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# COMMISSION STAFF WORKING DOCUMENT

## Impact Assessment on the role of land use, land use change and forestry (LULUCF) in the EU's climate change commitments

*Accompanying the document*

**Proposal for a DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL**

**on accounting rules and action plans on greenhouse gas emissions and removals resulting from activities related to land use, land use change and forestry**

{COM(2012) 93 final}
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## List of acronyms

| | |
|---|---|
| AD | Activity Data |
| A | Afforestation |
| AR | Afforestation / Reforestation |
| ARD | Afforestation, Reforestation and Deforestation |
| BAU | Business as Usual |
| CAP | Common Agricultural Policy |
| CL | Cropland |
| CM | Cropland management |
| COP | Conference of the Parties |
| COST | European Cooperation in Science and Technology |
| D | Deforestation |
| E | Emissions |
| EF | Emission Factor |
| EFISCEN | European Forest Information Scenario |
| ESD | Effort Sharing Decision |
| EU ETS | EU Emissions Trading System |
| FAO | Food and Agriculture Organization of the United Nations. |
| FL | Forest land |
| FM | Forest Management |
| G4M | Global Forest Model |
| GDP | Gross Domestic Product |
| GHG | Greenhouse gas |

| | |
|---|---|
| GL | Grassland |
| GM | Grazing land management |
| GPG | Good Practice Guidance |
| HWP | Harvested Wood Products |
| IPCC | Inter-governmental Panel on Climate Change |
| JRC | Joint Research Centre of the European Commission |
| KP | Kyoto Protocol |
| LULUCF | Land Use, Land Use Change and Forestry |
| MRV | Monitoring, Reporting and Verification |
| MS(s) | Member State(s) |
| NFI | National Forest Inventories |
| NGOs | Non-Governmental Organizations |
| NIRs | National Inventory Reports |
| R | Removals |
| REDD | Reducing Emissions from Deforestation and forest Degradation |
| RES-D | Directive on the promotion of the use of energy from renewable sources |
| SMEs | Small- and Medium sized Enterprises |
| RV | Revegetation |
| TFEU | Treaty on the Functioning of the European Union |
| UNFCCC | United Nations Framework Convention on Climate Change |

## List of definitions[1]

| | |
|---|---|
| Accuracy | Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, so far as can be judged, and that uncertainties are reduced so far as is practicable. Appropriate methodologies conforming to guidance on *good practices* should be used to promote accuracy in inventories. |
| Activity data | Data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time. In the LULUCF sector, data on land areas, management systems, lime and fertilizer use are examples of activity data. |
| Afforestation | The direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources. |
| Biomass | Organic material both above ground and below ground, and both living and dead, e.g., trees, crops, grasses, tree litter, roots etc. Biomass includes the pool definition for above - and below - ground biomass. |
| Carbon pool* | The whole or part of a geochemical feature or system within the territory of a Member State within which carbon, any precursor to a greenhouse gas containing carbon or any greenhouse gas containing carbon is stored. |
| Carbon stock* | The quantity of the element carbon stored in a carbon pool. |
| Comparability | Comparability means that estimates of emissions and removals reported by Parties in inventories should be comparable among Parties. For this purpose, Parties should use the methodologies and formats agreed by the Conference of the Parties (COP) for estimating and reporting inventories. |
| Completeness | Completeness means that an inventory covers all sources and sinks for the full geographic coverage, as well as all gases included in *the IPCC Guidelines* in addition to other existing relevant source/sink categories which are specific to individual Parties (and therefore may not be included in the *IPCC Guidelines*). |
| Consistency | Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base year and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. Under certain circumstances referred to in paragraphs 10 and 11 of FCCC/SBSTA/1999/6/Add.1, an inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner taking into account any *good practices*. |
| Cropland | This category includes arable and tillage land, and agro-forestry systems where vegetation falls below the threshold used for the forest land category, consistent with the selection of national definitions. |
| Cropland management* | Any activity resulting from a system of practices applicable to land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production |
| Deforestation | The direct human-induced conversion of forested land to non-forested land. |
| Disturbances* | Events including wildfires, insect and disease infestations, extreme weather events and geological disturbances, but not harvesting. |
| Emission factor | A coefficient that relates the activity data to the amount of chemical compound which is the source of later emissions. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions. |
| Forest | An area of land of at least 0.05 hectare with tree crown cover or equivalent stocking level of at least 10 per cent, covered with trees with the potential to reach a minimum height of at least 2 metres at maturity at their place of growth, including groups of growing young natural trees and all plantations which have yet to reach a tree crown cover or equivalent stocking of at least 10 per cent or tree height of at least 2 metres, and areas normally forming part of the forest area on which there are temporarily no trees as a result of human intervention, such as harvesting, or of natural |

[1] Source: IPCC (2003; 2006), with the exception definitions marked with a star (*).

| | |
|---|---|
| | causes, but which are expected to revert to forest |
| Forest land | The land that meets the definition of forest. This category includes all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided at the national level into managed and unmanaged and also by ecosystem type as specified in the *IPCC Guidelines*.6 It also includes systems with vegetation that currently falls below, but is expected to exceed, the threshold of the forest land category. |
| Forest management* | Any activity resulting from a system applicable to a forest and aimed at improving any ecological, economic or social function of the forest |
| Grassland | This category includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and is not expected to exceed, without human intervention, the thresholds used in the forest land category. This category also includes all grassland from wild lands to recreational areas as well as agricultural and silvo-pastural systems, subdivided into managed and unmanaged, consistent with national definitions. |
| Grazing land management* | Any activity resulting from a system applicable to land used for livestock production and aimed at controlling or influencing the quantity and type of vegetation and livestock produced. |
| Key category | A category that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both. |
| Reforestation | The direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989. |
| Removals* | Used, for the purposes of this report, synonymously with "sink". |
| Revegetation* | The direct, human-induced activity intended to increase the carbon stock of any site that covers a minimum area of 0.05 hectares, through the establishment of vegetation, where that activity does not constitute afforestation or reforestation |
| Sequestration | The process of increasing the carbon content of a carbon pool other than the atmosphere. It is preferred to use the term "sink". |
| Sink* | The rate of build-up of $CO_2$ in the atmosphere can be reduced by taking advantage of the fact that carbon can accumulate in vegetation and soils in terrestrial ecosystems. Any process, activity or mechanism which removes a greenhouse gas from the atmosphere is referred to as a "sink." Denoted in accounting and reporting with the negative (-) sign. |
| Transparency | Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information. |
| Wetland* | Any activity resulting from a system for draining and rewetting land that covers a minimum area of 1 hectare and on which organic soil is present, provided the activity does not constitute any other activity referred to in Article 3(1), and where draining is the direct human-induced lowering of the soil water table, and rewetting is the direct human-induced partial or total reversal of drainage.This category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions. |

# 1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

## 1.1. Introduction

In order to avoid dangerous anthropogenic interference with the climate system, the overall global annual mean surface temperature increase should not exceed two degrees Celsius above pre-industrial levels. This ambition was recognised in the Cancún Agreements[2] and requires global greenhouse gas (GHG) emissions to be cut by at least 50% below 1990 levels by 2050, or by 80-95% in developed countries (IPCC, 2007), and has been embraced by the European Council as a long-term goal.[3] The European Parliament similarly endorsed the a long-term reduction target of at least 80% by 2050 for the EU and other developed countries.[4] As a step towards the necessary long-term efforts, the Union has committed to reduce its GHG emissions to 20% below 1990 levels by 2020, or to 30% if conditions are right. The commitment forms part of one of the European Union's five headline targets in the Europe 2020 Strategy for smart, sustainable and inclusive growth.[5]

Land use, land use change and forestry (LULUCF) is not yet part of the EU's GHG emission reduction target for 2020. However, the European Council and Parliament requested the Commission to assess the possibility to include LULUCF in the 2020 target and make a legislative proposal, as appropriate. The timing of this work was made conditional on the outcome of the negotiations of an international agreement on climate change. In the absence of such an agreement at the end of 2010, the Commission is required to report on the results of its assessment in 2011 with the aim of the proposed act entering into force from 2013 onwards.[6] Whilst substantial progress was made at the Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in Cancún in December last year, no comprehensive agreement was reached. In fulfilment with the requirements and for the reasons provided in Section 2.1, this impact assessment accompanies a Communication and legislative proposal on accounting for LULUCF (agenda planning number 2011/CLIMA/008).

Emissions of greenhouse gases in the EU mainly come from energy production and other man-made sources, see Figure 1. But, countering some of the emissions, carbon is absorbed (removed) from the atmosphere through photosynthesis and stored in vegetation and soils. Different land uses and management practices in forestry and agriculture can limit emissions of carbon and enhance removals from the atmosphere, see Box 1. Carbon removed from land

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2 Decision 1/CP.16

3 European Council, Brussels, 29-30 October 2009, Presidency conclusions 15265/1/09, as reaffirmed by the Environment Council, Brussels, 14 March 2011.

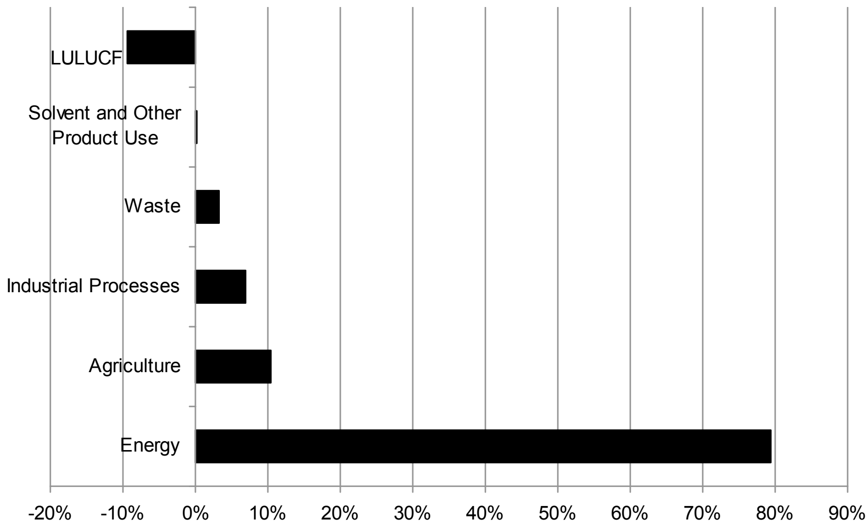
4 European Parliament resolution of 4 February 2009 on "2050: The future begins today – Recommendations for the EU's future integrated policy on climate change; resolution of 11 March 2009 on an EU strategy for a comprehensive climate change agreement in Copenhagen and the adequate provision of financing for climate change policy; resolution of 25 November 2009 on the EU strategy for the Copenhagen Conference on Climate Change (COP 15)

5 Europe 2020: A strategy for smart, sustainable and inclusive growth COM(2010) 2020 final, Brussels, 3.3.2010, adopted by the European Council on 17 June 2010

6 Article 9 of Decision 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020

can also stay bound in harvested wood products for a long period of time without being re-emitted to the atmosphere and the recycling of wood and production of long-lived products can therefore contribute to mitigation efforts. These practices and uses are covered by the land use, land use change and forestry (LULUCF) sector.[7] In 2009, LULUCF removed an amount of carbon from the atmosphere equal to about 9% of the EU's total greenhouse gas emissions in other sectors.

