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# Guidance on reporting and accounting for cropland and grassland management in accordance with Article 3(2) of EU Decision 529/2013/EU

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## Acronyms

AD	Activity data
AGB	Aboveground biomass
AR	Afforestation/Reforestation
BGB	Belowground biomass
C/N-ratio	Carbon to nitrogen ratio
C	Carbon
CAP	Common Agricultural Policy
CL rem CL	Cropland remaining cropland
CL	Cropland
CLC	Corine Land Cover
CM	Cropland management
CP	Commitment period
CRF	Common Reporting Format
CS	Country specific emission factor
D	Default emission factor
D	Deforestation
DG CLIMA	Directorate General for Climate Action
DOM	Dead organic matter
EF	Emission factor
EO(S)	Earth observation (system)
ERDF	European Regional Development Fund
ESDB	European Soil Database
FM	Forest management
FSS	Farm structure survey
GAEC	Good agricultural and environmental condition
GHG	Greenhouse gas
GIS	Geographical information system
GL rem GL	Grassland remaining grassland
GL	Grassland
GM	Grassland management
GPG	Good Practice Guidance
IACS	Integrated Administration and Control System
IE	Included elsewhere
INSPIRE	Infrastructure for Spatial Information in the European Community
IPCC	Intergovernmental Panel on Climate Change
IPCC GL	IPCC Guidelines
JRC	Joint Research Centre
KP	Kyoto Protocol
L to CL	Land converted to cropland
L to GL	Land converted to grassland
LIDAR	Light Detection and Ranging
LPIS	Land Parcel Identification System
LUC	Land use change
LUCAS	Land Use/Cover Area frame statistical Survey

LULUC	Land Use, Land Use Change
LULUCF	Land Use, Land Use Change and Forestry
MMR	Monitoring Mechanism Regulation
mmU	minimum mapping unit
MS	Member State
NA	Not applicable
NE	Not estimated
NFI	National forest inventory
NIR	National inventory report
NO	Not occurring
QA/QC	Quality Assurance and Quality Control
RV	Revegetation
SAPM	Survey on Agricultural Production Methods
T1, T2, T3	Tier 1, Tier 2, Tier 3
UAA	Utilised agricultural area
UNFCCC	United Nations Framework Convention on Climate Change
WDR	Wetland Drainage and Rewetting
WL	Wetland

## Overview

This guidance document has been prepared for DG Climate Action, to support Member States' implementation of the EU LULUCF Decision 529/2013/EU<sup>1</sup>. It focuses specifically on the requirements under Article 3(2) in relation to reporting and accounting for cropland management (CM) and grazing land management (GM).

The Decision requires Member States to account formally for emissions relating to CM and GM from 2021 onwards (to be reported for the first time no later than 15 March 2022). However, the Decision also sets out interim deadlines from 2015 onwards for Member States to provide preliminary estimates of their emissions and removals from CM and GM and to report on progress with the systems in place for making such estimates.

This guidance document is intended to support Member States in developing the information and systems needed to fulfil their obligations under the EU LULUCF Decision. It is organised in eight complementary chapters, divided into two main Parts as illustrated in Figure 1. Part A of the guidance provides information of how to get started and the initial steps that can be taken, building on information that is already available and prioritising improvements and developments in data and systems that are required. Part B provides more detailed information on how to improve the quality of activity data and the accuracy of emission factors, as well as providing useful information on developing organisational capacity and the data sets that might be used. Each section is colour coded to aid navigation.

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<sup>1</sup> Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities. 18.6.2013.



**Figure 1: Overview of Guidance**

# 1 Introduction and user guide

## 1.1 Purpose of the Guidance

There is a range of implementation options (technical, organisational and operational) that need to be considered if mitigation efforts in the area of Land Use, Land Use Change and Forestry (LULUCF) are to be successful. Such options have been explored in this study contract for DG Clima, as a means of supporting Member States' implementation of the EU LULUCF Decision 529/2013/EU<sup>2</sup>.

This guidance document relates specifically to the implementation of Article 3(2) of Decision 529/2013/EU, which commits Member States to account formally for emissions in relation to the activities of cropland management (CM) and grazing land management (GM) from 2021 onwards (to be reported for the first time no later than 15 March 2022).

The Decision sets out a stepwise approach (see chapter 1.3) to preparing and maintaining these accounts by Member States for these activities in the second commitment period (beginning on 1 January 2013). This requires that Member States report annually:

- by 15 March each year from 2015 to provide 'initial, preliminary and non-binding annual estimates of emissions and removals from CM and GM' (Article 3(2) (b)); and
- in 2016, 2017 and 2018 on 'the systems in place and being developed to estimate emissions and removals from cropland management and grazing land management' and 'how these systems are in accordance with IPCC methodologies and UNFCCC reporting requirements on greenhouse gas emissions and removals' (Article 3(2) (a)).

The internationally-agreed reporting and accounting rules for these activities specified in related IPCC guideline documents (IPCC 2006, 2014), remain fully valid at the EU level.

In particular, Member States are expected to follow the methodologies outlined in the 2006 IPCC guidelines (IPCC 2006) and the specific advice for KP accounting emissions and removals linked to these activities, based on the 2013 IPCC Revised Supplementary Methods and Good Practice Guidance arising from the Kyoto Protocol (IPCC, 2014).

During the negotiations leading up to the EU LULUCF Decision, Member States expressed concerns about the availability of data and suitable methods to fulfil their reporting and accounting obligations for CM and GM activities in an adequate way. However, analysis by the Commission's Joint Research Centre (JRC) of the recent reporting by Member States to the UNFCCC of emissions/removals of the land based LULUCF subcategories of cropland and grassland indicated that the gap between these and the additional needs for activity based

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<sup>2</sup> Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities. 18.6.2013.

estimates in these categories may be smaller than some Member States expected (JRC 2012, 2013).

Nonetheless, there is clearly still a need for further guidance to Member States on a range of issues beyond the framework guidelines within these IPCC documents with regard to making estimates and reporting on these activities. This guidance document is intended to go some way towards filling this gap.

It is recognised that Member States have varying institutional capacities and varying resources available to address these issues on their own. This guidance document provides a range of options available to Member States on how to bridge the gaps between:

- Their existing reporting on emissions/removals for CL and GL; and
- The necessary reporting on the related activities of CM and GM to bring them up to an adequate standard.

The advice contained with this guidance document is in line with the 2006 IPCC guidelines (IPCC 2006), the 2013 IPCC KP supplement (IPCC 2014) and any related decision at the UN- or EU-level.

## 1.2 Target audience and focus

The main audiences for this guidance document are:

- Inventory experts implementing the LULUCF decisions and experts running the assessment systems for the input data for CL, GL, CM and GM; and
- Policy and decision makers working in the field of LULUCF reporting and accounting.

The guidance aims to highlight a stepwise approach towards improving the accuracy of estimates of greenhouse gas emissions associated with CM and GM. It highlights the most common issues faced by Member States and provides ideas and suggestions on the steps that can be taken to resolve these in a cost-effective way and in line with the IPCC requirements.

## 1.3 Legislative context

### 1.3.1 *The EU Context: EU LULUCF accounting framework*

LULUCF is the last key sector of the economy remaining outside EU climate mitigation policies and outside EU emission-reduction targets currently. Based on an agreement by the Council and the European Parliament, Decision No 529/2013/EU aims to set obligations for Member States to implement accounting rules and provide information on their LULUCF actions for the accounting period 2013-2020 and thereafter.

The Decision entered into force on 8 July 2013 and aims to ensure that:

- *‘all land use should be considered in a holistic manner and LULUCF should be addressed within the Union’s climate policy’<sup>3</sup>;*

and that in relation to the introduction of mandatory reporting and accounting for emissions from cropland and grazing land management:

- *‘...these estimates [are used] to identify key categories and develop country-specific Tier 2 and Tier 3 key methodologies for the robust and accurate estimation of emissions and removals’<sup>4</sup>.*

To prepare for the potential inclusion of the LULUCF sector in the Union’s emission reduction targets in the post-2020 accounting period, the Decision aims to harmonise and improve monitoring and reporting, particularly for the emissions and removals associated with cropland and grassland on which there is less experience in Member States.

In tandem with the Decision, the **Regulation on the mechanism for monitoring and reporting (MMR) of greenhouse gases No 525/2013/EU**<sup>5</sup> also entered into force on 8 July 2013. It streamlines and enhances the legal basis for the Monitoring and Verification procedures for Member States’ annual GHG inventories, and for assessing efforts towards meeting the emission targets under the KP. The new MMR integrates requirements linked to the LULUCF reporting categories whilst building on the existing common processes for gathering and publishing Member States’ information on GHG projections as well as the policies and measures already in place to reduce emissions.

Member States are required to provide updates on progress with the systems in place and non-binding estimates of GHG emissions and removals in relation to cropland management and grazing land management under Article 3 of the LULUCF Decision. Box 1 provides an overview of the main reporting and accounting requirements for CM and GM, as set out under Article 3(2).

It is important to distinguish between the EU Decision and the international framework for KP when using the term ‘accounting’ as it has a different meaning.

‘Accounting’ under the EU Decision is the approach of balancing reported GHG emissions/removals for LULUCF activities following certain accounting rules to assess the effect of GHG mitigation measures taken in the LULUCF sector.

‘Reporting’ represents the basis for accounting.

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<sup>3</sup> Preamble 2 of the Decision No 529/2013/EU.

<sup>4</sup> Article 3(2)(b) of Decision No 529/2013/EU

<sup>5</sup> Regulation No [525/2013/EU](#) of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change. It replaces the earlier legislative act, Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

### **Box 1: Overview of the key requirements on reporting and accounting for GHG emissions and removals associated with LULUCF activities under Article 3(2)**

- A road map for improving the reporting and accounting systems for GHG emissions/removals associated with Cropland management and Grazing Land Management, to become mandatory from 1 January 2021 (Article 3(2));
- **Annual reporting from 2016 to 2018 (by 15 March each year)** on *‘the systems in place and being developed to estimate emissions and removals from cropland management and grazing land management’* and *‘how these systems are in accordance with IPCC methodologies and UNFCCC reporting requirements on greenhouse gas emissions and removals’* (Article 3(2) (a));
- **Annual accounting and reporting from 2015 (reporting year 2013) until 1 January 2022 (by 15 March each year)** on *‘initial, preliminary and non-binding annual estimates of emissions and removals from CM and GM’* following IPCC methodologies where possible. Tier 1 methodology is a minimum, and improvements toward the use of Tier 2 and Tier 3 key methodologies is encouraged (Article 3(2) (b)); and
- No later than 15 March 2022 *‘final annual estimates for accounting of CM and GM’* (Article 3(2) (c)) must be submitted, with derogations possible for Member States under specified conditions (Article 3(2d)).

#### **1.3.2 The International Context: Framework for UNFCCC reporting and KP reporting and accounting**

‘Reporting’ denotes annual GHG emission and removal estimates included in national GHG inventories. Reporting methods are based on relevant UNFCCC/IPCC guidelines. ‘Accounting’ is the approach of assessing variations in GHG emissions/removals for elected or mandatory activities compared to a base year or reference level following certain accounting rules to assess the contribution towards a GHG target as required by the KP. Reporting represents the basis for accounting.

Under the UNFCCC, the emissions and removals of carbon and emissions of other GHGs in the LULUCF sector are reported for all six land categories defined by the IPCC, namely forest land, cropland, grassland, wetlands, settlements and other land. Land use change from one category to another is also reported. This approach is called the ‘land-based’ approach. In contrast, to demonstrate progress towards reaching the KP targets, specific land use and land use change activities must be accounted for, according to a set of rules agreed mainly in 2011<sup>6</sup>. This approach is referred to as the ‘activity-based’ approach. The two sets of land use and land use change categories may overlap, either partially or fully.

For both UNFCCC and KP reporting purposes, all emissions and removals from all managed land<sup>7</sup> (for KP only those activities that are either mandatory or elected) need to be included. However because of differences in the definitions between categories for UNFCCC and activities under KP, the land-based areas and activity based areas may differ in many cases. Managed land in this context is ‘land where human interventions and practices have been

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<sup>6</sup> Make a reference to Decision 2/CMP.7, I think it would be not a bad thing to refer here: <http://unfccc.int/methods/lulucf/items/4129.php>

<sup>7</sup> Applies to all Annex 1 countries that signed the Convention. Emissions from unmanaged forests and unmanaged grasslands do not have to be reported in UNFCCC inventories.

applied to perform production, ecological or social functions’ (Chapter 1, Volume 4 of the IPCC 2006 Guidelines). Guidance on reporting and accounting is set out in the 2006 IPCC Guidelines, as well as in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement) and the 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement).

Mandatory reporting and accounting for GHG emissions and removals for the second commitment period under the KP is associated with three ‘activities’: afforestation/reforestation (AR), deforestation (D), and forest management (FM)<sup>8</sup>. Parties can elect to report and account for four additional ‘activities’: cropland management (CM), grazing land management (GM), revegetation (RV) and wetland drainage and rewetting (WDR)<sup>9</sup>. Parties are required to continue reporting on these activities once they have elected to account for them. Both the mandatory and elective supplementary information relating to these seven activities is provided as supplementary information in ‘Kyoto-Protocol-related’ additional (Common Reporting Format - CRF) tables and chapters of the national GHG inventories and National Inventory Reports (NIR), respectively.

For accounting purposes in the second commitment period under the KP, emissions and removals from CM, GM, RV and WDR are related to the emissions in a base year (in most countries 1990) or a base period (only for single countries). In contrast, the emissions/removals from forest management are related to a country specific reference level, and the resulting net removals (if any) can be accounted up to a maximum number or cap<sup>10</sup>. In contrast, all emissions/removals from AR and D that occur during the commitment period must be accounted for<sup>11</sup>.

The framework is underpinned by the following principles: that GHG reporting and accounting must be transparent, consistent over time, comparable among countries, complete in terms of coverage of emissions and removals, and accurate.

### **1.3.3 Relationship between the KP/UNFCCC framework and the EU Decision**

Table 1 presents the CM and GM LULUCF activities and their mandatory and elective status under the KP accounting rules alongside the provisions of the EU Decision.

Since there are many years of experience of reporting on cropland and grassland categories under the ‘land-based’ approach to the UNFCCC, Member States are not starting from zero in preparing the mandatory accounting for CM and GM using the activity-based approach,

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<sup>8</sup> Forest management was an elective category in the first commitment period of KP.

<sup>9</sup> For the first commitment period only the following EU MS have elected these activities: Denmark (CM, GM), Portugal (CM, GM), Romania (RV) and Spain (CM).

<sup>10</sup> Emissions from forest management in the 2<sup>nd</sup> commitment period are accounted for by subtracting a ‘reference level’ from the reported actual emissions or removals. Moreover, Decision 2/CMP.7 rules that the accounting of the net removals compared to the reference level are limited to a 3.5 per cent of base year emissions, defined in Article 3.7 of the Kyoto Protocol.

<sup>11</sup> ‘Gross/net’ method.

as required by the EU Decision. Improvements therefore can be introduced in a step-wise approach to enhance methods and improve the quality of estimates by 2021.

**Table 1: Mandatory/elective status of LULUCF activities under the KP and the EU Decision**

	KP-LULUCF 1 <sup>st</sup> commitment period	KP-LULUCF 2 <sup>nd</sup> commitment period <sup>12</sup>	Decision 529/2013/EU	Relevant article of Decision 529/2013/EU
Cropland management	Elective accounting against quantitative target a	Elective accounting against quantitative target <sup>13</sup> a	Mandatory reporting of emissions/removals estimates and accounting quantities from 2013 onwards to determine the overall impacts of GHG mitigation measures	Article 3(2)
Grazing land management	Elective accounting against quantitative target a	Elective accounting against quantitative target <sup>13</sup> a	Mandatory reporting of emissions/removals estimates and accounting quantities from 2013 onwards to determine the overall impacts of GHG mitigation measures	Article 3(2)

Source: own compilation

## 1.4 Key principles

This guidance has been designed according to the principle that actions for LULUCF should:

- ensure linkages are made to other national strategies and plans associated with cross-sectoral and climate policies;
- use and build on information available or under preparation within Member States' land use, forestry and/or agriculture policies;
- Identify and indicate potential synergies in existing spatial land data and information collection methods which should be available in Member States;
- be adaptable to the varying needs and situations in different Member States; and
- ensure compatibility with current KP reporting and accounting processes and to up-to-date UNFCCC reporting requirements and IPCC methodologies.

<sup>12</sup> Following Decision2/CMP.7.

<sup>13</sup> Mandatory, for those MS which elected the activity in the first commitment period

## Part A: Getting started and planning improvements

The sections of the guidance in Part A provide a guide to taking first steps towards calculating estimates for emissions sources and sinks from cropland management and grazing land management. It also provides suggestions on how to prioritise further efforts for improvements that need to be made during the second commitment period in order to meet the requirements of the EU LULUCF Decision.

Background information on the current state of play with reporting for cropland, grassland, cropland management and grazing land management is also provided as context.

More detailed information of improving the quality of activity data and the accuracy of emission factors is provided in Part B

## 2 Overview of current state of reporting on cropland and grassland in Member States

This section sets out the current state of reporting on cropland and grassland (land-based reporting) under the UNFCCC and, where elected, activity based reporting for cropland management (CM) and grazing land management (GM) under the first commitment period of the Kyoto Protocol. CL and GL reporting forms the basis for CM and GM reporting, but to report on CM and GM additional information and efforts that are needed, such as:

- land identification and tracking,
- further splitting of the C pools into five categories, rather than three;
- complete reporting for all C pools or the inclusion of robust 'no source' statements;
- once defined, certain areas of land are not or may not be covered by CM and GM despite being included in the CL and GL subcategory (e.g. Forest converted to CL/GL and different definitions of GL vs Grazing Land Management).

In the first KP commitment period only three Member States elected to report and account for CM and/or GM. However, all Member States report on CL and GL. Given that this represents the basis for CM and GM reporting, an overview of the state of reporting on CL and GL provides a good basis from which to assess the improvements that need to be made and data gaps that need filling for Member States to fulfil their reporting obligations for CM and GM in keeping with the IPCC 2006 guidelines (IPCC 2006) and particularly the IPCC KP supplement (IPCC 2014).

The results of an analysis carried out for all Member States are summarised in this section. The analysis is based on information for the 2014 reporting year (2012 data) from a survey of all 28 Member States conducted in summer 2014. Details of the analysis as well as an estimate for the time needed to move towards higher tier reporting on basis of appropriate activity data are provided in Annex 2.

**Completeness of reporting:** this has been assessed by reviewing the reporting of carbon pools and which notation keys have been used. For the Cropland and Grassland categories the most important carbon pools are perennial aboveground and belowground biomass as well as mineral soil. In northern/north-west countries organic soil is also relevant. Aboveground biomass and mineral soil are frequently reported with a greater degree of completeness than the other carbon pools. For belowground biomass, however, there are still quite a lot of Member States using the notation key 'NE' (not estimated) indicating the absence of appropriate methodologies or data to estimate the carbon pool. In comparison to a report by JRC (2012, 2013) which analysed the inventories of reporting year 2012, completeness of reporting of above and below ground biomass has increased.

**Reporting of sub-categories:** the analysis showed that there are still many Member States that do not sub-classify Cropland and Grassland. In the case of Cropland, 12 Member States do not report sub-categories for CL remaining CL and 15 Member States do not report sub-categories for Land to CL. In the Grassland category there are 17 Member States which do not split GL remaining GL and 16 Member States that report no sub-categories at all for Land to CL.

**Quality of the activity data:** this is crucial for accurate reporting. For all four Cropland and Grassland categories (conversion and remaining) the primary data sources are remote sensing/earth observation methods and ground based methods. Some Member States additionally use complementary sources, such as statistical methods and expert judgement. In addition, several Member States already use Approach 3 which implies that they gather spatially explicit land-use (conversion) data. Nevertheless, in many cases the geographical location cannot be determined due to the coarse resolution of the spatially explicit assessment systems.

In contrast, for providing information on the management of the land, Member States tend to use ground based and statistical methods. The most common sources of management information are national statistics, IACS/LPIS data and expert judgement.

With regard to time series completeness and consistency (commitment period vs. base year), many countries face data gaps and changes in methods over time. For this reason countries often apply extrapolations and interpolations to fill the data gaps.

**Accuracy of reported emissions:** the reporting of emission factors was reviewed for key categories/significant pools in particular. In general, many Member States still use Tier 1 methods for key categories as well as for non-key categories. This correlates often with the use of default emission factors and an analysis of current reporting shows no significant difference in the use of different tiers or default emission factors between the different pools. As sources of data, most Member States use national inventories and statistics as well as national research projects to determine country specific emission factors. The time series for emission factors can be seen as consistent for 19 Member States. However, this does not imply that there is no need to improve further the consistency and completeness, particularly the accuracy, of emission factors. Although an emission factor may be correct for the most recent years of a time series, it may not be adequate for historic years (or vice versa).

The most relevant improvements needed are to improve the consistency of the activity data time series with the base year, to complete the estimates of LUCs before the base year, provide estimates of soil emissions due to changes in CM and GM and appropriate emission factors for perennial biomass and soil. Chapters 5 and 6 provide guidance on how such improvements can be achieved.

## 3 First steps for moving from land-based reporting to activity-based reporting and accounting of CM and GM

### 3.1 Introduction

This chapter provides guidance to Member States on how to take the first steps to move from current land-based reporting to activity-based reporting on cropland and grazing land management as required under EU Decision 529/2013.

Member States have considerable experience in land-based reporting of cropland and grassland but for some it is not clear how best to move to activity-based reporting for CM and GM while maintaining maximum synergy and consistency with the inventory under the UNFCCC. For this reason, the initial steps proposed as set out in this section, have been organised into a structure that could be used to complete Chapter 11<sup>14</sup> of the NIR containing additional information as required under Art. 7.1 of the Kyoto Protocol<sup>15</sup> (see Table 2). This structure has been derived from experiences in reporting under Art. 3.4<sup>16</sup> of the Kyoto Protocol in the first commitment period.

This chapter describes some of the decisions and choices that a Member State will need to consider when reporting CM and GM for the first time. It is not intended to describe the final ideal system of tracking emission sources and sinks from land management under CM and GM, but shows how initial estimates for these activities could be derived and how to prioritise further efforts for improvement. It is estimated that to carry out the steps described below requires approximately five to ten person days of work (as estimated in a test case carried out in Germany and described in Annex 2). The time includes carrying out the additional calculations, uncertainty assessment, searching for and analysis of additional management data and writing of the information text. They do not include any methodological changes to higher Tiers.

Annex II of Decision 2 /C MP.8 of FCCC/KP/CMP/2012/13/Add.1<sup>17</sup> provides guidance about what kind of additional information is required for Activities under Art. 3.3 and 3.4 of the Kyoto Protocol. This information sets out the requirements for additional calculations when moving from the land-based reporting under the UNFCCC to the activity-based reporting under the Kyoto Protocol. The 2013 IPCC KP Supplement further specifies the definitions, methodologies and reporting requirements. In particular, the 2013 IPCC KP Supplement,

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<sup>14</sup> The standard NIR structure can be found here: [https://www.google.it/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCMQFjAA&url=https%3A%2F%2Funfccc.int%2Ffiles%2Fnational\\_reports%2Fannex\\_i\\_ghg\\_inventories%2Freporting\\_requirements%2Fapplication%2Fpdf%2Fannotated\\_nir\\_outline.pdf&ei=mfXJVLgllqtU\\_SGgaAE&usq=AFQjCNH0FmCRsukA8-y2cBzN6HwTarTptQ&sig2=6HNu0XK4fuAOHVAYkkaSUA&bvm=bv.84607526,d.d24](https://www.google.it/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCMQFjAA&url=https%3A%2F%2Funfccc.int%2Ffiles%2Fnational_reports%2Fannex_i_ghg_inventories%2Freporting_requirements%2Fapplication%2Fpdf%2Fannotated_nir_outline.pdf&ei=mfXJVLgllqtU_SGgaAE&usq=AFQjCNH0FmCRsukA8-y2cBzN6HwTarTptQ&sig2=6HNu0XK4fuAOHVAYkkaSUA&bvm=bv.84607526,d.d24)

<sup>15</sup> <http://unfccc.int/resource/docs/convkp/kpeng.pdf>

<sup>16</sup> <http://unfccc.int/resource/docs/convkp/kpeng.pdf>

<sup>17</sup> <http://unfccc.int/resource/docs/2012/cmp8/eng/13a01.pdf>

chapter 2.9.1, introduces a stepwise approach for estimating emissions and removals from CM, which is also applicable to GM. The stepwise approach is included in the guidance below.

This guidance document provides practical suggestions how reporting on CM and GM can be developed based on the reporting for Cropland and Grassland in the UNFCCC inventory. Moving from land-based reporting to activity based reporting of CM and GM is easiest and most straightforward when the methodology is developed with a clear focus on the additional information required. It is therefore important to assess up front what are the most significant types of management in terms of their carbon emissions or savings and focus efforts accordingly.

Articles 39, 40 and 41 of the Commission implementing regulation 749/2014<sup>18</sup> sets out the requirements for reporting on the systems in place and the emissions and removals from cropland and grazing land management. Article 41 (Reporting requirements on annual estimates of emissions and removals from cropland management and grazing land management), subparagraph 4 specifies that:

‘When providing the information [on CM and GM] Member States shall comply with the following requirements:

- (a) [...], and
- (b) include explanatory information on methodologies and data used as required in the national inventory report in accordance with Decision 2/CMP.8 under the Kyoto Protocol’.

Article 42 on ‘submission of information’ specifies that:

‘The information corresponding to the reporting requirements set out in Articles 39, 40 and 41 of this Regulation shall be submitted to the Commission as a separate annex to the national inventory report referred to in Article 7(3) of Regulation (EU) No 525/2013.’

Section 3.2 provides guidance on how to fulfil these reporting requirements.

### **3.1.1 Structure for reporting**

As set out above, the stepwise approach set out in this chapter for moving from a land-based approach to reporting to an activity-based approach is based upon a proposed structure for the relevant chapter in the NIR (Chapter 11). This is set out in Table 2.

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<sup>18</sup> COMMISSION IMPLEMENTING REGULATION (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member Sta

**Table 2: Proposed structure of the text with additional information under the KP, focusing on CM and GM (Chapter 11 of the NIR)**

Chapter 11	Additional information as required under Art. 7.1 of the Kyoto Protocol
11.1	General information
11.1.1	Elected Activities under Art. 3.4 of the Kyoto Protocol
11.1.2	Definition of the Activities
11.1.3	Hierarchy of Art. 3.4 Activities
11.1.4	Other definitional issues
11.2	Land based information
11.2.1	Methodology for identification of units of land under Art. 3.3
11.2.2	Methodology for the land-use matrix
11.2.3	Maps and/or data bases for determination of the geographical location of the boundaries of the areas and the respective system for land identification
11.3	Activity specific information
11.3.1	Methodologies for estimating the changes in carbon stocks, greenhouse gas emissions and removals in line with IPCC Guidelines
11.3.2	Information on which, if any carbon pools were not accounted for, together with verifiable information that demonstrates that these unaccounted pools were not a net source of anthropogenic GHG emissions
11.3.3	Information whether the estimates 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
11.3.4	Changes in data and methods since the last submission (recalculations)
11.3.5	Uncertainty estimates By carbon pool and emission source
11.3.6	Year of onset of an Activity if later than 2013
11.4	Article 3.3
11.5	Article 3.4
11.5.1	Demonstration that activities under Article 3, paragraph 4, have occurred since 1 January 1990 and are human induced
11.5.2	Anthropogenic GHG emissions by sources and removals by sinks for each year of the commitment period and for the base year for CM
11.5.3	Anthropogenic GHG emissions by sources and removals by sinks for each year of the commitment period and for the base year for GM
11.5.4	Anthropogenic GHG emissions by sources and removals by sinks for each year of the commitment period and for the base year for FM
11.5.5	Forest Management Reference Level (FMRL)
11.6	Key category analysis for Activities under Art. 3.3 and 3.4
11.7	Information on Article 6

### **3.1.2 Definition of the Activities (Section 11.1.2)**

This section should include the definitions of CM and GM and demonstrate how the definitions have been implemented and applied consistently over time. The steps for doing this as identified in chapter 2.9.1 of the 2013 IPCC KP Supplement are set out below:

#### **STEP 1: Define CM and GM and apply the definition in a consistent manner over time, including in the base year**

CM and GM are defined as Activities in a broad sense. The broad definition allows the CM and GM Activities to be matched with the land-use categories Cropland and Grassland as defined in the land-based approach of the UNFCCC inventory.

- **CM:** It may be easiest to adopt the 'Cropland' definition of the UNFCCC inventory. If a MS elects RV, which may include some of the perennial crops, the MS would need to specify what types of cropping systems are included within the definition. For example: arable land with annual crops, perennial crops, rice fields, horticulture, agroforestry. This may include olives, orchards, vineyards, short-rotation coppice, Christmas tree plantations etc. If the perennial crop is undersown with grass it may also be classified under GM. To avoid artefacts of frequent land-use changes, set-aside land, temporary grasslands and grass leys are best included in CM.
- **GM:** Define GM consistently with CM regarding set-aside land, temporary grasslands, grass leys, perennial crops and agroforestry. GM can also refer to sub-categories of Grassland that best match your country's view on GM. For example GM could focus on grasslands under agricultural use but exclude natural grasslands, heathlands, shrublands etc.

Matching CM and GM definitions with Cropland and Grassland as reported in the UNFCCC inventory saves resources for reporting and guarantees consistency and transparency in reporting and accounting. It also allows use to be made of existing calculations and key category analysis in the UNFCCC inventory for CM and GM.

## **STEP 2: Identify the land under CM and GM using Approach 2 or 3**

There is generally some uncertainty in the distinction between permanent grassland and non-permanent, rotational grassland. To avoid artefacts of frequent iterative changes between CM and GM it is advisable to include non-permanent grassland in the cropland definition.

If CM and GM definitions are consistent with those for Cropland and Grassland, the land-use matrix from the UNFCCC inventory can be used. CM then includes (Table 3):

1. All areas of cropland remaining cropland.
2. Areas with any land-use change to Cropland, except from Forest Land, as the latter is included in Deforestation.
3. Areas converted from Cropland to any land-use category except Forest Land included in Afforestation, Grassland included in GM and any other land under RV and WDR. These areas need to be reported under CM, but not the carbon stock changes and greenhouse gas emissions and removals associated with the land-use change or thereafter (2013 IPCC KP Supplement, Chapter 2.9.2).

**Table 3: Translation of land-use categories under UNFCCC into CM strata if the definition of CM is consistent with the Cropland definition**

Category under KP	Category under UNFCCC	
Cropland Management	4.B.1 Cropland remaining Cropland	
	4.B.2.2 Grassland converted to Cropland	4.B.2.2.1 Sub-categories of Grassland accounted under GM converted to Cropland
		4.B.2.2.x Sub-categories of Grassland not accounted under GM converted to Cropland
	4.B.2.3 Wetlands converted to Cropland	4.B.2.3.1 Subcategory 1 of Wetlands converted to Cropland
		4.B.2.3.n Subcategory n of Wetlands converted to Cropland
	4.B.2.4 Settlements converted to Cropland	4.B.2.4.1 Subcategory 1 of Settlements converted to Cropland
		4.B.2.4.n Subcategory n of Settlements converted to Cropland
	4.B.2.5 Other Land converted to Cropland	
	4.C.2.2.x Cropland converted to any sub-category of Grassland not accounted under GM	
	4.D.2.2 Cropland converted to Wetlands	4.D.2.2.1 Cropland converted to Subcategory 1 of Wetlands
		4.D.2.2.n Cropland converted to Subcategory n of Wetlands
4.E.2.2 Cropland converted to Settlements	4.E.2.2.1 Cropland converted to Subcategory 1 of Settlements	
	4.D.2.2.n Cropland converted to Subcategory n of Settlements	
4.F.2.2 Cropland converted to Other Land		

In the Cropland remaining Cropland category, it is important to track separately the land areas of sub-categories with distinct biophysical properties, e.g. perennial crops and agroforestry versus annual crops, paddy rice fields, as well as management regimes with significant trends (see step 4 in section 1.3.6 below). This stratification by type of management allows management changes to be treated in the same way as land-use changes.

GM land can be identified in the same way.

The land-use matrix developed for UNFCCC reporting may already meet the requirements for CM and GM if it is based on spatially explicit data. A minimum level of spatial explicitness is needed to identify the geographical boundaries of CM and GM. As a minimum, at least a time series of land cover maps or land-use maps that show the geographical boundaries of the croplands and grasslands that meet the CM and GM definition as well as any land-use changes are needed.

### **3.1.3 Hierarchy of KP Art. 3.4 Activities (Section 11.1.3)**

It makes sense to define the boundary (or hierarchy) between Art. 3.4 Activities<sup>19</sup> in accordance with the 2013 IPCC KP Supplement. Applying the land-based definitions of Cropland and Grassland allocates each hectare of land unambiguously to either Cropland or Grassland. Accordingly, the allocation to CM and GM will be the same and it will be clear whether CM takes precedence over GM or vice versa. With such an unambiguous land-based definition it does not really matter how the hierarchy between CM and GM is defined as long as it is consistent.

### **3.1.4 Other definitional issues (Section 11.1.4)**

In this section, Member States could provide any country-specific information, if applicable, concerning the definition of pools, for example; how mineral soil is separated from litter and litter from deadwood; how soil depth is defined (30 cm? any other depth?); how deadwood is defined (e.g. in grasslands with trees); how 'organic soils' are defined (and differentiated from mineral soils); how areas with trees under CM/GM are differentiated from AR/FM/D etc. Reporting that the Member State applies the IPCC definitions is also information and can be included here.

The understanding of land use transitions (conversions) may be also specified in this section. For example, if a certain piece of land is frequently switched from cropland to grassland and back, a Member State might have to define how these conversions are treated and when they are accounted as land-use change (and report this definition).

These issues might not be CM/GM specific, however, in case they are, they should be included in this chapter for the sake of transparency.

### **3.1.5 Methodology for the land-use matrix (Section 11.2.2)**

If the KP activity definitions match the land-use category definitions under UNFCCC the methodology for the land-use matrix is the same as under the UNFCCC. It is therefore sufficient to provide a brief methodological summary and links to the detailed description elsewhere. The area under CM and GM should be shown as well. The minimum detail required is the stratification of data by areas remaining, converted to, and converted from CM or GM. Further details, e.g. the original or new land-use class, or by further management strata for the remaining land, improves transparency. Table 4 shows an example of area reporting for CM. The land-use subcategories should be adjusted to national circumstances and the reported sub-categories.

The area under GM should be set out in this section in the same way.

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<sup>19</sup> Forest management, cropland management, grazing land management and revegetation)

**Table 4: Area under CM in the base year and the commitment period**

Cropland management (CM)	Area 1990 [kha]	Area 2013 [kha]
Sub-categories		
Cropland remaining Cropland		
Land converted from Grassland accounted under GM (GM to CM)		
Land converted from Grassland not accounted under GM		
Land converted from Terrestrial Wetlands		
Land converted from Water bodies		
Land converted from Settlements		
Land converted from Other Land		
Land converted to Grassland not accounted under GM		
Land converted to Terrestrial Wetlands		
Land converted to Water Bodies		
Land converted to Settlements		
<b>Total</b>		
Afforestation (cumulatively reported under KP Art. 3.3)		

Source: to add

### **3.1.6 Maps and/or data bases for determination of the geographical location of the boundaries of the areas and the respective system for land identification (Section 11.2.3)**

This section should include a list of the spatially explicit data sources which have been used to identify and track CM and GM. Most of its content is likely to have been reported already elsewhere in the NIR. It may be useful to display example maps of geographically explicit data and of tracking CM and GM land and conversions between KP Art. 3.3 and 3.4 activities.

This section can also refer to the broad land-use (sub)categories. Further stratification by type of management, in particular if not spatially explicit, should be reported in section 10.3.1.

### **3.1.7 Methodologies for estimating the changes in carbon stocks, greenhouse gas emissions and removals in line with IPCC Guidelines (Section 11.3.1)**

This section describes the methodologies used to estimate GHG emissions and removals for each carbon pool and emission source. This section also contains further detail about land-use stratification by soil type and management type. The steps for doing this as identified in chapter 2.9.1 of the 2013 IPCC KP Supplement are set out below.

#### **STEP 3: Distinguish between the two subcategories of CM: mineral soils and organic soils.**

Since the distinction between mineral and organic soils is already necessary for the UNFCCC inventory, Member States should already have this data available. The stratification of land by mineral and organic soils can be done by overlaying land-use maps or the spatially explicit land-use matrix on a soil map. Consistent land-use maps are needed for at least two points in time so that the stratification can also be derived for land-use changes.

If the boundary between mineral and organic soils can be considered to be static, Member States could also start from the soil map and develop two independent land-use matrices, one on mineral soils and one on organic soils. This may facilitate the detection of diverging trends in land-use changes and also would allow for different data sources or spatial resolutions to be used, if desired.

In some Member States shallow organic soils have gradually been lost, or are being lost as a result of degradation, subsidence or soil management. If this is the case then the boundary between mineral and organic soils is best considered in a temporally dynamic way, which requires a joint land-use matrix for mineral 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, and available data.

*(See also Section 4.2, Chapter 4, Volume 1 of the 2006 IPCC Guidelines and Figure 2.9.1 of the 2013 IPCC KP Supplement and Annex 2, section 10.3.13 in this guidance)*

Key category analysis is already part of the UNFCCC inventory requirements. No additional key category analysis for the activities is required. Key categories are determined by level, trends and uncertainties. For CM and GM it is most important to evaluate trends according to net-net accounting, which factors out constant emissions since the base year. These base emissions, however, give an important indication of the potential for mitigation measures. High emissions in the base year indicate a high potential for decreasing emission trends in the future.

For mineral soils, this section should include methodologies for monitoring land management activities and changes. This section should contain additional information to that provided in the UNFCCC inventory as it requires the tracking of management activities, in particular in cropland and grassland remaining in the respective land-use category. This Step may be considered the most challenging as it is the critical step to determine how best to stratify CM and GM land and which Tier methodology to apply for which carbon pool.

A series of Tier 1 checks is proposed here to support decision making about stratification and which Tier methodologies to use. These should be considered as examples and need to be adapted to national circumstances.

First we present a series of 'rules of thumb' for determining key categories and significant pools. The information in brackets shows whether the key category is most relevant to be assessed according to level, trend or uncertainty. CM and GM are most likely to be key categories and a carbon pool is likely to be significant if:

- For Cropland remaining Cropland / Grassland remaining Grassland:
  - Woody biomass is affected by significant area changes in perennial crops or agroforestry (trend)
  - Mineral soils are affected by significant management changes (trend, level, uncertainty)

- Drained organic soils occur (level, uncertainty, trend only in case of significant changes in drainage regime)
- For Land converted to Cropland / Grassland:
  - Land-use changes are associated with strong differences in woody biomass stocks (trend)
  - Mineral soils are affected by land-use change and there are significant land-use changes (level, trend, uncertainty)
  - Land-use changes occur on organic soils and are associated with strong differences in drainage regime (trend, uncertainty)

A series of more detailed checklists are provided in Table 5, Table 6 and Table 7 for testing the significance of pools that are likely to be important and drivers of trends for CM, GM and land use changes to cropland or grassland. These aim to help identify where higher Tier methods need to be applied, based on already existing data sources and where to prioritise efforts for future improvements.

Management effects are most relevant in the 'remaining' land-use categories. It is important to keep in mind that, in most situations, mineral soil carbon pools are expected to remain nearly constant. In specific situations, however, measurable changes occur, in particular if carbon input significantly changes (e.g. onset or abandonment of regular application of high amounts of organic manure, change in the duration or fraction of grass leys in rotations). The process of losing soil organic carbon is much faster than the process of carbon sequestration ('slow-in, fast-out', Körner, 2003). Keeping these processes in mind allows soils and regions to be identified where soil organic carbon is likely to be stable or dynamic. Reporting and monitoring efforts should find an appropriate balance between spatial representation (proving the no-change areas) and relevance (dynamic regions).

