CHAPTER 2

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

Sections 2.1, 2.2, 2.3.1–2.3.8, 2.4 and Annex 2A.1

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Chapter 2 of the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* (*KP Supplement*) provides a description of generic methodological issues concerning all possible land use, land-use change and forestry (LULUCF) activities under Kyoto Protocol (KP) Articles 3.3 and 3.4. Section 2.1 deals with the relationship between land-use categories in reporting under the United Nations Framework Convention on Climate Change (UNFCCC) and the KP, Section 2.2 deals with land areas, Section 2.3 with estimating carbon stock changes and non-CO_2 GHG emissions, including those from natural disturbances (Section 2.3.9), and Section 2.4 deals with other generic methodological issues. These are followed by specific methodologies related to Afforestation (A) and Reforestation (R) (treated together), Deforestation (D), Forest Management (FM), Harvested Wood Products (HWP), Cropland Management (CM), Grazing Land Management (GM), Revegetation (RV), and Wetland Drainage and Rewetting (WDR) (Sections 2.5 – 2.12). Readers should refer to both the generic and the specific methodologies for any one of these activities.

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

This section provides an overview of the relation between the activities under Articles 3.3 and 3.4 and the land-use categories introduced in Chapter 2, Volume 4 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (*2006 IPCC Guidelines*).

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

(i) Forest Land (Chapter 4)

(ii) Cropland (Chapter 5)

(iii) Grassland (Chapter 6)

(iv) Wetlands (Chapter 7)

(v) Settlements (Chapter 8)

(vi) Other Land (Chapter 9)

The relationships between the basic land-use categories (i) to (vi), described in Chapter 3, Volume 4 of the *2006 IPCC Guidelines* and the activities of the KP (Articles 3.3 and 3.4), are summarised in Table 2.1.1. Land subject to KP activities should be identified as a subcategory of one of these six main categories. There are no reporting or accounting requirements for emissions from unmanaged land categories under the KP or the UNFCCC. However, for completeness of reporting and consistency of time series, it is *good practice* to report the total area of the country including those areas not subject to any activity as well as the area of lands classified as unmanaged lands under the UNFCCC.

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 LULUCF GHG 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 (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 Chapter 1 and Section 2.1 to 2.4 of this supplement or in Volume 4 of the *2006 IPCC Guidelines*. It is recommended also to refer to relevant sections of the *2013 Supplement to the 2006 IPCC Guidelines for*

National Greenhouse Gas Inventories: Wetlands (*Wetlands Supplement*)[1]. For continuity and clarity, cross-references to these methods appear periodically in Boxes. For KP reporting, spatial stratification beyond that provided in the reporting tables in Volume 1 of the *2006 IPCC Guidelines* is required, and for the second Commitment Period (CP), additional reporting categories have been introduced. Section 2.4.4 introduces the additional reporting requirements and Annex 2A.1 to this document provides draft reporting tables.

TABLE 2.1.1
SUMMARY OF THE RELATIONSHIP BETWEEN UNFCCC LAND-USE CATEGORIES AND ACTIVITIES UNDER THE KP DURING THE CP

Transitions are from the "initial" to the "final" land-use category, indicating which KP Article 3.3 or 3.4 activities may have occurred on that land. Bold font indicates mandatory reporting activities; regular font indicates elective activities where the classification depends on the election of Article 3.4 activities by a country. Note that all possible LULUCF transitions have not been included in this table, only those which can be reported under Article 3.3 or 3.4 activities.

Initial \ Final	Managed Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land
Unmanaged Forest Land**	**FM**	**D****	**D****	**D**	**D**	**D**
Managed Forest Land	**FM, AR[a]**	**D****	**D****	**D**	**D**	**D**
Cropland	**AR***	CM, RV, WDR***	CM[#], GM, RV, WDR***	CM,RV, WDR***	CM****,RV	CM****
Grassland	**AR*, FM**	CM, GM[##], RV, WDR***	GM, RV, WDR***	GM, WDR***	GM****	GM****
Wetlands	**AR*, FM**	CM, RV, WDR***	GM, RV, WDR***	RV, WDR***	RV, WDR***	WDR***
Settlements	**AR***	CM, RV, WDR***	GM, RV, WDR***	RV, WDR***	RV	
Other Land	**AR*, FM**	CM, RV	GM, RV	RV, WDR***	RV	

Notes

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

a Twenty years after afforestation or reforestation land transitions from land converted to forest land to forest land remaining forest land but under KP this land continues to be reported as AR.

* If the conversion is direct human-induced then classify as AR which takes precedence over FM and therefore although the land is subject to FM, it is reported under AR. If the conversion is not direct human-induced, and the definition of FM is met, then the land is reported in FM.

** D takes precedence over cropland/grassland categories.

*** When elected, WDR only applies on land which is not accounted for under any Article 3.3, FM or other elected Article 3.4 activity

**** Once land has been reported under any Article 3.3 or 3.4 activity during a CP, it must continue to be reported.

Only if CM is elected and GM is not elected.

Only if GM is elected and CM is not elected.

Figures 2.1.1 and 2.1.2 exemplify the relationship between these land-use categories reported in national inventories under the UNFCCC and those under Articles 3.3 and 3.4 of the KP in any single reporting year. The outer rectangle represents the boundaries of a hypothetical country. Figure 2.1.1 shows the reporting categories

[1] The IPCC also produced the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (*Wetlands Supplement*) in parallel to this document in October 2013. The *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.

for the UNFCCC national inventory according to Volume 4 of the *2006 IPCC Guidelines*, and Figure 2.1.2 includes additional categories resulting from reporting requirements under the KP.

Figure 2.1.1 **Land use categories in the national inventories under the UNFCCC for a hypothetical country in year X of the CP. Emissions from unmanaged forests and unmanaged grasslands are not reported in UNFCCC inventories.**

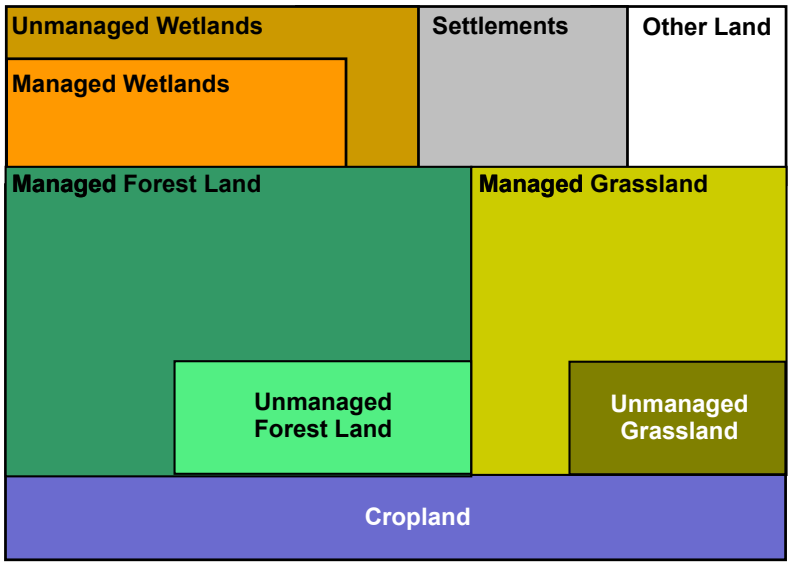
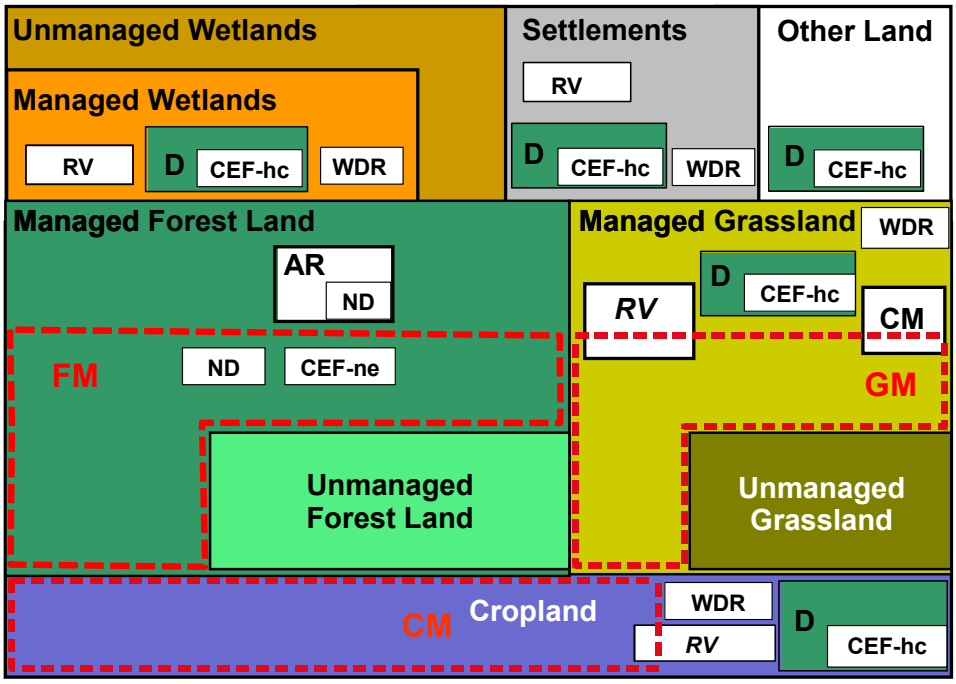


Figure 2.1.2 **Land in Article 3.3 and 3.4 activities for KP reporting for a hypothetical country in year X of the CP. This classification corresponds to the "final" status in Table 2.1.1[2]. See text for further explanation.**



[2] A- Afforestation; R- Reforestation; D- Deforestation; FM- Forest Management; CM- Cropland Management; GM- Grazing Land Management; RV- Revegetation; WDR- Wetland Drainage and Rewetting; ND - Natural Disturbances (ND in AR or FM that are subject to the provision to exclude emissions from the accounting.), CEFC- Carbon Equivalent Forest Conversion, CEF-hc: area where trees have been harvested and converted to non-forest land, CEF-ne: areas where equivalent forest has been newly established;

Figure 2.1.1 shows that under UNFCCC LULUCF reporting assigns a land-use category to all land within the country, while Figure 2.1.2 shows that KP Article 3.3 and 3.4 activities cover a sub-set of the total land area. KP reporting is complicated by two additional issues:

(i) KP reporting is backward looking, because the history of land use may be important in the determination of the activity under which a given land area should be reported; and

(ii) Parties have some flexibility in the definitions of which land-use category is to be included within a given Article 3.4 activity. See section 1.2.

In Figure 2.1.2, the dashed lines delineate areas subject to FM, and two of the elective activities under Article 3.4, CM and GM. RV can occur on various land-use categories. By definition, WDR can only occur on lands that are not already subject to one of the other Article 3.4 or Article 3.3 activities. The area subject to FM can be different, where this occurs usually smaller, than the area of managed forest under UNFCCC reporting because (i) countries could use different thresholds for defining forests for the KP and UNFCCC reporting, (ii) Article 3.4 requires that the management activity took place since 1990, and (iii) land subject to AR after 1990 transitions to Forest Land after 20 years under UNFCCC but remains in AR under the KP. Parties are encouraged to adopt definitions of land use and Article 3.4 activities which are consistent with each other. It is acknowledged that this may not be possible in all circumstances. 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 FM). Emissions and removals on unmanaged forests that remain unmanaged are included in neither UNFCCC nor KP reporting. The area of unmanaged land is reported under UNFCCC, and should, for example, a human-induced deforestation event occur in unmanaged forests, the associated emissions would be reported as D event under Article 3.3, or in the case of drainage of a natural wetland to cropland, the emissions could be reported under CM or WDR depending on the activities elected by the country. Lands for which emissions from natural disturbances are not reported (see Section 2.3.9 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 a CEFC include both the land area that was harvested and converted to non-forest land, CEF-hc and the previously non-forest land on which the equivalent plantation was newly established, CEF-ne and both of these are reported in FM, (see Section 2.7.7 for additional requirements).

Although, for KP reporting lands subject to CM can be similar to Cropland/arable/tillage lands in UNFCCC reporting, flexibility exists especially with regard to woody crops. In cases where there is conversion of forest land to cropland, these lands are reported under Article 3.3 D. Where GM is elected and CM is not, land subject to conversion from GM to Cropland during the CP continues to be reported (though the emissions and removals on that land could be accounted as zero if the land was GM in the base year, see Section 1.3) under GM because land cannot transition from an elected to an unelected Article 3.4 activity. The same argument is valid in the situation where there is a transition from CM to GM and CM is elected while GM is not.

GHG emissions and removals on unmanaged grasslands are excluded from both the UNFCCC and the KP reporting, however it is *good practice* to include the area of unmanaged lands in the KP reporting together with all other lands not subject to any activity under the UNFCCC.

Lands subject to AR are always managed forests but carbon stock changes and non-CO_2 GHG emissions are to be reported under Article 3.3 (AR) only.

Deforested lands are managed (thus, for instance, 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 2/CMP.7 and 2/CMP.8 state that those areas of land subject to Article 3.3 and 3.4 activities must be identifiable[3], adequately reported[4] and tracked over time.[5] Section 2.2.2 discusses two land reporting methods that can be applied to all Article 3.3 and 3.4 activities. Section 2.2.3 introduces the additional reporting requirements arising from accounting provisions for the second CP. Section 2.2.4 discusses how the two 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 detailed discussion of how lands subject to Articles 3.3 and 3.4 can be identified, so that the requirements of either Reporting Method can be satisfied.

2.2.2 Reporting Methods for lands subject to Article 3.3 and Article 3.4 activities

The reporting requirements set out in Decision 2/CMP.8 seek to avoid double counting of land areas and ensure completeness in land identification and consistency in reporting. The general information to be reported on activities under Articles 3.3 and 3.4 *shall*[6] include the geographical boundaries of areas encompassing land subject to AR, D, FM and lands subject to elected CM, GM, RV and WDR activities. To achieve this, and based on national circumstances such as the characteristics of existing forest inventory systems and the size of the country, a Party may choose one of two methods (Figure 2.2.1):

Reporting Method 1 uses a spatially-referenced approach that delineates the geographic boundaries that contain multiple land units subject to Article 3.3 or 3.4 activities. The geographic boundaries can be defined using georeferenced legal, administrative, or ecosystem boundaries. Information about activities within these areas is derived from (grid-based or other) sampling techniques using remote sensing or ground-based data or from administrative statistics, although the location of each land unit within these geographic areas may not be known. See Section 2.2.3 for additional georeferenced reporting requirements arising from Decision 2/CMP.7 for those countries that choose additional accounting provisions related to ND and CEFC.

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

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[3] Paragraph 25 of Annex to Decision 2/CMP.7: *National inventory systems established under Article 5, paragraph 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 on these areas shall 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.*

[4] Paragraph 2 of Annex II to Decision 2/CMP.8:

General information to be reported for activities under Article 3, paragraph 3, forest management under Article 3, paragraph 4, 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, of the Kyoto Protocol;

(ii) Units of land subject to activities under Article 3, paragraph 3, of the Kyoto Protocol which would otherwise be included in land subject to forest management or elected activities under Article 3, paragraph 4, of the Kyoto Protocol under the provisions of decision 2/CMP.7, annex, paragraph 9;

(iii) Land subject to forest management under Article 3, paragraph 4, in the second commitment period and to any elected activities under Article 3, paragraph 4; […]

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

[5] Paragraph 24 of Annex to Decision 2/CMP.7: *Once land is accounted for under Article 3, paragraphs 3 and 4, this land must be accounted for throughout subsequent and contiguous commitment periods.*

[6] See paragraph 2 of Annex II to Decision 2/CMP.8

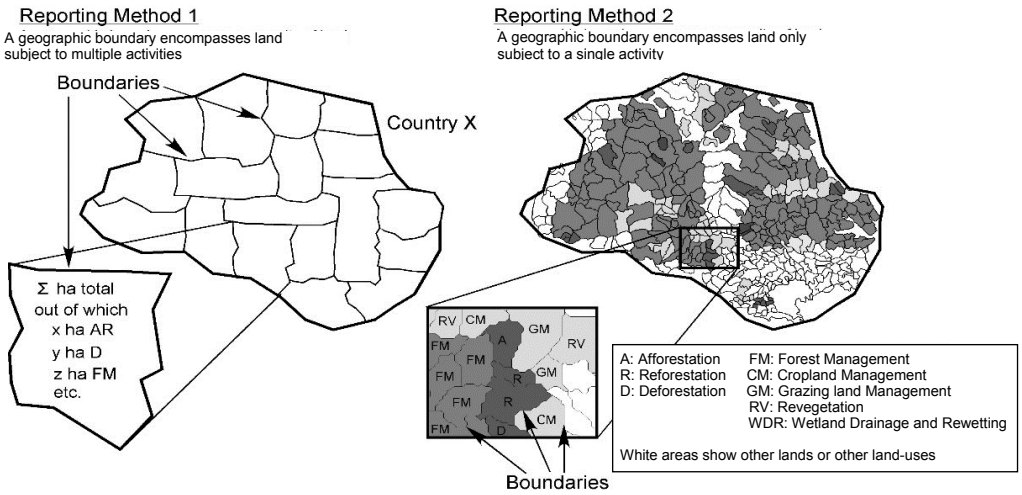
For Reporting Method 1, depending on the size of the country and the ecological and climate variability within the country, it is *good practice* to select the number of geographic areas for which the geographic boundaries of land are defined with the goals to reduce heterogeneity and to increase accuracy and reporting transparency. Thus, to maintain transparency and reduce uncertainty, 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. The choice of the number of reporting areas affects uncertainty estimates.

To implement Reporting Method 1, it is *good practice* to define and report the geographic boundaries with complete coverage and without gaps or overlaps. Criteria for delineating reporting regions within the country could include statistical considerations for the sampling intensity or sampling approaches, considerations of the type and amount of KP activities, as well as ecological or administrative considerations. Within each resulting geographic boundary lands subject to Article 3.3, FM or other elected Article 3.4 activities will then be quantified using the approaches described in Chapter 3 (Section 3.3 Representing land-use areas), Volume 4 of the *2006 IPCC Guidelines*, in accordance with the guidance in Section 2.2.3, as well as the methods in Sections 2.2.6 (generic methods) and 2.5 to 2.12 (activity-specific methods) of this supplement.

To implement Reporting Method 2, a country should identify and report the spatial location of all lands based on a complete mapping of all areas within its national boundary. This is described in Chapter 3, Volume 4 of the *2006 IPCC Guidelines* as the wall-to-wall mapping version of Approach 3 (see also Section 2.2.4.3). This Reporting Method uniquely identifies lands and enables activities to be reported without the risk of double counting of area. To put this Reporting Method fully into practice requires large-scale data collection and analysis, and the preparation of statistics, which summarise the detailed, polygon or pixel-level information, to ensure that reporting is transparent yet concise. Digital maps, which in practice will not be included in the National Inventory Reports (NIR), can be made available to Expert Review Teams who can then verify completeness of time series and of spatial coverage.

Examples of national implementations of Reporting Methods 1 and 2 are Canada and Australia, respectively. In Canada the land area is stratified into 18 reporting zones based on the Terrestrial Ecozone classification system. 15 of these zones contain some 230 million hectares of Managed Forest for which emissions and removals are estimated (Stinson *et al.,* 2011). The underlying analyses of C stocks are based on forest inventory and activity data compiled for over 500 forest management units, but within each of these geographic boundaries the exact location of each forest polygon is not included in the analyses. Australia's National Carbon Accounting System uses a wall-to-wall, spatially-explicit approach to estimating carbon stock changes and non-CO_2 emissions. Time series of Landsat images are used to determine land cover and land-use changes and to inform estimates of carbon stocks and stock changes (Richards and Brack, 2004; Waterworth and Richards, 2008). Other country-specific examples can be found in national inventory reports from the UNFCCC website[7].

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



[7] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/7383.php

With either Reporting Method, once land is reported as being subject to activities specified under the KP, it is *good practice* that the land be included in the reporting and accounting from the time it entered the system to the end of the second CP. Therefore, if a Party chooses Reporting Method 1 and sampling, it is *good practice* to record the information needed to identify the sample locations and the lands identified in the samples, and to use the same sample locations for any future monitoring. This ensures that land-use changes identified 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 CP. However, estimates of the rates of land-use change can also be obtained using combinations of permanent sample plots, temporary sample plots and time-series of remotely sensed land-cover change products.

It is *good practice* to report, using printed or digital maps, as described in Section 2.4.4.1(Reporting), the geographic boundaries resulting from the stratification of the country.

2.2.3 Reporting Methods for lands subject to additional accounting provisions for CP2

This Section is only applicable to countries that choose the special accounting provisions of Decision 2/CMP.7 to make use of the natural disturbances (ND) or Carbon Equivalent Forest Conversion (CEFC) provisions. Decision 2/CMP.7 introduced additional reporting requirements for (1) the georeferenced locations of forest areas subject to ND for which emissions and subsequent removals are excluded from the accounting[8] 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 and the georeferenced locations of these carbon-equivalent forests[9].

Georeferenced locations of areas affected by ND are required to ensure that subsequent removals from these areas are excluded from the accounting and to track whether or not these areas have been converted to non-forest land uses (deforestation) in the second CP after the natural disturbance. If land-use change does occur then the land is reported as D and emissions from the natural disturbance previously excluded are reported and accounted under D.

Decision 2/CMP.7 also states that countries need to demonstrate that emissions associated with salvage logging, i.e. the harvest of dead or dying trees affected by a natural disturbance (see Box 2.3.5 in Section 2.3.9.3 for the definition of salvage logging) of these areas were not excluded from the accounting. It is *good practice* to estimate, report and account emissions from all salvage logging, which includes emissions associated with salvage logging on lands affected by ND for which emissions were excluded from the accounting. See Section 2.3.9 for additional requirements associated with the ND provision.

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

These new reporting requirements imply that for countries that make use of the additional accounting provisions (exclusion of ND emissions and CEFC) Reporting Method 1 can only meet the reporting requirements if additional, georeferenced information about specific land areas within the geographic boundaries is provided. Two methodological approaches are available: either, mapping and ongoing monitoring of lands subject to the ND provisions to determine whether subsequent deforestation has occurred; or all lands that are subject to deforestation events are assessed to determine whether these lands are also subject to the ND provisions.

2.2.4 Relationship between Approaches in Chapter 3, Volume 4 of the 2006 IPCC Guidelines and Reporting Methods in Section 2.2.2

Chapter 3, Volume 4 of the *2006 IPCC Guidelines* (Consistent representation of lands) describes three Approaches for representing land area. The detailed reporting requirements of Articles 3.3 and 3.4 of the KP as elaborated in Chapter 3 are met by the two Reporting Methods previously described in this chapter. This section,

[8] Paragraph 34 (a) in Annex to Decision 2/CMP.7 establishes the requirement to report the georeferenced location of these areas. See also Decision 2/CMP.8.

[9] Paragraphs 37 – 39 in Annex to Decision 2/CMP.7 outline all the requirements that must be met for this provision. See also Decision 2/CMP.8

summarised in Table 2.2.1, discusses which of the three Approaches are suitable for identifying lands subject to Article 3.3, FM or elected Article 3.4 activities.

The following three Approaches are explained in more detail in Chapter 3, Volume 4 of the *2006 IPCC Guidelines*. Approach 1 identifies the total change in area for each individual land-use category within a country, but does not provide information on the nature and area of conversions between land uses. Approach 2 introduces tracking of land-use conversions between categories (but is not spatially explicit), therefore does not allow to track conversions over time for individual lands. Approach 3 is characterized by spatially-explicit observations of land-use categories and land-use conversions and thus enables tracking of conversions over time of individual lands.

Table 2.2.1 describes the three Approaches which will be described in the subsequent sections, and relations between Approaches and Reporting Methods.

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-analysing existing inventories with reference to boundaries of geographic areas or from sampling programs.	Not applicable
Approach 2 Total land-use area, including changes between categories	Can only be used if additional information is available by re-analysing existing inventories with reference to boundaries of geographic areas or from sampling programs.	Not applicable
Approach 3 Spatially explicit land-use conversion data	This is *good practice* if spatial resolution is fine enough to represent minimum forest area. Involves aggregating data within the reported geographic boundaries.	This is *good practice* if spatial resolution is fine enough to represent minimum forest area.

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

Approach 1 described in Chapter 3, Volume 4 of the *2006 IPCC Guidelines* provides information that is not spatially explicit and it only reports the net changes in the areas of different land-use categories. Hence, this approach does not meet the land identification requirements of Decisions 16/CMP.1 and 2/CMP.7. National inventory databases are often compiled from detailed inventories that can be based, for example, on sampling approaches that involve a grid or sample plot system. In countries where this is the case, it may be possible to re-analyse the detailed inventory information with reference to the geographical boundaries, which have resulted from the stratification of the country, to meet the reporting requirements of the KP. Inventories based on georeferenced permanent sample plots are suitable to detect land–use conversions. This means that Approach 1 can only be applied to Reporting Method 1 if additional spatial data at the required spatial resolution are available as a result of re-analysing the inventory information or from other sources, and if additional information is available to quantify the gross land-use transitions (rather than the net changes in land-use categories).

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

Approach 2 focuses on land-use transitions and provides an assessment of both the net losses or gains in the area of specific land-use categories and what these conversions represent (i.e. changes both from and to a category). The final result of this Approach can be presented as land-use conversion matrix that is not spatially explicit. Thus, Approach 2 differs from Approach 1 in that it includes information on conversions between categories, but is still only tracking those changes without spatially-explicit location data, which means that the Approach does not allow tracking of conversions between land-use categories. Hence, additional information is necessary to meet the reporting requirements of Decisions 16/CMP.1 and 2/CMP.7. This Approach can therefore only be used to identify lands subject to activities under Articles 3.3 and 3.4 if additional data are available that allow tracking

lands, and land-use changes, over time possibly on a statistical basis. As with Approach 1, it may be possible to apply Approach 2 to Reporting Method 1 if additional spatial data at the required spatial resolution become available from re-compiling the inventory information or other sources.

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 (Section 2.2.2), as long as the spatial resolution is fine enough to represent the minimum forest area as defined by the Party under Decision 2/CMP.7 and its precursors.

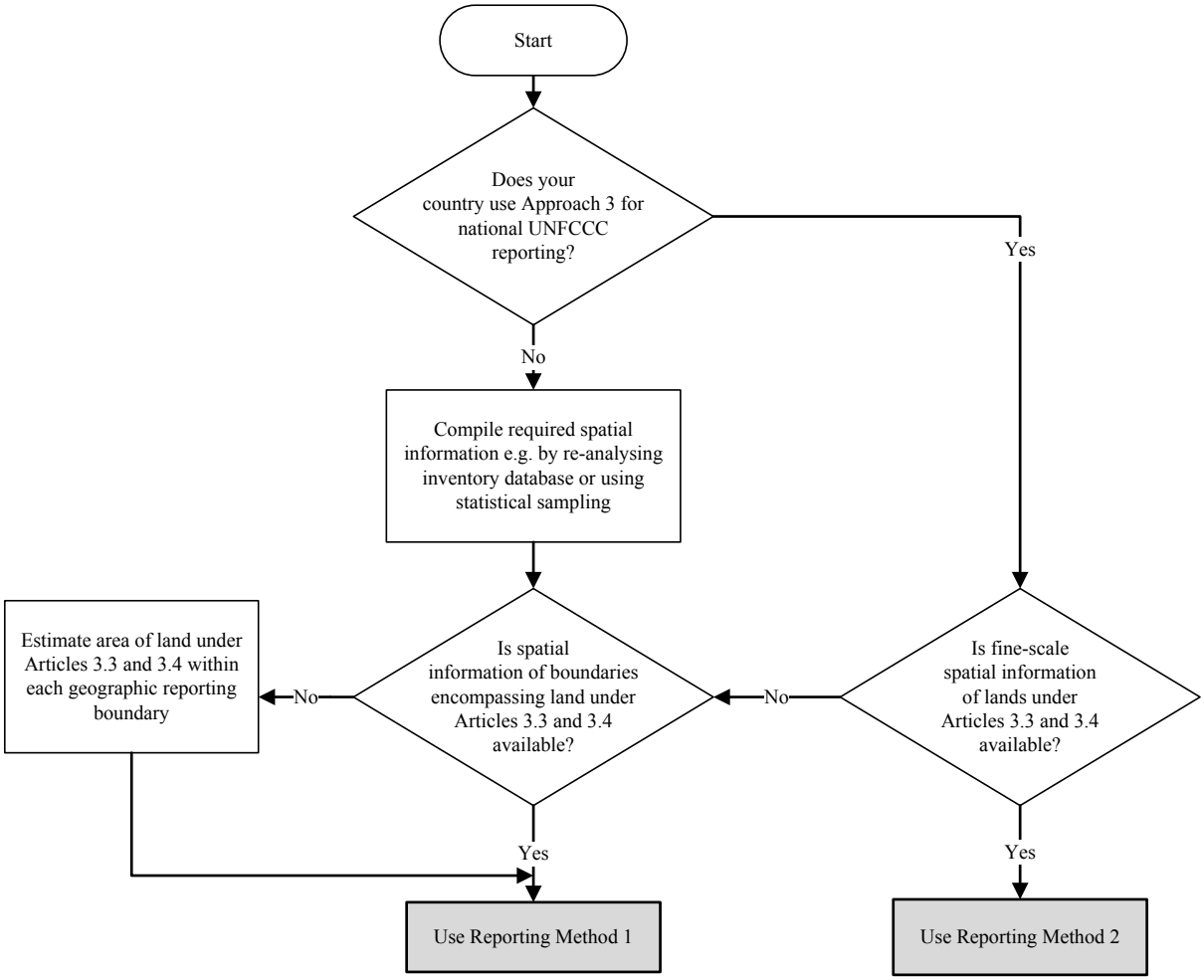
Note that even the most data-intensive Approach 3 can only be sufficient without supplemental information if the spatial resolution at which land-use changes are tracked is consistent with the size parameter selected by a country to define forest, i.e. polygon sizes of 0.05 to 1 ha or pixels of 22.4 to 100 m (see STEP 1.1 in Section 1.2). Mapping land cover and land-use using, for example, 1 km^2 (100 ha) pixel resolution may not meet the KP requirements because land-use change at finer resolution may not be detected. A well designed sample-based approach (Magnussen *et al.,* 2005) at the appropriate spatial resolution may therefore yield more accurate estimates than a wall-to-wall map at 1 km^2 resolution which may miss many small land-use change events. Sample-based approaches can provide the required supplemental information.

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 country 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 land using Reporting Method 1. Within those geographical boundaries where data for complete spatial identification of lands are available, Reporting Method 2 can then be applied.

As outlined in Section 2.2.3, additional georeferenced information is required for areas subject to ND and CEFC provisions. For either Reporting Method, this additional information could be reported using time series of maps or tables containing the georeferenced information about the location of these lands. See also the Reporting Tables presented in Annex 2A.1 to this document.

Figure 2.2.2 Decision tree for choosing a Reporting Method for land subject to activities under Articles 3.3 and 3.4



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

2.2.6 How to identify lands in general

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

Each Annex I Party to the KP has chosen country-specific parameters within the definition of forest for their KP reporting. This required selecting values for the following three parameters: the size of the minimum area of land that can constitute a forest, ranging between 0.05 and 1 ha, and parameters for minimum crown cover (or equivalent stocking level) between 10 – 30% and tree height at maturity (2 – 5 m). The parameter for the minimum area of land that constitutes a forest effectively also specifies the minimum area on which land-use change events occur (i.e. AR, D, or CEFC) and for those areas where natural forests are converted to planted forest. Thus a country that selects, for example 0.5 ha as the minimum area of forest land, must also identify all land-use change events that occur on lands that are 0.5 ha or larger. The identification of lands on which land-use

changes occur, such as deforestation, requires the detection of a direct human-induced reduction in tree crown cover from above to below the country-specific threshold of forest, accompanied by a change in land-use.

The CMP decisions do not specify the shape of areas, neither for forest, nor for those areas on which land-use change events occur. However, the *GPG-LULUCF* specified that it is *good practice* to define a minimum width in conjunction with a minimum area. Square areas that meet the 0.05 to 1 ha range would be 22.36 m to 100 m 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 the minimum width and area defined by the country can be considered a forest and any forest cleared for "linear events" that exceed the minimum width and area, such as roads, transmission right-of-ways, or pipeline corridors are considered deforestation. When such clearing has occurred since 1 January 1990, it is treated as D under Article 3.3.

For example, if a country selects 1 ha as the minimum area of forests and further specifies that these areas are square, then a 20 m wide corridor cut through a forest with 100% tree crown cover, will reduce tree crown cover to 80%. This is higher than the range of tree crown cover (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 clearing is part of a corridor that stretches for many kilometres, 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 of the area of land-use change events can have a large impact on the amount of land reported under Article 3.3 and FM.

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 land-use change occur. It is also *good practice* to apply these criteria consistently to the identification of land-use change events that have occurred since 1990, or the start of the second CP for conversion of natural forests to planted forests and CEFC. For instance, these criteria can simply be defined as the minimum width that will be accepted for a forest and an area subject to a land-use change 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 as FM the impacts on carbon stock changes of "linear clearing events" narrower than the selected minimum width criterion for deforestations events. Examples of such clearing events can include skid sites, forest roads, or seismic lines. 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 elected CM, GM, RV or WDR activities.

2.2.6.2 SOURCES OF DATA FOR IDENTIFYING LANDS AND ADDITIONAL NEW REPORTING REQUIREMENTS FOR THE SECOND CP

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 largely depend on national circumstances, including the investments made into the appropriate national GHG inventory systems, for monitoring, reporting, and verifying emissions and removals. 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 national statistics and 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 AR activities that are difficult to detect through remote sensing, in particular in regions with slow growth rates, such as boreal forests. To ensure integrity, such a reporting system should include verification and auditing procedures.

It is likely that in most countries the existing forest inventory systems will be combined with additional sources of information and in-country monitoring activities to meet all the land reporting requirements of the KP, 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 re-measurement 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. Data from forest management records could be used to estimate non-CO_2 emissions associated with fertilization. Or a country could determine that it would be most efficient to combine an activity reporting system to identify lands subject to AR (which can be difficult to detect using remote sensing in regions with slow growth rates), and a monitoring system to identify lands subject to D (which are more readily detected).

Remotely sensed data are increasingly contributing to land cover and land-use monitoring, to forest inventory systems, and to activity reporting systems as data for certain sensors become cheaper or freely available, and as computing power and algorithms are improving[10]. Nevertheless, 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 GHG emissions and removals from the remotely sensed data on land cover and land-use changes. In particular estimates of GHG emissions and removals associated with belowground biomass, dead organic matter and soil organic matter, which are carbon pools that cannot be directly inferred from remote sensing of land surface characteristics, will require additional efforts and investment. The use of remote sensing to construct and assess forest attribute maps is described by McRoberts *et al.* (2010) and McRoberts and Walters (2012). Information about the use of FAO data in GHG inventory preparation can be found in IPCC (2010b).

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 should 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 to allow tracking of land over time. 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 AR and D or natural forests to planted forest conversion events at a resolution of 0.05 to 1 hectares can be met, however, with additional statistical analyses to establish the area subject to AR and D 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 AR and D events in the country, using a statistical sampling approach. The proportion of the area of AR and of D 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 AR and D events from the 3-ha resolution inventory. For example, if the 3-ha resolution inventory shows that there have been 1,000 ha of AR events in units of 3 ha or larger, and the sample-based size-class distribution of AR events shows that on average 5% of the AR events is in areas of size between 0.05 – 1 ha and 3 ha, then the 1,000 ha represent 95% of the total AR 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. It is also *good practice* to avoid double counting when combining two different sources. 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 AR, D 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).

[10] For example, to obtain such information, the intergovernmental Group on Earth Observations (GEO) is working with government agencies to acquire and make freely available and accessible, relevant data and related products from remote sensing and *in-situ* platforms for various countries, including those subject to this supplement and, more broadly, all countries in their reporting under the UNFCCC.

Additional monitoring and data compilation may be required to meet the reporting requirements for land-use changes, conversion of natural forests to planted forests, WDR, 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 lands subject to AR activities can face the challenge that non-forest areas are not usually 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 national coverage for a single point in time.

Some events, such as the conversion of natural forest to planted forest, or salvage 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 freely available and 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 (Townshend *et al.,* 2012). However, given that land-use change often occurs on only a small fraction of the areas affected by land-cover change, additional information and/or inferences may be required to ascertain whether a land-cover change represents a land-use change (see Step 1.2 in Section 1.2). Moreover, special requirements such as the reporting of conversion of natural forests to planted forests will require additional 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 AR 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 AR events from inventory or monitoring systems, countries can request those individuals or agencies to report the AR 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 CM, or GM. Activity reporting may also be important for the attribution of land-cover change, including RV, and to identify where observed conversions to and from forest are linked through the provision of CEFC. 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 projected and actual carbon stocks for the land.

Activity reporting may be necessary for the identification of AR, D, conversion of natural forests to planted forests, or CEFC where the area of the activity is larger than the minimum area selected for the forest definition under the KP but is smaller than the minimum mapping unit in the forest inventory and may therefore go undetected. Coupled with high resolution remote sensed images, activity reporting can provide georeferenced information and detailed description of land cover change for small areas and sample plots.

It is *good practice* for countries 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 AR activities alone may not include information on plantation establishment success. Spatially explicit information, i.e. either the delineation of the lands, or references to a country's national map grid coordinates (e.g. UTM, Universal Transverse Mercator) or legal description of the land subject to an activity, are required for the domestic audit and verification procedures applied to a reporting system.

Detailed guidance for identifying lands is provided in the following sections: Section 2.3.9.2 (ND), Section 2.5.2 (AR), Section 2.6.2 (D), Section 2.7.2 (FM), Section 2.7.7 (CEFC), Section 2.9.3 (CM), Section 2.10.3 (GM), Section 2.11.3 (RV), and Section 2.12.3 (WDR).

2.3 GENERIC METHODOLOGICAL ISSUES FOR ESTIMATING CARBON STOCK CHANGES AND NON-CO_2 GHG 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 GHG emissions on these areas must be estimated following the methods outlined in Volume 4 of the *2006 IPCC Guidelines*, the *Wetlands Supplement* and this *KP Supplement*.

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 GHGs from all lands subject to the included activities and for all carbon pools with discretionary omission of those that are not a source of carbon, with higher-tier methods used for key categories. Parties do not have discretion in the exclusion of the HWP pool[11]. The GHG emissions and removals will be estimated regardless of their cause, such as growth, decomposition, harvest, natural disturbances, or the establishment of equivalent forest. In the case of natural disturbances on AR or FM lands, the emissions and removals shall be estimated and reported[12] 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 GHGs for which a Party elected to apply the CEFC, need to be reported and accounted under FM.

The methodology used to estimate carbon stock changes and GHG emissions and removals for any particular year depend on the land use in the current and in prior years, because shifts in categories or land uses can occur over time. Therefore, different methodologies may be applied to different lands reported within one Article 3.3 or Article 3.4 activity.[13] The methodology used to calculate GHG emissions or removals associated with 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 in the current year is not subject to an Article 3.3 activity, FM or an elected Article 3.4 activity, and if a reporting requirement was not established through such activities in prior years, then the emissions and removals for that land are not reported under the KP.

The generic methods of estimating the carbon stock changes, for all pools to be reported (see below), are described in Chapter 2, Volume 4 of the *2006 IPCC Guidelines*. This section provides supplementary guidance applicable to 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[14] include:

Mineral Soils

The inventory calculations are based on land area and lands that can be 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 carbon stocks for mineral soils (tonnes C ha^{-1} in 0-30 cm depth). Countries following Tier 2 methods may also refer to data provided in Batjes (2011). It is *good practice* whenever possible to verify soil carbon stock reference values by comparison with results from field measurements.

Organic soils

The *Wetlands Supplement* contains updated and new methodological guidance for estimating GHG emissions and removals from drained and rewetted organic soils.

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 below-ground 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 carbon stocks and stock changes in HWPs (see Section 2.8). Decreases in one pool may be offset

[11] Paragraph 26 in Annex to Decision 2/CMP.7

[12] Paragraph 33 in Annex to Decision 2/CMP.7

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

[14] Definitions of mineral and organic soils are provided in the *2006 IPCC Guidelines* - Annex 3A.5, Default climate and soil classifications

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 the Annex to this Chapter) 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 changing 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 of the *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 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 the total carbon stock change of the six pools, including HWP.

Decision 2/CMP.7 specifies that a Party may choose not to account for a given pool, except for HWP, in a CP, if transparent and verifiable information is provided that the pool is not a source,[15] although once a pool has been included in the Forest Management Reference Level (FMRL) inscribed in the Appendix to Decision 2/CMP.7, for consistency reasons it is *good practice* to report this pool during the CP, irrespective of the pool being a sink or a source (see section 2.7.5.2). *Good practice* in providing verifiable information, which demonstrates that excluded pools, if any, are not a net source of GHGs, can be achieved by one or more of the four approaches listed below:

- 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 a sufficient number of 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 an established cropland without litter or dead wood carbon pools, i.e. not orchards or agroforestry systems, is converted to forest land by AR, the dead wood pool cannot decrease, because there is no deadwood in that cropland; as is typically the case in areas with annual crops;
- Surveys of peer-reviewed literature suitable 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, AR of cropland leads to increases in soil organic carbon stocks); or
- Combined methods.

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). When two or more pools are combined in the reporting, then it is *good practice* to report carbon stock changes for the combined pool, unless a country can demonstrate that the aggregated pool is not a source.

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

Decision 2/CMP.7 specifies that the carbon stock changes and non-CO_2 emissions from land subject to Article 3.3 activities, FM and any elected activities under Article 3.4 be reported for each year of the CP[16], beginning with the start of the CP, or with the start of the activity, whichever is later. [17] Decision 2/CMP.7 also requires that each area that was subject to reported activities during the first CP has to be reported during subsequent CPs 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 during the CP, the carbon stock changes and non-CO_2 emissions should be reported for the year of the onset of the activity and for each of the remaining years of the CP. If the activity started after 1990 but before 1 January 2013, reporting of the carbon stock changes and non-CO_2 emissions for the CP should cover each year of the CP.

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

[15] See paragraph 26 in Annex to Decision 2/CMP.7, contained in document FCCC/KP/CMP/2011/10/Add.1.

[16] See paragraph 2(d) in Annex II to Decision 2/CMP.8.

[17] See paragraph 23 in Annex to Decision 2/CMP.7.

- For AR, D, FM and WDR (FM and WDR only, when a "narrow" approach (see section 1.2) to the implementation of their definition is applied) the area to be reported under the activity is the cumulative area of lands subject, for the first time, to the activity since 1990[18], minus the area converted to other elected or mandatory activities according to the hierarchy among activities (see section 1.2)[19]. Although for each land carbon stock 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 CP, whichever comes later.

BOX 2.3.1
EXAMPLE

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

- the first occurred in 2005, i.e. before the start of the first CP - and was 1,000 ha in size,
- the second in 2010, i.e. during the first CP, was 2,000 ha in size,
- the third in 2015, i.e. during the second CP, was 4,000 ha in size.

This Party will report during the second CP:

- for the first two years, i.e. 2013 and 2014, the total area deforested since 1990 until that date, i.e. 1,000 + 2,000 = 3,000 ha, and carbon stock changes and non-CO_2 emissions that occurred on those lands since the start of the second CP, i.e. 1 January 2013.
- for the remaining years of the second CP, the total area deforested since 1990 until that date, i.e. 1,000 + 2,000 + 4,000 = 7,000 ha, and carbon stock changes and non-CO_2 emissions that occurred since the start of the second CP, i.e. 1 January 2013, on the 3,000 ha deforested before the start of the second CP plus carbon stock changes and non-CO_2 emissions that occurred since 2015 on the additional 4,000 ha deforested in that year.

- For CM, GM and RV the area to be reported under the activity is the area that is subject to the activity since the start of the CP in which the activity has been elected, minus the area converted to other activities according to the hierarchy among activities (see section 1.2)[20]. Although for each land carbon stock 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 CP, i.e. 1 January 2013, whichever comes later.
- FM and WDR, when a "broad" approach (see Section 1.2) to the implementation of their definition is applied, the area to be reported under the activity is the area that is subject to the activity in the year 1990 plus the cumulative area of lands subject to the activity after 1990, minus the area converted to other activities according with the hierarchy among activities (see section 1.2) [21]. Although for each land carbon stock 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 CP, whichever comes later.

[18] No lands are subject to KP activities before 1 January 1990.

[19] Note that the area to be reported for estimating the base year for WDR is the area that is subject to drainage or rewetting in the year of the commitment period that is accounted.

[20] Note that, for each activity, the area to be reported for estimating the base year is the area subject to the activity in the year 1990 or the base year selected by the country.

[21] Note that the area to be reported for estimating the base year for WDR is the area that is subject to drainage or rewetting in the year of the commitment period that is accounted.

BOX 2.3.2
EXAMPLE

A Party is reporting the entire national forest area as subject to FM. There is no deforestation and the area subject to FM is continuously increasing during the first three years of the second CP due to expansion of forest which is not human-induced above the current timberline, adding 1,000 ha annually. The area reported subject to FM activity at the beginning of the second CP is equal to 1,000,000 ha.

This Party will report during each year of the second CP 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 stock 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 1,000 ha of new forest area subject to FM for the first time in this year. For the initial area associated carbon stock changes and non-CO_2 emissions, since 2013, will be reported. For the new area associated carbon stock changes and non-CO_2 emissions, since the beginning of 2014, 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 stock changes and non-CO_2 emissions, since 2014, will be reported. For the new area associated carbon stock changes and non-CO_2 emissions, since the beginning of 2015, 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 the lands have been reported under FM for the first time.

Countries must avoid any double counting of lands, and associated carbon stock changes and non-CO_2 emissions. Therefore, if transfers of land among categories occur, the transferred area of lands has to be subtracted from the old category and added to the new category, and the associated carbon stock changes and non-CO_2 emissions be reported under the new activity. Note that there are constraints outlined in Section 1.3.

Each activity (AR, D, FM, CM, GM, RV, and WDR) may consist of a suite of practices and may begin with one or several of these. For instance, an afforestation program may begin with planning, land purchase, producing propagation material, etc. Practices like site preparation can also precede the planting or seeding (as a result of which the land actually becomes a "forest"). Some of these practices 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 practices. 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 land 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 losses resulting from these site preparation practices.

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

The carbon stock-difference method outlined in the *2006 IPCC Guidelines*[22] requires information on carbon stock for a given area, at two points in time. When using this method for a specific activity, it is important to ensure that the area of land in that activity at times t_1 and t_2 is identical, to avoid confounding changes in stock caused by area changes. Per unit of area at time t_2, the annual stock change is the difference between the carbon stock at time t_2 and time t_1, divided by the number of years between the inventories. If the forest area is changing, for example as a result of D, AR, or both, then carbon stock changes can occur as a result of the transfer of land between UNFCCC or KP reporting categories (see Figure 11 in Kurz *et al.* (2009) for an example). Examples of possible approaches that can be implemented to address this issue are provided below.

Countries that use the IPCC stock-difference method for the calculation of stock changes[23] need to ensure that actual carbon stock changes are reported, and not artefacts resulting from changes in area over time. One example that represents *good practice* is to implement the calculations of annual carbon stock changes when using any stock difference method in the following sequence: for any carbon pool of each activity, for each area, the annual carbon stock change should first be calculated for the year of interest on the area at time t_2, and these stock changes should then be summed for all areas subject to the activity. The inverse sequence, i.e. first summing up carbon stocks across all areas of the activity 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. Indeed, if the area subject to an activity increases from the beginning to the end of the reporting year, then the reported carbon stocks reflect the transfer of area (and the associated carbon stocks) into the activity; similarly, carbon stocks will decrease, if area is removed from an activity[24]. The issue is of particular concern when areas outside the reporting system enter into the reporting system. For example, if the stock-difference method is erroneously applied, the estimate of C stock increase in soil organic matter of AR lands, which were previously unmanaged, will yield an apparent increase in the estimate of soil C stocks due to the transfer of the entire existing soil organic matter C stock into the AR accounting although this apparent increase does not correspond to C removals from the atmosphere.

It is *good practice* to distinguish clearly between C stock changes that result from area changes and the associated transfers of C stocks among activities, and C stock changes that result in corresponding emissions to and removals from the atmosphere. It is therefore *good practice* to ensure that when using the stock-difference method the area for the calculations of carbon stock differences for each activity at times t_1 and t_2 is identical. Furthermore it is *good practice* to conduct all calculations of annual carbon stock changes and non-CO_2 GHG emissions with the area of the activity at the end of the inventory year - i.e. the area at time t_2 in equation 2.5 of Chapter 2, Volume 4, *2006 IPCC Guidelines* - and to use this approach consistently through time.

When land-use change events occur, the associated fluxes are reported in the new land-use category. When using Tier 3 models and the IPCC default (Gain-Loss) method for the calculation of stock changes[25] it is *good practice* to ensure that the land-category attribute in the model is updated to reflect the subsequent land-use change **prior** to estimating any C stock impacts from the land-use change event. This ensures that all carbon stock changes and non-CO_2 emissions that occur during a year will be reported in the new category. (See Box 1 in Kurz *et al.* (2009) as an example of a Tier 3 modelling approach that implements the required change in the land-use category at the start of the year, i.e. prior to estimating any carbon stock changes and non-CO_2 emissions associated with land-use changes during that year).

[22] Section 2.2.1, Volume 4, *2006 IPCC Guidelines*.

[23] Section 2.2.1, Volume 4, *2006 IPCC Guidelines*.

[24] 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 CPs, 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 FM because of D.

[25] Section 2.2.1, Volume 4, *2006 IPCC Guidelines*.

BOX 2.3.3
EXAMPLE

During a year of the CP the area of land reported under FM varies because new forest land (natural forest expansion or previously unmanaged forest land that becomes subject to management) is added to the FM area and because of deforestation activities:

	At the start of year	**At the end of 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 start of year	**At the end of year**
Average per hectare biomass carbon stock of forest lands subject to FM	100 tC ha^{-1}	105 tC ha^{-1}
Average per hectare biomass carbon stock of **new** forest lands subject to FM	80 tC ha^{-1}	84 tC ha^{-1}
Average per hectare 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:
- managed forest lands that were subject to FM since the beginning of the year,
- forest lands where the FM activity started during the year,
- managed 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} = -800,000 tC
Total stock-change in FM areas (A+B)	4,950,000 + 40,000 = 4,990,000 tC
Stock change reported in Forest Land converted to Cropland under UNFCCC and in D under Article 3.3 (C)	-800,000 t C

It would be incorrect, for instance, to calculate the total aboveground biomass carbon stock on the 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 start of 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 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

2.3.4 Relationship between measurement and reporting intervals

The CMP decisions specify that all emissions by sources and removals by sinks caused by Article 3.3, FM and elected Article 3.4 activities be reported annually.[26] A number of methods are available to obtain annual estimates of emissions and removals and the annual reporting requirement does not imply that annual 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 2.3.5 (Interannual variability). Carbon stock changes for pools with high uncertainties in stock estimates, e.g. soil organic carbon, are usually not detectable on an annual or short-term basis (Saby *et al.,* 2008).

Broadly speaking, when countries are developing and selecting methods to meet their reporting requirements, it is *good practice* to seek a balance which is affordable, makes best use of data that are already available, allows 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 does not make GHG inventories susceptible to the impacts of annual fluctuations in weather which can mask the impacts of changes in anthropogenic activities. Although Section 2.3.5 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. 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 Interannual variability

The two largest causes of actual interannual variability in GHG 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 (Griffis *et al.,* 2003; Kurz, 2010; Richards, 2010; Stinson *et al.,* 2011; Li *et al*., 2011; Yasuda *et al.,* 2012). Consequently, the rate of net GHG 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.

The third cause of interannual variability in GHG emissions and removals is the variation in the rate of human activities, including forest harvesting, land use, and land-use change. Variations and trends in these human activities are of interest because they can demonstrate the consequences of climate mitigation efforts. Estimation of the impacts of human activities and trends over time is the main purpose of national GHG inventories. It is therefore *good practice* to reflect interannual variability and trends in rates of human activities in the inventories and to not use time-averaged activity data.

The 'signal' of the impact of human activities, including mitigation measures, on emissions and removals in the LULUCF Sector, may not be discernible against the 'noise' of large interannual variability in emissions originating from natural or indirect-human causes, because the impacts of natural disturbances and climate variability can obscure trends in the impacts of human activities. The ability to discern the signal of changes in human activities from the noise of the interannual variability is, however, important when inventory estimates are used to monitor the impacts of mitigation measures (IPCC, 2010a). The provision in Decision 2/CMP.7 that enables countries to elect to exclude from the accounting emissions from certain natural disturbances (see Section 2.3.9) removes some of the variability from indirect-human and natural factors.

The methodology used to calculate reported emissions and removals affects the extent to which these causes of variability are captured in the reporting. Lower tier methods are typically less affected by interannual variability in non-anthropogenic drivers of GHG emissions and removals than higher tier methods. Lower tier methods in which estimates of emissions and removals are insensitive to variation or trends in climate or other environmental conditions (such as atmospheric CO_2 concentrations or N-deposition rates) are likely to estimate lower interannual variability in emissions and removals than actually occurs. This is because IPCC default data (including those contained in the Emission Factor Database[27]) have been calculated by averaging data collected over time and space to estimate representative global, regional, and ecological factors. By averaging out time and

[26] Note that although annual reporting is required, countries have the option to account either annually or over the entire commitment period (see paragraph 1(h) in Annex I and paragraph 1 in Annex II to Decision 2/CMP.8).

[27] Emission Factor Database: http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

space variability Tier 1 methods that use these IPCC default 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 very high interannual variability in emissions and removals as a result of climate variability because these two fluxes (NPP and Rh) are very large. This can introduce fluctuations in annual GHG inventories that can completely mask impacts of changes in human activities (Richards, 2010). Forest inventory-based modelling approaches that implement the IPCC default approach (gain-loss method)[28] and that use empirical yield tables, which are not affected by interannual variability in climate, report lower interannual variability in GHG emissions and removals. Inventory-based modelling approaches represent interannual variability due to natural disturbances and human activity (e.g. Stinson *et al.* 2011 show high interannual variability in emissions and removals due to variations in annual area burned and insect infestations). Estimates of GHG emissions and removals derived from the stock-difference 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, without additional information, may not be able to attribute observed emissions and removals to the drivers of emissions such as natural disturbances, environmental change or human activities. Additional information could be derived from a continuous forest inventory design in which some data are collected each year, or from supplementary statistics on area annually affected by disturbances.

Interannual variability can 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 (Ciais *et al.,* 2005), 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.

In addition to GHG emissions and removals during the CP, Decision 2/CMP.8 also requires estimation and reporting of GHG emissions and removals during the base year (1990 in most cases) for those elected activities for which net-net accounting applies. 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 CP in which this activity occurred. The direction and magnitude of the impact depends on how the year 1990 deviated from the long-term emissions averages, e.g. as a result of variability in natural disturbances or climate. It is *good practice* to use longer-term averages of emissions and removals to represent the base year when environmental conditions in the base year (e.g. 1990) caused major deviations in GHG emissions and removals from their longer-term (e.g. 5-year) averages. However, it is **not** *good practice* to use averages to even out the effects of variations in the rate of human activities, such as the variation in harvest or land-use change rates, in the base year.