**Figure 1. Emissions and removals per sector in the EU-27 (2009)**




Note: Negative numbers denote net removals and positive numbers net emissions.

Source: EEA (2011)

In addition, land resources can contribute to mitigation efforts in other sectors through the substitution of fossil fuels in energy production and greenhouse gas intensive materials such as steel and cement with biomass (see e.g. Sathre and O'Connor, 2010), see Box 1.

**Box 1. Possible contribution of land use, land use change and forestry to climate change mitigation**

**Agriculture** contributes in a number of ways. Measures include agronomic practices such as using improved crop varieties, extending crop rotations (a shift to perennial crops) and avoiding or reducing the use of unplanted fallow through green cover; agro-forestry practices which provide higher carbon stocks through the tending of livestock or growing of food crops on land that also grows trees for timber, energy or other wood products; adjustments of the intensity and timing of grazing on lands can influence the growth, carbon allocation and flora of grasslands and thereby the removals and storage of carbon in soils; enhanced productivity of croplands and grasslands through returning or leaving organic materials (farmyard manure, straw, crop residues) on the land; improved management of organic soils through avoiding the drainage of these soils or re-establishing a high water table on peat lands; and restoration of degraded lands.

Similarly, there are many mitigation opportunities in **forestry**. They include the conversion of non-forest land to forest (afforestation); avoiding conversion of forest land to other types of land (deforestation); productiivity increases, conservation of carbon in existing forests e.g.through optimized tending and thinning, continuous crown harvesting (selective logging), longer rotation periods of trees, avoidance of clearfelling; conversion to wilderness forests and more widespread use of prevention measures to limit the impacts of disturbances such as fires, pests and storms.

In addition to the opportunities directly linked to forestry and agriculture, there are potential mitigation benefits in the **industry and energy sectors** if agricultural land and forests are managed for production of timber and energy. In this respect enhanced production in existing forests through adjusting rotations closer to the productive maximum, more production from low-production forests, increasing the harvest of timber offcuts and branchwood and changing species composition and growth rate

[7] Other greenhouse gases from agricultural activities, e.g. methane and nitrous oxide from ruminants and fertilisers, do not count under LULUCF, which deals primarily with carbon emissions and removals in vegetation and soils.

are equally important. While carbon is stored in vegetation and soils, it can also be stored for several decades in products, and industry can make an important contribution to mitigation through increasing the recycling of wood and / or production of pulp, paper and wood products. The bio-based industry can make use of crops grown for material substitution (e.g. hemp and grass for insulation instead of glass fibre, straw used for furniture production, biodegradable cutlery made from maize starch, car door panels made from flax or sisal plants, hemp plastic) or energy (e.g. biomass for energy instead of fossil fuels).

The measures in the different sectors have different advantages and limitations. An important consideration is that the positive impacts of measures that increase carbon stocks in vegetation and soils eventually saturate and are potentially impermanent. Equally, measures that avoid greenhouse gas emissions through the use of wood or other biomass instead of other materials may have negative impacts on carbon in vegetation in soil. It is therefore important to substitute materials and energy sources that have relatively high greenhouse gas emissions during their lifecycle. See Matthews et al. (2011) for more details on the different measures and their potentials.

## 1.2. Organisation and timing

For the preparation of this initiative, close inter-service consultation was ensured through the establishment of an inter-service group and impact assessment steering group which oversaw and followed the impact assessment work. DG Environment, DG Agriculture and Rural Development, the Joint Research Centre (JRC), DG Research and Innovation, DG Energy, DG Economic and Financial Affairs, DG Enterprise and Industry, DG Legal Services and the Secretariat General were directly involved.

The work draws on input from two contracts; one which involved investigating different options for the inclusion of the sector in the EU's reduction commitment (Matthews et al. 2011; Watterson et al. 2011) and one which involved modelling the projected emissions and removals from the sector as well as the impacts on the sector and Member States (MSs) of different options (Böttcher et al., 2011). The work also builds on input from the JRC on modelling and on monitoring and reporting (JRC 2011a and 2011b, see Annexes II and IV to this report).

## 1.3. Consultation and expertise

A number of consultative initiatives were undertaken in support of the work:

- An **expert group on climate policy for LULUCF** was established in 2010 under the European Climate Change Programme . The group involved a wide range of stakeholders: environmental NGOs, trade associations, experts from public administrations and researchers. The objective was to define and provide input on critical issues related to the inclusion of the LULUCF sector in the EU's climate change mitigation efforts, i.e. a scoping and steering exercise. The summary report is available on the Commission's website http://ec.europa.eu/clima/events/0029/index_en.htm

- In addition, an online **public consultation** was carried out in 2010 to collect views on the opportunities and challenges related to the inclusion of the sector in the EU's commitments. A total of 153 responses were received, representing the views of private companies, business and industry organisations, individuals and private land owners, NGOs, academia and research and public authorities. The same questions were subsequently used in a separate **consultation with MSs** and received 14 responses. The results of both consultations have been published in reports (Entec, 2011a and 2011b) http://ec.europa.eu/clima/events/0029/index_en.htm

- The Commission also held a **stakeholder meeting** on 28 January 2011 in Brussels. Around 75 participants representing MSs, trade associations, environmental NGOs and research institutes took part in the discussions. The proceedings are available on the Commission's website. http://ec.europa.eu/clima/events/0029/index_en.htm

The key findings of the consultation process are presented in boxes at the beginning of the relevant sections of this report.

### 1.4. Opinion of the Impact Assessment Board

The impact assessment (IA) was discussed at a meeting of the IA Board (IAB) on 4 May 2011. Following the IAB's recommendations, the report now clearly states that the option (2.II) which incorporates mitigation targets for LULUCF is included for illustrational purposes and to initiate further discussions. This impact assessment considers accounting for LULUCF in the context of the 20% GHG emission reduction commitment and not in the context of a step-up of the EU's overall efforts, as discussed in Sections 4 and 6, and there are uncertainties associated with the modelling and inventories which affect the potential to set targets at this stage, see Annex III. A commentary on the model-based predicted impacts and references to more information is provided in Annexes III and IV. The report also provides a description of the practical and political context in which the accounting for LULUCF is assessed throughout the report, in particular in Sections 2.1 and 6. Finally, references to the results of the various stakeholder consultations have been integrated in Sections 1 and 4.

## 2. PROBLEM DEFINITION

### 2.1. What is the issue or problem that may require action?

The purpose of this report is to assess how LULUCF may be addressed in relation to the EU's GHG emission reduction commitments. Accounting for the sector would enhance the **environmental integrity** of the commitments, strengthen the overall **coherence of climate policy** and improving the **economic efficiency** when taking on more ambitious commitments.

#### *2.1.1. Enhancing the environmental integrity of the EU's climate change commitments*

The current partial accounting risks hiding real emissions and negative trends in emissions and removals. The IPCC Good Practice Guidance (GPG) for estimating GHG inventories (1996; 2003, see p. 3.261) says that emissions from biomass used for energy should be noted but not included in accounting for the Energy sector or other sectors that produce biomass energy. In other words, emissions from biomass based energy production are recorded as zero and it is instead assumed that these emissions are accounted for in the LULUCF sector. Furthermore, unless harvested biomass is used for energy or industrial purposes or remains in situ it will ultimately end up in solid waste disposal sites (SWDS) but the waste sector does not estimate changes in the carbon stock in SWDS.

In summary, this means that unless emissions due to utilisation of harvested biomass are accounted for in the LULUCF sector, they will not enter accounting at all. Important emissions will therefore be disregarded and apparent GHG savings in other sectors (stemming from the use of biomass for energy production instead of e.g. fossil fuels) may in fact not be real.

#### *2.1.2. Strengthening synergies with wider policy objectives*

Including the sector in accounting would also enhance the **coherence of the EU's overall climate policy** for several reasons:

- Combating climate change is one of the five headline targets of the "Europe 2020" strategy.[8, 9] By reducing GHG emissions by 20% compared to 1990 levels, increasing the share of renewables in final energy consumption to 20%, and moving towards a 20% increase in energy efficiency the EU will contribute to the overall objective of smart, sustainable and inclusive growth. The Council and Parliament have agreed that all sectors should contribute to reaching the targets. This is important also for the EU's role in promoting a level playing field for businesses and a fair distribution of effort.

- Climate change mitigation will continue to play an important role in the reformed Common Agricultural Policy (CAP). Agricultural emissions of $CH_4$ and $N_2O$ from fertilization, livestock and manure are already reflected in targets (because they are included in the reporting of the "Agriculture" sector) whereas $CO_2$ emissions and removals from soils and vegetation are not (since they are reported under LULUCF). Thus, closely correlated emissions, often occuring on the same land, and sometimes as a result of the same activities, are not reflected in their entirety in accounting. The 2010 Communication on the future CAP[10] outlines how the environmental performance of the CAP could be enhanced through a mandatory "greening" component of direct payments that supports environmental measures and give priority to actions addressing climate change and environmental goals. One benefit which these greening components hold in common is carbon sequestration, see Table 1. Accounting is necessary for the efforts invested by MSs, foresters and farmers to be reflected in the EU's efforts to reach more ambitious GHG reduction targets. Measures to enhance and protect carbon stocks also demonstrate co-benefits for adaptation, through e.g. increased water holding capacity and reduced erosion, and for biodiversity (Natura 2000).