**Table 5: Checklist for potentially important strata and pools in the key category analysis for CM: Cropland remaining Cropland**

Stratum	Pool	Question	Indicator / data sources
Cropland on organic soils	Organic soils	How much cropland is located on organic soils?	Use the land-use matrix, agricultural or regional area statistics or use the LUCAS or LPIS data combined with a soil map.
Perennial crops	Carbon in woody biomass  Mineral soils: C stock change, e.g. by default factor $F_{LU}$	Has the area of perennial crops changed over time? Test separately for vineyards, orchards, olive trees, etc.	Use the area under each type of perennial crops. Use production data if area is unavailable.
Agroforestry and short rotation coppices		Has the area of agroforestry and short-rotation coppices changed over time?	Use the area under agroforestry or short rotation coppices. Use production data if area is unavailable.
Hedgerows and trees outside forests		Has the area, or length of linear structures, of hedgerows, shrubs or trees outside forests changed over time?	Use the area or length of hedgerows or tree lines from land-use maps or statistics
		Have there been any programmes, e.g. under the 2nd Pillar of CAP, to promote agroforestry, short rotation coppice, hedgerows or trees outside forests? How large is the area on which they have been	Use the area on which the programmes have been applied
Set-aside land	Mineral soils: C stock change, e.g. by default factor $F_{LU}$	Has the area of long-term set-aside land (e.g. 5 to <20 years) changed over time?	Use agricultural statistics or check the programme evaluation reports or surveys of programme implementation (e.g. budget). Make sure that you only include long-term set-aside land. Agricultural statistics often do not distinguish between rotational and long-term set-aside land.
Annual crops: Carbon input by crop residues	Mineral soils: C stock change factor $F_1$	Has the carbon input by crop residues changed over time?	Use the N input from N input by crop residues reported under 3.D.a.4 as indicator. Carbon can be estimated by applying C:N ratios. For a first estimate the carbon trend can be assumed proportional to the N trend.
Annual crops: Carbon input by intercrops		Has the carbon input by intercrops or catch crops changed over time?	Are intercrops or catch crops included in the N input by crop residues under 3.D.a.4? If not, use area data from agricultural statistics or, e.g. programmes under the 2nd pillar of the CAP.
Cropland: Carbon input by animal manure		Has the carbon input by animal manure changed over time?	Use the N input from N input by crop residues reported under 3.D.a.2a as indicator. Carbon can be estimated by applying C:N ratios. For a first estimate the carbon trend can be assumed proportional to the N trend.
Cropland: Carbon input by other organic sources		Has the carbon input by other organic sources changed over time?	Use the N input from N input by crop residues reported under 3.D.a.2b and 3.D.a.2c as indicator. Carbon can be estimated by applying C:N ratios. For a first estimate the carbon trend can be assumed proportional to the N trend.

Scientific knowledge about management effects on grasslands is much less advanced than on croplands, partly due to the wide diversity of grassland types and management regimes, which interact with climatic and soil conditions. The checklist in Table 6 can therefore only be seen as a first rough guide.

**Table 6: Checklist for potentially important strata and pools in the key category analysis for GM: Grassland remaining Grassland**

Stratum	Pool	Question	Indicator / data sources
Grassland on organic soils	Organic soils	How much grassland is located on organic soils?	Use the land-use matrix, agricultural or regional area statistics or use the LUCAS or LPIS data combined with a soil map.
Grassland type	Mineral soil	Are there clearly distinct grassland management regimes, e.g. improved / sown grassland, fertilized versus unfertilized grassland, rough grazing, heather and moorland? Are there temporal trends (e.g. shift from one management regime to another)?	Use data from agricultural statistics, land-use or land-cover maps etc. Check whether management regimes have been consistently defined over time.
Grazing versus cutting	Mineral soil	Has the grazing area or the grazing period or the number of grazing animals changed over time?	This indicators is based on the observation that the net carbon export from grazing land tends to be lower than from cut grassland, which is likely to increase soil C stocks. Use the N input from N input by grazing reported under 3.D.a.3 as indicator. It remains, however, to be nationally proven whether and how grazing or cutting regime affects carbon stocks.

Land-use changes to cropland or grassland (see Table 7) refer to those other than deforestation. Most of these will be changes from grassland to cropland and vice versa.

**Table 7: Checklist for potentially important strata and pools in the key category analysis for land-use changes to cropland or grassland**

Stratum	Pool	Question	Indicator / data sources
Cropland - grassland conversions on mineral soils	Mineral soil	Is there a clear difference in area converted from cropland to grassland and vice versa?	Use the land-use matrix, agricultural or area statistics.
		Is there a temporal trend in the total area converted?	
		Is there a clear difference in soil type of the area converted from cropland to grassland versus the area vice versa?	Use the land-use matrix, agricultural or regional area statistics or use the LUCAS or LPIS data combined with a soil map.
Cropland and grassland on organic soils	Organic soils	Is there a land-use trend on organic soils (land-use changes)?	Use the land-use matrix, agricultural or regional area statistics or use the LUCAS or LPIS data combined with a soil map.

Annex 1 shows how the checklists can be applied in practice, using the example of Germany.

**3.1.8 Information on which, if any, carbon pools were not accounted for, together with verifiable information that demonstrates that these unaccounted pools were not a net source of anthropogenic GHG emissions (Section 11.3.2)**

In CM and GM, litter and dead wood pools are usually very small and often reported as 'NO' (not occurring) or 'IE' (included elsewhere). Arguments to support why these pools were not accounted for and were not a net source of anthropogenic GHG emissions for can include the following:

- Regular tillage, which removes litter, combined with arguments that crop litter quickly decays or is in equilibrium over a crop rotation.
- Stable or increasing trends of carbon in crop residues. These can be derived from increasing trends of nitrogen input to soils by crop residues (reported under 3.D 'direct N<sub>2</sub>O emissions from N input to soils').
- A description of how dead biomass in grasslands varies (e.g. constant).
- A description of removals of pruning material from perennial crops from the fields.

Many long-term experiments and long-term observations on croplands and grasslands indicate stable soil organic carbon stocks in mineral soils. In this case the mineral soil pool is reported as 'NO' based on observational evidence. This 'NO' needs to be clarified because it can be misinterpreted. 'NO' in this case should be a Tier 2 estimate of 'no change' proven by measurements in the Member State or in neighbouring Member States with similar environmental and management conditions.

Organic soils under CM and GM are generally drained and a GHG source. If the organic soil pool is not accounted for, national evidence is needed that the soils are undrained and unmanaged and do not emit any GHGs.

**3.1.9 Information on whether the estimates 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 (Section 11.3.3)**

Section 10.3.3 is more relevant for FM than for CM and GM. It is impossible to distinguish between the effects of elevated CO<sub>2</sub> concentrations and progress in breeding, or between indirect nitrogen deposition and nitrogen fertilisation. Modelling may be an option for factoring out these indirect effects but a model would face the same challenge - that field evidence for calibration is unavailable and ambiguous. It is suggested therefore to conclude that anthropogenic effects override by far the indirect effects by climate change in CM and GM so that the estimates relate to anthropogenic GHG emissions and removals.

Age structure effects are restricted to forests and play a very limited role in CM and GM, e.g. only if the age of agroforestry trees or olive trees are taken into consideration.

**3.1.10 Changes in data and methods since the last submission (recalculations) (Section 11.3.4)**

This section can refer to the relevant respective sections in the NIR.

### **3.1.11 Uncertainty estimates (Section 11.3.5)**

Uncertainty estimates are made for each carbon pool and emission source. Uncertainty estimates are calculated by Gauss error propagation (tier 1) and by higher tier methods like Monte Carlo simulations. If GHG emission estimates are based on those for the UNFCCC estimates the uncertainty can be estimated as GHG-weighted means of the uncertainties of the sub-categories aggregated to CM and GM.

This guidance document does not include information on how to carry out an uncertainty analysis. Detailed information is available in the related section of the IPCC (2006) guidelines and in the specific methodological chapters for the LULUCF subcategories and pools. The IPCC (2006) guidelines also provide uncertainty values typical for area information and specific for the default emission factors. These relative uncertainty figures are conservative (in sense of not being too optimistic) and may be used in the uncertainty analysis if country specific uncertainty data are not available.

Country specific uncertainty data can be derived from the (statistical) assessment systems used, can be estimated on the basis of all available data for the input parameters, or may be robust background information from the tools used to carry out verification exercises, such as models.

A top down uncertainty assessment may compare the results/deviation of different information sources for one and the same parameter (e.g. the area of a land-use category) and may also help to identify and quantify the bias in the data used.

In the worst case, no information (not even those in the IPCC guidelines) may be available or suitable for the quantification of the uncertainty of an input parameter. In such cases, expert judgment of the uncertainty may be carried out (see chapter 5.1.1, p.47) and/or the uncertainty may be judged on the basis of a range of data that potentially fit the conditions required as found in the literature.

### **3.1.12 Year of onset of an Activity if later than 2013 (Section 11.3.6)**

CM and GM include a broad definition of activities. Most of each Activity has its onset in 2013. Land converted to cropland or grassland which enters CM and GM after 2013 is reported in this section. The year of onset of the activity equals the year of land-use change.

### **3.1.13 Demonstration that activities under Article 3, paragraph 4 (KP), have occurred since 1 January 1990 and are human induced (Section 11.5.1)**

CM and GM include a broad definition of activities and are characterised by frequent human interventions, which typically occur at least annually. To demonstrate that the activities have occurred since 1 January 1990 and are human induced a simple description of common management practices and the frequency of interventions is all that is needed. This should be set out separately for annual crops, perennial crops and different types of grassland management.

### **3.1.14 Anthropogenic GHG emissions by sources and removals by sinks for each year of the commitment period and for the base year for CM (Section 11.5.2)**

In this section the GHG emissions and removals for CM for the commitment period and the base year should be summarised. This section also shows the accounted net GHG emissions and removals, which are calculated as the emissions and removals in the commitment period minus those in the base year.

Table 8 shows an example summary table for CM, but with only one stratum. The table should include all strata and sub-categories for CM.

If the UNFCCC inventory uses the same stratification as used for CM reporting, the GHG emissions and removals of the sub-categories and land-use changes can simply be transferred to the summary table. The 2003 IPCC GPG and the 2013 IPCC KP Supplement (Box 2.9.1 and Section 2.9.2 in the respective documents) allow simplified reporting for land converted from CM to land-use categories that are not accounted for:

*'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.'*

In line with the IPCC guidance, the area of land that is no longer to be reported under CM is reported in NIR Section 11.2.2 (here section 10.3.3, Table 4) but the GHG emissions and removals from this land are accounted zero (Table 8).

The excluded amount of GHG emissions and removals can be estimated from the UNFCCC inventory in the base year and in the years of the commitment period by summing up the GHG emissions and removals of the respective land-use change categories (see 'Cropland converted to ...' in Table 4) in the NIR inventory. Some land-use changes are reported in other Art. 3.3 and 3.4 Activities so that care must be taken to avoid double-counting, in particular with AR activities.

**Table 8: GHG emissions and removals by CM in one year of the commitment period or in the base year**

Sub-categories	C stock change in biomass [Gg C]	C stock change in mineral soil [Gg C]	CO <sub>2</sub> from organic soils [Gg C]	CH <sub>4</sub> from organic soils [Gg CH <sub>4</sub> ]	N <sub>2</sub> O from organic soils [Gg N <sub>2</sub> O]	Direct and indirect N <sub>2</sub> O from mineralisation of soil organic matter after land-use change [Gg N <sub>2</sub> O]	Sum [Gg CO <sub>2</sub> -equ]	Accountable net GHG emissions or sink against base year [Gg CO <sub>2</sub> -equ]
Cropland remaining Cropland								
Land converted from Grassland accounted under GM (GM to CM)								
Land converted from Grassland not accounted under GM								
Land converted from Terrestrial Wetlands								
Land converted from Water bodies								
Land converted from Settlements								
Land converted from Other Land								
Land converted to non-accounted land-use categories	Accounted zero							
<b>Total</b>								

**3.1.15 Anthropogenic GHG emissions by sources and removals by sinks for each year of the commitment period and for the base year for GM (Section 11.5.3)**

This section contains information for GM with the analogous logic and content as section 11.5.2.

Many countries have diverse types of grasslands which may be classified as managed or unmanaged. The national definition of GM ultimately decides which grasslands are accounted under GM and which not. In some circumstances managed grasslands may have been abandoned and become unmanaged. The accounting principles, however, are very clear that land cannot leave the accounting ('once in, always in') but can only move between the mandatory or elected activities. This means that the area of grassland converted from managed to unmanaged must be reported in any case, e.g. as a separate subcategory.

The abandonment of management does not necessarily lead to zero GHG emissions and removals. If land is converted from managed to unmanaged, any anthropogenic GHG emissions and removals must continue to be reported. Natural GHG emissions and removals can be reported and accounted as zero. If a country cannot factor out the anthropogenic GHG emissions and removals from the natural the 'managed land proxy' is likely to apply.

This means that all GHG emissions and removals on managed land are considered anthropogenic. Once land has been managed at some point in 1990 or from 2013 onwards any GHG emissions and removals on it would remain anthropogenic. It is, however, beyond the scope of this guidance document to prejudge in a legally binding manner how reviewers would assess the reporting and accounting of land transitions from managed to unmanaged status.

**3.1.16 Key category analysis for Activities under Art. 3.3 and 3.4 of the KP (Section 11.6)**

The identification of key categories for activity reporting is based on the results of the key-category analysis for UNFCCC reporting. No additional key category analysis is needed.

Although it is not required, a more specific analysis of the emission/removal figures for CM and GM activities may allow for a better identification of the significant sub-categories and pools. For instance, the UNFCCC categories 'LUC to CL' and 'LUC to GL' also include the emissions/removals due to LUC from FL to these categories which may make a significant contribution to the sub-category totals, trends and uncertainties. However, these LUCs are not part of the CM and GM activity but belong to the activity 'deforestation'. Therefore, an analysis of the subcategory totals without these areas of LUC may identify better the appropriate level of assessment/reporting for the CM and GM activities and pools.

Key categories are identified by the following qualitative criteria:

1. If the corresponding land-use or land-use change is key in the UNFCCC inventory; or
2. If the absolute value of the GHG emission or removal is larger than the smallest key category in the UNFCCC inventory; or
3. If a strong increase in the absolute value of the GHG emission or removal is expected (e.g. through mitigation measures) so that criterion (1) or (2) is expected to be fulfilled in the near future.

General guidance is given in the 2013 IPCC KP Supplement, chapter 2.9.1, Step 4.

#### **STEP 4a: Key categories and significant pools by level**

Member States should already have information on the level of key categories and significant pools from the UNFCCC inventory. Key categories by level should be estimated with national data and be supported with additional information on management practices. Further stratification by management practices may be useful.

#### **STEP 4b: Key categories and significant pools by trend**

For CM and GM it is most important to evaluate trends for key categories and significant pools due to the requirement for net-net accounting. Therefore, uncertainty analysis should focus on uncertainty in activity data that determine the trend. Uncertainty in emission factor constants, however, only have a small impact on trend uncertainty as the emission factor uncertainty is temporally correlated and therefore cancels out to a large extent.

Key categories by trend should be estimated with national data and be supported by additional information on the trends for different management practices. Again, Member States should use the information on the key category analysis and significant pools regarding trend from the UNFCCC inventory. Further stratification by management practices may be useful to separate dynamic from static regions or management regimes.

#### **STEP 4c: Key categories and significant pools by uncertainty**

Assessing key categories and significant pools by uncertainty should be prioritised for further inventory development if the uncertainty associated with the estimates significantly affects the uncertainty in the trend. If uncertainty originates from uncertain constant emission factors and reflects the heterogeneity of circumstances in GM and GM further stratification should be tested to better reflect this heterogeneity.

Checklists for a more detailed first assessment of likely key categories and significant pools are provided in Table 5, Table 6 and Table 7. The results of the key category analyses should be summarised in a matrix as shown in Table 9.

**Table 9: Key categories and significant pools for CM and GM. The table can be used separately, and in combination, for level, trend and uncertainty analysis**

Is the category a key category? <sup>(1)</sup>			key category	If key category please tick the significant pools <sup>(2)</sup>					
				living biomass		dead organic matter		soils	
				above ground	below ground	litter	dead wood	mineral	organic
CM	5.B	1. Cropland remaining Cropland							
	5.B	2. Land converted to Cropland							
GM	5.C	1. Grassland remaining Grassland							
	5.C	2. Land converted to Grassland							

### 3.2 Creating accounts to determine the overall impacts of the GHG mitigation measures

This section sets out what the requirement on Member States under the EU Decision to ‘prepare and maintain annual accounts’ (Art 3.2 of Regulation 529/2013) means in practice, with reference to the requirements set out in Articles 38-43 of the Commission Implementing Regulation 749/2014<sup>20</sup>. Article 40(4) specifies that ‘When providing the information [on CM and GM] Member States shall ... (a) complete all relevant common reporting format tables as included in the Annex to Decision 6/CMP.9 for the respective activity under the Kyoto Protocol for the second commitment period, including the cross-cutting tables on activity coverage, the land transition matrix and the information table on accounting’.

Step-by-step guidance shows how to fill in the accounting tables for CM and GM. It explains how to move from the reporting information to creating the accounts and refers to the relevant CRF tables (i.e. the need to fill all the cells of KP LULUCF tables relevant to CM and GM<sup>21</sup>, including the cells in column ‘accounting quantity’<sup>22</sup> in the sheet ‘Accounting’.

The guidance refers to the draft KP-LULUCF tables from SBSTA 39<sup>23</sup> and is organised by accounting table. The tables must be filled in for the base year and for every year from 2013 onwards. The text in italics refers to the table headings of the KP-LULUCF tables. All articles refer to the Kyoto Protocol.

<sup>20</sup> COMMISSION IMPLEMENTING REGULATION (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council

<sup>21</sup> not only sheets 4(KP-I)B.2 and 4(KP-I)B.3, but also cells in other sheets relevant to CM and GM.

<sup>22</sup> To note: In the case of EU Decision 529/2013, the accounted quantity is reported for information purposes only (since LULUCF is currently not included in the EU 2020 targets). In the future, this kind of information will be used in ‘accounting toward a GHG target’ (in the sense of the KP) only at such time when new EU legislation specifies the modalities for the inclusion of LULUCF in the EU GHG targets.

<sup>23</sup> The 39<sup>th</sup> meeting of the Subsidiary Body for Scientific and Technological Advice, November 2013

*TABLE NIR 1. SUMMARY TABLE* - Activity coverage and other information relating to activities under Article 3.3, forest management under Article 3.4, and elected activities under Article 3.4: Indicate which activities and which carbon pools and GHG sources are reported. The table implies that some N<sub>2</sub>O emissions from soils under CM and GM are reported and accounted in the Agriculture sector and not under CM and GM. This includes N<sub>2</sub>O from N input and fertilization and from cultivated or drained organic soils. The following N<sub>2</sub>O sources, however, are reported and accounted under CM and GM: (1) N<sub>2</sub>O from nitrogen mineralization associated with carbon losses in mineral soils and (2) N<sub>2</sub>O from peat fires and biomass burning.

*Table NIR 2. LAND TRANSITION MATRIX* - Areas and changes in areas between the previous and the current inventory year: Indicate the areas under CM and GM in the lines for CM and GM, respectively. The sum of the line must add up to the CM and GM area in the previous year. There are separate cells for land transitions from CM or GM to any other mandatory or elected activity. Note that land cannot leave the accounting ('once in, always in'), so it can only move between the activities, but not to 'Other'. Land converted to CM and GM in the inventory year is entered in the line 'Other'. The cell 'Other/Other' contains all land outside the accounting and is used for consistency and completeness purposes to sum up all land to the national total land area.

*TABLE NIR 3. SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL* - The key category analysis for KP-LULUCF does not require any calculations beyond those made for the UNFCCC inventory. Key categories are identified by qualitative criteria:

- (1) If the corresponding land-use or land-use change is key in the UNFCCC inventory; or
- (2) If the absolute value of the GHG emission or removal is larger than the smallest key category in the UNFCCC inventory; or
- (3) If a strong increase in the absolute value of the GHG emission or removal is expected (e.g. through mitigation measures) so that criterium (1) or (2) is expected to be fulfilled in the near future.

Note that the national CM and GM definitions will not necessarily be consistent with the national definitions of cropland and grassland. Some of the GHG emissions or removals could also be accounted under e.g. ARD, FM or RV. Use criteria (1) and (3) if the definitions or emissions and removals agree between CM, GM, cropland and grassland. Use criteria (2) and (3) where they are not consistent.

*TABLE 4(KP). REPORT OF SUPPLEMENTARY INFORMATION FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL* - Information on Recalculations - Recalculated data for KP-LULUCF: In case of recalculations from the previous inventory year fill in the respective cells with the values of the previous submission and the latest submission (i.e. the one you are working on).

*TABLE 4(KP). REPORT OF SUPPLEMENTARY INFORMATION FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL. SUMMARY TABLE:* This table is calculated automatically. Cross-check whether the net GHG emissions and removals

for CM and GM are correct for the inventory year. Note that this is not the accounting table, but the one that shows the total net GHG emissions and removals for the base year and any inventory year from 2013 onwards.

*TABLE 4(KP-I)B.[2][3][4]. SUPPLEMENTARY BACKGROUND DATA ON CARBON STOCK CHANGES AND NET CO<sub>2</sub> EMISSIONS AND REMOVALS FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL* - Elected Article 3.4 activities: Cropland Management: Indicate the C stock changes or CO<sub>2</sub>-C emissions from CM in this table. 'Geographical location' means that you should do it separately for each subcategory or stratum (e.g., annual crops, perennial crops: vineyards, perennial crops: orchards, grassland converted to annual cropland ...). Each 'Geographical location' can be further subdivided ('Subdivision') according to climate zone, management system, soil type, vegetation type, tree species, ecological zone, national land classification or other criteria. Complete one row for each subdivision.

*TABLE 4(KP-I)B.[2][3][4]. SUPPLEMENTARY BACKGROUND DATA ON CARBON STOCK CHANGES AND NET CO<sub>2</sub> EMISSIONS AND REMOVALS FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL* - Elected Article 3.4 activities: Grazing Land Management: Indicate the C stock changes or CO<sub>2</sub>-C emissions from GM in this table. 'Geographical location' means that you should do it separately for each subcategory or stratum (e.g., fertilized grassland, unfertilized grassland, heathland, cropland converted to grassland, ...). Each 'Geographical location' can be further subdivided ('Subdivision') according to climate zone, management system, soil type, vegetation type, tree species, ecological zone, national land classification or other criteria. Complete one row for each subdivision.

*TABLE 4(KP-II)2. SUPPLEMENTARY BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL*- CH<sub>4</sub> and N<sub>2</sub>O emissions from drained and rewetted organic soils: Indicate the CH<sub>4</sub> emissions from drained and rewetted organic soils under CM and GM. The N<sub>2</sub>O emissions from drained and rewetted organic soils are reported and accounted in the Agriculture sector (3.D). Check whether the areas of drained and rewetted organic soils agree (keeping eventual differences in CM and GM versus cropland and grassland definitions in mind) and whether the drainage status is reported consistently.

*TABLE 4(KP-II)3. SUPPLEMENTARY BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL* - N<sub>2</sub>O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils: Indicate the land area with soil organic carbon losses, the soil organic carbon loss and the associated N<sub>2</sub>O emissions from N mineralization. The table is only meant for N<sub>2</sub>O from soil C and N losses, but there is no opposite process of N<sub>2</sub>O sequestration by N immobilization (despite the misleading table heading).

*TABLE 4(KP-II)4. SUPPLEMENTARY BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL*- GHG emissions from biomass burning: Indicate the fuel load from biomass and peat or the area burnt and related CO<sub>2</sub>, CO and CH<sub>4</sub> emissions. Report separately for controlled burning and for wildfires.

*INFORMATION TABLE ON ACCOUNTING FOR ACTIVITIES UNDER ARTICLES 3.3 AND 3.4 OF THE KYOTO PROTOCOL*- This table is the central table for CM and GM accounting. It is calculated automatically. It contains the net GHG emissions and removals in the base year and in every year from 2013 onwards. The column 'Accounting quantity' calculates the difference between the net GHG emissions and removals in the years since 2013 and the net GHG emissions and removals in the base year times the number of accounting years. Cross-check whether the net GHG emissions and removals for CM and GM are correct for the base year and every inventory year and whether the accounting quantity is calculated correctly.

## 4 Planning improvements – setting priorities

The schedule for mandatory accounting of CM and GM under Decision No 529/2013/EU defines a period in which to improve GHG reporting and accounting. No later than 15 March 2022 Member States shall submit ‘final annual estimates for accounting of CM and GM’ (Article 3(2) (c)), with derogations possible for Member States only under specified conditions (Article 3(2d)).

Given the limitations both in time and the resources generally available Member States are obliged to set priorities in planning the improvements required. The IPCC Guidelines give general guidance for improving GHG inventories but do not explicitly address the specific needs for CM and GM reporting or the challenges faced when moving from land-based reporting under the UNFCCC to activity based reporting under Decision No 529/2013/EU. This section is based on IPCC guidance and suggests some additional considerations which Member States will want to take account of when planning improvements in CM and GM reporting.

The general basis for setting such priorities is the key category and tier concept together with the decision trees set out in the 2006 IPCC Guidelines (IPCC 2006) and the 2013 IPCC KP Supplement (IPCC 2014). In some circumstances Member States may use Tier 1 values for key categories. In this case IPCC says that any key categories where the Good Practice method cannot be used should have priority in making future improvements. The 2013 IPCC KP Supplement (IPCC 2014) in principle allows Tier 1 reporting even in key categories. However, significant pools (>25 to 30 %) of key categories have to be reported with higher Tier methods and data. Non-significant pools, on the other hand may be reported with Tier 1 methods and data. Member States therefore are advised to make Tier 1 estimates and at the same time conduct a semi-quantitative sensitivity analysis of the assumptions and likely directions of changes in reported emissions/removals that will be needed when moving to higher Tiers. The most significant pools and those where the levels and trends are unclear should be prioritised in planning improvements.

For planning purposes key categories are determined not only by level and trend but also by degree of uncertainty. For CM and GM trend matters more than level because emissions that remain at the same level are cancelled out by net-net accounting against 1990 emissions.

Net-net accounting against 1990 emissions and removals implies that the quality of data and methodologies for 1990 reporting should be as good those for reporting in the relevant commitment period. This includes a capacity to report relevant land-use changes since 1971 that affect net C sinks and sources in the base year. This poses a serious challenge for many Member States in finding reliable past, often forgotten and often analogous data for the years concerned or robust proxies. Proxies should not over or underestimate emissions and removals in the base year. In case of doubt or serious uncertainty it may be advisable to make conservative estimates, i.e., higher net C sinks or lower net C sources in the base year. The principle of conservativeness is accepted by reviewers and will avoid derogations. Nevertheless, conservativeness is not an IPCC principle so countries should strive for

accuracy where possible. Furthermore, conservative estimates reduce the incentives for mitigation measures because part of the GHG gains is exhausted by the conservative approach.

Completeness is critical. Incomplete reporting or uncertain 'not occurring' emissions/removals may lead to derogations. Member States therefore should prioritise finding substantive qualitative arguments or semi-quantitative proof that a C pool is not a source if they cannot quantify net emissions and removals.

'Land identification' is an additional requirement for CM and GM, which is specific to activities under the Kyoto Protocol. Land identification means that the area on which management measures take place needs to be identifiable at least roughly on a map. Although criteria for land identification are not strictly spatially explicit, reviewers tend to prefer spatially explicit reporting, at least at the level of the major land-use categories.

CM and GM also require tracking of the management of the land concerned, e.g. tracking land cover under perennial versus annual crops, fertilizer and tillage regimes. It is almost impossible to track management of this kind in a spatially explicit way back to pre-1990. The 2013 IPCC KP Supplement (IPCC 2014) has recognised this challenge and gives guidance for management tracking in a non-spatially explicit way and with Tier 1 methods (Box 2.9.2, Box 2.9.3, Box 2.10.1 in the KP supplement). The national examples in these boxes can serve as orientation for minimum standards of relevant management tracking covering retrospective periods.

Quantification of uncertainty is mandatory but there is no minimum criterion for the allowable level of uncertainty. Addressing uncertainty is mentioned in the key category analysis but not as a first priority. Nevertheless, Member States should strive to minimise uncertainty in the reported trends compared to the 1990 emission/removal level. Uncertainty in activity is the main source of uncertainty in the data on trends because emission factors are often constants. By contrast constants affect uncertainty in levels much more than in trends.

Activity data are country specific. Emission factors, however, may be shared with neighbouring countries with similar conditions. Consequently Member States might be advised to prioritise national projects for improving activity data but to seek synergies with others or even European coordination for improving methodologies and emission factors.

The list of questions below summarises the considerations outlined in this chapter. The questions are ordered by (1) risk of derogation, (2) key categories, (3) accuracy and robustness of net-net accounting. The list may help Member States in orientating their priorities in planning improvements in CM and GM reporting by 2022.

1. Is reporting incomplete or are there uncertain 'not occurring' emissions/removals? Justify why the carbon pools are 'not a source' or address them as a first priority.
2. What are key categories in trends, in particular concerning the differences from the base year?

3. Which significant pools are found in the key categories by level and trend?
4. What additional pools are highly uncertain and may become significant when moving in future to higher Tier methods? In particular: What management measures or types have undergone drastic changes since 1990? Which carbon pools are most affected, and how much?
5. Are 1990 emissions/removals much more uncertain than recent ones? Does this uncertainty affect the robustness of the trend, and of net-net accounting? If so, are conservative estimates possible?
6. What parameters are most relevant in explaining the difference in emissions/removals between the base year and recent years?
7. Can the main land-use categories and main management types which are subject to reporting be tracked in a spatially explicit way?
8. Which kinds of activity data give rise to large uncertainties in the trend and in net-net accounting against 1990?
9. Which other Member States have interesting methodologies, emission factors or similar challenges so that active co-operation may save time and resources?
10. Which activity data and/or input parameters to emission factors contribute most to the total uncertainty in the trend in the emissions/removals of significant pools of key categories?

## Part B: Detailed guidance

Part B provides more detailed guidance for Member States on improving the quality of activity data (Chapter 5); improving the accuracy of emission factors (Chapter 6) as well as providing information and suggestions on how to address various organisational and operational issues that may arise (Chapter 7).

## 5 Improving the quality of activity data for cropland management and grazing land management

To build on the first steps identified in Part A, this section provides a number of options for sourcing activity data for CM and GM to improve reporting for these activities and related subcategories.

The options put forward respond to the main issues currently faced by Member States. The basic guidance included within the 2006 IPCC Guidelines (IPCC 2006) and the KP-Supplement (IPCC 2013) is not repeated here – the approaches and requirements are well described there and used for designing the area assessment system. Instead, the most relevant problems relating to activity data reporting, identified on the basis of the information from the analysis of recent Member States reporting (and as summarised in Annex 0) are listed below and proposals for solving each of these problems are provided on the basis of:

- suggestions for improvements from the project team; and
- alternative perspectives from international and EU wide assessment systems and projects;
- examples of problem solutions from Member States;
- planned improvements in some Member States;

### 5.1 Completeness and consistency of time series of activity data

A prerequisite for any estimating/reporting of the emissions/removals due to cropland management and grazing land management, even for Tier 1 estimations, is access to robust information on the areas of land use and land-use change for the activities taking place on cropland and grassland for the time period under consideration.

The area assessment system for these activities should be an integral part of a consistent and complete overall land-use and land-use change monitoring system in the country for all land-use and land-use change subcategories and activities to be reported. There will be a better chance of estimating accurately emissions from all subcategories and activities, of obtaining appropriate activity data, and of simultaneously and ultimately developing an accurate land use/change matrix, if all these categories are treated as interrelated elements of a complex system, LULUCF.

The system needs to be in line with the requirements set out within the IPCC 2006 guidelines (IPCC, 2006) and the IPCC KP supplement (IPCC, 2014). Two of the relevant requirements are: the completeness of the area statistics in sense of time and land coverage; and the consistency of the system across time. For the reporting and accounting of CM and GM these two points are crucial, because these activities are accounted net/net between the commitment period years and the base year. Incompleteness and inconsistency may lead to the accounting of artefact emissions/removals that deviate from real world results. This is particularly sensitive under net/net accounting since the real world situation with regard to emissions may be very different, compared to the accounted one due to the deficits in completeness and consistency, even changing whether or not overall emissions are a net source or sink.

The analysis of Member States reporting shows that the major challenges for Member States in reporting for these activities arise due to the net/net accounting approach with the base year and would not occur under a different accounting regime that built on more recent years for the baseline. The majority of Member States experience problems here. This is because current accurate and complete assessment systems were not in place in the base year and historic land uses and land-use changes cannot be reassessed easily – Member States have to work with the available images/statistics/information for the base year and cannot re-monitor the historic situation with current tools. The situation is further complicated by the fact that the base year represents just one year, and sometimes the result for one year needs to be derived from information that represents an average for several years or out of data from adjacent years to the base year.

The completeness and consistency of activity data need improving in several Member States. Amongst the issues faced are the following (see Annex 2):

- *Activity data for the complete time series are often not available* - extrapolations and backcasting to the base year is needed in several Member States: This introduces the risk of very uncertain base year emissions/removals that may have a significant influence on the amount accounted under CM and GM.
- *Lack of (complete) land use change (LUC) consideration before base year, but not for the commitment period*: The (base year) emissions/removals are influenced to a significant degree by previous land-use change. Frequently, the LUC categories to CL and GL represent key categories. Regarding CM and GM, land-use changes to cropland and grassland from all other subcategories except from forest land (which is accounted under KP Art. 3.3 deforestation) need to be covered in the accounting. For the base year, this requires land-use changes in the transition period to be considered for soil C stock changes (by default 20 years) before the base year (so, by default the time period of 20 years before the base year). If these previous land-use changes are not taken into consideration (fully) for the base year emissions/removals (identified for several Member States), but are considered for the commitment period only, the result will be incomplete and inconsistent figures and artefact accounting emissions/removals for these activities.
- Almost all Member States have a *consistency issue between the base year/commitment period for activity data* due to the changes or breaks in the assessment systems.

### **5.1.1 Suggestions for improvements**

One or a combination of the following approaches may be used (and are already successfully used) in Member States to improve completeness and consistency of activity data:

- A. Use one of the LULUC approach/assessment systems over time and improve it according to the reporting needs;
- B. Carry out a broad exploration of all available information sources on (historic) land-use and land-cover in the country;

- C. Adjust the results to be compatible with current assessment systems using splicing techniques (IPCC 2006 Guidelines, Vol. 1, Chapter 5).

It is important to note that **the establishment and use of a new accurate LULUC area assessment system should not be hindered by adherence to a less ideal historic system.** Splicing techniques can be used to make the historic data consistent to the data of the new system (see further below). An ideal assessment system should be accurate (fulfilling the requirements of the minimum mapping units), complete, consistent, spatially explicit and have sufficiently frequent re-assessments. The system should also be sustainable to run and maintain and should be run by well-established institutions. Optimising synergies with other reporting requirements saves resources and time.

***A. Use of one LULUC approach/assessment system over time and improve it according to the reporting needs***

Using one approach for the whole time series is something that is done in several Member States. The core systems used include the grid of the National Forest Inventory, Cadastral Systems, Corine Landcover or other EOS systems with higher resolution.

Some of all of the following steps may be useful to consider in order to improve the completeness and consistency of the system used:

- i. secure the minimum mapping unit required,
- ii. expand the system from region or land use type to the whole country,
- iii. back extrapolation with the help of historic images/orthophotos
- iv. improve the frequency of the update/re-assessment.

Each of these is discussed in turn below.

**i) Secure the minimum mapping unit required**

A critical problem of assessment systems whose resolutions are too coarse, like Corine Land Cover or some cadastral systems, is the frequent occurrence of mixed land parcels where several types of land-uses are included within one assessment unit. This becomes a particular problem when land-use changes should be tracked for these types of mixed parcels. A further problem may be that linear land-uses (like road, train lines, rivers etc) may be underrepresented in the results of such assessment systems.

Therefore, efforts should be made to improve the area resolution of such assessment systems to reflect the country-typical sizes of the land parcels representing a single land-use or consideration should be given to changing to more accurate EOS systems (as has happened in Luxembourg, see Box 2). The minimum unit for a sufficient resolution is likely to differ from country to country, since the typical size of cropland/grassland parcels or the heterogeneity of the land-use structure of the landscape varies between countries in Europe.

For historic years a sufficiently higher resolution may not be achievable if more accurate images are not available. A way to solve this problem for historic years is to carry out an

analysis of a representative subset of land parcels which do not contain different land-use types and to extrapolate these results to the whole area of that land-use type in the country. Care must be taken with this approach that the subset analysed is not biased (e.g. certain parts of the country or land-use types are underrepresented in the sample). A careful check should be undertaken to ascertain whether the trend (e.g. LUC from GL to CL) in the mixed parcels can be expected to follow the same relative trend as for the subsample. Any further information/statistics available on agricultural land-use should be considered in this analysis (see also chapter 7). In case of a biased subsample, correction factors, derived on the basis of the bias, need to be introduced before the sample results are extrapolated to the whole country.

A further helpful approximation approach for historic years may be to calculate the typical proportions of subcategories in such mixed parcels on the basis of current accurate results or further information which is available. Based on this information the historic areas of these mixed categories can be subdivided proportionally. This approach assumes that the proportions of different subcategories in the mixed categories have not changed over time and this assumption should be explored on the basis of further information.

Having assessed the time series for the area under a particular land-use or land-management with these approaches, checks on the basis of further available information sources can be carried out. For instance, the total areas derived using these methods, based on spatially explicit systems, can be checked against the results of other statistics or information sources after harmonising the results of the systems (e.g. harmonising for different definitions or coverage).

## **ii) Expand the system from region or land use type to the whole country**

Several countries have expanded their assessment systems for a particular region or type of land use to the whole country. Most frequently this has been carried out based on the National Forest Inventory (NFI), for instance in Estonia, Finland and Sweden (Box 3, Box 4, and Box 5) and is planned in Romania (Box 12). Also Germany and France (Box 6) successfully introduced a countrywide grid system of plots to analyse its LULUCs. However, in some cases an accurate and successfully used assessment system in one region of the country has been expanded to other regions of the country.

A sound NFI has a fixed grid with spatially explicit grid points and covers the whole country (a fixed grid of the NFI with spatially defined grid points is a prerequisite for using the NFI as LULUC assessment system). So, two very critical requirements for the activity specific LULUC assessments are already fulfilled. In addition, it represents a cost-effective and resource saving approach because only a representative subsample is analysed to get results for the whole country on basis of extrapolations according to the area representation of the plots. Within each NFI assessment period, all fixed NFI grid points need to be assessed, also all former non-forest grid points for the identification of any land-use change to forests. If there was afforestation the grid points are monitored. All new non-forest grid points (except those with deforestation) are usually not assessed within a NFI survey.

An overall assessment system for all LULUC-types in the country on the basis of the fixed-grid NFI needs a change to enable the monitoring of all grid points, independent of the land-use. At each grid point the land-use and land management information required is assessed. It should be noted that – as typical for statistical systems – the assessment per grid point must be very accurate to secure low uncertainty of the overall results for the country. The assessment of the land-use at NFI plots with two land use categories requires accurate measurement, thorough documentation and archiving of the polygons which divide the plot into the two land-use or land-management types in order to reduce the uncertainty and avoid artefact results (e.g. ‘land-use changes’ due to inaccurately measured polygons). This may be a challenge because the borders between the LUCs are seldom a well-defined line. Furthermore, a handbook with definitions and detailed methodological advice in addition to well-trained and harmonised assessment teams are needed for the successful implementation of this approach.

The LULUC-assessment on the NFI plots can be carried out on the basis of field surveys and/or high resolution images, like orthofotos. Field surveys allow also certain management parameters to be tracked which cannot be assessed from the images. They are therefore more accurate for cases where the land-use types cannot be well distinguished from the images. On the other hand, field surveys may not be appropriate to carry out on all plots due to the destructive nature of the measurements for annual cropland biomass. For historic years, there is no alternative to assess the LULUC on the NFI plots but to use images (see below).

