of the *2006 IPCC Guidelines.* See also Section 2.10.2 below.

Countries should aim for consistency and completeness across activities. For example, all lands that were forest land on 31 December 1989 and that are subject to grazing land management in the reporting year need to be identified, tracked and reported as a separate category under deforestation (see Section 2.6 Deforestation).

1990 BASE YEAR

See Section 2.9.1.1 Definitional issues and reporting requirements. It is *good practice* to use calendar year data whenever data are available. If calendar year data are unavailable, then other types of annual year data (e.g., non-calendar fiscal year data e.g., April – March) can be used provided that it is used consistently over the time series and the collection period for the data is documented (See 2.2.3 Adapting data for inventory use of the *2006 IPCC Guidelines,* Volume 1).

2.10.2 Choice of methods for identifying lands subjected to grazing land management

General guidance on identification of lands relevant to grazing land management is provided in Sections 1.1, 1.2, 2.1, and 2.2. According to Decision x/CMP.8, Annex II, paragraph 2), the geographical location of the

boundaries of the area that encompass land subject to grazing land management need to be reported annually, along with the total land areas subject to this activity.

The geographical location of the boundaries may include a spatially explicit specification of all land subject to grazing land management, but does not have to. This is analogous to the case for cropland management as discussed in Section 4.2.9.1 (Definitional issues and reporting requirements). It is *good practice* to follow continuously the management of land subject to grazing land management. This could be achieved either by continuously tracking each land subject to grazing land management from 1990 until the end of the commitment period (see Section 2.9.1), or by developing statistical sampling techniques consistent with the requirements of Section 5.3 that allow the management transition on grazing management land to be determined (see also Section 2.4.1 Developing a consistent time series).

At the national level, it is *good practice* to identify criteria that could be relevant to subdivision for the purpose of stratification when setting up a sampling strategy. Stratification criteria may include relatively static biophysical characteristics, such as climate and soil type, as well as management practices and natural disturbances which tend to be more dynamic drivers of change in emissions and removals from the carbon pools. Management factor and disturbance information which may be useful in establishing a national stratification include:

- Level of input of crop biomass or grassland productivity, organic amendments (e.g., vegetation growth, manure/compost, other amendments)
- Grazing intensity (stocking rate, frequency, seasonality)
- Prescribed fire
- Re-seeding
- Irrigation management
- Inclusions of woody biomass (shrubland, shelterbelts, orchards, other perennial plantations)
- Lands converted to grazing-lands since 1990 (land-use change) that are not in any other activity.

For all resulting subcategories under grazing land management, the area derived from conversion of forests (i.e., deforestation) since 1990 need to be tracked separately as these will be reported as units of lands subject to deforestation (See Section 2.6 Deforestation).

At higher tiers further subdivision of the area subject to grazing land management may be necessary. Methods to identify lands subject to grazing land management with necessary disaggregation available in some Annex I countries include the following:

National land use and management statistics: the agricultural land base including land subject to grazing land management is surveyed in most countries on a regular basis. These may be derived, in part, from remote sensing of pasture/rangeland and soil surface condition and changes in stocking rate.

Inventory data from a plot, statistically based, plot-sampling system: land use and management activities are monitored at specific permanent sample plots that are revisited on a regular basis.

Information on these areas would have to be compiled either for all lands subject to grazing land management or summarised as estimates for all the strata (defined by the boundaries of the areas of grazing land management) that a Party chooses to apply for the reporting of its land use statistics. Further *good practice guidance* on identifying land areas is given in Chapter 2 of the *GPG-LULUCF* (Basis for consistent representation of land areas).

Links to methods for area identification in other chapters of the *GPG-LULUCF* and the *2006 IPCC Guidelines* are given in Box 2.10.1.

Box 2.10.1

LINKS WITH CHAPTER 2 OR 3 OF THIS REPORT

Section 2.3.2 (Three approaches): Grasslands (unmanaged or managed) that become managed grasslands or any conversion that leads to managed grasslands in Chapter 2 (except forests to grasslands), provided that these managed grasslands are subject to grazing land management.

LINKS WITH THE *2006 IPCC GUIDELINES VOLUME 4*

Not available in a format that meets requirements in the Marrakesh Accords for geographical location of the boundaries.

2.10.3 Choice of methods for estimating carbon stock changes and non-CO_2 greenhouse gas emissions

As with cropland management, the *2006 IPCC Guidelines* identify three sources or sinks of CO_2 from agricultural soils subject to grazing land management.

- Emissions of CO_2 from liming. These, however, shall be reported in the Agricultural sector (see Section 11.3 CO_2 emissions from liming of the *2006 IPCC Guideline* Volume 4).
- Net changes in organic carbon stocks of mineral soils (see Section 6.2.3 Soil carbon of the *2006 IPCC Guidelines* Volume 4)
- Emissions of CO_2 from organic soils (see Section 6.2.3 Soil carbon of the *2006 IPCC Guidelines* Volume 4)

Total annual soil emissions/removals of CO_2 are calculated by summing up these sources excluding CO_2 emissions from liming (see Chapter 6 Grasslands, Section 6.2.3 and 6.3.3 in *2006 IPCC Guidelines*:

Carbon stock changes in other pools (aboveground and belowground biomass, litter, and dead wood) are estimated if applicable. For lands subject to grazing land management with no woody vegetation, carbon stock change in herbaceous biomass can be neglected. Carbon in biomass of woody vegetation on lands subject to grazing land management need to be accounted for unless an Annex I Party to the Kyoto Protocol provides verifiable information that carbon stocks are not decreasing (see Section 4.2.3.1 Pools to be reported). Methods for estimating carbon stock change in aboveground and belowground biomass, litter and dead wood are identical to those for cropland management (see Table 4.2.8 of this report). For guidance in estimating carbon emissions/removals in pools other than in the soil and non-CO_2 greenhouse gas emissions, see Box 4.2.13 and Table 4.2.8 of this report. Figure 2.2 in Chapter 2 of the *2006 IPCC Guidelines* provides further guidance on selecting appropriate methods.

Box 2.10.2

Links with Chapter 4 of the GPG 2000

Section 4.5 CH_4 and N_2O emissions from savannah burning

Links with chapter 2 of the *2006 IPCC Guidelines*

Section 2.3.1Change in carbon stocks in living biomass

Section 2.4 Non-CO_2 greenhouse gas emissions

Links with Chapter 6 of the *2006 IPCC Guidelines* VOLUME 4

Section 6.2.1 and 6.3.1 Biomass

Section 6.2.2 and 6.3.2 Dead organic matter

Section 6.2.3 and 6.3.3 Soil carbon

Section 6.2.4 and 6.3.4 Non-CO_2 greenhouse gas emissions from biomass burning

2.10.3.1 MINERAL SOILS

The decision tree used for selecting the appropriate tier for estimating carbon stock changes in mineral soils under grazing land management is analogous to the one used for cropland management (see Figure 2.9.1).

METHODS FOR ESTIMATING CARBON STOCK CHANGES IN MINERAL SOILS

The methods used for estimating carbon stock changes in mineral soils under grazing land management are identical to those used for cropland management. See the methods under Tiers 1, 2 and 3 described in Section 2.3.3 (Mineral soils) and also in Chapter 6 (Sections 6.2.3 and 6.3.3 of the *2006 IPCC Guidelines*). Same as

cropland management all methods require that the lands subject to grazing land management are tracked continuously through time. At Tier 1, the database of default annual stock change factors in Annex 4A.1 , is applicable also for grazing lands (see Section 2.3.3 Mineral soils). It is *good practice* to use Tier 2 or Tier 3 for estimating carbon stock changes in mineral soils if CO_2 emissions from grazing land management are a key category (see Figure.2.9.1).

CHOICE OF CARBON STOCK CHANGE FACTORS FOR MINERAL SOILS

The choice of carbon stock change factors at each tier follows the same lines as described under cropland management (see Equation 3.3.3 of the *GPG-LULUCF*). The carbon stock change factors are held within the same database (see Annex 4A.1). At higher tiers, same as cropland management, carbon stock change factors can be calculated from literature values (e.g., Follett et al., 2000), long-term experiments and model runs. It is *good practice* to replace carbon stock change factors or to use dynamic models derived from experiments that are well designed, with adequate sampling to give adequate statistical power. Any factors based on models shall only be used after the model has been tested against experiments such as those described above, and any model shall be widely evaluated, well-documented and archived. It is *good practice* to provide confidence limits and/or uncertainty estimates associated with any stock change factors. Carbon stock change factors shall be shown to represent local conditions or practice, based on measurements or experiments within the region.

CHOICE OF MANAGEMENT DATA FOR MINERAL SOILS

As with cropland management, if area and management data are available for 1970 through 1990, a base year (1990 or other) net carbon emission/removal can be established using the default carbon stock change factors described above. If area and management data are not available for 1970 through 1990 the options available are those already described for cropland management (see Section 2.9.1.1 Base year). Here only the activity data required for each of three tiers are outlined briefly.

Tier 1

The management practices at Tier 1 are the same as those given in the *2006 IPCC Guidelines* volume 4. The different management impacts defined there are: clearing of native vegetation with conversion to cultivated crops or pasture; land abandonment; shifting cultivation; differing residue addition levels; differing tillage systems; agricultural use of organic soils for grazing. Within these specific land-use or land-management changes, practices are defined semi-quantitatively, e.g., “high input” vs. “low input” systems. Land-use and management systems are not subdivided to finer levels of detail than this. Areas may be obtained from international data sets (e.g., FAO). If area and management data are available for 1970 through 1990, the 1990 base year net carbon stock change can be established using the default carbon stock change factors described above. If area and management data are not available for 1970 through 1990 the options available are those described above for cropland management (see Section 4.2.9.1.1 Base year). If grazing land management is deemed a key category, then it is good practice to use a Tier 2 or 3 methods (see Figure 2.9.1).