- In addition, the provision of renewable energy is an integral part of the "Europe 2020" targets and the legitimacy of policies that directly or indirectly promote the use of biomass for energy production, such as the Renewable Energy Directive (RES-D)[11], hinges on the correct accounting of resulting emissions and removals. The accounting of LULUCF can ensure that emissions and removals are correctly reflected and will balance incentives between different uses of biomass.

- Finally, the LULUCF sector forms part of the EU's commitment under the Kyoto Protocol (KP) in 2008-12. Therefore, whatever reductions in emissions or increases in removals the EU and its MSs achieve and use for compliance with that commitment have to be maintained also in future commitment periods. Indeed, COP16[12] confirmed that LULUCF will continue to count towards Parties' efforts in future commitment periods and this would need to be mirrored by the EU in its domestic commitments.

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8 Council Conclusions 17 June 2010, http://ec.europa.eu/eu2020/pdf/council_conclusion_17_june_en.pdf

9 Europe 2020 – A European strategy for smart, sustainable and inclusive growth, http://europa.eu/press_room/pdf/complet_en_barroso___007_-_europe_2020_-_en_version.pdf

10 European Commission (2010), "The CAP Towards 2020 – Meeting the food, natural resources and territorial challenges of the future", COM(2010) 672 final.

11 Directive 28/2009/EC of the European Parliament and of the council of 23 April 2009 on the promotion of the use of energy from renewable sources.

12 Decision 1/CMP.6

**Table 1. Possible carbon sequestration benefits of a post-2013 CAP**

| | Pillar One "Greening Components" | | | |
|---|---|---|---|---|
| | **Permanent Pasture** | **Crop Diversification** | **Ecological Set-aside** | **Natura 2000** |
| **Description of measure** | Protect permanent pasture | Several crops at the same time on the farm | Share of farm area to be devoted to green infrastructure | Assure survival of valuable and threatened species and habitats |
| **C sequestration benefits** | Maintain and enhance carbon stocks | Increased soil organic matter | Carbon sequestration for permanent crops | Maintain but not increase carbon stores |
| | Grasslands contain three times the carbon in arable land | Potential reduction in carbon losses | Greater benefit if non rotational | Extensive systems = above ground biomass (carbon storage) |
| | Grassland conversion is a hotspot for emissions | Reduced bare soil = reduced carbon loss | Of high benefit if encouraged on organic soils | |

### *2.1.3. Preparing the ground for more ambitious targets*

There is also scope for **economic efficiency** gains from including LULUCF in accounting. The *Roadmap for moving to a competitive low carbon economy in 2050*[13] shows that significant additional climate mitigation efforts will be required across all sectors, and that agriculture and forestry will become even more important over time both in terms of preservation and enhancement of carbon stocks and as a feedstock for energy and material production. Whilst opportunities to remove additional GHGs from the atmosphere appears relatively limited in the short term (see Section 5 of this report), the potential cost-efficiency of both short- and long-term efforts to reach higher targets than the current one would be compromised if mitigation opportunities are not taken into account.

## 2.2. What issues need to be addressed to include LULUCF in accounting and what is the current state of play?

Whilst there are good reasons to account for LULUCF in the EU's climate change commitments, accounting is not trivial. The Council and Parliament require[14] that three issues are addressed in this impact assessment; in particular (1) how to ensure **permanence** and the environmental integrity of the sector's contribution to the commitments, how to achieve robust (2) **monitoring** and (3) **accounting**. Another important issue is to determine (4) the **policy context** in which to include the sector. These aspects are elaborated in this section.

### *2.2.1. Addressing the non-permanence of emissions and removals and the influence of natural effects on emissions and removals*

Non-permanence refers to the reversibility of carbon sequestered in, or released from, the biosphere (Schlamadinger et al., 2007a). Reversals can be caused by natural disturbances such as fires, droughts, pests etc. and to some extent storms. Events which may increase in

[13] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels 8.3.2011, COM(2011) 112 final.

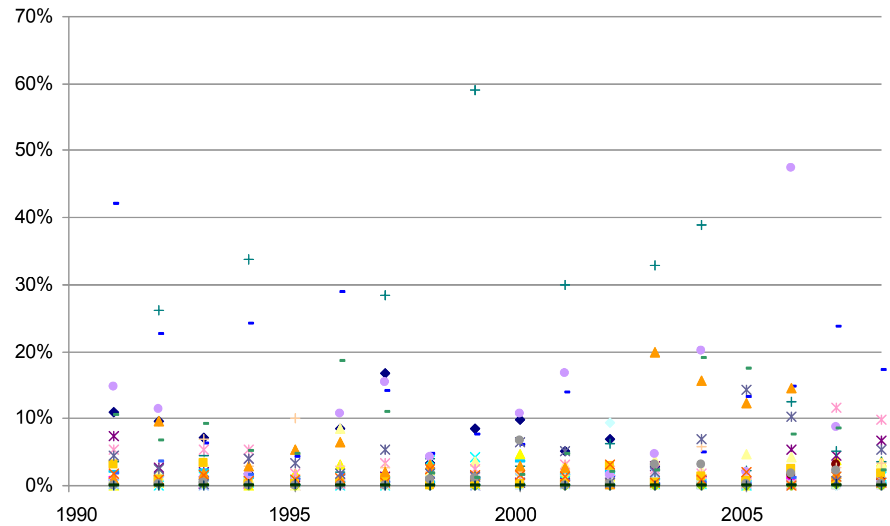
[14] Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020.

frequency and magnitude in the future (see e.g. IPCC, 2007), but also as a result of management decisions, e.g. to harvest or plant trees. The IPCC (2003; 2010) has concluded that there is currently no practicable methodology that can factor out direct human-induced from indirect human-induced effect and natural emissions and removals at one point in time. The IPCC GPG has therefore introduced estimates of GHG on managed land as an approximation of human-induced emissions and removals. Accounting methods are important to factor out natural influences between different points in time (see e.g. Canadell et al., 2007).

Fluctuations in emissions and removals in forests are significant. Figure 2 shows year-on-year changes in emissions and removals between 1990 and 2008 relative to the total emissions in the non-trading sectors (regulated by the Effort Sharing Decision; ESD). Whereas the EU average over the period varies between 1 and 4%, the fluctuations in individual MSs are as large as 60%, as illustrated by the spread of dots (each representing a MS) in the figure.

The high variability of removed or emitted GHGs caused by natural phenomena may affect countries' ability to comply with commitments and raise the question of how to deal with large natural disturbances in a commitment regime. The inter-annual fluctuations complicates the possibility of including LULUCF in the commitment on the basis of annual compliance – a key feature of both the ESD and the EU ETS which currently regulate the EU's 2020 target.

**Figure 2. Year-on-year fluctuations in emissions and removals (in forests remaining forests) over the period 1990-2008 as a percentage of 2008 emissions in the non-trading sectors (ESD)**




Note: Each dot represents the inter-annual fluctuations of a MS in a given year. Percentages are expressed in absolute terms.

Source: Calculations are based on data from EEA (2011) and the EU ETS data viewer (2010)

### *2.2.2. Ensuring robust monitoring and reporting*

GHG dynamics in the LULUCF sector involve vegetation and soil carbon pools and often a complex web of emissions and removals (for a detailed description, see Matthews et al., 2011). Their estimation requires investments in monitoring and reporting capacity. MSs are obliged to report annually to the UNFCCC on emissions and removals from forest land, cropland, grassland and all land use changes. The Kyoto Protocol adds additional reporting requirements for afforestation, reforestation and deforestation activities and, where applicable, forest management, cropland and grazing land management and revegetation. Three important aspects of the current state of monitoring and reporting are discussed below, and more details are provided in Annex I.

2.2.2.1. Completeness of estimates

In 2010 reporting under the UNFCCC was nearly complete for forest land but there were important gaps in reporting for cropland and grassland (see Table A1.2 in Annex I). At the same time, the expert review of the first reporting under the KP pointed to the need for improvements, particularly as regards soil and dead organic matter (JRC, 2011a). There were differences in reported data between MSs where reporting in the new MSs was generally less complete than in the EU-15. However, the completeness of reporting improved in recent years (Ciencala et al., 2010; and JRC, 2011a), especially for land use changes, likely as a result of the requirements to report under the KP which is expected to bring about further improvements in the next few years.

2.2.2.2. Accuracy of estimates

The IPCC GPG defines accuracy as a relative measure which means that estimates should not be systematically over nor under true emissions or removals (see List of definitions). Countries should seek to provide the highest possible accuracy of the estimates with the resources available. This is captured by two methodological concepts: “key category”[15] and “tier”[16]. A higher tier generally provides more accurate estimates. Key categories should be estimated with higher tiers (i.e. tier 2 or 3). Usually, MSs use a combination of different tiers (depending on the land use category or carbon pool) and higher tiers are more often used in the EU-15 than in the new MSs. Higher tiers are commonly applied to calculate emissions for forest biomass, whereas the lower tiers are frequently used for dead organic matter and soils. Currently, in some MS lower tiers than those required are applied[17].

Another measure of the accuracy of the data is the level of uncertainty associated with estimates. Based on information included in MSs’ GHG inventories, the uncertainty in LULUCF is 35%, with estimates for forest land at 26% and for cropland and grassland combined at 64%, see Table 2. The uncertainty is high compared to e.g. fuel combustion, transport and industrial processes, but similar to fugitive emissions and smaller than that of agriculture (non-$CO_2$ GHGs), all which are already part of the EU's GHG reduction target for 2020.

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15 The key categories are those categories that have a significant influence on a country’s total inventory of greenhouse gases in terms of the absolute level or trend of emissions and removals (the uncertainty of estimates may also be taken into account). Having accurate estimates for the key categories should be priority for countries during inventory resource allocation. Methods to estimate key categories are provided by IPCC.

16 A tier represents a level of methodological complexity to estimate emissions or removals. In this respect, it is useful to recall the two basic inputs required to estimate emissions or removals: “activity data” and “emissions factors”. For LULUCF, activity data typically refers to the area of a category; emission factors refer to emissions/removals per unit area. Any estimate of emissions or removals can be expresses as activity data multiplied by the relevant emission factor. Tier 1 is the basic IPCC method (associated to spatially coarse activity data and default IPCC emission factors), Tier 2 is an intermediate method (i.e. often using the same method as tier 1, but with higher resolution activity data are country-specific emission factors), and Tier 3 is the most demanding method in terms of complexity and data requirements (i.e. country-specific methods or models that use high-resolution and finely disaggregated activity data and emissions factors).