### **iii) Back extrapolation with the help of historic images/orthophotos**

Back extrapolation using images has been used successfully in several Member States, like Finland and Estonia (Box 3, Box 4) and is planned to be implemented in Romania (Box 12). Historic land use and land-use change is assessed with the help of historic orthophotos and colour infrared photographs. Orthophotos in particular should be available in many Member States for historic years, partly produced for military purposes, but perfectly useable for civil purposes. Orthophotos and infrared photographs represent the most accurate images for historic years and are very effective in allowing several different land-use and land-management types to be distinguished. Orthophotos may be available every few years, depending on the flight cycle in the country. They can therefore be used to detect changes over time.

The assessment plots of the fixed grid of the expanded LULUC assessment system (NFI) which are spatially identifiable can be inserted into the spatially oriented images and the LULUC within the plots can then be analysed using the historic images.

### **iv) Improve the frequency of the update/re-assessment**

A disadvantage of well-established systems like cadastral maps or the use of earth observation systems like Corine Landcover is the long time period between updates or re-assessments. For reporting purposes, these time periods may be too long for LULUC reporting purposes as the reviewers of the GHG inventory often insist that an extrapolation from the last assessment to the commitment period would not qualify the GHG inventory as being sufficient.

For this reason, some Member States using the cadaster (CZ, PL) shortened the cycles of updating the maps to an annual system (Box 8). For those countries using highly accurate EOS systems for ten yearly assessments, less resource demanding EOS techniques have been used in the intervening years. This allows the extrapolation of the last results of the highly accurate assessment systems to be adjusted for the commitment period as an intermediate resource saving step until the next high resolution reassessment is carried out (e.g. Luxembourg Box 2).

It should be noted that GHG reporting is a highly political process and decisions about reporting and accounting requirements change over time. For instance, reporting requirements for the 3<sup>rd</sup> commitment period are not yet known (e.g. time period, reporting demands). To invest in such resource intense assessment systems requires long term planning. Therefore, assessment systems need to be developed with sufficient flexibility and improvisation to enable the routines to be adjusted to changing reporting demands. Such adjustments, however, may be in conflict with other monitoring/reporting demands for which the assessment systems are used since the LULUC area assessment is not a stand-alone task for GHG reporting. It should be acknowledged therefore, that the solutions developed to meet all reporting requirements may have to deviate from what might be considered the ideal approach for GHG reporting.

#### ***B. A broad exploration of all available information sources on (historic) land-use and land-cover in the country***

Some Member States, such as Denmark (Box 9) and the UK (Box 10), use available data from several different assessment systems to construct the time series for LULUC regarding CL and GL (see Annex 2). Also Member States using only one approach for the whole time series (see previous section) frequently use further data sets as complementary information to address any information gaps.

The use of all available data sources on activity data to construct the time series for LULUC is certainly a very good approach because it integrates all available information and requires definitional differences in the assessment systems to be clarified and data sets to be harmonised.

A broad review of available data sets also has the advantage that unexpected shortcomings, inconsistencies, data gaps and misinterpretations of the data of one LULUC assessment system are easier to identify and can then be resolved. Each deviation between the results of the different systems requires the reasons for this to be clarified and should lead to adjustments in the system used. In an ideal situation the different assessment systems should be harmonised in such a way that the results become comparable among the different assessment systems that are run in the country. A substantial advantage of such a harmonisation would be that the outputs of the different assessment systems and the different results of the assessments for which they are used (e.g. GHG emissions reporting, land-management data for agricultural statistics and subsidy payments, land-cover assessments for natural protection purposes, base data for spatial planning) could be linked

without bias which would allow a thorough understanding of the correlation between certain trends. This would provide an advantage for both planning and decision making as well as for understanding the impacts of plans/decisions in a range of different thematic areas.

Member States that want to consider reviewing a number of additional data sources for their historic years to achieve consistency and completeness in their activity data could use some of the following information:

- i. Historic images from earth observation, orthophotos;
- ii. Historic agricultural statistics;
- iii. Information on surrogate parameters for the activity data required; and
- iv. Expert Judgements.

#### **i) Historic images from earth observation, orthophotos**

The advantages and ways of using orthophotos or EOS images for historic years to reconstruct historic LULUC has been described in the previous section, particularly using them in combination with statistical LULUC assessment grids. Of course, such images can be also used to improve the consistency and completeness of a wall-to-wall mapping system for the whole country or for the clarification of LULUC detail that cannot be derived from the data and systems currently used (e.g. the LULUC trend in a certain region or the area change of a certain perennial crop type which can be well assessed on basis of images).

Orthophotos are very accurate, while historic satellite images and the historic Corine Landcover typically have a coarse resolution which may make them less helpful in filling information gaps for LULUC. Careful consideration of the information needed is required in order to prioritise which data sources are reviewed.

#### **ii) Historic agricultural statistics**

Typically, all Member States have a long time series of agricultural statistics even back to years before the period that needs to be assessed for LULUC (since 1971). For this reason many Member States use this information source for GHG reporting purposes regarding CL and GL. Agricultural statistics usually provide area information on crops and types of management as well as information on yield. All such information may be useful for GHG reporting and its potential is elaborated in other chapters in this guidance (see Chapter 7). Here, the area information is of interest.

Agricultural statistics have the disadvantage that they are not spatially explicit, but provide aggregated information. Having said that, particularly in recent years, spatially explicit assessment systems like LPIS/IACS have started to be used in some Member States to derive these statistics. Regarding completeness and consistency, particularly with respect to the historic years, the following information from agricultural statistics with respect to area may be helpful:

- the (trend in and) total area of CL and GL
- the (trend in and) area of certain crop types
- the (trend in and) area of certain CL and GL management types

This area information usually represents net totals which are the result of area gains and area losses of these types of land. The actual gains and losses are often also of particular relevance for reporting on GHG emissions/removals (e.g. regarding biomass of perennial crops). However, this information should not be disregarded. The net areas may represent a very valuable information tool for a number of purposes, including:

- for splitting aggregated classes in the existing assessment system according to the relative area shares of these classes in the agricultural statistics;
- for adjusting trends and back extrapolation of area information from current assessment systems which have a lack of and/or sufficiently accurate historic information; and
- for checking the occurrence of certain types of crop or management in historic years

Although current assessment systems may be spatially explicit, the assessment technique used may not allow for the distinction between certain types of crop or management with different trends and impacts on the GHG emissions/removals. In such cases, the information in the agricultural statistics may be used to disaggregate the area results for these classes further.

The spatially explicit and accurate LULUC monitoring systems that are currently used may not have been in place in historic years. In such cases, back extrapolation on the basis of the area information from the agricultural statistics could be carried out (for techniques to use, please see the section about splicing techniques below). Or, if the agricultural statistics are consistent over time, their trend may be used to adjust breaks or jumps in the assessment system that occur due to methodological changes or gaps in monitoring. The interpolation of results from existing assessment systems between the survey years may be fine-tuned (instead of using linear interpolation) on the basis of the relative time-trend in the agricultural statistics. A further use for the agricultural statistics might be to use the data to inform adjustments/corrections in unclear situations.

Agricultural statistics can also be used to check whether or not certain types of crop or management occurred in historic years. Certain types of crop or management may have been introduced in the time period of interest but were not present in historic years. Some of these types of management may be long-term in duration (e.g.: management within a certified system, such as organic farming which required demanding management changes which are not easily given up; or the introduction of a particular perennial crop, the area of which due to its perennial nature simply increased but was very likely not converted before typical rotation periods to something else). In such cases the net area information in the agricultural statistics may be sufficient already for the GHG estimates and tracking it back in historic years may not be need to be spatially explicit to estimate accurately the emissions/removals.

In all these situations, care must be taken that the agricultural statistics are consistent over time. This is frequently not the case because for agricultural purposes, the historic years may no longer be of interest for a variety of reasons and as a result the statistics will not have been back-adjusted. Over time definitions may have changed, but also the methods and purpose of the survey (e.g. to move from national statistics to an EU-compatible system). Therefore, it is of utmost importance to consult experienced experts running the agricultural statistics for any changes in the system before using the data. In addition, a time series plotting of the data is needed and jumps in the trend (as requested as a QA/QC measure for any GHG time series) need to be investigated, clarified and eventually corrected/smoothed.

### **iii) Information on surrogate parameters for the activity data required**

Surrogate parameters for the activity data are used in some Member States as complementary information to improve the consistency and completeness of the data required. This information is sometimes linked to or based on expert judgement (see section below).

Some suggestions for surrogate parameters that could be used are provided below:

- The area trend of certain types of crop or management, of LUCs between GL and CL and of the abandonment of such lands may be correlated with the funding (or exclusion from funding) of these activities. Historic information on agricultural payments may be used to estimate the trend in the areas of these crop/management types.
- The general trend in agricultural income or specific economic trends may be correlated with the trends in area of LUC involving CL and GL or the trends in area of certain crops/management types.
- The introduction of a funding regime, significant changes in the incentive system, sudden changes in demand for certain crops and altered legal circumstances may well help define an unknown point of time when the area trend of a crop or management type significantly changed.
- The area of a certain crop/management type which is not known may be correlated or inversely correlated with the area of another crop/management type which is known.
- Yield over time may be a good indicator for the change of the area of crops. Or, a certain crop type may be correlated with a management type, occur only in a certain region and soil type (this example is also included in chapter 5.3.1 which deals specifically with management activities on CL and GL).
- The increase in settlement area may be well correlated with the decrease in CL and GL area. In these situations, settlement area trends can be used to adjust historic trends in CL and GL. Such consistency adjustments of the CL and GL area may also include the trend in forest area – part of the forest increase may be due to the cessation of CM and GM for economic reasons in some regions.

The identification of such surrogate parameters requires a thorough exploration of existing agricultural expertise in the country (see also chapter 7) and may also benefit from the use of expert judgement (see next section).

#### **iv) Expert Judgement**

Sometimes no data for historic years are available or the historic trend for the area of a crop/management type and LULUC is unknown. Additional data sources or surrogate parameters also may not be available. In such cases, the only alternative way to extrapolate the time series backwards may be to consult with experts. One should not underestimate the quality of judgement by experienced experts – in some cases the authors of this guidance were able to confirm preliminary expert judgements by later measurements. Nevertheless, expert judgement should be the last alternative as an approach.

The starting point for using expert judgement should be a clear written formulation of the problem that needs to be solved. With respect to consistency and completeness of area data, this may be for instance the trend of a certain crop or management type, the historic area of a certain crop type, the historic year of starting a certain management type or the historic trend of land-use changes.

A list of available experts should be compiled and screened with reference to the problem to be solved and several or all of the experts (not just one) should be invited for a first meeting where the issue to be resolved is explained. Before the meeting, a list of questions and check-points around the problem should be prepared to help identify a number of related, as well as contradictory, aspects of the problem. Additional information sources and surrogate parameters which may help to derive the information required should also be identified. The checklist/questionnaire should also include points where the rationale for the expert judgement needs to be explained (this may also serve later as documentation to support the judgement). After explaining the issue, the experts should work individually on their judgements to allow for a broad range of independent judgements to be provided.

A follow-up meeting should be arranged in which the experts present their judgements and the underlying arguments and considerations. It is likely that the judgements will deviate, as will the considerations and proxy parameters that have been used to inform them. A discussion on the different views and considerations should take place in order to come to a common view on the most likely judgement, in an ideal situation. If a common view cannot be reached, the experts should be sent away to reconsider the issue separately and then requested to work together on reaching a common judgement, taking the different, maybe partly new arguments from some experts, into consideration. If an agreed common opinion from the experts cannot be reached by a third meeting, the mean of their view could be used on the basis that any judgement is better than no value. The deviation between the judgements may be an indication for the uncertainty of the eventual value used.

An even better solution, but requiring more effort, would be that estimates are carried out for all deviating judgements and the resulting time series of activity data is crosschecked for consistency with other linked parameters (e.g. with totals or areas of other subcategories). The best fitting series of data can then be chosen.

### ***C. Adjustment of the results to be compatible with current assessment systems using splicing techniques***

The IPCC 2006 Guidelines, Vol. 1, Chapter 5 (IPCC, 2006) describes several possible methods to make the results of two data sources for the whole time series consistent or to fill data gaps (overlap, surrogate parameters, inter- and extrapolation). We do not repeat these methods here, but it is certainly worth looking at this helpful chapter in the IPCC guidelines, which LULUCF experts are not always aware of because it is in a different volume of the IPCC guidelines.

The following paragraphs provide a few additional ideas about how to proceed when adjusting two data sets to achieve time series completeness and consistency.

It should be noted that inconsistent data series from two information sources remain inconsistent when using an unexplained adjustment factor to achieve coincidence. There is a need to investigate and document the potential reasons for the inconsistency. On the basis of this analysis an adjustment may be needed of both time series, both the one for current years and the one for historic years, for instance where definitional differences between the data sets and the reported activity or land-use category have been identified.

If the reasons for inconsistency cannot be clarified, the time series resulting from the more accurate assessment system should be used and the other data set adjusted to it, if this is possible. Such adjustments can be carried out in several ways, for example:

- on basis of back-extrapolation with the relative trend (ratio of year-to-year change of the time series to be adjusted) starting from the value of the last year measured from the accurate time series;
- using one adjustment factor to shift consistently the time series to be adjusted to the more accurate one;
- using a regression estimate derived from the overlap of the time series and estimating the historic period to be adjusted.

Several options should be tested and examined by the experts, and related information should be compared with the results (e.g. totals of the subcategory, results for other subcategories or surrogate parameters).

An adjustment between different time series is not recommended if the two time series have a different trend, particularly in the overlapping period, and where this difference in trend cannot be explained (and therefore corrected). In such cases splicing with the unreliable time series should not be carried out. Instead, a review of existing information for reliable (or reconstruction of reliable) results for single historic years should be carried out and the back-extrapolation from the accurate time series should just take these single-year results into consideration (using interpolation). Alternatively, in such cases surrogate parameters may be used for back-casting (see previous section).

### **5.1.2 *Alternative perspectives from international and EU wide assessment systems and projects***

LPIS/IACS (for current years) and Corine Land Cover (CLC) are used by several member states for CL and GL activity data reporting, frequently as a complementary data set to other information sources. **In the future LPIS/IACS has certainly the potential to become the most important activity data source for CL and GL and CM and GM reporting.** Some limitations to its use have been highlighted by some Member States but these all seem to be solvable.

The CLC provides consistent data over time as well as data for the base year, but its resolution is too coarse to serve as the only data source. The long periods between the re-assessments presents a further problem. In addition, management practices in CL and GL which are relevant for the estimates of the soil C stock changes cannot be assessed with using CLC data (or other EOS technologies, so far).

A description of these systems, of their advantages and limitations for GHG reporting in CL and GL can be found in chapter 7.

### **5.1.3 *Examples of solutions from Member States to issues faced***

Below are a collection of examples of problem solutions regarding consistency and completeness of land use and land-use change data from Member States that have been extracted from the review of Member States reporting. Not all of them are necessarily perfect and Member States indicated further planned improvements, but they can serve as ideas for approaches to solve the challenges regarding consistency and completeness of land use and land-use change data.

#### **Box 2 - The LULUC area assessment in Luxembourg**

Luxembourg has established a very accurate geographically explicit wall-to-wall land-use and land-use change assessment system with a detailed list of subcategories on the basis of EO techniques.

The base data used since the 2010 submission under the UNFCCC as well as under the Kyoto Protocol is the so-called OBS map data 'Occupation Biophysique du Sol'. This is a detailed land use / land cover map in digital format covering the entire territory of Luxembourg. Three versions of the OBS map data set exist. The first OBS data set, the OBS89, was collected in the field over several years and published in 1989 by the Environment Ministry. The second data set for the year 1999, the OBS99, was collected based on aerial colour infra-red ortho-photos and some field surveying. The third set, covering the year 2007, is the OBS07, which is an update of the OBS99 using very high resolution satellite images (1m pixel size) of the US commercial Earth observation satellite IKONOS. To adjust the LULUC area extrapolation of the last highly accurate OBS07 survey for the commitment period, an intermediate less accurate survey was carried out until data from the next full OBS survey could be used. This intermediate survey on LULUC in Luxembourg (LU12) covers the year 2012 and is based on satellite images from the RapidEye (RE) space segment, which is composed of five sunsynchronous Earth observation satellites providing large area, multi-spectral images with high resolution (5m).

OBS 1999, 2007 was carried out through an ESA-project (GMES<sup>24</sup>) from 2003 to 2009. LU 2012 was carried out on the basis of satellite images with a lower resolution than those of OBS (Rapid-Eye) between 2011 and 2013 and therefore cheaper.

### Box 3 - Area estimation in Finland

Area estimates for the land-use categories are based on the National Forest Inventories (NFI) carried out by the Finnish Forest Research Institute (Metla). The assessment of the NFI plots was expanded to all grid points and therefore assesses all LULUC categories. The NFI is a sampling-based inventory system with plots covering the whole area of the country<sup>25</sup>. Sample plots are located in systematic clusters and the ratio of temporary and permanent clusters is 3:1. The distance between temporary clusters varies between 6 and 10 km in different parts of the country. The field measurements are carried out in five-year cycles and each year 20% of the plots are measured. The most recent inventories are NFI10 (2004-2008) and the NFI11 (2009-2013). Older NFI data were used to compute estimates for land-use changes before 1990.

The reasons for the use of NFI data for the area estimations in the GHG inventory are: i) NFI is the only data source which covers the whole country and all land-use types; ii) NFI data covers the whole time span needed for the inventory's time series; iii) NFI definitions and measurements of important variables relative to GHG inventory have not been changed; iv) NFI provides data on land use, land-use changes, soils and tree biomass on different land uses; and v) NFI is a continuous system which provides data also for recent years.

Proportions of land-use categories are calculated from the NFI sample plot data. The official total land area is multiplied by proportions of land-use categories resulting in areas of land-use categories in hectares. Due to the differences in the spatial variation of forests, areas are calculated separately for South and North Finland in sampling density regions, as well as separately for land areas and inland waters. This method gives each sample plot a specific representativeness in hectares. The sampling pattern is denser in the southern part of the country because of the higher spatial variation. All areas of different land-use categories and areas of land use conversions are derived from the plot data. The sum of individual land-use categories is equal to the official land area or inland water area of Finland. Final results are reported at the country level.

The NFI data are used to estimate areas of land-use categories and land-use transfers. Because the full record of NFI data takes five years to complete, land-use information for the NFI sample plots is intermediately updated by means of aerial photo interpretation (if needed) to produce the estimates for the latest years. There are also other data sources used for the updating, including Landsat images and land parcel register for croplands. Annual areas of land-use changes in 1990-2012 are based on a five-year moving average method which is used to decrease the effect of sampling error.

The transition areas between all land-use categories are calculated using NFI field data including both temporary and permanent sample plots from the 10<sup>th</sup> and 11<sup>th</sup> National Forest Inventory<sup>26</sup>. The NFI contains approximately 15,000 plots that are measured each year. Land use changes are assessed in the field but plots are checked for undetected changes by utilising other NFI variables (such as stand age), and auxiliary data such as old maps, satellite images, thematic maps and aerial photographs. For the historic land-use changes aerial photographs are also analysed. The aerial photographs used are from the year 1990, when available, and otherwise from the years 1987-1995. The aerial photographs used included low and high-altitude black-and-white images and false-colour images. The satellite images were from the years 1987-1994 and the thematic maps from multi-source NFI8 data based on these satellite images. If old aerial images taken in the years 1987-1995 were not available, these plots were checked from aerial images taken in the years 1996-2000 or from paper maps (125 plots). Aerial images were needed for the LULUC assessment of approximately 950 sample

<sup>24</sup> <http://www.gmes-forest.info/>

<sup>25</sup> <http://www.metla.fi/ohjelma/vmi/vmi11-otanta-en.htm>

<sup>26</sup> <http://www.metla.fi/ohjelma/vmi/vmi11-info-en.htm>

plots resulting in 190 observed land-use changes from images. Furthermore, there were 5,800 plots where land use change was observed in the field. The NFI data were complemented by the findings of image interpretation. The image interpretation is carried out once for each plot, hence in the next submission only the new data is checked.

Information on land-use changes before 1990 are needed for estimation of carbon stock changes in soil. Therefore the area statistics for land-use changes were estimated also for 1970-1989 by employing data from the 7<sup>th</sup> to 9<sup>th</sup> National Forest Inventories. The average annual area statistics of land-use changes were estimated for the mean years of the inventories based on land-use changes for the ten years prior to the field measurements. The mean years of the inventories applied in the area statistics calculations were computed from an average measurement year minus five years because of the ten-year period of land-use changes. In South Finland, the mean years of the inventories were in NFI8-NFI9 1984 and 1993. In North Finland, the mean years for NFI7, NFI8 and NFI9 were 1977, 1988 and 1996. The areas that were converted from one category to another between the inventories' mean years were interpolated (for the years 1970-1989).

Information on areas of mineral and organic soils is needed to estimate carbon stock changes and non-CO<sub>2</sub> emissions from soils. Areas were derived from NFI data and the geo-referenced soil database. The Finnish soil database includes a soil map at a scale of 1:250 000 and properties of the soil. The database was utilised for the NFI sample plots that did not have information on soil type (croplands and part of the grasslands). In the soil database, polygons smaller than 6.25 ha were merged with adjacent larger polygons. The soil database was produced by Agrifood Research Finland (MTT), the Finnish Forest Research Institute (Metla) and the Geological Survey of Finland (GTK).

The area data and their uncertainties are produced by Finnish Forest Research institute. The emission estimates for Croplands and Grasslands are calculated in MTT Agrifood Finland and those for other land categories in Finnish Forest Research Institute. Significant changes in methods are approved by the steering groups of the institutes and the advisory board of the inventory system.

The LULUC area analyses described here are split among four experts. Human resources are estimated to be 24 person-months.

#### **Box 4 - Assessing Activity data for all six LULUCF subcategories in Estonia**

Estonia uses also the NFI grid of the National Forest Inventory to assess all LULUCs in the country. The LULUC assessment was expanded to all grid points. Additional field studies are included in the assessment for a better estimation of the year of LUC (and soil type). Old maps and aerial photos are used in addition to the field observations by the NFI. Improvements to the system took one year to complete .

#### **Box 5 - The LULUC assessment system in Sweden**

The Swedish LULUC assessment system provides a further example of a system using a high number of permanent plots. Sweden uses a random sampling methodology to estimate land-use and land-use transfers (Naturvårdsverket 2014). The LULUC assessment for all categories is based on 30,000 permanent sample plots inventoried by the Swedish National Inventory of Forests (RIS) in five cycles, each based on around 6,000 plots per year. The permanent sample plots have been re-inventoried at intervals of 5-10 years (from 2003 every five years) and the land-use of each is described from the year of the first inventory and every year thereafter. The land-use of years between inventories has been interpolated.

This approach means that a full record of plots comprises 30,000 plots, whereas the latest year is only represented by 6,000 measured plots. As the inventory cycle continues in subsequent years, more data covering the latest years are made available. Estimates of the four most recent years in a given inventory submission are thus re-calculated using data from re-measured plots. The time period to implement this system was five years.

## Box 6 - Deriving the land-use matrix from TERUTI + LPIS in France

France has a history of ground-truthing on a systematic / stratified sample system that has been developed and integrated with LPIS. Such an approach may be useful for countries with small-scale land-use structures that are difficult to determine from remote sensing.

The statistical service of the ministry for Agriculture (SSP) carries out annual surveys of ground cover and the functional use of land for the whole of France (excluding the overseas territories). The overseas départements (except PTOM) have been covered since 2005, except for Guyane where only the coastline is covered. The surveys, called TERUTI, have a high resolution and are used for constructing the land-use matrix. There are three different TERUTI series available over time with different legends, but the main difference is in the number of observed samples.

TERUTI takes an annual statistical approach based on sample points spread over the entire territory. According to the sampling protocol, each chosen sample point is visited on the ground by an inspector who determines the land-use type including the functional role in socio-economic terms. Repeated observations allow land-use tracking.

Up to 2004, sampling was based on 15,600 aerial photographs on which 555,900 sample points were determined. In 2004 sample size was reduced to 155,000 for budget reasons. One sample point corresponds to 50 ha for Paris, its surroundings and the region of Belfort and to 100 ha for the rest. In 2004, the area represented by each point rose to 360 ha.

Since 2005 and TERUTI-LUCAS the principle has remained similar but sampling has been georeferenced and harmonised with other EU Member States. In France the sample points of TERUTI-LUCAS represent about 94 ha for Paris, its surroundings and the region Belfort and 178 ha for the rest (except for 2005 when only half of the samples were taken, and 2011, when no data were produced). There were significant changes in 2012 to reduce the work of the on-site controls.

The GHG calculations are based upon two types of matrices:

- Annual land-use change matrices for the evaluation of landscape phenomena where change is observed quickly e.g. deforestation
- Matrices covering a period of 20 years for phenomena where change is observed more slowly over time e.g. change of soil organic carbon stocks or litter. The 20 year period corresponds to the IPCC default.

## Box 7 - Deriving the land-use matrix from historical satellite imagery for Guyane (France)

France has reconstructed land-use and land-use changes for Guyane based on LANDSAT 1990 and SPOT 2000 and 2006 imagery, using point-wise (with buffer) sampling rather than a wall-to-wall classification. This may be much more robust and accurate than the classical classification approaches, and also easier in situations where CLC is not accurate or biased.

## Box 8 - The land-use representation and the land-use change identification system in the Czech Republic

As a data source for land-use change information, cadastral data (at an aggregated level) are used in the Czech Republic. The land-use representation and the land-use change identification system in the Czech Republic is exclusively based on the annually updated cadastral data from the Czech Office for Surveying, Mapping and Cadastre level (ČÚZK 2013). These data are elaborated at the level of about 13,000 aggregated spatial units. The source data are administered centrally by the Czech Office for Surveying, Mapping and Cadastre ([www.cuzk.cz](http://www.cuzk.cz)). It provides annually updated cadastral information on ten land use categories that were linked

to the nationally defined IPCC land use categories. Land-use change is quantified by calculating changes in size of the areas with each of the six major land-use types for each of about 13,000 cadastral units from year to year. The system ensures consistent representation of land areas having the attributes of both Approach 2 and Approach 3 (in accordance with the good practice guidelines for LULUCF), permitting accounting for all land-use transitions in the annual time step.

At present, however, the LULUCF team is negotiating a deeper collaboration with the Czech Office for Surveying, Mapping and Cadastre requesting its assistance in estimating the necessary land use change and providing the resulting matrices at cadastral level (so far conducted by the LULUCF compiler). This would be based on balancing the explicit land use changes as included in the COSMC database, which should make the land use change quantification even more accurate and consistent.

One person month per year is needed for the assessment. However, this information does not include the resources for maintaining and updating the database.

### **Box 9 - Activity data for all 6 LULUCF Subcategories in Denmark**

A land use/land cover map was produced for the Kyoto reference year 1990, 2005 and 2011 based on EO data for forest land use (Landsat 5 (TM), 7 (ETM+), LiDAR). For almost all other land uses the main data come from detailed vector maps from the Danish Geodata Agency. These include data such as different vector layers from cadastral maps, road maps, wetland areas, agricultural land use data, vector layers of established wetlands, gravel maps etc. as well as aerial photos.

Data on cropland (annual crops and grass in rotation) and permanent grassland are taken from IACS/LPIS and all the other map layers are collected and combined to an overall consistent map.

In terms of resources, this requires about 3-5 months per year of one expert from a research institute with a focus on working with GIS data estimates, for meetings, writing, keeping information up to date and doing the GIS.

### **Box 10 - The LULUC assessment in the United Kingdom**

In the United Kingdom, various sources of area statistics and information, including historic data, are integrated to derive a consistent LULUC Matrix (Webb et al. 2014). Areas of forest land are derived from statistics published by the Forestry Commission. Areas of Cropland, Grassland and Settlements in 1990, 1998 and 2007 are sourced from the Broad Habitat areas reported for each country (England, Scotland, Wales and Northern Ireland) in the Countryside Surveys<sup>27</sup>.

Areas of land use change to forest (afforestation) in GB since 1920 come from planting data provided by the Forestry Commission and areas pre 1920 come from modelling the age class structure of existing forests given by the National Inventory of Woodlands and Trees. Areas of land use change to forest in Northern Ireland come from planting statistics since 1900 supplied by the Northern Ireland Forest Service. Areas of land use change from Forest (deforestation) come from Forestry Commission data, the Department for Communities and Local Government and the Countryside Survey dataset and expert knowledge from representatives of the devolved administrations. Other land use change data comes from the changes between the three Countryside Surveys (1990, 1998 and 2007), rolled forward to 2011.

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<sup>27</sup> <http://www.countryside-survey.org.uk>

#### **5.1.4 Planned improvements**

Below are a collection of planned improvements regarding consistency and completeness of land use and land-use change data from Member States that have been extracted from the review of Member States reporting. They can serve as ideas for principal approaches to solve the challenges highlighted in this chapter with regard to activity data.

#### **Box 11 - Broad improvement programme for LULUCF reporting in Croatia**

Croatia has started with preparatory work to inform CM and GM reporting by implementing the specific activities that have been proposed via an ongoing research project 'Upgrading the Croatian National System for the reporting of greenhouse gas emissions for the implementation of the Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities' (abbreviated: LULUCF 2).

Additional work is planned and envisaged under a newly developed project proposal (so called LULUCF 3 project). Croatia also intends to let a new project (based on the findings of the LULUCF 2 project) to investigate the development of a harmonised land use and LUC assessment system which integrates all existing LULUCF assessment systems in Croatia.

#### **Box 12 - Improvement of LULUC information in Romania**

The Ministry of Environment and Climate Change (MMSC) in Romania is currently funding a project to improve land use information in order to respond to the requirements on CM and GM defined in Decision 529/2013/EU and develop a country-wide harmonized reporting land use system based on the National Forest Inventory grid back to the 1970s (MMSC project). It is intended that historically accurate orthophotos will be used as a complementary information source. Discussions are taking place on which data from LPIS can be used (from past and new types of declaration), how and who can process the data, and the methodology to combine LPIS data with the NFI grid.

In order to move to Approach 3 - statistical approach based on NFI grid and LPIS spatial data in the framework of MMSC project - definitions of CM and GM have to be set and clarified, in accordance with land use and soil management reporting requirements and assessment methodologies (ideally preference would be given to spatial rather than non spatial data collection). The MMSC project is intended to become a platform on which any spatial information can be integrated in the future (e.g. geo-referenced maps for vineyards).

60 person months are scheduled for this project over a period of three years.

#### **Box 13 - LUC transition matrix in the United Kingdom**

In the United Kingdom, work is being undertaken to improve the representation of land use change. A new approach has been developed to assimilate multiple land use data sets. This is summarised below and is due to be included in the next submission. It involves vector representation of land use history and derivation of the most probable set of land use vectors which represent the set of characteristic land use histories giving rise to the observed change in land use at national scale. This should provide a better representation of cycles or reversals in land use change which are especially important when considering long time horizons.

The starting point is provided by the satellite-derived Corine land cover maps from 1990, 2000 and 2007, which cover the UK at 100-m resolution. Overlain on this are the CEH Countryside Survey data and the Forestry Commission National Forest Estate and Woodlands ground-based data. Together, these data are used to produce a set of 100-m resolution maps, where each pixel has an associated vector of land use over time. The maps are aggregated into the set of distinct representative vectors with their corresponding areas. The vector

areas are then calibrated to match the observed time series of the areas of forest, urban, arable, and grassland reported in national statistics. Further data on agricultural land use will be available in the near future, from the land parcel information arising from the Integrated Administration and Control System (IACS) data, and will be included in the data assimilation.

This project is scheduled for a two-year period.

## 5.2 Reporting subcategories of cropland, grassland and land-use changes with these sub-categories

To ensure emission estimates that are as accurate as possible, the IPCC 2006 guidelines recommend the division of CL and GL into subcategories along climate zones, soil types, management types or any other parameter if the differences in these factors are connected with different C dynamics. Of course, subdivisions should stay within a practicable and rational range. Too many subdivisions may divide the country into a lot of very small parts which are underrepresented by the input data. In this situation, true accuracy is not increased by a greater division of subcategories, because the low number of input data per unit increases the uncertainty.

So far, only some countries report sub-categories (see Annex 2). Most Member States divide the subcategories into vegetation types. Several Member States divide cropland into annual and perennial cropland and assess LUCs between these types under CL remaining CL. This section considers possible approaches for reporting sub-categories. The division of CL and GL into management types in relation to soil C stock changes is carried out by some Member States, but the results are reported in an aggregated way – this specific sub-categorisation of the land is discussed in chapter 5.3.

### 5.2.1 Suggestions for improvements

The grid or assessment system can be subdivided in a series of steps. For example: in a first step into climate zones; in a second step, on the basis of available soil maps, further into zones of soil types with different C dynamics; and then in a third step into vegetation and management types. The pattern and scale of the subcategories should allow for sufficiently accurate estimates to be calculated for each of them, which means that they should be of a sufficient size for input data to be applicable.

Pragmatic approaches are indispensable here as the following demonstration shows: A division into three climate zones, three soil types per climate zone, three vegetation types per climate and soil type and three different management types for all three parameters would result in 81 different subcategories. It is evident that such a division would lead to a very poor representation of the subcategories by input data unless an unrealistic condensing of the sample grid is carried out. The implementation of such an approach would require, therefore, a non-achievable level of resources.

It is not possible to give generic advice for how many subdivisions are appropriate, given the very different conditions in Member States, but tests should be carried out to help identify the required and optimum level of aggregation/division for the specific country conditions. Subcategories that are too small, in the sense of being underrepresented by the available

results, should be merged with the most similar subcategories. In addition, separation can be different for each of the pools, e.g. soil is estimated in more subcategories while biomass C stock changes are estimated for more aggregated (or even different types of) subcategories. In the final step, the results of such different subdivisions can always be merged to totals for the subcategory (CL remaining CL etc.). The separation should reflect significant differences in the climatic and soil conditions regarding C dynamics. Such information can be taken from your own research results or literature on soil humus dynamics and content or on biomass growth in zones of different temperature/precipitation, geologic bedrock and vegetation cover. It should be noted that the IPCC (2006) guidelines include a proposal for how to subdivide into climate zones.

After such a division any input parameters required, such as areas of LULUC and land-management, soil C stock and C stock change rates, biomass C stock change should be assessed separately for each of the subcategories.

A further approach carried out by some Member States is to assess C stock changes separately for perennial CL and for any LUC between perennial CL and annual CL and GL (see Box 14). It is clear that particularly the biomass dynamics in perennial CL are very different to those in annual CL and in GL. Therefore, a separate assessment of these LUC types leads to more accurate results. The estimates also include the soil C stock changes following the IPCC approach of estimating soil C stock changes in LUC lands and using country specific soil C stocks for perennial and annual CL and GL.

For the assessment of LUC changes between CL and GL a spatially explicit area assessment system and analysis is crucial. Particularly, LUC between annual CL and GL may oscillate typically every few years. Under such conditions, the assessment of the C stock changes on such oscillating land parcels does not make sense. For such cases the IPCC (2006) guidelines recommend to keep the area in the predominant LU-category for the land parcel. These oscillating land parcels need to be identified and separated from those land parcels experiencing long term land-use change. This separation means that these parcels, or a representative subsample of them, must be tracked over time. This approach also ensures that the same land parcel is not accounted as a LUC area each time a LUC happens (if this were this case, the results of the accounting would lead to a false (and far too large) estimate of the total area of LUC between CL and GL).

Unfortunately, this issue makes LULUC monitoring systems which are not spatially explicit unsuited for such an assessment. Also spatially explicit assessment systems with long periods in between the re-assessment cycles are not ideal for such an assessment because the short-term oscillations in LUC areas cannot be identified and separated from the long-term LUCs (each observed change of vegetation cover would be accounted as LUC and the GHG emissions/removals estimated accordingly). Further information sources, for example from agricultural statistics or surveys should be used in such cases as these can provide an indication of the areas of 'permanent' LUCs between CL and GL. The IACS/LPIS system is perfectly suited to be used for such LUC assessment between CL and GL due to its spatially explicit nature and the fact that it is updated annually.

A further sub-division of the land, particularly for total grassland, may be needed to distinguish between the 'vegetation cover based' areas and the activity based areas, e.g. grassland that is accounted under 'grazing land' and grassland which does not fall into the national 'grazing land' definition. It should be noted that the IPCC (2014) KP Supplement provides framework definitions for the KP activities which Member States should specify further and define according to their national circumstances. A consistent use of the national definitions is required, and areas once accounted under an activity must not leave the accounting system.

There may be a need, therefore for Member States to divide the area of land reported in the UNFCCC grassland category into those falling under GM and those which do not, depending on the national definition. Such a separation may be also based on any spatially explicit assessment system which provides management information on these areas, such as IACS/LPIS. In addition, complementary spatially information may be used, for example layers detailing nature protection areas where certain grassland types can be identified which, for instance, are permanently not used or must not be used for growing forage crops, for grazing or any livestock production for nature conservation reasons (if such areas do not fall under the national grazing land management definition). Areas under CM that are only temporarily used for grazing, as part of a cropping rotation, would normally be included under CM. A comparison of agricultural land management area statistics with vegetation cover statistics (e.g. out of earth observation systems) may also help assess the share of grasslands which do not fall under the national GM definition and those which belong to the GM areas.

### ***5.2.2 Alternative perspectives from international and EU wide assessment systems and projects***

LPIS/IACS (for current years) and Corine Land Cover (CLC) are used by several Member States for CL and GL activity data reporting and have also the potential or are used to subdivide the 'remaining' and 'LUC' CL and GL categories further into subcategories, e.g. certain perennial CL types or LUC subcategories between annual and perennial cropland. Both are spatially explicit data sources.

The coarse resolution of CLC limits the possible divisions into certain LULUC subcategories. The long periods between the re-assessment of CLC further complicate the use of these data for LULUC purposes. In addition, management practices on CL and GL which are relevant for the estimates of the soil C stock changes cannot be assessed with CLC (or other EOS technologies, so far).

For some subdivisions, e.g. according to climate and soil type, further data sources and thematic maps are needed and should be overlain with the maps from the LULUC assessment systems to create subcategories. International data sets may also be available, such as the European soil map from the European soil data base, if national maps are not available.

A description of the various data sources and systems and their advantages and limitations for GHG reporting in CL and GL can be found in chapter 7.3.

### 5.2.3 Examples of solutions from Member States to issues faced

Below are a collection of Member States examples related to reporting subcategories for CL and GL extracted from a review of Member States reporting. Not all of them are necessarily perfect and many Member States indicated further planned improvements. Nonetheless they can serve as ideas for principal approaches to solve the challenges regarding the division of CL and GL into subcategories.

#### Box 14 - LUCs between annual and perennial CL and GL in several countries (AT, CR, LU)

**Austria** uses IACS/LPIS data to derive the LUCs between subcategories. A representative subset of land parcels with only one land-use is extracted for this purpose and the change of land-use on these parcels is traced across the years. Only long-time and non-oscillating LUCs are accounted. The results are extrapolated to the total CL and GL area. The approach will be improved further in the next years on basis of a completion of country-specific biomass C stocks and change rates and rotation periods.

Time and human resource needed to implement: single months (however, LPIS was already available in the Austrian GHG reporting unit, time for maintenance and infrastructure running IACS/LPIS is not included).

**Croatia** uses Corine Landcover data combined with information from agricultural statistics from the Central Bureau of Statistics.

**Luxembourg** derives these LUCs from its detailed LULUC assessment system (see Box 2). Agricultural expertise and the assessment of country specific funding regimes and subsidy payments helped to identify the share of permanent LUCs between CL and GL.

### 5.3 Reporting the management activities on cropland and grassland for soil C stock changes in the 'remaining' categories

This section focuses on the issue of determining the impact of certain management types on soil C stock changes on land 'remaining' CL and GL (e.g. land-use types, harvest residue inputs, tillage type, degradation/improvement of GL). This issue is discussed separately rather than as part of the previous sections due to the specificities of assessing the impact of these different types of management on C stocks as well as their potentially large impact on GHG emissions/removals in CL and GL.

The sub-categorisation and assessment of the areas under these types of management and their timing is discussed. Tables 5.5 and 6.2 in the IPCC (2006) guidelines should be consulted as these provide a helpful overview of these management factors and the related soil C stock change rates.