Because of interannual variability in environmental conditions, extrapolation 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, but could miss long-term trends in productivity e.g. due to increases in atmospheric CO_2 concentration or climate change (Briffa *et al.,* 2008, Hember *et al.,* 2012) One approach that meets *good practice* to reduce interannual variability is to use such growth functions to estimate biomass growth rates, because they represent the average annual 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, it is *good practice* to adjust growth estimates accordingly, and to incorporate the new data 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. Steps outlining the appropriate use of models in GHG inventories are further outlined in the IPCC expert meeting report on the subject (IPCC, 2010d).

It is encouraged at Tier 3 to assess and document clearly the extent to which natural and indirect-human factors influence the time series of reported annual GHG emissions and removals in the LULUCF Sector. While such factoring out has been recognised as difficult (IPCC, 2003b), new methods are becoming available that can help

[28] Section 2.1.1, Volume 4, *2006 IPCC Guidelines*.

inform the policy community about the relative contributions of natural and indirect-human factors compared to direct human factors (Smith, 2010). Measures to reduce the reported impacts of environmental variability (including climate, trends in atmospheric CO_2 concentration or N deposition) can include time-averaging of environmental data over 5-10-year or longer periods when using such data in higher-tier process models. However, because of non-linear ecological processes, average environmental conditions may not yield average net emissions or removals.

Methods used to reduce interannual variability can also help isolate the impacts of **changes** in human activities relative to a baseline. This can be achieved by calculating two time series of emissions and removals 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 **baseline** human land use and land-use change and forest management data – the baseline could be based on historic averages or business-as-usual assumptions); and second the actual emissions (with actual climate data, actual natural disturbance rates but **actual** human land use, land-use change and forest management 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)[29].

FM reference levels and the provision to exclude emissions from natural disturbances introduced for FM in Decision 2/CMP.7 can affect the extent to which interannual variability is reflected in the accounted estimates of GHG emissions and removals. Countries that elect to exclude emissions from natural disturbances will reduce the interannual variability in accounted emissions.

The impact on accounting of the use of FMRL on interannual variability will depend on the methods used to calculate the FMRL and the actual reported emissions. Countries could introduce large bias due to interannual variability in reported emissions if they use a FMRL 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 (including long-term trends) or with actual climate parameters. If a Party uses Tier 3 models responsive to environmental parameters, it is therefore *good practice* to use consistent methods, including the same environmental and climate data, to calculate both the FMRL and the estimated actual FM emissions. For example, if a technical correction (see section 2.7.6) to the FMRL calculations using Tier 3 methods used the same time series of climate parameters that are used in the calculation of the actual FM emissions, then the impacts of interannual climate variability on forest productivity (NPP) and respiration would cancel out in the difference between the two time series.

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

2.3.6 Choice of method

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

Whenever a category is identified as key in the UNFCCC inventory, it is *good practice* that the associated activity under the KP also be treated as a Key Category[30]. In the identification and documentation of Key Categories under the KP it is also *good practice* to include a qualitative assessment, because there is not always an unambiguous correspondence between the UNFCCC categories and KP activities. A country may also undertake Approach 2 for Key Category analysis (see Section 4.3.2, Volume 1 of the *2006 IPCC Guidelines*) to identify the Key Categories of their inventory including the KP activities.

Table 2.1.1 can be used to establish the relationship between land categories and KP activities for purposes of identifying Key Categories under Articles 3.3 and 3.4 of the KP. The first row of Table 2.1.1 lists the land uses of the *2006 IPCC Guidelines*. For each land use there are two land-use categories in the *2006 IPCC Guidelines*: 'land remaining in the same land-use category' (e.g. Cropland remaining Cropland) and 'land converted to

[29] While there can also be an interaction between climate change and FM activities, the incremental emissions or removals resulting from this interaction can be attributed to the management activity, as without it the interaction would not have occurred.

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

another land-use category' (e.g. Forest Land converted to Cropland). These land-use categories may have been used in the Key Category analysis of the UNFCCC inventory[31]. In Table 2.1.1, for a given column, i.e. a final land use, the entries in the rows show which KP activities could have occurred on that land. In particular, elements on the sub-diagonal of Table 2.1.1 correspond to land remaining in the same category (e.g. Cropland remaining Cropland), while the other entries of that column show possible KP activities on land converted to the given land use.

If any of the land-use categories of the *2006 IPCC Guidelines* is identified as key, the KP activities in the corresponding column of Table 2.1.1 (note again the distinction of land remaining in the same category in the sub-diagonal cell, and land converted to the given land use) could initially be considered key. However, as in some cases several KP activities potentially can be key, it is *good practice* to examine qualitatively which of the possible activities actually are key. For example, if land converted to Grassland was identified as key, this can involve D, RV, GM, WDR, or land-use changes not covered by the KP. The land area affected by RV or WDR may be much smaller than the land area of the land use category in which it occurs and in which other activities may also occur. If this is the case, and if RV is identified as potentially key according to Table 2.1.1, then countries may separately assess the importance of GHG emissions and removals in RV compared to the other activities which occur in the same land-use category. It is *good practice* to explain and document which of the potential key categories are identified as key for KP reporting.

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 KP:

- As shown in Table 2.1.1, several activities under the KP 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 sinks in future years.
- In some cases, it is possible that the emissions or removals from an activity under the KP 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 KP 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 subcategory or pool is particularly significant. Usually, for this purpose, the subcategories or pools are ranked according to their contribution to the aggregate Key Category. Those subcategories or pools that contribute together more than 60 percent to the Key Category are considered particularly significant. For example, if CM 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 or pools.

Tier 1 as elaborated in Chapter 4, Volume 4 of the *2006 IPCC Guidelines* assumes for Forest Land remaining Forest Land that the net change in the carbon stock for litter (forest floor), dead wood and soil organic carbon, in mineral soil pools is zero. However, paragraph 26 of the Annex of Decision 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 HWP. With the exception of HWP, a Party may choose not to account for a given pool in a CP, 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 FM is not considered a Key Category, which can only be the case if Forest Land remaining Forest Land (see Chapter 4 of the *2006 IPCC Guidelines*) is not a Key Category.

[31] 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*.

2.3.7 Factoring out indirect, natural and pre-1990 effects

CMP decisions specify that information needs to be provided on whether or not anthropogenic GHG emissions by sources and removals by sinks from activities under Articles 3.3 and 3.4 factor out removals from three processes: (1) elevated carbon dioxide concentrations above pre-industrial levels, (2) indirect nitrogen deposition, and (3) the dynamic effects of age structure resulting from activities prior to 1 January 1990[32]. In addition to the requirement to report whether or not these effects are factored out, those Parties that choose factoring out are expected to also report the methods they used. For the purpose of accounting under the KP "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 CP 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 sum to zero (see also section 2.3.5 and its discussion on reducing impacts of interannual variability).

2.3.8 Reference Levels

Decision 2/CMP.6 requests each Annex I Party to submit information on its FMRL and provides guidelines for the submission and review of information on FMRLs. Technically the FMRL is a level of GHG emissions and removals against which the emissions and removals reported for FM during the second CP will be compared for accounting purposes.

It is *good practice* to construct the FMRL taking into account historical data from GHG inventory submissions, age-class structure and the need to exclude removals from accounting in line with paragraph 1 of Decision 16/CMP.1. It is also *good practice* to take into account FM activities which were already undertaken, projected FM activities under a 'business as usual' scenario, and continuity with the treatment of FM in the first CP, where relevant. Finally, in the construction of the FMRL it is *good practice* to include pools and gases consistent with historic reporting and to also treat natural disturbances consistently. Details of the methodology for determining the FMRL can be found in Section 2.7.5 of this document.

The paragraph 14 of Annex to Decision 2/CMP.7 requests methodological consistency between the FMRL and reporting for FM during the second CP when accounting for FM. According to paragraph 15 of the Annex to Decision 2/CMP.7 a technical correction shall be applied if the reported data on FM or forest land remaining forest land used to establish the FMRL 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 according to Decision 2/CMP.7, a technical correction may be needed to ensure that the same method and data (climate, model parameters, etc.) are used for the construction of the FMRL and the reporting of FM during the CP, 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[33]

Disturbances affect the carbon cycle of forests and other lands, and may also lead to non-CO_2 GHG emissions. Disturbances can be either natural or human-induced. It is *good practice* that all methodologies adopted for reporting emissions from disturbances be based on the guidance provided in the *2006 IPCC Guidelines*.

Emissions from natural disturbances on managed land are included in the reporting under the UNFCCC, and were included in the accounting under the first commitment period of the KP for mandatory and elected activities. Emissions from natural disturbances on unmanaged lands were not included in the reporting so long as those lands continued to be unmanaged. The same rules apply for the second commitment period except that Decision 2/CMP.7 introduces the modification that, under certain conditions, and if the Party has indicated in its NIR submitted in 2015 that it wishes to do so[34], emissions from natural disturbances that occur on land subject to FM under Article 3.4 or AR under Article 3.3 may be excluded from accounting[35]. If a Party wishes to exclude

[32] See Paragraph 3 of Annex II to Decision 2/CMP.8

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

[34] According to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, in the report to facilitate the calculation of the assigned amount pursuant to Article 3, paragraphs 7bis, 8 and 8bis, a Party shall include an *indication of whether it intends to apply the provisions to exclude emissions from natural disturbances for the accounting for afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol and/or forest management under Article 3, paragraph 4, of the Kyoto protocol during the second commitment period in accordance with decision 2/CMP.7*.

[35] Paragraph 33 of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 17-18.

such emissions, it is required to separately calculate the emissions and removals that are subject to the requirements of Decision 2/CMP.7 for natural disturbances, and to provide transparent information regarding the estimation of annual emissions and subsequent removals. This section provides *good practice* guidance on the implementation of the relevant provisions of Decision 2/CMP.7 in relation to natural disturbances, including issues related to the background level and the margin.

2.3.9.1 DEFINITIONAL ISSUES

For the second commitment period, Parties may apply the provision for the treatment of natural disturbance emissions for FM under Article 3.4 and/or AR under Article 3.3 as set out in the Annex to Decision 2/CMP.7. According to Annex I to Decision 2/CMP.8, a Party's report to facilitate the calculation of the assigned amount pursuant to Article 3, paragraphs 7bis, 8 and 8bis *shall contain an indication of whether it intends to apply the provisions to exclude emissions from natural disturbances for the accounting for afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol and/or forest management under Article 3, paragraph 4, of the Kyoto Protocol during the second commitment period, in accordance with decision 2/CMP.7*. Parties are required to calculate emissions and removals from natural disturbances subject to the provisions of Annex to Decision 2/CMP.7 (including those in paragraphs 33 and 34), and to provide transparent information on how the annual emissions and subsequent removals associated with disturbances are estimated.

For reporting and accounting under the second commitment period of the KP, Decision 2/CMP.7[36] 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 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.

For practical purposes the requirement 'beyond the control of, and not materially influenced by a Party' replaces the anthropogenic/non-anthropogenic test as stated in the first sentence cited above, which may be difficult to establish, e.g. in the case of wildfires whose immediate cause may be difficult to determine. Decision 2/CMP.7 provides a list of examples under which the provision of natural disturbance may be applied:

- **Wildfires**: Wildfires occur in many forests and interact with the functioning of the forest ecosystems in which they occur. Wildfires can be important to the functioning of forest ecosystems, but they can also have undesirable environmental, social and economic impacts. Fire regimes (fire intensity, frequency and season of the occurrence (Gill, 1975)) can have significant impacts on forest carbon stocks across considerable spatial and temporal scales (King *et al*., 2011). Recent studies on wildfires and forests include: Hirsch and Fuglem (2006); Williams and Bradstock (2008); Swetnam and Anderson (2008); Girardin *et al*. (2010).
- **Insect pests and disease infestations**: Diseases (*pathogens such as fungi, phytoplasma, or viru*s, cf. page 4.74 in Chapter 4, Volume 4 of the *2006 IPCC Guidelines*) and insect pests can influence ecological processes and substantially affect large-scale regional GHG 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 in forests include: Canadian Council of Forest Ministers (2012a, 2012b and 2012c); Raffa *et al*. (2008); Bentz *et al*. (2010).
- **Extreme weather events**: Extreme weather events can involve droughts, floods, heavy and wet snowfall, avalanches, ice, and strong winds, occurring either as a single event or in combinations such as ice storms (Lindner *et al*., 2010; Yamashita *et al*., 2002; Allen *et al*., 2010; Kato 2008, Kramer *et al*., 2008; Bebi *et al*., 2009; Phillips *et al*., 2009; Chambers *et al*., 2007, Fujimori *et al.*, 1987). Besides causing emissions e.g. through the decay of dead organic matter (DOM) following storm damage or stem breakage due to high snow loads, extreme weather events can negatively affect forests, making them more susceptible to other natural disturbances. For example, there is a higher incidence of wildfires after drought periods.
- **Geological disturbances**: Geological disturbances may include volcanic eruptions, landslides, tsunamis, and earthquakes (Kamijo and Hashiba, 2003; Viña *et al*., 2011).

Decision 2/CMP.7 requires Annex I Parties that apply the provisions for natural disturbance to FM under Article 3.4, and/or to AR under Article 3.3 of the KP to provide transparent information, inter alia, *that demonstrates that the occurrences were beyond the control of, and not materially influenced by, the Party in the commitment*

[36] Paragraph 1(a) of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 13.

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 Annex to Decision 2/CMP.7[37].

Such practicable efforts include but are not limited to:

- Reducing the likelihood of the disturbance occurring, by preventive measures or modifying factors related to the occurrence or propagation of the disturbance. Examples include public information campaigns or fire bans during high-risk fire seasons. Some of the actions taken in this regard may themselves cause emissions which need to be estimated as part of the management practice. For example, thinning to increase stand stability against storm damage, prescriptive burning to reduce the amount of combustible material, or introduction of firebreaks to make the spread of fire less likely.
- Managing or controlling the disturbance during its occurrence. This may be facilitated through the implementation of monitoring programs and early warning systems, firefighting operations, integrated coordination with fire squads, etc.

Depending on national circumstances, particularly the organizational, administrational and governance responsibilities, examples of transparent and verifiable information demonstrating these efforts could include, but are not necessarily limited to:

- A national or sub-national (regional, provincial, community) level strategy, a forest policy, FM plan or fire management policy or plan that is valid and enforced for the region where the disturbance occurred, and that defines a national or sub-national strategy for managing the types of natural disturbance that led the Party to apply the provision for natural disturbance[38];
- Information showing that the Party took practicable efforts to manage or control the individual disturbances included under the natural disturbance provision (for example, expenditures on the fire suppression effort and/or the incident management plans for the disturbance, and their relationship to total budget for FM forest).

It is *good practice* to demonstrate that the strategy has been implemented, or is in the process of implementation, when a Party indicates its intention to apply the natural disturbance provision.

In some instances it may not be practicable to prevent, manage or control the disturbance. When a Party wants to include such events or circumstances under the natural disturbance provision, it is *good practice* to provide transparent and verifiable information demonstrating that no practical action could be taken to prevent, manage or control the occurrences of the event or circumstance to comply with paragraph 34(d) of Annex to Decision 2/CMP.7.

2.3.9.2 CHOICE OF METHODS FOR IDENTIFYING LAND SUBJECT TO NATURAL DISTURBANCE

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

Annex I Parties that choose to apply the natural disturbance provision outlined in Decision 2/CMP.7 need to be able to meet all of the requirements set out in paragraph 34, (a) to (f) of Annex to Decision 2/CMP.7. This includes providing transparent information '*Showing that all lands subject to paragraph 33(a) and (b) … are identified, including their georeferenced location[39], year and types of disturbances*' (paragraph 34(a)); '*Showing how annual emissions resulting from disturbances and the subsequent removals in those areas are estimated*' (paragraph 34(b)); '*Showing that no land-use change has occurred on lands for which the provisions in paragraph 33 … are applied and explaining the methods and criteria for identifying any future land-use changes on those land areas during the commitment period*' (paragraph 34(c)); '*That demonstrates 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…*' (paragraph 34(d)); '*That demonstrates efforts taken to rehabilitate,*

[37] Paragraph 34(d) of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 18.

[38] Paragraph 33 of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 17-18

[39] Consistent with the treatment in paragraph 6(b) of Annex to Decision 15/CMP.1, georeferencing is taken to refer to the geographical location of the boundaries of areas including disturbances. The requirements of paragraphs 33 and 34 of Annex to Decision 2/CMP.7, e.g. on demonstrating whether land-use change or salvage logging have occurred on disturbed areas, mean that ancillary data may also be required.

where practicable, the land for which the provisions in paragraph 33 …are applied' (paragraph 34(e)); '*Showing that emissions associated with salvage logging were not excluded from accounting*' (paragraph 34(f)). Parties also need to be able to reflect the treatment of emissions and removals on these lands in LULUCF accounting for subsequent commitment periods (paragraph 36 of Annex to Decision 2/CMP.7[40]). All of these requirements are linked to the identification of lands that are affected by natural disturbances, consistent with the guidance set out in this Chapter and in Chapter 1.

For lands subject to Articles 3.3 and 3.4, Section 2.2.2 outlines Reporting Method 1 and Reporting Method 2. As discussed in Section 2.2.4, these Reporting Methods are not the same as the underlying methods used to identify land areas for GHG inventory purposes, although there are linkages between them. Reporting Method 1 entails delineating areas that include multiple lands and assessing the respective contribution of relevant activities (or conditions) to the total emissions from these lands; it is often associated with the application of statistical sampling approaches to land identification. Reporting Method 2 is based on the spatially explicit and complete geographical identification of all lands subject to a single activity (or condition) and entails wall-to-wall mapping, which is frequently associated with the application of remote sensing[41] techniques. Similarly, identification of lands that are subject to natural disturbance can be undertaken with statistical sampling approaches, or via wall-to-wall mapping and ground-based surveys, carried out solely or in combination, and supported as necessary by relevant ancillary data.

Estimating the area affected by the disturbance requires, for each disturbance type, that the:

i. Proportion of affected area is assessed accurately if Reporting Method 1 is used and that each affected area is identified as being disturbed with georeferenced location, year and types of disturbances, when Reporting Method 2 is used, and

ii. Methods and algorithms used for detecting disturbances and disturbance type are suitable for the identification of areas affected by disturbances in a manner consistent with the Party's definition of forests used for reporting under the KP, and that respective area or areas of land be identified in subsequent years. General guidance on this topic is provided in Chapter 3 in Volume 4 of the *2006 IPCC Guidelines*. Fuller *et al*. (2003) discusses possible issues that are related to this.

Statistical sampling schemes do not provide delineation of disturbed areas directly, but rather an estimate of the total disturbed area by means of representative sample plots that were affected by the disturbance (refer to Chapter 3 in Volume 4 of the *2006 IPCC Guidelines* for guidance on sampling and area estimation). Identification and geographical location of the disturbance events are performed on a per-plot basis. Sampling schemes may be based, for example, on National Forest Inventory sampling grids (Tomppo *et al.*, 2010) if the information provided by them is sufficient to meet the requirements in Decision 2/CMP.7, set out in paragraphs 33 and 34. Depending on the type of disturbance and its associated characteristics (e.g. area, size, and distribution), it is *good practice* to intensify sampling in order to make the estimated uncertainty comparable with the uncertainty in the overall estimation of Articles 3.3 and 3.4 forest-related emissions.

When using remotely sensed data to detect changes triggered by the occurrence of natural disturbances, a Party needs to identify the necessary temporal and spatial resolutions, and to assess the need for complementary ancillary and/or ground truth data. Identification and assessment are specific to the type of individual natural disturbance events or circumstances that the Party intends to consider. While, for some types of disturbance, less frequent but more detailed data might provide better estimates (e.g. identification of areas affected by pest infestation), more frequent but less detailed data might be better for others (e.g. when identifying fire hot spot areas). Decisions concerning which data sources (e.g. spatial resolution of satellite imagery) will be used should take into account the specific characteristics of the type of disturbance (e.g. percentage loss in forest crown cover due to pest infestation). In addition, the timing of the surveying and of the analysis of the data is also relevant to ensure that the data capture the effect of the natural disturbance, rather than seasonal changes. For instance, if the analysis of the data occurs shortly after the occurrence of a discrete disturbance event, it is very likely that the changes on the ground will result from the event itself. Otherwise, the data may be confounded with land-use change, annual phenological and climatic differences, and/or other factors that may influence the pre- and post-disturbance conditions. It is therefore *good practice* for the Party to indicate how the remotely sensed data are used to identify the changes caused by the actual disturbance event, rather than other phenomena.

When considered individually, any approach may have strengths and limitations. For example, wall-to-wall approaches based on remotely sensed data may not discriminate among losses of tree cover associated with harvesting (either planned clear cut or salvage logging) and those associated with natural disturbances, while systematic sampling grids of existing forest inventories may not have an adequate sample size, design and

[40] Contained in document FCCC/KP/CMP/2011/10/Add.1., p. 18.

[41] Remote sensing includes satellite and air borne sensors. For general guidance on sampling and land identification issues, please refer to the *2006 IPCC Guidelines* (Chapter 2 in Volume 1; Annex 3A.3, Chapter 3 in Volume 4).

frequency to reliably identify the year of the disturbance or the affected area with the level of precision and accuracy desired by the Party. For both wall-to-wall mapping and statistical sampling techniques, existing national approaches for land identification may need to be adjusted and improved in order to fulfil the requirement for identification of lands that are subject to natural disturbance, including their georeferenced location, year and types of disturbances. Hybrid approaches, using a set of different types of data, may facilitate the fulfilment of the relevant requirements in Decision 2/CMP.7. The Party's choice as to which approach and data to use for land identification will depend on national conditions in land under FM and/or AR, the inventories and surveys already in place, and the type and magnitude of the disturbance(s) to be assessed (see Box 2.3.4 for examples). It is *good practice* for Parties to present information demonstrating the suitability of the methods and approaches used to identify the lands affected by natural disturbance, consistent with the requirements of paragraph 34(a) of Annex to Decision 2/CMP.7, as well as information on how the provisions concerning salvage logging and land-use change following such disturbances are monitored. Ancillary data may be needed (e.g. concerning disturbance characteristics, location and management activities), and this may be provided by amending or tailoring an existing inventory scheme to detect deforestation events in a way that also assesses whether land-use change has occurred on previously disturbed lands, or by incorporating the detection of salvage logging in harvest records as well as by collecting completely new data.

BOX 2.3.4
EXAMPLES OF APPROACHES FOR IDENTIFYING LANDS AFFECTED BY NATURAL DISTURBANCES

Example 1: Permanent sample plots with repeated measurements

A Party conducts a national forest inventory (NFI) based on a set of permanent sample plots, with a predefined sampling design, that regularly provide data, and estimates both the emissions and the area of land-use changes by using information and data collected on the sample plots.

Requirements: This approach requires that representative permanent sample plots with a predefined sampling design and regular measurement intervals be available. Guidance on sampling approaches, including sample size, is provided in Chapter 2 in Volume 1 and Annex 3A.3, Chapter 3 in Volume 4 of the *2006 IPCC Guidelines*. Measurements should provide data for the parameters of interest, including the disturbance type and year of occurrence, while meeting georeferenced-location requirements that may require ancillary data collection.

Estimation method: The annual area affected by a particular type of disturbance is estimated as the product of the fraction of plots affected (calculated as the ratio of sample plots disturbed and the total number of sample plots) and the total geographical area covered by the sample plots (refer to Section 3A.3.5 in Annex 3.A.3, Chapter 3 in Volume 4 of the *2006 IPCC Guidelines*). The associated total annual emission is estimated by multiplying the area affected and the area-specific, disturbance level- and/or disturbance type-specific emissions (CO_2 and non-CO_2) per unit area. The uncertainty in the area affected by disturbance can be estimated by following standard sampling theory (refer to Chapter 2 in Volume 1 of the *2006 IPCC Guidelines*). Parties should stratify the affected areas to allow representative sampling based on emission intensities and then generate the average emission accordingly. Ancillary data will likely be needed to monitor land-use change and the occurrence of salvage logging.

Potential challenges: This approach may have a high percentage sampling error associated with rare disturbance events (e.g. hurricanes, volcanic eruptions) that may be under-represented in the existing NFI or other sampling schemes, thus requiring an intensified sampling grid. When the regular inventory return interval is not sufficient to assign a year to the disturbance (e.g. for wind-throw), additional field visits or other data/methods may be required.

Example 2: Area estimation with full coverage and time series comparisons

A Party uses remotely sensed data or a complete land register-based system, the latter of which is a database for land use and land-use change estimation that contains information on land holdings based on ground-based administrative systems for forestry or land use in general.

Requirements: This approach requires full territorial coverage for remotely sensed data at an appropriate spatial resolution, as well as appropriate remote sensing techniques for assessing changes in land cover; or a complete and up-to-date land register-based system that contains the location, size of parcels of land, and information on land use/land cover (for additional information and guidance, refer to Section 3A.2.4 (Tools for data collection) in Annex 3A.2, Chapter 3 in Volume 4 of the *2006 IPCC Guidelines*). The data from remote sensing or land-register based techniques, including the classification algorithms and estimators, require calibration and validation using ground truth or equivalent data. Parties should demonstrate the suitability of the techniques, including classification algorithms and estimators, by presenting well-documented and transparent supplementary information that describes how they have been evaluated in terms of accuracy and precision using ground truth or equivalent data.

Estimation method: The emissions associated with areas affected by the various disturbance types and levels are summed. Time series measurements are then used as supporting evidence for extent and severity of disturbance. Estimation algorithms, which may need to be a function of type and extent of disturbance, can be used.

Potential challenges: Depending on the type and intensity of the disturbance, classification and mapping algorithms may have errors of omission and commission associated with area estimation, which can lead to high absolute errors if data from several maps are combined (see Fuller *et al*. (2003) for details). It may also be difficult to detect some disturbances by remote sensing (e.g. disturbances that cause dispersed single tree mortality over large areas, such as Ash dieback[42]). The land register also needs to be updated regularly to make use of the most current information. Another challenge is the accuracy of estimation models and algorithms and ensuring their uncertainty is within levels aimed for by the Party.

Example 3: Permanent sample plots with repeated measurements combined with remote sensing

A Party conducts a forest inventory based on representative permanent sample plots, using remotely sensed data for stratification.

Requirements: This approach requires availability of permanent sample plots with a predefined sampling design and regular measurement intervals and full coverage by remotely sensed data of appropriate spatial and temporal resolutions that allow for the identification and monitoring of disturbance events, combined with classification algorithms consistent with the accuracy and precision sought by the Party.

Estimation method: The total area affected by a disturbance type is determined from remotely sensed data and total emissions are estimated from the permanent sample plots that fall within the disturbed area. Plot data with the actual estimates of emissions and the area of the strata are used to compute the total emissions from the disturbance. Estimation algorithms based on ground variables can also be used to generate emission estimates. The strength of this method is that it potentially allows for estimates of both the emission and the affected areas that are more accurate than those in either Example 1 or 2 above. Classification algorithms will need calibration and validation, which should be documented and their performance evaluated.

Potential challenges: This approach requires both extensive remotely sensed data and intensive ground data-based inventory systems. Balancing and matching of the systems and methods, e.g. to avoid double-counting, may be difficult to achieve, especially in situations where more than one disturbance affects a given area. The use of remote sensing faces similar challenges to those identified in Example 2 above.

2.3.9.3 ESTIMATION OF CO_2 EMISSIONS AND REMOVALS FROM NATURAL DISTURBANCES

For the second commitment period, Parties may apply the provision for the treatment of natural disturbance emissions to FM under Article 3.4 and/or to AR under Article 3.3 consistent with Annex to Decision 2/CMP.7. To apply the provisions for natural disturbance, Parties are required to provide country-specific information on a FM background level and/or an AR background level of emissions associated with annual natural disturbances (cf. paragraphs 33(a) and (b) of Annex to Decision 2/CMP.7). Parties are also required to calculate the emissions and removals subject to the provisions for natural disturbances (cf. paragraphs 33 and 34 of Annex to Decision 2/CMP.7), and to provide transparent information on how the annual emissions and subsequent removals are estimated. This section provides guidance for estimating carbon stock changes in order to meet these requirements.

The incidence of natural disturbances varies 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 it could spread across small-discrete areas, with either homogeneous or heterogeneous intensity. Temporal variability refers to the occurrence of natural disturbances over time and the extension of post-disturbance effects over time: there may be direct releases of carbon to the atmosphere during the disturbance (e.g. from fires), delayed emissions (due to decay processes), and the redistribution of carbon among carbon pools (e.g. transfer to the dead wood, litter or soil organic matter pools), which may then also decay and cause emissions in subsequent years.

There are particular considerations in relation to the estimation of the effects of natural disturbances when a Party applies the provision for natural disturbances to FM and/or AR. These include the choice of the estimation

[42] *Chalara fraxinea (teleomorph: Hymenoscyphus pseudoalbidus)*, a fungus affecting ash trees in Europe.

method and tier level, accounting for emissions associated with salvage logging, and the exclusion of removals subsequent to the disturbance event on the affected lands.

CHOICE OF ESTIMATION METHOD AND TIER LEVEL

The methods for estimating CO_2 emissions associated with carbon stock changes in the relevant pools are given in the *2006 IPCC Guidelines* and are elaborated in Chapter 4 in Volume 4 for above and below-ground biomass, dead wood, litter, and soil organic matter. For HWP, estimation methods in line with Decision 2/CMP.7 are provided in Section 2.8 of the *KP Supplement*.

Land subject to natural disturbance in the context of Decision 2/CMP.7 is the land that has already been identified as land under FM or AR. The estimation of carbon stock changes and associated emissions due to natural disturbance should therefore be consistent with, and/or complementary to, the method and tier level applied to each of the pools under the activities of FM and/or AR for reporting under the KP. Estimations of carbon stock changes due to natural disturbance should include the disturbance's effect on carbon stock changes in the subsequent years of the second commitment period so that reporting reflects the emissions associated with carbon stock changes in the year they occur. 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 temporal dynamics of the natural disturbance. It is also *good practice* to estimate emissions associated with carbon stock changes from natural disturbance in a manner consistent with the method used for the calculation of emissions in the background level, and, if that is not the case, to conduct a technical correction of the background level and the FMRL.

When the *Forest Land Remaining Forest Land* category under the UNFCCC is a *key category* it is *good practice* to apply Tier 2 or Tier 3 methodologies to estimate carbon stock changes from natural disturbance for FM; and the same should be done for AR if the *Land Converted to Forest Land* category under the UNFCCC is a *key category* (Chapter 4 in Volume 1 of the *2006 IPCC Guidelines*). Under Tier 1, it is assumed that the net carbon stock change in DOM is zero. Decision 2/CMP.7 specifies that the carbon stock change in all pools must be accounted for, although, with the exception of HWPs, Parties may choose to exclude from accounting in the second commitment period pools which can be shown using transparent and verifiable information not to be a source[43]. During natural disturbance events significant amounts of carbon may be transferred to the DOM pool, which will then decay, and thus it becomes less likely that a Party could subsequently show that DOM pools are not a source. Therefore, countries with forests that experience significant changes in disturbance regimes (which would be the case if major natural disturbance events occur) should quantify the impacts from these changes using Tier 2 or Tier 3 methodologies (Section 2.2.1, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*).

It is *good practice* for methodologies to represent the effect of the particular natural disturbance event or circumstance on the carbon stocks on the land affected by the natural disturbance. The effects of natural disturbances that should be considered include: direct reductions in carbon stocks due to the disturbance (e.g. release of CO_2 to the atmosphere during wildfires), transfer of carbon between pools (e.g. transfer of living biomass to the DOM pool due to wind-throw), changes in carbon stocks following the disturbance (e.g. through the decay of DOM post disturbance), and the dynamics and growth rate of the post disturbance forest stands (e.g. early rapid growth in young trees that regenerate after a stand-replacing fire). The effects considered in estimation of emissions may require the appropriate stratification of the impacted area to adequately represent the disturbance types, climate zones, ecosystems and affected parts of ecosystems, and land-use history based on data available from national forest inventory, remote sensing and/or other sources; and appropriate estimation of emission factors, decomposition rates and other factors and functions involved that are representative of the disturbance event and the different strata. Remote sensing or ground-based assessments that focus on the disturbance event can be helpful for addressing spatial and temporal variability in order to attribute carbon stock changes due to natural disturbance to individual years. Other statistics that record, for example, salvage logging on an annual basis may also be relevant.

Parties included in Annex I that apply the provisions for natural disturbances are required to provide transparent information on how the emissions from natural disturbances and the subsequent removals have been estimated during the commitment period[44]. This includes documentation of the data sources and estimation methodologies in accordance with the tier level used for applying the natural disturbance provision. Disturbance matrices[45] (Section 2.3.1.1, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*) can be used to define the event's impact 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 HWP.

[43] Paragraph 26 of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 16.

[44] Paragraph 34(b) of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 18.

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

EXCLUSION OF REMOVALS

According to paragraphs 33(a) and (b) and 34(a) and (b) of Annex to Decision 2/CMP.7, for lands on which emissions have been excluded from accounting under the natural disturbance provision, *any subsequent removals during the commitment period on the lands affected shall also be excluded from the accounting*. Removals are considered to be positive changes in carbon stocks due to growth of forest vegetation on the lands subject to the provision. Removals in this context do not refer to physical removal of carbon from land affected by a natural disturbance, or due to salvage logging (see also the definition of salvage logging in Box 2.3.5 below).

The removals on lands previously disturbed can be estimated using the methodologies provided for Forest Land in Chapter 4 in Volume 4 of the *2006 IPCC Guidelines*. It is *good practice* to apply estimation methodologies that take into account the respective conditions found on the affected land following the natural disturbance event and to show that the subsequent removals are completely estimated and that double counting is avoided.

ACCOUNTING FOR SALVAGE LOGGING

When salvage logging occurs on land subject to natural disturbance, the carbon stock change due to salvage logging must be accounted for and not excluded with emissions associated with natural disturbances (cf. paragraphs 33(c) and 34(f) of Annex to Decision 2/CMP.7). Box 2.3.5 defines salvage logging in the context of the natural disturbance provision. The carbon stock change due to the harvest and physical removal of trees or parts of trees is treated as a loss of carbon (and consequently, as a CO_2 emission) from the affected land in the year the salvage logging occurs, and is subject to the HWP provisions of Decision 2/CMP.7 in situations where wood derived from salvage logging can be shown to enter the HWP pool. It is *good practice* to assign carbon stock changes from salvage logging to the year in which they take place.

Significant emissions from non-biomass carbon pools (e.g. soil organic matter) due to altered decay rates after salvage logging operations need to be included in the accounting if the required information or models are available to a Party and transparent information on the estimation of these emissions can be provided. The current state of knowledge indicates the limitations of, and generally high uncertainties for, emission estimation from these pools under natural disturbance conditions (Chapter 4 in Volume 4 of the *2006 IPCC Guidelines*), nevertheless countries that have the necessary capacities are encouraged to capture these dynamics.

BOX 2.3.5
DEFINITION OF SALVAGE LOGGING, IN THE CONTEXT OF THE EXCLUSION OF EMISSIONS FROM NATURAL DISTURBANCES

Salvage logging is the practice of harvesting and physically removing trees or parts of trees (living or dead) from disturbed areas. This management activity is also known as salvage cutting, salvage harvesting, sanitation cutting, and other designations. In case a Party chooses to exclude emissions due to natural disturbances, it *shall account for emissions associated with salvage logging* (paragraph 33(c) of Annex to Decision 2/CMP.7). Therefore, if a Party chooses to apply the natural disturbance provision, it is *good practice* to report in a transparent manner the emissions caused by salvage logging on land subject to natural disturbance so that these emissions can be transparently accounted for. For the purposes of the provision, these emissions result from the following:

1) Wood removal and fuelwood removal (and hence, carbon) from the disturbance area due to harvest and physical removal of trees or parts of trees. Wood removal and fuelwood removal is treated as a carbon loss (emission) (for example Equation 2.12, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*) in the year in which it occurs;

2) emissions of carbon due to the decay of dead wood discarded from salvage logging operations and remaining on site, litter, and any significant disturbance to the soil organic matter pools; and,

3) non-CO_2 GHG emissions due to management activities associated with salvage logging, e.g. burning of harvest residues.

Carbon stock increases due to gains in living biomass on the affected land are carbon removals from the atmosphere and are not combined with emissions associated with salvage logging.

A Party needs to demonstrate that the emissions from salvage logging in the area affected by the disturbance were not included in the total emissions associated with the disturbance event, and to demonstrate how, in the subsequent years (of the commitment period), disturbed areas are monitored for the occurrence of salvage logging, and how emissions associated with salvage logging are estimated if salvage logging is conducted in subsequent years, after the disturbance. This is particularly relevant to those Parties that report carbon stock changes using the stock difference method.

2.3.9.4 ESTIMATION OF NON-CO_2 GHG EMISSIONS FROM NATURAL DISTURBANCES

As Section 2.3, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines* specifies, losses in carbon stocks or pools may in particular cases imply emissions of non-CO_2 GHGs. Typically, such emissions occur due to fires, for which the estimation methodology is provided in Section 2.4, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*, which should be applied (together with land-use specific enhancements in Chapter 4 (Forest Land) in Volume 4 of the *2006 IPCC Guidelines*). This includes the requirement to check for complete coverage of CO_2 and non-CO_2 GHG emissions that are related to changes in carbon stocks and pools in order to avoid omissions and double-counting. It is also *good practice* to document how non-CO_2 GHG (e.g. N_2O) emissions due to natural disturbances are estimated and reported.

If fire in forests contributes to a *key category*, it is *good practice* to apply higher tiers and to develop a more complete and country-specific methodology that includes the dynamics of DOM and produces better estimates of direct and post-fire emissions.

2.3.9.5 METHODOLOGICAL ISSUES SPECIFIC TO THE ESTIMATION OF EMISSIONS AND REMOVALS UNDER THE NATURAL DISTURBANCE PROVISION

To satisfy the requirements of paragraphs 33(a) and (b) and 34(a) and (b) of Annex to Decision 2/CMP.7, further guidance on methodological issues is needed concerning the estimation of the effects of natural disturbances. These include the attribution of emissions from natural disturbance events to individual years, differentiating natural disturbance events from management activities and monitoring lands subject to natural disturbance.

ATTRIBUTION OF NATURAL DISTURBANCES TO INDIVIDUAL YEARS

For natural disturbances that occur during the second commitment period, it is *good practice* to report areas and emissions from lands subject to natural disturbances in the year in which the natural disturbance began and to continue reporting the emissions from these lands in the subsequent years of the commitment period.

It is *good practice* to attribute direct releases of carbon to the atmosphere such as those from wildfires, which occur during the disturbance event, to the year of occurrence. Post-disturbance emissions from the DOM pools through the decay process will, taking account of redistribution, extend over a period of time. It is *good practice* to estimate these legacy emissions in the year they occur, while avoiding double counting. For example, if a large amount of live biomass damaged during disturbances is transferred to the DOM pool, the loss of biomass should be estimated both as a loss from the biomass pool and an input to the DOM pool. Disturbances generally have impacts on carbon stocks for more than one year, and it is *good practice* to estimate, as emissions associated with natural disturbances, the carbon emissions in the year of the disturbance, as well as legacy emissions (e.g. decomposition of DOM) in the subsequent years of the commitment period. It is 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). It is *good practice* to ,in reporting, separately identify natural disturbance lands and their associated emissions from the year in which the natural disturbance first occurs until the end of the commitment period. Guidance on legacy effects associated with natural disturbances after the end of the second commitment period is provided in Section 2.3.9.9 below.

DIFFERENTIATION FROM MANAGEMENT ACTIVITIES

Lands affected by natural disturbances can be similar in appearance to, and thus can be confused with, forest areas where regular management activities have taken place. For example, areas affected by wildfire can be similar to prescribed burning, and wind damaged areas after salvage logging can be difficult to distinguish from clear-cuts. For the application of the natural disturbance provision the emissions from natural disturbances have to be clearly differentiated from the emissions due to management activities. It is *good practice* to show that the

emissions accounted for under the natural disturbance provision are unambiguously attributable to natural disturbances and do not contain or double count emissions from regular management activities.

MONITORING LANDS AFFECTED BY NATURAL DISTURBANCE

Parties that apply the natural disturbance provision to FM under Article 3.4 and/or to AR under Article 3.3 should monitor the lands that have been designated as affected by natural disturbance over the second commitment period. Monitoring of these lands will be required to:

- estimate changes in carbon stocks due to post-disturbance decay and removals;
- demonstrate that, where practicable, efforts have been made to rehabilitate the affected lands;
- identify cases in which land-use change has occurred after a natural disturbance;
- estimate the amount of carbon stock that has been removed in salvage logging; and
- identify lands where the natural disturbance is followed by another disturbance event, in order to avoid double-counting.

Monitoring natural disturbances and compiling the associated data on these lands including the disturbance type, size and location is required in order to provide consistent time series information about the affected area. The methods used in the post-disturbance monitoring of affected areas should be consistent within those used to monitor forestry activities in general; i.e. the underlying assumptions and estimation methods should be in common and activity data estimates should be consistent even if supplementary data are gathered from different sources, e.g. greater use of remote sensing for disturbance monitoring.

If land-use change occurs on lands affected by natural disturbances, and on which emissions were previously excluded from accounting, it is *good practice* to account for this land as being subject to deforestation in the year the land was subject to the natural disturbance. This results in all emissions caused by the natural disturbance and land-use change being accounted for under Deforestation.

2.3.9.6 GUIDANCE ON THE DEVELOPMENT OF THE BACKGROUND LEVEL AND MARGIN

Parties may exclude[46] emissions from natural disturbances for FM or for AR (or both) above the background level in years for which the emissions resulting from natural disturbances exceed a background level plus a margin, where a margin is needed, provided that they meet all the requirements set out in Decision 2/CMP.7[47]. Conceptually, the background level is the annual level (a positive number or zero) for disturbance emissions based on historical data, and the margin is a positive number or zero that should be set in conjunction with the background level. Because the background level is included in the FMRL, emissions from natural disturbances up to the background level are already implicitly excluded from accounting during the second commitment period. The sum of the background level and the margin is used to identify years (those for which emissions from natural disturbances during the commitment period were larger than this sum) when emissions from natural disturbances larger than the background level may be excluded from accounting. It is *good practice* that the background level and the margin be developed together so as to ensure that the exclusion of natural disturbances does not lead to the expectation of net credits or net debits.

In order to develop both the background level and the margin, Parties can apply either the default method described in the Annex to Decision 2/CMP.7, or alternative country-specific methods. The choice of methods will result in different background levels and margins, but regardless of the applied method, it is *good practice* to develop a background level and a margin that ensure the exclusion of natural disturbances does not lead to the expectation of net credits or net debits (see Box 2.3.6). Given the same set of data, in cases with a higher value of the background level and margin, more emissions are implicitly excluded and the individual exclusion of emissions is expected to be less frequent than in cases with a lower value of the background level and margin. In the latter case, higher costs for monitoring, estimation and reporting can be expected.

Decision 2/CMP.7 requires the development of separate background levels and margins for FM and AR. For both FM and AR, emissions from natural disturbances may occur as a result of several types of disturbances. In estimating the background level and margin it is *good practice* to combine emissions from different disturbance

[46] See requirements set out in paragraph 33(a)-(b) of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 17-18, and Paragraph 1(k) of Annex I to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, p. 17.

[47] Paragraph 34 of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 18.

types, and then to develop one overall background level and margin for FM, and one for AR, if Annex I Parties choose to apply the natural disturbance provision to both FM and AR.

Decision 2/CMP.7 requires that the background levels be constructed using consistent and initially complete time series that contain, but are not limited to, 1990–2009 annual emissions that are associated with natural disturbances[48]. The period for this time series of historical emissions is referred to as the calibration period.

To develop background levels and margins, it is *good practice* to apply the stepwise procedure[49] described below.

Step 1: Define the types of natural disturbances that the Party wishes to exclude from accounting

It is *good practice* that Parties define, and report in their NIR due in 2015, and in their report to facilitate the calculation of the assigned amount (see footnote 46), the natural disturbance types (which may include wildfires, insect attack and disease infestations, extreme weather events and/or, geological disturbances) whose emissions they wish to exclude from accounting during the commitment period under the natural disturbance provisions. Disturbance types may be subdivided as needed. For example, extreme weather events could be subdivided into wind storms and floods. These disturbance types can include rare events (such as volcanic eruptions) that may not have occurred during the calibration period.

Step 2: Establish a consistent and initially complete time series for the calibration period for each disturbance type

For each disturbance type considered by the Party, a time series of annual emissions that are associated with the disturbance type needs to be established for the calibration period. The emissions are entered into Table 2.3.1 for FM and in Table 2.3.2 for AR both for each year of the calibration period and for each type of disturbance considered, and are used for subsequent calculations and for reporting. In order to accurately establish the background level, Parties are encouraged to use the longest available time series. When using the default method, Parties are required to use time series of equal length for all disturbance types considered. If including years after the period 1990-2009 the Party should take care to ensure that this does not cause inconsistencies related to policy assumptions (prior to December 2009) applied in the construction of the FMRL (see Section 2.7.5).

For rare events (such as volcanic eruptions), the emissions in all the years in the calibration period may be zero, if the rare event has not occurred in that period. For other disturbance types, the Party needs to provide reliable and transparent emission estimates for the years in the calibration period. Parties may enter zero for years in which the disturbance type does not exceed a low level that is implicit in their national statistics (e.g. for a year when some trees may have fallen due to wind but when no wind-blow was registered at a stand level). It is *good practice* to sum for each year of the calibration period, separately for FM and AR, the emissions from all disturbances types considered, in order to obtain a combined disturbance time series for the calibration period. It is *good practice* to transparently report the combined time series (one for FM and one for AR) together with the methodology used to construct the time series. Finally, area-specific emissions are calculated for use in subsequent calculations, especially in the case of AR, for which the area may considerably vary.

[48] Footnote 7 to paragraph 33(a) of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 17.

[49] The stepwise procedure applies independently of how the FMRL has been set (see Section 2.7.5)

TABLE 2.3.1
TOTAL AND AREA SPECIFIC EMISSIONS FROM DISTURBANCES FOR THE CALIBRATION PERIOD FOR FM

Disturbance type*	**Inventory year during the calibration period**							
	. . .	1990	1991	1992	. . .	2008	2009	. . .
	Total annual emissions (Gg CO_2 eq.)							
Wildfires								
Insect attacks and disease infestations								
Extreme weather events								
Geological disturbances								
Other								
Sum								
For all lands under FM	Total area (kha)							
	Area-specific emissions (Emissions per unit of land area under FM, Mg CO_2 eq. ha^{-1})**							

* Sub-divisions of types can be added as needed.

**In any year, emissions per unit of land area are calculated as the Sum divided by the total area under FM.

TABLE 2.3.2
TOTAL AND AREA SPECIFIC EMISSIONS FROM DISTURBANCES FOR THE CALIBRATION PERIOD FOR AR

Disturbance type*	**Inventory year during the calibration period**							
	. . .	1990	1991	1992	. . .	2008	2009	. . .
	Total annual emissions (Gg CO_2 eq.)							
Wildfires								
Insect attacks and disease infestations								
Extreme weather events								
Geological disturbances								
Other								
Sum								
For all lands under AR	Total area (kha)							
	Area-specific emissions (Emissions per unit of land area under AR, Mg CO_2 eq. ha^{-1})**							

* Sub-divisions of types can be added as needed.

**In any year, emissions per unit of land area are calculated as the Sum divided by the total area under AR.

If emission estimates are missing for one or more years of the calibration period for a certain disturbance type, to develop a complete and consistent time-series it is *good practice* to apply an appropriate method for filling the gaps selected from among those described in Chapter 5 in Volume 1 of the *2006 IPCC Guidelines*. Surrogate data is the method most likely to be applicable. Interpolation will probably not be appropriate due to the likelihood of large year-to-year fluctuations in disturbance related emissions.

Emissions from and associated with salvage logging cannot be excluded from accounting during the commitment period[50]. Consequently historical emissions from natural disturbances should exclude emissions from salvage logging. It is therefore *good practice* that Parties provide transparent information on how this exclusion was carried out.

If the required historic time series of emissions associated with natural disturbances cannot be directly estimated for a particular disturbance type, country-specific methods can be applied to develop a time series. For example, if a Party lacks estimates of emissions from natural disturbances on AR land, it may choose to use disturbance- and area-specific emissions from natural disturbances on FM land as a proxy, and then combine it with the total area of AR land in order to estimate the emissions from natural disturbances on AR land. The use of the proxy must be justified. For instance, in this example, it should be demonstrated for each disturbance type that the applied area-specific emission rates on FM land are age-independent, or can be corrected for age, and are otherwise independent from the differences in species, size, density, management practices, etc. that may occur between the forests on AR land and those on FM land. Correction for age class may be achieved by stratifying FM data accordingly.

In the 2015 NIR and in subsequent years where recalculations leading to technical corrections occur, it is *good practice* to transparently report how the Party has estimated the emission data used in Table 2.3.1 and Table 2.3.2, including information on the methods used to estimate missing emission estimates in the time series.

Step 3: Develop the background level

Once the time series for the calibration period have been developed by disturbance type, and summed over the types by year, the Party can apply the default or an alternative method (see description below) in order to obtain the background level and the margin. Whatever method a Party chooses to establish the background level and margin, it is *good practice* to transparently describe the method and assumptions used and to demonstrate consistency with the FMRL or the methods and assumptions the Party applies for estimating emissions from AR. While the steps below are described for Table 2.3.1, they equally apply to Table 2.3.2 with the exception that, in the latter case, area-specific data are used (due to the probable large area change over time). The area-specific background level resulting from the procedure in this step must be multiplied by the average annual area of AR estimated for the commitment period. FM should also be corrected for area if there is significant change in the area of FM over the commitment period or significant change in the area is expected between the calibration and the commitment period.

The default method

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

(1) Calculate the arithmetic mean of the (area-specific, if necessary, cf. Box 2.3.8.) annual emissions summed over disturbance types (in the 'sum' or bottom row, respectively, of Table 2.3.1 or 2.3.2) using all years in the calibration period.

(2) Calculate the corresponding standard deviation (SD) of the annual emissions using the following formula:

[50] Paragraph 33(c) of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 18.

EQUATION 2.3.1
CALCULATION OF THE STANDARD DEVIATION FOR THE ANNUAL EMISSIONS FOR THE CALIBRATION PERIOD

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

Where

x_i = the emission estimate for year i, i = 1, 2…, N where N is the number of years in the calibration period for which emission estimates are available.

X = the arithmetic mean of all x_i, i.e. $X = \sum_{i=1}^{N} x_i / N$.

(3) Check whether any emission estimate is greater than the arithmetic mean plus twice the SD. If so, remove such estimate(s) ('outliers') from the dataset and go back to step (1) above using the reduced dataset. Emissions that are smaller than the mean minus twice the SD should not be removed from the dataset as this would lead to the expectation of net credits.

When no further outliers can be identified, the arithmetic mean and twice the SD, as calculated in the last step of the iterative process, define the background level and the margin, respectively.

An example of the application of the default method is found in Box 2.3.7, Example 1.

Alternative methods

Alternative methods are country-specific but should be based on a consistent time series of annual emissions for the calibration period as outlined in Step 2 above.

Alternative methods may include the use of other methods to exclude outliers and/or different criteria to define the background level than the average of the emissions (excluding outliers) used in the default method. Examples include setting the background level to a value equal to the lowest historical emission in the calibration time series; or to a value between the lowest emission and the average of the historical dataset (excluding outliers) or to zero. An example of an alternative method is described in Box 2.3.7, Example 2.

Step 4: Develop the margin

Depending on the method used to estimate the background level, a non-zero margin may be needed to avoid the expectation of net credits or net debits during the commitment period (refer to Step 5). For the default method (included in Step 3 above), the margin is twice the SD of the calibration period emission time series excluding outliers.

If the background level is defined in a different manner than the default method, then the margin may be different; e.g. if the background level is set equal to zero, or to the minimum emission value associated with natural disturbance during the calibration period (see example in Box 2.3.7), then the margin is zero, since all emissions in excess of the minimum level will be beyond the level assumed in the background level. Box 2.3.6 provides guidance on setting a margin that is consistent with an approach that avoids the expectation of net credits and net debits.

For the development of the margin for AR, the margin to be associated with the area-specific background level must first be developed; then, as with the background level, it must be multiplied by the average annual area of AR estimated for the commitment period. If the area of FM is expected to significantly vary, a similar correction should be made, maintaining consistency with the background level.

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

For any approach used to develop the background level and the margin, Parties need to report information on how the expectation of net credits or net debits[51] is avoided. To this end, it is *good practice* to analyse, using the list of requirements in Box 2.3.6, under what conditions the application of the background level and margin may yield net credits or net debits for the Party during the commitment period. If the expected conditions in the

[51] Paragraph 33(a) and (b) of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 17-18.

commitment period will lead to the expectation of net credits or net debits, it is *good practice* that Parties revise the approach used in order to avoid this. The results of the analysis and any action taken should be included in the NIR due in 2015, or in years when the background level and the margin are recalculated. If any of the requirements in bullet points (1) – (4) in Box 2.3.6 are violated, it is *good practice* that the Party applies a technical correction to the FMRL and the background level as needed in order to ensure consistency between the FMRL and accounting during the commitment period (see Section 2.7.6 for guidance on technical corrections).

BOX 2.3.6
AVOIDING THE EXPECTATION OF NET CREDITS OR NET DEBITS FOR THE APPLICATION OF THE NATURAL DISTURBANCE PROVISION

For developing a background level and a margin[52] each annual emission resulting from natural disturbances in the calibration period is either less than or equal to the background level plus the margin (these annual emissions are referred to below as the *background group*), or it is greater than the background level plus the margin. The background group is used to calculate the background level.

Any approach (default or alternative) will avoid the expectation of net credits or net debits so long as:

(1) There is no observed trend in natural disturbance emissions during the calibration period that is not considered in the background level estimation, or expected during the commitment period. This includes trends due to changing area under FM or AR.

(2) The background level of emissions for FM or AR, included in the FMRL or associated with AR, respectively, is equal to the average of the annual emissions from natural disturbances during the calibration period which are in the background group.

(3) Any emission from natural disturbances during the commitment period that falls into the background group is not separately excluded from accounting. During the commitment period, emissions are only excluded from accounting when the annual emissions are greater than the background level plus the margin. When this occurs, only those emissions that are greater than the background level are excluded.

(4) A test application of the constructed background level and the margin to the annual emissions in the calibration period leads to the same background group as used during the construction of the background level.

For FM, if all of bullet points (1)-(4) in Box 2.3.6 above are satisfied, and if the Party wishes to exclude emissions from natural disturbances, the accounting outcome for natural disturbance emissions will result in:

(1) Natural disturbance emissions which are greater than the background level are excluded from accounting in years where natural disturbance emissions are greater than the background level plus margin;

(2) The remaining emissions due to natural disturbances during the commitment period are included in accounting during the commitment period. These natural disturbance emissions are effectively balanced by the background level emissions from the natural disturbances that are included in the FMRL. The expected outcome is that the background level emissions will be equal to the average natural disturbance emissions over the commitment period that are not excluded from accounting individually.