Tier 2

The management practices considered at Tier 2 are the same as those given in the *2006 IPCC Guidelines,* volume 4 and at Tier 1. To make them country-specificsome practices may be subdivided, or new ones may be added. For example, within the agricultural management systems described in the *2006 IPCC Guidelines*, volume 4 management data includes descriptors such as “high input” and “low input”; these descriptors could be replaced at Tier 2 by more explicit descriptors; for example, high grazing level, medium grazing level, low grazing level, and zero grazing. Further subdivision of activities may also be necessary; for example, different forms of grazing. An alternative to the use of more detailed descriptor categories is the use of relationships relating the intensity of a practice (e.g., grazing level) with a change in the carbon emission/removal factor. Alternatively, well-calibrated and well-evaluated models of soil carbon change, e.g. RothC (Coleman and Jenkinson, 1996; Shirato et al. 2004, or others) can be used to generate either default carbon stock change factors, or to generate the intensity relationships for each activity, for different soils in different climatic regions. These examples show how, at Tier 2, activities can be made more country-specific, but other refinements are also possible. Rigorous criteria must be applied so that any increase in the sink size is not under- or overestimated.

Tier 3

Management data used in the more complex Tier 3 approaches are likely to be subdivided as described for Tier 2 above. For application of dynamic models (e.g., CENTURY (Parton et al., 1987), RothC (Coleman and Jenkinson, 1996; Shirato et al. 2004, or others), measured/estimated activity data based on national statistics (e.g., herbage yield, input level of organic amendment), detailed data of the combination of climate, soil and management are needed.

2.10.3.2 CO_2 EMISSIONS FROM ORGANIC SOILS

The decision tree for use with organic soils under grazing land management is identical to that from cropland management, cf. Figure 4.2.13. The methods described under Tiers 1, 2 and 3 for cropland also apply to grazing land, cf. Section 2.9.3.2 (Carbon stock changes in organic soils of this report) and also Chapter 3 (Sections 3.3.1.2 and 3.4.1.2). As for croplands, non-CO_2 greenhouse gas emissions/removals from organic soils are also important, with some emissions (i.e., methane, CH_4) decreasing as CO_2 losses increase with soil drainage. It is important when calculating changes in carbon emissions/removals from organic soils to also consider non-CO_2 greenhouse gas emissions, bearing in mind that, as a rule, these are covered in the Agriculture sector. However, note that the *2006 IPCC Guidelines* assume that all carbon is emitted as CO_2; if this assumption is departed from, it must be justified by scientifically sound and well-documented data.

CHOICE OF CARBON EMISSION/REMOVAL FACTORS FOR ORGANIC SOILS

For guidance on factors for on-site and off-site CO_2 emission/removal from organic soils refer to the equivalent subsection for cropland management (Section 2.9.3.2 Carbon stock changes in organic soils)

CHOICE OF MANAGEMENT DATA FOR ORGANIC SOILS

Management data for organic soils are as for *IPCC Guidelines* as described and amended above for mineral soils.

2.10.3.3 NON-CO_2 GREENHOUSE GASES

Non-CO_2 emissions on lands under grazing land management are by rule reported in the Agriculture sector in an analogous way to non-CO_2 emissions on lands under cropland management (see Section 2.9.3.4 of this reprot). Note that these non-CO_2 emissions are reported under agriculture even if grazing land management is not elected.

Non-CO_2 greenhouse gas emissions from deforested lands converted to grazing land (Article 3.3) need to be reported separately from those under grazing land management (Article 3.4). For further guidance, see corresponding section on cropland management (Section 2.9.3.4).

Management practices on lands subjected to grazing land management that increase soil carbon stock may influence the emissions of non-CO_2 greenhouse gases from soils and should at Tier 3 be reflected in reporting under Agriculture.

2.11 REVEGETATION

2.11.1 Definitional issues and reporting requirements

Revegetation is a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation [in paragraph 1(e) in the appendix to Decision 16/CMP.1].

Land should be classified as revegetation if it meets the revegetation definition and takes place after 1 January 1990 (see the decision tree Figure 2.5.1 in this report for further guidance). Revegetation typically affects the aboveground carbon pool significantly and may also have a significant impact on belowground carbon pools through increases in soil carbon stocks. Area for area, revegetation is likely to have a lower impact than reforestation. (Akala & Lal, 2000; Cowie et al., 2007; Gessesse, 2009).

Revegetation implies that vegetation is established to replace the previous (sometimes minimal) ground cover that had followed a land disturbance. For example, activities such as reclaiming/restoring herbaceous ecosystems on degraded or carbon-depleted soils, establishment of vegetation cover on disturbed construction sites or mined lands, planting of trees, shrubs, grass or other non-woody vegetation various types of lands including urban areas, might qualify as revegetation (see table 2.11.1). Tree planting may not qualify for afforestation/reforestation because it does not meet the requirements set for a forest in paragraph 1(a) in the annex to decision 16/CMP.1 or because the consistent application of spatial configuration criteria (see 2.2.6 of this report) excludes it. In such a case it may qualify as revegetation. Revegetation does not necessarily entail a change in land use, in contrast to e.g. afforestation or reforestation. Revegetation activities must be clearly differentiated from natural, non-human driven revegetation processes. For example, the natural revegetation on forest topsoil and subsoil along roadsides in boreal forest (Skrindo et al., 2008) or a passive revegetation leading to the restoration of coastal plain depression wetlands (De steven et al., 2006) should not been qualified as revegetation because these are not direct human-induced activities in the context of the Kyoto Protocol.

Any revegetation on set-aside lands likely to return to cropland under the national conditions for set-aside should be counted as cropland).

It is *good practice* for Parties electing revegetation to provide documentation (a) describing how the included areas meet the definition of revegetation; (b) indicating the plant species or life forms selected for the activity; and (c) explaining the restoration methods and procedures to be used.

The following general guidance is provided in order to ensure a reasonably transparent, consistent, complete and accurate reporting of revegetation activities:

(1) It is good practice to stratify lands subject to revegetation by either land-use category or land-use change type, by kind of revegetation activity, and final land-use if different from the initial one.

(2) It is good practice to further disaggregate each land-use category to be revegetated into subcategories characterised by available information on most relevant climate, soil and relief features, whatever is most relevant for stratifying land according to the activity effects on carbon stocks and carbon stock changes. This characterisation would aid selecting suitable revegetation options and activity tracking; i.e. species, planting design, and soil preparation (to name just a few).

(3) Lands subjected to revegetation and each of its subcategories (if any) must be clearly identified as to their individual locations and areas (see section 2.11.2 in this report).

Some revegetation activities are exemplified in the following box 2.11.1

Box 2.11.1

[4]Revegetation activities

Iceland: The conversion of eroded or desertified land from Other land or less vegetated subcategories of grassland to Grasslands (as defined by a vascular vegetation cover of 20% or larger) or grasslands with more vegetation cover.

Japan: Plantation of trees in parks and green spaces in both public and private urban areas.

Romania: Plantation of trees on degraded croplands: outside forestlands under administrative stewardship; roadsides; shelterbelts; around cities; and erosion-prone lands. All revegetated lands are classified as Croplands remaining croplands.

[138]

1990 BASE YEAR

See Section 2.9.1.1 (Definitional issues and reporting requirements) in this report.

2.11.2 Choice of methods for identifying lands

Land areas subject to revegetation can be represented with data obtained with either Approach 2—provided there is additional spatial information—or Approach 3 (§3.3.1[139]) It is *good practice* that the particular Approach chosen be consistent with the one used for identifying and tracking the lands of other Kyoto Protocol activities, be they mandatory (Art. 3.3) or elected (Art. 3.4).

Generally, all lands subject to revegetation since 1 January 1990 should be tracked in agreement with the national criteria that establish a hierarchy among Article 3.4 activities (if applicable) as explained in section 1 in this report.

The geographical location of area boundaries may or may not include a spatially explicit specification of each patch of land subject to revegetation. In case the location of boundaries is not explicitly specified the location of a larger area within which patches of land subject to revegetation are included must be provided. In either case, the lands subject to revegetation and the management thereon need to be tracked continuously through time. Continuity in monitoring/reporting of management of revegetated land could be achieved either by continuously tracking each land subject to revegetation from 1990 until the end of the commitment period [(e.g., see section 2.9.2 for cropland management) and section 2.10.2 for grazing land management or section 3.3 in Ch. 3, vol. 4 in *2006 IPCC Guidelines* for land-use categories in general, or by developing statistical sampling techniques (see annex 3A.3 in ch. 3, vol. 4 in *2006 IPCC Guidelines*) that allow the transition of different types of management on revegetation land to be determined (see section 2.4.1 Developing a consistent time series in the current guidelines) and section 3.3 in ch. 3, vol. 4 in *2006 IPCC Guidelines*.

Links to pertinent methods in *this report* and in the *2006 IPCC Guidelines* are provided in Box 2.11.2

[138] As described in each Party's NIR for 2011. See http://unfccc.int/national_reports/annex_i_GHG_inventories/national_inventories_submissions/items/6598.php

[139] The notation §N.M.O refers to section M.O in chapter N of volume 4 in *2006 IPCC Guidelines*

Box 2.11.2

LINKS WITH CHAPTERS 2 AND 3 OF *2006 IPCC Guidelines*

Section 2.3.2 (Three Approaches): No information on revegetation area in Chapter 2 approaches.

Requires country-specific criteria on what constitutes revegetation. Should include all transitions between 1990 (or 1970, where required for base year estimate) and 2008, and in later inventory years transitions on an annual basis.[140]

LINKS WITH THE *2006 IPCC GUIDELINES* VOLUME 4

Revegetation is not specifically addressed in the *IPCC Guidelines*.