Several Member States do not account for the impact of management activities on CL remaining CL and GL remaining GL on soil emissions/removals (see Annex 2). Arguments for not doing so are provided, but are often insufficient as they do not comprise a sound non-source statement (the minimum reporting requirements for KP activities and pools for which emissions/removals are not reported). Some of the reasons for not reporting the emissions associated with these management activities are as follows:

- Frequently, it is assumed that these management factors and consequently the soil C stocks did not change across time, without providing any evidence. This is highly questionable in many cases due to the substantial economic changes in several Member States in the last decades.
- Member States indicate that they do not have information on the change in management.
- Problems are identified by Member States about the use of suitable tools such as IACS/LPIS (for example, no access to data due to confidentiality reasons, incomplete coverage of the whole CL and GL area, inconsistencies over time and across the country – see chapter 7.3.3)

### **5.3.1 Suggestions for improvements**

Several Member States that do report the impact of management activities on soil C stock changes use proxies to derive the area under a particular management type and the way in which it has changed over time (see examples in Boxes below). The area data for the proxies are taken from assessment systems like IACS/LPIS or agricultural crop statistics, sometimes in combination with soil maps. Certain crops and agricultural management types are correlated with certain types of land-use, tillage, input and degradation/improvement. Examples of these are listed in Tables 5.5 and 6.2 in the IPCC (2006) guidelines and should be explored in relation to the agricultural expertise available in the country concerned.

However, agricultural assessment systems seldom provide data on the management parameters listed in these tables, such as ‘no tillage’, ‘low tillage’ etc. To obtain area information for these activities therefore requires is a full review of the agricultural information and expertise available in the country to identify the proxies. For example, in chapter 5.1.1 ideas for obtaining surrogate parameters and using expert judgement are provided and chapter 7.1 sets out the range of information that can be explored at a national level). For instance, Hungary uses the area information for a certain crop type in its agricultural statistics together with soil data and the knowledge about the soil type on which the crop is planted, together with information on field management practices and the way these correlate with the crop type to estimate the related soil C stock changes. Austria uses the (change of) area under organic farming, together with the (controlled) requirements of such farming systems among others aspects of management as surrogate parameters for the area undergoing changes in management towards more C sequestering management (see Box 15).

Highest Tier methods, as applied in Denmark and Sweden, use the area data for certain crops from systems like IACS/LPIS together with management information relating to these crops, residues connected with their management and further parameters like meteorological information, in order to run models to inform their estimates (see Boxes in chapter 6.5.3).

Common to all approaches is that the area information for these (surrogate) crop and management types used to assess the soil C stock changes is traced across time. The estimated changes in area provide the activity data basis on which to estimate the soil C stock changes (information on the estimate methods and emission factors is provided in chapter 6.5).

As with other issues, the derivation of base year activity data may present a challenge. Various approaches to solve this problem are described in chapter 5.1. (e.g. from historical agricultural information sources like national agricultural journals, yearbooks; consultations of experienced experts in agricultural stakeholder and research organisations; history of agricultural management techniques – certain management types may be only introduced in current years).

### ***5.3.2 Alternative perspectives from international and EU wide assessment systems and projects***

Among the international data sets, IACS/LPIS and FSS are used for the derivation of the activity data needed to assess the soil C stock changes in the land ‘remaining’ CL and GL categories. IACS/LPIS data in particular are well suited for these purposes due to their spatial explicitness and the fact that they are regularly updated. Information on these systems, their advantages and limitations as well as ideas to improve their utility are provided in sections 7.3.1 to 7.3.4. Data gaps for the base year may exist when using these systems (particularly for IACS/LPIS) and need to be solved by using other approaches (see chapter 5.1.).

### ***5.3.3 Examples of solutions from Member States to issues faced***

Below are a collection of examples for management activity reporting for CL and GL from Member States that have been extracted from a review of Member States reporting. Not all of them are necessarily perfect and in many cases, Member States indicated plans for making further improvements. Nonetheless they can serve as ideas for approaches to solve the challenges regarding measuring C stock changes in relation to specific management activities on CL and GL.

#### **Box 15 - Change of CL- and GL management over time in Austria**

Austria uses agricultural management statistics for the areas of specific management types (for current years on the basis of IACS/LPIS) to derive the change in CL and GL management types over time. Certain crop types and management types (e.g. organic farming) are correlated in Austria with different types of management regarding land-use, input use, tillage and degradation/improvement of GL. The change of these areas across time defines the change in these activities over time and is linked to (partly country specific) management factors to estimate the soil C stock changes (see Box 15 ) in the land ‘remaining’ CL and GL categories (Umweltbundesamt 2014).

### **Box 16 – Estimating the area of organic soils and mineral soils under cropland and grassland in Denmark**

In Denmark the soil map has been combined with IACS/LPIS data (DCE 2014) to help estimate the area of organic and mineral soils under CL and GL.

A new soil map of organic soils was produced in 2010. This is a statistical map based on;

- 10,000 soil samples down to the mineral soil in 30 cm intervals, combined with
- a very detailed digital elevation map (DEM) for each 1.6 x 1.6 m<sup>2</sup> covering all Denmark,
- water table maps; and
- old maps with organic soils.

Based on this newly produced organic soil map and a GIS analysis of the data in the LPIS, the agricultural area is distributed between mineral soils and organic soils and subdivided into cropland (annual crops and grass in rotation) and permanent grassland.

This allows the agricultural crops on different soil types to be estimated and hence changes in land use to be tracked. However, IACS and LPIS are only available from 1998 and onwards and estimates for 1990 are therefore more uncertain.

In terms of resource needs, the Danish expert estimated that about 3 months per year were needed for meetings, writing, keeping the information up to date and carrying out the GIS analysis.

Resources and time to implement this good practice example are described as depending very much on the own skills of the institute writing the National Inventory Report and on the type and quality of the data it gets. In Denmark the institute completing the inventory is a research institute with focus on GIS data, trained to use IACS/LPIS data, and the IACS/LPIS data are freely accessible within a short time frame. Human Resources necessary to do this GIS work are described as dedicated people used to the IACS/LPIS data, which is important as datasets differ from year to year based on the EU and national requirements. To set up the system of using IACS/LPIS data for the greenhouse gas inventory someone has to be aware of many 'loop holes and errors' which are due to different purposes of the reporting. So, adjustments of the system, data structure and/or analysis for GHG reporting purposes may be needed.

The Danish expert suggests an agreement with the Ministry of Agriculture, responsible for the IACS/LPIS data, is one of the best ways to smooth data exchange and to get the required analysis and data. Eventually the employees of the Ministry of Agriculture or the units running IACS/LPIS prepare the necessary data themselves to be used for the National inventory - this depends very much on national circumstances.

### **Box 17 - Assessment of cropland management practices in Spain**

Several soil management practices for perennial crops were considered in the reporting of emissions/removals of cropland remaining cropland by using activity data (area statistics) from the Spanish Association of Conservation Agriculture, combined with default IPCC emission factors. This association has existed since 1995 and collects information mainly from their associates on the use of soil conservation practices. This demonstrates the value in using alternative sources from credible organisations to complement a lack of information from official sources.

#### **5.3.4 *Planned improvements***

Several Member States indicated that they plan improvements regarding the assessment of different types of CM and GM with regard to assessing their impact on soil C. In some countries there are plans to test the ways in which IACS/LPIS data can be used for this purpose.

For example, in Croatia, during the 2nd CP the plan is to establish an effective system for land use and land use change assessment which will include the upgrade of the LPIS database in a way that it contains data and information about management practices on each land use type. Before that, data and information that already exists in LPIS database will be examined to see if it can be used for earlier reporting cycles.

## 6 Improving the accuracy of emission factors

In this section of the guidance a number of options for calculating emission factors for cropland management and grazing land management are provided to improve reporting for these subcategories and activities.

The options put forward reflect the main issues currently faced by Member States. The basic information and guidance provided in the 2006 IPCC Guidelines (IPCC 2006) and the KP-Supplement (IPCC 2013) is not repeated here. Instead, the most relevant challenges in relation to emission factors have been identified based on the information from the analysis of recent Member States reporting in Annex 2 and proposals for solving each of these are provided on the basis of:

- suggestions for improvements from the project team;
- alternative perspectives from international and EU wide assessment systems and projects;
- examples of problem solutions from Member States; and
- planned improvements in some Member States.

All proposals in this guidance are in keeping with the IPCC guidance documents.

### 6.1 Emission factors for perennial cropland biomass (aboveground)

Common challenges in improving the accuracy of emission factors for perennial cropland biomass can be separated into two different types of issue:

- 1) Determining carbon stocks of woody biomass affected by LUC; and
- 2) Determining changes in carbon stocks of woody biomass in perennial cropland remaining perennial cropland.

The LUC between perennial CL and annual CL and GL is associated with significant changes in biomass stocks. These changes should be assessed as a priority and require data on mean carbon stock of woody biomass for each perennial crop type. Indeed, most Member States that report on perennial cropland biomass focus on LUC.

The 2006 IPCC Guidelines use a gain-loss approach for estimating carbon stock changes in perennial croplands remaining perennial croplands. Growth of woody biomass and loss of woody biomass by harvest are estimated (IPCC 2006: Table 5.1, p. 5.9). However, they provide a default for carbon stocks at maturity/harvest and biomass accumulation rates for perennial crops which seem to be too high when compared to measured values.

Intensively used vineyards, orchards and other perennial agricultural systems are often managed in such a way that the harvest through prunings more or less equals growth. This means that the woody biomass is roughly constant over time. The gain-loss approach is impractical for such systems, which experience frequent cuts by pruning, short rotation cycles (10 – 30 years) and are characterised by a low amount of woody biomass. They can

be described accurately with a mean carbon stock of woody biomass for each perennial crop type, multiplied by the change in area of each perennial crop type. Indeed, most Member States use mean carbon stocks as a means of determining changes in carbon stocks of woody biomass in perennial cropland remaining perennial cropland.

### **6.1.1 Suggestions for improvements**

This section sets out the key common issues and proposes solutions for deriving national emission factors (EF) based on experience from Member States and the expertise of the authors. The section describes ideas for the following issues and steps to address carbon stocks and carbon stock changes:

- i. Separating perennial cropland types;
- ii. Finding national data for each perennial cropland type;
- iii. Use of country-specific data from neighbouring countries; and
- iv. Collecting national observational data.

#### **i) Separating perennial cropland types**

National agricultural statistics usually contain data on perennial crop types and cultivated areas with a high differentiation of crop species. Separate EFs for each perennial crop type are required because mean carbon stocks, tree size, tree densities (i.e. trees per hectare), growth rates and rotation periods differ significantly between perennial crop types. Perennial crop types can be aggregated for the inventory if it can be proven that carbon stocks and carbon stock changes are similar.

#### **ii) Finding national expertise and data for each perennial cropland type**

National agricultural statistics often contain data on perennial crop types and cultivars, cultivated area, yields, tree ages, etc., sometimes even the number of trees by age class.

Agricultural schools will also have practical knowledge of past and present management by perennial crop type and cultivar. They usually can provide tree densities, rotation periods, growth rates and pruning frequency and amount. They can provide data or expert judgement on the perennial crops or crop cultivars for which a simplified approach is adequate, using the mean carbon stock of woody biomass. They will often also have allometric equations for estimating above-ground biomass or the means to establish them.

Producer organisations are a further useful source of information and can provide information on common management practices and rotation periods and can give access to biomass for taking samples.

#### **iii) Use of country-specific data from neighbouring countries**

Several Member States have performed, started or planned research projects to derive country-specific EFs for woody biomass in perennial crops. The biological basis is universally applicable. Member States need to test whether their growth conditions and management are similar to those in the country of origin of the data. In particular, number of trees per

hectare, tree age and size, pruning intensity and rotation cycles need to be checked. The proof of applicability is particularly important for perennial crops which are produced in very diverse systems. For instance, apple orchards can range from traditional tall-tree systems to high-intensity shrub-like small-tree systems. Several management practices may exist in parallel, in which case an additional stratification is needed. Statistics on tree age and cultivar may provide useful data for such stratification. If national data is not available, judgement by experts from national producer associations and agricultural schools and a comparison of cultivars or yields may support the proof of national applicability.

EFs for perennial crops could be commonly derived via central data collection of available studies, e.g. by JRC, or joint research projects, e.g. by COST<sup>28</sup> or ERA-NET<sup>29</sup> actions.

#### **iv) Collecting national observational data**

Harvests of perennial biomass at the end of a rotation period can be used for own assessments (biomass from perennial crops in agricultural schools and research institutions may be measured cost-effectively by students within seminars). To do this the following steps are required:

1. Determination of the harvested crop species and cultivar, if applicable, age at harvest, number of plants harvested, area harvested, ideally with additional data on location, soil type and climate.
2. Weighing the fresh harvested biomass. This is most easily done on an agricultural balance where the vehicle is weighed without and with the harvested biomass.
3. A subsample of the fresh biomass is analysed for dry matter content and carbon content. Biomass per unit area and dry matter content are usually much more variable than the carbon content so the focus should be on getting many estimates for fresh and dry mass of woody biomass.

Alternatively, a survey on the basis of a questionnaire sent to a number of representative producers can ask for typical rotation periods of crops and for recently planned harvests of the perennial crops. Those with recently planned harvests may be contracted to submit data on area size, crop type, age and biomass. The fresh biomass can be easily assessed by the producer by passing a scale platform with the harvested material, something that is frequently available in agricultural regions (a financial incentive can help secure cooperation from the producer).

#### **6.1.2 Alternative perspectives from international and EU wide assessment systems and projects**

The authors are not aware of any international or EU wide assessment systems and projects that would allow carbon stock changes in woody biomass of perennial croplands to be estimated. There are, however, data sources that can support the estimation of carbon stocks. These include:

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- **The Farm Structure Survey (FSS)** which contains data about crop type, area and yield for many perennial crops. Data is available from national agricultural statistical offices or from EUROSTAT, which stores data back to 1975 for many Member States, partly in sub-national spatial resolution. FSS data is available in two- to six-yearly time steps.
- **LPIS/IACS** data may contain useful information in some Member States, in particular for crop type and area. The data is spatially explicit and offers the opportunity to analyse gross land-use changes between crops.
- **LIDAR data** could be used to determine the number of trees, tree height and shape. They can help with deriving national data about tree densities or typical management systems. Such data can support the proof of similarity of management with available data sources from other countries.

### 6.1.3 Examples of solutions from Member States to the issues faced

Several Member States have collected national data and have derived country specific EFs for various types of perennial croplands. Some examples, which may serve as basis for estimating EFs in other Member States or as recipe for developing country specific methodologies, are described in this section. The examples have been extracted from the review of Member States activity carried out in summer 2014. There are examples for:

- Hedgerows (Box 18 with examples from Denmark and Germany)
- Orchards (Box 19 with examples from Estonia and Germany)
- Vineyards (Box 20 with an example from Germany)

#### Box 18 - Assessment of C stocks and C stock changes in hedgerow biomass

##### Denmark: Area of hedgerow establishment and removal

Since the beginning of the early 1970s government subsidies have been available to increase the area with hedgerows as a means of reducing soil erosion. Therefore data on newly planted and removed hedgerows are based on subsidised hedgerows. Annually financial support is given to approximately 600-800 km of hedgerow. Hedgerow planting data is available from 1977 onwards. This includes data on hedgerow size (number of tree rows) and species. However, there are no figures on how many un-registered hedgerows have been removed in the same period as these are not protected to a large extent.

Therefore 144 aerial photos on a 2x2 km<sup>2</sup> square for 1990 and 2005 were analysed to monitor and detect changes in the landscape. The squares are distributed throughout Denmark in a stratified way according to primarily soil and wind conditions. A very large dynamic in the location of the hedges between 1990 and 2005 was observed. Only areas not meeting the definition of forests and areas not classified under Perennial Woody crops (fruit trees, willows etc.) were included in the analysis. The hedges were further allocated into eight different regions, mainly according to soil type (e.g. growth pattern).

##### Denmark: C stocks and C stock changes of hedgerow biomass

Denmark uses a model for carbon stock changes in hedges. It is based on a growth model from the National Forest Inventory (NFI) classified into plant and soil type and height. Data on hedgerow size (number of tree rows) and species from subsidy data on hedgerow planting are converted into volume and carbon stocks. The biomass estimation of the hedges is based on measurements made in the Danish NFI where plots with similar height and plant species are used as transfer functions. For details see Danish NIR 2014, part 1, chapter 7.4.1.

**Germany: Field data on mean C stocks in hedgerow biomass**

Germany reports hedgerows in the land-use category 'woody grassland'. A PhD thesis was commissioned to measure C stocks and biomass growth in orchards vineyards, Christmas tree plantations and hedgerows. The results have been included in the National GHG inventory. Carbon stocks of several tens of hedgerows were measured, which differed by age, dimension and species composition. The data were aggregated to obtain mean C stocks in German hedgerows. In Germany, hedgerows are pruned in an average rotation cycle of 20 years. It was therefore seen appropriate to work with a mean C stock representative of a 20 year rotation cycle. For details see German NIR 2014, chapter 7.4.4.2.2.

**Box 19 - Assessment of C stocks and C stock changes in woody biomass of orchards****Estonia: Field data and biomass model for mean C stocks of woody biomass in orchards**

Estonia has carried out national field measurements in randomly selected sample plots representing main market gardens and privately owned orchards. Field data were converted to total biomass carbon stocks by biomass functions developed for other tree species. The project has produced country specific mean C stocks per hectare for Estonian orchards, which are multiplied with area data to estimate C stock changes. For details see Estonian NIR 2014, chapter 7.3.2.1.

**Germany: Field data and biomass model for mean C stocks of woody biomass in orchards**

A PhD thesis was commissioned to measure C stocks and biomass growth in orchards, vineyards, Christmas tree plantations and hedgerows. The results have been included in the National GHG inventory. Measurements included 100 fruit trees (91 apple trees, 6 cherry trees and 3 plum trees) of different ages and varieties, from Germany's two main fruit-cultivation regions. Field data cover commercial plantation and traditional tall tree systems. Total C stock in tree biomass was modelled by biomass regression functions. The C stocks were upscaled to national data using national statistics on the number of trees per fruit species and age classes of the trees. For details see German NIR 2014, chapter 19.5.3.1.1.

**Box 20 - Assessment of C stocks and C stock changes in woody biomass of vineyards****Germany: Field data and biomass model for mean C stocks of woody biomass in vineyards**

A PhD thesis was commissioned to measure C stocks and biomass growth in orchards, vineyards, Christmas tree plantations and hedgerows. The results have been included in the National GHG inventory. Measurements included biomass in vine plants of different ages and varieties. Total C stock in vineyards was calculated by multiplying the mean C stock by plant with the average number of vine plants per hectare. For details see German NIR 2014, chapters 19.5.3.1.3.

**6.1.4 Planned improvements**

Some Member States have reported plans for improving EFs for woody biomass in our Member States survey. They could serve as starting points for developing synergies with activities in other Member States. Examples include the following:

- **Austria** intends to derive country-specific emission factors for perennial cropland biomass and typical rotation periods for those types still estimated with default values in the next years.
- **Denmark** plans a verification and additional study on hedgerows in 2016: Human resources: approx. 9 person months.
- **Latvia** plans to improve estimates of carbon stock changes in cropland biomass and dead wood using updated conversion factors for density and carbon stock, as well as biomass expansion factors (2015, 1 person month, 5,000 EUR).

## 6.2 Emission factors for annual cropland and grassland biomass (aboveground)

Information of annual CL and GL biomass is only needed for assessing losses or gains due to LUCs to or from annual CL and GL.

The common challenge for improving the accuracy of emission factors for annual cropland and grassland biomass is determining the carbon stocks of annual biomass affected by LUC. Several Member States have developed country-specific EFs already and these experiences can be built upon by other Member States (see below).

### 6.2.1 *Suggestions for improvements*

Several Member States (e.g. Austria, Bulgaria, Croatia and Germany) have developed country-specific EFs already and all have used existing yield statistics combined with biomass expansion factors. No additional resources were needed to carry out these calculations.

The annual cropland and grassland biomass was estimated from annually available yield statistics, differentiated by crop type. The crop yield was converted to maximum carbon stocks in annual biomass by converting the yield biomass to total plant biomass using expansion factors and the carbon content of dry matter. The expansion factors are usually based on grain:straw ratios or yield:shoot ratios. These are available from the literature and agricultural field trials. This approach uses the same statistical data and a similar methodology as the calculation of nitrogen input to agricultural soils by crop residues, which is part of the GHG inventory in the agriculture sector (section 3.D of the inventory).

### 6.2.2 *Alternative perspectives from international and EU wide assessment systems and projects*

The following data sources may be useful to inform estimates of emissions factors for determining the carbon stocks of aboveground biomass affected by LUC:

- **The Farm Structure Survey (FSS)** contains data about crop type, area and yield for many annual crops and area by grassland type. Data is available from national agricultural statistical offices or from EUROSTAT, which stores data back to 1975 for many Member States, partly in sub-national spatial resolution. FSS data is available in two- to six-yearly time steps.
- **LPIS/IACS** data may contain useful information in some Member States, in particular for crop type and area and grassland area when spatially explicit data is desired.
- Information for living biomass in croplands is also found in the EMEP/EEA emission inventory guidebook<sup>30</sup>.

### 6.2.3 *Examples of solutions from Member States to the issues faced*

Data and methodologies used for calculating nitrogen input to agricultural soils by crop residues in the agriculture sector (3.D) of the GHG inventory have been used as starting point for estimating carbon stocks in annual cropland biomass. Some Member States use

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annually updated agricultural statistics, which allows them to include the trends in increasing biomass by increasing yields or change in dominant crop types.

#### **6.2.4 Planned improvements**

No planned improvements have been reported by Member States in our Member States survey.

### **6.3 Emission factors for belowground biomass**

EFs for belowground biomass are needed for both perennial and annual biomass. Common challenges in improving the accuracy of emission factors for belowground biomass can be divided into two separate issues:

- 1) Determining the carbon stocks of belowground biomass affected by LUC; and
- 2) Determining the changes in carbon stocks of belowground biomass in CL remaining CL and GL remaining GL.

#### **6.3.1 Ideas for improvements**

Belowground biomass is rarely measured, but data from the literature are available for annual plants and trees to convert aboveground biomass to belowground biomass. For crops and grasses, root:shoot ratios are commonly used.

Measurements of belowground biomass may be possible for perennial cropland types together with the approaches as listed in chapter 6.1.1. For example, there may be a need to remove the roots of perennial crops when the land is converted to annual crops. The removed roots (alongside the aboveground biomass) can be assessed in such cases.

Nitrogen input to agricultural soils by crop residues, which is already part of the GHG inventory in the agriculture sector (3.D), should include nitrogen from belowground biomass. Member States should seek consistency in reporting nitrogen and carbon from cropland and grassland biomass and could therefore first check the data and methodology used for estimating nitrogen input to agricultural soils from belowground residues.

#### **6.3.2 Alternative perspectives from international and EU wide assessment systems and projects**

Other sources of information on which to base EFs from belowground biomass include the following:

- The 2003 IPCC Good Practice Guidance provides a default EF for grasslands.
- Several scientific synthesis papers have developed equations to convert crop yields to biomass, split into aboveground and belowground compartments. Equations and parameters are available from, for example, Bolinder et al. (2005) who used predefined crop specific fractions for roots, root exudates, yields and stem and leaves.
- Another established method to estimate the belowground carbon is the regression equation by Franko (1997), which estimates carbon input from grain yield.

### 6.3.3 Examples of problem solutions from Member States

Several Member States have collected national data and have derived country specific EFs for belowground biomass. Some examples are given in Box 21.

#### Box 21 – C stocks and C stock changes in belowground biomass

##### **Austria: EFs for belowground biomass**

Austria uses root/shoot ratios for below ground biomass of several annual crops using data from the USDA (West, 2008).

##### **Germany: EFs for belowground biomass**

In many cases data have been derived from country specific observations or nationally validated expansion factors and regressions. For annual crops root:shoot ratios are used based on standard values from the German Fertilizer Ordinance. For perennial crops, measurements were performed in the frame of a PhD thesis. In addition, regression equations were applied where national observations were missing or incomplete. For details see German NIR 2014, chapter 7.4.4.2.

### 6.3.4 Planned improvements

No planned improvements have been reported by Member States in our Member States survey.

## 6.4 Emission factors for dead wood and litter

Both the dead wood and litter pools are only of minor importance (if any) for GHG emissions/removals with respect to CM and GM. These pools are relevant when forests are converted to CL and GL, but this conversion is accounted under the KP Art. 3.3 activity Deforestation.

In most types of cropland and grassland dead wood (dead trees and pruning material) is usually immediately removed. Therefore, even in orchards, vineyards and Christmas tree plantations, the amount of dead wood is zero. It should not be a problem for Member States to provide sufficient arguments for reporting 'NO' (not occurring), justified on the basis of typical management practices. An exception to this may be for forest-like perennial cropland systems like chestnut plantations that are extensively managed. But, these types of cropland represent usually a negligible share of the total cropland area, meaning that the dead wood pool can be expected to be of minor relevance for emissions/removals. If present, it may be useful to take a conservative approach for calculating emissions, using dead wood emission factors from forests.

The litter pool also has no relevance for the emissions/removals on CL and GL, because of the lack of litter in cropland and grassland soils (litter from perennial plants is usually spread across wide areas due to the exposure of perennial plants in CL and GL to wind). For this reason it should be feasible to develop an adequate rationale for non-source statements. A possible exception may be the example given in the paragraph above for dead wood. If this is the case, a similar approach can be used to estimate the C stock change in the litter pool of such systems.

## 6.5 Emission factors for mineral soils in the 'remaining' cropland and grassland categories (reference soil C stocks, relative stock change factors)

Regarding mineral soils, it should be acknowledged up front that there are significant challenges inherent in assessing and estimating the GHG emissions associated with a huge but slowly changing C pool like mineral soil over short periods of time (even for one year like the base year, which is particularly sensitive for accounting) and to ensure that these are 'accurate' in keeping with reporting principles.

The disadvantage of the mineral soil C pool is its extreme variation per site. Soil samples for a previous inventory cannot be re-assessed due to the destructive nature of sampling. This means that C stock changes could be only assessed by monitoring an excessively high number of samples (which would not be feasible) or after decades. In addition, stock change averages for such long periods on the basis of inventories do not provide any usable information for short periods like the base year or a commitment period. Therefore, repeated soil inventories are not suited to assess short-term C stock changes in soil which need to be reported. Therefore, other tools are used to estimate proxies for the soil C stock changes over short periods of time, including models or management related typical soil C stock change factors together with area information on the activities (see chapter 5.3) and further input data needed by the models (soil and meteorological data, plant residue input data etc.).

However, soil inventories are still fundamentally important for making GHG emission estimates and for control purposes. They are needed to determine typical soil C stocks for the assessment of soil C stock changes on LUC areas (see chapter 6.6) and as reference C stocks for the assessments in the 'remaining' categories. In addition, soil inventories provide input data for modelling the C stock changes in soil. Repeating a soil inventory after some decades allows a verification of the soil C stock changes that have been estimated with other tools. For example, Bellamy et al. (2005) detected significant soil C stock changes for England and Wales over a time period of 25 years. In Wallonia (Belgium) a re-assessment of a historic soil inventory with C stock values for 1950 to 1970 was carried out (Box 22).

To date, many Member States do not account for the impact of management activities in CL remaining CL and GL remaining GL on mineral soil emissions/removals (see Annex 2). Those countries providing estimates for this pool and these categories use country specific activity data together with country specific reference C stocks in combination with default or country specific soil C stock change factors/rates (Box 23) or models (see Box 24, Box 25, Box 26).

### 6.5.1 *Suggestions for improvements*

To assess the C stock changes in mineral soils, Member States currently use a range of tools, including country specific reference C stocks from soil inventories (which already qualifies the method as being Tier 2) in combination with default or country specific soil C stock change factors/rates or models. Suggestions on how to go about deriving country specific soil C stock change factors are set out below. Two options are explored: deriving information from existing data from current or historic agricultural experimental plots; initiating soil monitoring programmes and experiments; and the use of models. The choice

of options will depend on the extent to which data already exists in a particular country as well as the significance of the pool. Guidance on the design of soil inventories is not covered in detail here. Descriptions of the different approaches taken can be found in national and regional soil inventory reports.

### **Monitoring mineral soils for GHG reporting:**

Some of the critical issues that need to be taken into account when monitoring mineral soils for GHG reporting are as follows:

- The sampling design should be a spatially defined, representative statistical grid across the country or region, and ideally it should be coincident with the grid of other assessment systems like the forest inventory.
- Monitoring plots (e.g. long-time experimental soil monitoring plots) should be embedded in the soil inventory grid. This enables available information to be combined and condensed from various monitoring activities and broadens the possibilities for analyses and understanding.
- For soil C stock estimates the following parameters need to be assessed as a minimum:
  - The C content and the weight of several soil fractions (e.g. <2 mm and beyond, i.e. the weight of the carefully cleaned and dried remains in the sieve with higher size). The soil samples need to be taken with a defined volume to allow for an estimate of the soil density and the C mass per ha. This last point may appear obvious, but is interestingly still not implemented in some current (international) soil assessment programmes. In addition, the weight of (dead) roots which remains in the sieve after sifting should be measured.
  - The N content is needed to derive the C/N ratio.
  - A thorough description and documentation of site parameters like land-use, vegetation cover and any observed (suspicious) issues on site which might have an influence on the results (also in the closer surroundings).
  - Further parameters could also be included which may eventually be needed as input /validation parameters for a soil model at a later stage. The models differ in the parameters required, depending on the level of model complexity - for instance Yasso07 does not need any further soil parameters while some require information on soil texture in addition.

As indicated in the previous sections a long time is needed between re-assessments to detect any significant C stock change. Some soil inventories have failed to detect significant soil C stock change where there has been too short period between the assessments. The period of time required depends on a number of factors, such as: the variation of C stock per site (which is also a result of the numbers of soil samples taken per site); and the total number of sites and the expected or theoretically possible C stock change rates in the soil (a conservative estimate for the time between the assessments would assume a low soil C stock change rate). As a rough general proxy, about two decades is the length of time needed between each re-assessment for assessing soil C stock changes. Given this, it is important to plan ahead for the resources needed to carry out follow-up assessments at the time of planning the first soil inventory.

**Use of data from experimental monitoring plots:**

The estimate of C stock change factors requires results from long-term experimental monitoring plots on CL and GL where the impact of different management techniques on soil has been tested. Many years of monitoring are needed to detect the new equilibrium soil C stock resulting from changed management. A change to the use of country-specific relative stock change factors could be challenging and time consuming for many Member States and cannot be achieved in the short term. However, the required data may be already available in the Member States but not explored so far. Typical soil C stock change factors for different management regimes may be derived from data from existing or historic agricultural experimental plots. Considerable research and monitoring has been carried out over a period of decades to optimise yield, fertilisation and management and soil fertility on agricultural land. Experimental plots used for these purposes frequently have measured also the humus content or soil C content. In some cases even the soil density was assessed. If the latter was not assessed, this can be estimated on the basis of other parameters that have been assessed or re-measured on the plots. Even if the C content was not measured it is worth checking whether archived soil samples are available which would allow re-analysis for this parameter.

To identify these data sources it is necessary to investigate thoroughly the institutional agricultural and soil expertise in the country and check whether the data available and samples of the plots will enable C stock change factors to be calculated. This approach has been successfully implemented in Austria (Box 23).

**Use of models:**

Models can also be used to estimate soil C stock changes and this is an approach used in a number of Member States (Box 24, Box 25, Box 26). As a minimum, existing models may be used, provided they have been calibrated and validated, the results have been verified for the conditions for which they are used and the necessary input data to run the model are available. Such validation and verification requires country specific data, generally using the results of well documented long-term (experimental) soil monitoring plots on CL and GL. In an ideal situation, it may be possible to develop a country specific soil model based on such data. This has been carried out in Germany, as shown in the examples below (Box 27). If the models do not perform well in producing results that are similar to the verification data in quantity and/or trend they should not be used and efforts should be made to improve their accuracy. In such cases the use of models would not lead to more accurate/appropriate estimates of the soil C stock changes than lower Tier methods.

Several soil models exist (e.g. CENTURY and DAYCENT, CoupModel, Forest-DNDC, Q, ROMUL, RothC, Yasso07 - see for instance compilations in Peltoniemi et al. 2007, Manzoni and Porporato 2009). Some of them are soil C models only and some are plant-soil models. The information required for running the models depends on the model. Essentially, data for the (plant residue) C flux to the soil and for its composition is needed. Also meteorological data (temperature, precipitation) are usually required. Further information on site and soil variables may be prerequisites for running the models. A sufficiently detailed stratification is needed according to climate types, soil types and management types. Most

accurate is to model on site resolution (e.g. for each site/type of the assessment grid/system) and aggregate the results to regions/subcategories afterwards.

Information on the requirements for using models for GHG reporting is given in the IPCC (2006) guidelines and in IPCC (2011).

### **6.5.2 *Alternative perspectives from international and EU wide assessment systems and projects***

The authors are not aware of any international assessment system which could support the derivation of C stock change factors for the 'remaining' CL and GL categories.

### **6.5.3 *Examples of solutions from Member States to the issues faced***

Below are a collection of examples for deriving emission factors and reporting of soil C stock changes in the 'remaining' CL and GL categories from Member States that have been extracted from the 2014 review of Member States reporting. Not all of them are necessarily perfect and in many cases Member States indicated further planned improvements. Nonetheless they can serve as ideas for approaches to solve the challenges relating to the measurement of C stock changes in mineral soils.

#### **Box 22 - SOC change detection by partially repeated soil inventories in Wallonia, Belgium**

In Wallonia, data are used from a study entitled 'Soil organic carbon evolution at the regional scale' (Goidts 2009, Goidts, Van Wesenmael and Van Oost 2009). The study area covers the Walloon region and was stratified into landscapes unit (LSU) based on the following criteria: the agricultural land use (cropland or permanent grassland), the agricultural region, and the soil type (soil texture and drainage). For each LSU, the SOC stock was available from the National Soil Survey (NSS) undertaken in Belgium between 1950 and 1970. In a first campaign, soil profiles of the 9 LSU having the highest potential for SOC change detection were re-sampled. In order to improve the analysis of the SOC evolution and to initiate a SOC stock monitoring network of agricultural soils, new field campaigns were conducted for 6 additional LSU (LSU 10 to 15 sampled between October 2006 and May 2007).

About 54% of the agricultural area is covered by the 15 LSU's having on average 28 soil profiles each (i.e. a sampling density of 0.03 plots/ km<sup>2</sup>). These soil profiles have not undergone any land use change since the NSS, and the SOC stock change in the soil surface (i.e. the plough layer for cropland and the 0-30 cm layer for grassland) was estimated for each one based on equivalent mass to correct for changes in the soil bulk density or in the rock fragment content.

#### **Box 23 - Soil management factors (relative stock change factors) for cropland remaining cropland in Austria**

In a long-term field study to evaluate climate change mitigation measures for cropland (as part of the Austrian agri-environment scheme), the results of several long-term experimental cropland plots with different treatments were analysed to derive the climate change mitigation impact of certain management types. The study was used to derive, as a side product, country specific soil emission factors (relative stock change factors) of different cropland management types. The example provides evidence that through an intensification of communication networks and collaboration certain needed studies or planned projects can be used to derive also information needed for GHG reporting – a cost effective way to get results for different tasks. This study took 12 months to conduct the analysis, excluding the time taken for the establishment and

monitoring of these long-time plots. The derivation of the emission factors was a side product of the study and almost free of additional costs.

#### **Box 24 - Use of a Tier 3 model for mineral soil C-stock changes in Denmark ('C-TOOL')**

Changes in carbon stock in mineral cropland soils are estimated using a nationally developed Tier 3 model. For agricultural soils Denmark is using this dynamic temperature dependent model (Tier 3), which is expected to give the best estimate of the actual emissions from soils compared to most other methods. C-TOOL is a 3-pooled dynamic soil model. The following input parameters are measured alongside temperature and humidity:

- The amount of yields and agricultural residues returned to soil as estimated by Statistics Denmark. Increased growing of (obligatory) N catch crops had increased the amount of C returned to the soil since 1997.
- The amount of animal manure produced and applied to soil is estimated with the same methodology as in the Agricultural sector for estimating CH<sub>4</sub> and N<sub>2</sub>O emissions where annually updated feeding and excreting data are provided for the regulation of the animal production in Denmark. Here detailed data on the number of animals, housing and manure type are available on farm level. This also includes data whether the manure has been turned into biogas or not. The manure data are used as input to C-TOOL.

Running of C-TOOL requires one person-month per year. This does not include the resources for setting up the system.

#### **Box 25 - Use of Yasso 07 model for the mineral soil C stock change in CL and GL in Finland**

Finland uses the Yasso 07 model to derive national emission factors and verifies the results on the basis of 40-year soil monitoring. There are now several papers for the verification in different ecosystems (Heikkinen et al. 2014, Karhu et al. 2011, Karhu et al 2012). The model was implemented over a period of four years.

#### **Box 26 - Use of a soil C model for estimating the mineral soil C stock changes in CL in Sweden**

Swedish arable land covers 3 Mha and its topsoil contains about 300 Mtonnes C. The mineral soils seem to be close to steady-state. The five-parameter soil carbon model ICBM-region (Andrén and Kätker 2001) is used to calculate annual C balance of the soil based on national agricultural crop yield/manuring statistics and allometric functions. The model is run for eight production regions and is calibrated using long-term field data. Daily weather station data for each region together with crop type (bulked from individual crop data) and soil type are used to calculate an annual soil climate parameter for each crop/soil type permutation in each region. The model set up for the reporting to UNFCCC use 14 soil types and 9 crop types, which gives 126 parameter sets for each year and region, each representing a fraction of the region's area. For each year, region, crop and soil type, ICBM-region calculates the change in young and old soil carbon per hectare, and sums up the changes to, e.g., national changes. The annual change per hectare is calculated on a national basis and used together with the area estimates from the RIS (as described in previous sections).

#### **6.5.4 Planned improvements**

Several countries plan a verification of default soil C stock change factors used in emission estimations related to land use, management and input of organic matter. Two examples are given below.

#### **Box 27 - National soil C stocks by national agricultural soil survey (2011-2018) and soil C stock changes by soil C modelling (2015-2018) in Germany**

The project aims to deliver the first nationally consistent and complete observation of C stocks in agricultural soils. The data will be used together with the complementary (but non-representative) data of long-term observations and long-term trials to model soil C stock changes. Germany would not directly use the model for reporting, but rather to develop Tier 2 approaches consistent with the activity data on land-use and from agricultural statistics.

The total project duration is eleven years (project planning started in 2007). Up to 50 persons will be involved for some years.

#### **Box 28 - Improvement of land management factors for mineral soil and biomass in UK**

An inventory development project (SP1113), with a focus on the impacts of cropland and grassland management on soil carbon, has been funded by the UK's Department of Environment, Food and Rural Affairs. The project will also use IACS data to provide a more accurate assessment of Grassland/Cropland turnover for each UK administration.

An extension to the project will investigate the effect of management practices on above and below biomass carbon stocks in Cropland and Grassland including dwarf shrub heath such as heather moorland

26 person months are planned for soil carbon stocks activities and, 5 person months for activities on biomass stocks. These figures do not include work still to be done to collect field data on the effects of intensification of GL on soil carbon stocks which would take about 24 person months.

## **6.6 Emission factors for mineral soils in the land-use change categories with cropland and grassland**

Most countries have country specific soil C stocks for CL and GL that have been derived on the basis of soil surveys (see Annex 2). These C stocks are frequently used together with the approach set out in the IPCC (2006) guidelines of estimating soil C stock changes due to land-use changes across a transition period of 20 years. Some Member States also use models to derive the soil C stock changes due to LUCs. The use of models has the advantage that a calculation across a transition period may not be needed if the change in C input to the soil and the decay of existing (known) soil C stock at the time of LUC can be simulated. Such an approach makes it unnecessary to source information on the areas of land-use change back to the year representing the base year minus the transition period (i.e. for most Member States 1970).

### **6.6.1 Suggestions for improvements**

A further stratification of the soil C stocks together with stratified LUC data and with an estimate for these strata may lead to more accurate estimates of the soil C stock changes due to LUC. Regional stratification should be carried out, given the significantly different soil C stocks within countries resulting from climatic and/or geologic conditions.