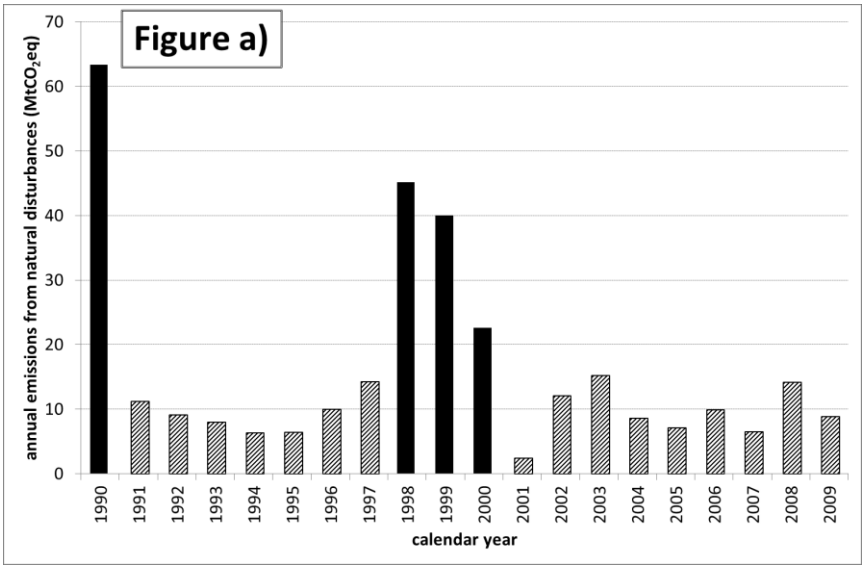
As stated in Step 3 above, the background level and the margin need to be adjusted if the area of the land in the AR or FM categories is expected to change during the commitment period. A possible way to do such an adjustment is demonstrated in Box 2.3.8. In such cases, it is *good practice* to calculate the background level and the margin so that they both relate to the expected area during the commitment period. In most, if not all, countries the area of AR changes considerably in the calibration period and will continue to change during the commitment period (e.g. for AR, it increases from 0 in 1990 up to the actual value in an inventory year), so the calculation should be done on a per unit area basis; the last two rows in Table 2.3.2 are meant to provide for AR information related to the area and emissions per unit area.

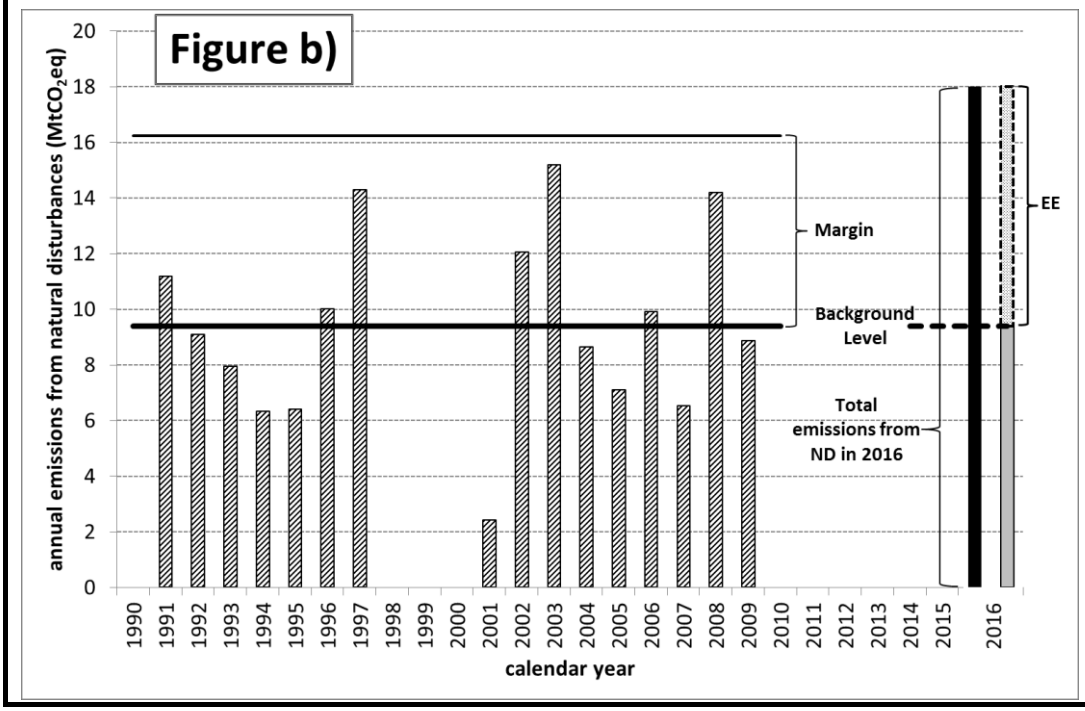
[52] A margin of zero is the same as the margin not being needed in terms of the language used in Decision 2/CMP.7.

BOX 2.3.7
EXAMPLES OF APPROACHES FOR THE DEVELOPMENT OF THE BACKGROUND LEVEL

Example 1. Application of the default method

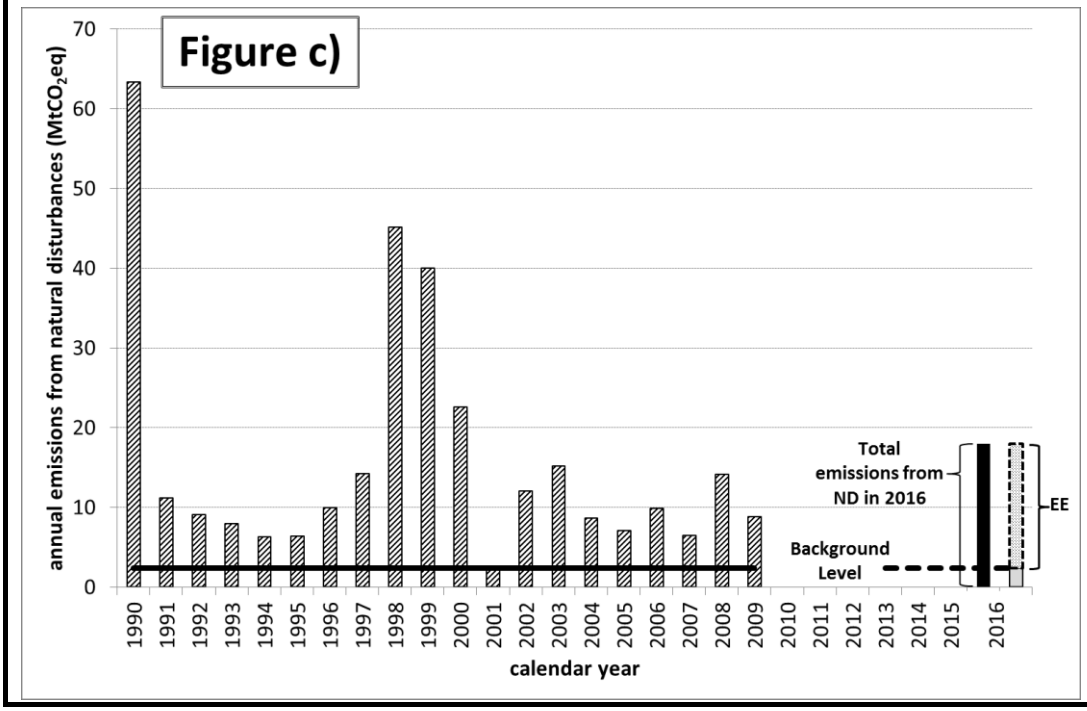
In this example, Party X uses Table 2.3.1 to calculate the total annual emissions from the natural disturbance types considered for FM lands for each year of the calibration period in row **Sum**. These total annual emission values are shown in Figure a) (all bars). Based on the iterative process described in Step 3 above, the outliers in the time series (the dark bars in Figure a)) are identified and removed. The background level is estimated as the mean (the thick black horizontal line in Figure b)) of the remaining emissions (the hashed bars). The margin is twice the standard deviation of these remaining emissions (shown by a thin black line above the background level in Figure b)). In a year during the commitment period for which the total emissions from natural disturbances (e.g. the dark bar for the year 2016 in Figure b)) exceeds the background level plus the margin, the emissions above the background level (the thick dashed line) may be excluded, provided that all of the other requirements for the application of the natural disturbance provision are met. The emissions that may be excluded are shown as the dotted part (EE) in Figure b). Note that annual emissions from zero to the background level plus the margin, but not higher than this, are also factored out by the accounting, since they are included in the FMRL. In order to avoid the expectation of net credits or net debits, the expected emissions from natural disturbances included in the FMRL need to be equal to the background level.





Example 2. An alternative method: the background level is set to the minimum level of a historical time series

A possible alternative approach is to set the background level to a value equal to the minimum emission value of the historical time series (i.e. the emissions for year 2001 in Figure a)). In this case, the emissions are expected to exceed this level in every year during the commitment period, and the margin is set equal to zero. In a year during the commitment period for which the emissions from natural disturbances (e.g. the dark bar for the year 2016 in Figure c)) exceed the background level (since the margin is equal to zero), the emissions above the background level (the thick dashed line) may be excluded, provided that all of the other requirements for the application of the natural disturbance provision are met. The emissions that may be excluded are shown as the dotted part (EE) in Figure c). Note that the emissions from zero to the background level (which are represented by the emissions that are below the dashed line in the last bar in Figure c)) are also factored out by the accounting, since they are already included in the FMRL.



BOX 2.3.8
EXAMPLE OF AN APPROACH FOR ESTIMATING THE BACKGROUND LEVEL IN CASE THE AREA OF LAND UNDER FM AND / OR AR CHANGES BETWEEN THE CALIBRATION PERIOD AND THE COMMITMENT PERIOD

This approach is demonstrated using an example when the area of AR changes during the commitment period. It would also apply to cases where the area of FM significantly changes, in which case the modifications for FM are necessary.

Suppose the area of AR at the end of the calibration period is $\mathbf{A_{cal}}$, and the area specific background level from Table 2.3.2 is **bgl**. The background level based on $\mathbf{A_{cal}}$ is therefore $\mathbf{BGL_{cal}}$, = **bgl** * $\mathbf{A_{cal}}$. Suppose that the mean area of AR land during the commitment period is expected to be $\mathbf{A_{comm}}$ and assume that **bgl** will not change, thus, the background level should be $\mathbf{BGL_{comm} = A_{comm} * bgl}$. Without adjustment, using $\mathbf{BGL_{cal}}$ would lead to net credits (in case $\mathbf{A_{comm} < A_{cal}}$) or net debits (in case $\mathbf{A_{comm} > A_{cal}}$). In order to avoid these situations, it is *good practice* to conduct the following steps:

(1) Calculate the area-specific annual emissions for the calibration period using the totals of all disturbance types (last row of Table 2.3.2 (for FM, Table 2.3.1)).

(2) Use these area-specific annual emissions to calculate the area specific background level **bgl** for AR using the stepwise guidance for developing the background level and margin.

(3) Make a projection, i.e. an unbiased estimate of the annual increase, of the area under AR for the commitment period. (For FM, this projected area should be consistent with the area projected under the FMRL.)

(4) Calculate $\mathbf{A_{comm}}$, the average of the projected area under AR (or FM, respectively) provided in step (3) above.

(5) Calculate the background level for the commitment period as $\mathbf{BGL_{comm} = A_{comm} * bgl}$.

2.3.9.7 EXCLUSION OF REMOVALS ON LANDS AFFECTED BY THE NATURAL DISTURBANCE PROVISION

In cases in which a Party excludes emissions from natural disturbances from accounting in accordance with the provisions detailed in paragraphs 33 through 36 of Annex to Decision 2/CMP.7, it should also exclude any subsequent removals during the commitment period on the affected land from accounting. Therefore it is *good practice* that the Party assess and report the removals (using the guidance given above in Section 2.3.9.3) that occur on lands affected by the disturbance(s) for which emissions were excluded from the accounting, regardless of whether they originate from the re-establishment of young forest vegetation by rehabilitation measures or from the natural re-growth of vegetation, and to ensure their subsequent exclusion from accounting. Special care needs to be taken to ensure 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; or that the national forest inventory is designed in a way that can provide separate outputs for these areas. It is *good practice* for Parties using a projected FMRL to provide information on how the estimation of emissions and removals following natural disturbances has been matched to the treatment of emissions and removals in the construction of the FMRL, in order to avoid double counting. For example, the FMRL may contain a certain amount of emissions and removals associated with the disturbed area, but originating from FM activities, in case the area would not have been disturbed.

2.3.9.8 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 land cover, where practicable, in order to restore or secure forest functions and prevent the further degradation of forests. Although rehabilitation is different from both restoration and revegetation in terms of GHG 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 the cost-benefit analysis, taking site characteristics into account. Following, for example, 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 DOM and soil organic matter pools) or preparation of planting sites in places, and subsequent planting of crop tree species or seed-bed preparation is conducted, if seeds or seed trees are still available on the lands. If seed trees or natural regeneration are available (such as in cases where 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, rehabilitation efforts may not be required; in these cases, it is *good practice* to demonstrate that no other direct human intervention is necessary for rehabilitation.

A Party applying the natural disturbance provisions *shall provide transparent information that demonstrates efforts taken to rehabilitate, where practicable, the land for which the provisions in paragraph 33 above are applied* (paragraph 34(e) of Annex to Decision 2/CMP.7). To demonstrate this, while allowing for the distinction of rehabilitation and other management activities that might constitute land-use change and avoiding double counting, it is *good practice* to provide transparent information on:

- Rehabilitated area, or are planned to be rehabilitated;
- 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. the recovery of carbon stocks, forest cover, or tree species structure and growth patterns, as well as ecosystem health conditions and 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. For example, natural regeneration in the disturbed area might make human intervention unnecessary or a volcanic eruption may completely cover an area with lava. In cases where natural or human-induced regeneration is not possible, and there is no land-use change, the area is still technically considered to be FM (no human-induced deforestation occurred) and included in the reporting and accounting appropriately. If, in the future, other uses are conducted in these areas, e.g. cattle is grazed on grass growing on the disturbed area, this indicates a change in land-use and may have to be considered as Deforestation (see decision trees in Sections 1.3 and 2.6).

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

Paragraph 36 of Annex to Decision 2/CMP.7 requires that the *treatment of emissions and removals that occur on the lands [subject to the disturbance provisions] in the subsequent commitment periods shall be reflected in land use, land-use change and forestry accounting for those commitment periods*. Therefore, it is *good practice* that these emissions and removals are estimated in a manner that is consistent with other forestry estimates in the GHG inventory and integrated into estimates for future years, so that accounting in subsequent commitment periods can reflect them.

2.4 OTHER GENERIC METHODOLOGICAL ISSUES

This section presents generic methodology to complement subsequent sections in the report as well as guidance for time series development and recalculations. Issues related to uncertainty assessment, reporting and documentation are also addressed. Draft reporting tables are presented in the Annex to this report.

2.4.1 Developing a consistent time series

Lands subject to Article 3.3 or 3.4 activities and the management thereon need to be tracked through time, to ensure that all GHG emissions and removals are reported throughout CPs 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 CM 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 track 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 periodically tracking lands subject to an Article 3.3, FM or an elected Article 3.4 activity from 1990 until the end of the CP (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, FM or elected 3.4 activities (see *2006 IPCC Guidelines*). 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 GHG 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) 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 tracked 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 and soil 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). It is assumed no tracking of the management on individual land. In order to simplify this example, suppose further that the land management in the year 1990 was unchanged for more than 20 years. The estimated soil carbon stock change is based on a matrix of coefficients; say 0.3 tonnes C/ha/yr for land shifting from CT to NT, and -0.3 tonnes 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[53] factor, over 20 years, for the management activity, and the length of the period, one year. See Chapter 5.2.3, and Tables 2.3 and 5.5, Volume 4 of the *2006 IPCC Guidelines*.) There has been no tracking of management on individual land. Based on a statistical analysis (e.g. a survey), it is possible to estimate, with 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) tonnes C/yr = 900 tonnes C/yr.

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

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 addressed 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 CP 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[54], 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 GHG emissions and removals reported for a given year during the CP can be recalculated in subsequent reporting years (up to the final year of the CP). 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*.

2.4.3 Uncertainty assessment

It is *good practice* that uncertainties are identified, quantified and reduced as far as is practicable and that all information on anthropogenic GHG emissions by sources and removals by sinks which result from mandatory and elective activities are reported with levels of confidence as elaborated by any IPCC *good practice* guidance adopted by the CMP.[55] 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, Volume 4 of the *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 KP LULUCF activities (IPCC 2010c). However, some issues and terms which are specific to the KP require additional uncertainty assessment, for example the estimation of the areas under KP LULUCF activities or the need to track activities since 1990. For KP reporting, uncertainty assessment is particularly important in order to support verification requirements. Moreover, while selecting a particular tier to estimate changes in carbon stocks and non-CO_2 GHG 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 KP reporting in the LULUCF Sector, 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 KP (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 harvest-regeneration cycle vs. deforestation or human-inducement of afforestation and reforestation).
- Identification errors arising while defining the geographical boundaries of areas encompassing lands subject to KP LULUCF activities

[54] See paragraphs 4, 12 (notably 12(d) and 12(e)), 13 and 14(e) in Annex to Decision 19/CMP.1 (Article 5.1), contained in document FCCC/KP/CMP/2005/8/Add.3.

[55] This refers to paragraph 6 (d) including footnote 5, and paragraph 9 including footnote 7 in Annex to Decision 15/CMP.1 (Article 7). Also refers to Decision 2/CMP.8, Annex II.

- Sampling errors, i.e. the difference between the estimate derived from a subsample of plots and the (unknown) value for the entire landscape. For the calculation of sampling error see, for example, Husch *et al.* (2003). Sampling errors can increase when samples do not sufficiently cover the temporal and spatial variability of the estimated parameter. This is particularly critical when reporting land areas that include multiple land units by using legal, administrative, or ecosystem boundaries.
- 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), due to different scales used to identify lands subject to the various activities, e.g. AR vs. D, or modifications made to the sampling procedures and/or densities over time or due to positional errors).
- Model errors occur whenever models or allometric equations are used to estimate carbon stock changes or non-CO_2 GHG 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. In some cases simpler models can be used to estimate typical uncertainty ranges that can be combined with central estimates from complex models.

Natural variability

Natural variability is a result of variations in natural controlling variables, such as annual climate variability, and variability within lands that are assumed to be homogenous, e.g. the spatial variability of forest soils within a given 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 interannual or periodical variability, large-scale disturbance 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-averaged coefficients and by averaging direct measurements over a time period that is long enough to reduce the variability, as discussed in Section 2.3.5 (Interannual variability).

Activity data

In addition to uncertainties in default carbon emission and removal factors, there are often uncertainties associated with missing or inaccurate activity data. Determining retrospectively the inventory for the base year, in most cases 1990, may pose a particular challenge for CM, GM, RV and WDR. 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 (see Section 2.4.6). It is also *good practice* to use in the estimation of base year emissions historical data on management practices prior to 1990, if available.

Spatial resolution of remote sensing and ground truth

The objective of using satellite imagery for land-cover and land-use assessments is to obtain, for an inventory region, total area estimates, percentages of land classes, or geographical boundaries. Remote sensing is particularly well suited to completely identify lands. 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 the 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 Chapter 3, Volume 4 of the *2006 IPCC Guidelines*, especially section 3A.2.4. An example of quantifying uncertainties in forest carbon estimation using a combination of remote sensing and field measurement is given by Gonzalez *et al.* (2010).

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.

Uncertainties for the KP activities 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 KP 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 FM (see figure 2.7.1), and also between Grassland area and area subject to GM implies that the areas for which uncertainties are being assessed may differ between the KP 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 on which farmers use a given amendment or practice. 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 CM, GM, WDR and/or RV (if elected) uncertainty estimates are also needed for the base year. It is *good practice* that the selected methodology neither over- nor underestimate emissions and removals in the base year. But uncertainties are likely to be higher than for estimates in the CP, because the estimates for the base year 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. 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 data sets 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 for the base year.
- When remote sensing is used for classification of land use and detection of land-use change, the uncertainties could be quantified by verifying classified lands with adequate actual ground truth data or higher spatial and temporal resolution imagery. Details of this methodology can be found in McRoberts *et al.* (2010). 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 (Lillesand *et al.,* 2008, McRoberts and Walters, 2012). The diagonal of this matrix shows the probability of correct identification and the off-diagonal elements show the 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/land-cover map category-by-category and an 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. A review of methodologies for monitoring ecosystem is presented by Coppin *et al*. (2004). Methodology for estimating uncertainties in area estimation is also presented by Olofsson *et al*. (2013).

Separate annual uncertainty estimates need to be made for each of the mandatory and elective activities, for each reported carbon pool each GHG and each reporting subdivision selected by the country. Estimates can be reported using tables generated following the model of Tables 1A-11B in Annex 2A.1 to this report. Separate tables are required for the base year if CM, GM, RV or WDR are elected. Estimates can be expressed as percent of the area and of emissions by sources or removals by sinks (or changes in stocks) reported in Tables 1A-11B.

Uncertainty associated with areas of lands 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 elected

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 sufficient to provide uncertainty estimates for the summary statistics and for the reporting strata selected by the country.

Where uncertainties are difficult to derive, it is *good practice* to use default values for uncertainties. Guidance on selecting default carbon emission or removal factors for CM can be found in Annex 4A.1 of the *GPG-LULUCF*, 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 RV and WDR, default uncertainty ranges cannot be specified at present. It is *good practice* for a country 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 compilers 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 on 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 to reduce uncertainties in future assessments. In particular, for reporting under the KP 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 KP 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 GHG emissions by sources and removals by sinks from KP activities, estimated using the methods described before and in the activity-specific Sections 2.5 – 2.12, must be reported as outlined in relevant CMP decisions[56]. Some information on definitions and elected activities must be reported once by 15th April 2015, as part of the report to facilitate the calculation of the assigned amount as established in Annex I to Decision 2/CMP.8, whereas supplementary information must be reported annually during the second CP as established in Annex II to Decision 2/CMP.8. The information to be reported is summarised in Table 2.4.1, but

[56] CMP decisions relevant for LULUCF accounting for the second CP: Decision 2/CMP6, Decision 2/CMP.7 and Decision 2/CMP.8.

excludes information associated with removal unit (RMU) accounting. It is *good practice* to report all information requested in Table 2.4.1.

Table 2.4.1 summarises CMP decisions which specify that annual reports under the KP include estimates of areas of land subject to activities under Article 3.3, FM and any other elected Article 3.4 activities, GHG emissions by sources and removals by sinks on these areas of land, and the associated uncertainties. Tables 1A through 11B in the Annex of this document provide a draft template for such reporting. 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 FIRST ANNUAL GHG INVENTORY DURING THE SECOND CP ACCORDING TO DECISION 2/CMP.8.
(*TEXT IN ITALICS INDICATES A DIRECT QUOTE FROM THE DECISION*)

Information to be reported	Detailed information	Reference in CMP decisions
Information on methods and approaches to estimate emissions and removals		
Identification of elected activities; and information on how lands subject to activities are identified and on how lands are tracked to ensure that, once accounted, never leave the accounting	*The identification of its election of activities under Article 3, paragraph 4, of the Kyoto Protocol for inclusion in its accounting for the second commitment period, in addition to those activities under Article 3, paragraph 4, of the Kyoto Protocol that were elected in the first commitment period, together with information on how its national system under Article 5, paragraph 1, of the Kyoto Protocol will identify land areas associated with all additional elected activities and how the Party ensures that land that was accounted for under activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol in the first commitment period continues to be accounted for in subsequent commitment periods, in accordance with decisions 16/CMP.1 and 2/CMP.7;*	Annex I of 2/CMP.8 Paragraph 1(g)

Specific information for activities under Article 3, paragraphs 3 and 4		
Specific information on Article 3.3 activities and Forest Management	*(f) The identification of its selection of single minimum values for tree crown cover, land area and tree height for use in accounting for its activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol, if the Party included in Annex I did not select a definition of forest for the first commitment period, together with a justification of the consistency of those values with the information that has been historically reported to the Food and Agriculture Organization of the United Nations or other international bodies, and in the case of difference, an explanation of why and how such values were chosen, in accordance with decisions 16/CMP.1 and 2/CMP.7. If the Party included in Annex I selected its forest definition for the first commitment period, the definition for the second commitment period shall be the same;* *(k) An indication of whether it intends to apply the provisions to exclude emissions from natural disturbances for the accounting for afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol and/or forest management under Article 3, paragraph 4, of the Kyoto Protocol during the second commitment period in accordance with decision 2/CMP.7, annex, paragraph 33, and any relevant supplementary methodological guidance developed by the Intergovernmental Panel on Climate Change and adopted by the CMP and the COP, including:* *(i) Country-specific information on the background level of emissions associated with annual natural disturbances that have been included in its forest management reference level;* *(ii) Information on how the background level(s) for afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol and/or forest management under Article 3, paragraph 4, of the Kyoto Protocol have been estimated, and information on how it avoids the expectation of net credits or net debits during the commitment period, including information on how a margin is established, if a margin is needed;*	Annex I of 2/CMP.8 Paragraph 1
Forest Management specific information	*(i) The forest management reference level as inscribed in the appendix to the annex to decision 2/CMP.7, any technical corrections as contained in the inventory report for the first year of the second commitment period and references to those sections in the national inventory report where such information is reported consistent with the requirements of decision 2/CMP.7, annex, paragraph 14;1* *(j) Information on how emissions from harvested wood products originating from forests prior to the start of the second commitment period have been calculated in the reference level in accordance with decision 2/CMP.7, annex, paragraph 16;*	Annex I of 2/CMP.8 Paragraph 1

TABLE 2.4.1 (CONTINUED)
SUPPLEMENTARY INFORMATION TO BE REPORTED FOR THE ANNUAL GHG INVENTORY DURING THE SECOND CP ACCORDING TO DECISION 2/CMP.8.
(*TEXT IN ITALICS INDICATES A DIRECT QUOTE FROM THE DECISION*)

Information to be reported	Detailed information	Reference in CMP decisions
Land related information		
Information on geographical location and identification of lands	*The geographical location of the boundaries of the areas that encompass:* *(i) Units of land subject to activities under Article 3, paragraph 3, of the Kyoto Protocol;* *(ii) Units of land subject to activities under Article 3, paragraph 3, of the Kyoto Protocol which would otherwise be included in land subject to forest management or elected activities under Article 3, paragraph 4, of the Kyoto Protocol under the provisions of decision 2/CMP.7, annex, paragraph 9;* *(iii) Land subject to forest management under Article 3, paragraph 4, in the second commitment period and to any elected activities under Article 3, paragraph 4;* If the Party applies the Natural Disturbance provision: *(i) Showing that all lands subject to the exclusion due to natural disturbances are identified, including their georeferenced location, year and types of disturbances;* *(iii) Showing that no land-use change has occurred on lands for which the provisions contained in decision 2/CMP.7, annex, paragraph 33, are applied and explaining the methods and criteria for identifying any future land-use changes on those land areas during the second commitment period;* If the Party applies the CEFC provision: *(i) The identification of all lands and associated carbon pools subject to decision 2/CMP.7, annex, paragraph 37, including the georeferenced location and year of conversion;*	Annex II of 2/CMP.8 Paragraph 2(b) Paragraph 2(f) Paragraph 5(g)
Spatial assessment unit	*The spatial assessment unit used for determining the area of accounting for afforestation, reforestation and deforestation;*	Annex II of 2/CMP.8 Paragraph 2(c)

Information on methods and approaches to estimate emissions and removals		
Description of methodologies used including methods used for calculating the reference level and the associated background level of emissions from natural disturbances	*Information on how inventory methodologies have been applied taking into account the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and any relevant supplementary methodological guidance developed by the IPCC and adopted by the CMP and the COP, and recognizing the principles as laid out in decision 16/CMP.1;*	Annex II of 2/CMP.8 Paragraph 2(a)
Justification when omitting any carbon pool	*Information on which, if any, of the following pools – above-ground biomass, below-ground biomass, litter, deadwood 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 GHG emissions;*	Annex II of 2/CMP.8 Paragraph 2(e)
Information on indirect factors on GHG emissions and removals	*Information should also be provided which indicates whether anthropogenic GHG emissions by sources and removals by sinks from LULUCF activities under Article 3, paragraph 3, forest management under Article 3, paragraph 4, and any elected activities under Article 3, paragraph 4, factor out removals from:* *(a) Elevated carbon dioxide concentrations above pre-industrial levels;* *(b) Indirect nitrogen deposition;* *(c) The dynamic effects of age structure resulting from activities prior to 1 January 1990.*	Annex II of 2/CMP.8 Paragraph 3
Changes in data and methods and recalculations	*(e) Information that demonstrates methodological consistency between the reference level and reporting for forest management during the second commitment period, including the area accounted for, the treatment of harvested wood products, and the accounting of any emissions from natural disturbances;* *(f) Any technical corrections made pursuant to decision 2/CMP.7, annex, paragraph 14, to ensure consistency between the reference level and reporting for forest management during the second commitment period;*	Annex II of 2/CMP.8 Paragraph 5
Specific information for activities under Article 3, paragraphs 3 and 4		
Specific information on Article 3.3 activities and Forest Management	If Party applies the Natural Disturbance provision: *(ii) Showing how annual emissions resulting from natural disturbances and the subsequent removals during the commitment period in those areas are estimated and excluded from the accounting;* *(iv) Demonstrating that the events or circumstances 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 events or circumstances that led to the application of the provisions contained in decision 2/CMP.7, annex, paragraph 33;* *(v) Demonstrating efforts taken to rehabilitate, where practicable, the land for which the provisions contained in decision 2/CMP.7, annex, paragraph 33, are applied;* *(vi) Showing that emissions associated with salvage logging were not excluded from accounting.*	Annex II of 2/CMP.8 Paragraph 2(f)

Specific information on Article 3.3 activities and Forest Management	If Party does not apply instantaneous oxidation for Harvested Wood Products: *(i) Information on activity data for the harvested wood products categories used for estimating the harvested wood products pool removed from domestic forests, for domestic consumption and for export, as appropriate;* *(ii) Information on half-lives used in estimating the emissions and removals for these categories in accordance with decision 2/CMP.7, annex, paragraph 29 or 30, or, alternatively, information on methodologies used to account for harvested wood products in accordance with decision 2/CMP.7, annex, paragraph 30, showing that the methodologies used are at least as detailed or accurate as the first-order decay method with default half-lives provided in decision 2/CMP.7, annex, paragraph 29;* *(iii) If the forest management reference level is based on a projection, information on whether emissions from harvested wood products originating from forests prior to the start of the second commitment period have been included in the accounting;* *(iv) Information on how emissions from the harvested wood products pool that have been accounted for during the first commitment period on the basis of instantaneous oxidation have been excluded from the accounting for the second commitment period;* *(v) Information showing that harvested wood products resulting from deforestation have been accounted on the basis of instantaneous oxidation;* *(vi) Information showing that carbon dioxide emissions from harvested wood products in solid waste disposal sites, where these emissions are separately accounted for, and from wood harvested for energy purposes have been accounted on the basis of instantaneous oxidation;* *(vii) Information showing that the emissions and removals resulting from changes in the harvested wood products pool accounted for do not include imported harvested wood products, irrespective of their origin.*	Annex II of 2/CMP.8 Paragraph 2(g)
Article 3.3 activities specific information	*(a) 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;* *(b) Information on how harvesting or forest disturbance that is followed by the re-establishment of a forest is distinguished from deforestation*	Annex II of 2/CMP.8 Paragraph 4
Forest Management specific information	If the Party applies the CEFC provision *(ii) A demonstration that the forest plantation was first established through direct human-induced planting and/or seeding of non-forest land before 1 January 1990, and, if the forest plantation was re-established, that this last occurred on forest land through direct human-induced planting and/or seeding after 1 January 1960;* *(iii) A demonstration that a new forest of at least equivalent area to 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;* *(iv) A demonstration that this newly established forest will 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 debit would be generated under Article 3, paragraph 4*	Annex II of 2/CMP.8 Paragraph 5(g)

Forest Management and any elected activities under Article 3.4 specific information	*(a) A demonstration that activities under Article 3, paragraph 4, have occurred since 1 January 1990 and are human induced;* *(c) Information that demonstrates that emissions by sources and removals by sinks resulting from forest management under Article 3, paragraph 4, and any elected activities under Article 3, paragraph 4, are not accounted for under activities under Article 3, paragraph 3;*	Annex II of 2/CMP.8 Paragraph 5
Information related to the estimates of emissions by sources and removals by sinks (for reporting data, see Tables 1A-11B in the Annex of this report)		
Estimates for GHG emissions by sources and removals by sinks	*Information on anthropogenic GHG emissions by sources and removals by sinks resulting from activities under Article 3, paragraph 3, forest management under Article 3, paragraph 4, and any elected activities under Article 3, paragraph 4, for all geographical locations reported in the current and previous years, under paragraph 3(b) above, 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 shall also be included. Once land is accounted for under activities under Article 3, paragraph 3, forest management under Article 3, paragraph 4, or any elected activities under Article 3, paragraph 4, reporting shall continue throughout subsequent and contiguous commitment periods;*	Annex II of 2/CMP.8 Paragraph 2(d)
	(b) For Parties included in Annex I that elect cropland management and/or grazing land management and/or revegetation and/or wetland drainage and rewetting, anthropogenic GHG 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 reported under paragraph 2(b) above. *(d) Information on how all emissions arising from the conversion of natural forests to planted forests are accounted for in accordance with any supplementary methodological guidance developed by the IPCC and adopted by the CMP;*	Annex II of 2/CMP.8 Paragraph 5
	[…] 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.[…]	Annex II of 2/CMP.8 Paragraph 1

It is *good practice* to use coordinates as set out in Sections 2.5 to 2.12 below for the reporting of the geographical location of the boundaries that encompass the lands subject to activities under Article 3.3, FM and elected activities under Article 3.4. This information can be summarised on a digital map for visual presentation and data sharing. It is also *good practice* to report the land transition matrix (Table 2A) to demonstrate that the country has accounted for all areas where AR, D and FM and, if elected, any 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. CM land converted to afforested land). It is *good practice* that the total area reported in consecutive inventories is constant and that any change in the total area is documented and explained.

For Article 3.3 and 3.4 activities (Tables 4A to 7), data should be provided by geographical locations (See Section 2.2.2: Reporting Methods for Lands subject to Article 3.3 and Article 3.4 activities). 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; in such a case, for each subdivision, one row should be completed in the table. The CMP decisions also require that, in addition to the data for the actual inventory year and any previous year of the CP, a Party also reports this information for the base year for CM, GM, RV and WDR. 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 decreases have a negative sign) while fluxes of CO_2 and non-CO_2 GHGs refer to exchanges with the atmosphere where emissions are additions to the atmosphere and therefore have a positive sign.

Table 1A (in the annex of this supplement) 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 also use the table for the base year for each elected Article 3.4 activity. This table summarises data of the compilation tables by activity across all carbon pools and non-CO_2 GHG emissions and across all strata within a country.

In addition to the data in the Tables, 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.

Decision 2/CMP.7 contains a clause for AR and FM activities that carbon stock changes and non-CO_2 GHG emissions resulting from natural disturbances may be excluded from accounting (see Tables 4B, 4C, 4D, 6D, 6E, 6F and Table 5B). If this provision is used then the areas where such disturbances occurred have to be identified and monitored for subsequent land-use change.[57] If such lands exist for the inventory year, it is *good practice* to distinguish them from other AR and/or FM lands and to report them (and the associated carbon stock changes and non-CO_2 GHG emissions, distinguishing emissions from subsequent removals) separately in Tables 4A to 6A. Although this is an issue related to accounting, it is mentioned here because inventory data are likely to be needed to implement the ND provision.

Decision 2/CMP.7 contains a clause that Parties can elect to report carbon stock changes and non-CO_2 GHG emissions resulting from conversion of forest plantation to non-forest land under FM together with carbon stock changes and non-CO_2 GHG emissions resulting from conversion of at least an equivalent area of non-forest land converted to forest land (CEFC, see Table 6C). If this CEFC provision is used, then all areas subject to this provision have to be identified and their georeferenced locations reported[58] in Table 6A. Although this is an issue related to accounting, it is mentioned here because inventory data are likely to be needed to implement the provision.

Separate tables should be reported for the base year when CM, GM, RV and/or WDR are elected.

Finally, separate annual uncertainty estimates should be reported for each activity under Articles 3.3 and 3.4, for each reported carbon pool, each GHG and geographical location. 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).

2.4.4.2 REPORTING NON-CO_2 GHG EMISSIONS AND CO_2 EMISSIONS FROM LIMING AND UREA APPLICATION

Reporting of emissions of non-CO_2 GHG emissions and CO_2 emissions from liming and urea application from lands subject to AR, D, FM, CM, GM, RV and WDR requires assigning emissions among the Agriculture Sector and the relevant KP LULUCF activity consistently with the UNFCCC reporting guidelines for national GHG inventories[59], whilst avoiding double-counting.

For lands under CM, GM, RV, WDR, D and FM[60] activities, which are under Cropland and managed Grassland use in the Convention reporting, the following N_2O and CH_4 emissions are reported under Agriculture[61]:

- Direct N_2O emissions due to
  - (i) Use of inorganic N (synthetic) fertilisers;
  - (ii) Use of organic N fertilisers (e.g. animal manure, sewage sludge);
- Direct and indirect N_2O emissions from N mineralisation associated with loss of soil organic matter resulting from change of land-use and management of mineral soils.
- Indirect N_2O emissions from nitrogen used in agriculture:

[57] Paragraphs 33, 34 and 35 in Annex to Decision 2/CMP.7

[58] Paragraphs 37, 38 and 39 in Annex to Decision 2/CMP.7

[59] See FCCC/SBSTA/2013/L.15 and its annexes. The SBSTA will conclude its work on these reporting guidelines at its 39th session in November 2013. Any change in the reporting of the emissions should be reflected also in the reporting under the KP LULUCF activities as well as any decisions under the Kyoto Protocol clarifying the use of this supplement.

[60] Only CEF-hc FM lands.

[61] According to Decision 16/CMP.1 estimates of emissions from sources and removals by sinks from 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 Annex to Decision 16/CMP.1 (Article 7), contained in document FCCC/CP/2001/13/Add.3, p.22).

(i) Volatilisation and subsequent atmospheric deposition of NH_3 and NO_x (originating from the application of fertilisers and manure); and

(ii) Nitrogen leaching and runoff.

- CH_4 and N_2O emissions from burning[62] of agricultural residues, *in situ*, and of prescribed burning of savannas.
- CH_4 and N_2O emissions from drainage and rewetting of organic agricultural soils[63].

For all other lands subject to CM, GM, RV, WDR, D and FM the above listed sources of emissions are reported under the relevant KP LULUCF activity. Methodologies are provided in Chapter 11, Volume 4 of the *2006 IPCC Guidelines* and in the *Wetlands Supplement.*

Emissions from the following practices are also reported under Agriculture, irrespective of land-use:

- CO_2 emissions from liming; and
- CO_2 emissions from urea application.

For lands under FM and AR, the direct N_2O emissions from N fertilisation (from either synthetic or organic N fertilisers) and the related indirect N_2O emissions can be reported under these KP LULUCF activities, when disaggregated data on N fertilisation by land-use category are available. Otherwise, these emissions are to be reported under Agriculture. Care should be taken that these emissions are not double-counted. Methods for estimating these emissions from N fertilisation are described in Section 11.2 of Chapter 11, Volume 4 of the *2006 IPCC Guidelines*.

For lands under FM[64] and AR, all emissions from fires, including fires from organic soils and N_2O and CH_4 emissions from drainage and rewetting of organic soils are to be included under these activities.

2.4.4.3 DOCUMENTATION

Documentation requirements under the KP are outlined in the relevant decisions of UNFCCC as part of the description of the requirements for inventory management[65]. The information required includes all disaggregated emission factors, activity data, and documentation about how these factors and data have been generated and aggregated for the preparation of the inventory.

It is *good practice* to document and archive the underlying data and description of, or reference to, methods, assumptions and parameters used to produce estimates of GHG emissions and removals that would allow independent reviewers to follow the process of developing the reported estimates. Documented data and explanation of methods, and the rational for their selection should be provided for both steps: the identification of land and the assessment of carbon stock changes and the emissions of non-CO_2 GHGs.

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

ACTIVITIES DEFINITION AND IDENTIFICATION

It is *good practice* to explain how the definitions of FM and of the elected Article 3.4 activities have been interpreted according to national circumstances. For instance, if only a part of the managed forests reported in the UNFCCC GHG inventory is excluded from FM in KP reporting, the criteria that are used to distinguish forests under FM from managed forests should be provided. It is also *good practice* to document differences between the definitions for Croplands (or Grasslands) in the UNFCCC GHG inventory and lands subject to CM (or GM).

DATA DOCUMENTATION

When using Reporting Method 1, the areas encompassed by the geographical boundaries resulting from the stratification of a country, should be identified by unique serial numbers in the tables. These serial numbers are

[62] The *Wetlands Supplement* includes guidance on emissions from burning of organic soils and N_2O and CH_4 emissions from drainage and rewetting of organic soils.

[63] This includes N_2O emissions from the category "cultivation of histosols".

[64] But excluding CEF-hc FM lands

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

to be cross-referenced to a database or other archive (the LULUCF Archive) specifying the locations in terms of established legal or administrative boundaries, or by means of an existing coordinate system, for example an established national grid system, the UTM (Universal Transverse Mercator) grid or latitude and longitude. When using Reporting Method 2, land-area identification should be possible through the databases associated with the use of this reporting method.

It is *good practice* to ensure that the documentation of estimates of GHG emissions and removals include:

- The sources of all data used in the calculations (i.e. complete citations for the statistical database(s) from which data were collected);
- The information, rationale and assumptions that were used to develop reported data and results, in cases they were not directly available from databases (for instance if interpolation or extrapolation methods have been applied) and a comparison to other published emission factors and explanation of any significant differences
- The frequency of data collection; and
- Estimates of the associated uncertainties with a description of the major sources of the uncertainties.

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, FM 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; references of maps used, if any;
- Choice of Tier(s) used for estimating GHG emissions and removals;
- Methods used for estimating carbon stock changes, non-CO_2 GHG 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 INTERANNUAL VARIABILITY

It is *good practice* to explain significant interannual variability in reported emissions or removals. 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, Volume 1 of the *2006 IPCC Guidelines* 'Time series consistency')

2.4.5 Quality Assurance and Quality Control

It is *good practice* to implement quality control checks as outlined in Chapter 6 (Quality Assurance/Quality Control and Verification), Volume 1 of the *2006 IPCC Guidelines*. 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 GHG emissions. A detailed treatment of inventory QA/QC for field measurement is described in Section 6.7.1.3, Volume 1 of *2006 IPCC Guidelines*.

Whilst Quality Control (QC) is a system of routine technical activities to assess and maintain the quality of the inventory as it is being compiled and it is performed by personnel compiling the inventory, Quality Assurance (QA) is a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Verification refers specifically to those methods that are external to the inventory and apply independent data, including comparisons with inventory estimates made by other bodies or through alternative methods. Verification activities may be constituents of both QA and QC.

Some important issues are highlighted and summarised below.

When compiling data, it is *good practice* to cross-check estimates of GHG emissions and removals against independent estimates. For instance, it is *good practice* that the inventory compilers:

- Cross-reference 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);
- Calculate implied emission/removal factors ;
- Compare implied emissions/removals factors and other parameters with default values and data from other countries;
- Compare results, for each Article 3.3 and 3.4 activity, from two different sources, such as national statistical data versus remote sensing source or two different remote sensing sources (e.g. Dymond *et al.,* 2012), or two methods (gain-loss and stock-difference method).

It is also *good practice* to check 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 Chapter 6, Volume 1 of *2006 IPCC Guidelines* (using the land-use change matrix). Checks that can be used in QA/QC are listed in Box 2.4.2.

BOX 2.4.2
QA/QC CHECKS OF LULUCF ESTIMATES

Checks:

Does the inventory document the data, assumptions and inferences used for estimating emissions and removals for all IPCC source/sink categories?

Have all carbon pools according to paragraph 26 of the Annex to Decision 2/CMP.7 been reported in the inventory?

If a sink/source category or pool or gas has been excluded, does the report explain why?

Are emissions and removals reported as *positive* and *negative* terms, respectively?

For each activity, is the area reported consistently reported across the time series?

Are any discontinuities in trends from base year to last reported year evaluated and explained?

Are geographical boundaries of each land subject to Article 3.3 and 3.4 activities specified?

Is the total land area reported under Article 3.3 and 3.4 constant or increasing over time?

Is information provided to distinguish deforestation from harvesting (clear-cut) or forest disturbance followed by re-establishment of a forest?

Is the forest definition consistent with that historically used by the Party for reporting information under international bodies (including the UNFCCC)? Is that definition applied consistently over time and among activities (i.e. FM, AR, D)?

2.4.6 Verification

Generic *good practice* guidance for verification is given in Section 6.10, Volume 1 of the *2006 IPCC Guidelines* (Verification). It is also *good practice* to develop verification activities as part of the overall QA/QC and verification system. Specific guidance and further issues are provided in the sections below.

2.4.6.1 SPECIFIC GUIDANCE FOR VERIFICATION OF LULUCF INVENTORIES

The checklist in the Box 2.4.3 summarises some of the tools that can be used for internal verification of a GHG inventory in the LULUCF Sector.

BOX 2.4.3
VERIFICATION OF LULUCF ESTIMATES

A. Comparisons of data:

Compare estimates with independently prepared estimates for the same country or compare regional sub-sets of the national inventory with independently prepared inventories for those regions (*Approach 1**).

Compare activity data and/or emission factors and implied emission factors of the estimate with independent international databases and/or equivalent elements of estimates of other countries. For example, compare Biomass Expansion Factors of similar species with data from countries with similar forest conditions (*Approach 1*).

Compare the estimate with results calculated using another tier methodology, including the IPCC defaults (*Approach 2*).

Compare the estimate with available intensive studies and experiments (*Approach 1-3*).

Compare land areas and biomass stocks used for preparing the estimate with remote sensing (land areas) and forest inventories (biomass stock) data (*Approach 4*).

Compare the estimate with models (Approach 5).

B. Comparisons of uncertainties:

Compare uncertainty estimates with uncertainty reported in the literature.

Compare uncertainty estimates with those from other countries and the IPCC default values.

C. Direct measurements:

Carry out direct measurements (such as time series of local forest inventory, detailed growth measurements and/or ecosystem fluxes of GHGs, *Approach 3*).

* See Section 5.7 of *GPG-LULUCF* for the details on each Approach.

Taking into account resource limitation, the information provided in the National Inventory Report should be verified as far as possible, particularly for Key Categories.

It is *good practice* to perform verification with at least one of the approaches listed in Box 2.4.3 (see also Table 5.7.1 and Section 5.7.2 in *GPG-LULUCF* for more information on the applicable approaches).

If independent estimates on GHG emissions and removals are not available, then internal or external verification will most probably be limited to scrutiny of the data and methods. Under these circumstances, it is *good practice* for the inventory compiler to carry out these checks and to provide sufficient documentation in the national inventory report and other supporting material to facilitate external review.

2.4.6.2 SPECIFIC ISSUES LINKED TO THE KYOTO PROTOCOL

An inventory compiler can use the questions in Box 2.4.4 to help guide the development of a verification plan for supplementary information reported under Articles 3.3 and 3.4 of the KP.

BOX 2.4.4
GUIDANCE FOR VERIFYING CARBON POOLS AND ACTIVITIES

Which carbon pools to verify?

It is *good practice* to focus verification on those carbon pools that are expected to be most relevant to the KP but also on non-CO_2 GHG emissions. The Decision 2/CMP.7 lists the following pools: above-ground and below-ground biomass, litter, dead wood, soil organic carbon and harvested wood products. A Party may exclude particular pools, with the exception of HWP, from accounting, if verifiable information is provided showing that the pool has not been a source of GHGs for that particular Article 3.3, FM or elected Article 3.4 activity. As for LULUCF inventories, if a pool is expected to change significantly over the inventory reporting period, particular attention should also be devoted to it. Data on carbon stock changes in reported carbon pools can be verified by assessing the mass balance of carbon stocks, carbon transfers between pools, and C emissions.

Which supplementary information to verify?

According to Decision 2/CMP.7, a Party has to report activities under Article 3.3 and FM, and may choose to report any or all elective activities under Article 3.4 of the KP. For all mandatory or elected activities, supplementary information that is specific to the reporting under KP includes: the identification of the areas in which such activities have taken place, demonstration that the activities have occurred since 1st January 1990 and are direct human-induced. Further, demonstration of the methodological consistency between the reference level or the base year for FM and eligible Article 3.4 activities should be reported. To verify land identification, including the year of the onset of the activity, the use of alternative independent data sources, e.g. remotely sensed data, is *good practice*, as such independent information contributes to verification.

The reporting of GHG emissions and removals of most Article 3.3 and 3.4 activities requires reference to 1990 or pre-1990 data (classification of forest/non forest lands for 1990, or base year information for CM, GM, RV and WDR, etc.). In some cases, these data may not be available or their reliability may be limited. In such cases, it is *good practice* to verify the methods and data as much as possible.

Inventory compilers, taking into account national circumstances, including resource availability, may choose the proper combination of approaches for verifying supplementary information reported under the KP. Among those listed, Approaches 1 and 2 can be easily implemented by an inventory compiler with low to moderate resources. Remote sensing is the most suitable for the verification of land areas. Direct measurements (under C in Box 2.4.3) are relevant, although this approach can be resource intensive and, on a large scale, costs may be a constraint. Models can be used as an alternative when direct measurements combined with remote sensing are not feasible. Some verification steps, which are unique to the KP, are presented in Box 2.4.4.

For verification, it is *good practice* to give priority to Key Categories as well as estimates with high uncertainty or with relevance to mitigation policies, or to carbon pools with a significant change, or all of these, when implementing the verification plan.

2.5 AFFORESTATION AND REFORESTATION

This section addresses specific methods applicable to Afforestation and Reforestation (AR) 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 in Decision 16/CMP.1, both Afforestation and Reforestation refer to direct human-induced conversion of non-forested land to forested land. For the first and second commitment period of the KP, AR activities are restricted to those that occurred since 1990. The distinction between Afforestation and Reforestation is linked to the period of time the land has been non-forested. Afforestation occurs on land that has not been forested for at least 50 years. Reforestation occurs on land that has been forested more recently but has been converted to non-forest land, and was non-forested on 31 December 1989[66]. Land that was subject to Deforestation (D), and is subsequently subject to regrowth of forests continues to be reported under D as a subcategory (see Section 1.2).

The country's definition of forest should be consistent with guidance provided in Section 1.2, and consistent with that used by the country in the first commitment period. A direct human-induced increase in forest cover meeting, or with the potential to meet, the country-specific forest thresholds is required as a precondition to report a land under AR activity. AR definitions do not include regrowth of forests following harvest or natural disturbance of forests. This is because the loss of forest cover in these cases is only temporary and the land remains as forested land. Harvesting followed by re-establishment of forest is considered a Forest Management (FM) activity (Section 2.7). Lands that would be subject to AR activity under Article 3.3 but are instead accounted for under FM activity under the Carbon Equivalent Forest Conversion (CEFC) provision should be identified separately (Section 2.7.7).

For identification of lands, 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 AR, assumptions about the initial size and composition of the litter, dead wood, and soil organic matter pools should reflect the preceding land-use type and history, rather than the distinction between afforested and reforested sites.

A Party's choice of methods for the development of an inventory of AR activities will depend on national circumstances. For the identification of lands subject to AR since 1990, it is *good practice* to use Approach 3 for consistent representation of lands (see Section 3.3, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*), or Approach 2, with supplementary information provided that allows identification and tracking of lands on a statistical basis[67]. A general discussion of methods for identifying and reporting on lands subject to AR activities is presented in Section 2.2 of this supplement. It is *good practice* to provide information on uncertainties in estimates of the total area of the lands subject to AR, as discussed in Section 2.4.3 of this supplement.

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 lands subject to AR activities- the geographical boundaries which are reported should correspond to strata in the estimation of land areas as described in Chapter 3, Volume 4 of the *2006 IPCC Guidelines*;
- for each of these areas, or strata, an estimate of the area of lands subject to AR activities under Article 3.3 of the KP; and

[66]This date is contained in the definition of reforestation for the first commitment period given in paragraph 1(c) of Annex to Decision 16/CMP.1 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2005/8/Add.3, p.5: *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 on 31 December 1989.* Paragraph 2 of Decision 2/CMP.6 contained in document FCCC/KP/CMP/2010/12/Add.1, p.5, indicates that*: [...]the definitions of forest, afforestation, reforestation, revegetation, forest management, cropland management and grazing land management shall be the same as in the first commitment period under the Kyoto Protocol*. This supplement assumes that the date of 31 December 1989 continues to be applicable in the second commitment period, but notes that a different interpretation may be possible subject to future decisions of the CMP.

[67]In the case of AR, the minimum information required is the land use that preceded the afforestation/reforestation event. This is particularly important for estimating the carbon stock change in soil, which may depend on the previous land use and soil type.

- the area of lands subject to direct human-induced AR in each of the previous land-use categories (e.g. Cropland, Grassland). This is to support transparent calculation of carbon stock changes and non-CO_2 GHG emissions and identification of lands.

A more comprehensive system (Reporting Method 2 in Section 2.2.2) identifies each unit of land subject to AR activities since 1990 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 AR activities. Chapter 3, Volume 4 of the *2006 IPCC Guidelines* (Consistent Representation of Lands) discusses in detail the possible Approaches for consistent representation of land areas.

In both cases, it is *good practice* to provide information on the area of AR activities by year, and any other information relevant for the estimation of emissions and removals (e.g. species, growth rate by species and / or site conditions, productivity classes, etc.).

2.5.2 Choice of methods for identifying lands subject to direct human-induced Afforestation/Reforestation

Parties are required to report on carbon stock changes and non-CO_2 GHG emissions during the commitment period on areas that have been subject to AR activities since 1990. The first step in this process is to make national parameter choices for the forest definition within the ranges indicated in Decision 16/CMP.1, namely minimum area of 0.05–1 ha, minimum tree crown cover of 10-30% (or equivalent stocking level), and minimum height at maturity of 2-5 m, and to report on these parameters in the annual greenhouse gas inventory. As explained in Section 2.2.6.1, it is also *good practice* to choose a parameter for the minimum width of forested areas. Once the parameters have been chosen, they will be used in identifying lands subject to AR.

The identification of lands subject to AR activities requires the determination of areas that:

1. meet or exceed the size of the country's minimum area in the applied forest definition (i.e. 0.05-1 ha); and
2. did not meet the country's definition of forest on 31 December 1989; and
3. meet (or have the potential to meet) the definition of forest at the time of the assessment as the result of direct human-induced activities; and
4. do not meet the criteria for CEFC at the time of the assessment if this provision is applied.