17 Compare Tables A1.10 and A1.11 in Annex I where tiers 2 or 3 should be applied to key categories.

**Table 2. Uncertainty of GHG emission estimates at the EU level**

| Sector | Level of uncertainty (%) |
|---|---|
| Fuel combustion | 2 |
| Transport | 6 |
| Industrial processes | 5 |
| Waste | 21 |
| Fugitive emissions | 32 |
| Agriculture (all categories) | 68 |
| *Enteric fermentation* | *12* |
| *Manure management* | *26-61** |
| *Rice cultivation* | *20* |
| *Agricultural soils* | *50-157** |
| LULUCF (all categories) | 35 |
| *Forest land* | *26* |
| *Cropland and grassland* | *64* |

Note: * The level of uncertainty varies with the type of GHG. The estimates are for the EU-15 and indicative, but are similar for the EU-12 (JRC, 2011a).

Sources: EEA (2010), JRC (2011a) and Leip (2010)

#### 2.2.2.3. Time consistency and comparability of estimates

The term "consistency" of data means that the same methodologies and consistent datasets should be used in the calculation of whole time series. The consistency of data over time within MSs appears to be reasonably good. Recalculations of reported data are frequent and sometimes substantial (see Annex I) but as long as the whole time series of data is updated this is not an issue for time consistency. However, the variability in tiers applied by different MSs and the existing flexibilities in definitions (see Annex I and e.g. Lawrence et al. 2010) suggest that data may not be fully comparable among MSs. For instance, National Forest Inventories have been developed for different purposes (socio-economic, historical and ecological) and over different time periods. This has resulted in variations in definitions (e.g. forest, growing stock volume and land use change) and in methodological approaches. Official frameworks, exist for comprehensive monitoring of soils in most MSs Soil inventories exist in very few MS. They are generally heterogeneous in methodology and coverage, both between and within countries (Arrouays et al., 2008). However, for the purpose of UNFCCC and KP reporting, the term "comparability" essentially refers to the fact that countries should use IPCC methodologies and agreed formats for estimating and reporting inventories. Compliance by MSs with the IPCC GPG is therefore a priority.

In summary, monitoring and reporting improved significantly in the last years and will likely continue to do so during the first commitment period of the KP. The current situation is sufficient for accounting for LULUCF; indeed, it is already being done in the KP. However, further consideration is needed in terms of how to improve the reporting of carbon pools, particularly dead organic matter and soils, especially so in the view of the more stringent reporting requirements for tier 1 level set in the 2006 IPCC Good Practice Guidance. The level of uncertainty in estimates of emissions and removals is higher than in other sectors (in particular those regulated under the EU ETS) but notably lower than that of the agriculture sector which is already part of the EU's climate change commitments. Recalculations are more common and significant in LULUCF than in other sectors and make it problematic to incorporate LULUCF in a system of annual compliance, a requirement which underpins the ESD and EU ETS.

### *2.2.3. Ensuring robust accounting rules*

Although LULUCF does not yet count towards the EU's GHG emission reduction target for 2020, it does count towards the EU and other Parties' commitments under the KP in 2008-2012 and will do so for the second commitment period. For the first commitment period under the KP, a set of rules is used to account for different directly human-induced activities: afforestation, reforestation, deforestation, forest management, cropland management, grazing land management and revegetation. The rules differ for the different activities (see Watterson et al. 2011 for a description). They have been subject to much criticism[18] and, as reflected in the international negotiations over the last years, there is generally a consensus that improvements are needed.

Rules for the second commitment period, addressing some of these improvements, was laid down with the draft decision in Durban in December 2011. However, these rules will apply internationally only when a second commitment period is finally agreed on and enters into force through ratification by the Parties. Therefore, when considering the inclusion of LULUCF in the EU's climate change commitments, the below points and possible alignment with the revised rules decided upon in Durban need to be considered:

- *Accounting for forest management does not reflect human-induced emissions and removals in the first commitment period*. Far from all emissions and removals in LULUCF are the result of human intervention. As noted above (see Section 2.2.1), the anthropogenic and natural factors cannot be separated at a single point in time. The rules laid down for the second commitment period address this issue by introducing accounting using a reference level. A reference level is an estimate of future emissions or removals based on a continuation of historical emissions and the effect of the implementation of known measures. Credits or debits are thus calculated based on whether the actual performance in the sector provides for more emissions or removals than anticipated.

- *The provision of incentives for mitigation efforts in forest management is insufficient*. With current accounting rules, credits are generated as long as a party reports removals that are greater than emissions, whether or not they are the result of human intervention. They are limited by a politically established cap. There is no incentive to mitigate once removals (or emissions) exceed the cap as the resulting changes will not be counted. This principle will be carried into a second commitment period also, as it was confirmed in the draft decision on LULUCF in Durban in December 2011.

- *Emissions resulting from deforestation may be understated in accounting*. Despite the existence of a cap on credits from forest management (see above bullet), countries may use removals above the cap to compensate emissions from debits that result from deforestation. The maximum allowance (equivalent to 165 $MtCO_2$) for each Party over the commitment period is very generous, meaning that large emissions from deforestation may potentially not be accounted for. The so-called compensation rule was left out of the Draft Decision on LULUCF and will not apply for a second commitment period under the Kyoto Protocol.

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18 See Watterson et al. (2011) and e.g. Schlamadinger et al. (2007b), Höhne et al. (2007) and Fry (2002 and 2007) for an overview.

- *Accounting of emissions and removals is partial and inconsistent*. Accounting is currently partly mandatory (afforestation, reforestation and deforestation) and partly voluntary (any or all of forest management, cropland management, grazing land management and revegetation). Just over half of the MSs account for forest management and only three for cropland and / or grazing land management (see Table 3). Whilst there are some benefits associated with the voluntary nature of accounting of some activities, e.g. countries have the option not to take on the burden of reporting and accounting if emissions and removals are deemed to be insignificant, it also gives little incentive for parties to select an activity if it is thought to generate debits. In addition, it introduces inconsistency and limited comparability between countries in the sense that some MSs account and others not, and because non-$CO_2$ emissions from managed land must be accounted in the agriculture sector but $CO_2$ from the same land may be ignored. The Durban decision made accounting for Forest Management activities mandatory, and thereby adressed the issue partly. However, accounting for $CO_2$ emissions from agricultural land and wetlands remain voluntary.

- *Accounting does not always reflect the actual time of emissions.* Current accounting rules make the assumption that carbon is released to the atmosphere instantaneously as a result of harvesting. Whilst this may be a good proxy for very short-lived products such as biomass that is used for energy purposes, wood used for more durable products such as sawn-wood or wood panels used for construction can retain carbon for several decades (IPCC, 2006). The different life time of products and the time at which emissions occure are not reflected in the KP rules for the first commitment period. In Durban the parties agreed that it should be possible to account gradually for emissions from harvested wood products better reflecting the actual time of emission. In future reporting, internationally agreed half lifes of products, or equivalent country specific data of sufficient quality can be used to calculate the amount of carbon still retained in a given category of products at a given point in time for each country.

**Table 3. Overview of activities that MSs have chosen to account for during the first commitment period of the KP**

| | Forest management | Cropland management | Grazing land management | Revegetation |
|---|---|---|---|---|
| **Member States that have chosen to account for the different activities** | Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovenia, Spain, Sweden and the United Kingdom | Denmark, Portugal and Spain | Denmark and Portugal | Romania |
| **Total number** | 17 | 3 | 2 | 1 |

Note: Accounting is mandatory for afforestation, reforestation and deforestation

### 2.2.4. *Defining the policy context for the inclusion of LULUCF in the EU's climate change commitment*

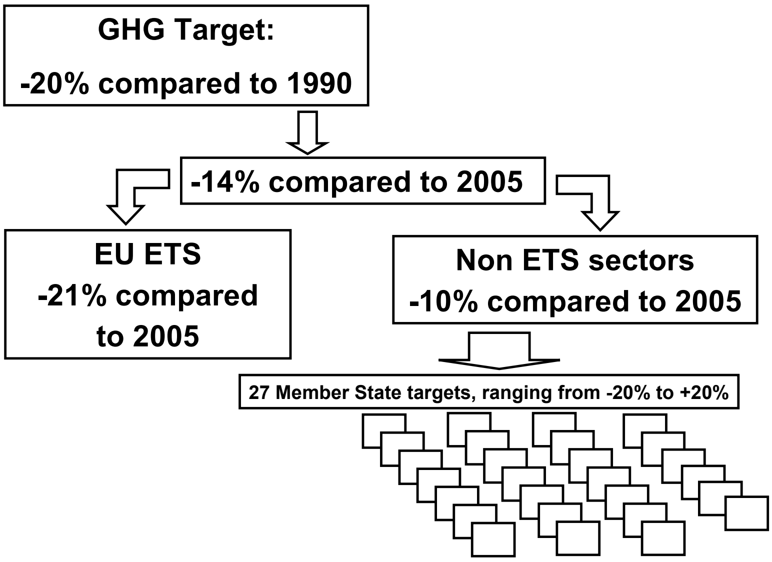
Once monitoring and accounting have been addressed, the overarching question is in which policy context the sector should be brought in to the EU's GHG reduction commitments. The current commitments are regulated through the EU ETS and the ESD which require trading sectors to jointly reduce emissions by 21% below 2005 levels and non-trading sectors to reduce emissions by 10%, see Figure 3. In theory, LULUCF could either form part of these existing policy frameworks, although the EU ETS as an option has been discarded early on (see Annex V), or be brought in under a new framework which is separate from the existing ones. Watterson et al. (2011) outlines the key features of the ESD and EU ETS that are relevant for the incorporation of LULUCF. Defining the policy context requires the consideration of the following issues:

- *Link to the overall commitment*. How would the link with the EU's overall target be regulated? Would targets be set? If so, how (taking into account the varying circumstances between MSs)?

- *Compliance and compliance risk*. How would compliance be defined? How could risks, in particular related to the high inter-annual variability of emissions and removals in the sector, be mitigated?