Some Member States indicated in their responses to our 2014 survey that the IPCC default 20 years transition period and the derivation of country-specific transition periods was inappropriate (see Box 29 ). This default method sometimes leads to unrealistic high annual C stock change rates in soil. If this is the case it may be worth considering making an adjustment to the transition period to a more realistic value on the basis of information on typical decay rates or C stock increase rates and the time required to reach a new equilibrium. Models are used for such estimates. However, it should be noted that some Member States faced difficulties in the UNFCCC reviews of their GHG inventory when country-specific transition periods are used.

The literature suggests that the 20 years transition period fits well for about two-thirds of the soil C stock under temperate conditions. The remaining third of the soil C fraction is very resistant to decay, needing up to thousands of years for this process (e.g. Harrison et al. 1993, Townsend et al. 1995, Trumbore et al. 1996). Given this, the IPCC approach of estimating soil C stock changes on land subject to LUC using a transition period of 20 years between the (equilibrium) soil C stocks of the land-uses should be understood as a pragmatic proxy. It is a means of accounting for the expected complete soil C stock changes due to LUC in a period which can be overlooked (which reduces the risk of unaccounted future soil C stock losses at the LUC lands).

### **6.6.2 Alternative perspectives from international and EU wide assessment systems and projects**

The EU soil data base and LUCAS (see chapters 7.3.6 and 7.3.7) may provide complementary soil data, provided the information in these data bases goes beyond what is already available in the Member States and the information is representative for the country.

### **6.6.3 Examples of problem solutions from Member States**

Below are a collection of examples for deriving soil C stocks as a basis for reporting soil C stock changes due to LUCs to CL and GL that have been extracted from the review of Member States reporting carried out in 2014. Not all of them are necessarily perfect and in some cases Member States have indicated that they plan improvements. Nonetheless, they can serve as ideas for approaches to solve the challenges regarding these reporting needs.

#### **Box 29 - Transition periods for soil C stock changes after LUCs from/to CL and GL in Denmark**

Concerning the transition periods for soil C stock changes after LUCs from/to CL and GL, the default IPCC value of 20 years seems not to be applicable for Danish conditions, according to Danish investigations. The actual amount depends on the type of land from which it is converted. To reach the new equilibrium state, a transition period of 50 years is used in Denmark.

### **Box 30 - Estimation of carbon stock in cropland remaining cropland and grassland remaining grassland in Latvia**

Carbon stock in soil in cropland remaining cropland and grassland remaining grassland is estimated for at least 20 years on the base of the NFI plots. Satellite imagery is used to identify plots with a considerably stable vegetation index value since 1990 and sampling of soil and analyses of bulk density and carbon stock were done at the end of the growing season. 100 plots in cropland and 100 plots in grassland are supposed to be analysed. The obtained results will be used to estimate carbon stock changes due to conversion of grassland to cropland and vice versa as well as due to deforestation and afforestation, because a similar study is already done in forest lands. The study will take two years and require six person months.

#### **6.6.4 Planned improvements**

Several Member States plan (re-)assessments of soil C stocks in the second commitment period and further improvement steps. For example, in Denmark a new soil inventory on agricultural land is planned in 2018/2019. Approximately 500 plots will be sampled and 16 person months are planned for this work.

### **6.7 Emission factors for organic soils**

Organic soils emit GHGs as long as they remain drained. Organic soils under cropland are typically deeply drained. The drainage status can be much more diverse under grassland where drainage depth is country-specific depending on management practices and peatland types. LUC means that the EF switches from the EF of the previous land-use category to the one of the new land-use category. So far, additional GHG emissions driven by LUC have not been taken into account. The 2013 IPCC Wetlands Supplement has substantially extended the guidance and requirements for GHG reporting from drained organic soils. It is not yet mandatory except for WDR reporting but is likely to become mandatory after 2020.

Common challenges in improving the accuracy of emission factors for organic soils can be separated into the following:

- 1) Implementing the additional guidance from the 2013 IPCC Wetlands Supplement;
- 2) Determining the area of organic soils and eventual changes over time
- 3) Determining the strata of organic soils by:
  - a. nutrient status (nutrient-rich / nutrient-poor) or peat type or peat properties
  - b. drainage status (deep-drained / shallow-drained).
- 4) Determination of on-site CO<sub>2</sub> emissions from drained organic soils, stratified by:
  - a. Climate
  - b. Land-use
  - c. Eventual nutrient status (nutrient-rich / nutrient-poor) or peat type or peat properties
  - d. Eventual drainage status (deep-drained / shallow-drained).

### **6.7.1 Suggestions for improvements**

This section lists common issues and proposes solutions for deriving national EFs based on experiences reported by Member States and the expertise of the authors. The section describes ideas for the following issues and steps:

- i. Implementing the new guidance from the 2013 IPCC Wetlands Supplement
- ii. Finding and combining national data for the area and status of organic soils
- iii. Determining on-site CO<sub>2</sub> emissions from drained organic soils
- iv. Use of country-specific data from neighbouring countries
- v. Collecting national observational data

#### **i) Implementing the new guidance from the 2013 IPCC Wetlands Supplement**

In this guidance document, CO<sub>2</sub> emissions have been split into on-site emissions from drained soil and off-site emissions triggered by loss of dissolved organic carbon into groundwater and surface water. CH<sub>4</sub> emissions from the drained soil and from drainage ditches have been added as mandatory reporting item as well as CO<sub>2</sub>, CH<sub>4</sub> and CO emissions from peat fires (IPCC 2014).

A test application for Germany has demonstrated that on-site CO<sub>2</sub> emissions from drained soil dominate by far (>90-95%) the GHG emissions in drained organic soils, i.e. where the mean annual water table is lower than 10 cm below the surface. The only exception may occur in situations where strong and large peat fires occur.

Consequently, it would seem logical that Member States could apply the default EFs provided in the 2013 IPCC Wetlands Supplement for all GHG sources except for on-site CO<sub>2</sub> emissions from drained organic soils. These on-site CO<sub>2</sub> emissions have been in the focus of research and methodological development in most Member States with significant areas of drained organic soils.

It is noted here that N<sub>2</sub>O emissions from drained croplands and grasslands can also be substantial but are reported in the GHG inventory under section 3.D Agriculture. N<sub>2</sub>O emissions are therefore not addressed here.

#### **ii) Finding and combining national data for the area and status of organic soils**

The area of organic soils is usually taken from national soil maps. A first estimate can also be taken from the European soil portal of the JRC<sup>31</sup> (Panagos et al. 2012). Data on nutrient status and soil properties or area data at good resolution are sometimes available from peat inventories established to determine peat deposits for peat extraction. Such data are often collected in local and regional peatland cadastres and geological surveys and are not necessarily connected with soil maps.

The 2006 IPCC Guidelines (Section 7.2.1.1, Chapter 7, Volume 4) provide guidance on how to distinguish between nutrient-rich and nutrient-poor organic soils.

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<sup>31</sup> Add link

The 2013 IPCC Wetlands Supplement (page 2.10) further distinguishes between undrained, shallow drained and deep drained drainage status and gives guidance on how to stratify drainage status based on national data (chapter 2). Germany (Bechtold et al. 2014) and the Netherlands (Kuikman et al. 2005) have developed national methodologies for estimating drainage status (Box 31).

### **iii) Determining on-site CO<sub>2</sub> emissions from drained organic soils**

Most Member States with significant areas of drained organic soils have supported intensive research on CO<sub>2</sub> emissions, driving factors and management options. Although research has tended to use well-established and largely standardised measurement techniques by eddy covariance and flux chambers, the observations generally produce CO<sub>2</sub> emissions for the ecosystem or soil, but do not separate the peat soil C source from other C sources such as biomass and litter. The original fluxes measured therefore need to be corrected to avoid double-counting or omissions of CO<sub>2</sub> emissions with litter and biomass derived CO<sub>2</sub> fluxes. The methodology for deriving the correct CO<sub>2</sub> emissions from organic soils is described in Annex 2A.1 of chapter 2 of the 2013 IPCC Wetlands Supplement.

Subsidence measurements are also common. These rely on measuring the height loss of the peat surface by poles over several years with additional measurements of the bulk density and carbon content in the profile to distinguish between soil compaction and oxidation (Schothorst, 1977). The peat loss by oxidation is approximately the CO<sub>2</sub> flux. This should be corrected for the C loss as dissolved organic carbon and CH<sub>4</sub> if relevant (see Annex 2A.1 of chapter 2 of the 2013 IPCC Wetlands Supplement). Subsidence measurements are a good means for monitoring and should be combined with measurements of the groundwater table. They are cheap and relatively easy so that they can also serve for upscaling CO<sub>2</sub> flux measurements over space and time.

The average soil subsidence can be calculated from elevation measurements of the area in the past and more recent altimetry. Repeated high-resolution elevation measurements (ground-based or by Laserscan), combined with additional measurements of the bulk density and carbon content in the profile at reference points, have been tested successfully in the German federal state of Baden-Württemberg. They allow robust estimates of peat subsidence on a decadal time scale. They allow for a fully spatially explicit and complete assessment of peat subsidence at a regional to national scale.

### **iv) Use of country-specific data from neighbouring countries**

Despite the wealth of field observations, national data may not fully represent the national spectrum of land-use and management types. Observations from neighbouring countries can fill gaps or help verify national EFs.

The EFs presented in chapter 2 of the 2013 IPCC Wetlands Supplement are based to a large extent on European data. The list of references can serve as a good, almost up-to-date bibliography for finding studies representative of national conditions.

Research on drained organic soils has mostly been coordinated and funded at a national level. European coordination in this area in the future could offer high potential for

resource-efficient improvements, capacity building and exchange of methodologies and data. Due to the complexity of the measurements and the diversity of data, the original researcher ideally needs to be involved. A purely centralised stock-taking and process of data collection would risk not producing robust results. A cooperative research project under Horizon 2020 or an ERA-NET may offer an appropriate format.

### **6.7.2 *Alternative perspectives from international and EU wide assessment systems and projects***

The European soil portal and Joint Research Center (JRC) offer a soil map including organic soils at 1:1,000,000 resolution which contains information on soil properties. The data is described in Panagos et al. (2012). The map of the organic carbon content of top soil (Jones et al., 2005) contains raster cells at 1 km<sup>2</sup> resolution. The map can also serve as a Tier 1 estimate of the area of organic soils. Due to the relatively coarse resolution, however, the map mixes properties of mineral and organic soils so that care must be taken that the results are reasonable and reflect the local situation (see discussion in Leppelt et al. 2014).

The 2013 IPCC Wetlands Supplement has a strong observational basis in Europe. Member States could source the national literature from there, use it for calculating the national EF, or demonstrate that the default EF fits to national conditions by comparing it with the original national data.

Remote sensing by radar or thermal channels may assist in updating maps of organic soils. The strong differences in physical properties between mineral and organic soils including thermal conductivity and capacity allow high-resolution mapping of the organic soil area.

### **6.7.3 *Examples of solutions from Member States to the issues faced***

Several Member States have collected national data and have derived country specific EFs for various types of perennial croplands. Some examples, which may serve as basis for developing EFs in other Member States or as a basis for the development of own methodologies, are described in this section. The examples have been extracted from the review of Member States activity carried out over summer 2014. There are examples for:

- Status of organic soils (Box 31 with examples from Germany and the Netherlands)
- On-site CO<sub>2</sub> emission factors from drained organic soils (Box 32 with examples from Denmark, Germany and the Netherlands).

#### **Box 31 Status of organic soils**

##### **Germany: stratification of organic soils by peatland type and drainage status for the national GHG inventory**

A recent PhD project (3 years half-time person) has produced a map of organic soils according to the IPCC definition for Germany at 25 m raster resolution. Data on organic soils or organic horizons was collected from diverse regional data sources, harmonized and corrected by plausibility checks, e.g. topographic position, slope etc. Types of organic soils were attributed to the raster cells, indicating groundwater influence, likely genesis of the peatland and presence of impermeable layers under the peat (Fell et al., Catena, in review).

Groundwater data from dip wells in peat soils were collected, digitised where necessary, plausibility-checked and harmonised in a 2 year project (one person full-time). This data was combined with the map of organic soils and additional GIS data to derive empirical rules for assigning most likely water table positions to each 25m raster cell of the map of organic soils. The resulting map of mean annual water tables and associated

uncertainties (Bechtold et al. 2014) has been used for the 2015 submission of the German GHG inventory.

**Denmark: stratification of organic soils in the national GHG inventory**

Denmark developed a new map of organic soils based on a similar approach to that taken in Germany (Danish NIR 2014, p. 467ff).

**The Netherlands: stratification of organic soils in the national GHG inventory (Kuikman et al. 2005)**

An overlay was made between a map with water level regimes from the water management authority and a map of organic soils at 1:50,000 scale. Peat soils were mapped twice, once around 1970 and once in 2001-2003. A significant fraction of drained shallow peat soils was lost in this period. The area of peat soil in agricultural use in 1990 was estimated by interpolation between the peat area in 2003 and around 1970.

The organic soils were stratified into types of peat and organic matter content (mixed or overlain with clay or sand or not), nutrient status (poor – medium – rich), ditch water level or groundwater (8 classes from groundwater table map).

**Box 32 On-site CO<sub>2</sub> emission factors from drained organic soils**

**Denmark: Tier 2 CO<sub>2</sub> emission factors for croplands on organic soils**

An intensive research programme has been carried out to monitor the CO<sub>2</sub> emissions from three organic soils in Denmark with annual crops in rotation and permanent fertilised grassland (Danish NIR 2014, p. 467ff). The results cover representative conditions for Denmark and were used as Tier 2 CO<sub>2</sub> emission factors for cropland.

**Germany: Tier 2 CO<sub>2</sub> emission factors derived from Tier 3 approach**

Germany has developed a national Tier 2 approach for the 2015 submission of the GHG inventory. It uses results from two national large-scale research projects where CO<sub>2</sub> flux measurements by flux chambers were conducted in diverse cropland and grassland types, regions, drainage and management conditions (total research budget of both projects > €3 million). The measured data showed a good, but uncertain correlation with mean annual groundwater table. The correlation was used to model CO<sub>2</sub> emissions for all 25m grid cells of the map of organic soils (Fell et al., Catena, in review) with mean annual water table below -0.1 m. The area-weighted mean CO<sub>2</sub> emissions per land-use category are used as Tier 2 emission factors for drained organic soils. Documentation of the method and results are in progress and will be summarised in the 2015 submission of the German GHG inventory.

**The Netherlands: subsidence measurements for CO<sub>2</sub> emissions**

The Netherlands have long-established subsidence measurements since 1972 (Schothorst 1977). The rate of oxidation can be calculated by comparing the bulk density of mineral elements in the layers above and below groundwater level (Schothorst 1977). They serve to distinguish between compaction and oxidation losses and serve as robust multi-site data for national CO<sub>2</sub> EFs. The subsidence measurements were aggregated into classes of peat type, nutrient status and drainage level according to the stratified map of organic soils. Each class has a typical mean subsidence rate from which CO<sub>2</sub> emissions have been estimated. As subsidence measurements have continued the EFs can be validated or updated with national data.

For the Dutch National Inventory Report carbon emissions per ha are calculated from the mean ground surface lowering using the following equation (Arets et al., 2013 p. 47-48):

$$C_{em} = R_{GSL} \cdot \rho_{peat} \cdot f_{ox} \cdot [OM] \cdot [C_{OM}] \cdot f_{conv}$$

With

$C_{em}$	Carbon emission from oxidation of peat (kg C ha <sup>-1</sup> year <sup>-1</sup> )
$R_{GSL}$	Rate of ground surface lowering (m year <sup>-1</sup> )
$\rho_{peat}$	Bulk density of lowest peat layer (kg soil m <sup>-3</sup> )
$f_{ox}$	Oxidation status of the peat (-)
$[OM]$	Organic matter content of peat (kg OM kg <sup>-1</sup> soil)
$[C_{OM}]$	Carbon content of organic matter (0.55 kg C kg <sup>-1</sup> OM)
$f_{conv}$	Conversion from kg C m <sup>-2</sup> year <sup>-1</sup> to kg C ha <sup>-1</sup> year <sup>-1</sup> (10 <sup>4</sup> )

#### 6.7.4 Planned improvements

##### Box 33 - Organic soil C pool in cropland, grassland, wetland, peat extraction, (forest) in Germany

In Germany, a national high-resolution map of organic soils according to IPCC definition has been developed, including soil properties, national GHG observations for major land-use types and management systems, national distribution of drainage level by land-use class (2007-2015). The project also aimed to test the feasibility of WDR accounting at national scale, and addressed the largest GHG source by far in Germany. The main project took 3.5 years, with two additional years for data analysis

##### Box 34 - Update of area and emissions of organic soils in Latvia

In Latvia, updated area of organic soil in cropland according to the NFI study started in 2012; the same values of share of organic soil will be used for land converted to cropland. Logarithmic regression will be used in time series to reduce share of organic soil in cropland before 1990 (5.18 %) to the actual value (no funding available to complete the study).

CO<sub>2</sub> emissions from organic soils are updated considering area changes and recent findings in Nordic and Baltic countries, particularly, the doctoral thesis 'Emission of greenhouse gases CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O from Estonian transitional fens and ombrotrophic bogs: the impact of different land-use practice' (Salm 2012). One person month is planned for this work.

## 6.8 N<sub>2</sub>O emissions resulting from the conversion of land to cropland

N<sub>2</sub>O emissions in relation to CM and GM are only relevant for the LUC from GL to CL, because such emissions resulting from LUC from FL to CL are accounted under the KP Art. 3.3 activity Deforestation. This subcategory of emissions has only a minor contribution to the LULUCF totals. Improvements are therefore of minor importance.

As a first step country specific soil C/N ratios may be used which is sufficient to qualify the method as Tier 2 (some Member States in our 2014 survey are already planning such improvements).

A derivation of country specific emission rates or the use of models for assessing these emissions may be not achievable due to the challenging methods.

## 6.9 Biomass burning

The emission subcategory of biomass burning is also likely to be of minor relevance for emissions relating to CM and GM. The legal framework in the EU forbids the burning of plant residues on CL to a very large extent. Given this, it is mainly wildfires on CL and GL that may be of relevance. To improve reporting, country specific EFs for biomass that is burning could be developed. Further improvements, like country-specific combustion efficiencies and emission factors are unlikely to be feasible due to the issues of measurement. Such efforts may also not be cost-efficient, given the limited contribution of this emission source to overall emissions from CM and GM.

## 7 Organisational and operational issues

This chapter proposes options for addressing the most common organisational and operational issues faced by Member States. The issues are based on the analysis of recent reporting by Member States and proposals for solving each of the problems identified are provided.

### 7.1 Exploring and including relevant national expertise

It is evident from the answers in the questionnaires and from the analysis in regarding reporting that some Member States have not yet fully explored and drawn upon the available national expertise relating to CL and GL. For instance, some Member States indicated that national expertise on certain topics related to CL and GL would not be available in the country while a survey through the web and literature suggests that capacity does exist. Related to this, the input data and references in the NIRs suggest that some relevant national data sources and institutions were not included.

Of course under current requirements reporting of the emissions/removals in CL and GL for UN-FCCC could have been carried out in a sufficient way using simpler approaches or with default emission factors from the IPCC (2003) GPG. So, greater recourse to national expertise and networking may not have been required. The UN-FCCC review of the GHG inventory is less critical for reporting emissions/removals that do not necessitate accounting against emission reduction targets.

However, the EU LULUCF Decision requests the Member States to gear up for accounting of the CM and GM activities by 2022, which may require improvements in national LULUCF expertise and systems, as described in the previous chapters.

Including the available national expertise at an appropriate level may be a very cost effective way to permit the needed improvements. The information and data needed may be available already in institutions not currently involved or may be secured with much less effort than by starting a further initiative on measurement initiative.

#### 7.1.1 *Suggestions for improvements*

A broad survey of the existing national institutional expertise and data on CL and GL should be considered. Agricultural and soil research institutions, statistical offices, units dealing with land use/cover, agricultural stakeholder organisations and major agricultural enterprises could be included. This would allow a full exploration and identification of the available capacity and information as well as opening perspectives for running cost-effective projects for deriving the activity data and emission factors required. A good network should involve the environmental (climate change related), agricultural, scientific units and the institutions dealing with related funding issues.

Creating an effective network and level of involvement requires considerable communication efforts at several levels and a broad national identification of the institutions best involved in delivering the reporting requirements. Given that institutions outside national ministries may not be aware of or prepared for a role in reporting, it may

well take some time both to bring them on board and to include the activities required in their work programmes.

Preparatory steps are likely to include thorough and steady communication, some at a high level. It may take some time before the new tasks are recognised and understood as being part of a broad national duty and involving several institutions beyond those units directly responsible for the GHG inventory. Building a sense of shared responsibility of the tasks may facilitate to get the flow of information in an adequate and timely manner. There may be several ways to successfully bind the relevant institutions to the reporting system, but contractual or even legal arrangements underpinning a longer term involvement in delivery may facilitate the collaboration in some cases.

Task forces and dedicated events for the network of institutions may be useful for a fruitful exchange on both GHG reporting requirements for these activities and ideas to deliver them efficiently. Those institutions which are responsible for defining related research programmes for agriculture, climate change mitigation and adaptation should also participate in these meetings.

### **7.1.2 Some national examples**

Below two examples of such an approach to strengthen the national system regarding LULUC reporting are given.

#### **Box 35 - Exploring the national LULUCF expertise in Croatia**

A process for improving LULUCF reporting has been initiated in Croatia on the basis of some projects involving several institutions dealing with the topic and a broad range of expertise, including foreign experts. This has created a clearer understanding of the problem and significant willingness to contribute to the improvements required by relevant institutions which are not directly responsible for GHG reporting (for instance, the unit that runs the LPIS in Croatia).

#### **Box 36 - Inclusion of more institutions in preparations for the AFOLU sector in Slovakia**

Slovakia plans to include more institutions in the preparation of the AFOLU sector inventory from the 2015 submission onwards. Cropland and Grassland categories will be prepared in cooperation with relevant research institutions such as the Research Institute on Soil Protection in Bratislava - the Ministry of Agriculture and Rural Development (Cropland), Animal Production Research Centre (Grazing management), and the Research Institute for grassland and mountain agriculture (Grassland).

## **7.2 Co-operation between Member States**

As the analysis presented in this document confirms, Member States share similar problems and cooperation between national authorities may reduce the efforts and resources needed to improve individual reporting and accounting systems. As an example, neighbouring countries or those sharing similar land use characteristics may team up to develop country-specific emission factors.

Based on the replies by Member States to the questionnaire and the problems and solutions they brought forward, it may be particularly worthwhile to cooperate amongst the following bundles of Member States.

### **Box 37 – Possible combinations of Member States for enhanced co-operation**

For the development of emission factors for organic soils, cooperation between Nordic Countries may be helpful, potentially including Sweden, Finland, Denmark, Estonia, Latvia and Lithuania.

Countries with small-scale land use structures, as is the case in parts of Italy or Austria, for example, face the problem that the development of consistent time series is resource-intensive. They might cooperate in developing efficient small-scale surveys.

Countries with more larger-scale structures, such as Finland, Sweden or Romania, may share their experience in optimising survey design on larger holdings.

There are a number of possibilities for co-operation amongst Member States with similar ecological, climatic and agronomic conditions. Member States themselves indicated the useful collaborations within several Member States clusters or regions, e.g. in the northern part of Europe; the Mediterranean part; UK, Ireland and western France; the western, more Atlantic influenced, or the eastern, more continental part, of central Europe etc.

#### **7.2.1 Some funding possibilities**

Various funding opportunities are available from the European Commission which may have potential to support aspects of improved cropland and grassland management reporting and accounting. In particular, there are the LIFE 2014-2020 Programme and the European Regional Development Fund. Both have a strong focus on implementation and dissemination measures. However a pure monitoring or scientific project will certainly not fulfil the eligibility for funding. Funding submissions for suitable projects need to be prepared carefully in the light of the criteria for the relevant funding instruments and in consultation with the regional programme experts.

### **Box 38 – The LIFE 2014-2020 Programme**

The LIFE 2014-2020 Regulation (EC) No 1293/2013 established the ‘environment’ and ‘climate action’ sub-programmes of the LIFE Programme<sup>32</sup> for the funding period 2014–2020. The latter sub-programme will provide €864 million in co-financing for climate projects between 2014 and 2020. Its main objectives are to:

- Contribute to the shift towards a low-carbon and climate-resilient economy
- Improve the development, implementation and enforcement of EU climate change policy and legislation
- Support better environmental and climate change governance at all levels
- Support the implementation of the 7th Environment Action Programme<sup>33</sup>

The ‘climate action’ sub-programme covers climate change mitigation, climate change adaptation and climate governance and information. It provides co-financing action grants for best practice, pilot and demonstration projects in the following areas:

- Reduction of greenhouse gas emissions

<sup>32</sup> <http://ec.europa.eu/environment/life/about/index.htm#life2014>

<sup>33</sup> <http://ec.europa.eu/environment/newprg/>

- Implementation and development of Union policy and legislation on climate change mitigation, including mainstreaming across policy areas, in particular by developing, testing and demonstrating policy or management approaches, best practices and solutions for climate change mitigation
- Improvement of the knowledge base for the development, assessment, monitoring, evaluation and implementation of effective climate change mitigation actions and measures that enhance the capacity to apply that knowledge in practice
- Development and implementation of integrated approaches, such as for climate change mitigation strategies and action plans, at local, regional or national level
- Development and demonstration of innovative climate change mitigation technologies, systems, methods and instruments that are suitable for being replicated, transferred or mainstreamed

Best practice, pilot or demonstration projects to improve reporting and accounting for cropland and grassland are in line with the objectives of the LIFE ‘climate action’ sub-programme, as they support implementation of climate change policy and governance. Better knowledge of related aspects of cropland and grassland management also helps in the development of low-carbon policies and measures.

As an example, a project with the objective of improving the knowledge base on pertinent land uses in order to respond requirements on CM and GM could be proposed. Similarly, projects to improve emission factors may be eligible to apply for LIFE funding, provided that the project setup demonstrably contributes to the LIFE ‘climate action’ objectives and criteria. More information on the LIFE 2014-2020 programme can be found on the programme’s website:

<http://ec.europa.eu/environment/life/about/index.htm#life2014>

Besides the LIFE programme, the European Regional Development Fund also provides opportunities to apply for support. Up to 85 % of the eligible project costs are funded by the regional funding programmes developed by Member States under the ERDF

### **Box 39 – The European Regional Development Fund**

The European Regional Development Fund (ERDF) aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions<sup>34</sup>. The ERDF focuses its investments on the following key priority areas:

- Innovation and research
- The digital agenda
- Support for small and medium-sized enterprises
- The low-carbon economy

As part of the ERDF, Interreg programmes<sup>35</sup> which are a relevant part of the ERDF support the harmonious development of the European Union’s territory at different levels (so-called European Territorial Cooperation). Interreg has three types of programmes: cross-border, transnational and interregional and has been utilised in the past for land management projects.

<sup>34</sup> [http://ec.europa.eu/regional\\_policy/thefunds/regional/index\\_en.cfm](http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm)

<sup>35</sup> [http://ec.europa.eu/regional\\_policy/cooperate/cooperation/index\\_en.cfm](http://ec.europa.eu/regional_policy/cooperate/cooperation/index_en.cfm)

As the low-carbon economy is one of the ERDF's key priority areas and the Fund supports, in particular, cooperation between neighbouring Member States, projects on cropland and grassland management may qualify. As an example, neighbouring Member States with similar land-use structures may set up a joint field survey project which would result in effective cross-border cooperation in line with the Fund's objectives.

More information on the ERDF can be found on the following website:

[http://ec.europa.eu/regional\\_policy/thefunds/regional/index\\_en.cfm](http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm)

### **7.2.2 Example of a joint initiative by Member States**

The Nordic-Baltic LULUCF project<sup>36</sup> is an example of international cooperation in the area of LULUCF reporting.

#### **Box 40 – The Nordic-Baltic LULUCF project**

The Nordic-Baltic LULUCF project was implemented in 2012/2013. It focused on the assessment of forestry and agriculture measures in the context of climate change and on greenhouse gas reporting for the LULUCF sector. The project aimed at:

- strengthening cooperation and networking
- sharing regional experiences
- identifying current difficulties & common challenges
- and seeking knowledge transfer and practical solutions.

Ministries, universities, research institutes and environmental and forestry agencies from Estonia, Finland, Latvia, Lithuania and Sweden were involved. The project partners concluded that the project provided a valuable platform for discussion and interaction between experts. Besides the development of a broader view, the project supported practical solutions, e.g. related to grassland management or concrete approaches to compile the greenhouse gas inventory.

### **7.2.3 Planned improvements**

Member States did not mention specific plans for international cooperation in their questionnaire responses, but several pointed out that their approaches may be useful for other countries.

France for example suggested that Member States with small-scale land-use structures may make use of France's experience with a systematic / stratified sample system that has been developed and integrated with the LPIS system (see chapter 5).

## **7.3 Perspectives from international and EU wide assessment systems and projects**

The use of assessment systems established for reporting and assessment purposes other than LULUCF may save resources. Several data bases are already established at national or European level to support other reporting obligations. Some of these assessment systems

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<sup>36</sup> <https://sites.google.com/site/lulucfnetwork/>

are linked with the Common Agricultural Policy. There can be some confidence in the regular maintenance and sustainability of several systems that have a key role in their respective policy areas. Time consuming doubling of broadly similar assessment work for GHG reporting purposes may be avoided by adjusting and using the assessment systems for the purposes of GHG reporting.

### **7.3.1 The Integrated Administration and Control System (IACS)**

Under the CAP Member States have to take measures to ensure that transactions financed by the European Agricultural Guarantee Fund are carried out correctly. Thus all EU Member States should operate an Integrated Administration and Control System (IACS)<sup>37</sup>.

IACS is the most important system for the management and control of EU payments to farmers established by the Member States in application of the Common Agricultural Policy (CAP). The legal requirements governing IACS are laid down in Council Regulation (EC) No 1306/2013 but it was originally adopted in 1992 by the EU.

IACS consists of a number of computerised and interconnected databases which are used to receive and process aid applications by farmers and the respective data. Thus it provides:

- a unique identification system for farmers;
- an identification system covering all agricultural areas called the Land Parcel Identification System (LPIS);
- an identification system for payment entitlements;
- a system for identification and registration of farm livestock (in Member States where livestock-based measures apply).

The system ensures the unique identification of each farmer as well as all agricultural parcels of land and, if needed, of livestock. The system also covers the processing of the aid applications. IACS applies to direct support schemes to farmers and land managers (Pillar I) as well as to those rural development measures (Pillar II) which are granted based on the number of hectares or livestock (in some cases) held by the farmer.

The IACS databases have to be regularly updated by the Member States and the historical data for the farms must be saved. Regular reviews take place in order to take into account newly available techniques as well as to simplify the system. Member States report annually to the Commission by submitting detailed statistics on applications, controls and any reductions in payments.

Both Pillar I and Pillar II payments are covered by IACS.

Due to the way the CAP is implemented in the respective EU countries the application of IACS varies between Member States. In some countries e.g. Austria where the majority of

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<sup>37</sup> According to the principle of shared management, Member States must take the necessary measures to ensure that transactions financed by the European Agricultural Guarantee Fund (EAGF) are not only actually carried out but are also implemented correctly. Furthermore, Member States must prevent irregularities and take the appropriate action if they do occur ([http://ec.europa.eu/agriculture/direct-support/iacs/index\\_en.htm](http://ec.europa.eu/agriculture/direct-support/iacs/index_en.htm))

farmers participate in the CAP the IACS data base is very comprehensive and covers about 86% of the agricultural area (77% of farms participate in one of several services of support the national agri environment scheme). Arable land in Austria and many other Member States (annual cropland) is almost fully covered by IACS. The relevant area of annual cropland is compiled by Statistics Austria and reported in the annual national agricultural statistics.

However, in Member States where fewer farmers participate in the CAP, IACS might not be a sufficiently comprehensive source of farm land information, as farmers who don't apply for CAP subsidies are not registered in IACS. At present, some but only few Member States use IACS and LPIS respectively for LULUCF reporting of GHG emissions in CL and GL (see Annex 2).

### **7.3.2 The Land Parcel Identification System (LPIS)**

As part of IACS; the European Union has created a system for the identification of agricultural land parcels. The LPIS is used for registration of reference parcels (part or all of a field) considered eligible for annual payments of CAP subsidies to farmers. The use of these computer-aided geographical information techniques (GIS) which also includes aerial photographs and satellite pictures is mandatory.

Information contained in the LPIS includes quantitative data, including parcel area and boundaries; and qualitative data, including crop description and land owner or herd number. It was designed as a key instrument for the implementation of the CAP first pillar which involves annual direct payments to farmers. Its role is to identify and quantify the land eligible for payments. Over time the role of GIS systems within the CAP has needed to expand beyond the role of controlling traditional direct payments in order to store additional data. This has been driven by policy changes such as cross compliance, which has environmental and livestock health components. Consequently the information stored in the LPIS now can be used for broader purposes. In some Member States the LPIS is effectively becoming the Land Management Information System for their rural areas<sup>38</sup>. The Institute for Environment and Sustainability (IES) is continuously working to adapt the newly developed methodologies, practices and templates in order to improve the LPIS and IACS-GIS applications. Information from the IES indicates that the 45 land parcel information systems across the EU hold data on more than 135 million detailed land parcels, declared annually by 8 million farmers in the EU.

In Austria for example agricultural parcels are identified at the plot level (graphically and digitally) using farm maps. There are cartographic documents which comprise an aerial photograph and the graphical data for the individual parcels. This is valuable information. Nevertheless it must be noted that the information contained in IACS and LPIS is subject to strict data security and the aggregated data can be used by third parties only with permission of the authority concerned in the country.

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<sup>38</sup> <http://ies.jrc.ec.europa.eu/our-activities/support-for-member-states/lpis-iacs.html>

### 7.3.3 The application of IACS and LPIS for GHG reporting in the Member States; some potential solutions

The questionnaire responses showed that currently only a few Member States use IACS and LPIS respectively for CL and GL reporting purposes as shown in the table.

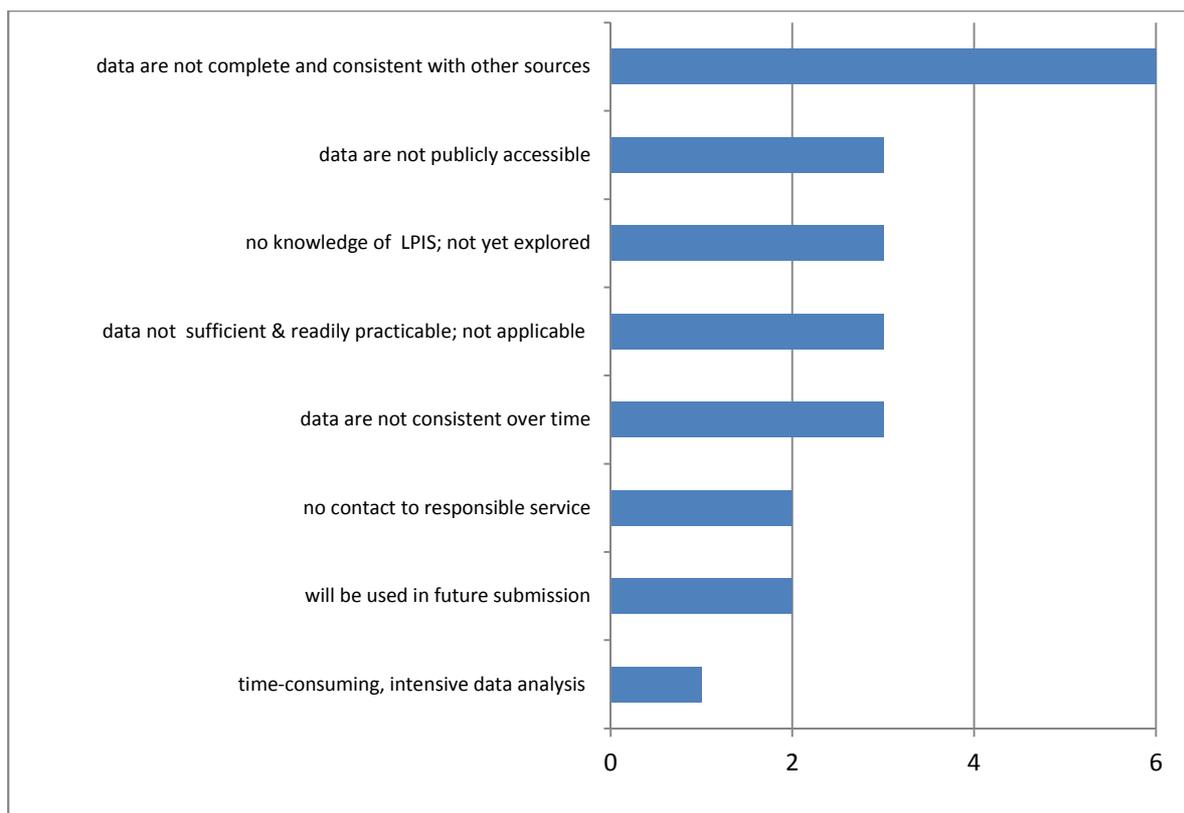
**Table 10: Information obtained from IACS/LPIS by the Member States (not all countries using LPIS indicated what kind of data they used)**

Member State	Information obtained from IACS/LPIS
BE	Use of LPIS in a statistical way
FI	Land conversion data
	Crop statistics used for C stock change modelling for mineral soils and for calculating the proportions of annual and perennial crops grown on organic soils
AT	Land conversion data
	Estimation of cropland management factors and land management information
DK	Data on crops grown on fields and soil level (used for a new soil map of mineral and organic soils), subdivided into cropland and permanent grassland
IE	To establish statistical probabilities of soil types associated with cropland and grassland.
	To verify the assumption that burning is not a management practice on cropland in Ireland.
FR	Data of 'Registre parcellaire graphique'
BG	Balance of physical blocks in permanent agricultural use and balance of ownership areas
SE	Crop harvest data

The results of the questionnaire showed that the majority of Member States do not use IACS/LPIS to estimate cropland and grassland area in relation to LULUCF reporting. This is likely to be because of a number of limitations in these data sets which are mentioned in the questionnaire responses:

- The data does not cover all agricultural land, only that receiving CAP subsidies
- is not updated sufficiently often
- is limited by restricted access to the database due to concerns about data protection
- may not be reliable because LPIS objects are not stable over time (e. g. changes in boundaries, intermittent recording when parcels are not subject to payment claims, changes in ownership)
- Data are not consistent with other data sources and
- the person responsible for LULUCF reporting had no knowledge about the IACS/LPIS database.

In addition to these limitations or restrictions some Member States mentioned that there was potential for analysing IACS/LPIS in greater depth. Several countries plan to investigate the use of this database for LULUCF reporting purposes. The UK indicated that it will use this data in their next submission.



**Figure 2: Reasons given by Member States for not using LPIS/IACS39 data**

National circumstances clearly determine to a considerable degree whether the IACS/LPIS can be successfully used for GHG reporting or not. Given this the following approaches should be taken into consideration to address some of the more technical barriers to its use encountered in the Member States.

*Ref. the problems ‘data are not complete’; ‘time-consuming, intensive data analysis’:*

It should be noted that there is no need to analyse the whole data set. The IPCC guidelines allow the use of statistical methods, as is usual in the forestry subcategory reporting regime for example. It is permissible to build on forest inventories where only a low percentage of the total forest is monitored but this allows sufficiently accurate results to represent the total forest. In the same way, IACS/LPIS data does not have to be complete to be usable; it simply has to be representative. In fact, the whole IACS/LPIS data set may be reduced to a representative subset of land parcels which are tracked over time for GHG reporting purposes (as is done in Austria for example). The results for these areas then can be expanded to the whole CM and GM area. This is likely to be a time and resource saving approach.

Furthermore, there is concrete experience that analysis using IACS/LPIS can be the opposite of a time-consuming, intensive process once the approach has been well defined, and established and when the analytical routines are carried out by those sufficiently familiar with the tool. It should be kept in mind that set-up, infrastructure demands, maintenance

<sup>39</sup> Assessment= AT, BG, CY, CZ, DK, EE, ES, FI, GR, HR, LT, LU, LV, PL, PT, RO, SE, SK, SI, UK; No answer=/ BE, NL

and personnel/financial resources are already covered by other funding sources in this case, so that only the costs of adjustment to the system and the related analysis need to be covered by the unit responsible for GHG reporting. Furthermore, the analysis does not have to be repeated each year, but only after a period of time, with intermediate reporting utilising extrapolated figures, while – of course - analysing each single year in the assessments.