Methods for monitoring revegetation lands depend on the kind of land-use at the start and termination of a revegetation activity. As common criterium, the minimum area of 0.05 hectares has to be detected and all carbon pools have to be considered unless they are demonstrated not to be a source. If revegetation were done with herbs or grasses, monitoring should use methods appropriate for monitoring grazing land management (see section 2.10 in this report). If revegetation were done with tree species, monitoring methods should be same with those used for monitoring afforestation/reforestation activities (see section 2.5 in this report) or forest management activities (see section 2.7 in this report). For designing revegetation activities on settlements it is *good practice* to use tree inventories (if available), cadastral information on parks and green spaces, brownfields and any other spatial information on areas amenable to revegetation. A clear definitional distinction with respect to afforestation or reforestation is required.

2.11.3 Choice of methods for estimating carbon stock changes and non-CO_2 greenhouse gas emissions

Methods for estimating changes in aboveground biomass, belowground biomass, litter and dead wood carbon pools in a revegetation activity are those appropriate for the land uses involved in it. Those are the *good practice* ones described in chapters 4 to 9 in volume 4 of *2006 IPCC Guidelines*. The biomass carbon pool is likely to be the carbon pool most affected by revegetation. Countries are encouraged to use higher tier methods for reporting C stock changes in biomass. It is *good practice* to use Tier 2 or Tier 3 for estimating carbon stock changes from biomass if revegetation is a key category.

For estimating carbon stocks in mineral soils and organic soils, and for estimating CO_2 emissions from liming revegetation lands, methods and tier structures are those good practice ones corresponding to the land uses involved in a particular revegetation activity. Relevant methods and approaches can be found in chapters 4 to 9 and 11 in volume 4 of in *2006 IPCC Guidelines*. For urban soils, methods are described for settlements in *2006 IPCC Guidelines* Volume 4.

In the case of a revegetation activity involving cropland or grassland, guidance on choice of methods (Tier 1) stock changes in mineral soils is in can be found in Sections 2.9.3.1 and 2.10.3.1 of this report. It is *good practice* to use Tier 2 or Tier 3 for estimating carbon stock changes from mineral soils if revegetation is a key category. A decision tree for selecting the tier for estimating carbon stock changes in mineral soils under revegetation can be derived mutatis mutandis from the one used for croplands – see Figure 2.9.1 of this report. At higher tiers, carbon stock change factors can be obtained from relevant literature (e.g., Akala *&* Lal., 2000), long-term experiments and models. Further guidance on the use of Tier 3 models can be found in section 2.5, chapter 3, Volume 4 in in *2006 IPCC Guidelines.*

The decision tree for methodologies for emissions from organic soils under revegetation is analogous to the one drawn for cropland management, cf. Figure 2.9.3of this report) if the revegetation activity did involve either cropland management or grazing land management. The methods described under Tiers 1, 2 and 3 for either cropland or grazing land or forest management also apply to revegetation activities involving either croplands or grasslands or treed lands, (cf. sections 2.10,2.7) and section 2.9 and chapters 7 to 9 in volume 4 of *2006 IPCC Guidelines* for other land- use categories.

[140] If more than one land conversion happens on the same unit of land in the transition period of the matrix, then the transition periods may have to be shortened to account for these transitions.

For the estimation of CO_2 emissions from liming revegetated lands, the *good practice* methods developed for either cropland management or grazing land management or forest land management can be used based on the annual amount of lime application. For general good practice guidance on the estimation of CO_2 emissions from liming see section 11.3 in volume 4 of 2006 IPCC Guidelines.

For urban soils, methods are described in Annex 3B of *GPG-LULUCF* Chapter 3 or see literature (Pavao-Zuckerman, 2008)]

Box 2.11.3

LINKS WITH CHAPTER 2 *2006 IPCC GUIDELINES*

Section 2.2	Change in biomass
Section 2.4	Change in carbon stocks in soils

LINKS WITH THE *2006 IPCC GUIDELINES* VOLUME 4

4	Non-CO_2 greenhouse gases
5 A	Changes in forest and other woody biomass stocks (grasslands / tundra)
5 C	Abandonment of managed lands (grasslands / tundra)
5 D	CO_2 emissions and removals from soils
5 E	Other (e.g., dispersed trees that are managed but do not constitute a forest such as agroforestry, also referred to as "managed trees outside forests")

(not all five pools are included: belowground biomass and litter are missing)

2.11.3.1 CHOICE OF CARBON STOCK CHANGE FACTORS

Estimation of revegetation is more dependent on national definitions than is the case for other Art 3.4 activities. In case Tier 1 methodologies are used it is *good practice* to provide national information substantiating they adequately represent a Party's the national circumstances (Section 2.3, and Ch. 5 to 9 in volume 4 of *2006 IPCC Guidelines* contain methodologies that may be relevant) It is *good practice* for a Party electing revegetation to provide values for stock change in each carbon pool. If Tier 1 default values are missing country-specific values need to be used. In the case of pools not reported, it is *good practice* to provide verifiable information to demonstrate that these pools are not a source of carbon and other greenhouse gases (see Equations 2.2 and 2.3 in volume 4 of *2006 IPCC Guidelines*). If revegetation is deemed a key category, then it is *good practice* to use Tier 2 or 3 methods.

At Tier 2, it is good practice to provide verifiable methods and documentation to show how the carbon stock change has been estimated for each pool elected under a revegetation activity. For any carbon pool not reported, it is good practice to provide verifiable information to demonstrate that it is not a source of greenhouse gas anthropogenic emissions (see paragraph 6(e) in the annex to decision 15/CMP.1)

At Tier 3 ecosystem carbon cycle models, parameterised for the relevant plant functional types and soils included in the selected revegetation area, could be used to estimate annual carbon and other greenhouse gas emissions and removals. These models need to be calibrated and validated against field observations that represent the national circumstances, be fully documented and archived.

2.11.3.2 CHOICE OF MANAGEMENT DATA

Activities such as reclaiming/restoring herbaceous ecosystems on carbon-depleted soils, environmental plantings, planting of trees, shrubs, grass or other non-woody vegetation on various types of lands including urban areas, which qualifying as revegetation can be considered. Area data on land uses and practices need to be available in accordance with Approach 2 or Approach 3 (Section 2.2 in this report), and guidance given in Section 2.2.3 of this report. The data on revegetation management required for each of three tiers are outlined briefly here.

TIER 1

Using the *2006 IPCC Guidelines* Volume 4 impacts of land-use change or land management change under a revegetation activity are assumed, by default, to fully develop at the end of 20 years. The choice of default

emission factors influenced by management factors depends on the particular land uses involved in a particular revegetation activity. As minimum the six broad land use categories and changes between these categories need to be specified and different types of revegetation activities separated.

TIER 2

For Tier 2 some management practices for revegetation may be either subdivided or new ones may be added to make them country-specific, depending of the land-uses involved in a revegetation activity. It is good practice that those subdivisions reflect close relationships between management practices and changes in carbon pools.

TIER 3

Management data used in the more complex Tier 3 methodologies need to be consistent with the level of detail required by the model or models used to describe a particular revegetation activity. It is *good practice* to use management data at a spatial resolution appropriate for the model, and to have, or be able to estimate reliably, quantitative measures of the management factors required by the model.

It is *good practice* to provide detailed documentation specifying the practices included under revegetation and the carbon emission/removal factors associated with each practice for each pool elected.

2.11.3.3 NON-CO_2 GREENHOUSE GASES

The methods for estimating N_2O and CH_4 emissions from a revegetation activity depend on the land-use categories and their particular management (e.g. biomass burning or nitrogen fertilisation, as the case might be). Methods can be looked up in relevant chapters in volume 4 of in the *2006 IPCC Guidelines*. Part of the non-CO_2 emissions on lands subject to revegetation are by rule reported under the Agriculture Sector (see Sections 2.9.3.4 and 2.9.10.4 of this report) and double-counting should be avoided.

Methodologies for estimating N_2O and CH_4 emissions are given in chapters 4 to chapter 11 of the *2006 IPCC Guidelines* Volume 4 or section 2.9, 2.10 in this report. For revegetation activities that involve biomass burning, non-CO_2 GHG emissions can be estimated with the methods described in §5.2.4—no land-use change—or in §5.3.4 (land-use change)]

For mineral soil, organic soilsand urban soils], methods for estimating N_2O and CH_4 emissions may be different. Methodologies for estimating emissions of non-CO_2 gases from biomass burning in grasslands or forests are given in *2006 IPCC Guidelines* Volume 4 or obtained from the scientific literature (e.g. Pickup et al., 2012; Worrall et al., 2011).

These emissions should not be reported under revegetation but as emissions in the Agriculture sector from sources listed in Annex A to the Kyoto Protocol, and they should clearly be distinguished from emissions from revegetation reported under Article 3.4 of the Kyoto Protocol.

For revegetation activities involving nitrogen fertilisation of soils N_2O emissions should be estimated with the good practice methodology described in §11.2. Revegetation activities where liming and/or urea were used would produce CO_2 emissions; these emissions should be estimated with the good practice methodologies described in §11.3 (liming) and/or in §11.4 (urea application). These emissions should not be reported under revegetation but as emissions in the Agriculture sector from sources listed in Annex A to the Kyoto Protocol, and they should clearly be distinguished from emissions from revegetation reported under Article 3.4 of the Protocol. These emissions should clearly be distinguished from emissions from revegetation reported under Article 3.4 of the Protocol. Double-counting of N_2O emissions from nitrogen fertilisation in the Agriculture section and from liming in other Art. 3.3 and 3.4 activities is to be avoided.

Non-CO_2 greenhouse gas emissions/removals on deforested lands subject to revegetation (Article 3.3) which are not included under Agriculture need to be reported separately from those under revegetation (Article 3.4). For further guidance, see corresponding section under cropland management (see Section 2.9.3.4 in this report).