- *Flexibilities*. Would credits and debits generated be transferrable, either between policy frameworks (i.e. EU ETS, ESD and a potential separate policy framework) or between MSs to create flexibility?

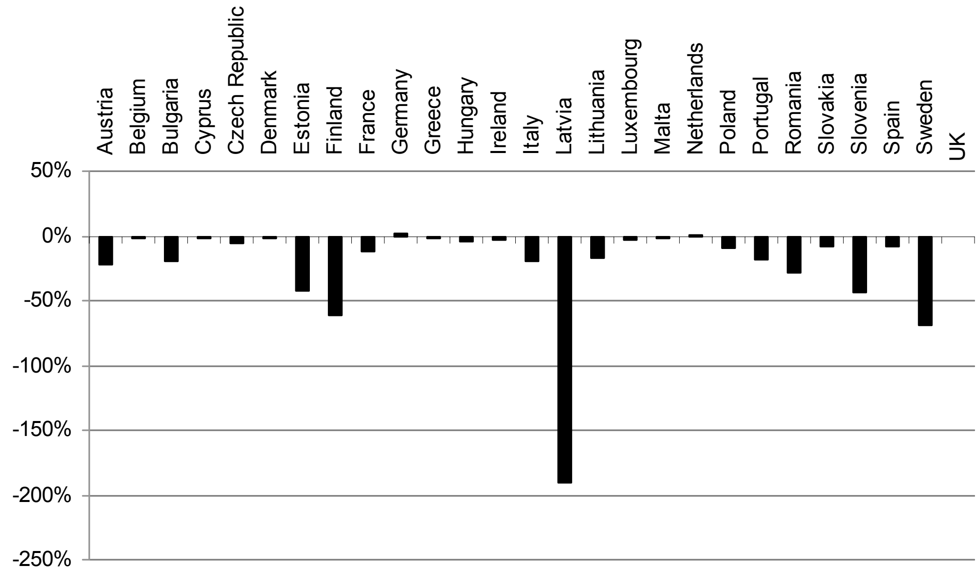
**Figure 3. Illustration of how the EU's current GHG reduction commitment is regulated**




## 2.3. Who is affected?

The accounting of LULUCF in the EU's GHGs reduction target would affect MSs directly. Firstly, it would extend the scope of the accounted emissions and removals by about 10% at the EU level but with varying importance across MSs. Both natural conditions, relating to e.g. climate and vegetation cover, and the size of LULUCF relative to other sectors in Member States play an important role in this regard. For instance, in Sweden and Finland net removals in LULUCF are more than half the total emissions in other sectors and in Latvia the double, see Figure 4. This highlights the importance of considering national circumstances when assessing the role of the sector in the climate change commitments. Also, accounting rules are of key importance. For example, accounting for LULUCF in the first commitment period of the KP is expected to generate credits of about 1% at the EU level, although there are variations across MSs (JRC, 2011a). Also, MSs would be required to improve monitoring and reporting in accordance with 2006 IPCC GPG in order to fulfil obligations. For some MS's some of these data are currently not yet routinely collected. Additional data collection would be done at country level as part of national reporting rather than at landholding level, which could impose an initial administrative burden on authorities and farmers. No impacts are expected on large businesses or small- and medium-sized enterprises (SMEs).

**Figure 4. Relative importance of LULUCF: emissions and removals of the sector relative to total GHG emissions (excl. LULUCF) in MSs, 2008**




Note: A negative number indicates that removals are greater than emissions in LULUCF for that Member State. (2) Due to inter-annual variations in emissions and removals the share varies between years.

Source: EEA (2011)

Secondly, it would adjust accounting to better reflect real changes in emissions and removals and to provide a level playing field between different mitigation options (i.e. sequestration / conservation in carbon in vegetation and soils in agriculture and forestry *vis-a-vis* substitution of materials with biomass in the energy and industrial sectors). In principle, this would affect agriculture and forestry and users of biomass for energy production, manufacture of pulp, paper and paper products, manufacture of wood and wood products or substitution of materials in construction. However, the extent to which these different sectors would be affected depends on at least three factors; firstly, how accounting rules are formulated, secondly, whether a target for LULUCF is introduced (either sector specific or more indirect via the ESD) and, thirdly, whether MSs translate the accounting framework into incentives at sector level (or else the impact will be on government expenditures and revenues).

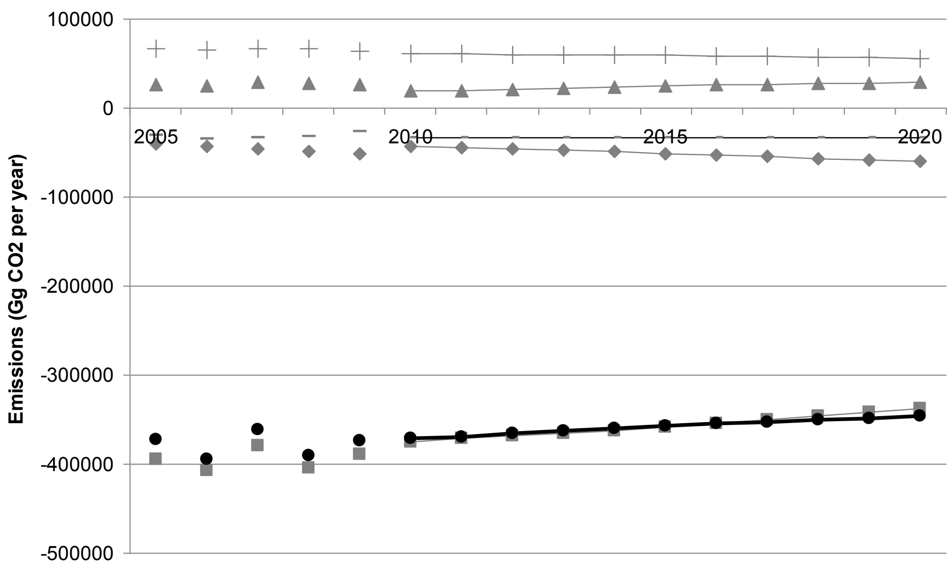
## 2.4. How would the problem evolve, all things equal?

As noted in Section 2.1 above, omitting the sector from accounting would risk undermining the environmental integrity of the commitments, reducing the coherence of EU climate policy and limiting the economic efficiency in reaching more ambitious targets. This section elaborates on how these aspects might evolve further if no action is taken.

Figure 5 shows the results of the projected emissions and removals in the reference scenario (see Annex IV for more detailed results of the projections and Annex III for the models and methodology used). Models project a decrease in the EU by 2020 under a business-as-usual scenario.[19] For the LULUCF sector as a whole, a decline of about 10% is expected in 2020 compared to the period 2005-2009, equivalent to emitting 33 $MtCO_2$ more per year. This roughly amounts to all greenhouse gas emissions in Latvia and Lithuania put together or twice those of Estonia in 2009.

A closer look at this projection shows that there are big differences between the individual activities within the sector. The decrease is expected to be very pronounced in forest management, for which a decrease in net removals of about 60 $MtCO_2$ is expected, i.e. roughly the equivalent of the total GHG emissions of Bulgaria, Denmark, Ireland or Sweden in 2009. Whilst this is partly the result of ageing forests (and related saturation in $CO_2$ uptake) it is also partly the effect of EU and MS policies, notably the expected impact of increased wood demand related to reaching the targets for renewable energy (Böttcher et. al, 2011, p. 19). This is partly compensated by plantation of "new" forests (afforestation). Emissions and removals from agricultural activities such as cropland management and grazing land management are expected to remain fairly stable or to improve. The predicted trend is consistent with findings of other studies, see Box 2, and illustrates the increasing importance of the problem discussed under **environmental integrity**; negative trends and emissions risk being disregarded unless LULUCF is part of climate policy and accounting.

**Figure 5. Projected emissions and removals in LULUCF 2000-2020**




Notation key: ●–●–● LULUCF (sum of all activities), ▲–▲–▲ Deforestation, +–+–+ Cropland management, —— Grazing land management, ♦–♦–♦ Afforestation, and ■–■–■ Forest management. Unconnected points show reported / historical data.

Note: (1) A negative number indicates that removals are greater than emissions for that activity. (2) Instant oxidation is assumed for the harvested wood products (HWP) pool. If this pool were included the projected forest management curve would shift downwards (increased removals) by approximately 55 Mt in the period 2013-2020 and by a similar amount for reported data (Rüter, 2011).

Source: Böttcher et al. (2011) and JRC (2011b)

[19] In this context "Business as Usual" assumes that Member States will reach their 20% reduction targets, including the targets for renewable energy.

**Box 2. How do the model results in this report compare with other studies?**

In 2011 MSs and other Parties to the UNFCCC submitted projected emissions and removals from forest management to facilitate the decision on accounting rules at the global climate change conference in Durban in december this year.[20] Some 10 MSs used country-specific models but 15 MSs based their submissions on the models used for this report (see Annex IV for more detailed results of the projections and Annex III for the models and methodology used here). The decline in the sink in Figure 5 is consistent with (although smaller than) the results obtained when combining the country-specific model results with the ones used here. Also the expected increase in wood demand for both material and energy use (i.e. a key driver for the evolution of the sink) is consistent with work undertaken by Mantau et al. (2010) The magnitude of potential supply in the latter study varies with assumptions about environmental, social and economic factors. As shown in the Roadmap for moving to a competitive low-carbon economy in 2050 (Op cit.), this trend is expected to continue in the long run and the role of agriculture and forestry in energy production is expected to increase.

The projected development of the sink would increasingly affect **policy coherence** and **economic efficiency**. If the decline in net removals stemming from non-action remain unaccounted for this would risk disincentivizing preservation and enhancement of carbon stocks and thereby creating an unlevel playing field between different mitigation options, that could result in an excessive use of resources for mitigation measures that count towards other objectives (substitution of fossil fuels in energy production and of GHG intensive materials in industry). This risks resulting in economic efficiency losses that may increase over time given that significant additional efforts will be required in all sectors to meet the long-term climate objectives.