Note that the definition of forest can be met by young trees that do not yet meet the minimum height or tree 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 tree crown cover threshold in the definition of forest, for example because of recent harvest or natural disturbances, from those areas that were non-forested on 31 December 1989, because only the latter areas are eligible for AR activities under Decision 16/CMP.1. Decision 16/CMP.1 requires that Parties provide information on the criteria used to distinguish harvesting or forest disturbance that is followed by the re-establishment of forest from deforestation[68]. It is *good practice* to apply the same criteria when evaluating whether 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 for more than X years prior to 31 December 1989 and that have not regenerated would be eligible for reforestation, as only they would be considered non-forested on 31 December 1989. Similarly, areas that have been disturbed by wildfire or other natural disturbances (Section 2.3.9) more than X years prior to 31 December 1989 and that have not regenerated to forest are classified as non-forested on 31 December 1989 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 wall-to-wall estimate of all lands subject to Article 3.3 activities, or to stratify the land into areas, i.e. to define the boundaries of these areas and then develop for each area statistical estimates of the lands subject to AR and D activities. Combined approaches are also possible: wall-to-wall 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.

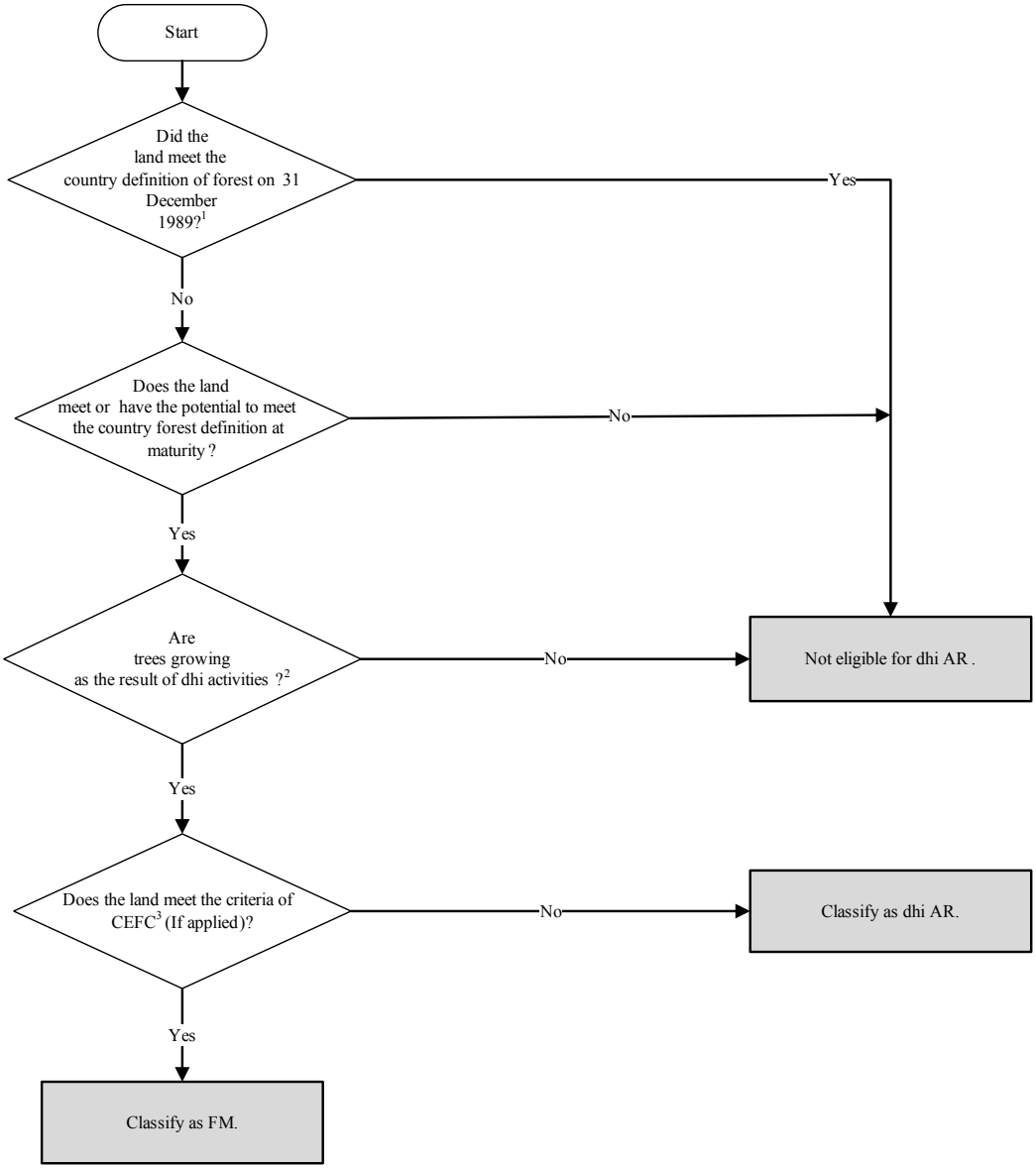
[68] Paragraph 5 of Annex to Decision 16/CMP.1 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2005/8/Add.3, p.6; Paragraph 4 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1, p.11.

It is necessary to provide information demonstrating that all AR activities included in the identified lands are direct human-induced[69]. Relevant information includes documentation demonstrating that a decision has been taken aimed at replanting or promoting or allowing forest regeneration, for example referencing laws, policies, regulations, management decisions, or practices. It may also include identification in field. In the absence of such information, forest regrowth as a consequence of abandonment does not qualify as direct human-induced AR. Forest regrowth as a consequence of environmental change (including global climate change), for example, vegetation thickening at high elevation or high latitude tree lines, is not direct-human induced and therefore does not qualify as AR.

In some cases it may be unclear whether newly established trees have the potential to meet the forest definition. Where it is uncertain whether trees on a land have the potential to exceed the thresholds of the definition of forest, it is *good practice* that if the land was already included in KP reporting, the carbon stock changes and non-CO_2 GHG emissions on these lands continue to be reported under that reported activity and to await confirmation (at a later time) that all the thresholds have been or will be passed before reporting these areas as AR. This approach is consistent with the treatment of D, i.e. after loss of forest cover that may be temporary, lands remain as forested lands until confirmed as D (see Section 2.6.2.1). A decision tree for determining whether an area will qualify for AR is given in Figure 2.5.1. If newly established vegetation does not pass the forest threshold it may be reported under other elected KP activities, e.g. RV (see Section 2.11).

[69] Decision 16/CMP.1 defines AR as *the direct human-induced conversion* of *[land that has not been forested for 50 years/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. Consistently, according to paragraph 4(a) of Annex II to Decision 2/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), contained in the document FCCC/KP/CMP/2012/13/Add.1, p.20, *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*. It is important to note that the demonstration of direct-human-induced AR is therefore a specific requirement under the Kyoto Protocol, additional to the reporting requirements under the UNFCCC. Due to this difference, it is possible that some areas that have been reported as *Land Converted to Forest Land* since 1990 in the UNFCCC inventory have not been converted through direct human-induced activity and cannot therefore be accounted for under AR activity under the Kyoto Protocol.

Figure 2.5.1 Decision tree for determining whether land qualifies for direct human-induced (dhi) AR



Note:

(1) Refer to Section 2.5.1

(2) Direct-human induced (dhi) AR activities occur if trees are growing as a result of laws, policies, regulations, management decisions, or practices aimed at planting, promoting or allowing forest regeneration. These may also include identification in the field.

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

Links with methodologies in the *2006 IPCC Guidelines* on identification and reporting of land areas in inventories under the UNFCCC are given in the Box 2.5.1.

BOX 2.5.1
IDENTIFICATION AND REPORTING OF AR LANDS: LINKS WITHIN THIS SUPPLEMENT AND WITH OTHER IPCC REPORTS

LINKS WITH OTHER CHAPTERS OF THIS SUPPLEMENT

Section 2.2.2: Reporting Methods for lands subject to Article 3.3 and Article 3.4 activities

LINKS WITH THE *2006 IPCC GUIDELINES*
Section 4.3 (Land Converted to Forest Land), Chapter 4 (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 (see footnote 69).

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

Estimation of carbon stock changes and non-CO_2 GHG emissions from AR activities should be consistent with the methods set out in Section 4.3 (Land Converted to Forest Land), Chapter 4 (Forest Land), Volume 4 of the *2006 IPCC Guidelines* and equations contained therein, and applied at the same or higher tier as that 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.

For AR under Article 3.3 activities, gross-net accounting rules are applied and information on carbon stock changes and non-CO_2 GHG emissions in the base year is therefore not required[70]. Only net carbon stock changes and non-CO_2 GHG emissions during each year of the commitment period are estimated and reported.

It is *good practice* to estimate emissions and removals of the harvested wood products (HWP) pool associated with AR activities using the guidance provided in Section 2.8 (Harvested Wood Products) of this supplement.

Carbon stock changes and non-CO_2 emissions for the three tiers are determined using guidance provided in Section 4.3 (Land Converted to Forest Land), Chapter 4, Volume 4 in the *2006 IPCC Guidelines.*

Determination of the size and dynamics of litter, dead wood and soil organic matter pools prior to the AR activity may require the use of methods developed for Cropland or other land uses (Chapter 5 and other relevant chapters of the *2006 IPCC Guidelines*).

Definition of pools under AR should be consistent with Section 1.2.2 (Carbon pool definitions and non-CO_2 gases) and Table 1.1, Chapter 1, Volume 4 of the *2006 IPCC Guidelines.*

It is *good practice* to report carbon stock changes and non-CO_2 GHG emissions from organic soils associated with drainage and rewetting of wetlands on lands subject to AR activities using the guidance provided in Section 2.12.4 (Wetland Drainage and Rewetting: Choice of methods for estimating GHG emissions and removals) of this supplement and the *Wetlands Supplement*.

It is *good practice* to estimate and report non-CO_2 GHG emissions and CO_2 emissions from liming and urea application using the guidance provided in Section 2.4.4.2.

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

[70] Except for Parties that fall under the provisions of the last sentence of Article 3.7 of the Kyoto Protocol, as adopted in Annex I to Decision 1/CMP.8 (Amendment to the Kyoto protocol pursuant to its article 3, paragraph 9) contained in document FCCC/KP/CMP/2012/13/Add.1.

BOX 2.5.2
METHODOLOGICAL GUIDANCE ON ESTIMATING CARBON STOCK CHANGES AND NON-CO_2 GHG EMISSIONS ON AR LANDS: LINKS WITHIN THIS SUPPLEMENT AND WITH OTHER IPCC REPORTS

LINKS WITH OTHER CHAPTERS OF THIS SUPPLEMENT

Section 2.4.4.2: Reporting non-CO_2 GHG emissions and CO_2 emissions from liming and urea application

Section 2.8: Harvested Wood Products

Section 2.12.4: Wetland Drainage and Rewetting

LINKS WITH THE *2006 IPCC GUIDELINES*

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

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).

LINKS WITH THE *WETLANDS SUPPLEMENT*

Guidance on estimation of carbon stock changes and non-CO_2 GHG emissions from lands with organic and wetland mineral soils in all land uses is provided in Chapters 2-5 of the *Wetlands Supplement.*

2.5.3.1 POOLS AFFECTED BY AFFORESTATION/REFORESTATION ACTIVITIES

AR activities may 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 below-ground biomass pools, but also soil organic matter, as well as dead wood, and litter, if (in the latter instances) land with woody shrub or sparse tree crown cover was afforested.

Decision 16/CMP.1 requires Parties to estimate carbon stock changes in all five pools (see Table 1.1, Chapter 1, Volume 4 of the *2006 IPCC Guidelines*) during the commitment period unless the Party can demonstrate by transparent and verifiable information that the pool is not a source[71], for which *good practice* guidance is set out in Section 2.3.1 of this supplement. Decision 2/CMP.7 further requires Parties to estimate carbon stock changes in the HWP pool. It is *good practice* to include carbon stock changes and non-CO_2 GHG emissions that result from pre-planting activities, such as site preparation or shrub removals. AR on mineral soils may maintain or create conditions that increase below-ground carbon stocks, particularly if the land was previously managed for annual crop production (Post and Kwon, 2000; Merino *et al.,* 2004; Schulp *et al.,* 2008; Laganière *et al.*, 2010; Don *et al.,* 2011). 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; Vesterdal *et al.,* 2002; Paul *et al.*, 2003; Tate *et al.,* 2003) and net losses of carbon after planting or seeding can persist over many years. It is therefore *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 AR activity, the methods given in the *2006 IPCC Guidelines* (Section 4.3: Land Converted to Forest Land, Chapter 4, Volume 4) for estimating non-CO_2 GHG emissions on *Land Converted to Forest Land* are applicable for AR activities.

For AR activities that begin during the commitment period, reporting for that land is required by Decision 2/CMP.8 to start at the onset of the activity[72]. Site preparation and seeding/planting activities should be

[71] Paragraph 26 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1, p.16; Paragraph 2 (e) of Annex II to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, p.19.

[72] Paragraph 2(d) of Annex II to Decision 2/CMP.8 contained in the document FCCC/KP/CMP/2012/13/Add.1, p.19.

considered part of the activity and associated emissions during the commitment period should therefore be included.

2.5.3.2 METHODS TO ADDRESS NATURAL DISTURBANCE

Calculation of carbon stock changes and non-CO_2 GHG emissions on areas subject to AR 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*. Decision 2/CMP.7 allows that under certain conditions, emissions from natural disturbances that occur in forests may be excluded from accounting under the KP for the second commitment period. Methods for addressing natural disturbances are provided in Section 2.3.9: Disturbances.

2.6 DEFORESTATION

This section addresses specific methods applicable to Deforestation (D) 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

According to the definition in Decision 16/CMP.1, *"Deforestation" is the direct human-induced conversion of forested to non-forested land*[73]. For the second commitment period, *Each Party…shall, for the purpose of applying the definition of forest as contained in decision 16/CMP.1*[74]*, apply the definition of forest selected in the first commitment period*[75] (see Section 1.2). The definition of Deforestation does not include loss 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 in these cases, a temporary loss of forest cover that is not associated with a land-use change is not considered D, and the land remains as forested land.

Harvest followed by re-establishment of forest is considered FM activity and is reported according to Section 2.7. Natural disturbance followed by re-establishment of forest is not considered as D and disturbance emissions may be excluded from accounting provided the relevant provisions are met, as explained in 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 D. All emissions and removals on lands subject to D must continue to be reported under D, even if these lands subsequently gain forest cover; it is *good practice* to report these lands as a separate subcategory[76].

AR land that is subject to deforestation is classified under D.

Following Decision 2/CMP.7 and Decision 2/CMP.8,[77] it is mandatory to report and account for all emissions and removals arising from the conversion of natural forest to planted forest under FM. This is not considered D, because the land remains under forest land use (Section 2.7). Under Decision 2/CMP.7[78], planted forest lands subject to conversion to non-forested land may, in special circumstances, be identified and accounted for as FM activity under the CEFC provisions and are not considered D (Section 2.7.7).

Parties will need to use the methods outlined in Chapter 3, Volume 4 of the *2006 IPCC Guidelines* (Consistent Representation of Lands), and the guidance in Section 2.2 of this supplement to ensure that lands subject to D are adequately identified in land-use change and other inventory databases and can be tracked over time once accounted under the KP. Land identification and tracking provide means to associate the relevant activity data to the correct emission factor. Decision 2/CMP.8[79] requires that areas subject to direct human-induced D since 1990 (Article 3.3) be identified separately from areas subject to direct human induced D that are also subject to other elected activities under Article 3.4 (such as CM). Providing information on these areas will improve transparency and ensure that carbon stock changes and non-CO_2 GHG emissions are not counted twice.

A Party's choice of methods for the development of an inventory of lands subject to D activities will depend on national circumstances. For the identification of lands subject to D since 1st January 1990, it is *good practice* to

[73] Paragraph 1(d) of Annex to Decision 16/CMP.1 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2005/8/Add.3, p.5

[74] Paragraph 1(a) of Annex to Decision 16/CMP.1 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2005/8/Add.3, p.5

[75] Paragraph 20 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1, p.16

[76] Treating deforested areas that are subsequently subject to a gain of forest cover as a separate sub-category is useful for transparency purposes, because different methods may be applied and different emission patterns may be reported for these subcategories.

[77] Paragraph 5 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in the document FCCC/KP/CMP/2011/10/Add.1, p.13: *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 Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, p.21, requires this activity to be reported under Forest Management.

[78] Paragraph 37 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1, p.19

[79] Paragraph 2(b) of Annex II to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1. p18.

use Approach 3 for consistent representation of lands (see Section 3.3.1, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*), or Approach 2 with supplementary information provided that it allows identification and tracking of lands on a statistical basis[80]. Section 2.2.2 of this report provides a general discussion of methods for reporting on lands subject to Article 3.3 activities. It is *good practice* to provide information on uncertainties in estimates of the total area of the lands subject to D as discussed in Section 2.4.3 of this report.

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 lands subject to direct human-induced D activities; the geographical boundaries which are reported should correspond to strata in the estimation of land areas as described in Chapter 3, Volume 4 of the *2006 IPCC Guidelines*;
- for each of these areas, or strata, an estimate of the area of the lands subject to direct human-induced D activities under Article 3.3 of the KP, and the area of these lands which would otherwise be included in lands subject to elected activities under Article 3.4 of the KP (CM, GM, RV and WDR); and
- the area of lands subject to direct human-induced D in each of the new land-use categories (Cropland, Grassland, Settlements, Wetlands and Other Land) and areas of lands subject to direct human-induced D that are subsequently subject to a gain of forest cover. This is to support the transparent calculation of carbon stock changes and non-CO_2 GHG emissions and identification of lands.

A more comprehensive system for compiling annual inventory (Reporting Method 2 in Section 2.2.2) identifies each unit of land subject to D 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 D activities. Chapter 3, Volume 4 of the *2006 IPCC Guidelines* (Basis for Consistent Representation of Lands) discusses in detail the possible Approaches for consistent representation of lands.

It is *good practice* to provide information on the area deforested by year, and any other information relevant to the estimation of emissions and removals (e.g. forest type, site conditions, etc.).

2.6.2 Choice of methods for identifying lands subject to direct human-induced Deforestation

Parties are required to report carbon stock changes and non-CO_2 GHG emissions during the commitment period on land areas that have been subject to direct human-induced D activities since 1990 (after 31 December 1989) .

To quantify D, forest must first be defined in terms of potential height, crown cover, and minimum area, as already described for AR activities. The same threshold criteria applied for the Party's definition of forest (see Section 1.2) must be used for determining the area of land subject to D.

Once a Party has chosen its definition of forest, the boundaries of the forest area can be identified at any point in time. Only areas within these boundaries are potentially subject to D activities.

The identification of lands subject to D activities requires the determination of areas that:

1. meet or exceed the size of the country's minimum forest area (i.e. 0.05-1 ha); and
2. have met the country's 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 conversion from forested to non-forested land; and
4. do not meet the criteria for CEFC if this provision is applied.

Lands can only be classified under D if they have been subject to direct human-induced conversion from forested to non-forested land. Areas in which forest cover was lost as a result of natural disturbances are therefore not considered D even if changed physical conditions delay or prevent regeneration, provided that these changes in physical conditions are not the result of direct human-induced actions (Section 2.3.9). Natural disturbance followed by land-use change will prevent regeneration of forest and is classified as Deforestation. Change in management or policy that could reasonably be expected to result directly in forest cover loss is considered to be direct human-induced D. For example, loss of forest cover in areas that have been flooded as a result of changed drainage patterns due to hydroelectric dams or road construction. Loss of forest cover due to environmental change (i.e. not direct human induced) not subject to land-use change, would not be considered D (e.g. natural raising or lowering of water tables in areas with permafrost thawing or river/coastal erosion).

[80]In the case of D, the minimum information required is the land use (or land uses) that followed the deforestation event.

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
IDENTIFICATION OF D LANDS: LINKS WITHIN THIS SUPPLEMENT AND WITH OTHER IPCC REPORTS

LINKS WITH OTHER CHAPTERS OF THIS SUPPLEMENT

Section 2.2.2: Reporting Methods for lands subject to Article 3.3 and Article 3.4 activities

Provides methods for identifying lands subject to direct human induced Deforestation, along with conditions for identifying areas of lands subject to Deforestation activity.

LINKS WITH THE *2006 IPCC GUIDELINES*

Volume 4: Agriculture, Forestry and Other Land Use

Chapter 3: Consistent Representation of Lands

Section 5.3 (Land Converted to Cropland), Chapter 5 (Cropland): methodological guidance on annual estimation of emissions and removals of GHG, which occur on *Land Converted to Cropland* from different land uses.

Section 6.3 (Land Converted to Grassland), Chapter 6 (Grassland): methodological guidance on annual estimation of emissions and removals of GHG, which occur on *Land Converted to Grassland* from different land uses.

Section 7.3.2 (Land Converted to Flooded Land), Chapter 7 (Wetlands): methodological guidance on annual estimation of emissions and removals of CO_2, which occur on *Land Converted to Flooded Land* from different land uses.

Section 8.3 (Land Converted to Settlements), Chapter 8 (Settlements): methodological guidance on annual estimation of emissions and removals of GHG, which occur on *Land Converted to Settlements* from different land uses.

Section 9.3 (Land Converted to Other Land), Chapter 9 (Other Land): methodological guidance on annual estimation of emissions and removals of GHG, 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 are required to report on how they distinguish between D and areas that remain forests but where tree crown cover has been temporarily removed[81], notably areas that have been harvested or have been subject to other human disturbance but where it is expected that a forest will be replanted or will regenerate naturally. It is *good practice* to develop and report criteria by which temporary removal or loss of tree cover can be distinguished from D. For example, a Party could define the expected time period (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, lands that were forest on or after 31 December 1989 and that have since lost forest cover due to direct human-induced actions and failed to regenerate are identified as deforested; carbon stock changes and non-CO_2 GHG emissions for these lands are therefore to be recalculated and added to those of other deforested areas. There is also an exception under the CEFC, which allows the carbon stock changes and non-CO_2 GHG emissions from some plantation conversions 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 or field inventories, the classification of an area as deforested and the identification of the new land use may be more challenging. This involves assessing the lands on which the forest cover loss has occurred, as well as the surrounding area, and typically requires data from multiple sources to supplement the change detection

[81] Paragraph 4 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1, p.13; Paragraph 4 (b) of Annex 2 to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, p.20.

information. In some cases a new land use can be determined from remotely sensed data, 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 D from temporary loss of forest cover. Where such information is missing or unavailable, only a lapse of time will reveal whether or not the forest cover has been temporarily lost. In the absence of land-use change or infrastructure development and until the time for regeneration has elapsed, these lands remain classified as forest. If the land does not meet the definition of forest once the time period has elapsed, it is classified as D and the new land use is determined. It could be the case that the information needed to distinguish D from temporary loss of forest cover (e.g. the expected time for regeneration has elapsed) will be available only in the following commitment period. To avoid potential underestimation of emissions from D in the commitment period, it is *good practice* to estimate by the last inventory reporting year of the commitment period, the proportion of lands without forest cover that is expected *not* to regenerate to forest[82]. This estimate could be based on country-specific or regional averages or on other spatial data consistent with national inventory methods. This proportion of the area will then be assigned to lands subject to D, while the remaining proportion will remain classified as forest[83].

It is *good practice* for Parties to identify and track lands with loss of forest cover that are not yet classified as deforested, and to report on their area and status in annual supplementary information (see Table 2.4.1 in Section 2.4.4.1). It is also *good practice* to confirm whether or not regeneration occurred within the expected time period on these lands. Lands for which, at the end of a commitment period, no direct information was available to distinguish D from other causes of forest 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 lands that had remained classified as forest should be reclassified as D and carbon stock changes and non-CO_2 GHG emissions calculated accordingly (see also Chapter 5, Volume 1 of the *2006 IPCC Guidelines*: Time Series Consistency).

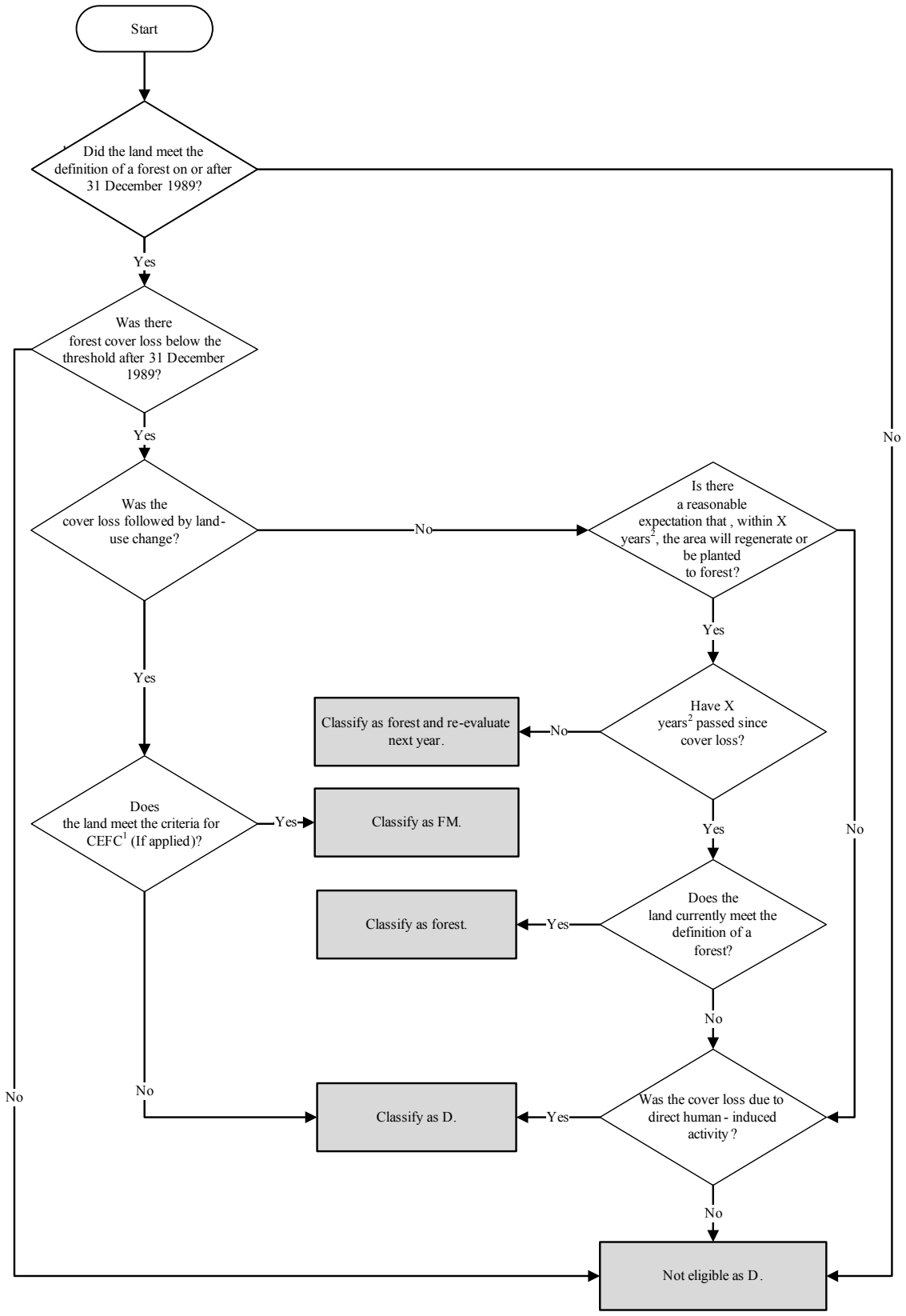
The task of distinguishing temporary forest cover loss from D can be supported by information on harvested areas and areas subject to natural disturbances. In many countries, information on harvest cut blocks and on natural disturbance events is more readily available than information on deforestation events. Such information can be used to distinguish direct human-induced D from temporary forest 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 lands subject to D.

A decision tree for determining whether a unit of land is subject to direct human-induced D is given in Figure 2.6.1.

[82]This method is necessary because emissions on affected lands may not necessarily be reported under FM.

[83]For instance, in the last inventory year of the commitment period, an area of 1000 ha was subject to loss of forest cover; 800 ha of this area were classified as D, while the information needed to classify the remaining 200 ha definitively as D was still not available. Of these 200 ha, based on country-specific or regional statistics or other data, the country estimates that 150 ha are expected not to regenerate. These 150 ha are assigned to D, while the remaining 50 ha remain classified as forest.

Figure 2.6.1 Decision tree for determining whether land is subject to direct human-induced (dhi) D.



Note:

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

2. Refer to country-specific criteria for distinguishing harvesting from D. Reassess annually or at a minimum prior to the end of the next commitment period.

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

All carbon stock changes and non-CO_2 GHG emissions during the commitment period on lands subject to direct human-induced D since 1990 are required to be reported[84]. Where deforestation occurred between 1 January 1990 and the beginning of the commitment period, changes in the carbon pools after the deforestation event need to be estimated for each inventory year of the commitment period[85]. After the deforestation event, losses during the commitment period will result primarily from continuing decay of dead wood, litter, below-ground biomass and soil carbon remaining on the site. These losses can be offset by an increase in biomass pools on this land. Definitions of pools under D should be consistent with provisions introduced by the *2006 IPCC Guidelines* (Section 1.2.2, Chapter1, Volume 4: Carbon pool definitions and non-CO_2 gases and Table 1.1).

On areas subject to Article 3.3 activities, gross-net accounting rules are applied[86] and information on carbon stock changes and non-CO_2 GHG emissions in the base year is therefore not required. Only net carbon stock changes and non-CO_2 GHG emissions during each year of the commitment period are required to be estimated and reported.

HWP derived from D activity are accounted for as an instantaneous emission at the time of deforestation (see Section 2.8).

For the estimation of carbon stock changes and non-CO_2 GHG emissions, it is *good practice* to use the same or a higher tier as that used for estimating emissions from forest conversion in Chapters 5, 6, 7, 8 and 9 (Conversion from Forest Land to any other land-use category), Volume 4 in the *2006 IPCC Guidelines*.

Carbon stock changes on lands subject to D activities during the commitment period can be estimated by determining carbon stocks in all pools prior to and after the deforestation event. Alternatively, stock changes can be estimated from carbon transfers out of the forest, e.g. the amount harvested (Chapter 2, Volume 4 of the *2006 IPCC Guidelines*) or the biomass consumed in the case of burning. For deforestation events that occur prior to the commitment period, knowledge of pre-deforestation carbon stocks will also be useful for the estimation of post-disturbance carbon dynamics. For example, estimates of emissions from decay of litter, deadwood, and soil organic matter pools can be derived from data on pool sizes and decay rates. Information about pre-deforestation carbon stocks can be obtained from forest inventories, aerial photographs and satellite data, by comparison with adjacent remaining forests, or through reconstruction from stumps where these remain on site. Information on the time since deforestation, on the current vegetation, and on management practices on that site is required for the estimation of carbon stock changes and non-CO_2 GHG emissions.

It is *good practice* that carbon stock changes on D lands subject to new land-use categories (such as Cropland, Grassland, Wetlands, Settlements, or Other Land) be estimated using the established methodologies to estimate carbon stock changes described in relevant sections of the *2006 IPCC Guidelines*. Several of these categories may contain little or no carbon, or the change in carbon stocks may be very small.

It is *good practice* to report carbon stock changes and non-CO_2 GHG emissions from organic soils associated with drainage and rewetting on land subject to D activities using the guidance provided in Section 2.12.4 (Wetland Drainage and Rewetting) of this supplement, and in the *Wetlands Supplement*.

It is *good practice* to estimate and report non-CO_2 GHG emissions and CO_2 emissions from liming and urea application using the guidance provided in Section 2.4.4.2.

Box 2.6.2 summarises links with methodologies for estimation of carbon stock changes and non-CO_2 GHG emissions provided in this supplement and in the *2006 IPCC Guidelines* and *Wetlands Supplement*, Chapters 2-5.

[84]Paragraphs 17, 18 and 19 of Annex to Decision 16/CMP.1 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2005/8/Add.3, p.8; Paragraphs 22 and 23 of Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p.16.

[85]Pools which are not a source can be excluded from accounting, though this is unlikely in the case of D.

[86]Except for Parties that fall under the provisions of the last sentence of Article 3.7 of the Kyoto Protocol, as adopted in Annex I to Decision 1/CMP.8 (Amendment to the Kyoto protocol pursuant to its article 3, paragraph 9) contained in document FCCC/KP/CMP/2012/13/Add.1.

BOX 2.6.2
METHODOLOGICAL GUIDANCE ON ESTIMATING CARBON STOCK CHANGES AND NON-CO_2 GHG EMISSIONS ON D LANDS: LINKS WITHIN THIS SUPPLEMENT AND WITH OTHER IPCC REPORTS

LINKS WITH OTHER CHAPTERS OF THIS SUPPLEMENT

Section 2.4.4.2: Reporting non-CO_2 GHG emissions and CO_2 emissions from liming and urea application

Section 2.8: Harvested Wood Products

Section 2.12.4: Wetland Drainage and Rewetting

LINKS WITH THE *2006 IPCC GUIDELINES* (Volume 4: Agriculture, Forestry and Other Land Use)

Section 5.3 (Land Converted to Cropland), Chapter 5 (Cropland): methodological guidance on annual estimation of emissions and removals of GHG, which occur on *Land Converted to Cropland* from different land uses.

Section 6.3 (Land Converted to Grassland), Chapter 6 (Grassland): methodological guidance on annual estimation of emissions and removals of GHG, which occur on *Land Converted to Grassland* from different land uses.

Section 7.3.2 (Land Converted to Flooded Land), Chapter 7 (Wetlands): methodological guidance on annual estimation of emissions and removals of CO_2, which occur on *Land Converted to Flooded Land* from different land uses.

Section 8.3 (Land Converted to Settlements), Chapter 8 (Settlements): methodological guidance on annual estimation of emissions and removals of GHG, which occur on *Land Converted to Settlements* from different land uses.

Section 9.3 (Land Converted to Other Land), Chapter 9 (Other Land): methodological guidance on annual estimation of emissions and removals of GHG, which occur on *Land Converted to Other Land* from different land uses.

LINKS WITH THE *WETLANDS SUPPLEMENT*

Guidance on estimation of carbon stock changes and non-CO_2 GHG emissions from lands with organic and wetland mineral soils in all land uses is provided in Chapters 2-5 of the *Wetlands Supplement.*

2.7 FOREST MANAGEMENT

According to Decision 2/CMP.7, accounting of emissions and removals from Forest Management (FM) under the Kyoto Protocol during the second commitment period is mandatory[87], and is based on a reference level[88].

This section addresses definitional issues and specific methods for identification of areas subject to FM and calculation of carbon stock changes and non-CO_2 GHG emissions for those areas (Sections 2.7.1, 2.7.2 and 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 (FMRL, Section 2.7.5);
- performance of Technical Corrections for accounting purposes (Section 2.7.6); and
- reporting and accounting of lands under the Carbon Equivalent Forest Conversion provision (CEFC, i.e. lands under FM that would otherwise be accounted as Article 3.3 lands, Section 2.7.7).

The treatment of HWP related to FM, according to Decision 2/CMP.7, is discussed briefly in this section and in more detail in Section 2.8. Natural disturbances as they relate to FM are dealt with briefly in Section 2.7.4 below and in greater depth in Section 2.3.9.

This section should be read in conjunction with the general methodological description in Sections 2.2 to 2.4 of this supplement.

2.7.1 Definitional issues and reporting requirements

Decision 2/CMP.7 maintains the same definition of "forest" and "Forest Management" as in Decision 16/CMP.1[89].

Decision 16/CMP.1 defines "forest" using the threshold criteria[90], including the potential to meet them, and including areas that are temporarily unstocked. Decision 2/CMP.7 specifies that, for the purpose of applying the definition of "forest", each Party shall apply the definition selected in the first commitment period. See guidance provided in Section 1.2.

According to Decision 16/CMP.1, *"*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*. It includes forests meeting the definition of "forest" in Decision 16/CMP.1 with the parameter values for forests that have been selected and reported by the Party, and that have not been classified by the Party under AR or D categories.

There are two approaches that countries may choose to interpret the definition of FM. In the *narrow approach*, a country would define a system of specific practices undertaken since 1990 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. In this approach, the area subject to FM may increase over time if the specific practices defined as FM activities are implemented on new areas. In the *broad approach*, a country would define a system of forest management practices, and identify the area that is subject to this system of practices during the inventory year of the commitment period without the requirement that a specified forest management practice has occurred on each land.

According to Decision 2/CMP.7, Parties are required to report and account for all emissions 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 replacement of natural forest with planted forests after harvesting. It is *good practice* that Parties, according to their national circumstances, provide their definition of natural forest and planted forest, with the latter including forest plantations (as defined in the *2006 IPCC Guidelines*), and apply these definitions consistently throughout the commitment periods. It is *good practice* that emissions and

[87] See paragraph 7 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry), contained in document FCCC/KP/CMP/2011/10/Add.1, p.14.
[88] See paragraphs 12 and 13 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry), contained in document FCCC/KP/CMP/2011/10/Add.1, p.14.
[89] See paragraphs 1, 20, and 21 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry), contained in document FCCC/KP/CMP/2011/10/Add.1, p.13 and 16.
[90] See footnote 84 and Section 1.2, step 1 for further guidance.

removals on lands subject to conversion from natural forest to planted forest are reported and accounted for under FM.

According to Decision 2/CMP.7, Parties applying the CEFC provision described in Section 2.7.7 are required to report these lands separately from other FM lands. These lands will include both forest and non-forest lands but are accounted for under FM.

Section 2.2 (Generic methodologies for area identification, stratification and reporting) explains that the geographical location of the areas encompassing lands subject to FM activities are to be defined and reported[91]. Two Reporting Methods are outlined in Section 2.2.2.

In Reporting Method 1, a boundary may encompass multiple FM lands and other kinds of land use such as agriculture or unmanaged forests. In Reporting Method 2, a Party identifies the geographic boundaries of all lands subject to FM throughout the country. Reporting Methods 1 or 2 are used for reporting carbon stock changes in above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter pools as well as non-CO_2 GHG emissions. Reporting and accounting for the HWP pool is at the national level. FM lands also include non-forest land accounted for under FM through the CEFC provision, if implemented (Section 2.7.7).

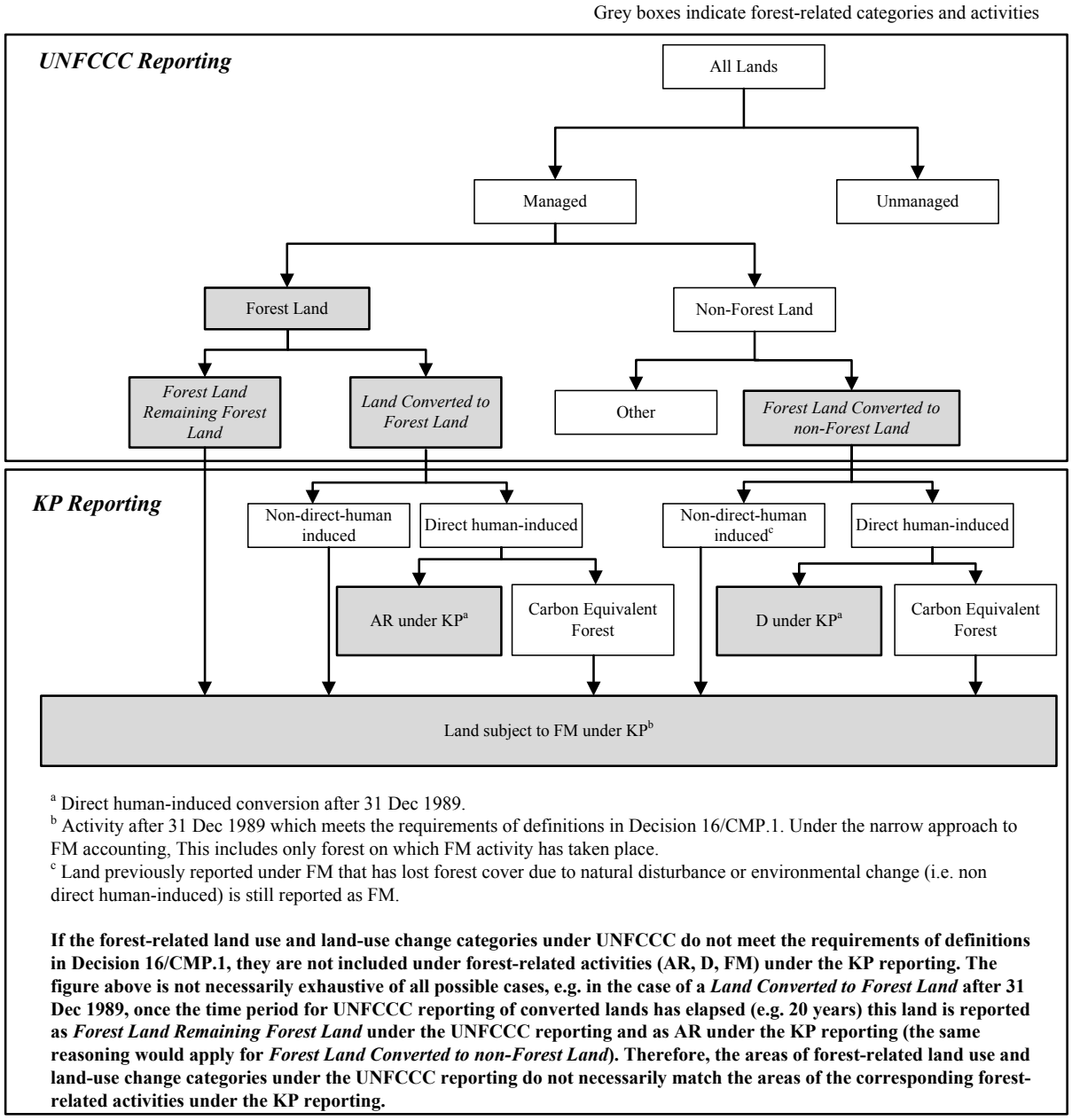
2.7.2 Choice of methods for identifying lands subject to Forest Management

It is *good practice* for each Party to describe in its NIR how it applies the definitions of "forest" and "Forest Management" under Decision 16/CMP.1 in a consistent way across space and time, and how it distinguishes areas subject to FM from other areas. It is *good practice* to base the assignment of land to activities following the guidance in Sections 1.1 and 1.2 of this supplement and Chapter 3, Volume 4 (Consistent Representation of Lands) of the *2006 IPCC Guidelines*.

Land subject to "Forest Management" as defined by Decision 16/CMP.1 is not necessarily the same area as "managed forest" used for UNFCCC reporting in the context of the *2006 IPCC Guidelines*. The latter includes all forest lands where human interventions and practices have been applied to perform production, ecological or social functions (Chapter 2, Volume 4, *2006 IPCC Guidelines*), and thus may include forests that do not meet the country-specific definition of "Forest Management" under Decision 16/CMP.1 or that have not been subject to any FM practice since 1990.

[91] According to paragraph 2 (b) of Annex II to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, p.18.

Figure 2.7.1 Relationship between different categories under UNFCCC reporting and forest activities under Kyoto Protocol reporting in a given inventory year. See Sections 2.7 and 2.7.1 for further explanation.



[a] Direct human-induced conversion after 31 Dec 1989.
[b] Activity after 31 Dec 1989 which meets the requirements of definitions in Decision 16/CMP.1. Under the narrow approach to FM accounting, This includes only forest on which FM activity has taken place.
[c] Land previously reported under FM that has lost forest cover due to natural disturbance or environmental change (i.e. non direct human-induced) is still reported as FM.

If the forest-related land use and land-use change categories under UNFCCC do not meet the requirements of definitions in Decision 16/CMP.1, they are not included under forest-related activities (AR, D, FM) under the KP reporting. The figure above is not necessarily exhaustive of all possible cases, e.g. in the case of a *Land Converted to Forest Land* after 31 Dec 1989, once the time period for UNFCCC reporting of converted lands has elapsed (e.g. 20 years) this land is reported as *Forest Land Remaining Forest Land* under the UNFCCC reporting and as AR under the KP reporting (the same reasoning would apply for *Forest Land Converted to non-Forest Land*). Therefore, the areas of forest-related land use and land-use change categories under the UNFCCC reporting do not necessarily match the areas of the corresponding forest-related activities under the KP reporting.

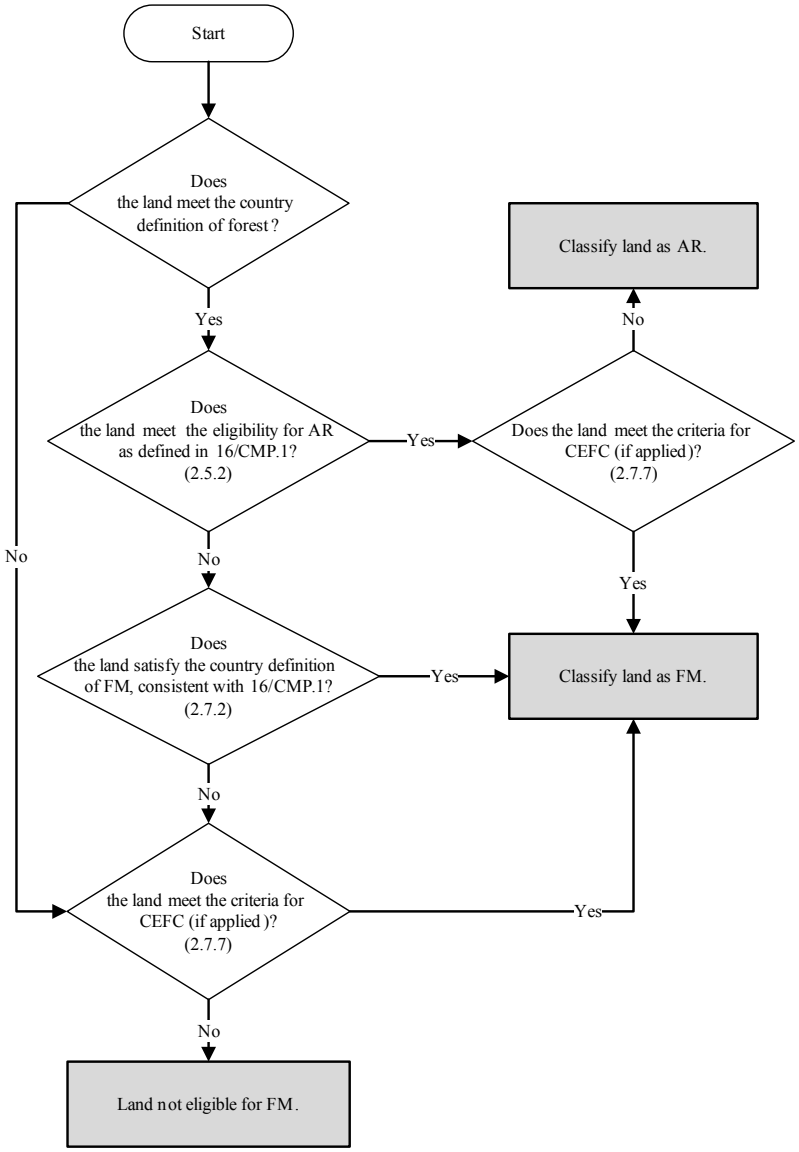
Figure 2.7.1 outlines the relationship between different forest categories. For UNFCCC reporting, countries may have subdivided their forest area into managed forests (those that are included in the reporting) and unmanaged forest (in which case areas are reported but not the emissions). Managed forests could further be subdivided into those areas that meet the definitions of "forest" and of "Forest Management" in Decision 16/CMP.1 and those (if any) that do not. However, 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*[92], the total area of managed forest in a country will often be the same as the area subject to FM plus any area subject to AR. Where differences occur between the areas of managed forest (as reported under the UNFCCC) and forest subject to FM (plus any area subject to AR), it is *good practice* to explain and document the extent of differences. In particular, where areas that are considered managed forest are excluded from the area subject to FM, it is *good practice* to provide the reason for the exclusion (including the use of the *narrow approach*), and to document how any possible

[92] See paragraph 1(f) of Annex to Decision 16/CMP.1 contained in document FCCC/KP/CMP/2005/8/Add.3, p.5.

unbalanced accounting is avoided. The *IPCC Report on Definitions and Methodological Options to Inventory Emissions from Direct Human-Induced Degradation of Forests and Devegetation of Other Vegetation Types* (IPCC, 2003c) discusses the issue of unbalanced accounting. In the context of the FMRL, unbalanced accounting can occur if areas that are considered more likely to produce a net debit in the accounting are preferentially excluded and areas considered more likely to produce a net credit are preferentially included in FMRL. In addition, unbalanced accounting may potentially occur where countries increase their area of land under FM compared to the area included in the FMRL. In the case of increase in FM area during the commitment period beyond what is included in the FMRL (e.g. when the *narrow approach* to FM is used), it is *good practice* to document transparently that this is not a result of change in the FM activity definition, but rather a result of newly implemented policies that were not included in the FMRL submission. The inclusion of non-forested areas within FM accounting under the CEFC provision can also lead to differences between the reported area of managed forest and the area under FM – 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 for FM. Land that is classified as being subject to FM is required to meet the country's criteria for forest or, if non-forest, is required to be subject to CEFC provision.

Figure 2.7.2 Decision tree for determining whether land qualifies for Forest Management.



It is *good practice* for each Party to describe its application of the definition of FM and to identify areas of land subject to FM in the inventory year of the commitment period. In most cases, this will be based on information contained in national forest inventories including criteria such as administrative, zoning (e.g. protected areas or parks) or ownership boundaries, since the difference between managed and unmanaged forest or possibly, between managed forest meeting the definition of FM in Decision 16/CMP.1 and managed forest not doing so,

may be difficult or impossible to detect by remote sensing or through other forms of observation. It is *good practice* for each Party to provide information to show how reporting and accounting of emissions and removals due to transition of natural forest to planted forest have been captured within FM.

According to Decision 2/CMP.7, carbon stock changes and non-CO_2 GHG emissions on lands subject to FM can be excluded from accounting if they are associated with natural disturbance (see Sections 2.2.3 and 2.3.9).

The area of lands subject to FM can increase or decrease over time, for example, if a country expands its road infrastructure into previously unmanaged forests and initiates management activities, or in the case of the *narrow approach*, as new specific FM practices are applied to new areas of forest land. In both these cases, the area of land subject to FM is increasing and the associated carbon stock changes need to be estimated accordingly. If an area of forest expansion after 1990 does not qualify for direct human-induced AR and if this area meets the requirements of FM under Decision 16/CMP.1, it is included under FM (see Figure 2.7.1). On the other hand, D activities decrease the area under FM. 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 of this supplement. Failure to use the correct computational methods may result in an apparent but incorrect increase or decrease in carbon stocks that is the result of change in area.

Once an area has been included in reporting under the KP it cannot be removed but the reporting category of the area can change (as outlined in Section 1.3). Lands that are deforested are subject to the rules of Article 3.3 and future carbon stock changes must be reported under D. Accordingly, the area reported under Article 3.4 would decrease, and the area reported under Article 3.3 would increase by the same amount.

Forests plantations that are harvested and converted to non-forest lands under the CEFC provisions are not regarded as being deforested (see Section 2.7.7). These lands are reported under FM, as are the compensating non-forest lands converted to forest land. This means that the area reported under FM may increase without an increase in forested land. Decision 2/CMP.7 mandates that lands subject to CEFC provisions be transparently identified and tracked.

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 THE *2006 IPCC GUIDELINES*

Volume 4: Agriculture Forestry and Other Land Use

Chapter 3: Consistent Representation of Lands

Section 4.2, Chapter 4: Forest Land Remaining Forest Land

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

Methods to estimate carbon stock changes and non-CO_2 GHG emissions within FM lands follow those in the *2006 IPCC Guidelines* provided in Section 4.2 (Forest Land Remaining Forest Land), Chapter 4, Volume 4 including in the case of conversion of natural forests to planted forests.

For the HWP pool, estimation methods in line with Decision 2/CMP.7 are provided in Section 2.8 of this supplement, including guidance to distinguish among HWP originating from lands subject to each forest-related activity, i.e. AR, FM, or D, or from lands not subject to any of those activities. On areas subject to FM activities, the reference level accounting rule is applied for the second commitment period, i.e. for each Party accounting is based on comparison between emissions and removals reported for FM during the commitment period and the FMRL inscribed in the Appendix to 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).

It is *good practice* to use the same or a higher tier for estimating carbon stock changes and non-CO_2 GHG emissions as the one that was used for the corresponding land use in the UNFCCC inventory, following the guidance on methodological choice and identification of key categories included in Chapter 4, Volume 1 of the *2006 IPCC Guidelines*. In particular:

- Tier 1 can only be applied if FM 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) of this supplement. Tier 1, as elaborated in Chapter 4, Volume 4 of the *2006 IPCC Guidelines,* assumes that for *Forest Land Remaining Forest Land* the net change in the carbon stocks in litter, dead wood, and soil organic matter pools is zero, but Decision 2/CMP.7 specifies that above- and below-ground biomass, litter, dead wood, and SOC shall all be accounted for

unless the country chooses not to report changes in a pool that has been demonstrated not to be a source. Tier 1 can therefore only be applied if the litter, dead wood and soil organic matter pools can be shown not to be sources using the methods outlined in Section 2.3.1 (Pools to be reported) of this supplement. It is important to note that, once a pool has been included in the FMRL, for reasons of consistency, this pool is also required to be reported and accounted for during the commitment period, irrespective of the pool being a sink or a source (see Section 2.7.5.2 on methodological consistency). For HWP, specific guidance is given in Section 2.8.

- It is *good practice* to apply Tier 2 and 3 methods if FM is a *key category* and if the pool is *significant*, according to the guidance given in Section 2.3.6. With the exception of the pools already included in the FMRL, 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.
- Where it is possible to obtain estimates from both the *Gain-Loss* and the *Stock-Difference* methods, it is suggested that a comparison between the two methods be used for verification purposes because this may help identify errors and understand better the trends and reasons for interannual variations.

It is *good practice* to report carbon stock changes and non-CO_2 GHG emissions from organic soils associated with drainage and rewetting under FM activities using the guidance provided in Section 2.12.4 (Wetland Drainage and Rewetting) of this supplement, and in the *Wetlands Supplement*.

It is *good practice* to estimate and report non-CO_2 GHG emissions and CO_2 emissions from liming and urea application using the guidance provided in Section 2.4.4.2.

In most cases, the information requirements for KP reporting exceed the information contained in the national UNFCCC inventory. To meet the KP reporting requirements, national inventory systems need be able to identify and track all forest areas 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 KP, and whether they have been subject to natural disturbances or to the CEFC accounting provisions. Such systems can then be used to calculate and report carbon stock changes and non-CO_2 GHG emissions in all relevant categories for both UNFCCC and KP reporting. Properly implemented, such a comprehensive approach ensures consistency across the methods used for calculating and reporting carbon stock changes and non-CO_2 GHG emissions, because the same forest and land-use change inventories are the basis for the computations used in both UNFCCC and KP reporting.

Box 2.7.2 summarises links with methodologies in this supplement and with the *2006 IPCC Guidelines* to estimate carbon stock changes and non-CO_2 GHG emissions.