2.12 WETLAND DRAINAGE AND REWETTING

2.12.1 Definitional issues and reporting requirements

"Wetland drainage and rewetting" (WDR) is a system of practices for draining and rewetting on land with organic soil that covers a minimum area of 1 hectare. The activity applies to all lands that have been drained since 1990 and to all lands that have been rewetted since 1990 and that are not accounted for under any other

activity, where drainage is the direct human-induced lowering of the soil water table and rewetting is the direct human-induced [141]partial or total reversal of drainage.[142] Wetland drainage and rewetting can be implemented on organic soils under any land-use category on Land Remaining Land or on Land converted to another land-use category.

Drainage and rewetting refer to all practices in and outside the area with organic soil that directly affect the hydrological system, leading to a change in the water table and its seasonal pattern in the area with organic soil [make this consistent with Wetlands Supplement]. The activity Wetland drainage and rewetting includes new drainage of formerly undrained land, changing an existing drainage regime (water table level and its seasonal changes), partial rewetting and complete rewetting to near-natural water regime or even beyond (cf. *2013 IPCC Wetlands Supplement*, Chapters 2 and 3), as far as these practices have taken place since 1990. Practices leading to direct human-induced drainage or rewetting may include e.g. the installation of (additional) ditches, pipes, wells or dams, and the implementation of pumping and groundwater extraction.

Flooded land (refer to *2006 IPCC Guidelines*, Vol.4, Section 7.3) is not included under this activity. Non-CO_2 emissions from drainage and rewetting on agricultural land are reported in the Agriculture Sector. CO_2 emissions from rice cultivation are by rule reported under the cropland management activity, but may be included under Wetland drainage and rewetting when organic soils are rewetted for rice cultivation, and cropland management is not elected.

As the activity includes only lands that are not accounted for under any other activity, most of the emissions and removals due to drainage and rewetting practices on organic soils will be reported under the Kyoto Protocol activities:

- Drainage and rewetting of forest land that remain forest land will be reported under forest land management
- Drainage and rewetting resulting in a conversion to forest, or from forest to any other land use, will be reported under afforestation/reforestation/deforestation.
- Lands drained and rewetted since 1990 that would meet the criteria for classification under cropland management, grazing land management or revegetation, will be reported under wetland drainage and rewetting only when the above-mentioned activities are not elected but Wetland drainage and rewetting is elected.

The guidance for estimating and reporting of emissions from drainage and rewetting is given in the *2006 IPCC Guidelines* and its supplement, *2013 IPCC Wetlands Supplement*. The *2013 IPCC Wetlands Supplement* introduces updated emission/removal factors and a new source category for drained organic soils.

The base year for wetland drainage and rewetting is the same as for cropland management, grazing land management and revegetation. Practical guidance for identification of land areas for wetland drainage and rewetting in the base year and during the commitment period is given in the Section Choice of Method for the Identification of Lands below.

Drainage and rewetting result in immediate changes of greenhouse gas emissions and removals so that there is no need to establish a land-use history prior to 1990. However, if higher-tier methodologies, that consider a dynamic transition time are used, information for the period before 1990 may be needed.

2.12.2 Choice of methods

Wetland drainage and rewetting addresses lands with organic soils where changes in management which may be on relatively small areas and can lead to proportionally large changes in greenhouse gas emissions and removals per hectare. Consequently, particular care must be taken to make accurate estimates of greenhouse gas emissions and removals both in the 1990 base year and in the commitment period. It is *good practice* to use stratification by land-use category (remaining or converted to the new land-use category) with subcategories according to water table. Updated methodological guidance is provided in Chapters 2 (drained organic soils) and 3 (Rewetting), of the *2013 IPCC Wetlands Supplement.*

The provision that the Activity only concerns minimum areas of 1 hectare implies that not every individual linear drainage element (ditch, canal) has to be monitored but only practises have to be accounted for that change the water regime over an area larger than [100 x 100 m]. Changes affecting areas of [e.g. 10 x 1000 m (although

[7] Durban decision 2/CMP.7, FCCC/KP/AWG/2011/L.3/Add.2, Annex, paragraph 1(b)

being 1 ha)] do not have to be reported. [consistency with e.g. geometry interpretation for minimum area in forest land management and revegetation.]

Figure 2.9.1 Decision tree for selecting the appropriate tier for estimating carbon stock changes in carbon pools under wetland drainage and rewetting for Kyoto Protocol reporting

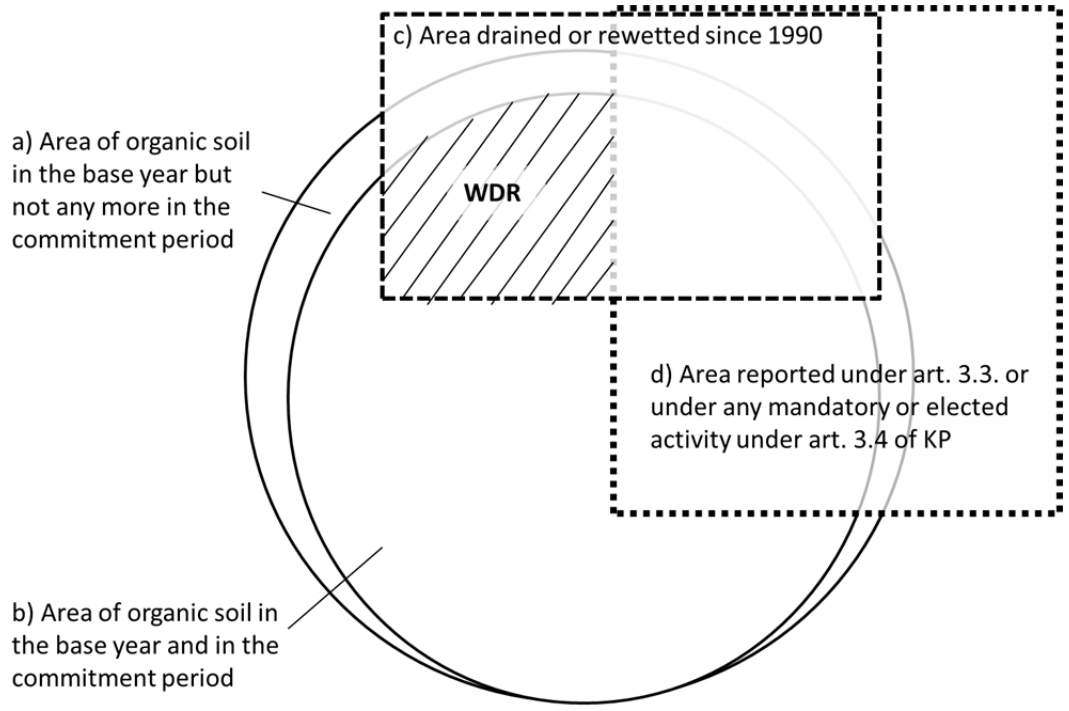
[to be completed for second order draft]

2.12.3 Choice of methods for identifying lands

2.12.3.1 General Guidance for identifying lands

The activity "wetland drainage and rewetting" can only be applied to organic soils that are drained or rewetted since 1990 and that are not included under any other accounted activity (see Section 2.1 for further guidance). As rewetting and drainage of organic soils may also occur under other accounted land-use activities, the wetland drainage and rewetting activity will always constitute a subset of the total area of organic soil in the country. As drained organic soil oxidizes, the organic material layer becomes shallower. Over time the organic soil layer may have become so shallow, that the area no longer complies does not comply with the criteria of an organic soil. It is *good practice* to apply the activity only on land that still has an organic soil in the commitment period and to exclude those lands that have changed from an organic soil into a mineral soil area between the base year and the commitment period. These issues are illustrated in Box 2.12.1.

BOX 2.12.1
WETLAND DRAINAGE AND REWETTING AREAS IN 1990 AND THE COMMITMENT PERIOD (NET-NET ACCOUNTING)



The area of organic soils in the base year (a) is larger than the area in the commitment period (b) as part of the organic soils have changed into mineral soils due to oxidation. The activity applies only to lands that have been drained and rewetted since 1990 (c) but the lands may *not* be accounted for under any other activity (d). The area that has to be reported under WDR (if elected) is thus the hatched area with the conditions: (b∩c) – (c∩d). This same area has to be accounted both in the base year and in the commitment period year (net-net accounting).

The identification of land to be included under the WDR should follow a similar approach as described in Section 2.9.1. The lands should be identified separately for areas drained since 1990 and areas rewetted since 1990.

There are two ways of identifying lands subject to WDR:

3. The 'Difference approach': Compare all organic soils in 1990 with all organic soils in the Commitment Period. All lands on organic soils where a direct human induced change in water regime is observed when comparing 1990 and the end of the Commitment Period and that are not included in any other activity, must be included in wetland drainage and rewetting when the activity wetland drainage and rewetting is elected.
4. The 'Change approach': Identify directly the area of organic soil where a direct human induced change in water regime has taken place since 1990. If these lands are not included in any other activity, they must be included under wetland drainage and rewetting when the activity wetland drainage and rewetting is elected.

For transparency drainage and rewetting areas should be reported and tracked separately. It is *good practice* to ensure that lands drained and rewetted since 1990 are completely included and that supplementary information is given about how completeness has been achieved. This could combine information from a specific land-use matrix on organic soils and a detailed description of the method for identification of drainage and rewetting, its spatial and temporal resolution and up-to-date-ness of water management information.

For transparency, it is *good practice* to explain what type of land-use and land-use changes are included in the activity and why, in case some lands on organic soils are excluded, also to explain the reasons for exclusion.