### 2.5. Does the EU have the right to act and is EU added-value evident?

The legal basis for this initiative is Article 192(1) of the Treaty on the Functioning of the European Union (TFEU). Article 9 of the ESD, also based on Article 192(1) TFEU, tasks the Commission with assessing if and how LULUCF should be included in the EU's GHG reduction commitment, and to make a legislative proposal, as appropriate. Climate change is a trans-boundary issue which requires joint action by countries. In particular, since the EU has a common emission reduction target any changes will require Union wide action. The principles of subsidiarity and proportionality have been duly considered.

## 3. OBJECTIVES

### 3.1. What are the general and more specific / operational objectives?

The general objective of the proposal which accompanies this impact assessment is to support the EU's ambition of limiting global warming to a maximum of two degrees Celsius above pre-industrial temperatures. The EU's short term commitment for 2020 is to reduce its overall GHG emissions by at least 20% below 1990 levels. As agreed by the European Parliament and Council, the contribution of all sectors should be reflected in the efforts of reaching the target.

For this objective to be achieved, the emissions and removals related to LULUCF would need to be reflected in accounting. However, they must be included so as to address the issues identified in Section 2.2; namely to ensure permanence and the environmental integrity of the EU's GHG reduction commitments as well as accurate monitoring and accounting. The

[20] The submission is the basis for forest management accounting and has undergone a review in accordance with Decision 2/CMP.6, see the UNFCCC website http://unfccc.int/meetings/ad_hoc_working_groups/kp/items/5896.php for information

correct policy context also needs to be defined. To this end, the following operational objectives have been identified:

- **Monitoring and reporting** activities undertaken by MSs should comply with the latest IPCC methodological guidance approved by UNFCCC to ensure the transparency, completeness, consistency and comparability and accuracy of estimates;

- **Accounting** rules should:

  (1) be extensive in terms of emissions and removals covered and, to this end, shall include at least all main LULUCF activities (afforestation, reforestation, deforestation, forest management, cropland management and grazing land management)[21],

  (2) ensure that the non-permanence of emissions and removals is fully reflected in accounting,

  (3) provide incentives for climate change mitigation whilst avoiding bias towards any particular measure to ensure an appropriate balance of measures in the contribution to climate change mitigation,[22]

- **The policy context** in which LULUCF is included should be such that the ability of MSs to comply with GHG reduction targets is not put at risk due to inter-annual variability of emissions and removals or large natural disturbances.

## 4. POLICY OPTIONS

### 4.1. What are the possible options for tackling the problem and meeting the operational objectives?

The problem definition shows that accounting for the sector would enhance the environmental integrity, policy coherence and economic efficiency of the EU's GHG emission reduction commitments. In the light of this, different objectives have been defined. Options can be divided into two levels to address, on the one hand, the objective related to the policy context and, on the other hand, the objectives related to accounting and monitoring and reporting.

Firstly, it is necessary to define the **policy context** in which the sector should be accounted since there is already legislation in place to regulate the existing commitment to reduce GHG emissions by 20% in 2020. Three options have been defined. Option 2 involves creating a legislative framework for LULUCF which is separate from the existing frameworks provided

[21] The choice of activities is based on key categories at the EU level in UNFCCC reporting. In this report, monitoring and reporting are generally discussed in terms of the UNFCCC rather than the KP since the former is the basis for all reporting and an important part of the latter is currently done on a voluntary basis (which means that data are not reported). The following subcategories of the LULUCF sector of the EU 15 GHG inventory were key categories for the trend and the level assessment in 2008 (for CO2): forest land, cropland, grassland and land converted to settlements.

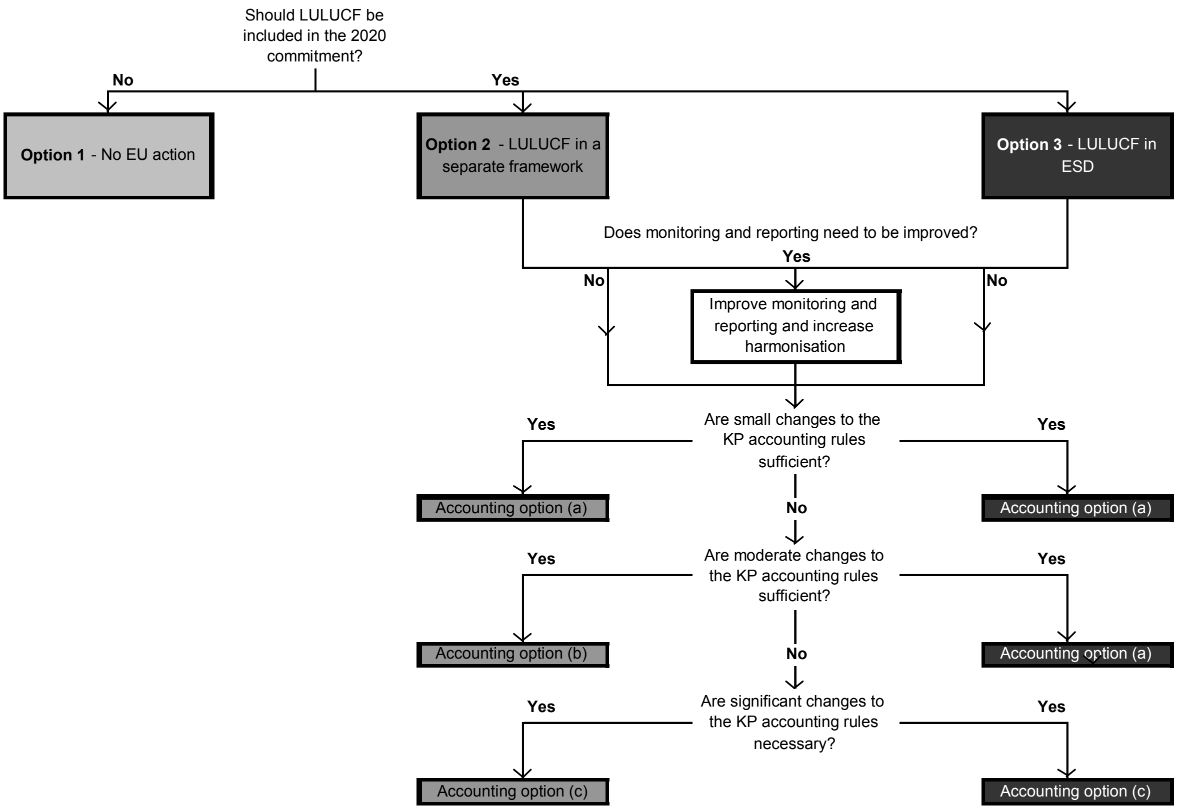
[22] A mitigation strategy aimed at maintaining or increasing carbon stocks while producing a annual sustained yield of timber, fibre or energy is expected to generate the largest sustained mitigation benefit (Nabuurs et al., 2007). However, the correct formulation of such a strategy requires that emissions from the different uses are accurately reflected in accounting.

by the ESD and the EU ETS. This option was divided into one without targets (Option 2.I) and one with targets (*Option 2.II*). It should be noted that the target option was included in the analysis for illustrational purposes only and to initiate discussions. Option 3 involves including LULUCF in the existing legislative framework of the ESD. The EU ETS as an option was discarded at an early stage (see Annex V for further details). It is good practice to consider also a non-regulatory / "no EU action" option (Option 1).

Secondly, different sub-options have been developed to assess how robust **accounting** (options (a) to (c)) and **monitoring and reporting** can be achieved. The sub-options are the same for Options 2 and 3 but their impacts differ depending on the policy context. Figure 6 illustrates how the two levels of options relate to one another.

A summary of stakeholder views on the different options is given at the beginning of each section to explain why particular options have been included in the assessment.

**Figure 6. Outline of options**




## 4.2. Options for the policy context in which to include LULUCF in the EU's GHG emission reduction commitments

This section describes the options for including LULUCF in the EU's commitments as regards the policy context. Option 1 involves no EU action. The implementation of Options 2 and 3 are described in terms of their link to the overall commitments, compliance and compliance risk and flexibilities. Both options would require new or amended legal acts.

**What are the views of stakeholders?**

The majority in both the consultation with the public and with MSs responded that LULUCF should be part of the EU's GHG emissions reduction target in 2020. In both consultations, but most notably in the consultation with MSs, there was a majority in favour of making the sector part of the target only if the EU were to take on a more ambitious commitment than the current one of a 20% reduction compared to 1990.

In the public stakeholder consultation there was a slight preference for regulating the role of LULUCF in the climate change commitments through a policy framework which is separate from those that currently regulate the EU's GHG reduction commitment (i.e. the ESD and the EU ETS), preferably with a sector target of some sort. The option of regulating the sector through the ESD was second. The reverse was true for the MS consultation where the ESD was the favoured option. Only a small share of the respondents in the public consultation and none in the MS consultation wanted the sector to form part of the EU ETS.

*See Section 1.3 for links to more detailed information.*

### *4.2.1. Option 1 – No EU action*

This option involves not accounting for LULUCF in the EU's climate change commitments at all. In practice, this is only realistic in the absence of an international agreement; given that the EU is a Party to the KP, any commitment there would have to be shared between MSs and would necessitate a common approach to both accounting rules (determined internationally) and to how debits and credits would be treated in relation to existing commitments under the ESD and the EU ETS. Therefore, "do nothing" really translates into delaying all action until an international agreement on a second commitment period has been reached.

### *4.2.2. Option 2 – Include LULUCF as a separate policy framework*

This option involves establishing a policy framework which is separate from the ones currently regulating the EU's GHG reduction target (the ESD and the EU ETS). Emissions and removals would be accounted for at the level of MSs.

In terms of **linkages to the EU's climate change commitments**, two sub-options are considered.

<u>Sub-option 2.I – No mitigation targets</u>: The EU is already on track to achieve its 20% reduction target of GHG emissions without the contribution of LULUCF. Before the level of ambition is increased beyond that target conditions need to be right. In Sub-option 2.I credits and debits generated by LULUCF would therefore not count towards the current level of the EU's commitments. As a first step, the objective would be to ensure that emissions and removals from the sector will be properly accounted for. Any credits or debits generated in LULUCF would be treated as a memo item. However, as a second step, and as part of a step-up of the EU's climate change commitments beyond 20%, a specific target for the sector to increase net removals or reduce net emissions could be envisaged as illustrated by Sub-option 2.II below, or the sector could be included in Option 3. As an intermediate step, action plans would be formulated by MSs to ensure that mitigation action is taken in the sector.