*Ref. the problem 'data are not publicly accessible'*

Of course there is the need to establish and maintain collaboration with the unit running the system. Whilst the information in the system is confidential this is not necessarily a problem because the data for GHG reporting is only needed on a very aggregated level (indeed, IACS/LPIS is used for the derivation of agricultural statistics in many countries).

*Ref. the problem 'data not sufficient & readily practicable; not applicable'*

It may be worth considering making adjustments in the national IACS/LPIS system before introducing a separate assessment system for GHG reporting. The IACS/LPIS combination system already provides the survey background required in a complete way and the necessary activity data for CM and GM reporting. Replicating this would be time consuming. So, adjustments to this system or the introduction of further survey parameters for GHG reporting may be less demanding than an independent exercise. Maintenance is secured and the system should provide rather robust data, keeping in mind that it is not only statistical information, but is linked to the agricultural subsidy payments where records need to be maintained to a high standard.

*Ref. the problem 'data are not consistent over time'*

This may be a severe problem and in some cases difficult to solve, particularly if the label and size of the land parcels are not consistent over time. However, one solution may be to analyse only a representative, but consistent subset of land parcels over time. In a first step, an analysis to identify a set of consistent land parcels, in the sense of category and size, probably will be necessary. Furthermore, the problem of mixed parcels comprising different land uses notably GL and CL, which particularly cannot be used for LUC analysis, should be addressed by deleting such parcels before the data analysis. Such initial steps in Austria reduced the IACS data set to be analysed to approximately one third of the total farmed area –which is still a larger share of the total than within a forest inventory. A check to consider the shares of the crop and grassland types in both the full data set and the reduced data set will identify any bias in the subsample being analysed. Correction factors for the resulting bias then can be utilised in adjusting. The extrapolation of results for the reduced data set to the whole country.

At a European level there may be a role for a task force including the units running the IACS/LPIS, the responsible agricultural institutions and the GHG reporting community in the Member States. This could serve as a useful platform to consider and resolve these problems and make the system more fit for GHG reporting in CL and GL.

### **7.3.4 The EU Farm structure survey**

Another key source of data organised at an EU level in relation to the CAP is the survey on the structure of agricultural holdings. This is known as the Farm Structure Survey (FSS), and is used to assess the agricultural situation across the EU on a routine basis.

The FSS is conducted in all EU Member States on the legal basis of Regulation (EC) 1166/2008. Member States collect information from individual agricultural holdings; these data then are forwarded to Eurostat. The Regulation states that a census of agricultural holdings in the EU is necessary at least every ten years. The last full agricultural census took place in 2010<sup>40</sup>. Sample surveys were conducted in 2013 and 2016.

Within this survey the confidentiality of data is protected by limiting the availability of information concerning the location parameters of individual holdings and by appropriate aggregation of the data. Data are widely available, e.g. from the EUROSTAT database (available for download), in national publications or for download from national statistics sites.

The information collected in the Farm Structure Survey covers land use, livestock numbers, rural development, management and farm labour input. The list of parameters to be collected in the survey exercise can vary and is defined in EUROSTAT working groups. All EU countries must answer the same questions. The survey data can be aggregated by different geographic levels (for Member States, regions and also districts). Amongst its other roles the survey is used to contribute data on agri environment indicators throughout the EU. The basic unit underlying the survey is the agricultural holding, which is a technical-economic unit under single management engaged in agricultural production<sup>41</sup>.

Although the thresholds for defining an agricultural holding and particularly its minimum size can be different between countries, the survey covers 98 % of the agricultural area (UAA) and the livestock of each country. Until 2007, the Farm Structure Survey covered all agricultural holdings with an UAA of at least one hectare (ha) and those holdings with a UAA of less than one hectare if their market output exceeded certain thresholds. However, following a legislative change the minimum size threshold for agricultural holdings changed from one hectare to five hectares for the 2010 survey.

Under the legislation, common land (land shared by or accessible to several holdings) is not included in the UAA in Bulgaria, Germany, France, Greece, Ireland, Hungary, Slovenia and the United Kingdom. In all other has been included in the survey where it exists.

The holdings are assigned geographically as far as possible according to their actual location where the relevant information is available. However, the FSS does not provide any spatially explicit information (GIS) for the field plots.

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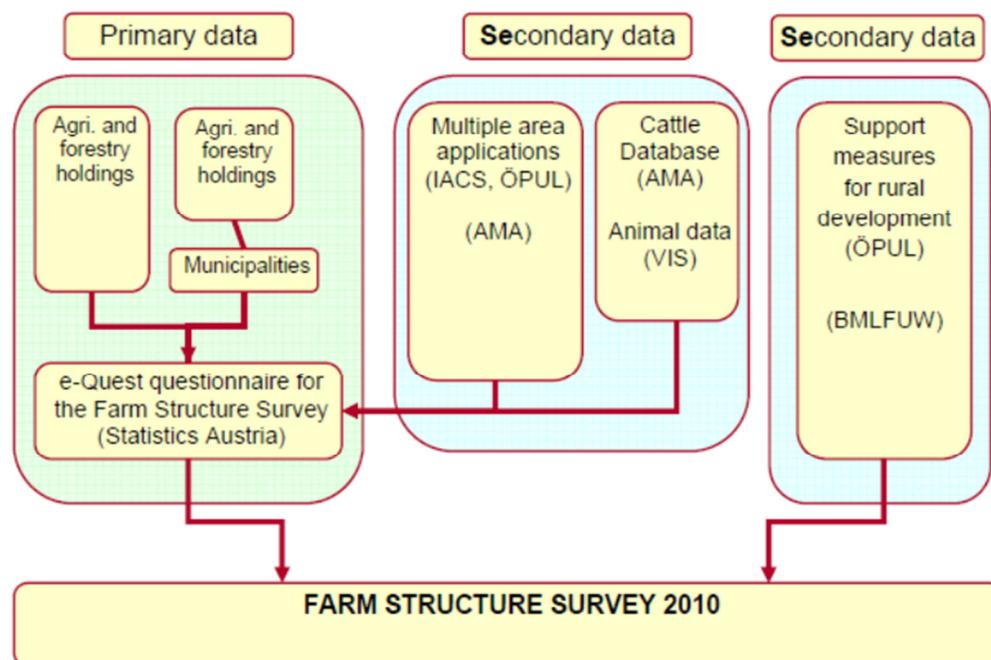
<sup>40</sup> the previous years were full agricultural census-1999, sample surveys 2003, 2005 and 2007

<sup>41</sup> [http://epp.eurostat.ec.europa.eu/statistics\\_explained/index.php/Agricultural\\_census\\_2010\\_-\\_main\\_results](http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Agricultural_census_2010_-_main_results)

In certain countries some information derived from administrative data is implemented in the FSS (e.g. Austria where annual cropland area data are fully covered by IACS and subsequently implemented in FSS). Regulation (EC) No 1166/2008 permits the use of data from IACS in this way. Only information that cannot be obtained from administrative data is taken from primary statistics. For instance, in respect of cultivated land, only those holdings that have not applied for an annual CAP payment as part of the IACS procedure and so are outside the IACS system must provide these details in the Farm Structure Survey.

In 2010 a Survey on Agricultural Production Methods (SAPM) was carried out in conjunction with the Farm Structure Survey 2010. . A significant amount of data on land management (manure application, tillage methods, soil conservation, crop rotation), irrigation, types of livestock housing and animal manure was recorded for the first time.

Information from this source on land management in particular potentially can be used as input data for reporting Cropland and Grassland management, all the more because such data are available in all Member States.



**Figure 3: Data sources covered by the Farm Structure Survey using the example of Austria** (Standard documentation; Meta information on the Farm Structure Survey 2010)

### 7.3.5 CORINE Land Cover

Another potentially useful source of data is CORINE Land Cover (CLC) which is a geographic land cover/land use database covering EU countries. First proposed in 1985 by the European Commission, CLC describes land cover (and land use to some extent) according to a nomenclature of 44 classes of cover. The first survey and estimate of land cover was undertaken in 1990. Updates of the CLC database occurred in 2000 and 2006. Currently a new update is being generated and will be released in 2015.

The CLC is based on the visual interpretation of satellite images and so is quite different from IACS or the FSS. Ancillary data (aerial photographs, topographic or vegetation maps, statistics, local knowledge) have been used to refine the interpretation of satellite images and the subsequent assignment of the territory into the categories selected for the CORINE Land Cover nomenclature. The smallest surfaces mapped (minimum mapping Units- mmU) is 25 hectares. Linear features of less than 100 m in width are not considered either. This is a very large database and the scale of the output is fixed at 1:100.000. Thus, the precision with which the CLC database identifies the location of any particular point is 100 m. The following CCL classes refer to agriculture and provide information on CM and GM

- 211 agriculture
- 212 irrigated agriculture
- 221 vineyards
- 231 pastures
- and various mixed classes like class 2.4 heterogeneous agricultural areas ( with 4 sub-classes)

The main drawbacks of using the CLC approach are the relatively large time spans between the surveys (1990 to 2000, update 2006, 2012) and the mmU of 25 ha that does not distinguish small or areas of land with different forms of cover, which do occur in many parts of Europe.

The responses to the questionnaire indicate that 7 Member States (CY, GE, HR, HU, IE, MT and SE) use CLC to assess cropland and grassland activity data. The advantage is that CLC provides consistent land cover information that spans all land cover classes.

### **7.3.6 LUCAS (Land Use/Cover Area frame Statistical Survey)**

An additional and more recent source of information is LUCAS. This is an EU field survey programme supervised by EUROSTAT. LUCAS provides information on land cover and land use on the basis of a sample survey. Since 2006 the survey has been undertaken to estimate the state of land use and cover in the EU and the dynamics of change. The specific land cover/use statistics are collected in co-operation with authorities from all EU countries. The LUCAS surveys are carried out in-situ every three years; this means that observations are made and registered on the ground. The latest LUCAS survey (2012) covers all EU countries and observations on more than 270 000 points.

Three types of information can be obtained:

1. Micro data: land cover, land use and environmental parameters associated to the single surveyed points,
2. Point and landscape photos in the four cardinal directions,
3. Statistical tables with aggregated results by land cover, land use at the geographical level; these estimates are based on the point data appropriately weighted.

In 2009, the European Commission extended the periodic Survey to sample and analyse the main properties of topsoil in 23 EU Member States. This topsoil survey represents the first attempt to build a consistent spatial database of the soil cover across the EU based on standard sampling and analytical procedures, with the analysis of all soil samples being carried out in a single laboratory (<http://eusoils.jrc.ec.europa.eu/projects/Lucas/>). Approximately 20,000 points were selected out of the main LUCAS grid for the collection of soil samples. A standardised sampling procedure was used to collect around 0.5 kg of topsoil ranging from 0-20 cm. The samples were dispatched to a central laboratory for physical and chemical analyses.

At this point in time there are some questions about the suitability of LUCAS data for GHG reporting purposes. The LUCAS data and other sources of specific land cover/use data are not always comparable mainly due to methodological differences.

In Austria for example a comparison showed relatively little accordance between LUCAS data and national data (FSS and IACS) used for LULUCF reporting purposes (e.g. LUCAS data estimated an increase in the area of cropland over a period of years when in reality the cropland area was known to have decreased; LUCAS estimates of the extent of land use change towards settlements were ten times higher than the real ones). This is due to methodological differences many related to sample size; for example the LUCAS grid of survey points is too coarse for tracking national detailed change at the national level and there has been insufficient adjustments with national data. These issues currently are under discussion by experts at the European level. Based on this Austrian experience, improvements to the LUCAS design and methodological approach would seem to be essential before its results can be used for national GHG reporting. However, the situation may be completely different in other Member States – the responses to the questionnaire did not allow a meaningful evaluation of its suitability for LULUC assessment because LUCAS is used by the Member States for that purpose. Only one country has been identified as utilising LUCAS for GHG reporting: LUCAS soil data were successfully used as a complementary information source for soil C stocks in Portugal.

### **7.3.7 The European soil data base**

The European Soil Database (ESDB) comprises maps of soil classes, aggregated into soil typological units and soil mapping units. These maps show soil properties, derived via soil transfer functions. Values are given as class ranges only. The soil properties covered include soil organic carbon content in the topsoil, pH, and texture.

The ESDB covers all EU Member States. Resolution is presented as 1:1,000,000 map, but more details are available in Member States and regions that have submitted higher resolution data.

Most of the data offered are at a European scale, but when possible, links to national or global datasets are provided. For instance, the 'European Soil Database v2 Raster Library' contains raster (grid) data files with cell sizes of both 1km x 1km and 10km x 10km for a large number of soil related parameters. The 10km x 10km rasters are in the public domain and allow expert users to use the data for instance to run soil, water and air related models.

The grids fit with the INSPIRE raster to develop ‘nested’ systems for reporting and updating European soil data at different scales, according to a hierarchy of grids with a common point of origin and standardised location and size of grid cells.

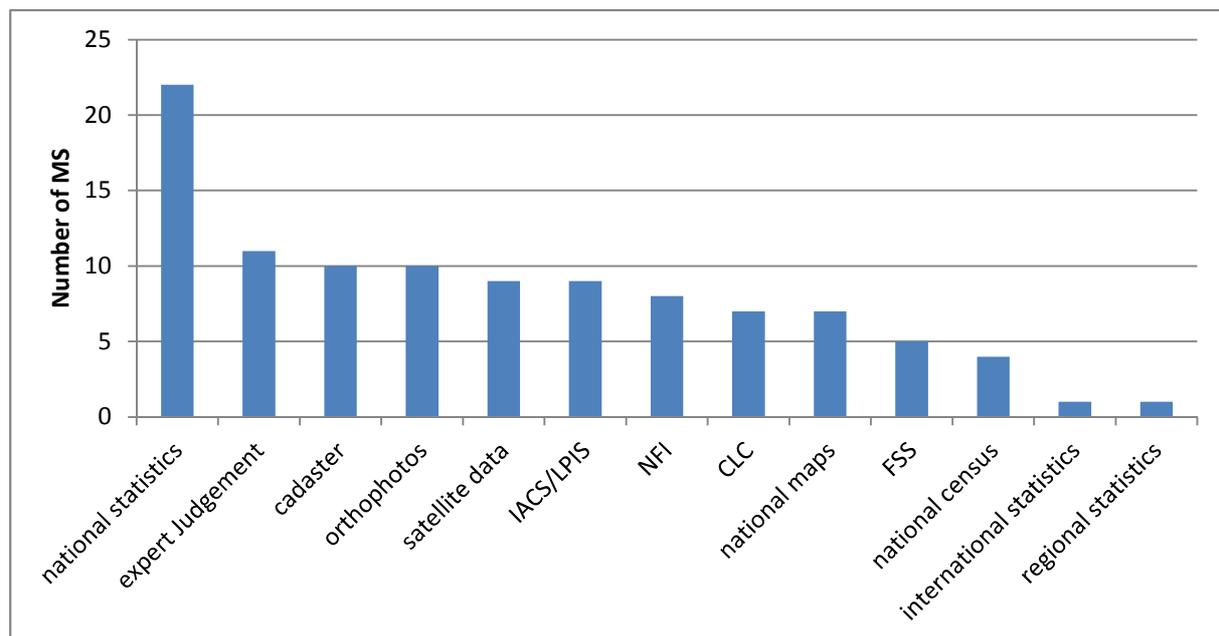
### 7.3.8 INSPIRE (Infrastructure for Spatial Information in the European Community)

In May 2007 an EU initiative called INSPIRE was introduced in the form of a Directive with a view to establishing an infrastructure for spatial information in Europe. The purpose is to support those EU environmental policies and activities which may have an impact on the environment. Full implementation of the initiative is required by 2019 <http://inspire.ec.europa.eu/>

The Directive establishing INSPIRE addresses [34 spatial data themes](#) needed for environmental applications, with key components specified through technical implementing rules.

## 7.4 Resources and cost effective approaches

The questionnaire responses indicate that Member States use a sizeable number of sources of data for LULUCF GHG reporting, including the EU data sets summarised here. The results are shown in Figure 4.



**Figure 4: Methods and sources used by Member States for assessing activity data**

Some Member States indicated in their answers to the questionnaire limited financial and personnel resources were a significant barrier to taking steps to improve the LULUCF GHG reporting system. In times of reduced public expenditure, but often increasing workloads such answers are entirely understandable. Therefore, cost effective approaches are needed to facilitate progress and some general ideas are provided below.

#### **7.4.1 Ideas for improvements**

Co-operation between countries to share the effort and resources required for the derivation of mutually useable input data could bring about a significant reduction in the level of resources needed in the Member States for reporting (see chapter 7.2). In the ideal case, such co-operation could be founded on a broad EU funded project addressing several topics regarding climate change (mitigation or adaptation) which would further reduce the financial resources required from national budgets. Chapter 7.2 describes two useful sources of EU funding.

The use of well-established assessment systems created for other reporting purposes in order to assess the input data related to LULUCF also may be an effective approach to cost-saving. A number of such systems are likely to exist on both the national or international level. Those at the European level which are or can be used are described earlier in this in chapter in section.

These sources of data may not be immediately obvious and an investigative exercise and / or communication may be required in a country to speed up identification of existing or planned projects/assessment systems with different goals, but potentials for providing the input data needed for CL and GL GHG estimates. The same is true for existing or planned funding programmes for research which may be used or adjusted to fill-in the knowledge gaps in GHG reporting. Section 7.1 of this chapter addresses this issue.

#### **7.4.2 Alternative perspectives from international and EU wide assessment systems and projects**

An overview of the potentially available EU and international assessment systems and projects which may be used for CM and GM reporting together with their advantages and disadvantages is provided in Section 7.3.

#### **7.4.3 Examples of problem solutions from Member States**

A good example for a resource saving approach based on networking and intensified communication has been reported from Austria (See chapter 6.5.3). Further examples can be found in those countries which use assessment systems established for other purposes like IACS/LPIS for GHG reporting (see chapter 7.3.3). The establishment, and maintenance costs of the surveys, infrastructure and personnel resources are already covered by other sources so, employing these systems for GHG reporting as well saves considerable costs

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## 9 Annex 1: Making a rough assessment of a key category – the case of Germany

This annex offers the case of Germany as an example of a way to make a rough key category assessment for both CM and GM, applying the checklists in Chapter 3, Tables 5-7. The assessment includes separate estimates of management effects and significant pools in cropland remaining cropland, grassland remaining grassland and land-use changes between cropland and grassland.

### 9.1 National definitions of CM and GM

Germany defines CM as Cropland remaining cropland together with land converted to cropland (except via Deforestation). Cropland includes both perennial and annual crops and horticulture.

Germany defines GM as the subcategory of Grassland covered by herbaceous plants. It includes herbaceous grassland (called 'Grassland in a narrow sense') remaining herbaceous Grassland, land converted to herbaceous grassland except via deforestation. Herbaceous grassland includes pastures, meadows, rough grazing areas, heathlands and swamps.

### 9.2 Detailed example of calculating C stock changes in woody biomass and croplands with mineral soils.

The trend in the area of land involved is already a good indicator. It can be converted into an estimate of C stock changes by applying the IPCC Tier 1 methodology or national EFs if available. Detailed example calculations are presented for estimating both the:

- Carbon stocks in the woody biomass of perennial crops in 1990 and 2013; and
- Potential changes in the carbon stocks of mineral soils arising from changes in carbon inputs from manure and organic residues in cropland, applying the Tier 1 default relative stock change factors for  $F_{LU}$  and  $F_I$  of the IPCC Tier 1 methodology (2006 IPCC Guidelines, Volume 5 Chapter 5, Table 5.5).

The examples serve to show the detailed steps involved in activity data collection, combining them with default EFs or national EFs, the additional assumptions to be made, arguments for these assumptions, the results of the estimated C stock changes and the conclusions drawn for identifying significant C pools.

#### 9.2.1 C stock changes in the woody biomass of perennial crops

The checklist in Table 5 asks the question for perennial crops: 'Has the area of perennial crops changed over time? Test separately for vineyards, orchards, olive trees, etc.'

In Germany the area of perennial crops broken down by crop type was taken from the national agricultural census (Table 11). The total area of perennial crops and of vineyards and orchards slightly decreased between 1990 and 2013.

**Table 11 Area of perennial crops, by crop type, from German agricultural statistics**

Perennial crop type	Area in 1990 (data for 2002)	Area in 2013 (data for 2012)	Area difference 2013 - 1990
Total perennial crops	167,753 ha	162,465 ha	-5,288 ha (-3%)
Vineyards	102,989 ha	102,172 ha	-817 ha (-8%)
Orchards (mainly apples)	49,635 ha	45,593 ha	-4,042 ha (-8%)

Germany has national data for C stocks in perennial crops (German NIR 2014). C stocks in the aboveground and belowground woody biomass of vineyards are estimated as constant, with a value of 1.66 t C ha<sup>-1</sup>. C stocks in the aboveground and belowground woody biomass of apple trees are estimated from total tree numbers. Tree density in orchards increased from 1990 to 2013. Accordingly, average C stocks also increased from 6.7 t C ha<sup>-1</sup> to 8.8 t C ha<sup>-1</sup>. Applying the C stocks for both vines and orchards to the area of perennial crops (Table 11) gives the C stock changes in woody biomass of perennial crops (Table 12). Overall, despite the reduced area of perennial crops, the increasing tree density in orchards led to an overall slight increase in C stocks in perennial crops. This more than compensates for biomass losses in vineyards. The total C stock change, however, is very small compared with other C pools.

**Table 12 Area of perennial crops by crop type from German agricultural statistics**

Perennial crop type	C stocks in 1990 (data for 2002)	C stocks in 2013 (data for 2012)	C stock difference 2013 - 1990
Vineyards	125 Gg C	115 Gg C	-10 Gg C
Orchards (mainly apple)	333 Gg C	403 Gg C	+70 Gg C

The 2006 IPCC Guidelines, Volume 5 Chapter 5, Table 5.1 give a default C stock for perennial woody biomass of 63 t C ha<sup>-1</sup> at the end of a 30 year rotation cycle. Taking the rotation mean of half of the maximum biomass gives a mean wood biomass of 31.5 t C ha<sup>-1</sup>. If Germany had applied the IPCC default C stock the calculation would have resulted in a net C loss of -167 Gg C from total perennial crops following from the reduced area. This is also not a huge change, but the sign of the change indicates a net C loss rather than a net C gain. The example shows that the order of magnitude of C stock changes can be estimated with Tier 1 methodologies but the direction can be wrong if the C stocks per hectare are not constant over time.

### **9.2.2 C stock changes in croplands with mineral soils**

Germany uses an estimated mean C stock in mineral soils under cropland of 60.4 t C ha<sup>-1</sup>, combined with the default relative stock change factors given in Table 5.5 of the, 2006 IPCC Guidelines, Vol. 4 Chapter 5. The reference C stock value was derived from soil maps intersected with a land-use map and calculated as the area-weighted mean C stock, stratified by soil type and several different climate zones. It does not consider any stratification according to the management regime. The example calculation uses the

60.4 t C ha<sup>-1</sup> value as the reference C stock for long-term cultivated land ( $F_{LU} = 0.69$ ), with full tillage ( $F_{MG} = 1.00$ ) assuming at medium intensity cropland ( $F_I = 1.00$ ).

In the first step, any change in manure application was assessed. N input to the cropland arising from animal manure reported under 3.D.a.2a was converted to carbon employing a C:N ratio of 12 (i.e., manure is dominated by slurry). C input from manure in 1990 was 10.6 Mio t C, (decreasing by 1.3 Mio t C to 9.3 Mio t C) in 2012. This is equivalent to a 13% decrease in manure carbon input to soil since 1990. According to a German agricultural survey in 2010, 48% of manure is applied on cropland and 52% on grassland. It was further assumed that typical, conservatively estimated, doses of slurry application are 20 to 30 m<sup>3</sup> ha<sup>-1</sup> yr<sup>-1</sup>, equivalent to 0.7 to 1 t C ha<sup>-1</sup> yr<sup>-1</sup> from manure application. Taking the numbers together, croplands have received 0.66 Mio t C less as manure. This means that 630.000 to 950.000 ha or 5 to 7% of croplands may have been subject to a reduction in manure applications between 1990 and 2012. For this area, C stocks in mineral soils would move from the higher intensity status of  $F_I = 1.44$  (high with manure) to the reference medium intensity cropland ( $F_I = 1.00$ ), or from 87 t C ha<sup>-1</sup> to 60.4 t C ha<sup>-1</sup>. The reduced manure input may have led to soil C losses of 16,712 to -25,068 Gg C between 1990 and 2012. Mineral soils may therefore constitute a significant C source. It has to be mentioned, however, that the IPCC default factor for  $F_I = 1.44$  (high with manure) is at the very high end of European long-term experiments on manure so that the overall effect is probably overestimated in this simple example calculation.

In the second step, change in carbon input from crop residues was assessed using a similar approach. N input from crop residues reported under 3.D.a was converted to carbon with a roughly estimated average C:N ratio of ~64. C in crop residues was 54 Mio t C in 1990 and increased by 11 Mio t C to 65 Mio t C in 2012, equivalent to a 21% increase in C input from crop residues since 1990. In other words, average C input from crop residues was 4.0 t C ha<sup>-1</sup> yr<sup>-1</sup> in 1990 and 4.8 t C ha<sup>-1</sup> yr<sup>-1</sup> in 2012. It was conservatively assumed that soils would move from medium intensity ( $F_I = 1.00$ ) to high intensity without manure ( $F_I = 1.11$ ) if the 1990 C input rate is doubled. Almost 2.8 Mio hectares or 21% of croplands would have shifted from medium to high intensity without manure since 1990, or from 60.4 t C ha<sup>-1</sup> to 67.0 t C ha<sup>-1</sup>. Increased C input by crop residues may have led to an enlarged soil C sink of 18,500 Gg C between 1990 and 2012. Mineral soils may therefore also constitute a significant C sink.

Combining the estimates for C stock changes in mineral soils under cropland arising from reduced manure application and increased C input from crop residues shows that the two compensate for each other. This is supported by observations from long-term monitoring plots in Germany and supports the Tier 2 approach used in Germany, which considers that mineral cropland can be regarded as having a zero C stock change during this period. The combined assessment confirms that mineral soils under cropland are not a significant C pool in Germany.

### 9.3 Rough key category assessment by checklists

This section gives a national example and shows how Germany would fill in the checklists in Chapter 3, Tables 5-7. The first three columns of the checklists, the 'Stratum', 'Pool' and 'Question' are repeated. The last three columns of the following tables, with the headings 'Indicator / data sources', 'Result of assessment', 'Comment' provide the data sources and results for Germany. The assessment was made separately for:

- management effects and significant pools in cropland remaining cropland (Table 13)
- grassland remaining grassland (Table 14) and
- land-use changes between cropland and grassland (Table 15).

**Table 13 German example of using the checklist for potentially important strata and pools in the key category analysis for CM: Cropland remaining Cropland**

Stratum	Pool	Question	Indicator / data sources	Result of assessment	Comment
Cropland on organic soils	Organic soils	How much cropland is located on organic soils?	Topographic maps intersected with high resolution map of organic soils: 356 kha out of 13.5 Mha (2.6%). Annual EF for CO <sub>2</sub> is 8.1 t C ha <sup>-1</sup> yr <sup>-1</sup>	Key category by level and by far the most significant pool!	Reported in NIR with Tier 2-3. The area of organic soils times the IPCC default EF would also result in key category.
Perennial crops		Has the area of perennial crops changed over time? Test separately for vineyards, orchards, olive trees, etc.	Agricultural statistics provide area of vineyards, Christmas tree plantations, tree nurseries, short rotation coppices and orchards by fruit type as well as number and age class of fruit trees: ~200 kha (1.5% of cropland). 5% of perennial crop area has been lost since 1990. Loss of orchard area was compensated by higher tree density. Average C stock is 12.5 t C ha <sup>-1</sup>	Not significant for level, trend and uncertainty.	Reported in NIR with Tier 2-3.
Agroforestry and short rotation coppices	Carbon in woody biomass Mineral soils: C stock change, e.g. by default factor F <sub>W</sub>	Has the area of agroforestry and short-rotation coppices changed over time?	Agroforestry comprises Christmas tree plantations, tree nurseries and short rotation coppices. Total area ~40 kha (0.3% of cropland). Short-rotation coppice has only been part of the agricultural census since 2010 (4 kha).	Not significant for level, trend and uncertainty.	Reported in NIR with Tier 2.
Hedgerows and trees outside forests		Has the area, or length of linear structures, of hedgerows, shrubs or trees outside forests changed over time? Have there been any programmes, e.g. under the 2nd Pillar of CAP, to promote agroforestry, short rotation coppice, hedgerows or trees outside forests? How large is the area on which they have been implemented?	Length of hedgerows can be derived from topographic map with high uncertainty. Woodland is a sub-category under Grassland and not included in CM and GM land. Yes, but there is no central documentation of the programme implementation and the acceptance by farmers was very low.	Not applicable in Germany for CM and GM. Probably insignificant.	Criterion cannot be assessed.
Set-aside land	Mineral soils: C stock change, e.g. by default factor F <sub>W</sub>	Has the area of long-term set-aside land (e.g. 5 to <20 years) changed over time?	Unclear. Set-aside land has not been separated into short-term rotational fallow and long-term set-aside land. Set-aside land has been very variable, driven by subsidies, and has been drastically reduced after CAP reform in 2005.	Probably no long-term effect on soil organic carbon in mineral soils.	Criterion cannot be assessed.

Stratum	Pool	Question	Indicator / data sources	Result of assessment	Comment
Annual crops: Carbon input by crop residues		Has the carbon input by crop residues changed over time?	N input by crop residues reported under 3.D.a was converted to carbon with a roughly estimated average C:N ratio of ~64. C in crop residues in 1990: 54 Mio t C, in 2012: 65 Mio t C, equivalent to a 20% increase in C input from crop residues since 1990.	Probably a chance for a slight C sequestration.	C sequestration effect has not been confirmed by observations in long- term soil monitoring plots where the majority shows no change in C stocks.
Annual crops: Carbon input by intercrops		Has the carbon input by intercrops or catch crops changed over time?	Intercrops are included in the crop residues.	See above	See above
Cropland: Carbon input by animal manure	Mineral soils: C stock change factor $F_i$	Has the carbon input by animal manure changed over time?	N input by animal manure reported under 3.D.a.2a was converted to carbon with a C:N ratio of 12 (i.e., dominated by slurry). C input by manure in 1990: 10.6 Mio t C, in 2012: 9.3 Mio t C, equivalent to a 13% decrease in manure carbon since 1990.	Probably a chance for a slight C loss.	Lower C input by manure may compensate the effect of more C input by crop residues.
Cropland: Carbon input by other organic sources		Has the carbon input by other organic sources changed over time?	N input by other sources reported under 3.D was very much lower than from crop residues and manure and was not assessed.	Not assessed	Not assessed

**Table 14 German example of using the checklist for potentially important strata and pools in the key category analysis for GM: Grassland remaining Grassland**

Stratum	Pool	Question	Indicator / data sources	Result of assessment	Comment
Grassland on organic soils	Organic soils	How much grassland is located on organic soils?	Topographic maps intersected with high resolution map of organic soils: 970 kha out of 5.8 Mha (17%). Annual IEF for CO <sub>2</sub> is 6.8 t C ha <sup>-1</sup> yr <sup>-1</sup>	Key category by level and by far the most significant pool!	Reported in NIR with Tier 2-3. The area of organic soils times the IPCC default EF would also result in key category.
Grassland type	Mineral soil	Are there clearly distinct grassland management regimes, e.g. improved / sown grassland, fertilized versus unfertilized grassland, rough grazing, heather and moorland? Are there temporal trends (e.g. shift from one management regime to another)?	Neither agricultural statistics nor LPIs contain appropriate data on management regimes. 42 long-term soil monitoring sites are available in two regions, cover a period of 20 – 25 years. Most of the sites exhibited no changes in the carbon stocks in mineral soils.	Mineral soils under grassland are probably no relevant net sink or source.	The long-term monitoring plots were used as argument for reporting zero C stock changes with Tier 2 method. It is planned to collect additional data from long-term monitoring and long-term experiments and develop a model-based assessment of C stock changes based on upcoming data from the German Inventory of Agricultural Soils by 2018.
Grazing versus cutting	Mineral soil	Has the grazing area or the grazing period or the number of grazing animals changed over time?	Excretion of volatile solids by grazing animals reported under 3.B.(a) indicates that the fraction of grazing dairy cows has decreased since 1990 and the fraction of other cattle has increased. No major changes have occurred in other animal categories. Nitrogen excretion on pastures reported under 3.B(b) steeply declined after 1990, leveling off in recent years.	The excreta trends suggest that grazing management has been converted to cutting. Overall, the number of forage using animal has decreased as well. It is unclear how the trends would affect carbon stocks.	Grazing and cutting are mentioned in the IPCC Guidelines as important management regimes. There is, however, no hypothesis for German conditions how shift in grazing intensity or shift from grazing to cutting would affect C stocks in grassland biomass or soils.

**Table 15 German example of using the checklist for potentially important strata and pools in the key category analysis for land-use changes to cropland or grassland**

Stratum	Pool	Question	Indicator / data sources	Result of assessment	Comment
Cropland - grassland conversions on mineral soils	Mineral soil	<p>Is there a clear difference in area converted from cropland to grassland and vice versa?</p> <p>Is there a temporal trend in the total area converted?</p>	<p>The land-use matrix shows relatively high conversion rates from grassland to cropland after 1990, a slow-down in-between and a clear increase after 2005, which has leveled off at rates above the 1990 conversion rates. Cropland to grassland conversion was lower than vice versa throughout the time series and also had a decreasing trend.</p>	<p>Net conversion of grassland to cropland is a key source for CO<sub>2</sub> from mineral soil.</p> <p>Cropland to grassland: 1990 &gt; recent years. Grassland to cropland: 1990 &lt; recent years.</p>	<p>Land-use changes between cropland and grassland are relatively uncertain before 2000 due to lack of adequate thematic and spatial resolution of land-use maps in some regions of Germany. The general trend, however, is consistent with agricultural census or estimated conservatively.</p>
Cropland and grassland on organic soils	Organic soils	<p>Is there a clear difference in soil type of the area converted from cropland to grassland versus the area vice versa?</p> <p>Is there a land-use trend on organic soils (land-use changes)?</p>	<p>The spatially explicit land-use matrix intersected with the soil map would allow such an analysis. Germany reported by soil type in the past but was discouraged by UNFCCC reviewers and has moved to using average C stocks in mineral soils by land-use category only.</p> <p>The land-use matrix intersected with the soil map indicates minor changes between cropland and grassland on organic soils. Conversion to grassland exceeded conversion to cropland throughout the time series.</p>	<p>Not assessed</p> <p>Small net emission reduction.</p>	<p>A spatially explicit analysis of land-use changes by soil type is planned for 2018 to test whether it would increase accuracy. Past assessments have not shown drastic differences in soil types for the two conversion directions, so the approach with mean C stocks per land-use type is most likely accurate.</p>

## 9.4 Interpretation of the checklist results for likely key categories and significant pools

The results of the checklist analysis (Table 13, Table 14, Table 15) for Germany highlight the overwhelming importance of CO<sub>2</sub> emissions from drained organic soils under CM and GM, which account for >90% of the CO<sub>2</sub> emissions. Cropland remaining cropland and grassland remaining grassland are key categories in level, trend and uncertainty, primarily due to drained organic soils (Table 16).

Germany notes, however, the high uncertainty in the estimate of zero C stock change estimate for mineral soils under cropland because management trends counteract each other.

Land-use changes have not been identified as key categories in the past but there are plans for a new policy regime to require the compensation of land-use changes from grassland to cropland by converting other croplands to grassland. This would produce significant effects on future trends in mineral soil C stocks (Table 16).

**Table 16 Key categories and significant pools in German CM and GM**

Is the category a key category? <sup>(1)</sup>		key category	If key category please tick the significant pools <sup>(2)</sup>					
			living biomass		dead organic matter		soils	
			above	below	litter	dead wood	mineral	organic
CM	5.B 1. Cropland remaining Cropland	Yes	No	No	No	No	No; maybe uncertainty?	Level, trend, uncertainty
	5.B 2. Land converted to Cropland	No	No	No	No	No	No; maybe trend?	No
GM	5.C 1. Grassland remaining Grassland	Yes	No	No	No	No	No	Level, trend, uncertainty
	5.C 2. Land converted to Grassland	No	No	No	No	No	No; maybe trend?	No

## 10 Annex 2: Current state of reporting of Cropland and Grassland and related activities

This section sets out the current state of reporting on cropland and grassland (land-based reporting) under the UNFCCC and, where elected, activity based reporting for cropland management (CM) and grazing land management (GM) under the first commitment period of the Kyoto Protocol. CL and GL reporting forms the basis for CM and GM reporting, but to report on CM and GM additional information and efforts will be needed, such as:

- spatially explicit reporting,
- further splitting of the C pools into five categories, rather than three;
- complete reporting for all C pools or the inclusion of robust 'no source' statements;
- once defined, certain areas of land do not or may not be covered by CM and GM despite being included in the CL and GL subcategory.

In the first KP commitment period only three Member States elected to report and account for CM and/or GM. Consequently an analysis of CM and GM reporting in only these three countries would give a rather limited picture for the current state of reporting in the EU. However, an analysis of the current reporting of CL and GL – which represents the basis for CM and GM reporting – provides a good basis from which to assess the improvements that need to be made and data gaps that need filling for MS to fulfil their reporting obligations for CM and GM in keeping with the IPCC 2006 guidelines (IPCC 2006) and particularly the IPCC KP supplement (IPCC 2014). The results of this analysis for all MS are provided in this section.

It should be noted that MS may have more than one response or points per issue analysed, so totals for all MS in the figures may be more than the number of MS.

**It is also important to note that the land-use change categories from forest land to CL and GL were not included in the analysis because these are accounted under the KP Art 3.3 activity Deforestation.**

### 10.1 Definition of the LULUCF land use categories Cropland (CL) and Grassland (GL) and – if elected – KP activities of Cropland Management (CM) and Grazing Land Management (GM)

#### 10.1.1 Cropland

In defining the Cropland category, many Member States distinguish between annual and perennial crops or croplands and horticulture. Some Member States include in their definition also temporary fallows or temporary grasslands, whereas some MS include the criterion of tillage (Cropland) or no-tillage land (Grassland). Under 'annual crops' MS consider for instance cereals, corn, vegetables, berries and kitchen gardens. There are MS that also include greenhouses under this category.

The perennials include orchards, vineyards, olive tree gardens, energy plantations, tree nurseries, Christmas trees, fruit and berry plantations, hedgerows and bushes. Many MS

also mention agro-forestry systems under this category as long as they do not fall under the definition of forest.

### **10.1.2 Grassland**

Under the Grassland category many MS report different grassland types and include grazing land (permanent), meadows (natural or cut), permanent pastures, hayfields, or woody grasslands. Some MS differ between productive and non-productive grasslands, which are kept open for recreational purposes.

With regard to vegetation, grasslands are often defined as including herbaceous vegetation, with shrubs and bushes. In some cases bio-energy feedstocks are included as well. There are MS which include bogs not used for peat extraction and wet grasslands that are intermittently inundated. Compared to Cropland, the definition of Grassland means that it is not rotated with arable land, can be fertilised or not fertilised and is not or not regularly ploughed.

### **10.1.3 Cropland Management**

Cropland Management was elected/reported by 3 MS (DK, ES, PT) for the first commitment period and is in general defined as Cropland on which specific management practices take place. Some examples of these activities include:

- Changes in the cultivation of N-fixing crops
- Cultivation of winter crops
- Land temporarily set aside from use

Germany has elected CM for the second commitment period. CM is defined as Cropland.

### **10.1.4 Grazing Land Management**

Only 2 MS (DK, PT) elected/reported Grazing land Management in the first commitment period. In PT the land under GM is identical with that under GL, while DK includes only grazed grassland under its definition of GM.