2.12.3.2 GEOGRAPHICAL BOUNDARIES

A country that elects wetland drainage and rewetting must identify the geographical boundaries of all drainage and rewetting events that are one hectare or larger, are directly human-induced, and do not fall under any other activity that takes precedence. Countries may use the following steps:

Step 1: The first step produces the potential area for wetland drainage and rewetting. Identify the geographical boundaries of organic soils and establish separate land-use matrices for organic soils and mineral soils. The area of organic soils and mineral soils, respectively, needs to be constant over time unless it is demonstrated that organic and mineral soils are converted over time. The sum of the areas of organic and mineral soils also needs to be constant over time and equal the total national land area , taking account of any areas that do not have soil..

Step 2: Add spatial information to comply with the minimum area and land tracking requirements for activities under the Kyoto Protocol (see Section 2.2 of this report?]. Approach 2 will result in a non-spatially explicit land use matrix, while Approach 3 is spatially explicit.

Step 3: Identify the areas accounted under any other activity that takes precedence over wetland drainage and rewetting and exclude them from the spatial information in step 2 to avoid double-counting.

Step 4: Identify areas on organic soils where drainage or rewetting has taken place since 1990, separately for drained and rewetted areas. Drainage can occur on any land on organic soils regardless of whether it was undrained, rewetted or drained in the base year, in the third case so long as it had been rewetted since the drainage. Areas where since 1990 opposite practises have taken place (e.g. first drained, subsequently rewetted, or the opposite) resulting in the same water regime (and emission/removal characteristics) in the base year and in the commitment period also fall under the wetland drainage and rewetting. Information about drainage and rewetting systems is country-specific. Guidance about how to derive this information is given below.

It is *good practice* to demonstrate with national data the completeness with respect to (1) spatial coverage of organic soils and (2) drainage and rewetting events since the base year.

Approach 2 with supplementary information or approach 3 described in Chapter 3.3.1 of the *2006 IPCC Guidelines* can be chosen for land area identification. For approach 2, existing land-use databases and soil maps may have relevant information. Additional spatially explicit data through sampling or otherwise geographically referenced methods is likely to be necessary to delineate the occurring combinations of land-use categories, land-use changes and drainage and rewetting systems and their changes over time on organic soils. This supplementary information allows creating a detailed non-spatially explicit land-use matrix for the wetland drainage and rewetting activity that tracks changes in land use and drainage over time. The area under the activity wetland drainage and rewetting is cumulative and includes *all* land that has been drained or rewetted since 1990, independent of what the former or later drainage situation was.

Information sources about drainage and rewetting activities since 1990 with adequate disaggregation may include:

- National land use statistics, land use maps and soil maps, maps of water and nature conservation zones with restrictions for water management, wetlands.
- National water management statistics: in most countries, the agricultural land base including croplands is usually surveyed regularly, providing data on distribution of different land uses, crops, tillage practice and other aspects of management, often at sub-national regional level. These statistics may originate, in part, from remote sensing methods, from which additional information about wetness or periods with flooding could be extracted.
- Inventory data from a statistically based, plot-sampling system of water table wells, ditches and surface waters on organic soils: water table is monitored at specific permanent sample plots either continuously or on plots that are revisited on a regular basis. It has to be documented that the water data represent the water table in the organic soil and for what land-use and drainage or rewetting activity or stratum and that the data cover a representative period, which is robust to interannual variability in water table.
- Water management plans and documentation from water management installations.
- Drainage maps.
- Maps of rewetting projects including remote sensing.

The geographical boundaries of identification option 1 (the 'difference approach') include the whole area of organic soils identified after step 3 described above in this section. Approach 2 with supplementary information or approach 3 can be used for identification option 1.

The geographical boundaries of identification option 2 (the 'change approach') identify the areas on which drainage or rewetting activities have occurred since 1990, equivalent to the area after step 4 described above in this section. This included changes in land-use. Only spatially explicit data (approach 3) that allow land tracking on one hectare minimum area is suitable for definition option 2.

2.12.3.3 STRATIFICATION

Stratification options are in principle the same for identification options 1 and 2. Stratification needs to be consistently applied in the base year and the commitment period. The following factors may be useful in establishing a national stratification.

- Land use,
- Drainage regime (water level, seasonality), at least:
  - (xii) undrained / near natural water regime
  - (xiii) drained comparable to the typical water table range of *2013 IPCC Wetlands Supplement* for drained organic soils (Chapter 2 of *2013 IPCC Wetlands Supplement*),
  - (xiv) drained deeper than water level range of *2013 IPCC Wetlands Supplement* for part or all of the year if applicable,
  - (xv) drained more shallow than the water table range of *2013 IPCC Wetlands Supplement* / partially drained or rewetted for part or all of the year if applicable,
- Rewetting regime
  - (xvi) back to near-natural water regime (cf. Chapter 3 of the *2013 IPCC Wetlands Supplement*)
  - (xvii) flooding (maybe further stratified by seasonally flooded or flooded throughout the year) if applicable. Flooding usually only occurs in a transitional period so that the area does not fall into the category of flooded land.

For all resulting subcategories where drainage and rewetting have taken place, the areas afforested, reforested or deforested since 1990 need to be tracked separately as these areas will be reported as units of lands subject to the activity afforestation, reforestation and deforestation. Similarly areas under Forest Management or any elected activity shall be tracked and reported separately.

At higher tiers further subdivision of the area under wetland drainage and rewetting may be useful, e.g. by seasonality of drainage management.

[Guidance to avoid double-counting with other KP activities when identifying land (decision tree, link to Chapter 2.1, 2.2) and other sectors (e.g in agriculture) – to be elaborated]

2.12.4 Choice of methods for estimating greenhouse gas emissions and removals

[Text needs to be elaborated and reflect SOD of *2013 IPCC Wetlands Supplement*, which is not yet available.]

Guidance on relevant methodologies for assessing soil GHG emissions and removals in commitment period and base year

base year emissions and removals: methods, data, proxy approaches

2013 IPCC Wetlands Supplement, drained organic soils: high intensity land use and associated deep drainage assumed (= defaults are high emission). Rewetting deals with optimally rewetted situations (= default is no emission). May lead to overestimated accountable benefits.

Guidance on sufficiency of available Tier 2 methodologies: cf. guidance in *2013 IPCC Wetlands Supplement* on drainage intensity in drained lands and flooded rewetted lands.

It is *good practice* to develop country specific emission factors by land-use category with an additional stratification by drainage intensity, e.g. by including strata by land-use category drained and rewetted more, similar or less than the drainage levels given as defaults in the *2013 IPCC Wetlands Supplement*, applicable to

the strata. Countries are encouraged to develop higher Tier methodologies that consider a dynamic transition time to account for higher greenhouse gas emissions or removals in the years after drainage and rewetting.

At minimum: national data to demonstrate the applicability of the default EFs in the *2013 IPCC Wetlands Supplement* in terms of greenhouse gas emissions and removals and drainage levels. And proxies for additional stratification by drainage intensity.

Carbon pools:

- woody biomass: reference to *2006 IPCC Guidelines*, individual land-use sections and sections 2.x (FM), 2.9 (cropland management), 2.10 (grazing land management) of this supplement. Consistency in reporting and emission factors across elected activities
- organic soils:

(xviii) drained: reference to Chapter 2 of *2013 IPCC Wetlands Supplement*, tier 1 and higher tiers

(xix) partially rewetted: reference to Chapter 2 of *2013 IPCC Wetlands Supplement*, higher tiers

(xx) fully rewetted to natural status: Chapter 3 of *2013 IPCC Wetlands Supplement*, tier 1 and higher tiers

(xxi) flooded: missing (methodology will differ from flooded land because of the transient nature and the re-establishment of vegetation; flooding is shallow compared to reservoirs), reference to Chapter 3 of 2013 IPCC Wetlands Supplement, higher tiers

- Dissolved organic carbon: reference to Chapter 2 and 3 of *2013 IPCC Wetlands Supplement*, tier 1 and higher tiers
- Fire: reference to *2013 IPCC Wetlands Supplement* if applicable
- Extracted peat: how to deal with it, imbalance for areas with peat cut for energy and horticulture: [to be elaborated]

Excluding C pools from accounting: reference to LUCF 2003 GPS and section 2 of this supplement?

N_2O from drainage and rewetting: reference to *2013 IPCC Wetlands Supplement:* reference to Chapter 2 and 3 of *2013 IPCC Wetlands Supplement*, tier 1 and higher tiers

CH_4 from drainage ditches: reference to *2013 IPCC Wetlands Supplement*: reference to Chapter 2 and 3 of *2013 IPCC Wetlands Supplement*, tier 1 and higher tiers

CH_4 from flooding: reference to Chapter 3 of *2013 IPCC Wetlands Supplement,* higher tiers

Issues to be developed further:

Links between KP and UNFCCC reporting (data, methodologies)

Time series consistency since 1990

Interannual variability: should higher Tier methods use long-term or mid-term climate rather than annual climate? Implications for e.g. drainage, yield/residues,… Reference to *2013 IPCC Wetlands Supplement*?

It is *good practice* to include all carbon pools and associated gas emissions and removals reported under the UNFCCC land-use categories and land conversion categories in estimating greenhouse gas emissions and removals of the lands included in wetland drainage and rewetting. Reporting of non-CO2 emissions on lands under wetland drainage and rewetting are often by rule reported under the Agriculture sector and double-counting of the emissions should be avoided. Table 2.12.1 provides general guidance how to avoid double-counting across Activities and sectors.