<u>Sub-option 2.II – Sector mitigation targets (included for illustrational purposes only)</u>: Targets could be set as part of an economy-wide step-up of efforts beyond 20%. This impact assessment does not analyse targets that support a legislative proposal to this end. Rather, the option of setting targets is analysed in a preliminary way and only to initiate discussions. If targets were to be introduced at a later stage, a similar approach to the ESD could be adopted such that targets set for individual MSs would be fair and achievable. Credits and debits generated by LULUCF would count towards the EU's GHG reduction commitment in accordance with agreed accounting modalities. Targets to increase net removals (or decrease

net emissions) could be set explicitly for individual MSs based on one of several parameters; for instance the estimated mitigation potential in LULUCF (underpinned by modelling), GDP per capita, or a uniform percentage change compared to business-as-usual projections. However, sufficient flexibilities would have to be ensured to minimise adverse risks of the uncertainty in estimates (see Section 2.2.2 and Annex III) which would otherwise have implications for reaching targets. For illustrational purposes only, this report takes a closer look at the possible impact of introducing targets based on mitigation potential, underpinned by modelling (see Annexes IV).

**Flexibility mechanisms** are only relevant in the case of Sub-option 2.II where they would safeguard cost-efficiency and ensure that a failure to meet sector-specific targets could be compensated by efforts in other sectors to preserve the overall EU target. This could be allowed through purchases and sales of LULUCF credits among MSs to facilitate their compliance with LULUCF targets, or through compensation with credits resulting from over-compliance in the ESD. Again for illustrational purposes only, this report looks at the possibility of transferring LULUCF credits between MSs.

As regards **compliance** (again relevant when accounting towards a target), Section 2.2.1 shows that the inter-annual variability of emissions and removals is very high. This makes annual compliance unsuitable (see the discussion in Option 3 for more details). Instead, compliance would be based on the average of emissions and removals over the period 2013 to 2020. Annual reporting would still be required as currently done under the UNFCCC and the KP. Compliance risk due to large natural disturbances would be addressed by way of specific accounting provisions (see below).

#### *4.2.3. Option 3 – Include LULUCF in the Effort Sharing Decision*

This option involves amending the ESD in order to include LULUCF among the sectors covered by existing commitments. Hence, liability for both emissions and removals would fall on MSs. An overview of the key features of the legislation is provided in Watterson et al. (2011).

In terms of **linkages to the EU's climate change commitments**, the ESD specifies binding targets for MSs between plus / minus 20% in 2020 relative to emissions in 2005, estimated on the basis of GDP per capita. If LULUCF were to be included, the distribution of individual MSs' efforts would have to be adjusted accordingly.[23] In theory, this could be done by changing the MS targets (based on GDP per capita) on the basis of the estimated mitigation potential in LULUCF, underpinned by modelling (see Annexes VI and VII). Or, given sufficient flexibilities, the targets could also be adjusted based on simpler metrics such as a uniform percentage change compared to business-as-usual projections. The most straightforward option is to maintain the current targets based on GDP per capita. This approach would mean that the challenge for MSs to reach their targets would most likely change with the inclusion of the sector, the reason being that diverse natural conditions relating to e.g. climate, vegetation cover, age of forests and soil throughout the EU play an important role in the mitigation potential of MSs. Given the difficulties associated with including LULUCF in the ESD in its current form, particularly in relation to the requirements of annual compliance (see discussion in Section 2.2 and below), the present analysis is limited to the impacts of maintained targets only.

[23] See Article 9 of Decision 406/2009/EC.

The ESD contains different **flexibility mechanisms**. Within a MS, over-achievement during 2013-19 can be carried over to the subsequent years, up to 2020. Up to 5% of the annual emission allocations of the following year may be brought forward during 2013-19. A transfer of up to 5% of annual emission allocations for a given year can be transferred between MSs. Such a transfer may be used for the implementation of a MS's obligations for the same year or any subsequent years until 2020. These flexibilities would continue to apply if LULUCF were included in the commitment, but the possibility for borrowing and lending between years would need to be significantly expanded in several MSs due to the inter-annual variability of emissions and removals.

In terms of **compliance**, MSs are required to annually limit their GHG emissions, in accordance with a linear trajectory for 2013-2020. This includes also making use of specified flexibilities in order to make sure that emissions do not exceed their limit in 2020. The starting point for the trajectory is the average emission level in 2008-2010. To address some compliance risks, there are provisions for extreme meteorological events so a MS may request an increased carry-forward rate in excess of 5% in 2013 and 2014 if substantially increased GHG emissions occur in those years compared to normal years. This provision would not be adequate if it were to apply also to large natural disturbances such as wildfires and storms. It would be difficult to recover emissions related to such events through removals, both because of the short time span and because of the high global warming potential of non-$CO_2$ emissions associated with fires which would take a long time to recover (since removals of $CO_2$ is the only way to compensate). As this provision was designed for sectors other than LULUCF, changes would be needed to address disturbances (see accounting options below).

### 4.3. Options for improving monitoring and reporting

This section outlines an approach for meeting the monitoring and reporting objectives defined in this report. In practice, the implementation would involve revising the Monitoring Mechanism Decision[24]. A separate impact assessment and proposal from the Commission address this issue but complementary information is provided here.

**What are the views of stakeholders?**

Whilst both the public consultation and the consultation with MSs have shown that the majority favours an inclusion of LULUCF in the EU's GHG commitment, a common reason amongst those who did not wish to include the sector related to perceptions about the reliability and comparability of data. This suggests that improvements to monitoring and reporting may be needed.[25] In both the public and MS consultations the majority agreed that there is a need for further harmonisation and standardisation between MSs in terms of monitoring, reporting and verification of emissions and removals.

*See Section 1.3 for links to more detailed information.*

There is no unique way of reaching the objective because the IPCC methodological guidance allows for different methodologies and approaches to be applied according to national circumstances. For instance, a number of tools exist for representing land areas (e.g. use of existing data, remote sensing and ground-based surveys) and for deriving emission factors

[24] Decision 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.

[25] This view was confirmed also in a different but related public consultation on the *Green Paper on Forest Protection and Information in the EU: Preparing Forests for Climate Change*[25], where a majority argued for more harmonised and more readily available information about EU forests, with links being made to a variety of policies, including climate change mitigation, see http://ec.europa.eu/environment/forests/fprotection.htm.

(e.g. default values, literature, measurements and models), and these can be combined in a number of ways. However, in a broader sense, a three-step approach can be envisaged (see Annex I for more details).

A first step is to ensure complete reporting of land categories and carbon pools using at least simple methodologies. The objective of this step is to ensure the level of completeness stipulated by the IPCC / UNFCCC to a minimum level of tier 1. Fulfilling this objective require increased collection of activity data.

A second step would involve increasing the accuracy of the reported key categories and carbon pools to a minimum of tier 2. Tier 1 methodologies only distinguish between the broad categories of land management, which means that the effects of some of the available mitigation activities are not reflected in the inventories. This step would therefore mainly imply requirements to improve the level of accuracy of monitoring and reporting of emissions and removals related to soils as this is where most efforts are needed. This step would ensure the completeness stipulated by the IPCC methodological guidance and a methodology consistent with key category analysis.[26] Moving to tier 3 (including modelling) would be encouraged to further increase accuracy (and in some cases for cost efficiency), but it is not an essential requirement of Step 2.

A third step would aim to improve the comparability between MSs by harmonising monitoring, reporting and related nomenclature. Cienciala et al. (2010) investigated harmonised methods for assessing carbon sequestration in European forests. Tomppo et al. (2010) showed that harmonisation is possible and on-going in COST Action 43, which reviewed the potential for common reporting in the context of National Forest Inventories. In addition, Kibblewhite et al. (2008) have described requirements for a harmonised soil monitoring system in the EU. Steps 1 and 2 would go some way towards harmonisation. However, processes leading to change in inventory practices, such as acceptance of new definitions, are usually slow. McRoberts et al. (2010) concluded that whilst important differences in national forest inventories remain, because of the use of different national definitions and methodologies, prospects are generally positive for developing procedures leading to compatible estimates among countries. This step should be seen as a gradual process which will need to take place over the next compliance period and beyond and could involve collaborative efforts between the Commission and MSs through workshops and working groups.

### 4.4. Options for accounting

This section outlines different options for meeting the objectives related to accounting. Consultations carried out with a range of stakeholders and MSs and on-going discussions under the auspices of the UNFCCC suggest that there are three main options to account for emissions and removals resulting from afforestation, reforestation, deforestation, forest management, cropland management, grazing land management, revegetation, changes in the harvested wood products (HWPs) pool, and disturbance events. The practical implications of implementing either of the options would be to define the accounting modalities in EU legislation.

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[26] Moving up higher tiers means that the same methodological approach as tier 1 may be used (for tier 2) but emission and stock change factors must be based on country- or region-specific data, should have a higher temporal and spatial resolution and should use more disaggregated activity data as compared to tier 1 (IPCC, 2006).

**What are the views of stakeholders?**

In the public stakeholder consultation, the majority of respondents suggested that emissions and removals related forestry activities should be accounted for on a mandatory basis. About half wanted accounting for GHG associated with some agricultural activities to be mandatory. The tendency was similar across MSs, but few wanted agricultural activities to be included on a mandatory basis.

As regards how accounting should be done, in particular for forest management, the public consultation showed that there were two dominant groups; one that thought that changes in emissions and removals should be measured against a benchmark of some sort, either emissions in a base year (1990) or a business-as-usual projection ("reference level"), and one group that believed that no benchmark should be used (meaning that credits would be generated as long as forests remove more carbon from the atmosphere than they emit, regardless of the trend in emissions and removals). MSs felt that accounting for changes against a benchmark ("reference level") was the most appropriate option.