BOX 2.7.2
METHODOLOGICAL GUIDANCE FOR ESTIMATION OF CARBON STOCK CHANGES AND NON-CO_2 GHG EMISSIONS FROM FM ACTIVITIES: LINKS WITHIN THIS SUPPLEMENT AND WITH OTHER IPCC REPORTS

LINKS WITH OTHER CHAPTERS OF THIS SUPPLEMENT

Section 2.4.4.2: Reporting non-CO_2 GHG emissions and CO_2 emissions from liming and urea application

Section 2.8: Harvested Wood Products

Section 2.12.3: Wetland Drainage and Rewetting

LINKS WITH THE *2006 IPCC GUIDELINES*

Section 4.2, Chapter 4: Forest Land Remaining Forest Land.

Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application.

The area subject to FM may not be the same as the area of *Forest Land Remaining Forest Land* and estimates may have to be adjusted accordingly.

LINKS WITH THE *WETLANDS SUPPLEMENT*

Guidance on estimation of carbon stock changes and non-CO_2 GHG emissions from lands with organic and wetland mineral soils in all land-uses is provided in Chapters 2-5 of the *Wetlands Supplement.*

2.7.4 Methods to address natural disturbance

Calculation of carbon stock changes and non-CO_2 GHG emissions in areas subject to FM can be influenced by 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*. Accounted emissions from FM can be influenced by natural disturbances in three ways: 1) through emissions from natural disturbances occurring in the commitment period; 2) through the choice of the background level and the margins; and 3) through an inconsistency between the treatment of natural disturbances in the reporting of FM emissions in the commitment period and the FMRL. Methods for addressing natural disturbances in cases 1) and 2) are provided in Section 2.3.9. Guidance to address inconsistencies in the treatment of natural disturbances in reported data and the FMRL is presented in Sections 2.7.5 and 2.7.6.

2.7.5 Forest Management Reference Levels

According to Decision 2/CMP.7[93], for the second commitment period, accountable anthropogenic greenhouse gas emissions by sources and removals by sinks resulting from Forest Management under Article 3.4*, ...shall be equal to anthropogenic greenhouse gas emissions by sources and removals by sinks in the commitment period,* less the duration of the commitment period, in years, multiplied by the FMRL inscribed in the appendix [to the Decision]. The FMRL is a value of average annual net emissions and removals from FM in the second commitment period, against which the net emissions and removals reported for FM during the second commitment period will be compared for accounting purposes.

This section addresses methodological issues related to the FMRL, including: 1) an overview of approaches and methods used and the elements taken into consideration by Parties for the construction of their FMRL (2.7.5.1); 2) a description of how to demonstrate methodological consistency between the FMRL and reporting for FM during the commitment period (2.7.5.2); and 3) a description of how and when to perform Technical Corrections for accounting purposes, if necessary, to ensure consistency applying IPCC methods, or to exclude from accounting any impact due to inconsistencies (2.7.6). This section should be read in conjunction with the general guidance on FM provided in Sections 2.7.1 to 2.7.4.

The guidance on how to construct the FMRL is provided in Appendix II to Decision 2/CMP.6 and is not repeated here. The overview of approaches, methods, and elements used in the construction of FMRLs is provided below to clarify discussions on methodological consistency and Technical Corrections.

2.7.5.1 Overview of approaches, methods and elements considered in the construction of FMRL

Decision 2/CMP.6 requested Annex I Parties 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: 1) 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 to paragraph 4 of Decision 2/CMP.6[94] were taken into account by Parties in the construction of FMRLs, and to provide any additional relevant information; 2) to document the information that was used by Parties in the construction of FMRLs in a comprehensive and transparent way; and 3) to provide transparent, complete, consistent, comparable, and accurate methodological information used at the time of the construction of the FMRL.

The information provided by Parties on how the FMRL was constructed provides the basis for assessing methodological consistency between the FMRL and the reporting of FM during the second commitment period. This section summarises the approaches and methods used and the elements considered in the construction of the FMRL, based on FMRL submissions made by Parties and on the synthesis report of technical assessments provided by the UNFCCC Secretariat[95].

[93] Decision 2/CMP.7 (Land use, land-use change and forestry), contained in document FCCC/KP/CMP/2011/10/Add.1.

[94] 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; and (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.

[95] Submissions on forest management reference levels submitted by Parties to the secretariat by 28 February 2011 and synthesis report of the technical assessments of the forest management reference level submissions (note by the secretariat) contained in document FCCC/KP/AWG/2011/INF.2, http://unfccc.int/bodies/awg-kp/items/5896.php.

APPROACHES AND METHODS USED TO CONSTRUCT FMRL

The FMRL submissions included a description of the approaches, methods, and models used in the construction of the FMRLs, including assumptions used referring, where relevant, to the latest available NIR. Based on the submissions on the FMRL made by Parties, three general approaches used to construct FMRLs may be recognized, as described in Box 2.7.3.

BOX 2.7.3
APPROACHES AND METHODS 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 extrapolation of historical data, three proposed historical FMRLs based on a single year, and one proposed an FMRL of zero. The three *approaches* used are summarised below. The first *approach* is further split into two *methods*.

1) FMRLs based on projections under a 'business-as-usual' scenario. These include two *methods*:

a) 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 as a source of information on 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 the 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 were used to project annual estimates of emissions and removals for FM and averaged to calculate the FMRL.

b) projections based on the elaboration of historical data from greenhouse gas inventories, assumed as proxy for a 'business-as-usual' scenario

Average of historical data. For its FMRL, one Party used the average of historical removals under the *Forest Land Remaining Forest Land* category.

Extrapolation from a historical time series trend. Two Parties used a linear extrapolation of net historical emissions data to construct the FMRLs.

2) Historical FMRL based on the single year 1990

Three Parties proposed the use of a historical FMRL based on 1990 data.

3) FMRL equal to zero

One Party used the *narrow approach* for FM and set its FMRL equal to zero.

ELEMENTS CONSIDERED IN THE CONSTRUCTION OF FMRL

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 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 FM or *Forest Land Remaining Forest Land*.

Decision 2/CMP.7 also specified that for the second commitment period, Parties *shall account for all changes in ... above-ground biomass, below-ground biomass, litter, dead wood, soil organic matter and harvested wood products* (see Section 2.3.1 for additional information and methodological guidance). Nevertheless, with the exception of HWP, 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.

Area under Forest Management

The FMRL submissions contain information on the FM area used in the construction of the FMRL with the aim of showing consistency with the reporting of FM 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 being subject to D and AR activities. In the case of modelled projections, consistency between FMRL area and area under FM means that future D is taken into account by projecting a decreasing FM area in the second commitment period[96], and

[96]Some Parties 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.

that the expected future AR does not affect the evolution of FM area considered for the FMRL. In some cases, an increase in future FM area was included in FMRL due to new forest area (e.g. previously unmanaged) assumed to enter the FM area.

Historical data from greenhouse gas inventory

Parties were requested to include in the FMRL submissions information on the relationship between FM 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 consistency between the proposed FMRLs and historical data as reported in each Party's GHG inventory and NIR. Historical data came from the 2010 GHG inventory, unless otherwise specified. In the case of modelled projections, consistency with historical data can be shown by the fact that the model used for constructing the projected FMRL reproduces historical data for FM or *Forest Land Remaining Forest Land* from the GHG inventory or that *ex-post* calibrations have been carried out to align the model results with historical data.

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 forest types, soil types, growing stock, tree species composition and silvicultural practices (including regeneration modality, type and frequency of cuttings, etc.). In the case of models used for projected FMRLs, other information included assumptions about future silvicultural practices, key drivers (i.e. harvest rates), and expected evolution of key forest characteristics (age structure, increment), with the aim of transparently describing 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 net emissions and removals from FM. The FMRL submissions included the time series of historical harvesting rates and predicted future harvest rates. In the case of modelled projections, it is particularly important that the information shows that the historical harvest used by the models is consistent with the 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, Parties provided information on assumptions about 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 for business-as-usual scenario, while others predicted the future harvest amount (or future harvest relative increase or decrease as compared with historical period) based on macroeconomic scenarios or based on the continuation of current forest management activities associated with actual age-class structure. For purposes of transparency, 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, see Section 2.8.1) was useful to demonstrate consistency between biomass losses due to assumed future harvest rates and 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). Since FMRLs were submitted before Decision 2/CMP.7, it is essential to consider the need for a Technical Correction for accounting purposes in order to reflect Decision 2/CMP.7. See Section 2.8 for detailed information and *good practice* guidance on HWP.

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 was incorporated into 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 FMRL were submitted before Decision 2/CMP.7, 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 emissions from 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 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 they can therefore be assumed to be factored out. For projected FMRLs, it is generally assumed that the 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 (assuming that both include or exclude these effects). Similarly, the dynamic effects of differing age-class structures across forests resulting from past activities and practices and natural disturbances are included in both the construction of the FMRL and the estimation of net FM emissions during the reporting period and therefore they cancel out.

Continuity with the treatment of FM in the first commitment period

This is not a relevant element for most approaches used to calculate the FMRL. For one Party, continuity with the treatment of FM in the first commitment period means that the same *narrow approach* with gross–net accounting will continue, and the FMRL was therefore 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 domestic policies adopted and implemented no later than December 2009 and to 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 does not include assumptions about changes to domestic policies adopted and implemented after December 2009. The aim of this information is also to document policies and assumptions included in the FMRL in relation to country-specific circumstances. A few Parties also clarified the effects of policies related to use of biomass as a renewable source included in the calculation of their FMRLs.

Parties proposing historical FMRLs based on 1990 emissions do not take into account policies and measures since that year.

2.7.5.2 METHODOLOGICAL CONSISTENCY BETWEEN FMRL AND REPORTING FOR FM DURING THE COMMITMENT PERIOD

According to Decision 2/CMP.7, when accounting for Forest Management, Parties *shall demonstrate methodological consistency between the* [FMRL][97]*and reporting for Forest Management during the second commitment period…* and *…shall make technical corrections, if necessary, to ensure consistency, including applying IPCC methods for ensuring time-series consistency...* This section discusses general issues and *good practice* guidance related to methodological consistency. Technical Corrections are addressed in the following section.

Consistency is a key principle in the estimation of GHG inventories. According to the *2006 IPCC Guidelines*, consistency means that an inventory should be internally consistent in all its elements over a period of years, i.e. it refers to the need for 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 GHG emissions during the whole period. Under certain circumstances[98] 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* (Chapter 5, Volume 1) and with *GPG-LULUCF* (Chapter 5).

Chapter 5, Volume 1 of the *2006 IPCC Guidelines* (Time series consistency) describes common situations in which time series consistency may not be achieved, including: 1) recalculations due to methodological changes and refinements and 2) adding new categories. A methodological change is a switch to a different tier (or to a different method, e.g. from *Stock-Difference* to *Gain-Loss*, or from an inventory-based to a process-based method) from the one previously used for reporting, often driven by the development of new and different data

[97] As inscribed in Appendix of Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1

[98] Referred to in paragraph 4(b) of Annex I to Decision 15/CP.17 contained in document FCCC/CP/2011/9/Add.2, p.27.

sets. A methodological refinement occurs when an inventory compiler uses the same tier to estimate emissions but applies it using a different data source, a different model version or a different level of aggregation. Both methodological changes and refinements over time are an essential part of improving inventory quality. The addition of new categories also includes the addition of new carbon pools and gases.

In the context of FMRL, methodological consistency refers to the need that during the commitment period consistency is ensured between the methodological elements used in the construction of FMRL and those used in the reporting of FM. To this end, it is *good practice* to consider all the specific elements highlighted in paragraphs 14 and 15 of the Annex to Decision 2/CMP.7. Specifically, the *methodological elements* include:

(i) the method used to establish the FMRL, as reported in the FMRL submission (only for approach 1 in Box 2.7.3: projected FMRL): models or average/extrapolation of historical time series;

(ii) the historical data[99] used to establish the FMRL, as reported in the FMRL submission: forest area, harvest, increment, age structure, forest characteristics and management, net emissions and related estimation parameters etc.;

(iii) other methodological elements used to establish the FMRL as reported in the FMRL submission, including: pools and gases, the treatment of HWP, the treatment of natural disturbances, climate and other ecological parameters used by models for projecting FMRL; and

(iv) elements newly introduced or modified by Decision 2/CMP.7 as compared to the text in Decision 2/CMP.6, including: the accounting HWP removed from areas under FM (see Section 2.3.8) and the possible exclusion of emissions associated with natural disturbances (see Section 2.3.9).

A change in methodological elements used in the construction of FMRL triggers a methodological inconsistency, to be addressed through a Technical Correction (see section 2.7.6.1).

By contrast, for projected FMRL only, a deviation in *policy assumptions under business-as-usual scenario* (as reported in the FMRL submission) from those assumed in constructing the FMRL does not represent a methodological inconsistency, and thus is not considered for Technical Correction. Specifically, policy assumptions under business-as-usual scenarios include economic assumptions or responses (e.g. harvesting decisions), and assumptions about future FM area, about future management of forest (including activities such as fertilization and planting), about forest characteristics, about harvesting rates (including variations in harvesting rates as compared to historical period) or amounts, and about production of HWP (including assumptions about the quantities of HWP produced in the major categories, i.e. sawn wood, panels, and paper). In the event of change in FM area during the commitment period (e.g. if the *narrow approach* to FM is used), it is *good practice* to document transparently that this is not a result of change in FM activity definition, but rather a result of newly implemented policies that were not included in the FMRL submission. During the commitment period, the country's chosen definitions of "forest" and "Forest Management" need to be consistently applied across the time series and need to be the same as the ones used for FMRL calculations.

A common situation of methodological inconsistency is change, after the FMRL has been set, of one or more of the methodological elements used in its construction. For instance, a methodological change (e.g. from *Stock-Difference* to *Gain-Loss*) or refinement (e.g. updated data or model parameters) may lead to recalculation of historical data used to establish FMRL, or treatment of HWP or natural disturbances may change in the commitment period as compared to the FMRL. These changes would introduce methodological inconsistencies. Other cases of inconsistency between the FMRL and reporting for FM 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 between reporting of FM during the second commitment period and the FMRL). For instance, given that harvest rate is generally the main driver of forest carbon balance in the short term, it is *good practice* to show that, e.g. 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 contributing to the difference. It increases transparency to provide in the annual inventory submission concise information to explain major drivers (e.g. harvesting rates) affecting the trend in net emissions under FM as compared to what was assumed in the FMRL. The aim of this information is to show that the estimates reported 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. In addition, it is *good practice* to show that model-

[99] Historical data refers to data for the time period used in the construction of the FMRL (including model parameters, emission factors, etc.)

based calculations used for constructing a projected FMRL reproduce the data for FM or *Forest Land Remaining Forest Land* for the historical period reported in the FMRL submission (i.e. for the period *not* affected by possible deviations from policy assumptions under the business-as-usual scenario). It is also *good practice* to provide documentation fulfilling the general criteria listed in Annex I of the *Use of Models and Facility-level Data in Greenhouse Gas Inventories: Report of the IPCC Expert Meeting on the Use of Models and Measurements in GHG Inventories* (IPCC, 2010d), 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.

According to Decision 2/CMP.7, a Party may choose not to account for a given pool in a commitment period (with the exception of HWP) if transparent and verifiable information is provided that demonstrates that the pool is not a source. However, 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 this pool is required to be reported and accounted for also during the commitment period, irrespective of the pool being a sink or a source.

2.7.6 Technical Corrections for accounting purposes

Estimation of the FMRL typically relies upon data inputs, assumptions, and models brought together in a consistent and transparent way. For accounting of FM, what counts is the difference in emissions and removals between the FMRL and the actual FM emissions and removals in the second commitment period. It is therefore important to ensure that the FMRL and reporting of FM during the commitment period are as methodologically consistent as possible (see Section 2.7.5.2).

If the reported data on FM 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 FM reporting during the commitment period, to ensure consistency, Parties are required[100] to apply a Technical Correction. The Technical Correction removes the impact of any methodological inconsistency when accounting and thus ensures methodological consistency between the FMRL and the reporting of FM during the commitment period.

The Technical Correction is essentially a net value of emissions and removals, 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, as expressed in Equation 2.7.1 (in Mt CO_2eq yr^{-1}):

EQUATION 2.7.1
TECHNICAL CORRECTION

$$Technical\_Correction = FMRL_{corr} - FMRL$$

Where:

FMRL = Forest Management Reference Level inscribed in Appendix to 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, when 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 that is not affected by any methodological inconsistencies.

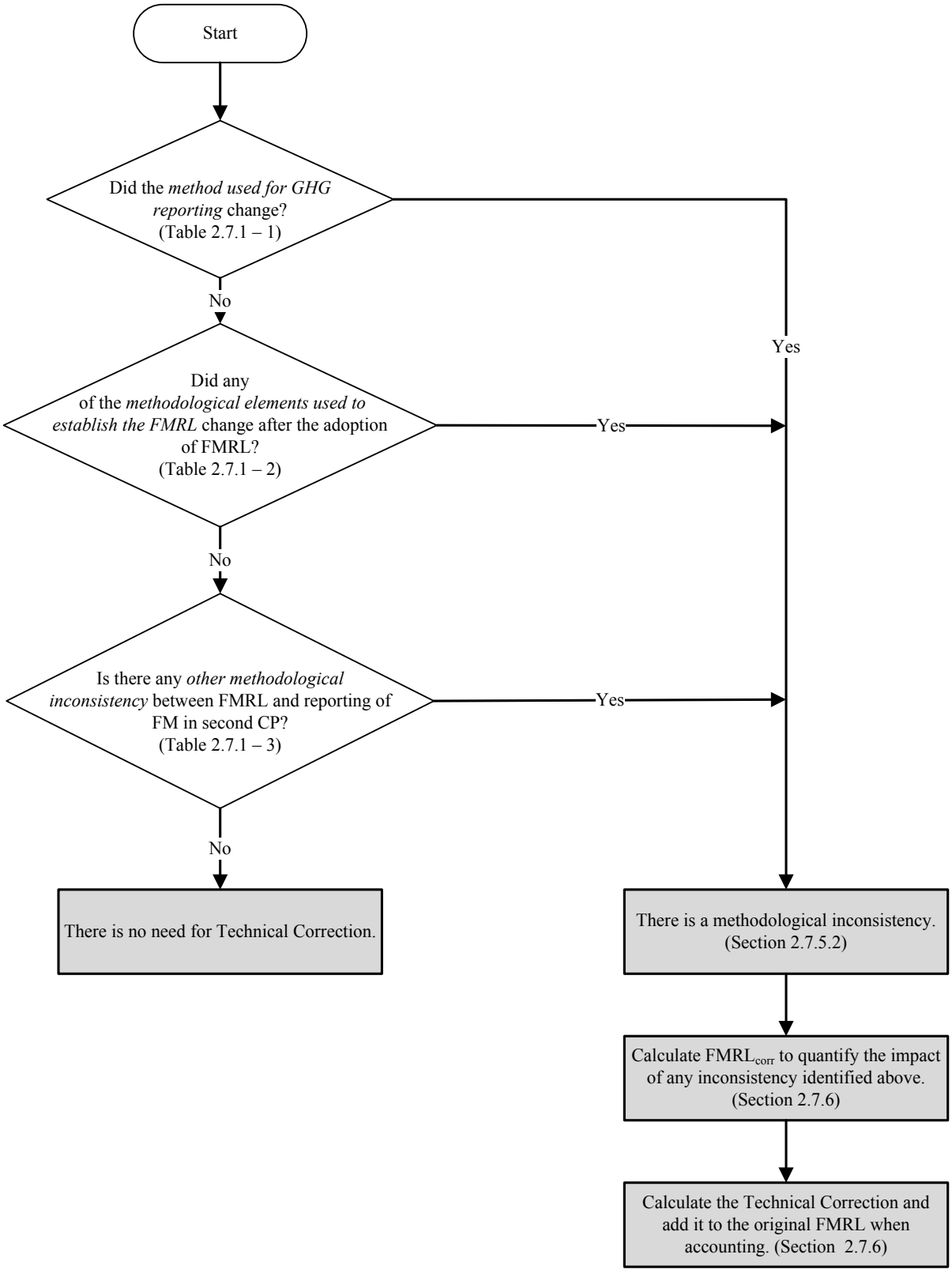
This section describes how to detect the need for Technical Correction, how to calculate $FMRL_{corr}$, and when to apply the Technical Correction.

2.7.6.1 HOW TO DETECT THE NEED FOR TECHNICAL CORRECTIONS

Figure 2.7.3 provides a general decision tree on how to identify the need for Technical Correction. Table 2.7.1 provides specific criteria and elements to be checked to detect possible methodological inconsistencies and the consequent need for Technical Correction.

[100] Paragraphs 14 and 15 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1, p.15.

Figure 2.7.3 Decision tree for identifying methodological inconsistencies and the need for Technical Correction during the second commitment period.



The need for Technical Correction may arise only if at least one of the following conditions is met (see Table 2.7.1 for a full list of criteria and elements to be checked, and examples in Box 2.7.4):

1. The *method used for GHG reporting* changed after the adoption of FMRL, or errors in the methods have been identified, as part of improving inventory quality. For instance, 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 are making it feasible to estimate historic emissions from land clearing activities more accurately than by using simple aggregate emission factors 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.

   This change will lead to a recalculated time series that might also lead to an inconsistency between FMRL and reporting of FM in the second commitment period.

2. Any of the following *methodological elements used to establish the FMRL* (as reported in the FMRL submission) changed after the adoption of FMRL:

   (i) New carbon pools or non-CO_2 GHG sources are included in reporting for FM in the second commitment period. For instance, if a pool that was not a source and therefore not reported earlier (and also not included in the FMRL) becomes a source in future, it is *good practice* to include this pool in the reporting of FM, applying a Technical Correction.

   (ii) Recalculated historical data. For example, forest inventory data may be compiled only once in a five- or ten-year period. In the event that recalculated historical 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, and these new data are used in GHG reporting in the second commitment period, a Technical Correction would allow the inclusion of such new information in the $FMRL_{corr.}$

   In the case of FMRLs based only on elaboration of historical data from GHG inventories (average of past data, linear extrapolation) or FMRLs based on the single year 1990, any recalculation of the time series used to establish the FMRL will trigger a Technical Correction.

   (iii) In the event that the FMRL was constructed using models that are responsive to climate variability, if climate data observed during the commitment period is different from that assumed by the models used to construct FMRL, then a Technical Correction would allow application of actual climate data to the models (see also Section 2.3.5 on interannual variability).

   (iv) Treatment of elements newly introduced or modified by Decision 2/CMP.7:

   - The accounting of HWP as agreed in Decision 2/CMP.7: since FMRLs were submitted before Decision 2/CMP.7, a Technical Correction related to HWP is expected to be a common case.

   - The application of natural disturbances provision in Decision 2/CMP.7: since FMRLs were submitted before Decision 2/CMP.7, they may be inconsistent with the agreed provisions, including those specifying that the expectation of neither credits nor debits is to arise from application of the disturbance provisions. For instance, if the background level as established by the Party requires exclusion of emissions from the projected FMRL (either due to the background level and margin selected, or because the emissions are outliers), it is *good practice* to remove these emissions, to calculate $FMRL_{corr}$ and to apply a Technical Correction. Using the methods set out in Section 2.3.9 (on natural disturbances), it is *good practice* that the Parties provide information in NIRs on how the Technical Correction for changes in the treatment of emissions from natural disturbances was calculated.

3. *Other kinds of methodological inconsistency*. For example, if a model used for constructing a projected FMRL does not reproduce the data for the historical period reported in the FMRL submission for FM or *Forest Land remaining Forest Land*, this is a sign of likely inconsistency. In this case, it is *good practice* either to provide additional evidence demonstrating consistency or to apply a Technical Correction.

TABLE 2.7.1
CHECK LIST TO DETECT METHODOLOGICAL INCONSISTENCIES AND THE NEED FOR TECHNICAL CORRECTION

Criteria		Comment /action
1 The *method used for GHG reporting* of FM or *Forest Land remaining Forest Land* (FL-FL) changed after the adoption of FMRL		Calculate $FMRL_{corr}$ ensuring consistency between reported FM and FMRL (see examples in Box 2.7.4)
2. Any of the following *methodological elements used to establish the FMRL* (as reported in the FMRL submission) changed after the adoption of FMRL		
Element	**Addition to or modification in the GHG inventory**	
a) Pools and gases	New pools or gases[101]	Calculate $FMRL_{corr}$ by including new pools or gases
b) Area under FM	Recalculated historical data* on area	Calculate $FMRL_{corr}$ using recalculated area
c) Historical data from GHG inventory	Recalculated historical data* for FL-FL or FM.	Calculate $FMRL_{corr}$ using recalculated data
d) Forest characteristics and related management[102]	Recalculated historical data*	Calculate $FMRL_{corr}$ using recalculated data and information
e) Historical harvesting rates	Recalculated historical data*	Calculate $FMRL_{corr}$ using recalculated harvesting rates
f) Climate data assumed by models for projecting FMRL	Different observed climate data as compared to what was assumed in the FMRL	Calculate $FMRL_{corr}$ by applying actual climate data to the models (see Section 2.3.5)
g) HWP	New/recalculated data and/or methods; inclusion of provisions	Calculate $FMRL_{corr}$ by applying new data and/or methods or provisions
h) Natural disturbances	New/recalculated data (Section 2.3.9.6, Step 2) and/or method; inclusion of submitted (in 2015) or revised (later) background level and margin with assumptions inconsistent with those of the FMRL (Section 2.3.9.6, Step 5)	Calculate $FMRL_{corr}$ by applying new data and/or method s or provisions
3. *Other possible methodological inconsistencies*, e.g. the FMRL model's outputs are not capable of reproducing the historical data* reported for FM or FL-FL		If needed, calculate $FMRL_{corr}$, e.g. by applying IPCC methods to ensure time-series consistency

* For each of the methodological elements, "historical data" refers to data for the time period used in the construction of the FMRL (including model parameters, emission factors, etc.).

For projected FMRLs, deviations from *policy assumptions under business-as-usual scenarios*, including economic assumptions or responses (e.g. harvesting decisions), and assumptions about future FM area, about future management of forest, about forest characteristics, about harvesting rates or amounts, and about production of HWP (including assumptions about the quantities of HWP produced in the major categories) do not affect methodological consistency and thus are *not* considered for Technical Corrections (see Section 2.7.5.2).

Under Decision 2/CMP.7[103], Parties may account for emissions by sources and removals by sinks resulting from the harvest and conversion of a forest plantation to non-forest land under FM, provided that a forest of at least the same area and carbon stock potential is established on non-forest land, and provided that all other requirements are satisfied (CEFC, see Section 2.7.7). Given that emissions and removals from plantation harvesting and replanting or equivalent forest establishment are already included in the FMRL, and that the effects of implementing CEFC will be accounted for against the FMRL (see Section 2.7.7), the decision to apply the CEFC provision does not in itself trigger a Technical Correction. A methodological inconsistency between reporting of FM in the second commitment period and the FMRL included in the Annex to Decision 2/CMP.7 (including methods to estimate emissions and removals from lands subject to the CEFC provision) will trigger a Technical Correction.

[101] Note that, when accounting, it is not possible to exclude a pool or gas already included in the FMRL.
[102] This includes, among others age-class structure, increment, species composition, rotation lengths, management practices, etc.
[103] Paragraphs 37-39 of Decision 2/CMP.7 (Land use, land-use change and forestry), contained in document FCCC/KP/CMP/2011/10/Add.1, p.19.

BOX 2.7.4
EXAMPLES OF CASES WHICH MAY LEAD TO METHODOLOGICAL INCONSISTENCY BETWEEN FMRL AND REPORTING OF FM DURING THE SECOND COMMITMENT PERIOD.

Case 1:

At the time of FMRL submission:

-The GHG inventory used *Stock-Difference* or *Gain-Loss* method (i.e. not a model).

-The FMRL was constructed using model X.

Can this country apply a different method in GHG reporting during the second commitment period?

Yes, but this will create a methodological inconsistency, which triggers a Technical Correction process.

Can this country apply model X (same version used for FMRL) in GHG reporting?

Yes, this will ensure consistency between the methods used for FMRL and FM reporting. However, it is always *good practice* to check the need for Technical Correction (Figure 2.7.3).

Can this country apply a new model Y (or a new version of model X) in GHG reporting?
Yes, but this will create a methodological inconsistency, which needs to be addressed through the Technical Correction process. In this case, a possible way to address the inconsistency is using the new model Y (or a new version of the model X) also for calculating $FMRL_{corr}$ as part of the Technical Correction process.

Case 2:

At the time of FMRL submission:

- The GHG inventory used model X.

- FMRL was constructed using model X.

Can this country use a new model Y (or a new version of model X) in GHG reporting?

Yes, but this will create a methodological inconsistency, which may be addressed by using the new model Y (or new version of the model X) also for calculating $FMRL_{corr}$ as part of the Technical Correction process.

Case 3:

At the time of FMRL submission:

- The GHG inventory used data from NFIs representing the years 1995 and 2005.
- FMRL was modelled using historical input data for the period 2000-2009, where data for 2000-2005 were based on the two NFIs and those for 2006-2009 were extrapolated using existing NFI data.

In 2012, a new NFI was finalised resulting in recalculation of data for the period 2006-2009. This triggers a recalculation of the GHG inventory, and consequently a Technical Correction has to be applied. The new time series for 2000-2009 including historical data for 2000-2005 and recalculated historical data for 2006-2009 are used for calculating $FMRL_{corr}$. The same approach would apply in the case where, at the time of FMRL submission, the GHG inventory and the FMRL used preliminary data from an on-going NFI (e.g. to be completed after the FMRL submission). In this case, when the NFI is completed, the historical data used in FMRL construction are recalculated and consequently a Technical Correction has to be applied using the recalculated historical data for calculating $FMRL_{corr}$. In both cases, only the data representing the same years as the data used to calculate the initial FMRL shall be used to calculate $FMRL_{corr}$.

Case 4:

At the time of FMRL submission, the FMRL submission included emissions from natural disturbances. In the 2015 NIR, the background level (and the margin if relevant, see Section 2.3.9) were set to zero. In this case, it is *good practice* for zero emissions to be factored in the FMRL and for all emissions from natural disturbances to be excluded. This requires a Technical Correction to the FMRL.

2.7.6.2 HOW TO PERFORM AND DOCUMENT THE CALCULATION OF $FMRL_{CORR}$

If the need for Technical Correction is determined, it is *good practice* to calculate $FMRL_{corr}$. Several methods may be considered to address methodological inconsistencies and to calculate $FMRL_{corr}$, depending on the approach used to construct FMRL, the cause of the inconsistency, and the data that are available to perform the recalculations. Irrespective of the method used, it is *good practice* to provide information that the method used

avoids the expectation of net credits and net debits linked to any methodological inconsistency between $FMRL_{corr}$ and reporting for FM during the commitment period.

In the case of projected FMRLs, $FMRL_{corr}$ may be calculated by, *inter alia*, a new model-based 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 policy assumptions under the business-as-usual scenario (as reported in the FMRL submission) unchanged. It is also *good practice* to show that the new model-based calculations used for constructing $FMRL_{corr}$ are capable of reproducing the data for FM or *Forest Land Remaining Forest Land* for the historical period reported in the FMRL submission (i.e. for the period not affected by possible deviations from policy assumptions under the business-as-usual scenario), or to provide any explanation if this is not the case.

If the need for a Technical Correction due to a methodological inconsistency has been identified, but a new model run cannot be performed, time-series consistency can be ensured by using one of the methods described in the *2006 IPCC Guidelines*, including overlap between model results and data for FM 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.

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, it is *good practice* to use the same period for $FMRL_{corr}$ in case a recalculation of historical time series occurs. This is because, for the FMRL submission, the period selected was assumed as a proxy for a business-as-usual scenario, and changing the period would mean changing the policy assumptions. 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 $FMRL_{corr}$.

Irrespective of the method applied to calculate $FMRL_{corr}$, it is *good practice* to complement any Technical Correction with transparent information on:

- the rationale for calculating $FMRL_{corr}$ (description of which criteria in Table 2.7.1 have been met);
- the methods used to calculate $FMRL_{corr}$; in case a model is used, it is *good practice* to document the implementation of the model following the criteria listed in Annex I of IPCC (2010d); and
- results (i.e. the $FMRL_{corr}$) and discussion of the differences between $FMRL_{corr}$ and FMRL; for this purpose, it is *good practice* to report a comparison of recalculated estimates with previous estimates, e.g. as shown in Table 2.7.2 and if possible also as a graphical plot showing the temporal dynamics of the estimates underlying $FMRL_{corr}$ and FMRL.

TABLE 2.7.2
EXAMPLE OF SUMMARY TABLE WHEN PERFORMING A TECHNICAL CORRECTION FOR A SINGLE YEAR

	Emissions and removals
FMRL	-10,000 [Gg yr^{-1}]
$FMRL_{corr}$	-10,500 [Gg yr^{-1}]
Difference in per cent =100●[($FMRL_{corr}$ – FMRL)/FMRL] %	5%
Technical Correction= $FMRL_{corr}$ – FMRL	-500 [Gg yr^{-1}]
FM reported during the commitment period	-12,000 [Gg yr^{-1}]
Accounting Parameter = reported FM – (FMRL + Technical Correction)	-1,500 [Gg yr^{-1}]

2.7.6.3 WHEN TO APPLY A TECHNICAL CORRECTION

According to Decision 2/CMP.7[104], Technical Correction shall be applied when accounting.

Information on technical corrections and methodological consistency shall be reported as part of annual GHG inventories and inventory reports. To this aim, it is *good practice* for Parties to assess annually the need for Technical Correction (Figure 2.7.3), i.e. checking the criteria set in Table 2.7.1, and to report transparent information on this in the annual NIR.

[104] Paragraph 14 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry) contained in document FCCC/KP/CMP/2011/10/Add.1.

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 under FM, provided that certain requirements are met. The main requirement is that a new forest of at least equal area and carbon stock potential (including soil carbon) is created on non-forest land. Carbon Equivalent Forest Conversion (CEFC) is the practice of converting a forest plantation to non-forest land while establishing a "Carbon Equivalent Forest" on non-forest land elsewhere.

CEFC requires two land components – the existing forest land to be harvested and converted to non-forest land (CEF-hc) and the non-forest land on which a forest is to be newly established (CEF-ne). Both components shall meet the criteria for CEFC set out in Decision 2/CMP.7[105] in order to be accounted for under FM. The forest cleared is required to be a forest plantation as defined in Annex 4A.1 of the *2006 IPCC Guidelines*, and both this and the new forest established have to meet the definition of forest as selected by the Party and used for reporting other FM lands. It is *good practice* for Parties to provide, according to their national circumstances, the definition of forest plantation that is used in the application of the CEFC provision. This definition needs to be consistent throughout the time series and the inventory.

Decision trees for categorising forest harvest and conversion (Figure 2.6.1) and forest establishment (Figure 2.5.1) are provided in Sections 2.5 (Afforestation and Reforestation) and 2.6 (Deforestation), respectively. Criteria for eligibility under the CEFC provision are described in Section 2.7.7.2.

In accordance with Decision 2/CMP.7 *all lands and associated carbon pools subject to the CEFC provision shall be identified, monitored and reported, including the georeferenced location and year of conversion.* Accounting for FM lands is with respect to the FMRL, so pools need to be consistent with the pools included within the FMRL, including HWP. Section 2.2 (Generic methodologies for area identification, stratification and reporting) describes two Reporting Methods that can be used to define and report the geographical location of land areas subject to FM activities. Reporting Method 1 can only meet the CEFC reporting requirements if additional, georeferenced information about specific land areas within the geographic boundaries is provided. This additional information could be reported using a time series of maps or data sets containing the georeferenced information about the location of these lands. The year of conversion will be between 1 January 2013 and the end of the last inventory year. For practical reasons harvesting, conversion to a non-forest land use and new forest establishment may occur in different years within the commitment period. The year of CEFC conversion is taken as the year in which land-use change on CEF-hc land is confirmed or the year in which new forest is established on CEF-ne land, whichever is earliest within the commitment period.

It is *good practice* for the Party to also provide:

- the area of lands subject to CEFC activity in each productivity class and species combination (where relevant) to support the calculation of carbon stock changes and non-CO_2 GHG emissions;
- documentation that demonstrates the relationship between forest land harvested and converted and the corresponding land established in forest under the CEFC provision;
- the normal harvesting cycle (in years) and the carbon stock at the time of harvest of each unit of CEF-hc land; if the FMRL is based on a business as usual projection then it is *good practice* that the normal harvesting cycle is used as it was assumed in the FMRL; and
- information to demonstrate that the new forest established has the potential to reach a carbon stock no less than the stock that was contained in the harvested forest plantation it replaces at the time of harvest, within the normal harvesting cycle of the harvested forest plantation.

The carbon stock at harvest and the normal harvesting cycle of the forest plantation harvested and converted provide the targets for the new forest established on CEF-ne land. It is *good practice* to monitor progress of the CEF-ne land towards achieving carbon equivalence by reporting the current area, age and estimated carbon stock in each inventory year. This needs to be reported until the carbon stock in the original forest plantation has been met or exceeded.

[105] Paragraphs 37-39 of Annex to Decision 2/CMP.7 (Land use, land-use change and forestry), contained in document FCCC/KP/CMP/2011/10/Add.1, p.19.

2.7.7.2 CHOICE OF METHODS FOR IDENTIFYING LANDS SUBJECT TO CARBON EQUIVALENT FOREST CONVERSION

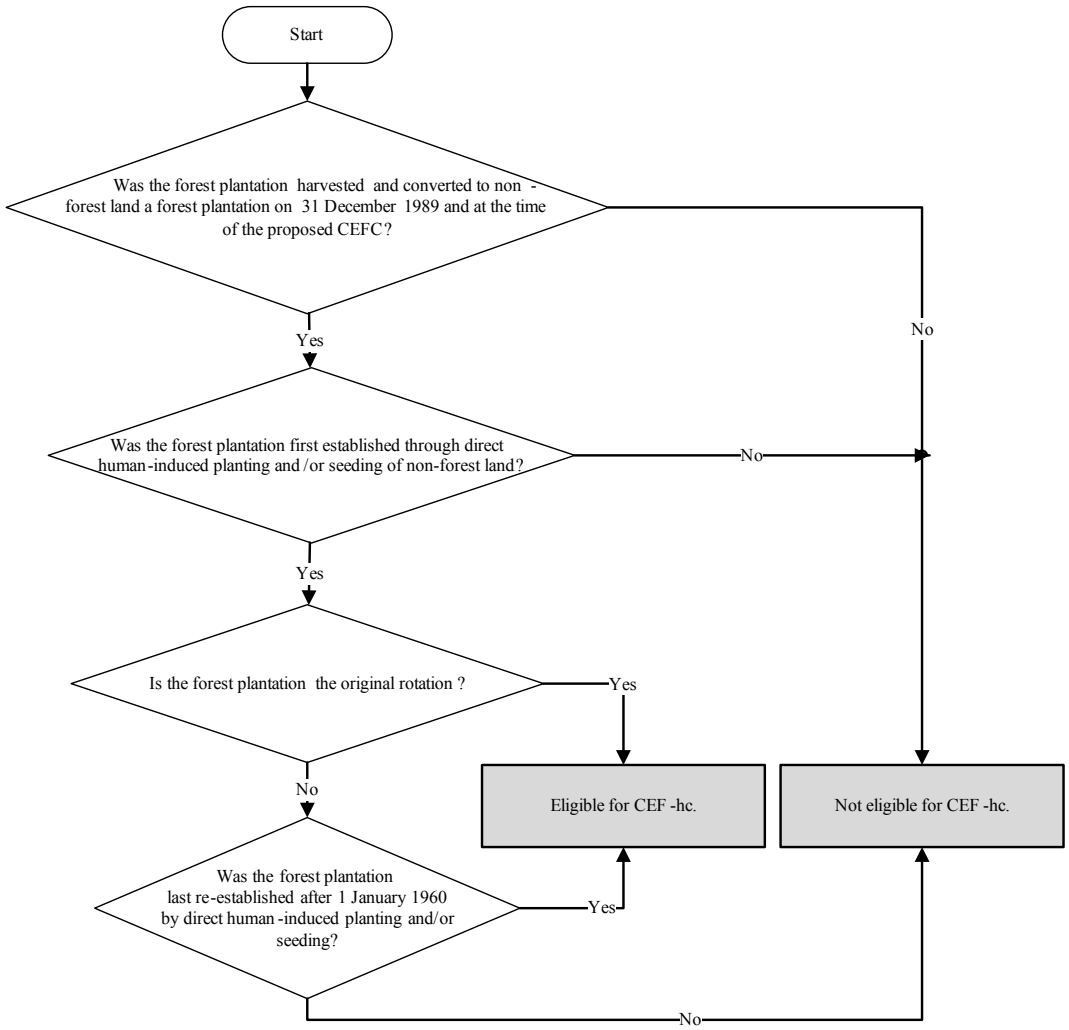
For eligibility under the CEFC provision, conditions apply to both the land converted from forest plantation to non-forest (CEF-hc) land and the corresponding land converted from non-forest to forest (CEF-ne land). The requirements of Decision 2/CMP.7 for a forest plantation to be harvested and converted under the CEFC provisions (CEF-hc) are as follows:

- The forest plantation meets the requirements for the country's definition of forest as well as their specific definition of forest plantation at the time of conversion.
- The forest plantation existed on 31 December 1989.
- The forest plantation had been first established by direct human-induced planting and/or seeding.
- The forest plantation had first been established on non-forest land. If this non-forest land was previously forested (that is to say it had been converted from forest to another land use), it is *good practice* to apply the same criteria as those used to distinguish D from harvesting or forest disturbance that is followed by the re-establishment of a forest (see Section 2.6.2.1). For example, if normal practice in a country is to re-establish forests within three years after harvesting, then a forest plantation that was first established on land that had remained non-forest for more than three years would normally be eligible under the CEFC provision.
- The forest plantation is still the original forest first established on non-forest land before 1 January 1990, or, if re-established after harvesting, this last occurred through direct human-induced planting and/or seeding after 1 January 1960.

It is *good practice* to apply the methods described in Section 2.6.2 for identifying lands subject to direct human-induced D to also identify lands cleared of forest which may be accounted for under the CEFC provision, since only land that would otherwise qualify as D land will qualify as CEF-hc 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 2.7.4.

Figure 2.7.4 Decision tree for determining the eligibility of land to be harvested and converted to non-forest under CEFC provision (CEF-hc land)



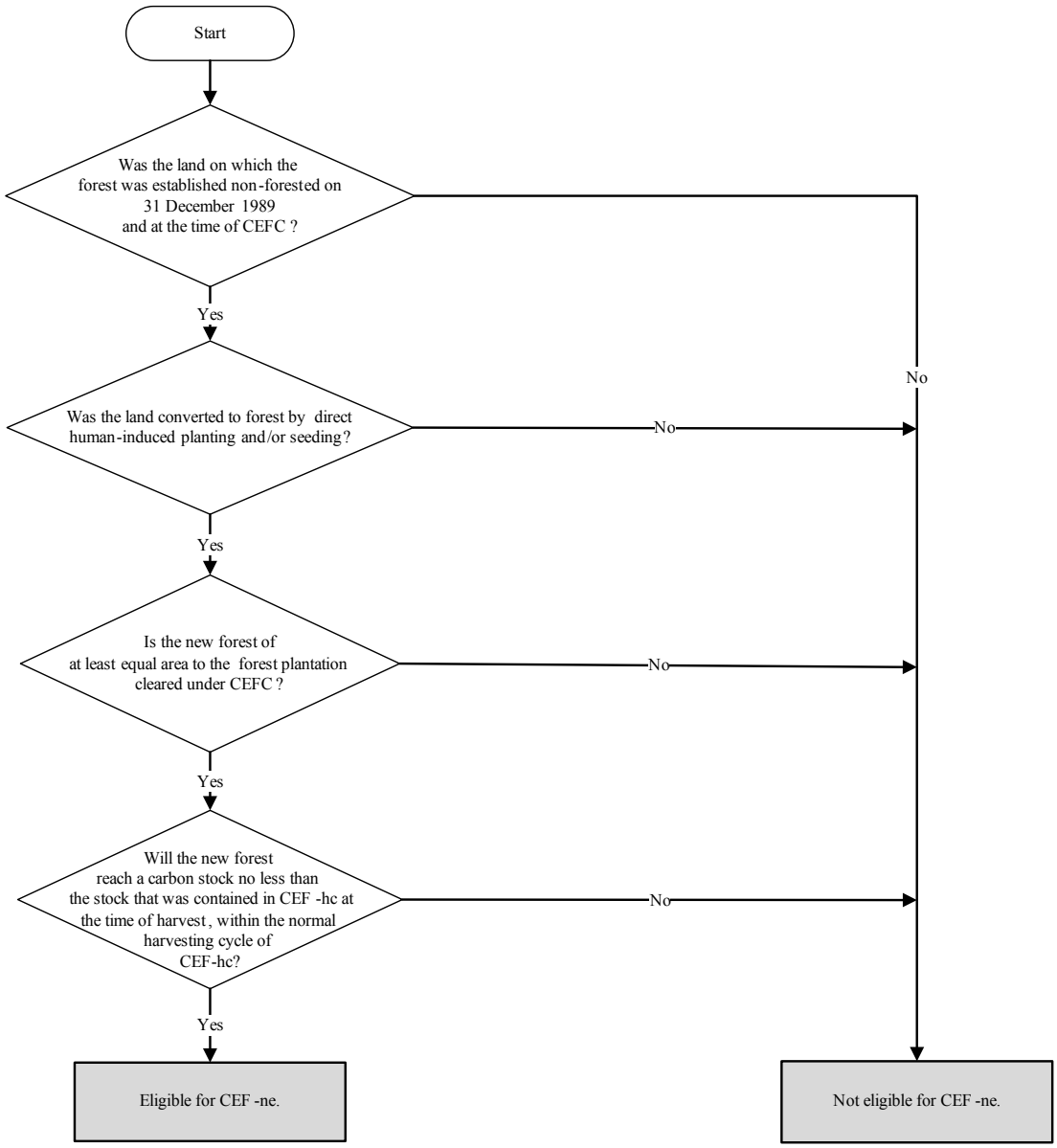
The requirements of Decision 2/CMP.7 for forest land established under the CEFC provision (CEF-ne land) are as follows:

- The land did not contain forest at the time of conversion.
- The land did not contain forest on 31 December 1989.
- The land has been converted to forest land through direct human-induced planting and/or seeding.
- The forest established is at least equal in area to the forest plantation converted to non-forest.
- The forest established is shown to have the potential to reach a carbon stock no less than the stock that was contained in the harvested forest plantation it replaces at the time of harvest, within the normal harvesting cycle of the harvested forest plantation.

It is *good practice* to apply the methods described in Section 2.5.2 for identifying lands subject to direct human-induced AR, also for identifying lands established in forest which may be accounted for under the CEFC provision, since only land that would otherwise qualify as AR land will qualify as CEF-ne 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 2.7.5.

Figure 2.7.5 Decision tree for determining eligibility of land to be established in forest plantation under CEFC provision (CEF-ne land)



All lands and associated carbon pools subject to the CEFC provision should be accounted under FM. This includes any HWP resulting from the conversion of forest to non-forest land under the CEFC provision.

It is *good practice* to provide documentation that the CEF-ne lands identified are forests established by direct human-induced planting and/or seeding.

DISCRIMINATING BETWEEN ARD LAND AND CARBON EQUIVALENT FOREST CONVERSION LAND

Both CEF-hc and CEF-ne lands are reported as part of FM lands from the time of conversion, and any double-counting with AR and D land needs to be avoided. Documentation should be provided to demonstrate that all the requirements for the CEFC provision have been met and that there is no double-counting of emissions or removals.

If CEF-ne land is deforested during the commitment period before reaching the country-specific thresholds for defining forest, both this and associated CEF-hc land need to be reclassified under D. Emissions associated with harvesting and conversion of the CEF-hc land should be included under D. Any removals occurring on CEF-ne land before the deforestation event should be accounted for under AR. If D of CEF-ne land takes place after the forest thresholds are reached, only the CEF-ne land needs to be classified as D land.

DISCRIMINATING BETWEEN CM, GM AND RV LAND AND CARBON EQUIVALENT FOREST CONVERSION LAND

It is a requirement under Decision 2/CMP.7 that areas subject to the CEFC provision are reported under FM that has priority over elected activities under Article 3.4 (see Section 1.2). This means that there may be lands that are subject to elective Article 3.4 activities (e.g. CM) but are reported under FM. It is *good practice* to identify and report these lands separately from other FM lands. Methodologies appropriate to the actual land use can be applied to ensure that emissions and removals are neither under- nor over-estimated. It is *good practice* to provide documentation to show how double counting of emissions and removals has been avoided.

2.7.7.3 CHOICE OF METHODS FOR ESTIMATING CARBON STOCK CHANGES AND NON-CO_2 GHG EMISSIONS

It is *good practice* to apply the same methods for estimating carbon stock changes and non-CO_2 GHG emissions on CEF-ne lands as are applied on AR lands, described in Section 2.5.3. Estimation and reporting for these lands begin from the year of conversion, which may be before the new forest is established but in any event will be within the commitment period. Methods that apply for harvesting on FM lands are appropriate for CEF-hc lands, because stock changes will be captured in all pools, including HWP. In both cases, it is *good practice* to use the same or a higher tier. In addition, forest land converted to non-forest under the CEFC provision may be subject to management that results in carbon stock changes and non-CO_2 GHG 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 removals by applying the methods for the appropriate land use (e.g. Cropland or Grassland) found in the *2006 IPCC Guidelines*.

Accounting for FM is based on the reference level approach (FMRL), as described in Section 2.7.5. The basis for determining accounting credits or debits in the commitment period is a comparison of actual emissions and removals in FM, including any emissions and removals in CEF-hc and CEF-ne lands combined, with the FMRL.

If forest land established under the CEFC provision is affected by natural disturbance, 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 provisions apply to emissions from forests and therefore cannot be used for natural disturbances affecting non-forest CEF-hc land even though these lands are accounted for under FM.

2.8 HARVESTED WOOD PRODUCTS (HWP)

Section 2.8 provides *good practice* guidance for estimating annual changes in carbon stocks and associated CO_2 emissions and removals from the Harvested Wood Products (HWP) pool (hereinafter referred to as the *HWP contribution*) to be reported and accounted for in accordance with Decision 2/CMP.7 and 2/CMP.8.[106] It provides guidance for selecting adequate data and methods consistent with the system boundaries of the accounting approach defined in the Decision.

Various approaches have been proposed for estimating and reporting the *HWP contribution*. They differ in the reference to the atmosphere and the treatment of HWP trade, due to different interpretations of some key terms that are relevant for the reporting framework (Winjum *et al.,* 1998, Cowie *et al.,* 2006). This situation is reflected in Chapter 12, Volume 4 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, Chapter 12, Volume 4 of the *2006 IPCC Guidelines*).

One of the implications of Decision 2/CMP.7 is that accounting of HWP is confined to products in use where the wood was derived from domestic harvest, i.e. trees harvested in the reporting country.[107] In principle, this is similar to basing estimates of the *HWP contribution* on changes in the pool (i.e. stock-changes) reflected by variable 2A in Table 12.1, Chapter 12, Volume 4 of the *2006 IPCC Guidelines*, however Decision 2/CMP.7 imposes some additional constraints and limits the extent of HWP which can be included in the estimates.

2.8.1 Initial steps to estimate the HWP contribution

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 below.

STEP 1: Check the construction of the forest management reference level (FMRL) and the availability of transparent and verifiable activity data on HWP

According to Decision 2/CMP.7 Parties are required to 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 are available for the three HWP categories, sawn wood, wood panels and paper.[108] In the case that the country's FMRL is based on a projection, accounting shall be on the basis of the change in the HWP pool (i.e. Tier 2 or 3 methods).[109] In order to meet the requirements of Decision 2/CMP.7 countries should:

STEP 1.1: Check whether the FMRL has been based on a projection (see 2.7.5). If this is the case, skip the next steps and go to STEP 1.4.

STEP 1.2: Check databases of international organizations, such as the public database of the Food and Agriculture Organization of the United Nations (FAO)[110] for the availability of production and trade statistics on the HWP categories defined in Decision 2/CMP.7. Detailed guidance is given in Section 2.8.1.1.

STEP 1.3: 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. In the case that data from STEP 1.2 and/or 1.3 are available go to STEP 1.4, otherwise apply Tier 1 (Section 2.8.2).

STEP 1.4: Ensure that HWP data represent information on the material use of wood (products in service) in order to exclude the HWP used for energy purposes and HWP in solid waste disposal sites (SWDS)[111] and cross-check the information with guidance given in Sections 2.8.1.1 and 2.8.4.1. If activity data represent information on material use of HWP in service go to STEP 2, otherwise apply Tier 1 (Section 2.8.2).

[106] References to paragraphs in this chapter refer to the Annex of Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, unless indicated otherwise

[107] Paragraph 27

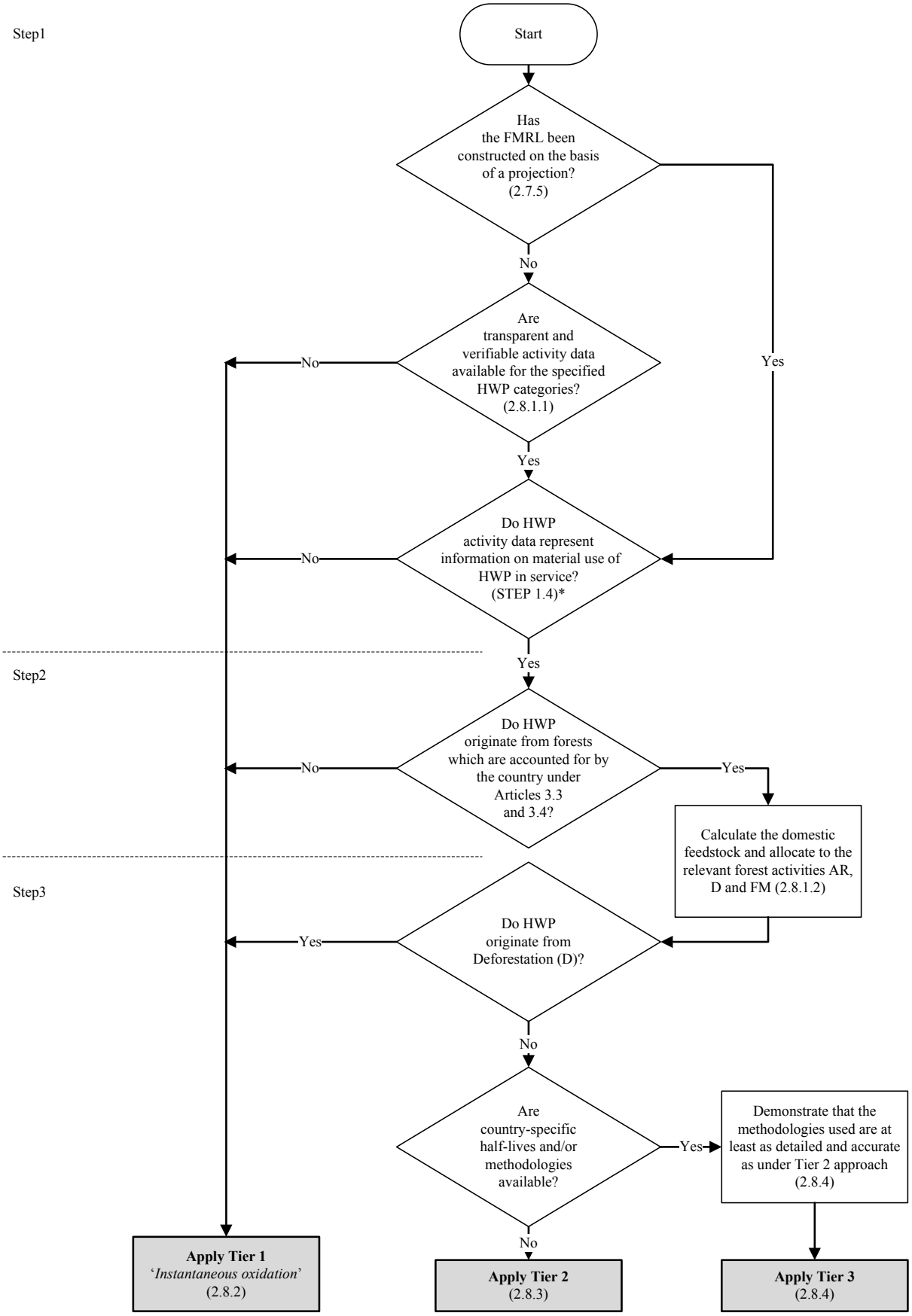
[108] Paragraph 29

[109] Paragraph 16

[110] http://faostat.fao.org/site/630/Default.aspx

[111] Paragraph 32

Figure 2.8.1 Decision tree for selection of a correct tier method for estimating HWP carbon stock change



*This only applies to cases especially mentioned in STEP 1.4, i.e. "HWP used for energy purposes and HWP in solid waste disposal sites".