Germany has elected GM for the second commitment period. GM is defined as 'Grassland in narrow sense'<sup>42</sup>, which is identical to one of the two grassland categories in the UNFCCC inventory.

## **10.2 Completeness of reporting**

### **10.2.1 Overview**

This section contains tables and figures compiling the information we have collected from Member States in relation to the current state of reporting on the relevant parameters. The parameters covered are:

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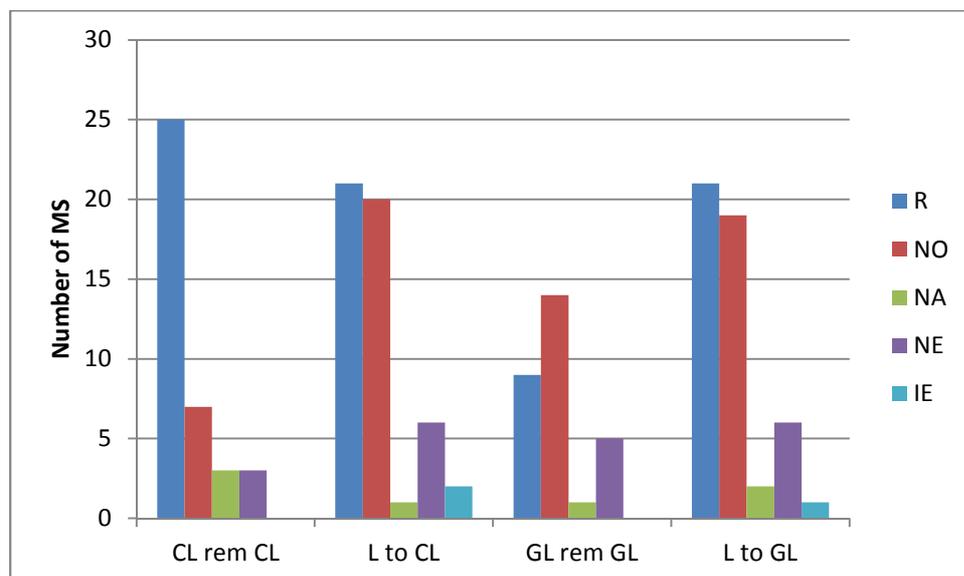
<sup>42</sup> Defined as 'Meadows, pastures, greenery along transport infrastructure, heathland, swamp, reeds and water-saturated area that is intermittently inundated (wet grassland)'.

- Aboveground biomass;
- Below ground biomass;
- Dead wood;
- Litter;
- Mineral soil;
- Organic soil;
- N2O emissions due to conversion to cropland;
- Biomass burning.

### 10.2.2 Aboveground biomass (AGB)

The figure below shows how many MS report the aboveground biomass pool for the Cropland and Grassland sub-categories. It can be seen that above ground biomass is reported by 25 MS for Cropland remaining Cropland, by 21 MS for Land converted to Cropland, by 9 MS for Grassland remaining Grassland, and by 21 MS for Land converted to Grassland. Nevertheless, to get a complete picture it is necessary to consider additionally the notation keys which MS have used.

NO (not occurring) is the most common notation key reported in this pool and it is principally used in the Land to Cropland and Land to Grassland sub-categories. In Grassland remaining Grassland most MS report NO for the AGB pool. In sum, compared to the other pools, AGB is rather reported on a higher level of completeness.



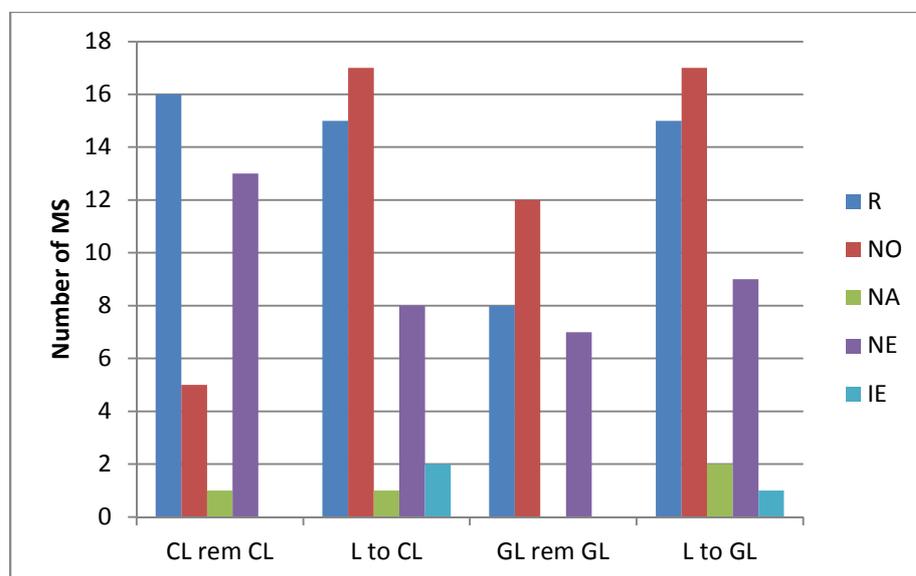
**Figure 5: Number of MS reporting aboveground biomass (R) or notation keys for the sub-categories of Cropland and Grassland\*<sup>43</sup>**

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

\* Note: This figure considers all reported sub-categories. A MS can additionally report several notation keys for one sub-category

### ***Below ground biomass***

The below ground biomass carbon pool is reported by 16 MS for CL remaining CL, 15 MS for Land to CL, 8 MS for GL remaining GL and 15 MS for Land to GL. For this carbon pool the level of completeness is generally lower than in AGB. With regard to notation keys, NO is the most frequently reported key, followed by NE (not estimated) which also indicates a lower level of completeness.



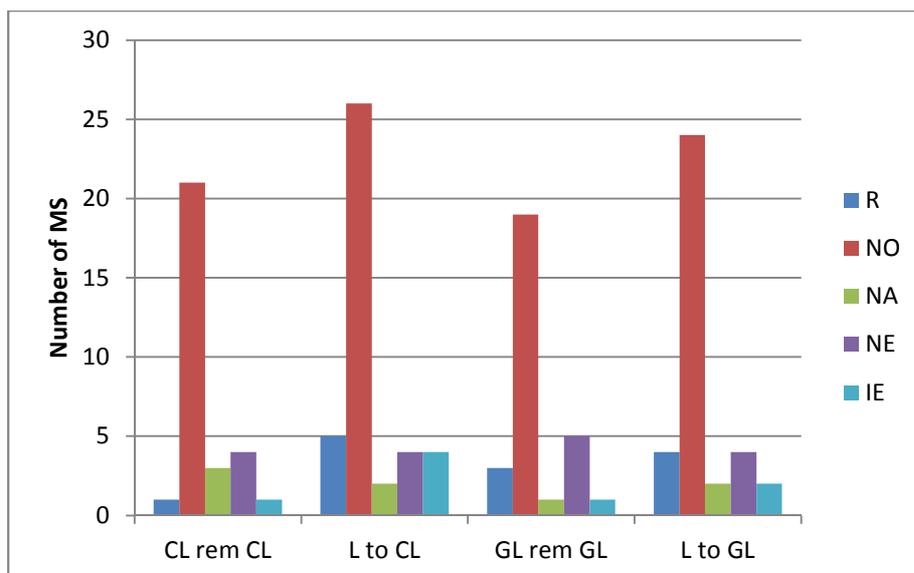
**Figure 6: Number of MS reporting below ground biomass (R) or notation keys for the sub-categories of Cropland and Grassland\***

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

In comparison to a report by EC, JRC (2012, 2013) which analysed the inventories from the reporting year 2012, the completeness of reporting of above and below ground biomass has increased. According to the report, 20 MS reported living biomass for CL remaining CL. However, for the 2013 reporting year, This number has increased to 25 countries reporting above ground biomass for CL remaining CL. Likewise, the number of MS reporting AGB increased for GL remaining GL from 6 to 9 MS. With regard to below ground biomass only, the JRC report (2012, 2013) identifies 10 MS which estimated the pool for CL, whereas in the 2014 submission 16 (CL remaining CL) and 15 (L to CL) reported below ground biomass.

### ***Dead wood***

For this carbon pool most MS report NO (not occurring) for all categories. This is what one would expect, because agriculturally managed systems usually do not have dead wood (except maybe some systems including trees or other woody vegetation) and the land-use change categories from forest land to CL and GL (for which the dead wood pool may be relevant) were not included in the analysis because these are accounted under the Art 3(3) activity Deforestation. Only one country reports dead wood for CL remaining CL. Five MS report this pool in Land converted to CL. In the Grassland categories in total seven MS report the dead wood carbon pool.

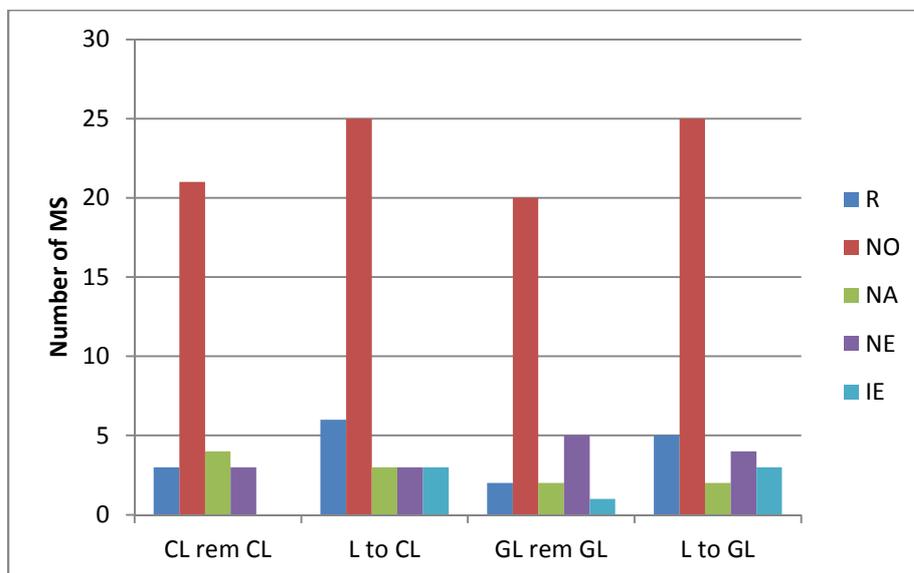


**Figure 7: Number of MS reporting dead wood (R) or notation keys for the sub-categories of Cropland and Grassland\*<sup>44</sup>**

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

### Litter

The pattern of reporting for the litter carbon pool is similar to that for dead wood. Most MS use the notation key NO (not occurring) for the Cropland and Grassland categories and only a few MS report the carbon pool. This is because the litter pool is likely to be relevant only in some specific CL systems which include trees as well as the land-use change categories from forest land to CL and GL. The latter were not included in the analysis because these are accounted under the Art 3.3 activity Deforestation.



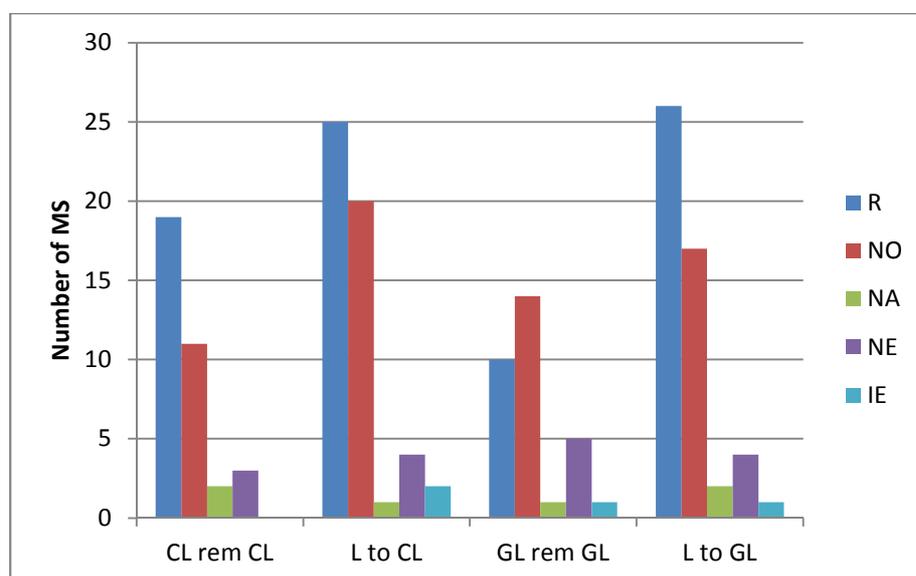
\* Note: This figure considers all reported sub-categories. A MS can additionally report several notation keys for one sub-category

**Figure 8: Number of MS reporting litter (R) or notation keys for the sub-categories of Cropland and Grassland\***

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

**Mineral soil**

The mineral soil carbon pool is reported by the majority of MS for both Cropland and Grassland categories. Almost all MS report this pool for land use changes from Land to Grassland and Land to Cropland. However, many MS also report NO (not occurring) for these categories, especially the ‘remaining’ categories. It should be noted that the number of MS which report estimates for the mineral soil in the CL remaining CL category partly reflect estimates of soil C stock changes due to land-use changes within this category (e.g. shifts from perennial crops to annual crops). If the reporting of soil C stock changes due to changes in CL management were analysed the number of MS would be lower.



**Figure 9: Number of MS reporting mineral soil (R) or notation keys for the sub-categories of Cropland and Grassland\*<sup>45</sup>**

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

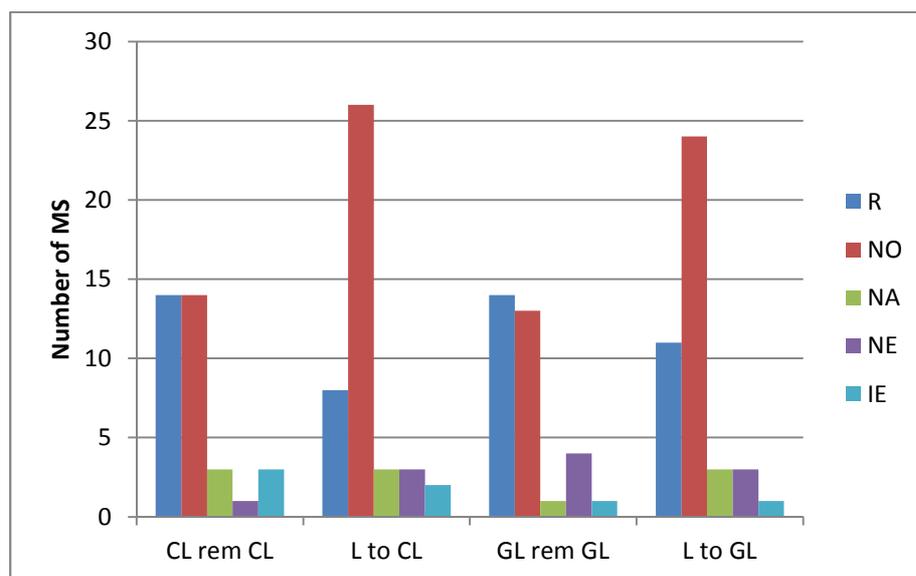
Again, since the submission year 2012, the number of MS reporting mineral soil for CL remaining CL, Land converted to CL and Land converted to GL has increased - from 16 to 19, 21 to 25, and 21 to 26, respectively (JRC, 2012, 2013).

**Organic soil**

Organic soil is reported as NO (not occurring) by most MS for the categories of Cropland and Grassland. Whereas in the land use change categories NO is reported by the majority of MS, in the ‘remaining’ categories only half of the MS report the organic soil pool. This pool is

\* Note: This figure considers all reported sub-categories. A MS can additionally report several notation keys for one sub-category

particularly relevant in Nordic European countries, while the more southern MS usually do not have such soil types in these categories.



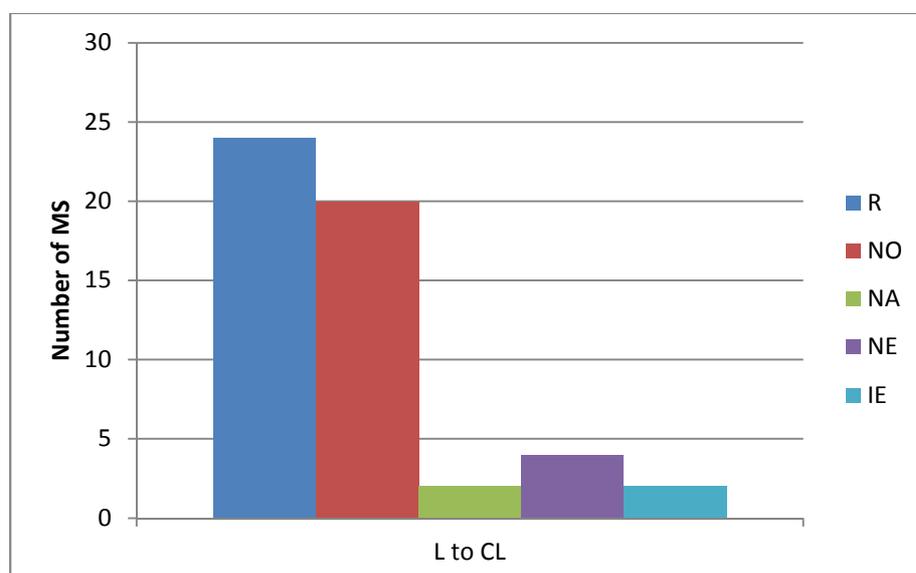
**Figure 10: Number of MS reporting organic soil (R) or notation keys for the sub-categories of Cropland and Grassland\***

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

Similar to the mineral soil pool, the number of MS which report the pool has increased in all categories: From 13 to 14 for CL remaining cropland, from 6 to 8 for Land converted to CL, from 10 to 14 for GL remaining GL, and from 8 to 11 for Land converted to GL (c.f. EC, JRC, 2012, 2013)

### ***N<sub>2</sub>O emissions due to conversion to cropland***

N<sub>2</sub>O emissions resulting from the conversion of cropland are reported by 24 MS, although 20 MS report NO (not occurring) in the Land to Cropland category. It should be noted that this result may be misleading and irrelevant for CM reporting, because it may reflect to a large extent LUC from forest land to cropland which are accounted under Deforestation.

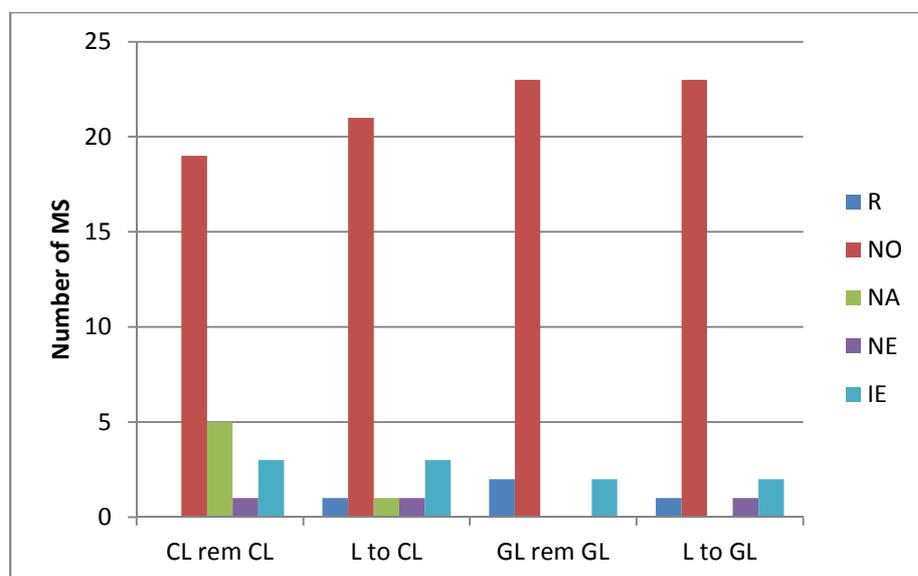


**Figure 11: Number of MS reporting N2O emissions due to conversion to cropland (R) or notation keys for the sub-categories of Cropland and Grassland\*<sup>46</sup>**

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

***Biomass burning***

Biomass burning categories cover controlled biomass burning and wildfires. Most of the MS report these two emission sources as NO (not occurring) for the CL and GL subcategories. Two countries report emissions from controlled burning under GL remaining GL, and 11 MS report wildfires under the GL remaining GL category.

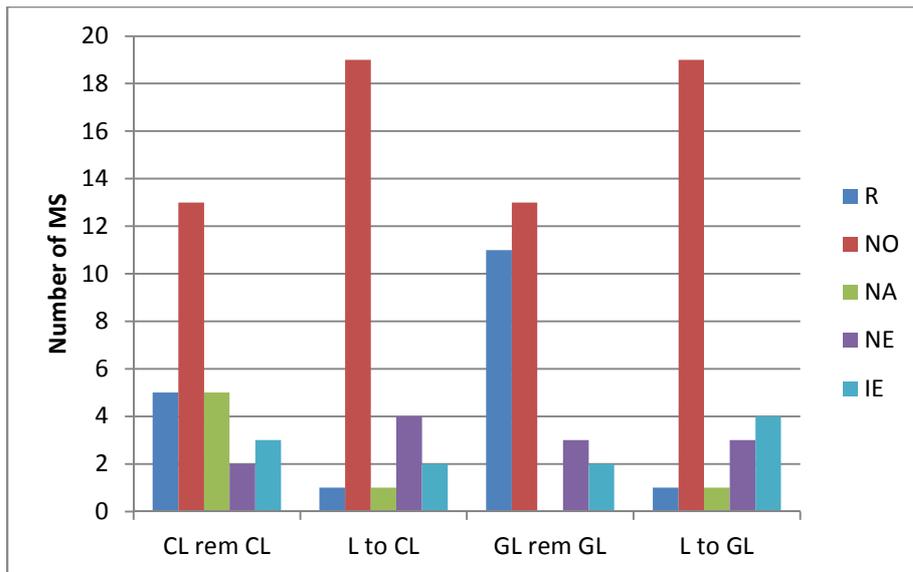


**Figure 12: Number of MS reporting controlled biomass burning (R) or notation keys for the sub-categories of Cropland and Grassland\*<sup>47</sup>**

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

\*Note: This figure considers all reported sub-categories. A MS can additionally report several notation keys for one sub-category

\*Note: This figure considers all reported sub-categories. A MS can additionally report several notation keys for one sub-category.



**Figure 13: Number of MS reporting wildfires (R) or notation keys for the sub-categories of Cropland and Grassland\***

Key: R=Reported; NO=not occurring; NA=not applicable; NE=not estimated; IE=included elsewhere

### 10.3 Reporting of sub-categories

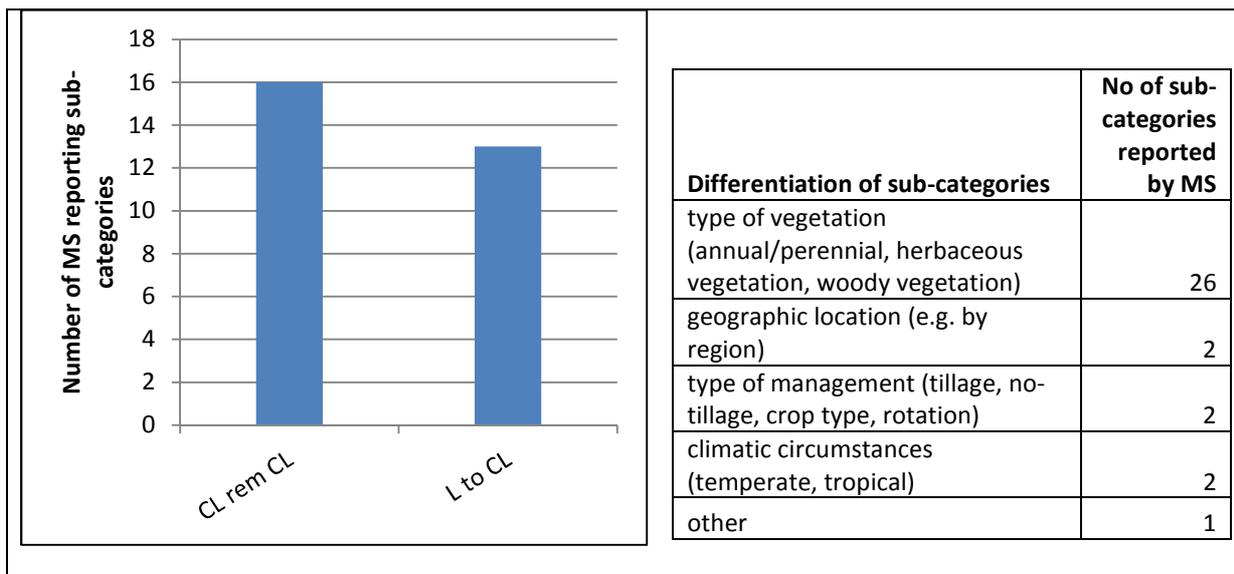
This section contains tables and figures compiling the information we have collected from Member States in relation to the types of sub-categories reported.

#### ***Cropland***

There are 16 MS reporting one or more sub-categories under Cropland remaining Cropland, and 13 MS reporting one or more sub-category under Land converted to Cropland.

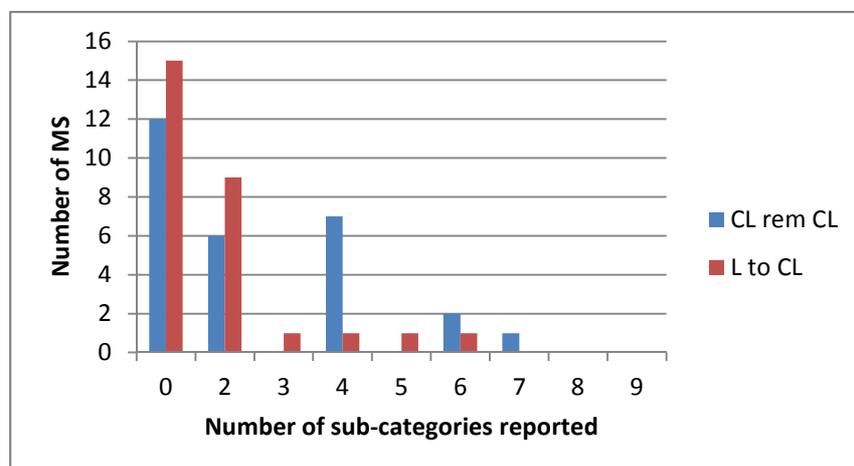
This land use category is very often divided into Annual cropland and Perennial (woody) cropland. Some MS use the geographic location, type of management or climatic circumstances to determine the sub-categories.

Within this land use category, there are MS which report land use changes between sub-categories as well (e.g. annual cropland to perennial cropland).



**Figure 14: Number of MS reporting sub-categories under Cropland remaining Cropland and Land converted to Cropland,**

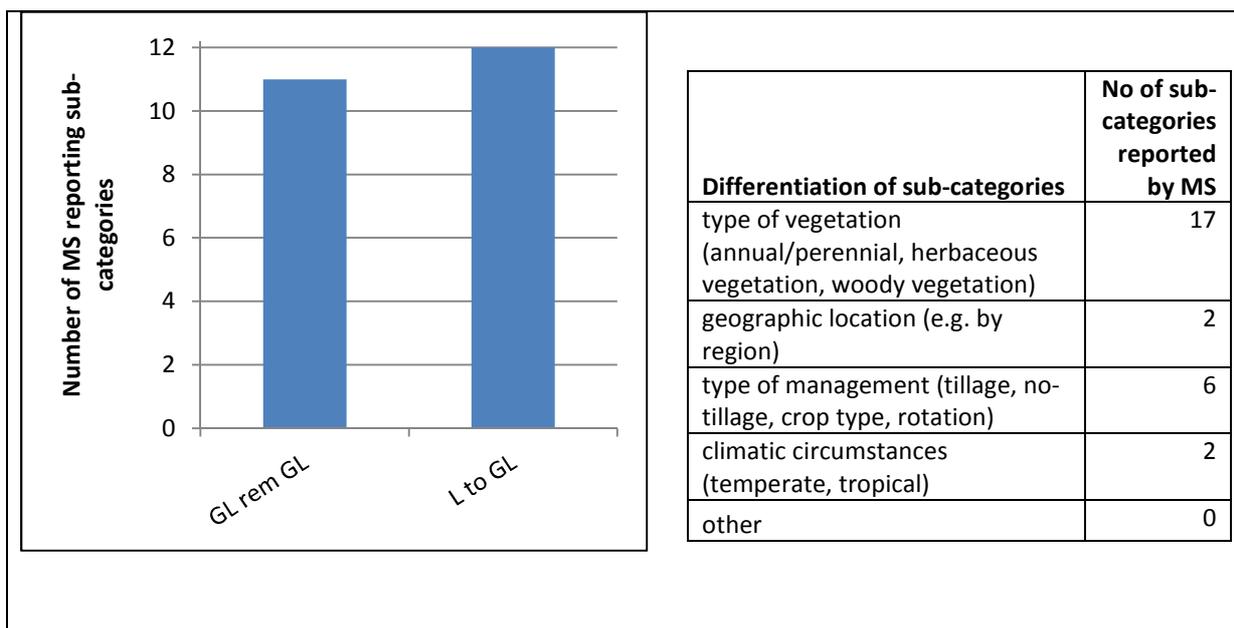
Under Cropland remaining cropland MS report in total 59 sub-categories, for Land converted to cropland 36 sub-categories. Figure 15 illustrates this figure split to Member State level. It can be seen that still a lot of Member States do not report sub-categories at all (12 countries for CL remaining CL and 15 countries for L to CL). About a quarter of countries report 2 categories for CL remaining CL and a third for L to CL. There is a clear trend for more sub-categories in the CL remaining CL category.



**Figure 15: Number of sub-categories reported by MS**

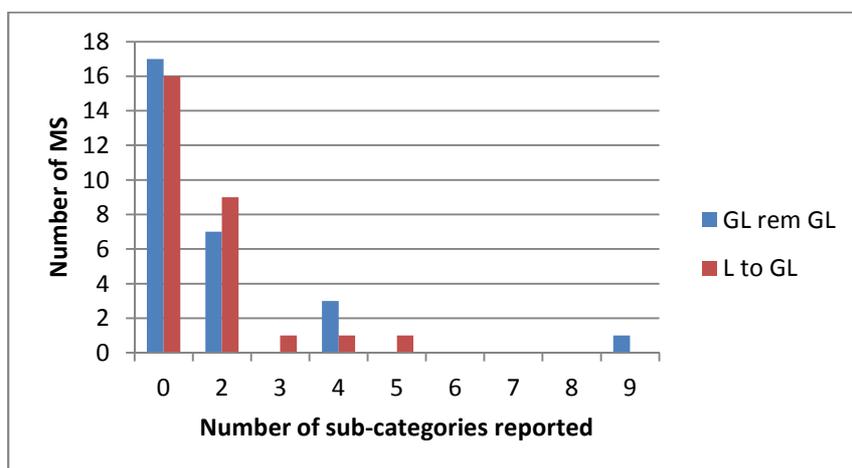
### **Grassland**

Under the Grassland category 11 MS report sub-categories for Grassland remaining Grassland and 12 MS report sub-categories for Land converted to Grassland. Most of the sub-categories are differentiated by type of vegetation, for instance woody vegetation and herbaceous vegetation. Some MS divide sub-categories by type of management such as pastures or hay fields.



**Figure 16: Number of MS reporting sub-categories under Cropland remaining Cropland and Land converted to Cropland,**

Under Grassland remaining grassland the MS report in total 35 sub-categories, for Land converted to Grassland MS report 30 sub-categories. As Figure 17 illustrates, 17 MS do not report sub-categories under GL remaining GL, and 16 MS do not have sub-categories for Land to GL. Many MS report 2 sub-categories for GL remaining GL and Land to GL, and some countries apply even more splits.

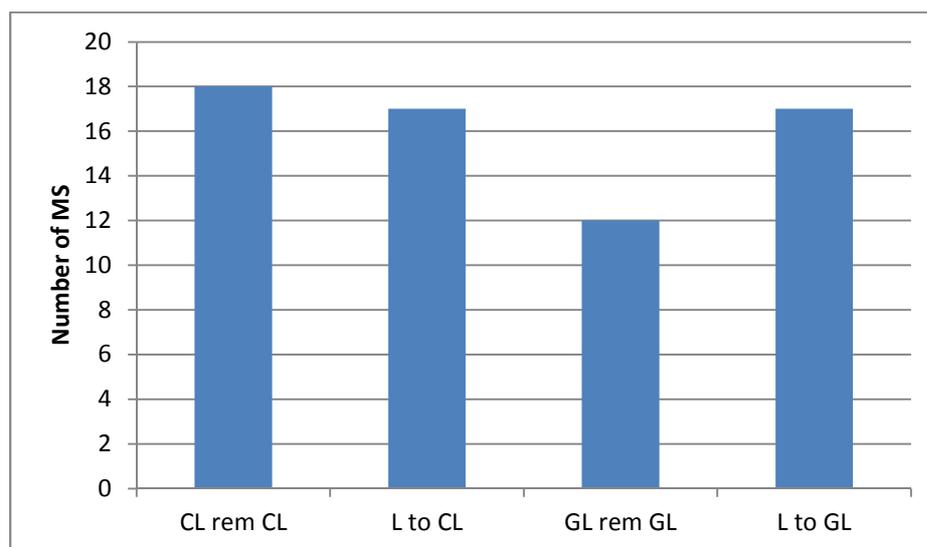


**Figure 17: Number of sub-categories reported by MS**

## 10.4 Key categories and related significant pools

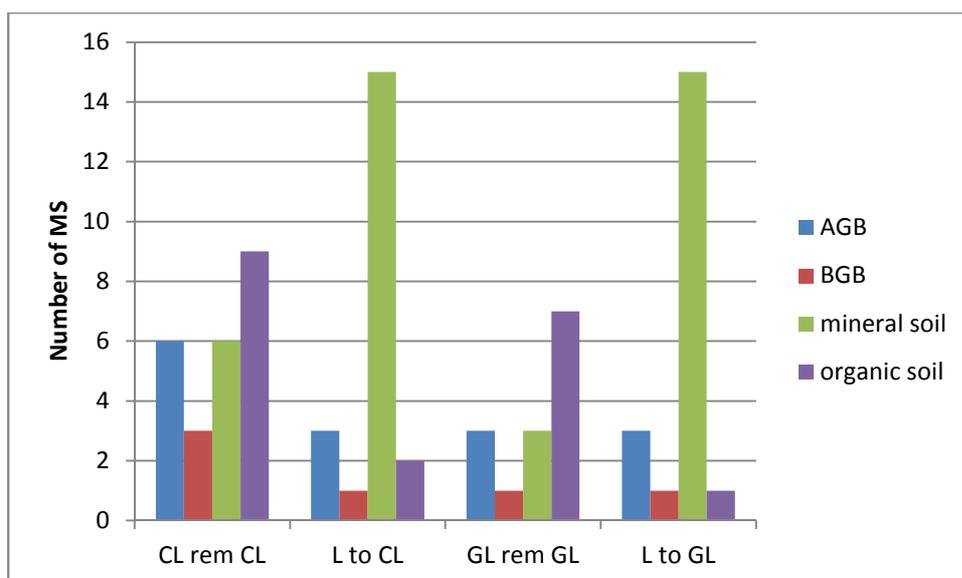
This section contains information on the key categories of emissions and significant pools identified by Member States.

Figure 18 shows the land use categories in which MS report key categories. 18 MS report CL remaining CL as a key category, followed by Land to CL and Land to GL (17 MS). And GL remaining GL (12 MS).



**Figure 18: Allocation of key categories for Cropland and Grassland**

When the significant pools of the key categories were analysed (those contributing to > 25 to 30 % to the totals of the key categories), it is clear that above ground biomass (AGB) represents a significant pool for CL remaining CL in six MS. In contrast, AGB is only significant for 3 MS in the other categories. Organic soil is a significant pool in both 'remaining' categories. 15 MS report mineral soil as a significant pool of a key category in the Land conversion categories.



**Figure 19: Significant pools of the key categories**

Generally, MS should report higher tiers for significant pools (tier 2 and 3). If a lower tier or the NO or NE notation keys are reported against significant pools, this may indicate a lack of data availability or that methodologies have not been developed to a sufficient level of detail. It is likely that the results of Figure 15 would look different if full reporting for all categories were available in all countries (e.g. estimates for emissions relating to mineral soils in the ‘remaining’ categories as well as the land use change categories).

Table 17 provides an overview of the number of MS that report the notation key NE (not estimated) in any sub-categories of a significant pool. It shows that 4 MS report NE in above ground biomass in the land use change categories. For below ground biomass, 3 MS report a NE in CL remaining CL and Land to GL. Five MS report NE for the mineral soil pool across all categories are concerned. Only one MS reports NE for organic soil as a significant pool.

**Table 17: Number of MS reporting NE in a key category and in a significant pool**

NE in...	AGB	BGB	Mineral soil	Organic soil
CL rem CL	0	2	1	0
L to CL	1	0	2	0
GL rem GL	0	0	1	1
L to GL	3	1	1	0

## 10.5 Activity data reporting

This section provides a summary of the most up to date information available about the level of area related reporting in Member States regarding CL and GL.

Figure 20 illustrates the type of assessment systems that have been used by the MS to gather land area information. MS may use several methods, so the totals per subcategory are significantly above the number of EU MS. In all four Cropland and Grassland categories remote sensing/earth observation (EO) methods and ground based methods are the primary data sources. More than half the MS use these two sources in all categories, whereas some MS additionally use complementary sources, e.g. in combination with statistical methods and expert judgement.

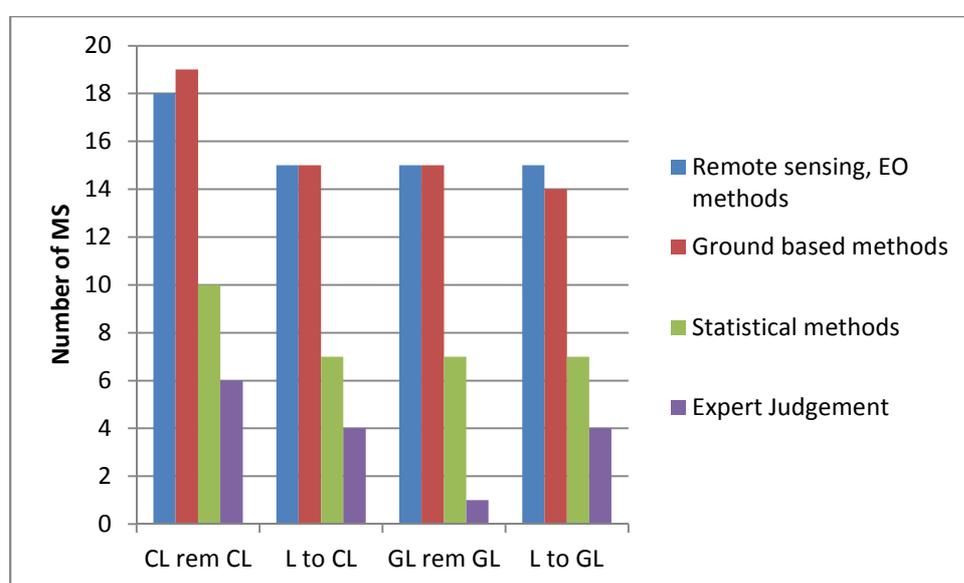
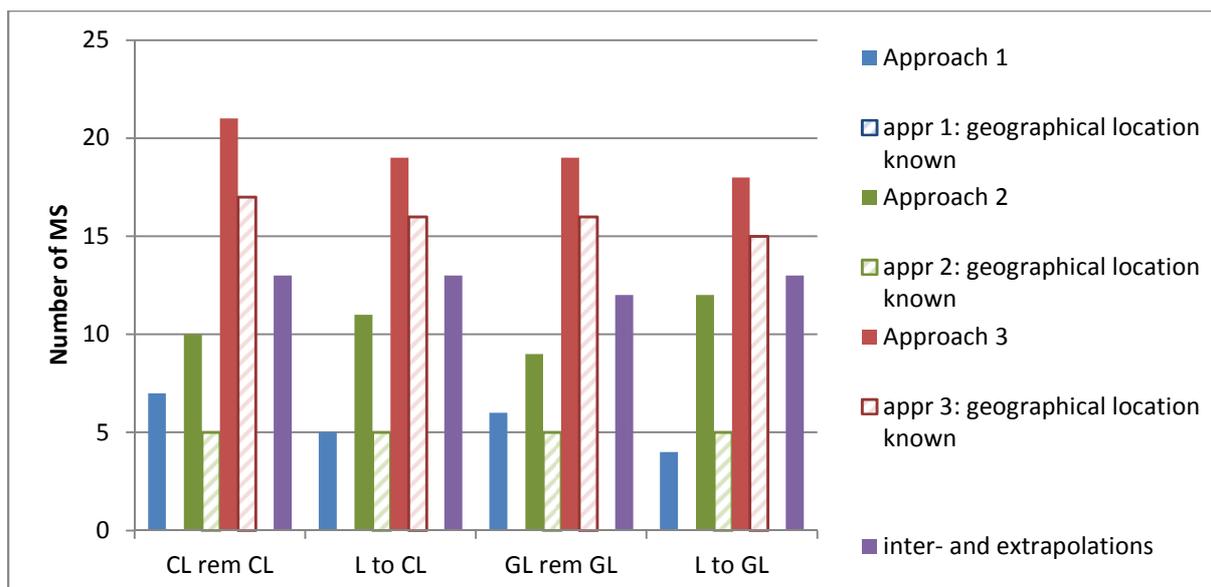


Figure 20: Type of activity data used to gather land area information<sup>48</sup>

The IPCC 2006 Guidelines<sup>49</sup> distinguish three approaches for reporting land area information, depending on the availability of spatially explicit data. Figure 21 illustrates the approaches used by MS for each Cropland and Grassland category. The most prevalent approach used for all categories is Approach 3. This implies that most MS already use spatially explicit land-use (conversion) data. Despite this, however, the precise geographical location of the activity is not always known. The reason for this in most cases is due to the coarse resolution of the spatially explicit assessment systems, which means that only the aggregated results out of the survey are used. In a few cases, the reason is that the information is simply not provided by the MS. At least 12 MS apply inter- and extrapolations to their data in all categories, however there is no clear picture as to whether or not the remaining MSs do so as this is not reported transparently by all MS.