TABLE 2.12.1	
UNFCCC land-use category or Activity	Checks to avoid double counting and to ensure completeness
Agriculture	Non-CO2 emission for most parts agricultural soils and CO_2 emissions from urea application and liming are reported under Agriculture.
Afforestation, Reforestation, Deforestation	All greenhouse gases are reported under Art. 3.3.
Forest Land	Forest Lands included in Forest Management: All greenhouse gases are reported under Forest Management. Forest Land on organic soils not included in Forest Management: All greenhouse gases are reported under wetland drainage and rewetting.
Cropland	N_2O from drained organic soils and nitrogen input and CH_4 from paddy rice are reported under Agriculture. Cropland included in Cropland Management: CO_2 from drained organic soils, CH4 from drainage ditches and CO_2 from liming is reported under Cropland Management. Cropland on organic soils not included in Cropland Management: CO_2 from drained organic soils, CH_4 from drainage ditches and CO_2 from liming is reported under wetland drainage and rewetting.
Grassland	N_2O from drained organic soils and nitrogen input is reported in the Agriculture sector. Grassland included in Grazing Land Management: CO_2 from drained organic soils, CH_4 from drainage ditches and CO_2 from liming is reported under Grazing Land Management. Grassland on organic soils not included in Grazing Land Management: CO_2 from drained organic soils, CH_4 from drainage ditches and CO_2 from liming is reported under wetland drainage and rewetting.
Wetlands	Peat extracted for energy is reported in the Energy sector. All other greenhouse gas emissions including peat extracted for horticulture are reported under wetland drainage and rewetting.
Settlements	All greenhouse gas emissions are reported under wetland drainage and rewetting.
Other Land	All greenhouse gas emissions are reported under wetland drainage and rewetting.
Revegetation	Revegetation is defined according to national specific criteria so that no general guidance can be given.

6393

6394

References

COMMON TO THE ENTIRE DOCUMENT

IPCC (1997). Revised 1996 IPCC Guidelines for Greenhouse Gas Inventories - Vol 3 Chp 5 Land Use Change and Forestry. IPCC/OECD/IEA, 76 p.

IPCC (2003). Good Practice Guidance for Land Use, Land-Use Change and Forestry. In: Penman J., Gytarsky M., Hiraishi T., Krug T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Eds). Intergovernmental Panel of Climate Change (IPCC), IPCC/IGES, Hayama, Japan.

IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

UNFCCC 2006. Decision 16/CMP.1: Land use, land-use change and forestry.FCCC/KP/CMP/2005/8/Add.3, United Nations Framework Convention on Climate Change, Bonn, Germany, unfccc.int/resource/docs/2005/cmp1/eng/08a03.pdf

UNFCCC 2011. Decision 2/CMP.6: The Cancun Agreements: Land use, land-use change and forestry. FCCC/KP/CMP/2010/12/Add.1, United Nations Framework Convention on Climate Change, Bonn, Germany, http://unfccc.int/resource/docs/2010/cmp6/eng/12a01.pdf#page=5

UNFCCC 2012. Decision 2/CMP.7: Land use, land-use change and forestry. FCCC/KP/CMP/2011/10/Add.1, United Nations Framework Convention on Climate Change, Bonn, Germany, http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf#page=11

SECTION 1.1 THROUGH SECTION 2.4

Allen C.D., Macalady A.K., Chenchouni H., Bachelet D., McDowell N., Vennetier M., Kitzberger T., Rigling A., Breshears D.D., Hogg E.H. (Ted), Gonzalez P., Fensham R., Zhang Z., Castro J., Demidova N., Lim J.-H., Allard G., Running S.W., Semerci A., Cobb N. (2010).l A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. Forest Ecology and Management 259(4), 660-684.

Batjes. N.H 2011 Soil organic carbon stocks under native vegetation - Revised estimates for use with the simple assessment option of the Carbon Benefits Project system. Agriculture, Ecosystems and Environment, 142, 9.

Bebi P., Kulakowski D., Rixen C. (2009). Snow avalanche disturbances in forest ecosystems-State of research and implications for management. Forest Ecology and Management 257(9), 1883-1892.

Bentz B.J., Régnière J., Fettig C.J., Hansen E.M., Hayes J.L., Hicke J.A., Kelsey R.G., Negrón J.F., Seybold S.J. (2010). Climate change and bark beetles of the western United States and Canada: direct and indirect effects. Bioscience 60(8): 602-613.

Bokalo, M., S. J. Titus, and D. P. Wiens 1996. Sampling with partial replacement extended to include growth projections. Forest Science, 42, 7.

Canadian Council of Forest Minister (2012a). Forest pest monitoring in Canada [electronic resource]: current situation, compatibilities, gaps and proposed enhanced monitoring program.

Canadian Council of Forest Minister (2012b). Forest pest knowledge collection and exchange [electronic resource]: Pest Strategy Information System.

Canadian Council of Forest Minister (2012c). National forest insect and disease diagnostic and taxonomic resources and tools [electronic resource]: current situation and future considerations.

Congalton, R. G. A. K. G. 2009. Assessing the Accuracy of Remotely Sensed Data: Principles and Practices, Boca Raton, CRC Press.

Dymond, C.C., E.T. Neilson, G. Stinson, K. Porter, D.A. MacLean, D.R. Gray, M. Campagna, and W.A. Kurz, 2010, Future spruce budworm outbreak may create a carbon source in Eastern Canadian forests, Ecosystems 13: 917–931 DOI: 10.1007/s10021-010-9364-z.

Fleming, R. A., J. N. Candau and R. S. McAlpine (2002). "Landscape-scale analysis of interactions between insect defoliation and forest fire in Central Canada." Climatic Change 55(1-2): 251-272.

Fuller, R. M., G. M. Smith and B. J. Devereux (2003): "The characterisation and measurement of land cover change through remote sensing: problems in operational applications?" International Journal of Applied Earth Observation and Geoinformation 4(3): 243 - 253.

6445 Girardin M.P., Ali A.A., Hély C. (2010). Wildfires in boreal ecosystems: past, present and some emerging trends.
6446 International Journal of Wildland Fire 19, 991–995.

6447 Griffis T.J, T. A. B., K. Morgenstern, A. G. Barr, Z. Nesic, G. B. Drewitt, D. Gaumont-Guay and J. H.
6448 Mccaughey 2003. Ecophysiological controls on the carbon balances of three southern boreal forests.
6449 Agricultural and Forest Meteorology, 117, 19.

6450 Hicke, J.A., Allen, C.D., Desai, A.R., Dietze, M.C., Hall, R.J., Hogg, E.H., Kashian, D.M., Moore, D., Raffa,
6451 K.F., Sturrock, R.N., and Vogelmann, J. 2012. Effects of biotic disturbances on forest carbon cycling in the
6452 United States and Canada. Global Change Biol. 18(1): 7−34.

6453 Hirsch, K.G. and Fuglem, P., Technical Coordinators (2006). Canadian Wildland Fire Strategy: background
6454 syntheses, analyses, and perspectives. Canadian Council Forest Ministers, Natural Resources Canada,
6455 Canadian Forest Service, Northern Forestry Centre, Edmonton, AB.

6456 IPCC 2003. Definitions and Methodological Options to Inventory Emissions from Direct Human-induced
6457 Degradation of Forests and Devegetation of Other Vegetation Types. In: Penman J., Gytarsky M., Hiraishi T.,
6458 Krug T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., Wagner F. (Eds).
6459 Intergovernmental Panel of Climate Change (IPCC), IPCC/IGES, Hayama, Japan.

6460 IPCC 2010. Revisiting the Use of Managed Land as a Proxy for Estimating National Anthropogenic Emissions
6461 and Removals. In: EGGLESTON H.S., S. N., TANABE K., BAASANSUREN J. (ed.). IGES, Japan.

6462 Kamijo T. & Hashiba K. (2003). Island ecosystem and vegetation dynamics before and after the 2000-Year
6463 eruption on Miyake-jima island, Japan, with implications for conservation of the island's ecosystem. Global
6464 Environmental Research, 7, 69-78.

6465 Kato A. (2008). Characteristics for Sugi (Cryptomeria japonica D. Don) Stands and Trees with High Snow
6466 Accretion Damage Risk in Toyama Prefecture. FORMATH, 8, 45-61. (in Japanese with English abstract)

6467 Kramer K., Vreugdenhil S.J., van der Werf D.C. (2008). Effects of flooding on the recruitment, damage and
6468 mortality of riparian tree species: A field and simulation study on the Rhine floodplain. Forest Ecology and
6469 Management 255(11), 3893–3903.

6470 Kurz, W.A., Dymond, C.C., White, T.M., Stinson, G. , Shaw, C.H., Rampley, G.J., Smyth, C., Simpson, B.N.,
6471 Neilson, E.T., Trofymow, J.A., Metsaranta, J., Apps, M.J. (2009). CBM-CFS3: a model of carbon-dynamics
6472 in forestry and land-use change implementing IPCC standards, Ecological Modelling 220: 480-504,
6473 doi:10.1016/j.ecolmodel.2008.10.018.

6474 Kurz, W.A, C.C. Dymond, G. Stinson, G. J. Rampley, E.T. Neilson, A. L. Carroll, T. Ebata, and L. Safranyik.
6475 (2008). Mountain pine beetle and forest carbon feedback to climate change, Nature 452:987-990,
6476 doi:10.1038/nature06777.

6477 Kurz, W.A. 2010. Large inter-annual variations in carbon emissions and removals, Invited background paper,
6478 pages 41-48. In: IPCC 2010, Revisiting the Use of Managed Land as a Proxy for Estimating National
6479 Anthropogenic Emissions and Removals, eds: Eggleston H.S., Srivastava N., Tanabe K., Baasansuren J.
6480 Meeting Report, 5 -7 May, 2009, INPE, São José dos Campos, Brazil, Pub. IGES, Japan 2010

6481 Kurz, W.A., Dymond, C.C., White, T.M., Stinson, G. , Shaw, C.H., Rampley, G.J., Smyth, C., Simpson, B.N.,
6482 Neilson, E.T., Trofymow, J.A., Metsaranta, J., Apps, M.J. (2009). CBM-CFS3: a model of carbon-dynamics
6483 in forestry and land-use change implementing IPCC standards, Ecological Modelling 220: 480-504,
6484 doi:10.1016/j.ecolmodel.2008.10.018.