STEP 2: Check whether HWP categories originate from forests that are accounted for by the country and allocate HWP to the particular forest related activity

Decision 2/CMP.7 limits the mandatory accounting to HWP originating from domestic forests which are accounted for under Article 3, paragraphs 3 and 4. Imported HWP, irrespective of their origin, are excluded[112]. Figure 2.8.1 shows that Decision 2/CMP.7 specifies the methods to be used for the estimation of the *HWP contribution* depending on the land of origin of HWP.[113]

Detailed guidance on how to implement all the following steps is given in Section 2.8.1.2.

STEP 2.1: Estimate the share of HWP originating from forests within the country. The default assumption is that domestically consumed industrial roundwood represents the domestic production feedstock for the subsequent processing of the semi-finished product categories sawnwood and wood panels. Domestically consumed wood pulp is the feedstock for paper production.

STEP 2.2: Estimate the share of HWP originating from Afforestation (A), Reforestation (R) and Deforestation (D) 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 amount of HWP entering the accounting framework (i.e. activity data) is obtained by combining the information from STEPS 2.1 and 2.2 with the annual production of the HWP commodity categories obtained from STEP 1.

STEP 3: Check the availability of country-specific information and estimate carbon stock in HWP and its annual change

Depending on the results of STEPS 1 and 2, and on the availability of country-specific half-lives and/or country-specific methodologies, the estimation of the *HWP contribution* follows different tier methods.

Tier 1 method specifies the assumption of instantaneous oxidation and is to be used under certain circumstances and for specific parts of the HWP pool as explained further down below. 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 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. In order to choose the appropriate tier method, please follow all the steps presented below.

STEP 3.1: In case HWP originate from Deforestation (D) 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 the country following the guidance given in Section 2.8.4.1. If this is the case, allocate HWP activity data in line with STEP 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 their 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 the country is unable to apply 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. Guidance on Tier 2 is given in Section 2.8.3.

2.8.1.1 AVAILABILITY OF TRANSPARENT AND VERIFIABLE ACTIVITY DATA

A prerequisite for Parties when accounting for HWP on the basis of the change in the HWP pool is the availability of "*transparent and verifiable activity data*" for the three specified HWP categories "*paper,* […]

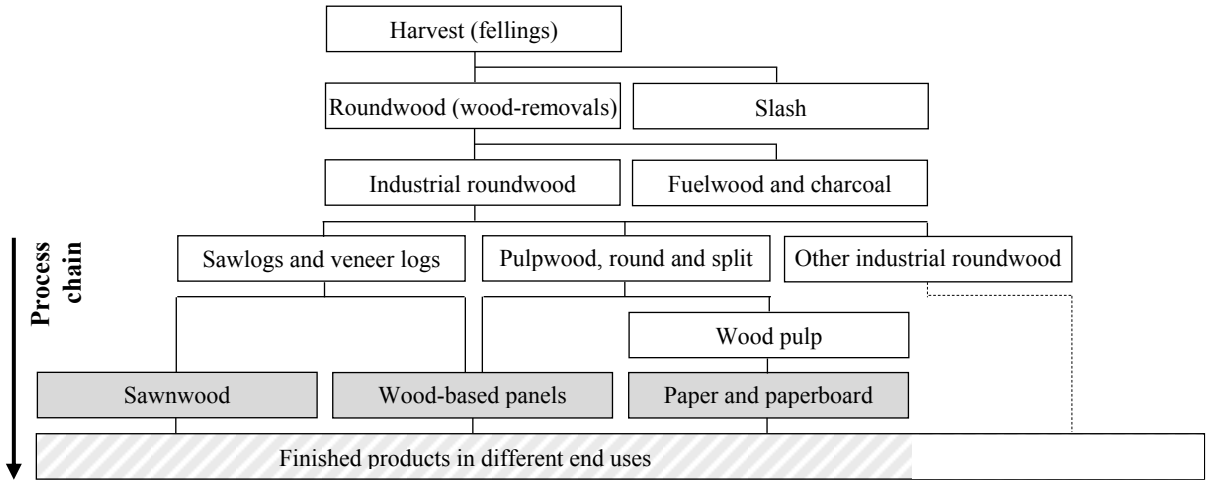
[112] Paragraph 27

[113] Paragraphs 28, 29, 31 and 32

wood panels, and […] *sawnwood*" (see STEP 1).[114] This section provides 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, UNFCCC Secretariat 2003), the categories named in Decision 2/CMP.7 refer to the definitions of semi-finished wood products of the international classification system of forest products.[115] It is thus *good practice* to assume that the three HWP categories named in Decision 2/CMP.7 accord with these commodities. Other terms commonly used include "removals" (i.e. roundwood) are a subset of "forest harvesting" of biomass (i.e. fellings) at the beginning of the forest-wood chain (see definitions below). Following the forest products definitions of the FAO, Figure 2.8.2 furthermore shows the relevance of the aggregate commodity "industrial 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 forest products can be related to the Harmonized Commodity Description and Coding System (HS) of tariff nomenclature provided by the World Customs Organization (WCO).[116]

Figure 2.8.2 Simplified classification of wood products based on FAO forest products definitions



Definitions of semi-finished product commodities, which are relevant for the application of the guidance on estimating the *HWP contribution* in line with Decision 2/CMP.7, are listed below (cf. Figure 2.8.2). They are drawn from the definitions of the Joint Forest Sector Questionnaire (JFSQ) as established by the Intersecretariat Working Group on Forest Sector Statistics[117] and form the basis for the forest products statistics e.g. provided by FAO. The JFSQ also includes conversion factors to be used for converting e.g. from nominal to solid volume in the compilation of statistics if required.[115] 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.[118]

SAWNWOOD (Decision 2/CMP.7 refers to this as "sawn wood")**:** "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."[115]

[114] Paragraph 29

[115] http://www.fao.org/forestry/statistics/80572/en/ (2013/08/27)

[116] http://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-online.aspx (2013/08/27)

[117] Comprising the Forestry Department of FAO, the United Nations Economic Commission for Europe (UNECE), the Statistical Office of the European Communities (EUROSTAT) and the International Tropical Timber Organization (ITTO)

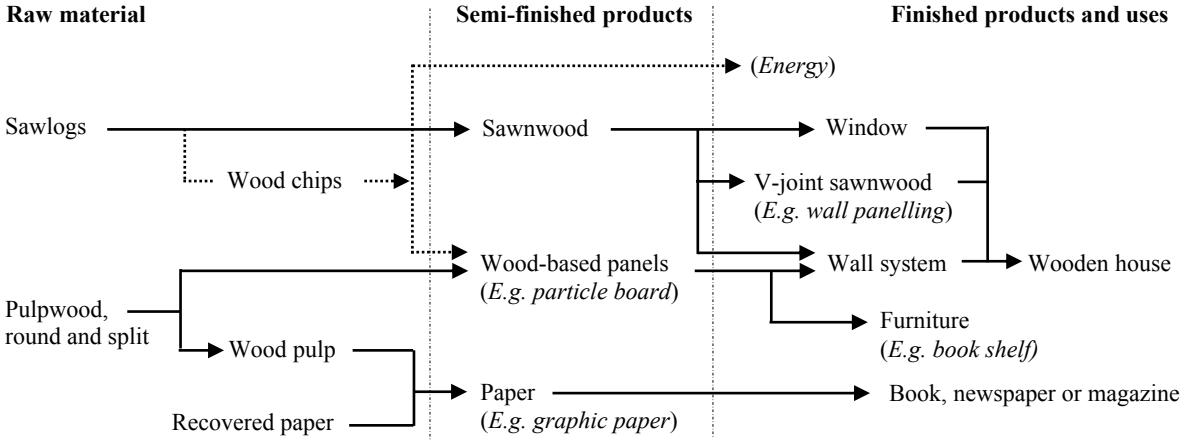
[118] http://faostat.fao.org/site/630/default.aspx (2013/08/27)

WOOD-BASED PANELS (Decision 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."[115] For the definitions of these subcategories please see FAO.

PAPER AND PAPERBOARD (Decision 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."[115]

By definition, these three aggregate commodities of semi-finished wood products represent information on the material use of HWP and equal the default categories mentioned in Decision 2/CMP.7. 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-jointed sawnwood or laminated veneer lumber (LVL)) may be the result of subsequent processing and therefore fall under the category of finished wood products as illustrated in Figure 2.8.3. This also applies e.g. to wooden flooring that is produced from sawnwood and/or hardboard which belongs to the category of wood-based panels; wooden flooring in this case is therefore implicitly covered by the semi-finished HWP categories sawnwood and wood-based panels and included in the estimates for the *HWP contribution*. Thus, using statistical data both for sawnwood and for wooden flooring would result in double counting.

Figure 2.8.3 Examples of different processing stages of wood products along the process and value chain



To avoid potential double counting, countries are encouraged to consult e.g. FAO for further clarification on the mass flows along the forest wood processing chain depending on the classification and definition of the relevant commodities.[115] The inclusion of the commodity wood pulp under the HWP category "paper" would for example result in double counting, as wood pulp by definition constitutes the feedstock for the production of paper and paperboard (cf. definition below and Figure 2.8.2). The application of information on wood pulp does, however, enter the default method to calculate the share of HWP coming from domestic forests as reflected in Equation 2.8.2. Wood pulp data may also be used in higher tier methods provided that the country can demonstrate transparently that double counting is avoided (see Section 2.8.4.1).

In order to implement STEP 2 (see Section 2.8.1), further information is needed on commodities representing the raw materials eventually used as feedstock for the production of the semi-finished HWP categories listed above (cf. Figure 2.8.2). Some possible feedstock commodities are not included in the default method to allocate HWP to domestic forest activities as described in Section 2.8.1.2 below, due to difficulties in determining sources and multiple uses, e.g. wood chips used in wood-based panel and wood pulp production as some chips come from industry co-products, others could be recycled products and others go to energy use (see Figure 2.8.3). Definitions of some key feedstocks used are provided below.

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)." [115]

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."[115]

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."[115]

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 WCO HS tariff nomenclature (see above) 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). Consequently, *good practice* in providing transparent and verifiable activity data for HWP, which qualifies for the provision of Decision 2/CMP.7 to account for the *HWP contribution* on the basis of changes in the HWP pool, is achieved by the availability of data for the three aggregate HWP commodities sawnwood, wood-based panels and paper and paperboard in publicly available databases of international organizations, such as FAOSTAT (cf. *IPCC 2006 Guidelines*). It is *good practice* to report on uncertainties related to these datasets (see Section 2.8.6).

In addition, countries with available data on finished wood products produced from the default HWP categories 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 Decision 2/CMP.7, accounting for the *HWP contribution* is restricted to carbon in HWP from forests which are accounted for by the particular Party under Article 3, paragraphs 3 and 4. Carbon in imported HWP is to be excluded.[119] As the accounting framework 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 activities. Within Article 3 paragraph 3, HWP from Deforestation (D) is treated differently from HWP derived from A and R activities.

This section describes a default method on how to implement STEP 2 (see Section 2.8.1) for estimating the *HWP contribution* originating from forests that are accounted for under the particular forest activities.

Implementation of STEP 2.1

Firstly, the share of carbon in HWP coming from domestic forests is estimated. For this purpose, the share of feedstock from domestic sources remaining within the country as against the overall availability of feedstock used for subsequent processing within the country (i.e. apparent consumption generally computed from production data plus import minus export) is calculated. In the case of HWP categories sawnwood and wood-based panels, the apparent consumption of industrial roundwood (see Section 2.8.1.1) is assumed to equal the feedstock used to manufacture those products (Rüter 2011, Johannsen *et al.,* 2011). Some industrial roundwood can also be used for the production of pulp, serving as feedstock for the semi-finished HWP commodity paper and paperboard. As pulp is also a traded commodity, the share of pulp produced from domestic sources as against the overall availability of pulp is to be calculated in a second step. Generally, domestic consumption is computed from production data plus imports less exports.

However, commodities other than industrial roundwood and/or wood pulp can also 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 used for the manufacture of particle board (Wilson 2010) (cf. Figure 2.8.3). If 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).

[119] Paragraph 27

If country-specific methods and/or estimates are not 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.[120]

EQUATION 2.8.1
ESTIMATION OF ANNUAL FRACTION OF FEEDSTOCK FOR HWP PRODUCTION ORIGINATING FROM DOMESTIC HARVEST

$$f_{IRW}(i) = \frac{IRW_P(i) - IRW_{EX}(i)}{IRW_P(i) + IRW_{IM}(i) - IRW_{EX}(i)}$$

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 (i.e. paper is also produced from traded pulp) and in order to provide more reliable estimates, 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 ($f_{PULP}(i)$).[120]

EQUATION 2.8.2
ESTIMATION OF ANNUAL FRACTION OF DOMESTICALLY PRODUCED WOOD PULP AS FEEDSTOCK FOR PAPER AND PAPERBOARD PRODUCTION

$$f_{PULP}(i) = \frac{PULP_P(i) - PULP_{EX}(i)}{PULP_P(i) + PULP_{IM}(i) - PULP_{EX}(i)}$$

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}

The resulting feedstock factor $f_{IRW}(i)$ is then 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 in order to exclude both wood pulp produced from imported industrial roundwood, and paper produced from imported wood pulp (see above and Equation 2.8.4).

Implementation of STEP 2.2

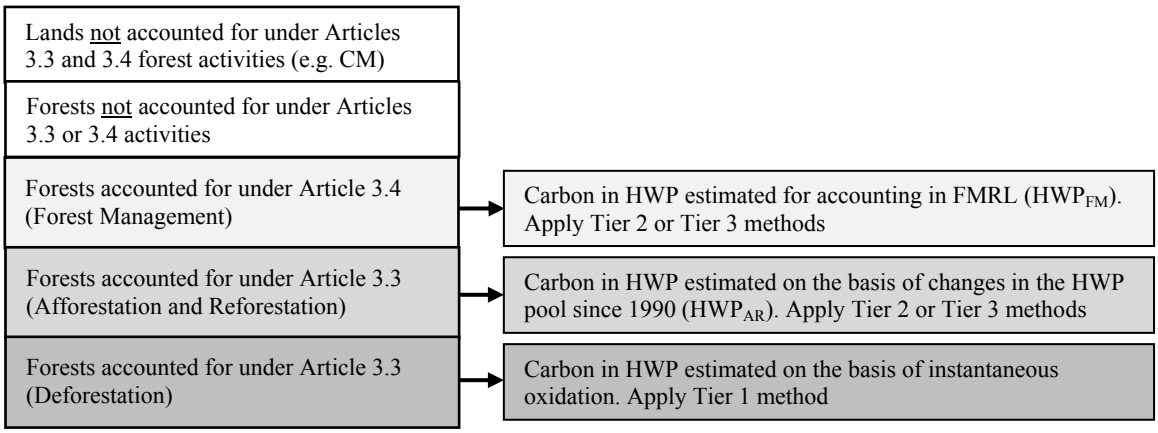
In STEP 2.2, the carbon in HWP is allocated to the particular forest activities under Article 3, paragraphs 3 and 4 (see Figure 2.8.1) as the *HWP contribution* is estimated differently depending on the origin of the wood. Under Article 3 paragraph 3, the *HWP contribution* originating from forest activities A, R and D is estimated since the

[120] Since the application of the equations only apply to the feedstock calculation, it does not result in the exclusion of exported HWP (see Sections 2.8.3 and 2.8.4)

base year 1990. The *HWP contribution* from HWP originating from the activity FM under Article 3 paragraph 4 is accounted for in the second commitment period consistently with the FMRL [121] (see Sections 2.7.5 and 2.8.5).

It is *good practice* to apply Tier 2 or Tier 3 methods for the particular fractions of HWP that are 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[122] (see Section 2.8.1.2 and Figure 2.8.4). In both cases, guidance on estimation methods is provided in Sections 2.8.3 and 2.8.4. For HWP originating from D activities the Tier 1 method shall be applied (Section 2.8.2).

Figure 2.8.4 Relationship between sources of feedstock for HWP, forest activities and the application of the relevant tier method for estimating the HWP contribution



If country-specific approaches are not available to allocate domestic harvest and subsequently produced HWP therefrom to the activities AR, D and FM (e.g. by track and trace systems), it is *good practice* to apply Equation 2.8.3 for estimating the annual fraction of HWP derived from the specific forest activity ($f_j(i)$) as a default. This also includes harvest that has been subject to salvage logging. The identified share of the total harvest is then assigned to the HWP associated with the particular forest activity by application of Equation 2.8.4.

EQUATION 2.8.3
ESTIMATION OF ANNUAL FRACTION OF FEEDSTOCK FOR HWP ORIGINATING FROM FOREST ACTIVITIES UNDER ARTICLE 3, PARAGRAPHS 3 AND 4

$$f_j(i) = \frac{harvest_j(i)}{harvest_{Total}(i)}$$

Where:

$f_j(i)$ = share of harvest originating from the particular activity j in year i

j = activity FM or AR or D in year i

Where countries already collect data of harvesting discriminating among different activities (i.e. lands subject to FM, lands subject to AR, lands subject to D, and any other treed land) – and among material and energy use of harvested roundwood (i.e. industrial roundwood and fuelwood, cf. Figure 2.8.2), this information can be used. This is usually the case where countries apply the gain-loss (i.e. flux data) method[123].

Most countries only report industrial roundwood from forests in their statistics and the uncertainties associated with feedstock for HWP production (cf. Figure 2.8.2) originating from lands other than forests (see Figure 2.8.4) are generally expected to be insignificant. 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 does not originate from forests which are accounted for under Article 3, paragraphs 3 (AR and

[121] Paragraphs 12 and 14

[122] Paragraphs 16, 29 and 30

[123] Section 4.2.1.1, Chapter 4, Volume 4 of the *2006 IPCC Guidelines*

D) and 4 (FM) (cf. Figure 2.8.2).[124] In the Kyoto Protocol accounting framework, activities on lands which are not considered to be forests (see Section 1.2) and which could provide industrial roundwood to the markets (e.g. short-rotation plantations), could possibly be accounted for under the activity Cropland Management[125] (e.g. as perennial crops including trees, see Section 2.9). Following the guidance given in Sections 2.9.1 and 2.9.2 countries are encouraged to provide information on how lands that could potentially be the source of industrial roundwood have been included in their accounting. This is relevant also for forest lands which are not subject to FM, depending on the countries' interpretation of FM (see Section 2.7.1). It is thus *good practice* to ensure that no significant amounts of biomass not originating from forests-related activities have been used as feedstock for the production of the HWP default commodities, and explain how this has been achieved.

Countries that apply the stock-difference method to estimate forest carbon stock changes as outlined in Section 2.3.3 may need to collect additional data for estimating harvest fractions associated with the particular activity *j* related to forests under Article 3, paragraphs 3 and 4 to apply Equation 2.8.3. When countries cannot track the harvested wood by the land of origin (FM, AR, D, or from treed lands, cf. Figure 2.8.4) and by different uses of wood (i.e. industrial roundwood, fuelwood), the following *good practice* applies:

For deforested lands, the starting information is the standing volume of tree before the deforestation event, which corresponds to the total harvest (i.e. fellings). The following steps apply:

STEP 1: Disaggregate the harvest into roundwood and slash by one of the following methods.

- Either multiply the standing volume by the ratio of roundwood to total harvested removals that has been calculated for other activities or at national level;
- Or divide the standing volume by the biomass expansion factors (BEF_2) provided in Table 3A.1.10, Annex 3A.1 to Chapter 3 of the *GPG-LULUCF*, thereby deriving the amount of roundwood.

STEP 2: Disaggregate the roundwood into industrial roundwood and fuelwood (cf. Figure 2.8.2) by one of the following methods.

- Either multiply the roundwood by the ratio of industrial roundwood to roundwood that has been calculated for other activities or at national level;
- Or multiply the roundwood data derived from STEP 1 by the factor 0.87[126] in order to exclude harvest losses, bark (cf. FAO roundwood definition, Section 2.8.1.1) and fuelwood not covered by the statistics and subsequently disaggregate the result by using the proportion derived from FAOSTAT production data of the commodities industrial roundwood and wood fuel.

For AR lands, the starting information is the standing volume of trees from which fellings is derived according with the age-class structure and/or yield tables and/or information on the timing of harvesting and thinning operations for each management system. Then, STEPS 1 and 2 as described above for deforested lands apply in order to divide harvest into roundwood and slash and disaggregate roundwood into industrial roundwood and fuelwood.

For lands that are not reported under any forest-related activity (see Sections 1.1 and 1.2), and that produce significant amounts of harvest (i.e. lands from which timber is extracted, cf. Figure 2.8.4), then the country should estimate the amount of industrial roundwood annually produced from those lands in order to exclude it from the HWP estimation.

Industrial roundwood from those lands could be estimated by:

- Either by determining, for each tree species, the total amount of harvest, from which the amount of harvest originating from AR and D lands is subtracted and the remaining amount is apportioned among lands subject to FM and other lands from which significant amounts of timber are extracted based on the proportion of the total area covered by each species under FM and under those other lands; or
- Or by subtracting from the total harvest the amount of fellings originating from AR and D lands, as quantified by available data or as estimated according to above-listed guidance, and, then, apportioning the remaining quantity on the basis of the proportion of the area under FM and under those other lands.

[124] Paragraph 27

[125] Paragraph 6

[126] This factor represents a mass weighted average for the years 2003-2007 that has been derived from information on harvest data included in countries' FMRL submissions (http://unfccc.int/bodies/awg-kp/items/5896.php) and production data of the UNECE statistics for the commodity roundwood (Rüter 2011). Please note that this factor varies between countries depending *inter alia* on the national definition of volume of living stems above stump. Further guidance can be found e.g. in Lawrence *et al.,* 2010 and Karjalainen *et al.,* 2004.

Once the amount of fellings has been apportioned to lands not reported under any forest-related activity from which significant amounts of timber are extracted the industrial roundwood is estimated by applying the same steps as those described for afforested/reforested lands.

Finally, the amount of industrial roundwood produced from FM lands is estimated by subtracting from the total harvest the quantity of fellings originating from AR, D and those other lands and by calculating the amount of industrial roundwood associated with FM in line with the guidance given above.

For each forest-related activity, for the years of the time series for which a ratio of industrial roundwood originated by the activity to the total produced roundwood cannot be estimated, it is *good practice* to derive missing values from the values of the ratio that have been calculated according to methods of gap-filling as provided in the *2006 IPCC Guidelines*.

Countries that use the stock-difference method to estimate forest carbon stock changes as outlined in Section 2.3.3, and that apply the above-listed *good practice* for estimating the fellings for D, AR and/or FM, are encouraged to ensure the quality of estimated values of harvesting by checking their consistency with the estimated net changes in aboveground biomass.

In case it is not possible to differentiate between the harvest from AR and FM, it is conservative and in line with *good practice* to assume that all HWP entering the accounting framework originate from FM. The reason is that the potential contribution to the reported carbon stock changes is higher if HWP originate from AR rather than from FM, as for AR, the estimates start in 1990 and AR is accounted against a benchmark value of 0 (i.e. gross-net accounting, see Sections 2.5.3 and 2.8.3). It is furthermore conservative and in line with *good practice* to assume that all harvested wood prior to the start of the first commitment period is derived from FM, since 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.

Implementation of STEP 2.3

In order to obtain the annual fractions of HWP entering the accounting framework from domestic harvest associated with the particular activity *j* (AR, D and FM), the results of STEP 2.1 (i.e. the factors ($f_{IRW}(i)$ and $f_{PULP}(i)$) from Equations 2.8.1 and 2.8.2) and STEP 2.2 (i.e. $f_j(i)$ from 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). In cases where no country-specific track and trace systems are available, it is *good practice* to apply Equation 2.8.4 for this purpose.

EQUATION 2.8.4
ESTIMATION OF ANNUAL HWP AMOUNTS 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'
with: $f_{IRW}(i) = 0$ if $f_{IRW}(i) < 0$ and $f_{PULP}(i) = 0$ if $f_{PULP}(i) < 0$

Where:

$f_{DP}(i)$ = share of domestic feedstock for the production of the particular HWP category originating from domestic forests in year *i*

$HWP_j(i)$ = HWP amounts produced from domestic harvest associated with activity j in year *i*, in $m^3\ yr^{-1}$ or Mt 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 $m^3\ yr^{-1}$ or Mt yr^{-1}

Note: 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 forest related activities AR, D 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 accounted for under Article 3, paragraphs 3 and 4 using country-specific activity data is provided in Section 2.8.4.1.

2.8.2 Tier 1: "Instantaneous oxidation"

The method presented in this section is to be applied by countries as the default method to estimate the *HWP Contribution*.[127] It is based on the assumption that the annual amount of carbon leaving 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 the biomass harvested is oxidised in the removal year (i.e. year of harvest) 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).

For the first commitment period, the storage of carbon in HWP was not included in the reporting since "the mere presence of carbon stocks be excluded from accounting" [128] and HWP "is not listed as a pool covered by the Marrakesh Accords" (IPCC 2003). Countries following the *good practice* as described in *GPG-LULUCF* (IPCC 2003) and applying instantaneous oxidation, did thus not report and/or account for emissions from HWP in the first commitment period.

Decision 2/CMP.7 establishes mandatory accounting of all changes in the HWP pool.[129] A prerequisite for accounting HWP on the basis of delayed emissions is the availability of transparent and verifiable HWP activity data (see Section 2.8.1.1). Consequently, it is *good practice* to apply the Tier 1 method as outlined in this section (i.e. reporting no net-emissions from HWP) only in the case that transparent and verifiable activity data for the default HWP categories sawnwood, wood-based panels and paper and paperboard as outlined in Section 2.8.1.1 are not available.[130] However, Decision 2/CMP.7 specifies that "the treatment of HWP in the construction of a projected FMRL (see Section 2.8.5) shall not be on the basis of instantaneous oxidation".[131]

For the following HWP fractions instantaneous oxidation (i.e. Tier 1) shall be applied (see Figure 2.8.1):

- HWP resulting from D activities under Article 3 paragraph 3 (see Section 2.8.1.2);[132]
- HWP in SWDS [133]
- Harvested wood used for energy purposes.[133]

Following the guidance given in Section 2.8.1.2, the fraction of HWP originating from domestic forests that are 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 the *HWP contribution* and which is equivalent to applying instantaneous oxidation. In line with the requirements of Decision 2/CMP.8[134], it is *good practice* to demonstrate that harvested wood originating from D (i.e. $harvest_D$, see Equation 2.8.3) has not been included in the estimates on the basis of the change of the HWP pool. This can be done by reporting the annual share of the overall harvest originating from D ($harvest_D$ (i)).

By estimating the *HWP contribution* on the basis of methodologies as outlined in Sections 2.8.3 and 2.8.4, only the *HWP contribution* of HWP in use is estimated. HWP in SWDS and wood harvested for energy are thus implicitly treated on the basis of instantaneous oxidation (i.e. reporting no net-emissions from HWP). Estimates that are based on the three default commodities are by definition not derived from wood harvested for energy purposes. Where CO_2 emissions from HWP in SWDS are separately accounted for, it is *good practice* to include them on the basis of "instantaneous oxidation".

2.8.3 Tier 2: First order decay

Provided that 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 appropriate country-specific information required to apply a Tier 3 method are available (see Section 2.8.4), Parties are

[127] Paragraph 28

[128] Decision 16/CMP.1

[129] Paragraph 26

[130] Paragraph 29

[131] Paragraph 16

[132] Paragraph 31

[133] Paragraph 32

[134] Paragraph 2 of the Annex II of Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1

required to obtain estimates on the *HWP contribution* by application of the Tier 2 method as outlined in this section.[135]

In line with Decision 2/CMP.7, it is *good practice* to estimate the change in carbon stocks separately for each of the HWP fractions originating from AR (HWP_{AR}) and from FM (HWP_{FM}) as estimated from Equation 2.8.4. 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, Chapter 12, Volume 4 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

$$C(i+1) = e^{-k} \bullet C(i) + \left[\frac{(1-e^{-k})}{k}\right] \bullet Inflow(i)$$

$$\Delta C(i) = C(i+1) - C(i)$$

Sources: IPCC 2006 ; Pingoud and Wagner 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 FOD for each HWP category (HWP_j) 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 the semi-finished wood product categories sawnwood, wood-based panels and paper and paperboard that have been assigned to the particular forest activities (HWP_{AR} *and* HWP_{FM}) (see Section 2.8.1). In combination with semi-finished wood product commodities, 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 2.8.2) are described realistically by the exponential decay pattern" (Pingoud and Wagner 2006). The timing of emissions from wood processing residues used for energy purposes along the process chain of HWP are also well described by FOD (cf. Rüter and Diederichs 2012).

Whereas Equation 12.1, Chapter 12, Volume 4 of the *2006 IPCC Guidelines* suggests to start with i = 1900, 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*."[136] The term "emissions" from HWP (which are defined as a pool[137]) thus refers to the "decay" from that pool, which is the discarding of HWP from end uses described e.g. by FOD (i.e. Equation 2.8.5). Discarding, thus, does not mean that the carbon in the products is oxidized, but describes the release of HWP from the HWP pool in use (or in service) from where the products are potentially recycled, burned, composted or transferred to solid waste disposal.[138] The discard from the pool of HWP in use (comprising wood products in service), therefore depends on the historic level of Inflow (see Section 2.8.1) and the particular service life and/or half-life of the HWP commodities (see Sections 2.8.3.2 and 2.8.4.2).

[135] Paragraph 29

[136] Paragraph 16

[137] Paragraph 26

[138] For more information see IPCC FAQ, Q4-29 (http://www.ipcc-nggip.iges.or.jp/faq/faq.html)

In order to account for the *HWP contribution* from AR activities, estimates are to be based on activity data since the base year 1990. It is thus *good practice* to include inherited emissions from the pool that has been established from HWP_{AR} since 1990. This is implemented by the use of Equation 2.8.5 starting with i = 1990 and C(1990) = 0.

For HWP from FM activities, the inclusion of inherited emissions in the estimates of the HWP carbon pool depends on the Party's approach used for FMRL construction. In case the FMRL is based on a projection which represents a 'business as usual scenario' (see Sections 2.7.5.1 and 2.8.5), Parties may exclude inherited emissions from before the start of the second commitment period in their estimates.[139] In this case, the estimation by means of Equation 2.8.5 starts with i = 2013 and C(2013) = 0. If the Party's FMRL is not based on a projection representing a 'business as usual scenario', it is thus *good practice* to include inherited emissions from the pool.

As reflected by Equation 2.8.4 ($HWP_j(i)$), it is also *good practice* to separately estimate and report using the above procedure the annual *HWP contribution* for:

- HWP from AR activities (HWP_{AR}) and for HWP from FM activities (HWP_{FM})
- HWP for each of the particular commodities (i.e. sawnwood, wood-based panels, paper and paperboard or their subcategories)

The availability of activity data series (i.e. $Inflow(i)$) varies. For most countries the FAO statistics provide data on the HWP commodity categories since 1961.[140] However, for some countries activity data are available only since their independence or foundation (e.g. in 1991). Further guidance on the activity data to be used for the Tier 2 method is provided in Section 2.8.3.1.

As a proxy in the Tier 2 method it is assumed that the HWP pools are in steady state at the initial time t_0 from which the activity data start. This means that as a proxy $\Delta C(t_0)$ is assumed to be equal to 0. This steady state carbon stock $C(t_0)$ for each HWP commodity category is approximated by means of Equation 2.8.6 based on the average of $Inflow(i)$ during the first 5 years for which statistical data are available. By substituting $C(t_0)$ in Equation 2.8.5, the $C(i)$ and $\Delta C(i)$ in the sequential time instants can be calculated. In the Tier 2 method, it is *good practice* to use Equation 2.8.6 for estimating the stock at $t = t_0$.

EQUATION 2.8.6
APPROXIMATION OF THE CARBON STOCKS IN HWP POOLS AT INITIAL TIME, I.E. SINCE WHEN ACTIVITY DATA ARE AVAILABLE

$$C(t_0) = \frac{Inflow_{average}}{k}$$

With: $Inflow_{average} = \left(\sum_{i=t_0}^{t_4} Inflow(i)\right)/5$

Only in case a projected FMRL is applied (see Section 2.8.5), other methods could also be used. Further estimation methods for calculating the carbon inflow to the HWP_{FM} pool ($Inflow(i)$) back to the year 1900 are provided by the *2006 IPCC Guidelines* (i.e. on the basis of estimated annual rates of increase for industrial roundwood production that are based, inter alia, on the annual per cent change of population growth) or in Rüter 2011 (i.e. calculate missing activity data since the year 1900 on HWP_{FM} carbon pool inflow from the average of the first five years for which activity data are given for the country).

In case the FMRL has been based on a projection representing a 'business as usual scenario' (see Section 2.7.5 and 2.8.5), in line with Decision 2/CMP.8, it is *good practice* to provide information whether and how inherited emissions have been included in the HWP estimates. Otherwise, if the inclusion of HWP in the countries' FMRL is not based on a projection, it is *good practice* to explain that the approach chosen to include inherited emissions in the estimates of the HWP carbon pool reflects best the countries' circumstances (e.g. data availability). Further guidance on the consideration of HWP in the FMRL is provided in Section 2.8.5.

[139] Paragraph 16

[140] http://faostat.fao.org/site/630/default.aspx

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 by –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 the *HWP contribution*. In order to increase transparency and facilitate potential changes in the methodology used to estimate the *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 2.8.5, it is *good practic*e to determine C(*i*) and *Inflow* (*i*).

TABLE 2.8.1
DEFAULT CONVERSION FACTORS FOR THE DEFAULT HWP CATEGORIES AND THEIR SUBCATEGORIES

HWP categories	Density (oven dry mass over air dry volume) [Mg / m^3]	Carbon fraction	C conversion factor (per air dry volume) [Mg C / m^3]	Source
Sawn wood (*aggregate*)	0.458	0.5	0.229	1
Coniferous sawnwood	0.45	0.5	0.225	2
Non-coniferous sawnwood	0.56	0.5	0.28	2
Wood-based panels (*aggregate*)	0.595	0.454	0.269	3
Hardboard (HDF)	0.788	0.425	0.335	4
Insulating board (Other board, LDF)	0.159	0.474	0.075	5
Fibreboard compressed	0.739	0.426	0.315	6
Medium-density fibreboard (MDF)	0.691	0.427	0.295	4
Particle board	0.596	0.451	0.269	4
Plywood	0.542	0.493	0.267	7
Veneer sheets	0.505	0.5	0.253	8
	(oven dry mass over air dry mass) [Mg / Mg]		(per air dry mass) [Mg C / Mg]	
Paper and paperboard (*aggregate*)	0.9		0.386	9

[1] Calculated from the weighted average of coniferous and non-coniferous sawnwood production volumes (FAOSTAT average of the years 2006-2010) of the countries as listed in Appendix of the Annex of Decision 2/CMP.7

[2] IPCC 2003, Appendix 3a.1

[3] Calculated from the weighted average of included subcategories of the production volumes (FAOSTAT average of the years 2006-2010) of the countries as listed in Appendix of the Annex of Decision 2/CMP.7

[4] Rüter and Diederichs (2012)

[5] Derived from Environmental product declarations EPD-GTX-2011111-E, EPD-KRO-2009212-E and EPD-GTX-2011211-E provided by IBU e.V. (http://bau-umwelt.de/hp550/Insulating-materials.htm)

[6] Calculated from 50% of HDF and 50% of MDF

[7] Derived from Wilson and Sakimoto (2005) and basic density for non-coniferous species listed in the table above

[8] Calculated from 50% sawnwood (Coniferous) and 50% of sawnwood (Non-Coniferous)

[9] Calculated from the weighted average of included subcategories of the production volumes (FAOSTAT average of the years 2006-2010) of the countries as listed in Appendix of the Annex of Decision 2/CMP.7, including information derived from Fengel and Wegener (1984), Paulapuro (2000), Gronfors (2010) and industry information.

For this purpose, Tier 2 uses forest products data from the FAO or other international organizations, such as the United Nations Economic Commission for Europe (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) are largely dependent on the 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.

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) 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 Decision 2/CMP.7 refers to HWP in use (see Section 2.8.1.1), the half-life to be applied is a function of the adjusted estimated service life (ESL) of the particular HWP commodities (with HL = Adjusted ESL * ln(2), see 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[141] OF HWP CATEGORIES

HWP categories[142]	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 (i.e. Tier 3) for the relevant HWP categories is available 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 *HWP contribution*. They may include country-specific half-lives and/or methodologies and may be applied by Parties where sufficient data are available, in line with requirements as outlined in Section 2.8.1 and the Decision 2/CMP.7[143] covering the three semi-finished HWP categories. 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"[143] as those described in Section 2.8.3 (Tier 2). *Good practice* thus includes a verification of the Tier 3 methods used,

[141] See footnote of paragraph 29 of Decision 2/CMP.7: Half-lives are based on Table 3a.1.3 of the *GPG-LULUCF*.

[142] 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 forest products (see guidance in Section 2.8.1.1)

[143] Paragraph 30

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 the *HWP contribution* has been estimated. More information on how to verify Tier 3 methods can be found in IPCC FAQs on HWP.[144]

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 the production and trade of HWP (see Section 2.8.1.1), whereas information on the discard from the HWP pool is incomplete. Using this incomplete discard information (e.g. from waste statistics) to calculate the above difference would lead to an overestimation of the HWP carbon pool and its changes. Thus practicable flux data methods that comply with *good practice* rely on service life information of HWP. They are based on the use of decay functions and dynamic models ensuring the continuity of mass so that all HWP carbon entering the pool will be discarded eventually.

The 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 (e.g. HS code 440792 sawnwood made of beech (Fagus spp.) of a certain dimension) included in the three HWP commodities that follow the HS nomenclature system as explained in Section 2.8.1.1 (see Section 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 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).

Furthermore, it is with *good practice* to separately estimate and report the *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 the case HWP pools of both semi-finished and finished products are included in Tier 3 calculation models it is *good practice* to eliminate any overlapping of the HWP pools and thereby to avoid any double-counting of HWP carbon stock changes.

COMBINED HWP STOCK INVENTORY AND FLUX DATA METHODS

HWP stock inventory methods use HWP carbon pool data for two or preferably more separate points in time to estimate changes in the pool. Their 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 2.8.3) 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 the 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 identification of the proportion of the HWP carbon stock originated from domestic forests and being thus accountable (see Section 2.8.1). Furthermore, in line with Decision 2/CMP.7, imported HWP must be excluded from the estimated HWP pool, therefore increasing the uncertainties.[145]

[144] http://www.ipcc-nggip.iges.or.jp/faq/faq.html

[145] Paragraph 27

Since in practice inventory data are not available for all finished HWP for domestic and export markets covering the HWP categories sawnwood, wood-based panels, paper and paperboard (e.g. wooden houses, furniture, newspaper), it is *good practice* to apply inventory methods only in combination with flux data methods.

In cases where a Party applies inventory methods for specific HWP end uses (e.g. the housing sector), it is thus *good practice* to estimate the *HWP contribution* for the remaining fraction of the three 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 Decision 2/CMP.7.

2.8.4.1 COUNTRY-SPECIFIC ACTIVITY DATA

Section 2.8.1.1 introduces the international classification system of forest products following 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 produced from the three default HWP categories as defined in Decision 2/CMP.7[146] (cf. Figure 2.8.2).

Country-specific HWP activity data that could be used for Tier 3 include:

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. from 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 data 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 Figures 2.8.2 and 2.8.3). 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 (see above) are used (see Figure 2.8.3). 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.

Some of the above mentioned country-specific activity data (1, 2 and 3) may be available from annual statistics being applicable for flux data methods. Other activity data might be available only at the start and at the end of the commitment period for use in combined HWP stock inventory and flux data methods. Whereas data derived from inventories (e.g. for buildings, see 3) could not be used for the share of exported HWP, data from production and export statistics for finished product categories, such as books or furniture, could be used to estimate the contribution of exported HWP.

In order to allocate the carbon in HWP to the particular forest activities under Article 3, paragraphs 3 and 4 (see Section 2.8.1.2) Parties could apply the relevant equations as suggested in Section 2.8.1 for 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 (e.g. wood pulp, recovered wood pulp from recovered paper, etc. for

[146] Paragraph 30

paper and paperboard). 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 (see Table 2.8.1) may not be readily available. In particular, HWP activity data representing finished commodities (see Figure 2.8.2) or market segments of wood use (e.g. wooden building components, see Figure 2.8.3 in Section 2.8.1.2 and 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 (ISO 2006a) and 14044:2006 (ISO 2006b). 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 e.g. 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 with regard to 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 transparent and verifiable data.

Several approaches can be used to derive country-specific service- and half-life values based on transparent and verifiable data:

- Following the ISO 15686 standard series approach, since this is an already established system for service life estimation on a case specific level. A modified approach is used here on a national level (see Box 2.8.1) in combination with obsolescence on national level,
- A combination of production and trade statistics data with building stock inventory information in order to estimate more realistic country-specific service and half-live values through this calibration, and/or
- National surveys on the final market use of wood.

Below examples on how to improve 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 ESL (see Section 2.8.3.2), 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), the 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 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: the function is 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 also includes 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 in Tier 3 estimates of the *HWP contribution* to reflect 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 a 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.[147]

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.

[147] 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 ISO 15686-8:2008, but elevated from the case specific level given in the standard to a national level. Details about RSL and service life estimation are in ISO 15686-8:2008.

A factor of "1" is used when the factor does not deviate from the RSL conditions. A higher value (x>1) is given if the national performance is better than RSL conditions; a lower value (x<1) is given if the national performance is lower than the RSL conditions. Non relevant factors are excluded from the equation.

The RSL is based on accelerated field trials and the threshold for 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 ESL = 55(RSL)*1(A)*1(B)*1(C)*1.2(E)*1(F)*0.9(G) = 59.4 years

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. A more detailed explanation for the choice of factors used is to be provided in the countries' annual reporting.

A = Inherent performance level represents the grade of the component as supplied.

- Here equals the RSL.

B = Design level reflects the component's installation in the building/constructed asset and is typically based on the level of shelter and protection from agents provided by the design of the building/constructed asset.

- Here equals the RSL.

C = Work execution level considers the level of skill and control in sitework.

- Here equals the RSL.

D = Indoor environment considers the exposure of the object to indoor agents of degradation and their severity.

- Not relevant in this example.

E = Outdoor environment considers exposure to outdoor agents of degradation and their severity.

- In this example the climate on a national level is less harsh than at the test sites included in RSL.

F = Usage conditions reflects the effect of the use of the building/constructed asset.

- Here equals the RSL.

G = Maintenance level reflects the level of maintenance assumed. For certain components that are inaccessible or require special equipment for access, a particularly low maintenance level should be considered.

- Here slightly lower than RSL intervals.

Another example in Table 2.8.3 shows how to derive country-specific half-life values 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. 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 normally have 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 obtain improved service life estimates for the particular HWP categories. Thereby, it is important to note that the assumed service life is driven by the products technical properties and, depending on this, its particular application area (e.g. load-bearing beam or wood panelling, both made of sawnwood). Thus, in order to calculate a country-specific emission factor (i.e. service- or half-life), different sources of information, e.g. on the market use of different HWP categories, could be combined as illustrated in Table 2.8.3.

The definition of half-life and also guidance on how to calculate half-life for Tier 2 is provided in Section 2.8.3.2.

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		

* As the use of the HWP categories in different markets, such as the construction sector, consists of different end uses (e.g. wall systems, flooring, roof construction), Parties are encouraged to allocate the contribution of the different end uses to the relevant HWP category or subcategory (e.g. non-coniferous sawnwood used for windows).

HALF-LIFE DATA TO BE USED FOR EXPORTED HWP

"*In the case of exported HWP, country-specific data refers to country-specific half-lives and HWP usage in the importing country.*"[148] Thus, if country specific half-life information should be used also for the exported HWP categories, the half-life information from the importing country must be used. For this purpose, it is necessary to quantify export activity data within the three HWP categories and/or sub categories. Furthermore, in order to ensure that the country-specific half-life information from the importing country complies with the categories of the activity data for the exported HWP, it is *good practice* to only apply country-specific half-life information in case the same categories of activity data for the exported HWP both in the exporting and importing country are used. Otherwise the default values (Tier 2) are to be used. When transparent and verifiable activity data are available, the categories should be broad enough to capture significant volumes contributing to the pool. The amount of exported and domestic wood should be separately reported.

2.8.5 Consideration of the HWP pool in FMRLs

In this section, guidance is given on the relation of HWP originating from FM as described in Section 2.8.1 and its consideration in the FMRL as outlined in the Decisions 2/CMP.6[149], 2/CMP.7 and 2/CMP.8. Guidance on the FMRL is provided in Section 2.7.5.

APPROACHES AND METHODS FOR CONSIDERATION OF HWP IN FMRL

Decision 2/CMP.6 requested Parties to *inter alia* submit descriptions of how HWP were considered in the construction of the FMRL.[150] In line with the different approaches and methods used by Parties to construct the FMRL as listed in Section 2.7.5.1, two general approaches on how to treat HWP in FMRL can be differentiated:

1. Instantaneous oxidation

In this case, Parties only presented values for a FMRL which do not contain estimates on the *HWP contribution*.[151] Similar to the treatment of HWP in the first commitment period as described in *GPG-LULUCF*,

[148] Paragraph 30, Footnote 6

[149] Paragraphs 2, 4 and 9 of Appendix II contained in document FCCC/KP/CMP/2010/12/Add.1

[150] 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

as result of the assumption of instantaneous oxidation, changes in the HWP carbon pool are not reported (cf. Section 2.8.2). This approach mirrors the HWP Tier 1 estimation method as described in Section 2.8.2.

2. Inclusion of the HWP pool on the basis of modelled 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.[152] This approach was chosen by Parties following the FMRL approaches 1a) and 1b) as described in Box 2.7.3. 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 2.8.2 for the HWP categories sawnwood, wood panels and paper (see Section 2.8.1.1).[153] However, different approaches had been used in regard to the consideration of HWP originating from forests prior to the start of the second commitment period[154], as indicated in the application of HWP activity data (i) since 1900, or (ii) since 1990.

BOX 2.8.2
EXAMPLE ON THE ESTIMATION OF THE *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 FM.

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 $Mm^3\ yr^{-1}$*

(ii) *Projected harvest (in $Mm^3\ yr^{-1}$): 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 (see Section 2.8.3), in order to project the future carbon inflow to the HWP pool.

Numeric example:

(i) *Average production of sawnwood for the years 2005-2009: 10 $Mm^3\ yr^{-1}$*

(ii) *Projected production of sawnwood (in $Mm^3\ yr^{-1}$): 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 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 the considerable variability in the proportions of harvested timber being used for HWP production 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.

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 regarding the projected *HWP contribution* and/or its relation to particular projected

[151] See FMRL values in column '*Reference level*' in the table of the Appendix of the Annex to Decision 2/CMP.7

[152] 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

[153] Paragraph 27 of Chapter II, Annex I contained in document FCCC/KP/AWG/2010/18/Add.1.

[154] Paragraph 15 sexies, ibid.

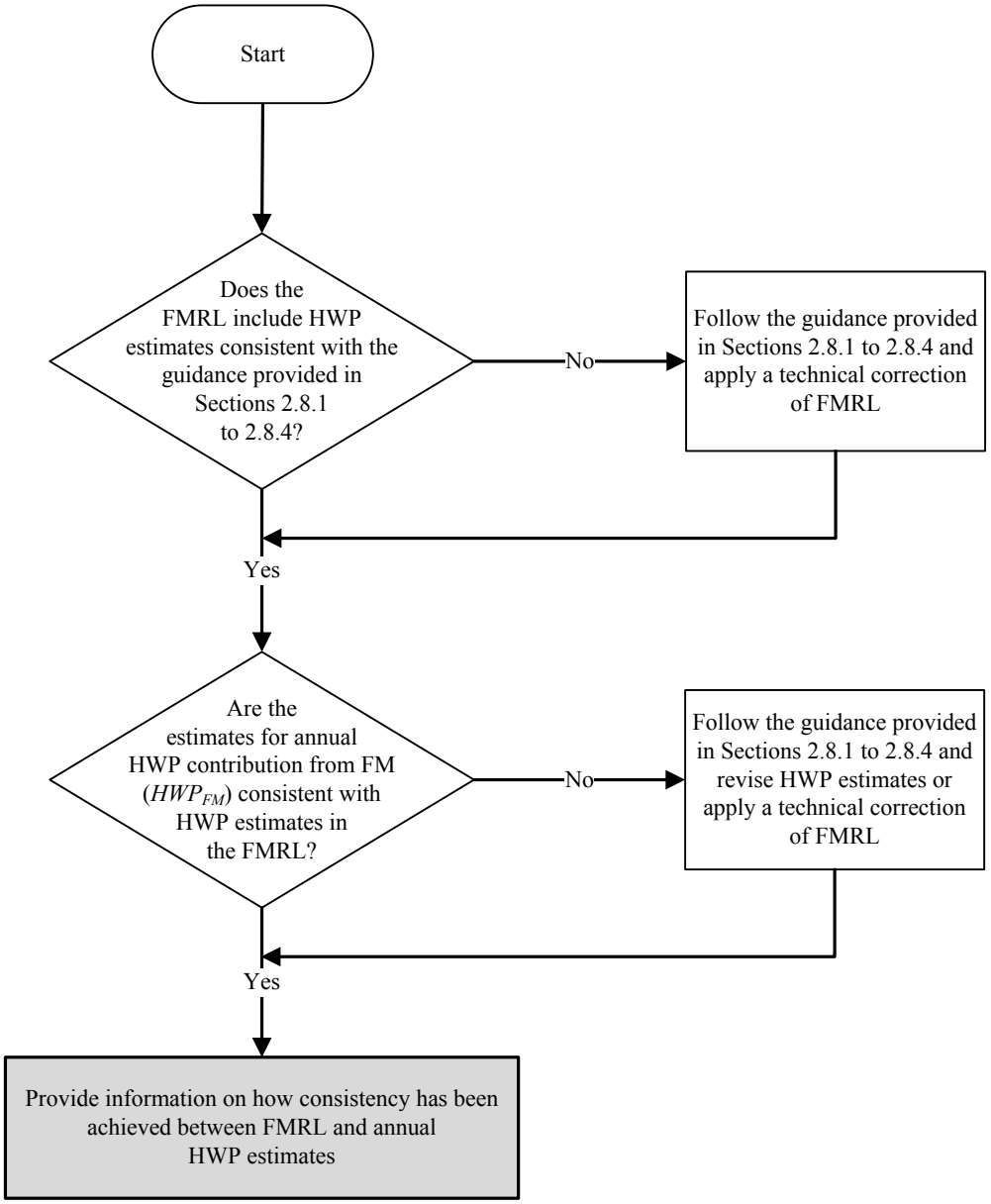
harvest rates of Parties. An example of how estimates of the *HWP contribution* in the FMRL could be derived is listed in Box 2.8.2.

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 FMRL and the reporting for FM during the second commitment period.[155] 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 below and in the relevant Sections 2.8.1, 2.8.2, 2.8.3 and 2.8.4. In order to check methodological consistency it is *good practice* to follow the decision tree provided in Figure 2.8.5.

Figure 2.8.5 Decision tree for consistency check of HWP estimates with FMRL



[155] Paragraph 14

Provided that Parties comply with the requirements as outlined in Section 2.8.1 to estimate the *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[156]:

- 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
  - (i) the method(s) to be used for estimating HWP contribution following the different tiers have been applied consistently including the treatment of inherited emissions (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 (HWP_P) 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)

Further general guidance on the detection of 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. 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. Although FOD decay is assumed to be a good proxy for the decay of semi-finished products, other types of distributions could also 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 during 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 the initialisation of the FOD model. Due to lack of long historical data series on semi-finished HWP – for some countries data series are only available since the early 1990s – the initial stocks of the HWP categories (C (t_0)) are approximated by assuming that the stock change was zero at the 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 only 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 disaggregated sub-pools (e.g. for sawnwood) with differing half-lives based on their

[156] This information includes methodological elements as used in the estimation of the *HWP contribution* to the FMRL and the reporting during the second commitment period as defined in Annex II to Decision 2/CMP.8

end-use (cf. Table 2.8.3) or based on subcategories (e.g. wood-based panels disaggregated to particle board, fibreboard etc., see 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 they remove the need for idealised models with uncertain assumptions on decay pattern 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 in the calibration 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. Inventory methods cannot be applied for HWP in export markets by the reporting country 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 the associated uncertainties of the estimates of the level of the *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 m^3, 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 as proposed in Section 2.8.1.2), uncertainty could be caused by unreported sources, by-product use or trade data.

The semi-finished HWP categories (i.e. sawnwood, wood-based panels and paper and paperboard) are also subject to the above mentioned conditions. An overall estimate of these factors results in an estimated uncertainty of the reported values between -25% to +5% (based on the authors' expert judgement).

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 averages which may 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. The scientific evidence behind the default values given in Table 2.8.2 is not robust[157]. 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 not practical for 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 such calibration 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 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.

[157] Paragraph 29

2.9 CROPLAND MANAGEMENT

2.9.1 Definitional issues and reporting requirements

Cropland Management (CM) 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[158]. CM 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 CM, all the lands in the Cropland category of Section 3.2, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*, namely cropped land, including rice fields, except for land reported under deforestation. It is also *good practice* for countries to specify how land subject to CM is distinguished from other activities under the KP using the guidelines provided in Section 3.3, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*, together with the guidance presented here.