<sup>48</sup> This figure considers sub-categories as well.

<sup>49</sup> 2006 IPCC Guidelines, Volume 4, Ch. 3.3.1



**Figure 21: Use of approach and availability of information on the geographical location**

## 10.6 Reporting of management types within CL and GL

This section provides a summary of information collated from Member States on the current state of reporting on specific management types related to cropland and grassland. Currently 15 MS consider the impact of management activities for Cropland. In the Grassland category 12 out of 28 MS include the impact of management activities.

To provide management information, MS tend to use ground based methods and statistical methods for CL remaining cropland. For the other categories, in addition to ground based methods, expert judgement is an important source of information.

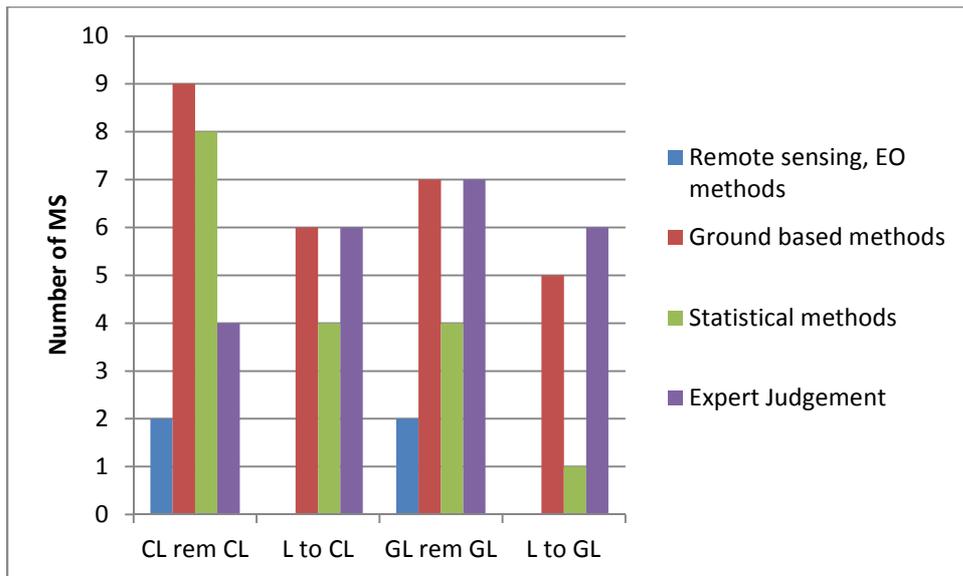


Figure 22: Type of activity data used to gather management information<sup>50</sup>

A more detailed breakdown of the methods used, is provided in Figure 23 and Figure 24 for Cropland remaining Cropland and Grassland remaining Grassland. The most common data sources used for reporting both the cropland and grassland categories in most MS are national statistics, expert judgement as well as IACS/LPIS.

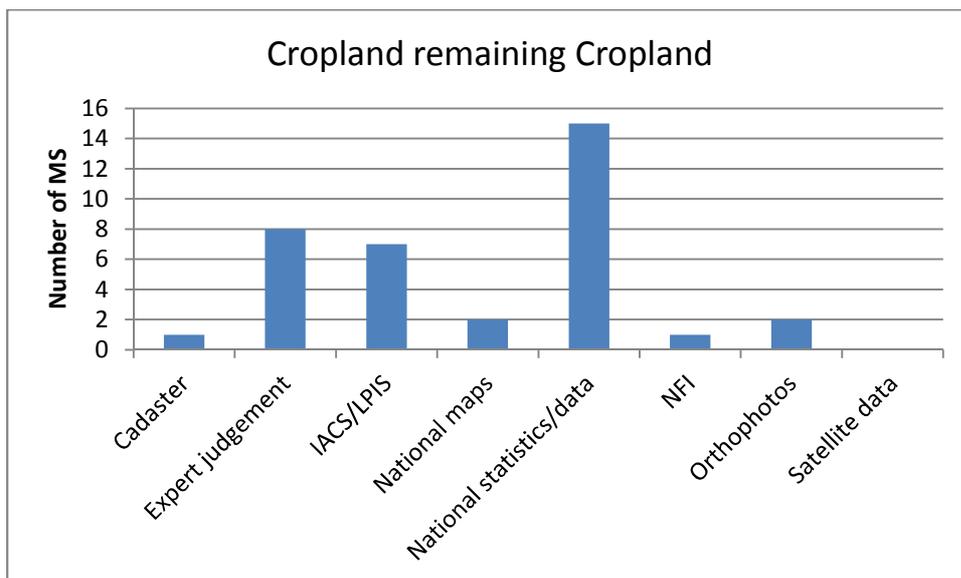
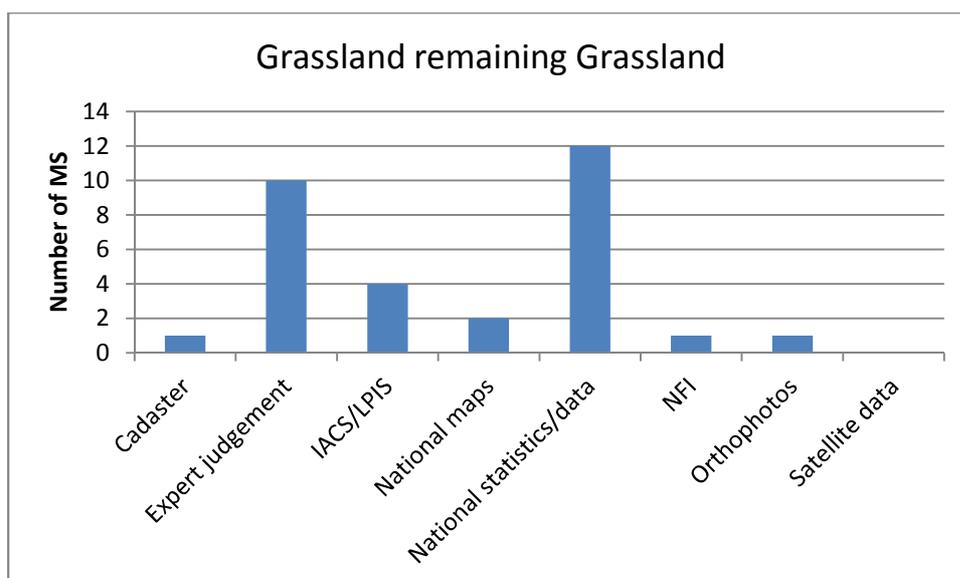


Figure 23: Methods applied by MS to report management information for Cropland remaining Cropland<sup>51</sup>

<sup>50</sup> A MS may select more than one method, therefore the numbers presented are not fully reflected in Figure 23.

<sup>51</sup> In some cases the methods could not be further specified.



**Figure 24: Methods applied by MS to report management information for Grassland remaining Grassland**

### 10.7 Consistency and completeness of activity data time series

Regarding time series consistency, most MS have a consistency issue in the reported time series which will require improvement when introducing CM and GM accounting against the base year. A change in methods for recording land use changes and the availability of new data sets are very common reasons.

There is a particular absence of data in many countries for reporting land use changes between 1970 and 1989. Many MS use extrapolations to fill data gaps for historic years to the reference year 1990.

**Table 18: Assessment of time series consistency and consideration of land use changes from 1970-1989**

	Is time series consistency provided?			Are LUCs from 1970-1989 considered?		
	yes	no	partly	yes	no	partly
Number of MS	7	19	2	10	17	1

## 10.8 Emission factor reporting

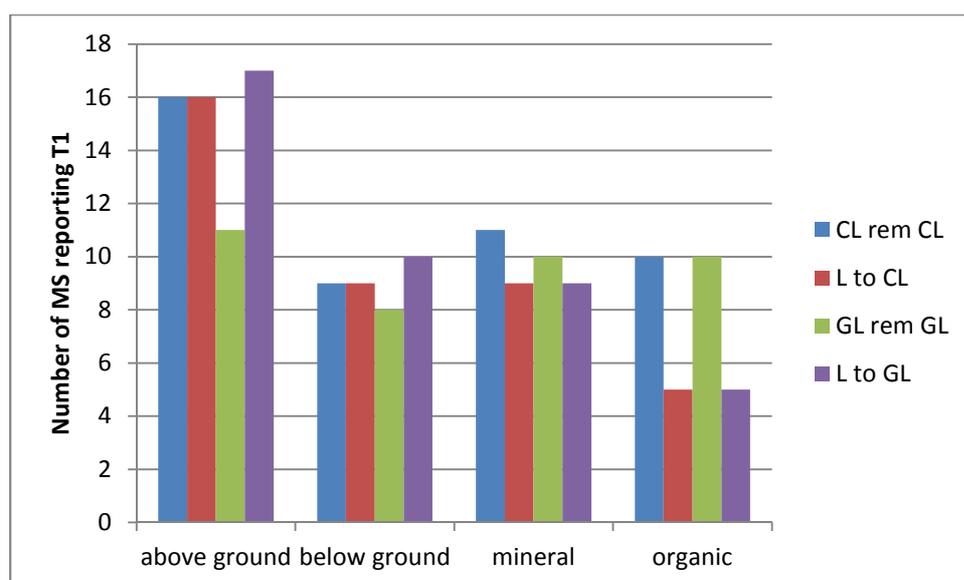
### 10.8.1 Overview

This section provides information on the emission factors used and any issues arising in relation to the accuracy of the emission factors and data sources available. It includes information for each of the main categories and also provides summary information, including:

- Tables and figures compiling the information available from the questionnaire review of all Member States carried out for this study;
- Tiers vs. key category/significant pool; and
- Data sources for CS EFs.

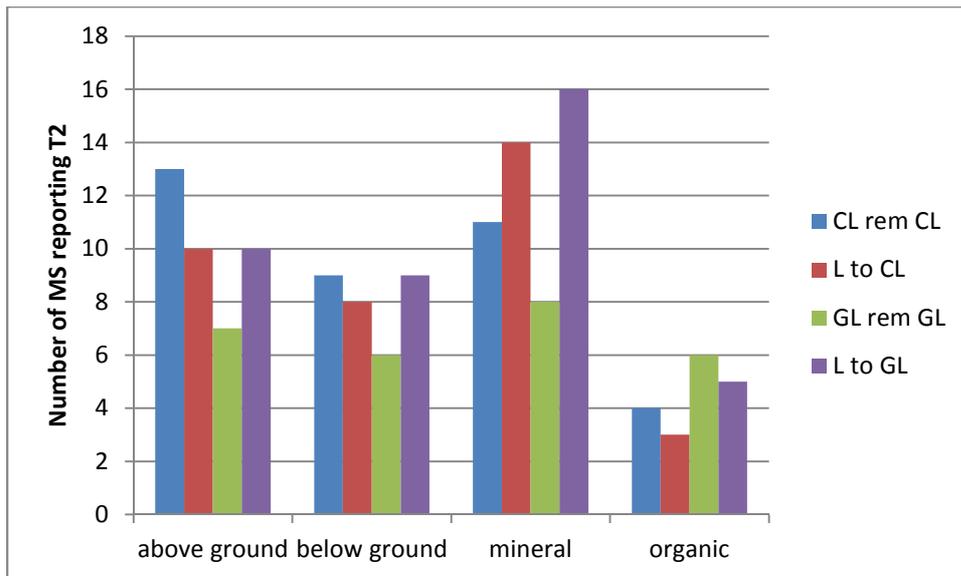
To provide an overview of the accuracy of the reported emissions, a summary of the Tier methods applied by carbon pool is set out below.

As shown in Figure 25, Tier 1 methods are applied mainly in the aboveground biomass pool, whereas in the other pools fewer MS apply T1. In the organic soil pool MS tend to use T1 for the 'remaining' categories than the LUC categories.



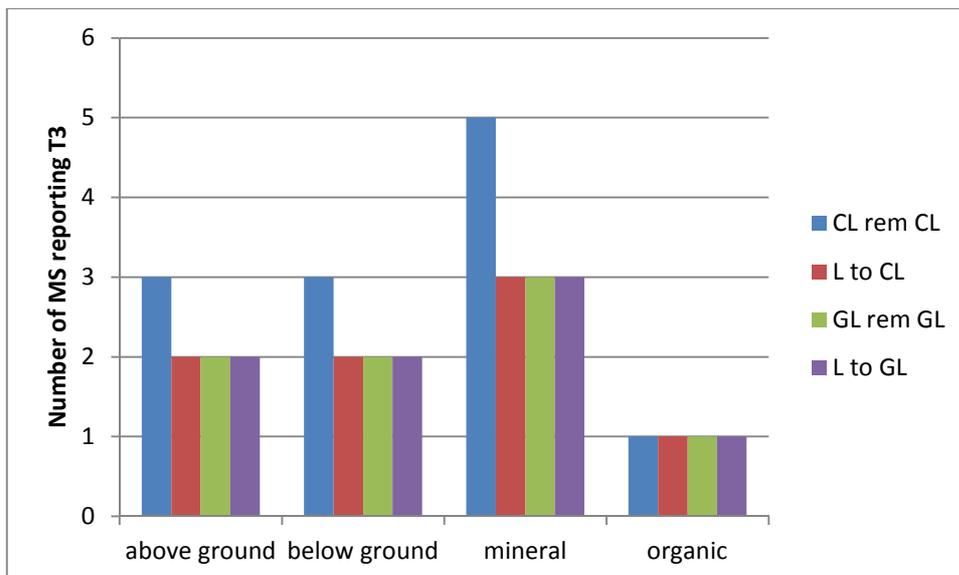
**Figure 25: Number of MS using Tier 1 methods for aboveground and belowground biomass, mineral and organic soil**

Tier 2 methods are used for reporting emissions in all pools, but more frequently in the mineral soil pool. In this pool, 16 MS apply a T2 method in the Land to GL category, and 14 MS use it in the Land to CL category.



**Figure 26: Number of MS using Tier 2 methods for aboveground and belowground biomass, mineral and organic soil**

As can be seen in Figure 27, Tier 3 methods are only applied by a few MS, compared to Tier 1 and 2. The mineral soil pool is more often reported at a Tier 3 level than the other pools, and also more frequently in the CL remaining CL category.

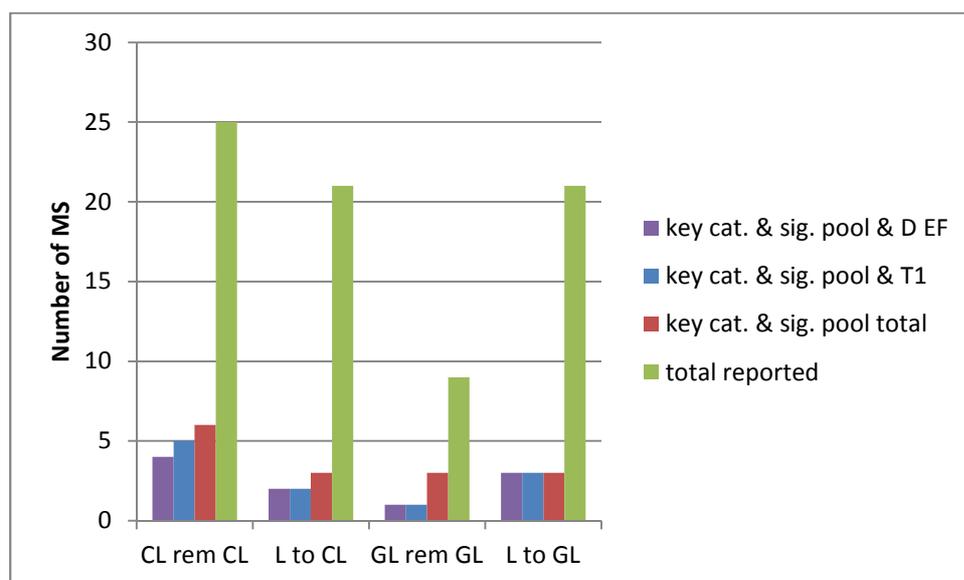


**Figure 27: Number of MS using Tier 3 methods for aboveground and belowground biomass, mineral and organic soil**

The following section shows the extent to which countries use Tier 1 methods for reporting emissions for key categories and significant pools. Significant pools of key categories have a significant influence on the country’s GHG emissions and therefore higher Tier methods should be applied (Tier 2 and 3). However, due to lack of data, methodologies and/or resources, this can be a challenge for some countries.

### 10.8.2 Aboveground biomass

Figure 28 illustrates how many MS report aboveground biomass with a Tier 1 method and a default emission factor when this is a key category and a significant pool. The category CL remaining CL is reported by 25 MS, whereas 6 MS report it as key category for which AGB represents a significant pool. Five out of these 6 MS use a T1 method for calculating the pool, and 4 MS use a default emission factor. It should be remembered that several methods can be used to estimate a pool. In the category Land converted to Grassland all three MS for which AGB is a significant pool report using a T1 method and default emission factor. Almost all MS that use a T1 method also apply a default emission factor.

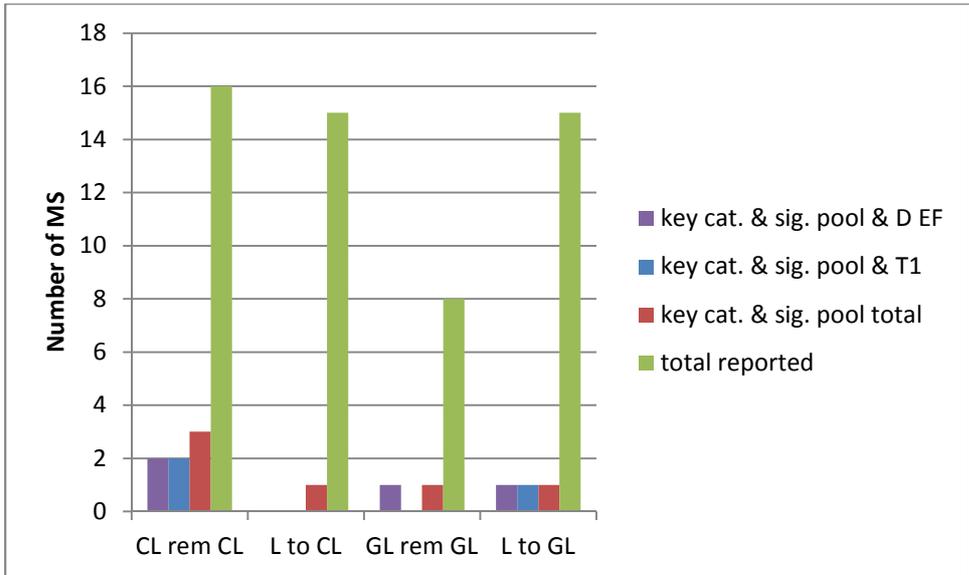


**Figure 28: Number of MS reporting a Tier 1 (T1) method or default emission factor (D EF) in case aboveground biomass is a significant pool compared to the total number of MS reporting the category.<sup>52</sup>**

### 10.8.3 Belowground biomass

Belowground biomass is reported as a significant pool by only few MS. According to Figure 29, two out of three MS apply a T1 method and use a default emission factor when BGB is a significant pool in the category CL remaining CL. The BGB pool is significant in Land converted to CL in one country, but in this case no T1 and default emission factor is applied. Likewise, in the GL remaining GL category BGB represents a significant pool only in one country. In this case a default emission factor is applied, but no T1 method has been used. For the Land to GL category, BGB is a significant pool only in one MS and in the case a T1 method and a default emission factor is applied.

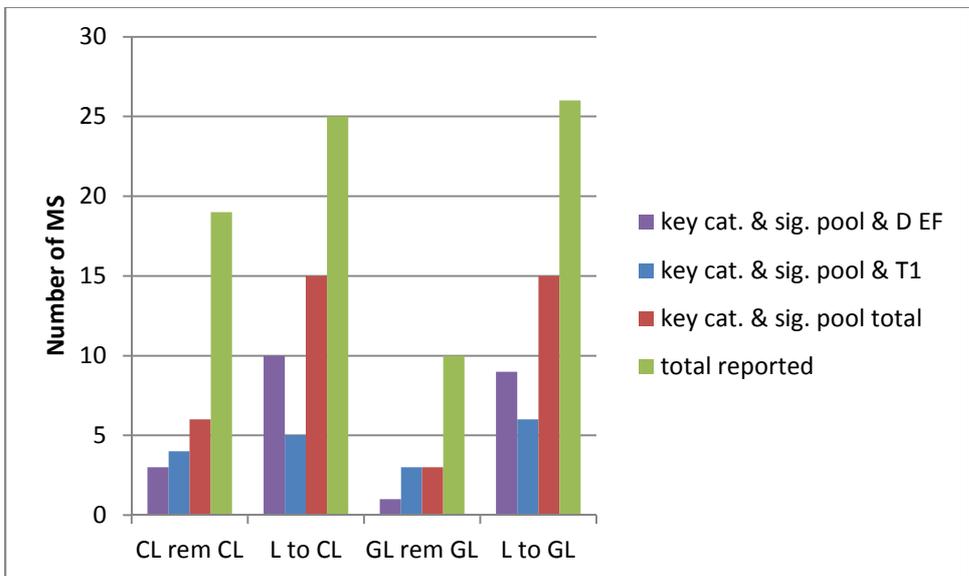
<sup>52</sup> MS may report several different Tiers for a category when there are sub-categories - for analytical reasons any T1 has been accounted even if other subcategories were reported with higher Tiers



**Figure 29: Number of MS reporting a Tier 1 (T1) method or default emission factor (D EF) in case belowground biomass is a significant pool compared to the total number of MS reporting the category.<sup>53</sup>**

#### 10.8.4 Mineral soil

The mineral soil pool is a significant pool in the LUC categories in 15 MS. However, fewer than half these MS apply a T1 method, but more than half use a default emission factor.



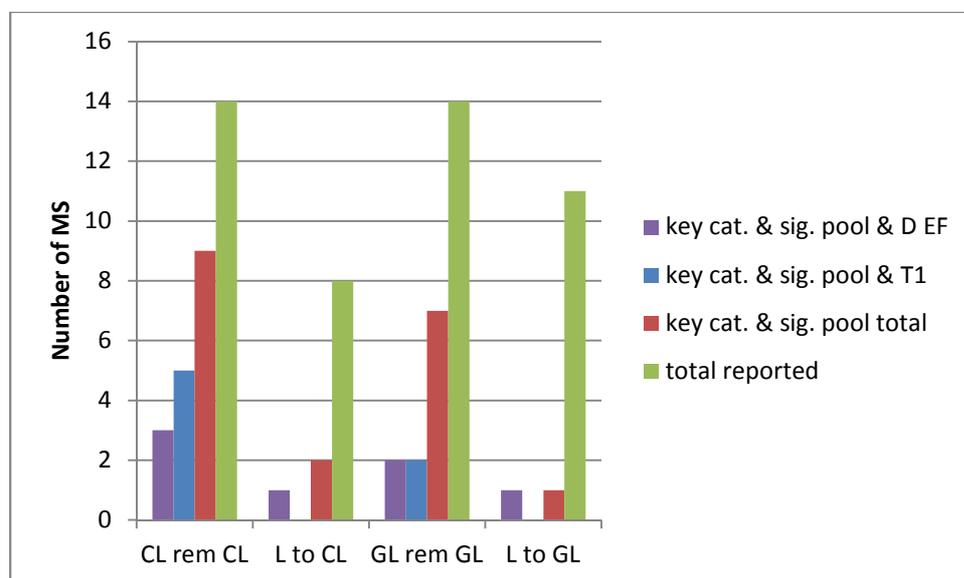
**Figure 30: Number of MS reporting a Tier 1 (T1) method or default emission factor (D EF) in case mineral soil is a significant pool compared to the total number of MS reporting the category.<sup>54</sup>**

<sup>53</sup> MS may report several Tiers for a category when there are sub-categories - for analytical reasons any T1 has been accounted even if other subcategories were reported with higher Tiers.

<sup>54</sup> MS may report several Tiers for a category when there are sub-categories - for analytical reasons any T1 has been accounted even if other subcategories were reported with higher Tiers.

### 10.8.5 Organic soil

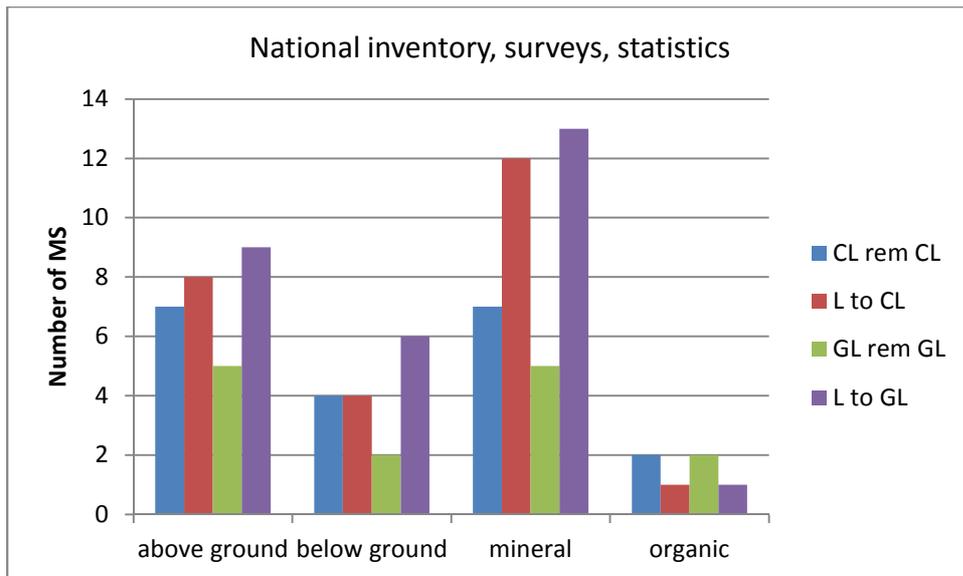
In contrast to mineral soils, the organic soil pool is reported as significant in the 'remaining' categories in 9 MS for cropland remaining cropland and 7 MS for grassland remaining grassland. Similar to mineral soil, some of these MS apply a T1 method, although the majority apply T2/T3 methods. Default emission factors are used, but in only 3 out of 9 MS in the CL remaining CL category, and 2 out of 7 MS in the GL remaining GL category.



**Figure 31: Number of MS reporting a Tier 1 (T1) method or default emission factor (D EF) in case mineral soil is a significant pool compared to the total number of MS reporting the category.<sup>55</sup>**

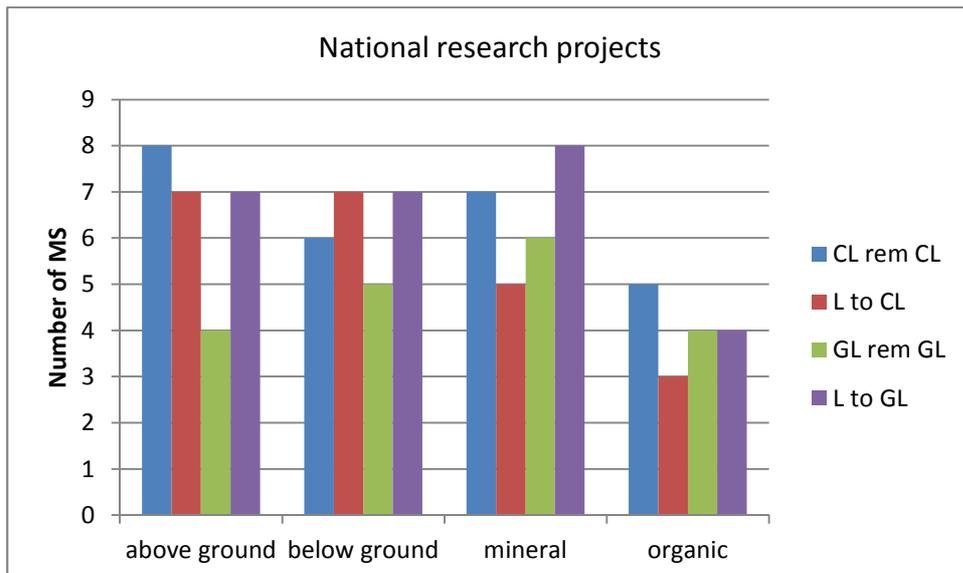
The following section sets out which data sources have been used to determine country specific emission factors. The first category analysed includes national inventories, surveys and statistics. Many MS use these data sources to estimate the above ground biomass and mineral soil pool.

<sup>55</sup> MS may report several Tiers for a category when there are sub-categories - for analytical reasons any T1 has been accounted even if other subcategories were reported with higher Tiers.



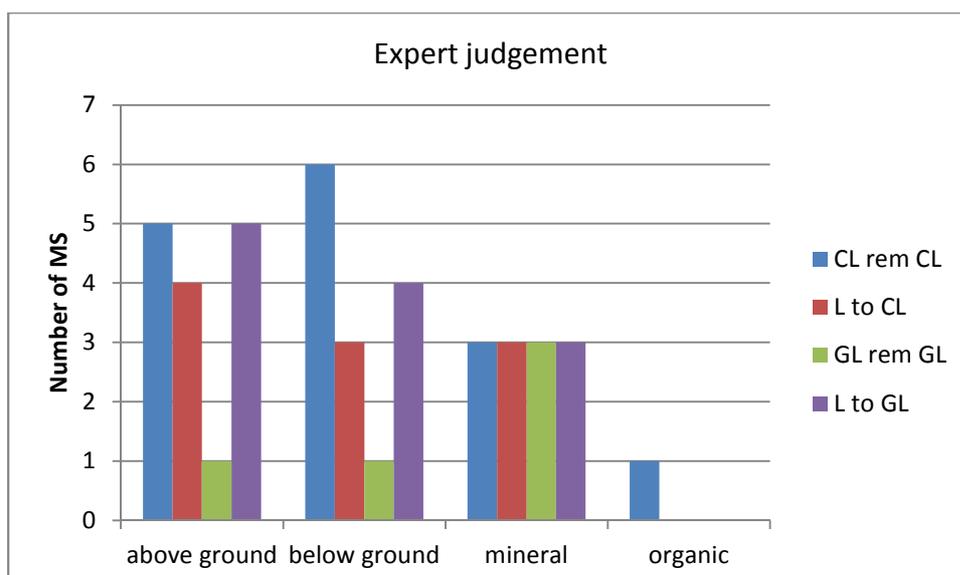
**Figure 32: Number of MS using national inventories, surveys and statistics to determine country specific emission factors.**

National research projects are quite common among MS to determine country specific emission factors. This applies to all categories and all pools.



**Figure 33: Number of MS using national research projects as a source to determine country specific emission factors**

Another source of information used to determine country specific emission factors is expert judgement. This informs the calculations particularly for the aboveground, belowground and mineral soil pool. Other sources of data used include international research projects and models, although the latter are used by very few MS.



**Figure 34: Number of MS using expert judgements as a source to determine country specific emission factors**

## 10.9 Consistency and completeness of emission factors

This section summarises the information available about the extent to which the emission factors currently used are consistent over time and whether or not further work is required to improve the completeness of the data. In fact, for 19 MS it appears that the time series of data for emission factors can be considered to be consistent. For four of the remaining MS at least issues of consistency and completeness remain.

**Table 19: Time series consistency of emission factors**

Can the data series be considered consistent?	yes	no	partly	not answered
Number of MS	19	4	1	3

These results might lead one to conclude that less effort is needed to improve emission factors. However, this would be a wrong interpretation of the results. Consistency and completeness of time series data on emission factors does not indicate whether or not the emission factors used are well suited, representative and accurate for the whole time series. For instance, the emission factor may be derived from a current study and used for the whole time series while for historic years a different emission factor may be more suitable. However, such an analysis (accuracy and fit of the emission factor per MS and pool for the whole time period) would be extremely demanding and was not possible within the framework of this project

## 10.10 Indicative timelines for the completion of Tier 2/3 accounting for Member States

A thorough analysis of the needed time for each MS to reach a Tier 2/3 accounting would be an extremely resource demanding undertaking. Therefore, a pragmatic approach based on the analyses of the current state of reporting was carried out. Given that not all the information is available with which to make such an assessment, a pragmatic approach was taken, basing the analysis on a number of basic assumptions (see below).

The analysis did not focus on a general shift towards Tier 2/3 reporting for CL and GL as a whole, rather it focussed on moving to Tier 2/3 reporting for the key categories and significant pools of key categories (pools which contribute to < 25 to 30 % to the totals of key categories). The key categories of CL remaining CL, LUC to CL, GL remaining GL, LUC to GL are already known from the analysis for UNFCCC reporting.

The results of this analysis indicate which of the CM and GM activities are likely to be key categories and which pools are significant. However, the further separation of pools into five categories that is needed for activity reporting may slightly change or further specify the significant pools. And of course, any further introduction of estimates for pools which are currently reported as NO in line with Tier 1 approaches or, for activity reporting purposes, are accompanied by insufficient argumentation, such as 'management did not change', may change the results of the key category analysis.

Only the most critical parameters and input data for the GHG estimates of CM and GM were assessed. Some pools were generally assumed to require higher Tier reporting and some pools were generally assumed to be insignificant (and therefore that Tier 1 reporting was possible).

In summary it was assumed that:

- changes in perennial biomass on cropland represent a significant pool of a key category;
- each soil C stock change (except for organic soils where changes are not significant) represent significant pools of key categories;
- litter and dead wood would not be significant pools of key categories and do not require a Tier 2/3 reporting;
- equal time periods would be needed for all MS to move towards higher Tier reporting, irrespective of the issue that needs to be addressed.

In addition to the need for Tier 2/3 emission factor reporting, an assessment of the time needed to achieve the activity data for CM and GM in line with the IPCC reporting requirements for these activities was carried out. Adequate activity data constitute the backbone for reporting under higher Tiers for CM and GM. This includes:

- consistent and complete land use and land-use change statistics;
- spatially explicit data for the activities; and
- the sub-division of the land into different management types and sub categories with different C dynamics in biomass and soil.

With this in mind, the following parameters from current reporting were assessed for each MS to identify the time required to make the improvements needed:

- Quality of the land use and land-use change assessment system regarding its spatial explicitness and resolution;
- Subcategories in terms of the management types assessed;
- The emission factors used for perennial biomass; and
- The input data and methods for the assessment of the soil C stock change in the 'remaining' CL and GL categories.

The time required for each MS to reach higher Tiers was assessed for each of the identified improvements needed to move towards the 'Tier 2/3 reporting' (as understood in the sense described above). This was judged on basis of the experiences of the project team and the MS responses to the study questionnaire. It is clear that the establishment of a spatially explicit assessment system for the management in CL and GL would require significantly longer (4 years was assumed in the analysis) than improvements in the consistency of relevant land management data (2 years was assumed in the analysis). Regarding emission factors, the derivation of a higher Tier emission factor for biomass (2 years was estimated) will need less time than one for soil C stock changes in the 'remaining' CL and GL categories (see next paragraph).

A short note on the Tiers to be achieved considered in the analysis: The time required to move to Tier 2 reporting was assessed, but not the time needed to achieve Tier 3 reporting. The reasons for this are as follows. A move to Tier 3 reporting for certain pools given the situation in relation to data availability and the way reporting is organised in the MS may need significantly more time than the period until January 2022. For instance, Tier 3 reporting for soil C stock changes would need the development and/or the use of soil models, because an assessment of short term C stock changes in soil with soil inventories is impossible due to the high variation of the soil C stocks per site and the impossibility to re-measure the identical soil samples over time. The development of a model requires several years. In addition, various input data from long time soil monitoring plots are a prerequisite, so several years of monitoring before model development are needed. If soil models developed for different environments are intended to be used, a validation and verification of the fit of the model for the different conditions is needed. This also requires input and test data from soil monitoring plots. So, it is very unlikely that the development of a Tier 3 assessment system for mineral soil can be completed in the reporting period for the 2<sup>nd</sup> commitment period if such input data from long time soil monitoring plots are missing and the available soil models were not validated and adjusted for the conditions they are to be used for.

The needed time for all improvements was assessed on basis of the improvement step which needs most time. For instance, if a MS needs three improvement steps taking 4 years, 2 years and 1 year, the total needed time for all three steps was assumed to be four years. So, the individual time values were not added, but the maximum value of the single periods was taken. This suggests that there are possibilities in each of the MS to solve the problems in parallel and/or related problems by the same approach or project. However, a further prolongation in needed time (2 additional years) was foreseen if the MS had a large number of needed improvements. This is because, in such a situation, it is unlikely that all

improvements could run in parallel (or only to a limited extent). Additional time to deliver the solutions needed was assumed also, in cases where the responses from the MS to the questionnaires did not list any (or sufficient) plans for making improvements to address the identified problems (within one year from problem identification to project start).

In a final step, the MS were grouped into MS that need up to two years, up to four years or until the beginning of 2022 (up to seven years) for carrying out the full suite of improvements needed. It should be noted that the completion of ‘higher Tier reporting’ depends on when it starts. So, a MS needing just two years may finalise the improvements only in January 2022 if it starts late. It is also clear that MS which are likely to need the whole reporting period to implement the improvements needed, have a significantly higher risk of failing to develop fully adequate reporting systems within the deadlines as defined by the EU LULUCF decision.

The results are presented in **Table 20** below. It can be seen that in our view, we anticipate that about half of MS will need between four and seven years to reach a ‘Tier 2/3 reporting’ on the basis of adequate activity data in line with the reporting requirements.

**Table 20: Estimated timeline to reach Tier 2/3 emission estimates for CM and GM on basis of adequate activity data**

	Up to 2 years	Up to 4 years	Until January 2022
number of MS	6	7	15

The results of this analysis suggest that the lack of assessment systems for the different types of management on CL and GL (needed for the estimates of the soil C stock changes in the CL and GL without land-use change) is the most frequent reason for longer time periods needed to improve reporting. Issues with consistency and assessments of pre 1990 land-use change are also frequent (in more than 2/3 of the MS) but require significantly less time to resolve (2 years assumed here).

About half of MS would need to improve the accuracy of their emission factors to achieve higher Tier reporting. The development of higher Tier emission factors for relevant pools should not be too time consuming, provided that the lowest Tier 2 standard is used for the C stock changes in the soil of the ‘remaining’ CL and GL categories. As indicated above, a higher level of the Tier 2 standard using country specific soil C stock change rates for different types of CL and GL management or the use of models (Tier 3) would not be likely to be ready before 2022, except in countries where such data are already available but have not yet been explored.