6485 Li, W., P. Zhang, J. Ye, L. Li and P.A. Baker. 2011. Impact of two different types of El Niño events on the
6486 Amazon climate and ecosystem productivity. Journal of Plant Ecology, 4, 9.

6487 Lilles and, T. M., R. W. Kiefer and J. W. Chipman 2008. Remote Sensing and Image Interpretation, New York,
6488 John Wiley & Sons, Inc.

6489 Lindner M., Maroschek M., Netherer S., Kremer A., Barbati A., Garcia-Gonzalo J., Seidl R., Delzon S., Corona
6490 P., Kolström M., Lexer M.J., Marchetti M. (2010). Climate change impacts, adaptive capacity, and
6491 vulnerability of European forest ecosystems, Forest Ecology and Management, Volume 259, Issue 4, 5
6492 February 2010, Pages 698-709.

6493 Martin, P. H., T. J. Fahey and R. E. Sherman (2011). "Vegetation Zonation in a Neotropical Montane Forest:
6494 Environment, Disturbance and Ecotones." Biotropica 43(5): 533-543.

6495 McCullough, D. G. (2000). "A review of factors affecting the population dynamics of jack pine budworm
6496 (Choristoneura pinus pinus Freeman)." Population Ecology 42(3): 243-256.

Perry, D. A., P. F. Hessburg, C. N. Skinner, T. A. Spies, S. L. Stephens, A. H. Taylor, J. F. Franklin, B. McComb and G. Riegel (2011). "The ecology of mixed severity fire regimes in Washington, Oregon, and Northern California." Forest Ecology And Management 262(5): 703-717.

Phillips O.L., Aragão L.E.O.C., Lewis S.L., Fisher J.B., Lloyd J., López-González G., Malhi Y., Monteagudo A., Peacock J., Quesada C.A., van der Heijden G., Almeida S., Amaral I., Arroyo L., Aymard G., Baker T.R., Bánki O., Blanc L., Bonal D., Brando P., Chave J., Alves de Oliveira Á.C., Dávila Cardozo N., Czimczik C.I., Feldpausch T.R., Freitas M.A., Gloor E., Higuchi N., Jiménez E., Lloyd G., Meir P., Mendoza C., Morel A., Neill D.A., Nepstad D., Patiño S., Peñuela M.C., Prieto A., Ramírez F., Schwarz M., Silva J., Silveira M., Sota Thomas A., ter Steege H., Stropp J., Vásquez R., Zelazowski P., Alvarez Dávila E., Andelman S., Andrade A., Chao K., Erwin T., Di Fiore A., Honorio C., Keeling E., Killeen H., Laurance T.J., Peña Cruz W.F., Pitman A., Núñez Vargas N.C.A., Ramírez-Angulo P., Rudas H., Salamão A., Silva R., Terborgh N., Torres-Lezama J.A. (2009). Drought sensitivity of the Amazon rainforest. Science 323, 1344–1347.

Raffa K.F., Aukema B.H., Bentz B.J., Carroll A.L., Hicke J.A., Turner M.G., Romme W.H. (2008). Cross-scale drivers of natural disturbances prone to anthropogenic amplification: the dynamics of bark beetle eruptions. Bioscience 58, 501–517.

Richards, G. 2010. Background Paper to the IPCC Expert Meeting Revisiting the use of Managed Land as a Proxy for Estimating Anthropogenic Emissions and Removals, pages 30-38. In: IPCC 2010, Revisiting the Use of Managed Land as a Proxy for Estimating National Anthropogenic Emissions and Removals, eds: Eggleston H.S., Srivastava N., Tanabe K., Baasansuren J. Meeting Report, 5 -7 May, 2009, INPE, São José dos Campos, Brazil, Pub. IGES, Japan 2010

Rouault, G., J. N. Candau, F. Lieutier, L. M. Nageleisen, J. C. Martin and N. Warzee (2006). "Effects of drought and heat on forest insect populations in relation to the 2003 drought in Western Europe." Annals Of Forest Science 63(6): 613-624.

Smith P., Powlson D.S., Glendining M.J., Smith J.U. (1998). Preliminary estimates of the potential for carbon mitigation in European soils through no-till farming. Global Change Biology, 4: pp. 679-685.

Tate K.R., Scott N.A., Saggar S., Giltrap D.J., Baisden W.T., Newsome P.F., Trotter C.M., Wilde R.H. (2003). Land-use change alters New Zealand's terrestrial carbon budget: uncertainties associated with estimates of soil carbon change between 1990-2000. Tellus, 55B: pp. 364-377.

Tomppo, E.,,Gschwantner, T., Lawrence, M., McRoberts, R.E. (Eds.) (2010): National Forest Inventories – Pathways for Common Reporting, Springer: USA, p. 612, ISBN978-90-481r-r3232-4.

Xiao, J. F. and Q. L. Zhuang (2007). "Drought effects on large fire activity in Canadian and Alaskan forests." Environmental Research Letters 2(4).

Yamashita A., Sano J. & Yamamoto S. (2002). Impact of a strong typhoon on the structure and dynamics of an old-growth beech (Fagus crenata) forest, southwestern Japan. Folia Geobotanica, 37, 5-16.

SECTION 2.5 THROUGH SECTION 2.7

Davis M.R. and Condron L.M. (2002). Impact of grassland afforestation on soil carbon in New Zealand: a review of paired-site studies. *Soil Research 40*: pp. 675-690

Guo, L.B. and Gifford R.M. (2002). Soil carbon stocks and land use change: a meta analysis. *Global Change Biology,* 8: pp. 345-360.

IPCC 2010, Use of Models and Facility-Level Data in Greenhouse Gas Inventories (Report of IPCC Expert Meeting on Use of Models and Measurements in Greenhouse Gas Inventories 9-11 August 2010, Sydney, Australia) eds: Eggleston H.S., Srivastava N., Tanabe K., Baasansuren J., Fukuda M., GHG Pub. IGES, Japan 2010.

Merino A., Perez-Batallon P., Macıas F. (2004). Responses of soil organic matter and greenhouse gas fluxes to soil management and land use changes in a humid temperate region of southern Europe. *Soil Biology & Biochemistry 36:pp.* 917–925

Paul K.I., Polglase P.J., Richards G.P. (2003). Predicted change in soil carbon following afforestation or reforestation, and analysis of controlling factors by linking a C accounting model (CAMFor) to models of forest growth (3PG), litter decomposition (GENDEC) and soil C turnover (RothC). *Forest Ecology and Management 177*: pp. 485–501

Post W. M. and Kwon K.C. (2000). Soil carbon sequestration and land-use change: processes and potential. *Global Change Biology 6*: pp. 317-327

6550 Schulp C.J.E., Nabuurs G., Verburg P.H. (2008). Future carbon sequestration in Europe—Effects of land use
6551 change. *Agriculture, Ecosystems and Environment 127*: pp. 251–264

6552 Tate K.R., Scott N.A., Saggar S., Giltrap D.J., Baisden W.T., Newsome P.F., Trotter C.M., Wilde R.H. (2003).
6553 Land-use change alters New Zealand's terrestrial carbon budget: uncertainties associated with estimates of
6554 soil carbon change between 1990-2000. *Tellus,* 55B: pp. 364-377.

6555 Vesterdal L., Ritter E., Gundersen P. (2002). Change in soil organic carbon following afforestation of former
6556 arable land. *Forest Ecology and Management 169*: pp. 137-147

6557 **SECTION 2.8**

6558 Brown, S., Lim, B. and Schlamadinger, B. (1998). Evaluating Approaches for Estimating Net Emissions of
6559 Carbon Dioxide from Forest Harvesting and Wood Products. IPCC/OECD/IEA Programme on National
6560 Greenhouse Gas Inventories, 20 p.

6561 Cowie, A., Pingoud, K. and Schlamadinger, B. (2006). Stock changes or fluxes? Resolving terminological
6562 confusion in the debate on land-use change and forestry. *Climate Policy* **6**: 161-179.

6563 European Union (2010). Specific guide for Life Cycle Inventory data sets. First edition March 2010.Publications
6564 Office of the European Union, International Reference Life Cycle Data System (ILCD) Handbook, EUR
6565 24709 EN, 142 p.

6566 FAO (2009). Forest Products 2005-2009. FAO Yearbook, Forestry Series No. 44, Statistics Series No. 200, 337
6567 p.

6568 FAO (2012). FAOSTAT-Forestry Database [online]. Food and Agriculture Organization of the United Nations
6569 (FAO) <http://faostat.fao.org/>

6570 Forest Products Laboratory (2010). Wood Handbook: Wood as an Engineering Material. United States
6571 Department of Agriculture, General Technical Report, FPL–GTR–190, 509 p.

6572 Gjesdal, S.F.T., *et al.* (1996). A balance of use of wood products in Norway. Norwegian Pollution Control
6573 Authority SFT, Report 96:04, 54 p.

6574 IPCC (2006). IPCC Guidelines for Greenhouse Gas Inventories - Vol 4 Agriculture, Forestry and other Land Use.
6575 In: Eggleston S., Buendia L., Miwa K., Ngara T., Tanabe K. (Eds). IEA/OECD, IPCC National Greenhouse
6576 Gas Inventories Programme, Technical Support Unit, Hayama, Kanagawa, Japan.

6577 ISO (2006). Umweltmanagement - Ökobilanz - Anforderungen und Anleitungen. *DIN EN ISO 14044:2006-10*.

6578 ISO (2006). Umweltmanagement - Ökobilanz - Grundsätze und Rahmenbedingungen. *DIN EN ISO 14040:2006-*
6579 *10*.

6580 ISO (2008). Buildings and constructed assets - Service life planning - Part 8: Reference service life and service
6581 life estimation. *ISO 15686-8:2008(E)*.