Perennial crops can include orchards, vineyards and plantations such as cocoa, coffee, tea and bananas. In the first commitment period, some countries included certain types of perennial crops (e.g. fruit orchards, Christmas tree plantations) within CM even if the cover met the thresholds for forest. For consistency and to achieve transparency in reporting, it is *good practice* in the second commitment period for those countries to ensure that double-counting with FM is avoided and to document how consistency is achieved with KP activities reported previously. Areas having tree cover, such as orchards or shelterbelts that were established after 1990 and meet the definition of a forest can qualify as AR and, in such cases, are included under AR.. Further guidance about the inclusion of orchards and other tree crops under CM is provided in Section 1.2 of this supplement.

Rice paddies are also included under Cropland, but associated CH_4 and N_2O emissions are reported under Agriculture in reporting under the UNFCCC and KP and hence not under this activity. Cropland that is temporarily used for grazing or perennial fodders can also be included under CM. Set-aside lands are included in CM when they return, or are expected to return, to cropping after some period of time. Countries are encouraged to develop consistent criteria for defining set-aside lands and their allocation among activities.

The aim of the reporting exercise is to identify and report trends and systematic changes in the carbon stocks resulting from changes in CM practices over time. The premise is that changes in soil carbon stocks result from changes in CM practices that influence the rates of either additions to, or losses of, soil organic carbon. However, CM is not the only driver of changes in carbon stocks. Natural phenomena, 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 CM practices, as elements of CM 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 how to use higher tier methods to estimate management effects on CM emissions and removals is provided in Sections 2.3.6 and 2.9.4 of this supplement.

The main processes involved in estimating emissions and removals are stratification of croplands followed by estimation of emissions and removals resulting from changes in land management within each stratum. Inventory compilers first identify croplands and subdivide the total cropland area into strata that represent consistent classes of land, biophysical characteristics and management practices for the base year and each of the years in the commitment period (see Section 2.9.3 of this supplement and examples in Table 5.5, Chapter 5, Volume 4 of the *2006 IPCC Guidelines*). CM practices that affect soil carbon emissions and removals include tillage practices, rotation and cover crops, fertility management, plant residue management, erosion control and irrigation management (IPCC, 2000). The second main process is to estimate how the types of and changes in management practices influence emissions and removals over time, using methods discussed in Section 2.9.4 of this supplement.

It is *good practice* that Parties ensure consistency in methods applied for estimating emissions and removals from KP activities, e.g. methods across different practices covered under Articles 3.3 and 3.4 and management practices occurring on land that was deforested should be consistent with methods used for the surrounding CM practices.

It is *good practice* to apply the following steps for estimating emissions and removals from CM:

STEP 1: Define CM and apply the definition in a consistent manner over time, including in the base year. Croplands such as vineyards and orchards that meet the definition of forest can be included under CM or FM, but

[158]Paragraph 1(g) in the Annex to Decision 16/CMP.1 contained in document FCCC/KP/CMP/2005/8/Add.3, p.5.

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 CM using the Approaches described in Section 3.3, Chapter 3, Volume 4 of the *2006 IPCC Guidelines* and the appropriate sections in this supplement.

STEP 3: Distinguish between the two subcategories of CM: mineral soils and organic soils.

STEP 4: Select the appropriate tier and methodology for estimating emissions and removals based on *key category* analysis, including assessment of significant subcategories (Section 4.2, Chapter 4, Volume 1 of the *2006 IPCC Guidelines* and Figure 2.9.1 of this supplement), and 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 relevant biophysical characteristics of the land, such as soil type, and CM practices (see Section 2.9.3 of this supplement).

STEP 6: For each stratum, estimate the CM emissions and removals for the base year and each year in the commitment period using Tier 1, Tier 2 or Tier 3 methods (see Section 2.9.4 of this supplement). Total emissions are the sum of emissions and removals from mineral soils and organic soils.

Methods to identify land under CM 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 or 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.

2.9.2 Base year

Under Article 3.4 of the KP, emissions and removals resulting from CM are estimated using a net-net accounting approach (as are all elective activities under Article 3.4). Net-net accounting requires that GHG emissions and removals are estimated for the base year and each year of the commitment period[159]. This entails determining the total area under CM for the base year and for each year of the commitment period and estimating carbon emissions and removals resulting from changes in land management for those areas. Guidance for estimating the corresponding non-CO_2 GHG emissions from Cropland for 1990 are covered in Chapters 10 and 11, Volume 4 of the *2006 IPCC Guidelines* (see the text on non-CO_2 gases in Section 2.9.4 of this supplement).

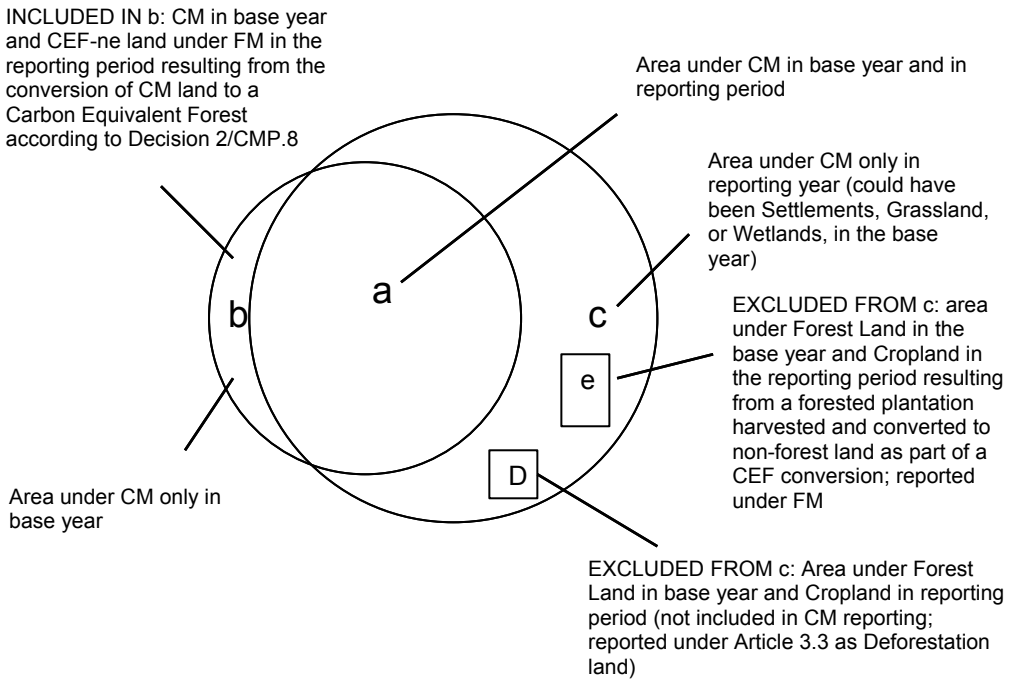
For most Parties with commitments under the KP, the base year is 1990. Under the provisions of Article 4.6 of the UNFCCC and Article 3.5 of the KP, however, Parties with economies in transition (EITs) are granted some flexibility on the level of historical emissions chosen as a reference.

If the area under CM changes between the base year and the commitment period, e.g. due to AR or land moving into another elected activity under the KP, this may lead to estimates on the basis of moving land (that is, subtraction of stock changes on a land base that changes in size over time), as illustrated in the example in Box 2.9.1. In principle, once land has been reported under any Article 3.3 or 3.4 activity during a commitment period, it must continue to be reported. For CM, the guidance provided in the *GPG-LULUCF* (Box 4.2.8) acknowledges that some of the area of the activity in the 'base year only' may no longer be reported under that activity in the reporting year. Where this area is not transferred to another reported activity the associated emissions and removals will be accounted as zero in that year. In order to achieve transparency in reporting, it is *good practice* to describe the consequences of this exclusion on reported emissions and removals.

[159] Net-net accounting refers to the provisions of paragraph 10 of the Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p.14.

BOX 2.9.1
AN EXAMPLE OF CROPLAND MANAGEMENT AREAS IN BASE YEAR AND IN THE COMMITMENT PERIOD (NET-NET ACCOUNTING)

In this example the area under CM in the base year expands to a larger area in the reporting year during the commitment period. Some of the area was under CM in both the base year and during the reporting period (a). Some of the area under CM in the base year is no longer under CM in the reporting year (b). There are also areas under CM in the reporting year that were not under CM in the base year (c). Area (D) is under CM, but was subject to Deforestation (D) which takes precedence. Area (e) has been converted to cropland, but remains under FM under the CEFC provision. Under the KP, the emissions and removals in areas (a) + (b) in the base year are compared to emissions and removals in areas (a) + (c) – (D) – (e) in the reporting year.



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 and removals of soil carbon from CM. The Tier 1 method described in Section 5.3.3, Chapter 5, Volume 4 of the *2006 IPCC Guidelines* for mineral soils assumes that a change in land use or management has an impact on carbon emissions and removals for a duration of 20 years; hence, under this tier and if a change in management has taken place since 1970, it is *good practice* to calculate the net carbon stock change in 1990 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 as long-term cropped organic soils. Tier 1 emission factors are provided in Table 5.6, Chapter 5, Volume 4 of the *2006 IPCC Guidelines* and updated by the *Wetlands Supplement* (see Footnote 1, Section 2.1 of this supplement).

The duration of impact of management practices on soil organic carbon may differ from the 20 years used as a default to reach a new equilibrium. 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 2.9.4 of this supplement).

If area and activity data are not available for 1970 to 1990, countries can establish the base year 1990 carbon stock change using the most appropriate time series to estimate the 1990 value, in a manner consistent with guidance provided in Section 5.3, Chapter 5, Volume 1 of *2006 IPCC Guidelines*. It is *good practice* to use a time period equivalent to 20 years that includes 1990 or as close to 1990 as possible.

The results of accounting on a net-net basis depend not just on changes in land management practices, but also partly on when the base year and commitment period years fall within the temporal dynamics of carbon sequestration processes. As noted above, carbon stock changes resulting from land use and land management changes on mineral soil tend to persist for about 20 years, after which the carbon levels approach a new

equilibrium carbon stock. The rate of carbon sequestration in mineral soil following a change in management in which carbon additions increase or carbon losses decline tends to be high in the first decades and then declines over time, as illustrated in Figure 2.9.2.

2.9.3 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 CM provided in Sections 1.1, 1.2, 2.1, and 2.2 of this supplement.

According to Decision 2/CMP.8[160], the geographical location of the boundaries of the area that encompass land subject to CM 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 land subject to CM, but does not have to. Instead, the boundaries of larger areas encompassing smaller lands subject to CM may be provided, along with estimates of the area subject to CM in each of the larger areas. In either case, the land subject to CM 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.

It is *good practice* to follow continuously the management of land that is subject to CM. This could be achieved by tracking land subject to CM from 1990 until the end of the commitment period (e.g. see Section 2.9.2 of this supplement). Alternatively, countries could develop statistical sampling techniques, consistent with the advice in Annex 3A.3, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*, which allow the transitions of management practices on lands subject to CM to be determined (see also Section 2.4.1 of this supplement).

At the national level, it is *good practice,* when developing a sampling strategy, to identify criteria that could be used to set up a stratified sampling scheme. Stratification criteria may include relatively static biophysical characteristics - such as climate and soil type, typical crop rotation systems, as well as management practices that tend to be more dynamic drivers of change in emissions and removals from carbon pools. Guidance on stratifying land to match data needs for estimating emissions and removals is provided in Section 3.3.2, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*.

Management factors that may be useful in establishing a national stratification scheme include:

- Degree of soil disturbance (e.g. tillage frequency and intensity)
- Level of input of crop biomass or organic amendment
- Crop rotation system
- Frequency of fallow practices
- Inclusion of woody biomass in the farming system (e.g. shelterbelts, orchards, other perennial plantations)
- Temporary use for livestock grazing

At higher tiers further subdivision of the CM area may be necessary.

For all resulting subcategories under CM, the areas derived from the conversion of forests (i.e. D) since 1990 need to be tracked separately as these will be reported as lands subject to D under Article 3.3 of the KP. Emissions and removals resulting from conversion of FM to CM due to the harvest and conversion of forest plantations to non-forest land could be reported under CEFC according to Decision 2/CMP.8[161].

2.9.4 Choice of methods for estimating carbon stock changes and non-CO_2 GHG

For CM, the *2006 IPCC Guidelines* give methodological guidance for estimating:

- Annual changes in carbon stocks of above- and below-ground biomass
- Annual changes of dead organic matter (DOM; dead wood and litter)

[160]Paragraph 2(d) in Annex II to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, p. 19.

[161]Paragraph 5(g) in Annex II to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, p. 21.

- Annual changes in organic carbon stocks in mineral soils and emissions and removals in organic soils
- Annual emissions of non-CO_2 gases from woody biomass burning

Section 2.3.6 of this supplement provides guidance on the choice of methods and for identifying whether CM is a *key category*. If CM is a *key category*, the inventory compiler should determine which subcategories such as mineral soil, organic soil or above-ground biomass, are significant. Section 1.3.3, Chapter 1 in Volume 4 of the *2006 IPCC Guidelines* suggests ranking subcategories according to their contribution to the aggregate *key category*. It is *good practice* to focus efforts towards methodological improvements of these significant subcategories.

Decision 2/CMP.7[162] specifies that a Party may choose not to account for a particular pool in a commitment period if transparent and verifiable information is provided that demonstrates that the pool is not a source. Requirements for reporting excluded pools and documenting that a pool is not a source can be found in Section 2.3.1 of this supplement. It is possible that Parties will use different tiers to prepare estimates for individual subcategories (e.g. changes in organic carbon stocks in mineral soils and emissions and removals in organic soils). Since different methods may yield different estimates, each with different levels of uncertainty, it is *good practice* to use the same tier and methodology for estimating carbon emissions and removals from each subcategory and pool for the full time series, for example, in the base year and during the commitment period.

Methods for estimating Cropland CO_2 emissions and removals or carbon stock changes for the base year and the commitment period are provided in Chapters 2 and 5, Volume 4 of the *2006 IPCC Guidelines*. The following sections of this supplement highlight aspects of these methods specific to the KP.

2.9.4.1 BIOMASS AND DEAD ORGANIC MATTER

For perennial crops (e.g. trees, shelterbelts and orchards), carbon stock changes in biomass and DOM pools should be estimated unless the Party to the KP chooses not to report on a certain pool and provides verifiable information that carbon stocks are not decreasing.

For carbon stock changes in biomass resulting from changes in CM, it is *good practice* for Parties to use the decision tree in Figure 2.9.1 to identify the appropriate tier to estimate carbon stock changes in biomass and DOM under the KP. Relevant methods for estimating carbon stock changes in above- and below-ground biomass, and DOM can be found in Sections 5.2.1 and 5.2.2, Chapter 5, Volume 4 of the *2006 IPCC Guidelines*, respectively. Default coefficients for above-ground woody biomass and harvest cycles in cropping systems containing perennial species are provided in Table 5.1; potential C storage for agroforestry systems in different eco-regions of the world are provided in Table 5.2; default above-ground biomass for various types of perennial croplands are given in Table 5.3 of Chapter 5, Volume 4 of the *2006 IPCC Guidelines*. Box 2.9.2 is an example of how to estimate carbon stock changes for biomass for fruit orchards.

[162]Paragraph 26 in the Annex to the Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p. 16.

BOX 2.9.2
EXAMPLE OF ESTIMATING BIOMASS CARBON CHANGES FOR FRUIT ORCHARDS

Canada chose to consistently include the orchards of fruit trees as a practice within CM. The general Canadian orchard recommendations are to replace about 5% of the orchard each year. Therefore it was assumed that the orchard consisted of an even representation of all age classes from 0 to 20 years. With this constant tree removal and addition to the orchard area, the gain in carbon from growing trees would equal the loss of carbon from removed trees. The loss of carbon from removed trees was assumed instantaneous. Because of intense pruning, above- and below-ground carbon stocks of fruit trees were considered to increase linearly with age. The average carbon stock of an orchard was therefore the equivalent of 10-year old fruit trees. Any conversion of orchards to other land uses was assumed to result from drivers other than old age class structure. Consequently, the loss of orchard was the equivalent of losing an average orchard of carbon stocks equivalent to an orchard composed of entirely 10-year old trees. New orchard areas were assumed to accumulate carbon stock linearly for 10 years, up to the amount of a 10-year old tree. After new orchard area had existed for 10 years, it was assumed that carbon stock removal equalled carbon stock gain because of regular tree removal and pruning so there is no further gain or loss of carbon.

2.9.4.2 SOIL CARBON

In most croplands, the main carbon flux associated with changes in land use and management for CM activities is from changes in organic carbon in soil. Chapter 5, Volume 4 of the *2006 IPCC Guidelines* identifies two sources or sinks of CO_2 from agricultural soils:

- Net changes in soil organic carbon associated with changes in land use and management on mineral soil;
- Emissions of CO_2 from cultivated organic soils (updated by the *Wetlands Supplement*).

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, Chapter 2, Volume 4 of the *2006 IPCC Guidelines* and updates in the *Wetlands Supplement* (see footnote 1, Section 2.1 of this supplement).

MINERAL SOILS

Methods for estimating mineral soil carbon stock changes resulting from changes in CM fall under one of three methodological tiers described in Sections 1.3.2 and 1.3.3, Chapter 1, Volume 4 of *2006 IPCC Guidelines*.

Methods for estimating carbon stock changes in mineral soils

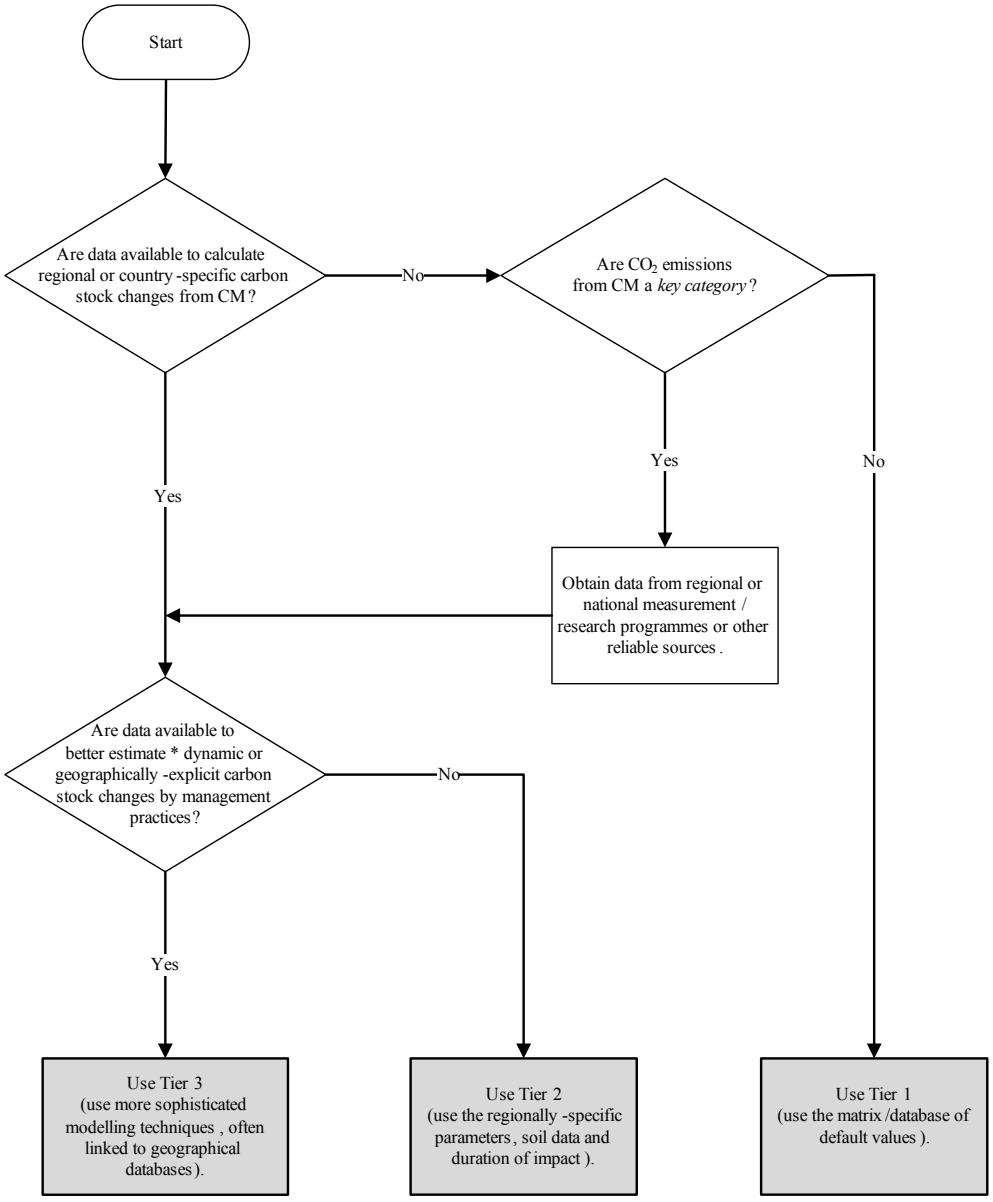
It is *good practice* to use the decision tree in Figure 2.9.1 to decide which tier to use for estimating carbon stock changes associated with changes in CM practices under the KP. It is *good practice* to use Tier 2 or Tier 3 methods for reporting carbon stock changes from mineral soils if CM is a *key category* and mineral soils are a significant subcategory under CM. It is *good practice* to follow continuously the CM practices from the base year through the commitment period as described in Section 2.9.3 of this supplement. For discussion of how to estimate the CM area, see Section 1.3 of this supplement.

Tier 1

The Tier 1 method for estimating carbon stock changes in mineral soils is described in Section 2.3.3.1, Chapter 2, and Section 5.2.3, Chapter 5 in Volume 4 of the *2006 IPCC Guidelines.* This guidance assumes a new equilibrium soil organic carbon stock is achieved after 20 years in a practice.

Section 5.2.3.4, Chapter 5 and Chapter 2 in Volume 4 of the *2006 IPCC Guidelines* outline the steps for estimating average annual rates of carbon stock change of in mineral soils of croplands using the default reference carbon stocks (Table 2.3), carbon stock change factors (Table 5.5) and Equation 2.25. The Tier 1 method can be used to estimate carbon flux resulting from changes in management practices across a range of temperature and moisture regimes and soil types. Box 2.9.3 (this supplement) provides an illustration of how to apply Tier 1 to estimate carbon stock changes for CM practices that are not continuous over time.

Figure 2.9.1 Decision tree for selecting the appropriate tier for estimating emissions and removals in the carbon pools under CM for KP reporting (see also Figure 2.4, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*)



* a better estimate improves consistency, comparability, completeness, accuracy and transparency.

Tier 2

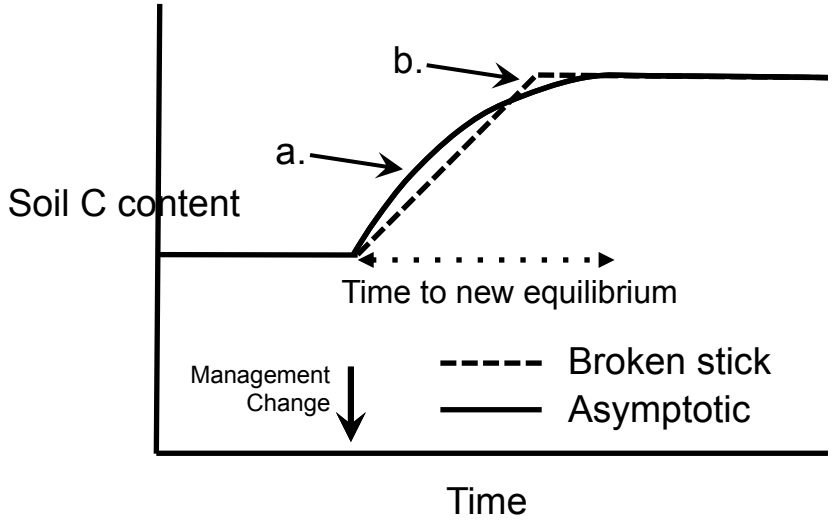
The Tier 2 method also uses the methodology described in Chapter 5, Volume 4 of the *2006 IPCC Guidelines*, but the default relative carbon stock change factors are replaced with region- or country-specific values. It is *good practice* to obtain region- or country-specific emissions factors from literature 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 region-specific carbon stock change factors better represent actual emissions and removals in a given region than default relative carbon stock change factors, rigorous criteria demonstrating that the more specific factors do not lead to under- or overestimation of the soil carbon stock change should be applied. Region- or country-specific factors should be based on verified soil carbon model estimates or measurements that are, in addition to being documented in accessible publications, conducted frequently enough, over a long enough time period and with sufficient spatial density to reflect variability of the underlying biochemical processes.

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 practices to reach a new equilibrium in soil carbon stocks.

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' in Figure 2.9.2), nor overestimated as the soil approaches the new equilibrium ('b' in Figure 2.9.2).

Figure 2.9.2 Schematic representation of a change in soil carbon stocks after a carbon-sequestering management change



At Tier 2, default factors associated with a land-use or 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 an annualized change in emissions or removals in the soil carbon pool. For example, in Europe, Smith *et al.* (2000) developed such relationships [e.g. average annualized soil carbon stock change (tonnes C ha^{-1} yr^{-1}) = 0.0145 x amount of animal manure (tonnes d. m. 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 should be applied in order to ensure emissions and removals are neither under- nor overestimated. It is *good practice* that stock change factors be based on experiments sampled according to the principles set out in Section 2.3.3, Chapter 2, Volume 4 of the *2006 IPCC Guidelines* and to use the experimental values if they are more appropriate than the default values for 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 or uncertainty estimates associated with regional, country-specific or local stock change factors.

Tier 3

Tier 3 methods generally encompass a range of methodologies that are more elaborate than Tier 2. Tier 3 methods are usually based on sophisticated modeling techniques and are often linked to geographical databases. 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 including rotational changes in land use. Like Tier 2 methods, Tier 3 methods can also take into account a longer time period to reach equilibrium than 20 years. Current computing power makes it possible to link spatially-disaggregated (stratified) land data to management practice data. Using these analytical systems, carbon stock changes can be estimated over time by linking equations describing the rate of change in soil carbon under specific management practices with carbon content, initialised by existing data 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, Chapter 3, Volume 4 of the *2006 IPCC Guidelines.* The sampling protocol should be of sufficient density to capture the soil types, climatic regions and management practices.

BOX 2.9.3
ILLUSTRATION OF ESTIMATING CARBON STOCK CHANGES FOR DISCONTINUOUS CROPLAND MANAGEMENT PRACTICES

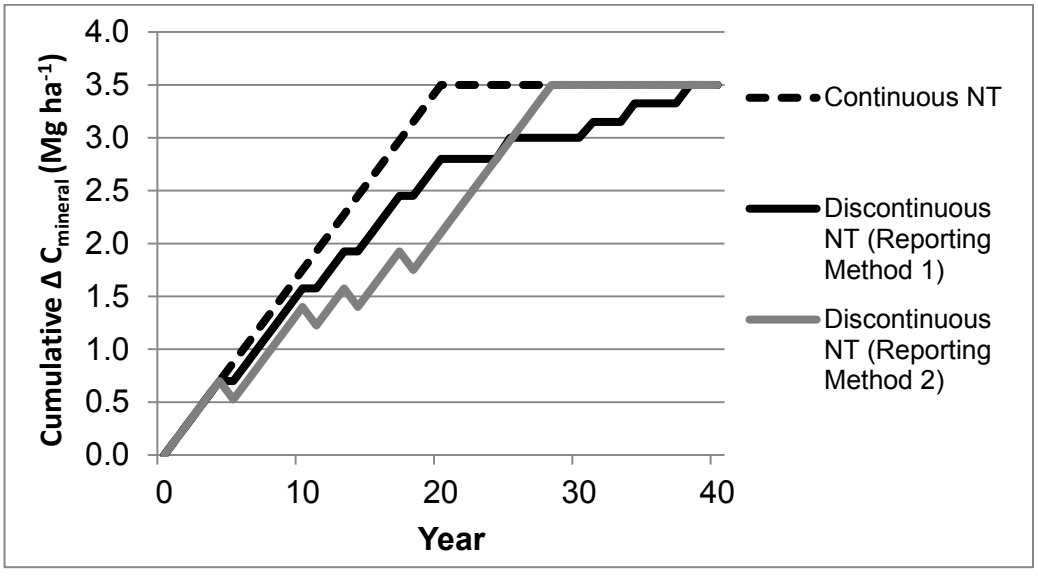
Many inventory compilers need to use Reporting Method 1 [non-spatially explicit aggregate statistics of total areas of practices (see Section 2.2.4 of this supplement)] for representing areas of CM practices due to a lack of available activity data. Using non-spatial data, it is not possible to discern if practices are continuous over time. This discontinuity in practice is expected to affect soil carbon stock change. This is a particular concern for no-till (NT) practices because it is not uncommon for there to be occasional tillage within NT cropping systems. The amount of accumulated additional carbon that is reduced from single tillage on land under long-term NT ranges from 0-11% (VandenBygaart and Kay, 2004; Koch and Stockfisch, 2006; Conant *et al.*, 2007; Quincke *et al.*, 2007). In some situations, however, more than a 30% loss of accumulated additional soil carbon occurs from single plowing of land that had been in long-term NT (VandenBygaart and Kay, 2004).

Tier 1 estimation methods can be applied for discontinuous CM practices when using Reporting Method 1. To illustrate, consider a parcel of land under NT with occasional full tillage (FT) and having consistent medium input. From Table 2.3 in Chapter 2, Volume 4 of the *2006 IPCC Guidelines,* the reference soil organic carbon stock is 34 Mg ha^{-1} and F_{LU}=0.69. This land parcel undergoes FT in years 5, 11, 14 and 18. As is necessary when using Reporting Method 1, each decrease of NT is assumed to occur on land that has been under NT for at least 20 years and each increase on land that has been under FT for at least 20 years. The carbon stock change is also assumed to continue for 20 years after a change in tillage is identified as a change in net areas under FT and NT. Following guidance in Chapters 2 and 5, Volume 4 of the *2006 IPCC Guidelines*, the effect of carbon change is calculated using Formulation A (Box 2.1 in Chapter 2) of annual soil organic carbon stock change (applying Equation 2.25 in Chapter 2 and Table 5.5 in Chapter 5). As shown in the figure below, the calculated cumulative $\Delta C_{mineral}$ is lower with occasional FT than for continuous NT; discontinuous NT is 80% of carbon stock change of continuous NT at year 20 until that land has been under NT for 20 years continuously (i.e. year 38). This is consistent with understanding of the effect of intermittent tillage on soil organic carbon on land otherwise under NT. This example illustrates that Tier 1 methods can be applied for discontinuous practices embedded within the data of net areas under different CM practices.

If, for the example presented, spatially explicit data were available in order to apply Reporting Method 2, the Tier 1 cumulative C stock change would be calculated using Formulation B (Box 2.1 in Chapter 2, Volume 4 of the *2006 IPCC Guidelines*). This estimate is shown in the figure below. As expected, in both cases of discontinuous NT, the estimated soil organic carbon changes are lower than those for continuous NT during the period of discontinuous NT.

If there are spatially explicit data on CM practices, it is *good practice* to use Reporting Method 2.

If there are available data on discontinuity of CM practices and on the effect of discontinuity in practice on soil organic carbon change, it is *good practice* to use higher tier methods.



Choice of carbon stock change factors for mineral soils

The carbon emission and removal factors used at each tier are described briefly in the following sections.

Tier 1

At Tier 1, average annualized carbon stock changes in mineral soils are calculated from default values by dividing the 20-year stock change by 20, as formulated in Equation 2.25 in Chapter 2, Volume 4 of *2006 IPCC Guidelines*. Default reference (under native vegetation) soil organic carbon stocks (SOC_{REF}) for mineral soils and 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}), Chapter 2 and Table 5.5 (for F_{LU}, F_I and F_{MG}), Chapter 5, Volume 4 of the *2006 IPCC Guidelines*, respectively. Management practice is assumed to influence stocks to a depth of 30 cm. For a summary of the steps, see Sections 2.3.3 and 5.2.3.4 of Chapters 2 and 5, Volume 4 of the *2006 IPCC Guidelines*.

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 specific to account for national or regional soil carbon stock changes. These new values may be based on literature values, measured changes in carbon stocks, carbon models, or a combination of these sources. (See 'Choice of management data for mineral soils' below for examples). It is *good practice* to derive relative stock change factor values for a higher resolution classification of management, climate, and soil types if, based on an empirical analysis, there are significant differences in the stock change factors among more disaggregated categories. 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 Section 2.3.3.1, Chapter 2, Volume 4 of the *2006 IPCC Guidelines*.

Tier 3

For mineral soils, Tier 3 approaches may use dynamic models and detailed soil C inventory measurements as the basis for estimating annual stock changes. Tier 3 methods may involve the use of country-derived carbon stock change factors which may be calculated using sophisticated models. The carbon models used for Tier 3 are generally more complex than those of 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 selected models and assumptions used are described transparently.

In all cases, rigorous criteria should be applied to ensure that any change in carbon stocks is neither under- nor overestimated; models used to estimate carbon stock changes should be well-documented and evaluated using reliable experimental data for conditions and practices to which the models are applied. It is *good practice* to provide confidence limits or uncertainty estimates according to the descriptions in Sections 5.2.3.5 and 5.3.3.5 in Chapter 5, Volume 4 of *2006 IPCC Guidelines*. Default carbon stock change factors may also be replaced by values that are generated as part of national or regional carbon accounting systems (see Section 2.9.3 of this supplement).

Choice of management data for mineral soils

Area data on land use and practices can be available according to either Reporting Method 1 or 2 as described in Section 2.2 of this supplement. Management data required for each of the three tiers are outlined briefly below.

Tier 1

Following Volume 4 of the *2006 IPCC Guidelines*, land management change is assumed, by default, to have an impact for 20 years. If area and activity data are available for the period 20 years prior to the base year, net carbon emissions and removals for the base year can be established using the default carbon stock change factors described above. The changes in management practices at Tier 1 are the same as those given in the *2006 IPCC Guidelines*: differing cultivation, tillage, and input levels. Within these specific management changes, activities are defined semi-quantitatively, for example: low, medium or high inputs without manure; high inputs with manure; full, reduced and no-till systems. Area data may be obtained from international data sets (e.g. FAO World Census of Agriculture, FAOSTAT), 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 to 1990, countries can establish the 1990 carbon stock change using the most appropriate time series to estimate the 1990 value, in a manner consistent with guidance provided in Section 5.3, Chapter 5, Volume 1 of the *2006 IPCC Guidelines*. It is *good practice* to use a time period equivalent to 20 years that includes 1990 or as close to 1990 as possible.

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 subdividing annual cropping input categories (e.g. 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 incorporate 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 should be applied so that emissions in the base year and removals in each year of the commitment period are 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.

ORGANIC SOILS

It is *good practice* to use the decision tree in Figure 2.9.1 to decide which tier to use for estimating emissions and removals in organic soils associated with changes in CM under the KP. It is *good practice* to use Tier 2 or Tier 3 methods for reporting emissions and removals in organic soils if CM is a *key category* and organic soils are a significant subcategory under CM.

Methods for estimating CO_2 emissions and removals from organic soils

When organic soils are converted to or managed for agriculture, they are typically drained, tilled and fertilised, resulting in on-site CO_2 emissions to the atmosphere as well as waterborne carbon losses that lead to off-site CO_2 emissions. Countries may use methods of different tier levels 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, nutrient status and practices such as fertilisation and liming. Oxidation of organic material 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 no longer feasible. Drained organic soils under CM can be rewetted while remaining under CM. Guidance on rewetting and drainage of organic soils can be found in Section 2.12 of this supplement. The *Wetlands Supplement* contains updated and new methodological guidance for estimating GHG emissions and removals from organic soils (see Footnote 1, Section 2.1 of this supplement).

Tier 1

The Tier 1 approach is described in Section 2.3.3 of Chapter 2 and Section 5.2.3.4 of Chapter 5, Volume 4 of the *2006 IPCC Guidelines* and updated by Chapters 2 and 4 of the *Wetlands Supplement*, which include guidance for on-site CO_2 (including peat fires), off-site CO_2 and CH_4 from drained organic soils and drainage ditches (see Footnote 1, Section 2.1 of this supplement).

Tier 2

If 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 of the national conditions, than defaults. It is *good practice* to use a finer classification for climate and management practices, such as 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 GHG emissions in an integrated way. However, the non-CO_2 emissions should be reported under Agriculture (see Section 2.4.4.2 of this supplement), and double-counting and omissions should be avoided. It is *good practice* to use models that are calibrated using measurements at benchmark sites, and to describe transparently the models and assumptions used.

Choice of carbon emission and removal factors for organic soils

Tier 1

The Tier 1 default emission and removal factors are provided in Table 5.6, Chapter 5, Volume 4 of the *2006 IPCC Guidelines* and updated by Chapters 2 and 4 of the *Wetlands Supplement* for on-site CO_2 (including peat fires), off-site CO_2 and CH_4 from drained organic soils and drainage ditches (see Footnote 1, Section 2.1 of this supplement).

Tier 2

For organic soils, it is *good practice* to replace the default values with country- or region-specific factors. It is *good practice* to use country- or region-specific emission and removal factors derived from measurements or experiments within the region that are well-designed and employ adequate sampling and coverage. It is *good*

practice to provide confidence limits or uncertainty estimates associated with any country- or region-specific emission and removal factors.

Tier 3

For organic soils, CO_2 emissions and removals may be estimated using a model or measurement based approach. Time-dependent emission and removal factors capture more accurately the effects of land-use and management changes. Dynamic models could 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 using country- or region-specific field data.

Choice of management data for organic soils

The same considerations apply as for management data for CM activities on mineral soils, as described in Section 2.9.4.2 of this supplement.

Area data on land use and practices can be available according to either Reporting Method 1 or 2 as described in Section 2.2 of this supplement. Management data required for each of the three tiers are outlined briefly below.

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, peat thickness, and technical possibilities of deepening the drainage base in the subsiding land. Net carbon emissions and removals from the soil in the base year can be established based on data from only the base year. The types of land-use changes and management practices that occur at Tier 1 are in principle 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 organic soil type if appropriate emissions factors for on-site and off-site CO_2 emissions and removals are available. In many instances, standard drainage depths are used in management practices and disaggregation may not be useful for improving the accuracy of the emission and removal estimates. Where significant variation in drainage depth exists for different management practices, and where appropriate emission and removal factors exist, it is *good practice* to improve the accuracy of an inventory by, for example, separating out drainage classes. Tier 2 methods may require area descriptions of higher resolution than those in Tier 1. Rigorous criteria should be applied to ensure that any change in emissions or removals is neither under- nor overestimated.

Tier 3

Management data used in the more sophisticated Tier 3 methodologies need to be consistent with the level of detail required by the model. It is *good practice* to use quantitative management data at a spatial resolution appropriate for the model.

2.9.4.3 NON-CO_2 GHG EMISSIONS FROM *IN-SITU* ABOVE-GROUND WOODY BIOMASS BURNING

In-situ above-ground woody biomass burning is reported under CM. The decision tree in Figure 2.9.1 provides general guidance for applying the appropriate tier level. Equation 2.27 in Chapter 2 and Section 5.2.4 in Chapter 5, Volume 4 of the *2006 IPCC Guidelines* give guidance for estimating N_2O and CH_4 emissions from *in-situ* above-ground woody biomass burning. If CM is a *key category* and *in-situ* above-ground woody biomass burning is significant, it is *good practice* that Parties use either Tier 2 or Tier 3 methods.

2.9.4.4 REPORTING[163,164] NON-CO_2 GHG EMISSIONS AND CO_2 EMISSIONS FROM LIMING AND UREA APPLICATION

The non-CO_2 GHG emissions associated with soil management on land under CM as well as CO_2 emissions from liming and urea application are in most cases not reported under CM but under the Agriculture Sector.

[163] According to paragraph 1 of Annex II to decision 2/CMP.8 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 KP (FCCC/KP/CMP/2012/13/Add.1, p.18).

[164] The reporting categories for the emissions will be considered by SBSTA at its 39th session. Any change to the decisions about reporting of these emissions should also be reflected in the reporting under the KP LULUCF activities.

When reporting these emissions, it is *good practice* to ensure consistency, completeness and no double-counting under Agriculture or CM (see Section 2.4.4.2 of this supplement).

2.9.4.5 THE TRADE-OFFS AND SYNERGIES OF CM ON SOIL CARBON STOCKS AND NON-CO_2 GASES

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 Chapters 5 and 11, Volume 4 of the *2006 IPCC Guidelines*, but there may be other effects on non-CO_2 gases not considered. The effects on non-CO_2 emissions of these and other management practices may be included in higher tier methods for estimating CM emissions and removals. Examples of how these effects could be estimated include: 1) direct measurement of the non-CO_2 GHG at representative sites and 2) estimation of emission rates based on literature values taking into account management, soil and climate. Box 2.9.4 gives examples of such potential trade-offs and synergies.

BOX 2.9.4
EXAMPLES OF POSSIBLE INFLUENCES OF REDUCED TILLAGE ON N_2O EMISSION

Adoption of reduced tillage or NT often increases soil carbon in croplands. At the same time, however, it may also alter N_2O emissions, through effects on porosity (and the fraction of the porosity occupied by water; (Ball *et al.*, 2008), nitrogen and carbon cycling (Six *et al.*, 2004; Drury *et al.*, 2006; Ahmad *et al.*, 2009) 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 NT 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), while others show little effect or lower N_2O emissions (Helgason *et al.*, 2005; Venterea *et al.*, 2005; Elder and Lal, 2008; Gregorich *et al.*, 2008; Petersen *et al.*, 2008; Bhatia *et al.*, 2010; Chirinda *et al.*, 2010). The available data suggest that this variable response depends on interactive effects of soil and climate, and that more wet environments with poorer aeration, in which N_2O emissions generally tend to be highest, are also associated with higher emissions under NT than under conventional tillage (Ball *et al.*, 2008).

2.10 GRAZING LAND MANAGEMENT

2.10.1 Definitional issues and reporting requirements

Grazing Land Management (GM) is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced[165]. Lands under GM are predominantly used for production of herbaceous perennial vegetation (introduced or indigenous) for harvest by grazing, cutting, or both.

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 and elected under Article 3.4. This will enhance the comparability of reporting across countries and ensure there is no double-counting of GHG emissions and removals.

Parties 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 GM in the reporting year need to be identified, tracked and reported as a separate category under D (see Section 2.6 of this supplement).

Some lands included under GM may have trees or shrubs. In the first commitment period, some countries included certain types of lands with woody biomass under GM, even if the cover met the thresholds for forest. For consistency and to achieve transparency in reporting, it is *good practice* in the second commitment period for those countries to ensure that double-counting with FM is avoided and to document how consistency is achieved with KP activities reported previously. Further guidance is provided in Section 1.2 of this supplement.

Permanent grasslands, pastures, rangelands or savannahs are normally included under GM if growing of forage crops or grazing is the most important activity on the area (see Section 1.2 of this supplement). Protected lands, such as those subject to permanent cover programmes, are also normally included under GM if they are also used for livestock production. Treed areas on grassland or being grazed that were established after 1990 and meet the definition of a forest can qualify as AR, and if they do, are included under those categories (see Section 1.3 of this supplement). Recognizing that the forest definition is threshold based, in order to achieve consistency with established practice during the first commitment period, countries can continue to report by taking account of predominant land use, as reviewed under the provisions of the KP (Section 1.2 of this supplement).

Areas under CM that are only temporarily used for grazing, as part of a cropping rotation, would normally be included under CM (see Section 2.9 of this supplement). If CM is not elected, such land can be included under GM, subject to national criteria that are consistently applied. If a country reports all cropland and grassland used for livestock production under CM (or GM), then the Party does not need to differentiate between CM or GM activities. If GM is elected with CM, it is *good practice* to include all cropland under CM and all grassland used for livestock production under GM (see Chapter 1 of this supplement). The criteria used to distinguish between land under CM and GM needs to be explicitly stated and applied consistently based on national definitions.

If GM is elected with RV (see Section 2.11 of this supplement), the criteria used to distinguish between land under RV and GM needs to be explicitly stated and applied consistently based on national definitions. It is *good practice* to include revegetated land that is used predominantly for production of livestock under GM.

The aim of reporting is to identify and report trends in the carbon stocks resulting from GM over time. The methodology for estimating CO_2 emissions and 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 management practices have not changed over a long period, the carbon stocks are assumed to be at equilibrium, and hence the change in carbon stocks is deemed to be zero. Parties are encouraged to use methods that show systematic changes in the carbon stocks 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 land under GM. Box 2.10.1 provides an example of practical application of elected GM.

[165]Paragraph 1(h) in the Annex to Decision 16/CMP.1 contained in document FCCC/KP/CMP/2005/8/Add.3, p.5.

BOX 2.10.1
GRAZING LAND MANAGEMENT – COUNTRY EXAMPLE

Denmark elected GM. The land included in GM is equal to the area of permanent grassland. Grassland is defined as all land not meeting the definitions of Forest Land, Cropland, Wetlands, or Settlements and is identified using remote sensing. All grass in rotation with annual crops is included within Cropland. Grassland includes land identified as under permanent grazing plus any other permanent grassland regardless of grazing. Denmark uses the same carbon stock change estimation methods for Grassland for national inventory reporting as used for GM for reporting for the KP. Grazing on Grassland is extensive and carbon stocks of mineral soils are estimated not to change over time. Some carbon stock losses occur under grazing management as emissions from organic soils under Grassland remaining Grassland and residual C losses from Land converted to Grassland in the past. The number of days of grazing within GM is also used in the estimates of N_2O emissions from nitrogen deposited from grazing animals. This ensures consistent reporting between N_2O emissions under Agriculture and CO_2 emissions under GM for the KP.

To use the proposed methodology for determining carbon stock change, the total GM area needs to be subdivided into areas of mineral and organic soils. The lands under GM are also subdivided 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, Chapter 6, Volume 4 of the *2006 IPCC Guidelines*. GM practices that affect carbon stocks include animal stocking rate, fertility management, irrigation management, species composition and fire management. 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, while others may be in equilibrium and this may change if management changes. Further details can be found in Chapter 6, Volume 4 of the *2006 IPCC Guidelines.* See also Section 2.10.2 of this supplement.

2.10.2 Base year

Under Article 3.4 of the KP, emissions and removals resulting from GM are estimated using a net-net accounting approach (as are all elective activities under Article 3.4). Net-net accounting requires that GHG emissions and removals are estimated for the base year and each year of the commitment period[166]. This entails determining the total area under GM 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 GHG emissions from GM are covered in Chapters 10 and 11, Volume 4 of the *2006 IPCC Guidelines*. Guidance on reporting those non-CO_2 GHG emissions under Agriculture is identical to that provided in Section 2.9.4.4 and 2.4.4.2 of this supplement.

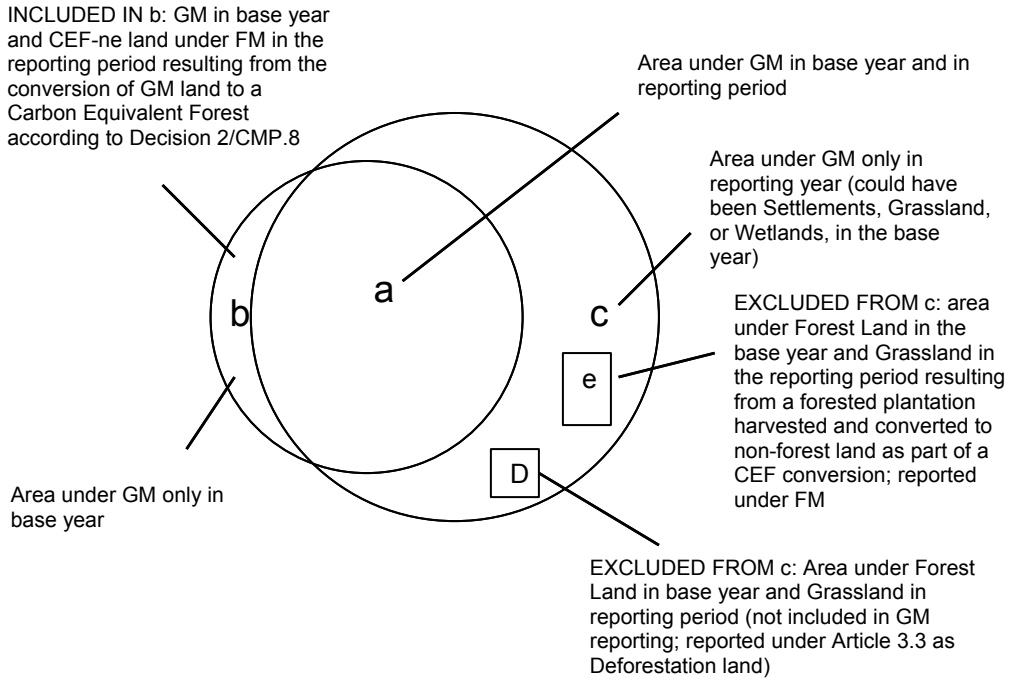
For most Parties with commitments under the KP, the base year is 1990. Under the provisions of Article 4.6 of the UNFCCC and Article 3.5 of the KP, however, Parties with economies in transition (EITs) are granted some flexibility on the level of historical emissions chosen as a reference.

If the area under GM changes significantly between the base year and the commitment period, this may lead to estimates on the basis of moving land (that is, subtraction of stock changes on a land base that changes in size over time; see Box 2.10.2). For GM, the guidance provided in the *GPG-LULUCF* (Box 4.2.8) acknowledges that some of the area of the activity in the 'base year only' may no longer be reported under that activity in the reporting year. Where this area is not transferred to another reported activity the associated emissions and removals will be accounted as zero in that year. In order to achieve transparency in reporting, it is *good practice* to describe the consequences of this exclusion on reported emissions and removals.

[166]Net-net accounting refers to the provisions of paragraph 10 of the Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/Add.1, p.14.

BOX 2.10.2
AN EXAMPLE OF GRAZING LAND MANAGEMENT AREAS IN BASE YEAR AND IN THE COMMITMENT PERIOD (NET-NET ACCOUNTING)

In this example the area under GM in the base year expands to a larger area in the reporting year during the commitment period. Some of the area was under GM in both the base year and during the reporting period (a). Some of the area under GM in the base year is no longer under GM in the reporting year (b). There are also areas under GM in the reporting year that were not under GM in the base year (c). Area (D) is under GM, but was subject to Deforestation (D) which takes precedence. Area (e) has been converted to cropland, but remains under FM under the CEFC provision. Under the KP, the emissions and removals in areas (a) + (b) in the base year are compared to emissions and removals in areas (a) + (c) – (D) –(e) in the reporting year.



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 and removals of soil carbon from GM. The Tier 1 method described in Section 6.3.3, Chapter 6, Volume 4 of the *2006 IPCC Guidelines* for mineral soils assumes that a change in land use or 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 as long-term drained organic soils, with Tier 1 emission factors provided in Chapter 2 of the *Wetlands Supplement* (see Footnote 1, Section 2.1 of this supplement).

The duration of impact of management practice on soil organic carbon may be different from the default period of 20 years used to reach a new equilibrium. 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 2.10.4 of this supplement).

If area and activity data are not available for 1970 to 1990, countries can establish the base-year 1990 carbon stock change using the most appropriate time series to estimate the 1990 value, in a manner consistent with guidance provided in Section 5.3.1, Chapter 5, Volume 1, of the *2006 IPCC Guidelines*. It is *good practice* to use a time period equivalent to 20 years that includes 1990 or as close to 1990 as possible.

The results of accounting on a net-net basis depend not just on changes in land management practices, but also partly on when 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 management changes on mineral soil tend to persist for about 20 years, after which the carbon levels of land under GM approaches a new equilibrium carbon stock. The rate of carbon sequestration in land under GM following a change in management in which carbon additions increase or carbon losses decline tends to be high in the first decades and then declines over time, as illustrated in Figure 2.9.2 of this supplement. This will be reflected in net sinks and sources in the accounting.

2.10.3 Choice of methods for identifying lands subjected to Grazing Land Management

General guidance on consistent representation of lands is provided in Chapter 4 of the *2006 IPCC Guidelines* with additional guidance about identification of lands subject to GM provided in Sections 1.1, 1.2, 2.1, and 2.2 of this supplement.

According to Decision 2/CMP.8[167], the geographical location of the boundaries of the area that encompass land subject to GM 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 land subject to GM, but does not have to. Instead, the boundaries of larger areas encompassing smaller lands subject to GM may be provided, along with estimates of the area subject to GM in each of the larger areas. In either case, the land subject to GM 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.

It is *good practice* to follow continuously the management of land subject to GM. The tracking can be achieved by continuously tracking land subject to GM from 1990 until the end of the commitment period (see Section 2.10.1). Alternatively, countries could develop statistical sampling techniques, consistent with the advice in Annex 3A.3, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*, which allow the transitions of management practice on GM land to be determined (see also Section 2.4.1 of this supplement).

At the national level, it is *good practice,* when developing a sampling strategy, to identify criteria that could be used to set up a stratified sampling scheme. 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 carbon pools.

Management factors and disturbance information that may be useful in establishing a national stratification scheme include:

- Level of input of biomass or grassland productivity, manure, and other organic amendments
- Grazing intensity (stocking rate, frequency, seasonality)
- Prescribed fire
- Re-seeding
- Irrigation management
- Drainage
- Inclusions of woody biomass (e.g. shrubland, shelterbelts, other perennial plantations on grazed lands)

For all resulting subcategories under GM, the area derived from conversion of forests (i.e. D) since 1990 need to be tracked separately, as these will be reported as units of lands subject to D (See Section 2.6 of this supplement). Emissions and removals resulting from conversion of FM to GM due to the harvest and conversion of forest plantations to non-forest land could be reported under CEFC according to Decision 2/CMP.8[168].

At higher tiers, further subdividing of the area subject to GM may be necessary. Methods to identify lands subject to GM 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 GM 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 statistically based, plot-sampling system: land use and management activities are monitored at specific permanent sample plots that are revisited on a regular basis.

[167]Paragraph 2(d) in Annex II to Decision 2/CMP.8.contained in document FCCC/KP/CMP/2012/13/Add.1., p.19.

[168]Paragraph 5(g) in Annex II to Decision 2/CMP.8 contained in document FCCC/KP/CMP/2012/13/Add.1, p.21.

Information on these areas either needs to be compiled for all lands subject to GM or summarised as estimates for all the strata (defined by the boundaries of the areas of GM) that a Party chooses to apply for the reporting of its land use statistics. Further *good practice* guidance on identifying land areas is provided in Section 2.2 of this supplement.

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

It is *good practice* to report GM following the *2006 IPCC Guidelines* methodologies for grassland estimates of:

- Annual changes in carbon stocks of above- and below-ground biomass;
- Annual changes of dead organic matter (dead wood and litter; DOM);
- Annual changes in organic carbon stocks in mineral soils and emissions and removals in organic soils;
- Annual emissions of non-CO_2 gases from woody biomass burning.

Section 2.3.6 of this supplement provides guidance about the choice of methods and identifying whether GM is a *key category*. If GM is a *key category*, the inventory compiler can determine if certain subcategories, such as mineral soil or above-ground biomass, are significant. Section 1.3.3, Chapter 1, Volume 4 of the *2006 IPCC Guidelines* suggests ranking subcategories according to their contribution to the aggregate *key category*. It may be appropriate to focus efforts towards methodological improvements of the significant subcategories (see Section 2.3.6 of this supplement).