6582 ISO (2011). Buildings and constructed assets - Service life planning - Part 1: General Principles. *ISO 15686-*
6583 *1:2011(E)*.

6584 Johannsen, V.K., Nord-Larsen, T. and Suadicani, K. (2011). Submission of information on forest management
6585 reference levels by Denmark. Forest & Landscape Denmark, Forest & Landscape Working Papers No. 58-
6586 2011, 35 p.

6587 Kangas, K. and Baudin, A. (2003). Modelling and Projections of Forest Products Demand, Supply and Trade in
6588 Europe. United Nations Economic Commission for Europe (UNECE), Timber Section, ECE/TIM/DP/30, 206
6589 p.

6590 Karjalainen, T., Kellomäki, S. and Pussinen, A. (1994). Role of wood-based products in absorbing atmospheric
6591 carbon. *Silva Fennica* **28**(2): 67–80.

6592 Marland, E., Stellar, K. and Marland, G. (2010). A distributed approach to accounting for carbon in wood
6593 products. *Mitigation and Adaptation Strategies for Global Change* **15**(1): 71-91.

6594 Pingoud, K., Perälä, A.L. and Pussinen, A. (2001). Carbon Dynamics in Wood Products. *Mitigation and*
6595 *Adaptation Strategies for Global Change* **6**(2): 91-111.

6596 Pingoud, K. and Wagner, F. (2006). Methane Emissions from Landfills and Carbon Dynamics of Harvested
6597 Wood Products: The First-Order Decay Revisited. *Mitigation and Adaptation Strategies for Global Change*
6598 **11**(5): 961-978.

6599 Rüter, S. (2011). Projection of Net-Emissions from Harvested Wood Products in European Countries - For the
6600 period 2013-2020. Thünen-Institute of Wood Research, Report No: 2011/01, 63 p.

6601 Rüter, S. and Diederichs, S. (2012). Ökobilanz-Basisdaten für Bauprodukte aus Holz. Thünen-Institute of Wood
6602 Research, Report No: 2012/01, 316 p.

6603 Skog, K. and Nicholson, G.A. (1998). Carbon cycling though wood products: the role of wood and paper
6604 products in carbon sequestration. *Forest Products Journal* **48**(7/8): 75-83.

6605 Statistics Finland (2011). Greenhouse gas emissions in Finland 1990-2008: National Inventory Report under the
6606 UNFCCC and the Kyoto Protocol. 470 p.

6607 Tsunetsugu, Y. and Tonosaki, M. (2010). Quantitative estimation of carbon removal effects due to wood
6608 utilization up to 2050 in Japan: effects from carbon storage and substitution of fossil fuels by harvested wood
6609 products. *Journal of Wood Science* **56**(4): 339-344.

6610 Wilson, J.B. (2010). Life-Cycle Inventory of Particleboard in Terms of Resources, Emissions, Energy and
6611 Carbon. *Wood and Fiber Science* **42**(1): 90-106.

6612 Winjum, J.K., Brown, S. and Schlamadinger, B. (1998). Forest Harvests and Wood Products: Sources and Sinks
6613 of Atmospheric Carbon Dioxide. *Forest Science* **44**(2): 272-284.

6614 **SECTION 2.9 THROUGH SECTION 2.12**

6615 Akala V A. And Lal R..2000.Potential Of Mine Land Reclamation For Soil Organic Carbon Sequestration In
6616 Ohio.Land Degrad. Develop. 11: 289-297.

6617 Andreae, M O, Merlet, P. 2001. Emission of trace gases and aerosols from biomass burning. Global
6618 Biogeochemical Cycles 15:955-966.Cofer III, W R, Levine, J S, Winstead, E L, Cahoon, D R, Sebacher, D I,
6619 Pinto, J P, Stocks, B J. 1996. Source compositions of trace gases released during African savanna fires.
6620 Journal of Geophysical Research D: Atmospheres 101:23597-23602.

6621 Cowie A L, Penman T. D, Gorissen L. Winslow M. D,Lehmann J., Tyrrell T. D. et al.2011.sustainable land
6622 management in the drylands: scientific connections in monitoring and assessing dryland degradation, climate
6623 change and biodiversity.Land Degrad. Develop. 22: 248–260

6624 Cowie A, Schneider U A, Montanarella L. 2007.Potential synergies between existing multilateral environmental
6625 agreements in the implementation of land use, land-use change and forestry activities. Environmental science
6626 and policy,10,335 – 352

6627 De Steven D, Sharitz R R, Singer J H,Barton C D. 2006.Testing a Passive Revegetation Approach for Restoring
6628 Coastal Plain Depression Wetlands. Restoration Ecology,14(3): 452–460

6629 Gessesse T A.Assessment of the impact of different revegetation methods on soil carbon stocks in iceland. Land
6630 Restoration Training ProgrammeFinal project 2009

6631 Hirata, R, Miyata, A, Mano, M, Shimizu, M, Arita, T, Kouda, Y, Matsuura, S, Niimi, M, Mori, A, Saigusa, T,
6632 Hojito, M, Kawamura, O, Hatano, R. 2013. Carbon dioxide exchange at four intensively managed grassland
6633 sites across different climate zones of japan and the influence of manure application on ecosystem carbon and
6634 greenhouse gas budgets. Agricultural And Forest Meteorology (in review).

6635 Holden J, Gascoign M, Bosanko N R. 2007.Erosion and natural revegetation associated with surface land drains
6636 in upland peatlands Earth Surface Processes and Landforms .Earth Surf. Process. Landforms, 32, 1547–1557

6637 IPCC Report on Definitions and Methodological Options to Inventory Emissions from Direct Human-induced
6638 Degradation of Forests and Devegetation of Other Vegetation Types

6639 Jiang S.-C., He N.-P., Wu L. & Zhou D.-W. 2010. Vegetation restoration of secondary bare saline-alkali patches
6640 in the Songnen plain, China .Applied Vegetation Science, 13: 47–55

6641 Madej M A., Seney J, van Mantgem P.2012 .Effects of Road Decommissioning on Carbon Stocks, Losses, and
6642 Emissions in North Coastal California. Restoration Ecology, doi: 10.1111/j.1526-100X.2012.00911.x

6643 Mitchell A. Pavao-Zuckerman.2008.The Nature of Urban Soils and Their Role in Ecological Restoration in
6644 Cities. Restoration Ecology,16(4),642–649

6645 Muzzi E,Fabbri T.2007.revegetation Of Mineral Clay Soils: Shrub And Tree Species Compared.land Degrad.
6646 Develop. 18: 441–451

6647 Pavao-Zuckerman M A. 2008.The Nature of Urban Soils and Their Role in Ecological Restoration in Cities.
6648 Restoration Ecology, 16(4): 642–649

6649 Pickup M, Wilson S, Freudenberger D, Nicholls N Gould L, Hnatiuk S, Delandre J.2012.Post-fire recovery of
6650 revegetated woodland communities in south-eastern Australia. Austral Ecology, doi:10.1111/j.1442-
6651 9993.2012.02404.x

6652 Reid N B, M. Naeth A.2005.Establishment of a Vegetation Cover on Tundra Kimberlite Mine Tailings: 1. A
6653 Greenhouse Study. Restoration Ecology, 13(4):594–601

6654 Shimizu, M, Hatano, R, Arita, T, Kouda, Y, Mori, A, Matsuura, S, Niimi, M, Jin, T, Desyatkin, A R, Kawamura,
6655 O, Hojito, M, Miyata, A. 2013. The effect of fertilizer and manure application on ch4 and n2o emissions
6656 from managed grasslands in japan. Soil Science and Plant Nutrition 59 (in press).

6657 Shirato, Y, Hakamata, T, Taniyama, I. 2004. Modified rothamsted carbon model for andosols and its validation:
6658 Changing humus decomposition rate constant with pyrophosphate-extractable al. Soil Science and Plant
6659 Nutrition 50, 149-158.

6660 Sigurdsson B D,Snorrason A. 2000.Carbon sequestration by afforestation and revegetation as a means of limiting
6661 net-CO2 emissions in Iceland.Biotechnol. Agron. Soc. Environ. 4 (4), 303–307

6662 Simmers S M, Galatowitsch S M. 2010.Factors Affecting Revegetation of Oil Field Access Roads in Semiarid
6663 Grassland .Restoration Ecology ,18(S1): 27–39

6664 Skrindo, A.B. & Halvorsen, R. 2008.Natural revegetation on forest topsoil and subsoil along roadsides in boreal
6665 forest .Applied Vegetation Science doi: 10.3170/2008-7-18552

6666 Smith P. 2004.Soils as carbon sinks: the global context. Soil Use and Management,20, 212-218

6667 Soini P, Riutta T, Yli-Pet¨ays M, Vasander H. 2010.Comparison of Vegetation and CO2 Dynamics Between a
6668 Restored Cut-Away Peatland and a Pristine Fen: Evaluation of the Restoration Success.Restoration
6669 Ecology ,18(6), 894–903

6670 Tormo J, Bochet E, Garcı´a-Fayos P. 2007. Roadfill Revegetation in Semiarid Mediterranean Environments. Part
6671 II: Topsoiling, Species Selection, and Hydroseeding. Restoration Ecology ,15(1):97–102

6672 Tripathi K P, Singh B.2005.The Role of Revegetation for Rehabilitation of Sodic Soils in Semiarid Subtropical
6673 Forest, India.Restoration Ecology, 13(1):29–38

6674 Worrall F, Rowson J. G., Evans M. G, Pawson R, Daniels S,Bonn A. 2011.Carbon fluxes from eroding peatlands
6675 – the carbon benefit of revegetation following wildfire.Earth Surf. Process. Landforms,36, 1487–1498

6676 Young I W. R, Naguit C, Halwas S J, Renault S,and Markham J H. 2012.Natural Revegetation of a Boreal Gold
6677 Mine Tailings Pond .Restoration Ecology,2012