Decision 2/CMP.7[169] specifies that a Party may choose not to account for a particular pool in a commitment period, if transparent and verifiable information is provided that demonstrates that the pool is not a source. Requirements for reporting excluded pools and documenting that a pool is not a source can be found in Section 2.3.1 of this supplement. It is possible that Parties will use different tiers to prepare estimates for individual subcategories (e.g. changes in organic carbon stocks in mineral soils and emissions and removals in organic soils). Since different methods may yield different estimates, each with different levels of uncertainty, it is *good practice* to use the same tier and methodology for estimating carbon emissions and removals from each subcategory and pool for the full time series, for example, in 1990 and during the commitment period.

Methods for estimating GM carbon emissions and removals for the base year and the commitment period are provided in Chapter 2 and Chapter 6, Volume 4 of the *2006 IPCC Guidelines*. The following sections of this supplement highlight aspects of these methods specific to the KP.

2.10.4.1 BIOMASS AND DEAD ORGANIC MATTER

Without changes in management practices, herbaceous grassland vegetation is assumed to cycle annually such that biomass gains equal biomass losses in a single year. For perennial woody biomass, carbon stock changes in biomass and DOM pools should be estimated unless the Party to the KP chooses not to report on a certain pool and provides verifiable information that carbon stocks are not decreasing.

For carbon stock changes in biomass resulting from changes in GM, it is *good practice* for Parties to use the decision tree in Figure 2.10.1 to identify the appropriate tier to estimate carbon stock changes in biomass and DOM under the KP. Relevant methods for estimating carbon stock changes in above- and below-ground biomass, and DOM can be found in Sections 6.2.1 and 6.2.2, Chapter 6, Volume 4 of the *2006 IPCC Guidelines*, respectively. Default coefficients for above-ground woody biomass and harvest cycles in agroforestry or silvopastoral systems containing perennial species are provided in Table 6.1, Chapter 6, Volume 4 of the *2006 IPCC Guidelines*.

2.10.4.2 SOIL CARBON

In most grasslands, the main carbon emissions and removals associated with changes in land use and management for GM activities is from changes in organic carbon in soil. The *2006 IPCC Guidelines* identifies two sources or sinks of CO_2 from agricultural soils:

- Net changes in soil organic carbon associated with changes in land use and management on mineral soil (Chapter 6);

[169]Paragraph 26 in the Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p.16.

- Emissions of CO_2 from drained organic soils (updated by Chapters 2 and 4 of the *Wetlands Supplement;* see footnote 1, Section 2.1 of this supplement).

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 6 and Equation 2.24 of Chapter 2, Volume 4 of the *2006 IPCC Guidelines* and updated in the *Wetlands Supplement* (see footnote 1, Section 2.1 of this supplement).

MINERAL SOILS

Methods for estimating mineral soil carbon stock changes resulting from changes in GM fall under one of three methodological tiers described in Sections 1.3.2 and 1.3.3, Chapter 1, Volume 4 of the *2006 IPCC Guidelines*.

Methods for estimating carbon stock changes in mineral soils

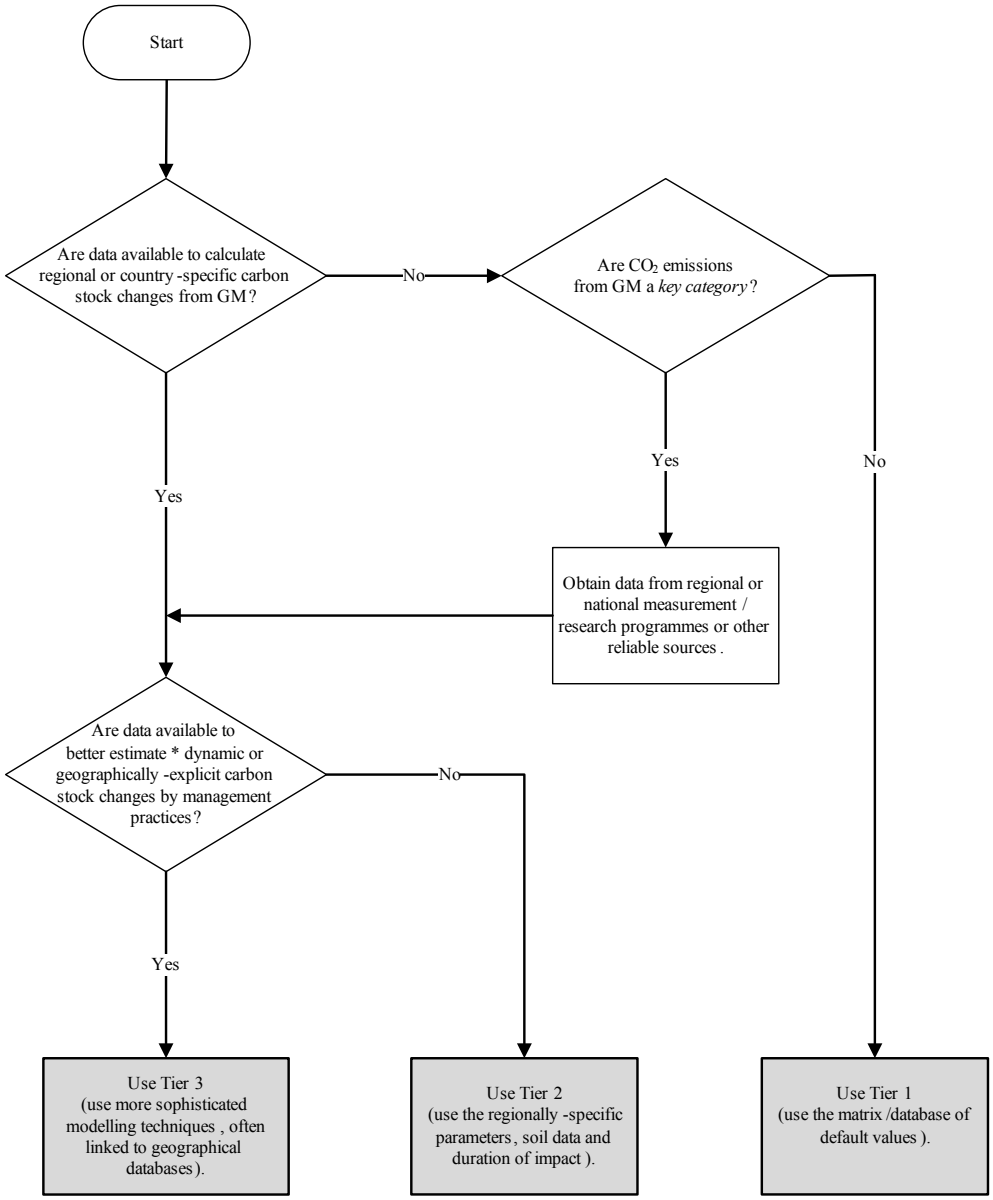
The decision tree in Figure 2.10.1 should be used to decide which tier to use for estimating carbon stock changes associated with changes in GM practices under the KP. It is *good practice* to use Tier 2 or Tier 3 methods if mineral soils are a significant subcategory under GM. It is *good practice* to follow continuously the GM practices from the base year through the commitment period as described in Section 2.10.3 of this supplement. For discussion of how to estimate the GM area, see Section 1.3 of this supplement.

Tier 1

The Tier 1 method for estimating carbon stock changes in mineral soils is described in Section 2.3.3.1, Chapter 2, Volume 4 and Section 6.2.3, Chapter 6 in Volume 4 of the *2006 IPCC Guidelines.* This guidance assumes a new equilibrium soil organic carbon stock is achieved after 20 years in a practice.

Section 6.2.3.4, Chapter 6 and Chapter 2 in Volume 4 of *2006 IPCC Guidelines* outlines the steps for estimating average annualized rates of organic carbon stock change in mineral soils of grasslands using the default reference carbon stocks (Table 2.3), carbon stock change factors (Table 6.2) and Equation 2.25. The Tier 1 method can be used to estimate carbon emissions and removals resulting from changes in management practices across a range of temperature and moisture regimes and soil types. Box 2.9.3 provides an illustration of how to apply Tier 1 to estimate carbon stock changes for CM practices that are not continuous over time, which is also applicable for GM.

Figure 2.10.1 Decision tree for selecting the appropriate tier for estimating emissions and removals in carbon pools under GM for KP reporting (see also Figure 2.4, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*)



* a better estimate improves consistency, comparability, completeness, accuracy and transparency.

Tier 2

The Tier 2 method also uses the methodology described in Chapter 6, Volume 4 of the *2006 IPCC Guidelines*, but now the default relative carbon stock change factors are replaced with region- or country-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 region-specific carbon stock change factors better represent actual emissions and removals in a given region than default relative carbon stock change factors, rigorous criteria demonstrating that the more specific factors do not lead to under- or overestimation of the soil carbon stock change should be applied. Region- or country-specific factors should be based on verified soil carbon model estimates or measurements that are, in addition to being documented in accessible publications, conducted frequently enough, over a long enough time period and with sufficient spatial density to reflect variability of the underlying biochemical processes.

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 GM practices to reach a new equilibrium in soil carbon stocks.

Rigorous criteria should be applied in order to ensure that any carbon stock change is neither under- nor overestimated. It is *good practice* that stock change factors be based on experiments sampled according to the principles set out in Section 2.3.3, Chapter 2, Volume 4 of *2006 IPCC Guidelines*, and to use experimental values if they are more appropriate than the default values for 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 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. Tier 3 methods are usually based on sophisticated modeling techniques, and are often linked to geographical databases. 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 including rotational changes in land use. Like Tier 2 methods, Tier 3 methods can also take into account a longer time period sufficient to reach equilibrium (i.e. longer than 20 years). Current computing power makes it possible to link spatially disaggregated (stratified) land data to management practice data. The analytical system can estimate carbon stock changes over time by linking equations describing the rate of change in soil carbon under specific management practices with carbon contents, initialised by existing data 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, Chapter 3, Volume 4 of the *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

Tier 1

At Tier 1, average annualized carbon stock changes in mineral soils are calculated from default values by dividing the 20-year stock change by 20, as set out in Equation 2.25, Chapter 2, Volume 4 of the *2006 IPCC Guidelines*. Default reference (under native vegetation) soil organic C stocks (SOC_{REF}) for mineral soils and 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 6.2 (for F_{LU}, F_I and F_{MG}) in Chapters 2 and 6, respectively, of Volume 4 of the *2006 IPCC Guidelines*. Management practice is assumed to influence stocks to a depth of 30 cm. For a summary of the steps, see Section 2.3.3, Chapter 2 in Volume 4 of the *2006 IPCC Guidelines*.

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 specific to account for national or regional soil carbon stock changes. These new values may be based on literature values, measured changes in carbon stocks, carbon models, or a combination of these sources. (See 'Choice of management data for mineral soils' below for 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 carbon stocks (SOC_{REF}) can also be derived from country-specific data in a Tier 2 approach. Additional guidance is provided in Section 2.3.3.1, Chapter 2, Volume 4 of the *2006 IPCC Guidelines*.

Tier 3

For mineral soils, Tier 3 approaches may use dynamic models and or detailed soil carbon inventory measurements as the basis for estimating annual stock changes. Tier 3 methods may involve the use of country-derived carbon stock change factors which may be calculated using sophisticated 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. species introduction or removal, carbon inputs, fertility amendments, vegetation utilization by grazing livestock). *Good practice* requires that the models be calibrated using measurements at benchmark sites, and that models and assumptions used are described transparently.

In all cases, rigorous criteria should 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 confidence limits or uncertainty estimates according to the descriptions in Sections 6.2.3.5 and 6.3.3.5, Chapter 6, Volume 4 of the *2006 IPCC Guidelines*. Default carbon stock change factors may also be replaced by values generated as part of national or regional carbon accounting systems (see Section 2.10.3 of this supplement).

Choice of management data for mineral soils

Area data on land use and practices can be available according to either Reporting Method 1 or 2 as described in Section 2.2 of this supplement. Management data required for each of the three tiers are outlined briefly below.

Tier 1

Following Volume 4 of the *2006 IPCC Guidelines*, impacts of 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 emissions and removals for the base year can be established using the default carbon stock change factors described above. The changes in management practices at Tier 1 are the same as those given in the *2006 IPCC Guidelines*: differing degradation states, improved vs. unimproved grassland, and differing input levels for improved grassland. Within these specific management changes, activities are defined semi-quantitatively, e.g. non-, moderately-, and severely-degraded. Areas may be obtained from international data sets (e.g. FAO, World Census of Agriculture, FAOSTAT), 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 to 1990, countries can establish the 1990 carbon stock change using the most appropriate time series to estimate the 1990 value, in a manner consistent with guidance provided in Section 5.3, Chapter 5, Volume 1 of the *2006 IPCC Guidelines*. It is *good practice* to use a time period equivalent to 20 years that includes 1990 or as close to 1990 as possible.

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. These can include further subdivisions of GM categories (e.g. nature of degradation, improved grassland subdivided by vegetation community). It is *good practice* to further subdivide default classes based on empirical data that demonstrates significant differences in soil organic carbon 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. 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 or removal factor. Alternatively, well-calibrated and well-evaluated models of soil carbon change, e.g. RothC (Coleman and Jenkinson, 1996; Shirato *et al*., 2004) 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. In any case, rigorous criteria should be applied so that emissions in the base year and removals in the inventory year are neither under- nor overestimated.

Tier 3

Management data used in the more sophisticated 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), measured/estimated activity data based on national statistics (e.g. herbage yield, input level of organic amendment), and detailed data of the combination of climate, soil and management are needed.

ORGANIC SOILS

It is *good practice* to use the decision tree in Figure 2.10.1 to decide which tier to use for reporting carbon stock changes in organic soils under the KP.

Methods for estimating CO_2 emissions and removals from organic soils

When organic soils are converted to or managed for agriculture, they are typically drained, tilled and fertilised, resulting in on-site CO_2 emissions to the atmosphere as well as waterborne carbon losses that lead to off-site CO_2 emissions. Countries may use methods of different tier levels 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, nutrient status and practices such as fertilisation and liming. Oxidation of organic material 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 no longer feasible. Drained organic soils under GM can be rewetted while remaining under GM. Guidance on rewetting and drainage of organic soils can be found in Section 2.12 of this supplement. The *Wetlands Supplement* contains updated and new methodological guidance for estimating GHG emissions and removals from drained and rewetted organic soils, (see Footnote 1, Section 2.1 of this supplement).

Tier 1

The Tier 1 method for estimating emission and removals in organic soils is described in Sections 2.3.3 and 6.2.3.2, Chapters 2 and 6, Volume 4 of the *2006 IPCC Guidelines*, which include guidance for on-site CO_2 (including peat fires), off-site CO_2 and CH_4 from drained organic soils and drainage ditches (see Footnote 1, Section 2.1 of this supplement).

Tier 2

If 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 if organic soils are a significant subcategory under GM. 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, such as 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 GHG emissions in an integrated way. However, double-counting and omissions in relation to reporting under Agriculture (see section 2.4.4.2 of this supplement) need to be avoided.

Choice of carbon emission and removal factors for organic soils

Tier 1

The Tier 1 default emission and removal factors are provided in Table 6.3, Volume 4 Chapter 6 of the *2006 IPCC Guidelines* updated for on-site CO_2 (including peat fires), off-site CO_2 and CH_4 from drained organic soils and drainage ditches (see Footnote 1, Section 2.1 of this supplement).

Tier 2

For organic soils, it is *good practice* to replace the default values with country- or region-specific factors. It is *good practice* to use country- or region-specific emission and removal factors derived from measurements or experiments within the region that are well-designed and employ adequate sampling and coverage. It is *good practice* to provide confidence limits or uncertainty estimates associated with any country- or region-specific emission and removal factors.

Tier 3

For organic soils, CO_2 emissions and removals may be estimated using a model or measurement based approach. Time-dependent emission and removal factors capture more accurately the effects of land-use and management changes. Dynamic models could 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 using country- or region-specific field data.

Choice of management data for organic soils

The same considerations apply as for management data for GM activities on mineral soils, as described earlier in Section 2.10.3 of this supplement.

Area data on land use and practices can be available according to either Reporting Method 1 or 2 as described in Section 2.2 of this supplement. Management data required for each of the three tiers are outlined briefly below.

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 emissions and removals 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.

If rewetting of organic soils for GM occurs additional guidance for those lands is found in Chapter 3 of the *Wetlands Supplement* (see Footnote 1, Section 2.1 of this supplement).

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 organic soil type if appropriate factors for on-site and off-site CO_2 emissions and 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 and removal estimates. Where significant variation in drainage depth exists for different management practices, and where appropriate emission and removal factors exist, it is *good practice* to improve the accuracy of an inventory by, for example, separating out drainage classes. Tier 2 methods may require area descriptions of higher resolution than those in Tier 1. Rigorous criteria should be applied 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 quantitative management data at a spatial resolution appropriate for the model.

2.10.4.3 NON-CO_2 GHG EMISSIONS FROM *IN-SITU* ABOVE-GROUND WOODY BIOMASS BURNING

N_2O and CH_4 emissions related *in-situ* above-ground woody biomass burning is reported under GM. The decision tree in Figure 2.10.1 provides general guidance for applying the appropriate tier level.. Equation 2.27, Chapter 2 and Section 6.2.4, Chapter 6 in Volume 4 of the *2006 IPCC Guidelines* are applied to estimate N_2O and CH_4 emissions from *in-situ* above-ground woody biomass burning. If GM is a *key category* and *in-situ* above-ground woody biomass burning is significant, it is *good practice* to use either Tier 2 or Tier 3 methods.

2.10.4.4 REPORTING[170,171] NON-CO_2 GHG EMISSIONS AND CO_2 EMISSIONS FROM LIMING AND UREA APPLICATION

The non-CO_2 GHG emissions associated with soil management on land under GM, CH_4 and N_2O emissions associated with burning of savannas as well as CO_2 emissions from liming and urea application are in most cases not reported under GM but under the Agriculture Sector. When reporting these emissions, it is *good practice* to ensure consistency, completeness and no double-counting under Agriculture and GM (see Section 2.4.4.2 of this supplement).

[170] According to paragraph 1 of Annex II to Decision 2/CMP.8 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 KP (FCCC/KP/CMP/2012/13/Add.1, p.18).

[171] The reporting categories for the emissions will be considered by SBSTA at its 39th session. Any change to the decisions about reporting of these emissions should also be reflected in the reporting under the KP LULUCF activities.

2.11 REVEGETATION

2.11.1 Definitional issues and reporting requirements

Revegetation (RV) 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 AR[172] (see also Footnote 1, Chapter 1 of this supplement).

Land should be classified as RV if it meets the RV definition and the activity takes place since 1 January 1990. RV typically affects the above-ground carbon pool significantly and may also have a significant impact on below-ground carbon pools through increases in soil carbon stocks.

RV 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 or restoring herbaceous ecosystems on degraded or carbon-depleted soils, establishment of vegetation cover on disturbed construction sites or mined lands, planting of trees, shrubs, grasses or other non-woody vegetation on various types of lands, including urban areas, might qualify as RV (see Box 2.11.1). Any tree planting could be elected as a RV activity, if besides meeting the area requirement for this activity it does not meet the requirements for a forest[173], or satisfies the criteria a Party uses to specify the shape of forests and areas subject to AR, D, or conversion of a natural forest to a planted forest (see Section 2.2.6.1 of this supplement). For example, in contrast to AR, RV does not necessarily entail a change in land use. RV activities must be clearly separated from natural, non-human driven revegetation processes.

Set-aside lands such as cultivated lands subjected to RV may be included under CM, if they are only temporarily set-aside (typically this is for 5 years or less, but any set-aside land likely to return to Cropland under the national conditions for set-aside land should be counted as Cropland).

It is *good practice* for Parties electing RV to provide documentation (a) describing how the included areas meet the definition of RV and (b) how they can be distinguished from other activities under Articles 3.3 and 3.4.

The following general guidance is provided in order to ensure a reasonably transparent, consistent, complete and accurate reporting of RV activities:

- It is *good practice* to stratify lands subject to RV by either land-use category or land-use change type, by type of RV activity, and final land use if different from the initial one.
- It is *good practice* to further disaggregate each land-use category to be revegetated into subcategories characterised by available information on climate, soil etc., whatever is most relevant for stratifying land according to the effects of the activity on carbon stocks and carbon stock changes. This characterisation would aid selecting suitable RV options and activity tracking; i.e. species, planting design, and soil preparation.
- Lands subjected to RV and each of its subcategories (if any) must be clearly identified as to their individual locations and areas (see Section 2.11.3 in this supplement).

Further guidance is provided in Section 1.2 in this supplement.

[172] Paragraph 1(e) in the Annex to Decision 16/CMP.1 contained in the document FCCC/KP/CMP/2005/8/Add.3, p.5.

[173] Paragraph 1(a) in the Annex to Decision 16/CMP.1 contained in the document FCCC/KP/CMP/2005/8/Add.3, p.5.

BOX 2.11.1
RV ACTIVITIES[A]

Iceland: The conversion of eroded or desertified land from Other Land or unmanaged less vegetated subcategories of grassland to managed Grasslands (as defined by a vascular vegetation cover of 20% or larger).

Japan: Urban green facilities like, for example, urban parks and many diverse green areas that are subjected to RV activities since 1990 were grouped into the following RV activities: parks and green space, public green space and private green space guaranteed by administration.

Romania: Planting of trees on degraded croplands: outside forest lands under administrative stewardship; roadsides; shelterbelts; around cities; and erosion-prone lands. All revegetated lands are classified as Croplands remaining Croplands.

[A]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

2.11.2 Base year

See Section 2.9.2 of this supplement and apply it in analogous manner.

2.11.3 Choice of methods for identifying lands

Land areas subject to RV can be represented with data obtained with either Approach 2, provided there is additional spatial information, or Approach 3 (see Section 3.3.1, Chapter 3 in Volume 4 of the *2006 IPCC Guidelines*). It is *good practice* that the chosen Approach be consistent with the one used for identifying and tracking the lands of other KP activities, be they mandatory (Article 3.3) or elected (Article 3.4).

Generally, all lands subject to RV 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 1.2 of this supplement.

The geographical location of boundaries may include a spatially explicit specification of each land subject to RV, but does not have to. Instead, the boundaries of larger areas encompassing smaller lands subject to RV may be provided, along with estimates of the areas subject to RV in each of the larger areas. In either case, the lands subject to RV and the management thereon need to be tracked continuously through time. Continuity in monitoring and reporting of management of revegetated land could be achieved either by continuously tracking each land subject to RV from 1990 until the end of the commitment period (see Section 2.9.2 for CM and Section 2.10.2 for GM of this supplement or Section 3.3, Chapter 3 in Volume 4 of the *2006 IPCC Guidelines* for land-use categories in general) or by developing statistical sampling techniques (see Annex 3A.3, Chapter 3 in Volume 4 of the *2006 IPCC Guidelines*) that allow the transition of different types of management on RV land to be determined.

Methods for monitoring RV lands depend on the kind of land use at the start and end of a RV activity. A common criterion, the minimum area of 0.05 hectares, has to be applied and all carbon pools have to be considered unless they are demonstrated not to be a source. If RV were done with herbs or grasses, monitoring should use methods appropriate for monitoring GM (see Section 2.10 of this supplement). If RV were done with tree species, monitoring methods should be the same as those used for monitoring AR activities (see Section 2.5 of this supplement) or FM activities (see Section 2.7 of this supplement). For designing RV activities on settlement lands, it is *good practice* to use tree inventories (if available), land surveys on parks and green spaces, brownfields and any other spatial information on areas amenable to revegetation. A clear definitional distinction with respect to AR is required.

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

Methods for estimating changes in above-ground biomass, below-ground biomass, and DOM carbon pools in a RV activity are described in Chapters 4 – 9, Volume 4 of the *2006 IPCC Guidelines*. The biomass carbon pool is likely to be the carbon pool most affected by RV. Parties are encouraged to use higher tier methods for reporting

carbon stock changes in biomass. It is *good practice* to use Tier 2 or Tier 3 methods for estimating carbon stock changes from biomass if RV is a *key category*.

Relevant methods and approaches for estimating carbon stock changes in mineral soils and carbon emissions and removals from organic soils on RV lands can be found in Chapters 4 - 9 and 11, Volume 4 of the *2006 IPCC Guidelines*. For urban soils, methods are described in Chapter 8, Volume 4 of the *2006 IPCC Guidelines*.

In the case of a RV activity on Cropland or Grassland, guidance on choice of methods (Tier 1) for stock changes in mineral soils can be found in Sections 2.9.4.2 and 2.10.4.2 of this supplement. It is *good practice* to use Tier 2 or Tier 3 for estimating carbon stock changes from mineral soils if RV is a *key category*. The decision tree for selecting the tier for estimating carbon stock changes in mineral soils under RV is analogous to that for CM (see Figure 2.9.1 of this supplement). At higher tiers, carbon stock change factors can be obtained from relevant literature (e.g. Akala and Lal, 2000), long-term experiments and models. Further guidance on the use of higher tier models can be found in Section 2.3.3, Chapter 2, Volume 4 of the *2006 IPCC Guidelines.*

The decision tree for methods to estimate emissions from organic soils under RV is similar to the one drawn for CM (see Figure 2.9.1 of this supplement) if the RV activity occurs on Cropland or Grassland. The methods described under Tiers 1, 2 and 3 for either FM, CM or GM also apply to RV activities involving either treed lands, croplands or grasslands (see Sections 2.7, 2.9 and 2.10, respectively, of this supplement) and Chapters 4 - 9 in Volume 4 of *2006 IPCC Guidelines*).

CO_2 emissions from liming are reported under Agriculture.

2.11.4.1 CHOICE OF CARBON STOCK CHANGE FACTORS

TIER 1

Estimation of RV is more dependent on national definitions than is the case for other Article 3.4 activities. When using Tier 1 methodologies, it is *good practice* to provide national information that substantiates that they adequately represent a Party's national circumstances (Sections 2.2 and 2.3 of this supplement and Chapters 4 – 9, Volume 4 of the *2006 IPCC Guidelines* contain methodologies that may be relevant). It is *good practice* for a Party electing RV to provide values for stock changes in each carbon pool. If RV is deemed a *key category*, then it is *good practice* to use Tier 2 or 3 methods. Decision 2/CMP.7[174] specifies that a Party may choose not to account for a particular pool in a commitment period, if transparent and verifiable information is provided that demonstrates that the pool is not a source. Requirements for reporting excluded pools and documenting that a pool is not a source can be found in Section 2.3.1 of this supplement.

TIER 2

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 RV activity. For any carbon pool not reported, it is *good practice* to provide verifiable information to demonstrate that it is not a source of anthropogenic GHG emissions.

TIER 3

At Tier 3, ecosystem carbon cycle models parameterised for the relevant plant functional types and soils included in the selected RV area could be used to estimate annual carbon emissions and removals. These models need to be calibrated and validated against field observations that represent the national circumstances, be fully documented and archived.

2.11.4.2 CHOICE OF MANAGEMENT DATA

Activities such as reclaiming or restoring herbaceous ecosystems on carbon-depleted soils, environmental plantings, planting of trees, shrubs, grasses or other non-woody vegetation on various types of lands, including urban areas, which qualify as RV can be considered. Area data on land uses and practices need to be available in accordance with Approach 2 or Approach 3, following guidance given in Section 2.2.4 of this supplement. Management data on RV required for each of three tiers are outlined briefly here.

TIER 1

Following guidance in Volume 4 of the *2006 IPCC Guidelines,* impacts of land-use change or land management change under a RV 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

[174]Paragraph 26 in the Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p.16.

RV activity. At a minimum, the six broad land-use categories and changes between these categories need to be specified and different types of RV activities considered separately.

TIER 2

For Tier 2, some management practices for RV may be either subdivided or new ones may be added to make them country-specific, depending on the land uses involved in a RV 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 RV 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 RV and the carbon emission and removal factors associated with each practice for each pool elected.

2.11.4.3 NON-CO_2 GREENHOUSE GASES

The choice of methods for estimating N_2O and CH_4 emissions from a RV activity depend on the land-use categories involved (e.g. Cropland, Grassland, etc.) and the particular management practices (e.g. biomass burning, nitrogen fertilisation, liming, etc.) on those lands.

Methodologies for estimating N_2O and CH_4 emissions from RV activities involving the management of trees (outside forests but not in settlements), croplands or grasslands can be found in Sections 2.7.3 (FM), 2.9.4 (CM) or 2.10.4 (GM), respectively, of this supplement. For RV activities leading to the establishment of wetlands, appropriate methodologies can be found in the *Wetlands Supplement* (see Footnote 1, Section 2.1 of this supplement. N_2O and CH_4 emissions from the RV on Settlements can be estimated with methods described in Chapter 8, Volume 4 of the *2006 IPCC Guidelines.* When reporting N_2O and CH_4 emissions from RV, it is *good practice* to ensure consistency, completeness and no double-counting under Agriculture or CM (see Section 2.4.4.2 of this supplement).

2.12 WETLAND DRAINAGE AND REWETTING

2.12.1 Definitional issues and reporting requirements

According to Decision 2/CMP.7 *"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, where drainage is the direct human-induced lowering of the soil water table and rewetting is the direct human-induced partial or total reversal of drainage*[175]

Wetland Drainage and Rewetting (WDR) can only be implemented on organic soils, but under any land-use category. Organic soils are defined in Annex 3A.5, Chapter 3, Volume 4 of the *2006 IPCC Guidelines*. The definition of the *2006 IPCC Guidelines* largely follows the FAO (1998, 2006) definition of 'Histosol', but allows for country-specific definitions (Chapter 1 of the *Wetlands Supplement* [see Footnote 1, Section 2.1 of this supplement)]. It is *good practice* that Parties clearly define organic soils and use this definition consistently over time. All other soils are classified as mineral soils following Annex 3A.5, Chapter 3 in Volume 4 of the *2006 IPCC Guidelines*.

Under WDR, drainage and rewetting refer to all practices that directly affect the hydrological system, leading to a change in the mean annual water table in the organic soil. Drainage includes both new drainage of formerly undrained land and a change in an existing drainage regime, whereas rewetting includes partial and total reversal of drainage (hereafter addressed as 'partial' and 'total rewetting', respectively). In case of WDR, these practices and their results are only considered, as far as the practices have taken place since 1990. Chapter 2 of the *Wetlands Supplement* provides methodological guidance for drained and partially rewetted organic soil. Partial rewetting is referred to as a change in drainage class that results in a shallower water table. Chapter 3 of the *Wetlands Supplement* provides methodological guidance for organic soil totally rewetted to near-natural water table level. Chapter 4 of the *Wetlands Supplement* provides methodological guidance for drainage and rewetting of organic soils in coastal areas.

Human-induced drainage includes, for example, the installation of (additional) ditches or drainage pipes. Additionally, groundwater extraction in and outside of the organic soil area may result in drainage. Direct human-induced rewetting includes, for example, blocking drainage ditches and pipes or disabling pumping facilities. Also, a decision that leads to abandoning the maintenance of ditches and results in water table rise is considered to be direct human-induced rewetting. Relevant information that WDR activities included in the identified lands are direct human-induced includes documentation that a decision has been taken that aimed at or implied altering the water table, for example referencing laws, policies, regulations, management plans, decisions and practices. Naturally rising or falling water tables, for example as a result of natural succession or river/coastal erosion, are not considered to be direct human-induced rewetting or drainage. The WDR activity includes only lands that are not accounted for under any other activity. Emissions and removals due to drainage or rewetting practices on organic soils will be reported under other KP activities (see Box 2.12.1) as follows:

- Emissions and removals from drainage and rewetting associated with a conversion from non-forest to forest or from forest to non-forest land will be reported under A, R or D.
- Emissions and removals from drainage and rewetting of land remaining under FM will be reported under FM.
- Emissions and removals from drainage and rewetting on lands that meet the criteria for classification under CM, GM or RV, will be reported under these activities if elected.

Flooded land (as defined in Section 7.3, Chapter 7, Volume 4 of the *2006 IPCC Guidelines*) is not included under this activity. CO_2 emissions from rice cultivation are by priority reported under the CM activity, but may be included under WDR when organic soils are rewetted for rice cultivation, and CM is not elected.

The guidance for estimating and reporting of emissions and removals resulting from drainage and rewetting practices (i.e. emissions and removals from drained and rewetted land) is given in the *2006 IPCC Guidelines* and the *Wetlands Supplement* (see Footnote 1, Section 2.1 of this supplement). The *Wetlands Supplement* introduces updated emission and removal factors and new sources of off-site CO_2 emissions and CH_4 emissions from ditches for drained organic soils.

The base year for WDR is the same as for CM, GM and RV. Practical guidance for identification of land areas for WDR in the base year and during the commitment period is given in Section 2.12.3 of this supplement.

[175] Paragraph 1(b) in the Annex to Decision 2/CMP.7 contained in the document FCCC/KP/AWG/2011/10/Add.1, p.13.

The practices of drainage and rewetting result in immediate changes of GHG emissions and removals so that there may be less need to establish a land-use history prior to 1990 for Tier 1 methods.

BOX 2.12.1
EXAMPLES FOR REPORTING OF EMISSIONS AND REMOVALS FROM DRAINED OR REWETTED ORGANIC SOILS UNDER THE VARIOUS KP LULUCF ACTIVITIES

Whereas the activity WDR – if elected - only applies to lands on organic soils that have been drained or rewetted since 1990 and that are not subject to any other mandatory or elected activity, the practices of drainage and rewetting of organic soils may occur under any other activity under Articles 3.3. or 3.4 and would be reported under these mandatory or elected activities accordingly. The resulting emissions and removals from drained or rewetted lands on organic soil would, for example, be reported under:

D when

- a forest with organic soil is drained and converted to e.g. cropland
- forest harvesting affects hydrologic conditions to the extent that regeneration to forest is not anymore possible (e.g. when reduced evapotranspiration and consequent higher water tables after clear felling prevent re-establishment of forest)
- rewetting practices change the hydrologic conditions to the extent that forest cannot persist or is not allowed to regenerate (e.g. when forest with organic soils is rewetted and felled to enhance specific biodiversity)

AR when

- land other than forest is drained for forestry (e.g. when a naturally treeless or sparsely treed organic soil is drained to stimulate forest growth)
- land other than forest is rewetted for forestry (e.g. when drained organic soil used for grassland is rewetted and planted with wetland trees, e.g. alder/*Alnus*)

FM when

- a forest is drained and remains a forest (e.g. when unproductive forested organic soil is drained to increase productivity)
- a forest is rewetted and remains a forest (e.g. when an ash/*Fraxinus* forest on organic soil is rewetted for alder/Alnus forestry)

CM (if elected[1]) when

- land other than forest is drained for agriculture (e.g. when a treeless peatland is converted to cropland)
- cropland is rewetted but remains cropland (e.g. when a potato field on organic soil is rewetted for paludiculture)

GM (if elected[1]) when

- land other than forest is drained to improve grazing
- grassland on organic soil is rewetted but remains grassland (e.g. when a drained grassland for dairy cow husbandry is converted to a wet grassland for water buffalo husbandry)

RV (if elected[1]) when

- land other than forest is revegetated and rewetted (e.g. when an abandoned bare peat extraction site is actively converted to a vegetated wetland)

WDR when

- land other than forest land is rewetted and is not subject to any other mandatory or elected activity.

[1]If a Party had already elected this activity in the first commitment period, reporting under this activity will be mandatory during the second commitment period.

2.12.2 Base year

Managed land on organic soils in the base year is identified with the criteria set out in Section 2.12.3 of the *KP Supplement*. These include the, land-use category, the status of the organic soils, in particular a stratification of organic soils that are drained, eventually further stratified by drainage class and nutrient status, and wet organic soils.

Drainage and rewetting practices on organic soils can lead to large changes in GHG emissions and removals per hectare (Tuittila *et al*., 1999; Drösler, 2005). Consequently, particular care must be taken to make accurate estimates of GHG emissions and removals both in the base year and in the commitment period.

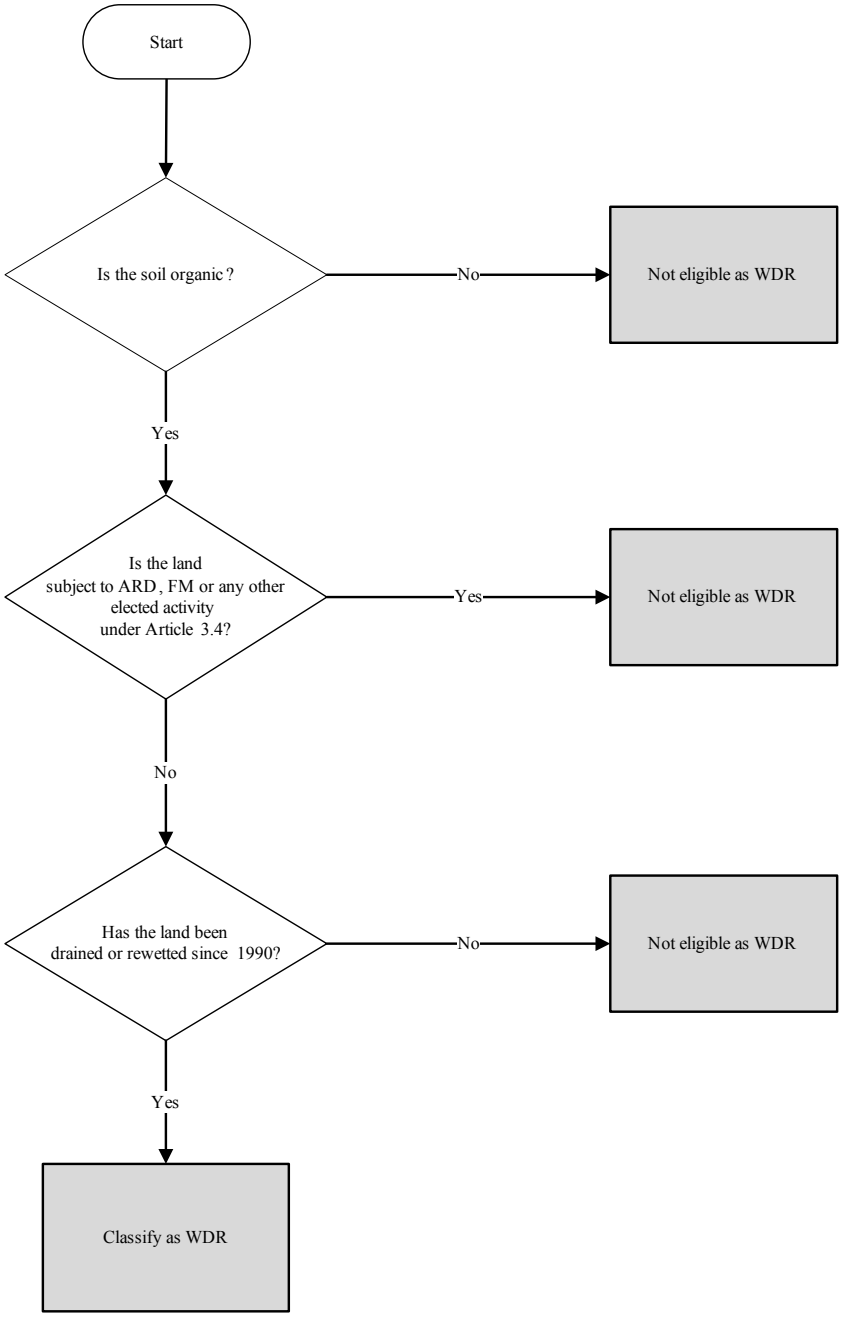
It is *good practice* to use the same methodologies for estimating emissions and removals in the base year and in all years of the commitment period.

2.12.3 Choice of methods for identifying lands

2.12.3.1 GENERAL GUIDANCE FOR IDENTIFYING LANDS

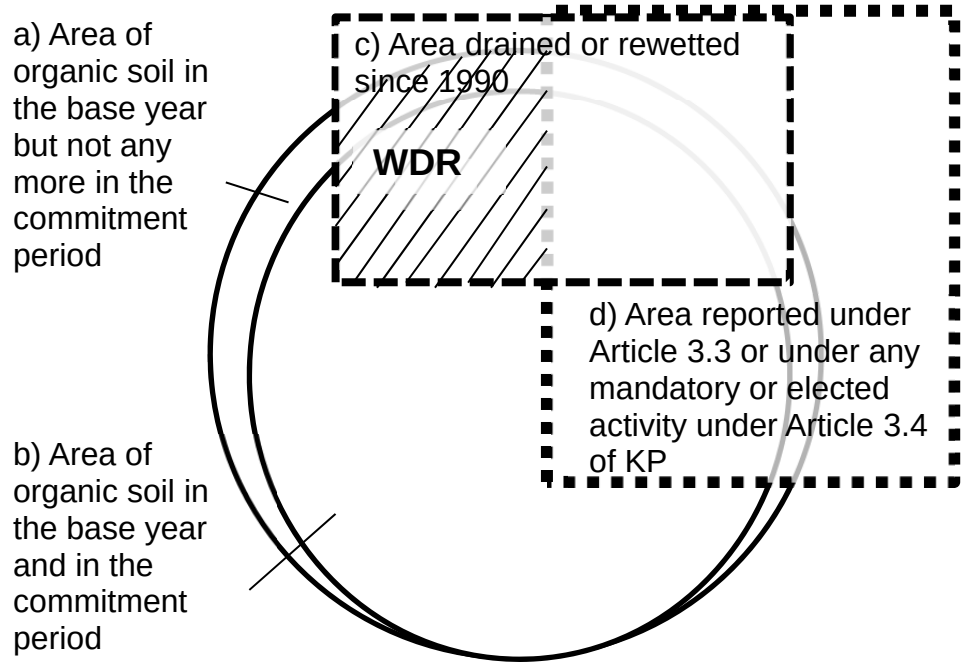
The activity WDR can only be applied to organic soils that are drained or rewetted since 1990 and that are not included under any other mandatory or elected KP activity (see Chapter 1 and Figure 2.12.1 of this supplement for further guidance).

Figure 2.12.1 Decision tree for identifying land under the Article 3.4 activity WDR if this activity is elected.



As drainage or rewetting of organic soils may also occur under other accounted land-use activities, the WDR activity will always concern only a subset of the total area of organic soil in the country. When drained organic soil oxidizes, the organic soil layer becomes shallower. Over time the organic soil layer may become so shallow that an area no longer complies with the criteria of an organic soil. It is *good practice* to apply the activity to all land with an organic soil that has been drained or rewetted since 1990 even if the soil on these lands has converted to mineral soil before or in the commitment period. These issues are illustrated in Box 2.12.2.

BOX 2.12.2
WETLAND DRAINAGE AND REWETTING AREAS IN 1990 AND THE COMMITMENT PERIOD (NET-NET ACCOUNTING)



Lands to be reported under WDR if elected. The area of organic soils in the base year (a+b) can be larger than the area in the commitment period (b) if part of the organic soils has changed into mineral soils due to e.g. oxidation, peat extraction or deep-ploughing (a). The activity applies only to those lands that have been drained and rewetted since 1990 (c) and that are *not* included in any other activity (d). The land that will be reported under WDR (if elected) is thus the hatched area. Emissions and removals from the same land are to be reported both for the base year and for the commitment period year.

Countries are encouraged to use stratification by land-use category or similar or further subcategories in a way that the guidance in the *Wetlands Supplement* (see Footnote 1, Section 2.1 of this supplement) on methodologies and emission factors best matches the national conditions.

It is *good practice* for Parties to describe the criteria used to identify areas where WDR applies and to apply these criteria consistently (see Section 2.2 of this supplement).

With respect to the minimum area of 1 ha to which WDR applies, criteria can be defined as to the minimum width. Then the minimum length of the area follows from the combination of width and the prescribed minimum area of 1 ha. For example, with a minimum width of 20 m, a rectangle of minimum width has to be at least 500 m long to meet the 1 ha size requirement.

2.12.3.2 SPECIFIC GUIDANCE FOR IDENTIFYING LANDS

The identification of lands to be included under the WDR should follow a similar approach as described in Section 2.2 of this supplement (see also decision tree in Figure 2.2.2). It is *good practice* to identify the lands drained since 1990 and the lands rewetted since 1990 separately.

There are two ways of identifying lands subject to WDR:

OPTION 1

All managed lands with organic soils in 1990 are compared with all managed lands with organic soils in the commitment period, using the following steps:

STEP 1: Identify the area of managed land on organic soil separately for 1990 and for the commitment period. Information can be taken from the UNFCCC inventory. WDR may occur on the lands identified for 1990 and for the commitment period minus the land reported under any other Article 3.3 or 3.4 activity in the commitment period.

STEP 2: Define water table sub-categories (e.g. deeply-drained, shallowly-drained, wet, at a minimum covering drained and wet as defined by the *Wetlands Supplement*) and stratify the land defined in Step 1 according to these sub-categories for both 1990 and the commitment period. Data and information from the past can be of lower quality than recent data, whereas data sets may also be incomplete or not available for all years. Section 5.4 in Volume 1 of the *2006 IPCC Guidelines* provides guidance for how to provide consistent time series in these cases. Water table classes can be identified on the basis of proxies/indicators (e.g. groundwater observations, land use, management practice).

STEP 3: Identify areas of land where a change in water table subcategory occurred between 1990 and the commitment period (wet-dry/dry-wet transition matrix), while complying with the minimum area and land tracking requirements for WDR (see Section 2.2). When, for higher tiers, transitional emission factors are applied for recently drained or rewetted land, it may be necessary to construct a transition matrix including more disaggregated water table classes, time since drainage or rewetting and other characteristics relevant to emissions and removals as described in Section 2.12.2.4 of this supplement.

OPTION 2

The areas of managed lands with organic soil where direct human-induced drainage or (partial) rewetting has taken place since 1990 are directly identified, using the following steps:

STEP 1: Identify the area of managed land on organic soil in 1990 and in the commitment period. Information can be taken from the UNFCCC inventory. WDR may occur on the areas identified for 1990 and for the commitment period minus the area reported under any other Article 3.3 or 3.4 activities in the commitment period.

STEP 2: Within the area identified in Step 1, identify the areas where a direct human-induced drainage or rewetting has occurred since 1990, while complying with the minimum area and land tracking requirements for WDR (see Section 2.2 of this supplement). Identify lands where drainage and lands where rewetting has taken place separately (wet-dry/dry-wet transition matrix). Approach 2 will result in a non-spatially explicit land use matrix, while Approach 3 is spatially explicit.

STEP 3: Identify for the lands identified in Step 1 the magnitude of changes in water table by drainage or rewetting. This can include changes in water table classes (e.g. deeply-drained, shallowly-drained, wet, at a minimum covering drained and wet).

For both options 1 and 2, all the lands thus identified fall under WDR both in the base year (i.e. when the practice of rewetting or drainage may not yet have taken place) and in the reporting year of the commitment period. Therefore, the land under WDR in the base year must match the land under WDR in each reporting year of the commitment period. Land that has been reported under CM or GM in the base year but not in any year of the commitment periods is included in WDR only in the commitment period to avoid double-counting with CM or GM in the base year. As the area of land under WDR may grow during the commitment period when newly drained or newly rewetted lands are added, the area of land under WDR in the base year also has to grow accordingly. For QA/QC, identify the geographical boundaries and areas of managed lands on organic soils in the base year and for the commitment period. It is *good practice* to provide information on changes in the reported area of managed organic soils (see also Box 2.12.1 of this supplement).

2.12.3.3 GEOGRAPHICAL BOUNDARIES

A country that elects WDR must identify geographic boundaries of all areas of land on organic soil that have been subject to the practices of directly human-induced drainage or rewetting (see Section 2.12.1 of this supplement) since the base year that are one hectare or larger, and do not fall under any other activity that takes precedence.

Either Approach 2, with supplementary information, or Approach 3, as described in Section 3.3.1, Chapter 3, Volume 4 of the *2006 IPCC Guidelines,* can be chosen to identify land area. For Approach 2, existing administrative records, land-use databases and soil maps may have relevant information to identify the relevant combinations of land-use categories and management practices with drained or rewetted status and their changes

over time. It may be necessary to obtain additional data through sampling or other methods to allow the creation of a detailed non-spatially explicit land-use matrix for the WDR activity that tracks changes in land use and drainage status over time.

Information sources about drainage and rewetting practices since 1990 with adequate disaggregation may include:

- National land use registries and statistics, land-use maps and soil maps, maps of water and nature conservation zones with restrictions for water management and maps of wetlands.
- National water 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 or 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 that allow interpretation of data in terms of human-induced drainage and rewetting rather than inter-annual variability.
- Water management plans and documentation from water management installations. Information on the effects of groundwater extraction on neighbouring water levels is generally available in the licensing for groundwater extraction.
- Drainage maps.
- Maps of rewetting projects including remote sensing.

2.12.3.4 STRATIFICATION

Stratification needs to be consistently applied in the base year and the commitment period. The following criteria may be useful in establishing a national stratification for drained and rewetted land, which result in different levels of GHG emissions or removals:

- Land use and management practices, as relevant
- Drainage regime (water level, seasonality), following the water table classes defined in the first steps of the options 1 and 2 (Section 2.12.3), respectively, e.g.
  - (i) undrained /near natural water regime (Chapter 3 of the Wetlands Supplement),
  - (ii) drained comparable to the typical water table range of the *Wetlands Supplement* for drained organic soils (Chapter 2 of the *Wetlands Supplement*),
  - (iii) drained deeper than water level range of *Wetlands Supplement* for part or all of the year if applicable,
  - (iv) drained more shallowly than the water table range of *Wetlands Supplement* for partially drained or rewetted for part or all of the year if applicable,
  - (v) flooded land (maybe further stratified by seasonally flooded or flooded throughout the year), if applicable, which does not fall under the definition of "flooded land" or "reservoir" (See Section 7.1, Chapter 7 in Volume 4 of the *2006 IPCC Guidelines*).

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 lands subject to the activities AR and D. Similarly areas under FM or any elected activity need to be tracked and reported separately.

At higher tiers further subdivision of the area under WDR may be useful, e.g. by seasonality of drainage management.

2.12.4 Choice of methods for estimating GHG emissions and removals

Guidance on methodologies for estimating carbon stock changes, CO_2 emissions and removals and non-CO_2 GHG emissions on land subject to WDR is given in the *2006 IPCC Guidelines* supplemented by the *Wetlands Supplement*. The *2006 IPCC Guidelines* provide methodologies for the estimation of carbon stocks and carbon stock changes in above- and below-ground biomass, dead wood and litter for inland organic soils, whereas

Chapter 4 of the *Wetlands Supplement* provides additional guidance for these pools for coastal organic soils. The *Wetlands Supplement* provides methodologies and updated emission factors for estimating emissions and removals from organic soils. Chapter 2 of the *Wetlands Supplement* provides guidance for drained inland organic soils, Chapter 3 of the *Wetlands Supplement* for rewetted and wet inland organic soils and Chapter 4 of the *Wetlands Supplement* for coastal organic soils.

It is *good practice* to estimate and report GHG emissions from drained organic soils (Chapter 2 of the *Wetlands Supplement)* and from rewetted organic soils (Chapter 3 of the *Wetlands Supplement)* under WDR separately.

Generic guidance about the choice of methods is given in Section 2.3.6 of this supplement. For *key category* analysis, the absolute values of emissions and removals from all land under WDR are summed. WDR is a *key category* if (1) this sum is greater than the emissions from the *key category* with the smallest emissions as identified in the UNFCCC inventory (including LULUCF) (= level analysis) or (2) the trend (change over time) of WDR is larger than that from the key category with the smallest changes (= trend analysis).

If WDR is a *key category*, it is *good practice* to determine whether one of the two subcategories rewetting or drainage is particularly important. Following decision trees in Figures 1.2 and 1.3 in Chapter 1, Volume 4 of the *2006 IPCC Guidelines*, a subcategory is considered *significant* if it accounts for 25-30 percent of the overall emissions or removals of the category (which applies to at least one of the two subcategories drainage or rewetting). It is *good practice* to report the *significant* subcategories with higher tier methods and to focus efforts towards methodological improvements on these subcategories.

Detailed guidance is found:

- for above-ground and below-ground biomass, dead wood and litter on organic soils in Volume 4 of the *2006 IPCC Guidelines* in Chapter 2 (generic), Chapter 4 (Forest Land), Chapter 5 (Cropland), Chapter 6 (Grassland), Chapter 7 (Wetlands) and Chapter 8 (Settlements), as well as Chapter 4 of the *Wetlands Supplement* (coastal wetlands).
- for non-CO_2 GHG emissions from biomass burning by controlled burning and wildfires in the under the respective land-use categories in the *2006 IPCC Guidelines*.
- for GHG emissions from peat fires: Chapter 2 of the *Wetlands Supplement,* including Tier 1 methods for CO_2 and CH_4 and higher tier methods for N_2O.
- for on-site CO_2 emissions and removals from organic soils:
  - (i) for drained and partially rewetted inland organic soils: Chapter 2 of the Wetlands Supplement, including Tier 1 and higher tier methods,
  - (ii) for fully rewetted and wet inland organic soils: Chapter 3 of the *Wetlands Supplement*, including Tier 1 and higher tier methods,
  - (iii) for coastal organic soils: Chapter 4 of the *Wetlands Supplement*, including Tier 1 and higher tier methods.
- for off-site CO_2 emissions from dissolved organic carbon: Chapter 2 (from drained land) and Chapter 3 (from rewetted land) of the *Wetlands Supplement*, Tier 1 and higher tier methods.
- for off-site CO_2 emissions from peat extraction for horticulture and soil amendment: Chapter 7, Volume 4 of *2006 IPCC Guidelines* for Tier 1. Countries using higher tier methods that deviate from the Tier 1 assumption that the peat is fully oxidized during the extraction year need to document that no double-counting takes place and that CO_2 emissions from peat in horticultural use are taken into account.
- for N_2O emissions from drained organic soils: Chapter 2 of the *Wetlands Supplement* for inland organic soils; Chapter 4 of *Wetlands Supplement* for coastal organic soils, Tier 1 and higher tier methods, whilst avoiding double-counting with N_2O reported under Agriculture.
- for CH_4 emissions from drainage ditches on organic soils: Chapter 2 of the *Wetlands Supplement*, Tier 1 and higher tier methods.
- for CH_4 emissions from rewetted organic soils: Chapter 3 of the *Wetlands Supplement,* Tier 1 and higher tier methods.

Decision 2/CMP.7[176] specifies that a Party may choose not to account for a particular pool in a commitment period, if transparent and verifiable information is provided that demonstrates that the pool is not a source.

[176]Paragraph 26 in the Annex to Decision 2/CMP.7 contained in document FCCC/KP/CMP/2011/10/Add.1, p.16.

Requirements for reporting excluded pools and documenting that a pool is not a source can be found in Section 2.3.1 of this supplement.

It is *good practice* to use consistent methodologies and emission factors across ARD, FM and elected Article 3.4 activities.

It is *good practice* to use the same methodologies for estimating emissions and removals in the base year and in all years of the commitment period.

Some of the CH_4 and N_2O emissions on agricultural soils as well as CO_2 emissions from liming and urea application are in most cases not reported under WDR but under the Agriculture Sector. When reporting these emissions, it is *good practice* to ensure consistency, completeness and no double-counting under Agriculture or WDR (see Section 2.4.4.2 of this supplement).

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