*See Section 1.3 for links to more detailed information.*

**Table 4. Summary of accounting options**

| Activity/Provision | Accounting rules by option | | |
|---|---|---|---|
| | **Accounting option (a)**<br>Small changes to the current KP rules | **Accounting option (b)**<br>Likely outcome in the UNFCCC negotiations | **Accounting option (c)**<br>UNFCCC+ |
| Afforestation and reforestation | Accounting for emissions and removals without a benchmark (so-called "Gross/Net accounting")<br>Mandatory | Accounting for emissions and removals without a benchmark (so-called "Gross/Net accounting")<br>Mandatory | Accounting for emissions and removals without a benchmark (so-called "Gross/Net accounting")<br>Mandatory |
| Deforestation | Accounting for emissions and removals without a benchmark (so-called "Gross/Net accounting")<br>Mandatory | Accounting for emissions and removals without a benchmark (so-called "Gross/Net accounting")<br>Mandatory | Accounting for emissions and removals without a benchmark (so-called "Gross/Net accounting")<br>Mandatory |
| Forest Management | Accounting without a benchmark (so-called "Gross/Net accounting") but emissions and removals are discounted by 85%<br>Mandatory | Accounting relative to a reference level based on business-as-usual projections for 2013 to 2020<br>Mandatory | Accounting relative to a reference level based on business-as-usual projections for 2013 to 2020<br>Mandatory |
| Cropland Management | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Voluntary | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Voluntary | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Mandatory |
| Grazing Land Management | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Voluntary | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Voluntary | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Mandatory |
| Revegetation | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Voluntary | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Voluntary | Accounting for emissions and removals relative to 1990 (so-called Net/Net accounting)<br>Voluntary |
| Changes in the Harvested Wood Products carbon pool | Accounting for emissions from harvested wood at the time of harvest | Accounting for emissions from harvested wood at the time they actually occur (depending on the lifetime of wood products) | Accounting for emissions from harvested wood at the time they actually occur (depending on the lifetime of wood products) |
| Natural disturbances | No specific provisions for emissions related to natural disturbances | Emissions from natural disturbances exeeding a background level, may be excluded from accounting<br>Voluntary | Emissions from natural disturbances, exceeding a background level, may be excluded from accounting<br>Voluntary |

Note: Shaded areas indicate a change from the accounting rules under the Kyoto Protocol in the period 2008-12.

In Table 4 above, shaded areas indicate where the options differ from the accounting rules under the KP in the period 2008-12. A more detailed explanation and rationale for the different rules is given under each option. Background reading is provided also by Watterson et al. (2011). Some options, such as accounting for the specific activity of rewetting and drainage on land with organic soils, were excluded at an early stage for the reasons given in

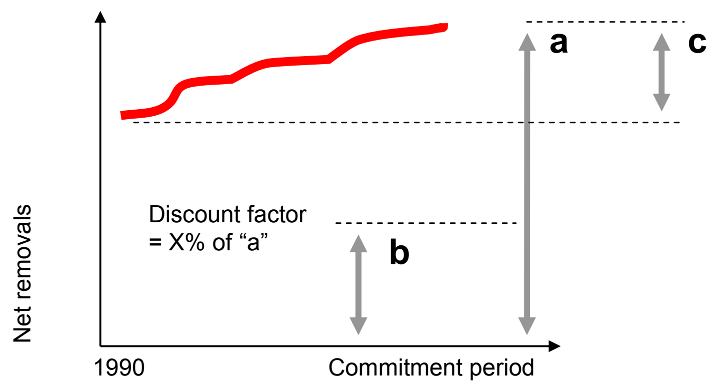
Annex V. It should be noted that where cropland and grazing land management are accounted for the vast majority of emission from organic soils are captured anyway.

4.4.1.1. Accounting option (a): Small changes to the current Kyoto Protocol rules.

In this option, accounting for **forest management** would be done on the basis of so-called Gross/Net accounting and discounted at a rate of 85%. This means that credits (debits) would be calculated as 15% of all net removals in the commitment period without consideration of net removals in a base year or period, i.e. no benchmark. In the example given in Figure 7, this translates to credits equal to "b" which is a fraction (15%) of "a". As discussed in Section 2.1, in the absence of a benchmark it will be impossible to separate anthropogenic from natural factors but the discount factor is a proxy for the share of human-induced emissions and removals. This accounting option for Forest Management is no longer on the table in the international negotiations.

**Afforestation and reforestation** involve establishing forests on land that was not forested at the very beginning of 1990, and **deforestation** involves converting areas, which in 1990 were covered by forest, for other uses or activities. Emissions and removals related to these activities in the commitment period would be accounted for in their entirety ("Gross/Net accounting") as they are a direct result of human activities (i.e. it is possible to determine human-induced impacts).

**Figure 7. Illustration of accounting methods**



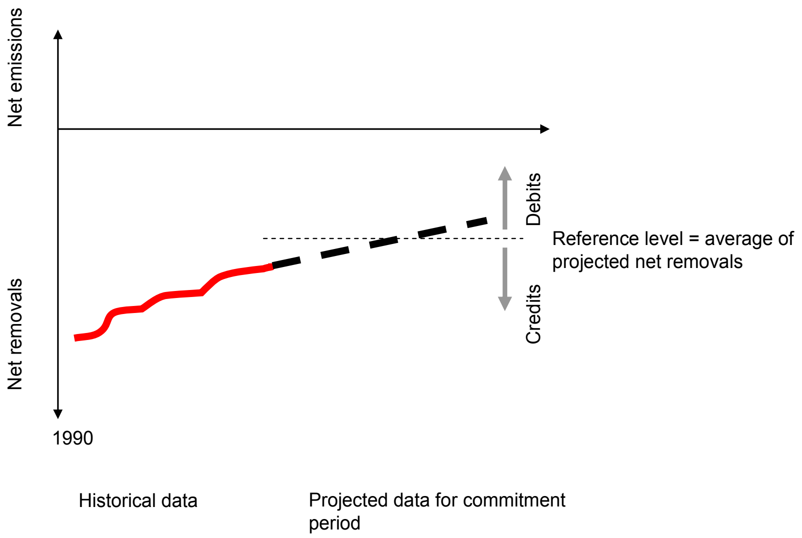

Note: Gross/Net – Credits are equal to all net removals during the commitment period = "**a**"; Gross/Net with a discount factor – Credits are equal to all net removals during the commitment period and discounted by a factor of X% = " **b**"; Net-net compared to 1990 – Credits are equal to the difference between the removals during commitment period and the net removals in 1990 = "**c**".

As under the accounting rules of the first commitment period of the KP, accounting for emissions and removals in **cropland and grazing land management** and **revegetation** would be voluntary and done on the basis of changes relative to 1990 (see "c" in Figure 7). This means that credits (debits) would be generated to the extent that net removals are higher (lower) in the commitment period as compared to the base year. Soils have different characteristics to biomass and the inter-annual variations in cropland and grassland are much smaller than those of forests. This means that accounting will not be as sensitive to the choice of base year (cf. fluctuations in forest management in Figure A5.1 in Annex V).

#### 4.4.1.2. Accounting option (b): Likely outcome in the UNFCCC negotiations

This accounting option reflects aligning to the outcome on accounting rules in the UNFCCC negotiations in Durban in December 2011. It differs from accounting option (a) in three ways. Firstly, accounting for emissions and removals in **forest management** is done relative to a reference level in order to factor out the impact of natural influences on removals and emissions, see Box 2 and Figure 8. The reference level is combined with a quantitative limitation ("cap") on credits corresponding to 3,5 % of base year emissions (excluding LULUCF) to limit the effects of the inherent uncertainty of (any) projections and to avoid that unwarranted credits arise. The quantitative limitation is expressed as a percentage of a MS's total GHG emissions in 1990 in order to ensure the link to compliance risk (because GHG reduction targets are expressed relative to this year). The cap ensures that some incentives for improvements in management practices are provided., see Annex III for more details on the impacts of different caps.

**Figure 8. Accounting emissions and removals in forest management against a reference level**




Note: Accounted emissions and removals are equal to the average of actual net removals in the commitment period minus the projected emissions and removals under business-as-usual, the so-called reference level. Credits are obtained when actual net removals exceed the reference level, and debits are obtained when actual net removals are less than the reference level.

**Box 2. Accounting for forest management on the basis of a reference level**

*What is a reference level?*

The reference level is set as the average of the projected removals and emissions under business as usual in the period for which the EU commits to reduce its overall emissions, in this case the period from 2013 to 2020, see Figure 8. In essence, accounting against the reference level means that a Member State will receive neither credits nor debits if the average of actual net removals in the compliance period equals the reference level, but that if net removals are higher (lower) this will result in credits (debits). In fact, in response to a decision[27] in the Cancun Agreements, Member States submitted numbers for reference levels to the UNFCCC for review by expert teams for consideration prior to the decision on accounting rules at the Conference of Parties in Durban last December. The outcome of the review process (http://unfccc.int/bodies/awg-kp/items/5896.php) has been assessed by the CMP7. The reference levels take into account the effect of removals or emissions from forest management as shown in greenhouse gas inventories and relevant historical data; forest characteristics such as age class structure, increments and rotation lengths; and domestic policies implemented and adopted no later than June 2009. Importantly, the cut-off date means the expected impacts on harvesting of reaching the renewable energy targets (as set out in Directive 28/2009/EC) are not included in the reference levels.

[27] Decision 2/CMP.6.

*What is the rationale behind reference levels?*

Emissions and removals depend on a number of natural (regional/geographical) circumstances such as variations in growing conditions (temperature, precipitation and droughts) and natural disturbances (storms, fires) as well as past and present management practices (e.g. rotation lengths which affect the distribution of age classes in forest stands) and therefore the rate of removals. Ultimately, the capacity of forests and soils on a given area of land to remove carbon from the atmosphere will saturate because a steady state will occur in the balance of emissions and removals. By measuring changes in emissions and removals relative to business-as-usual projections these circumstances are "factored out" so that only changes related directly human-induced activities are measured. This also provides incentives for improving on the current situation and gives an equal value to mitigation whether through sequestration or conservation or material and energy substitution.

Secondly, provisions for **disturbance** events would be needed to deal with substantial natural disturbances that are beyond the control of and not materially influenced by MSs and the resulting compliance risks, see Box 3.

**Box 3. Accounting for natural disturbances**

In the case of extraordinary occurrences whose associated total annual GHG emissions and removals are a minimum of e.g. 3-5% per cent of the total national emissions (excl. LULUCF) in 1990, it should be possible to exclude part of the associated emissions from accounting. The trigger for the application of these provisions would be defined in terms of base year emissions because it is designed to address compliance risk with the EU's climate change commitments (which are determined on the basis of total GHG emissions in 1990). MSs would be able to exclude part of emissions from the lands affected minus any subsequent removals on those lands until the end of the commitment period. However, in the case of land-use change following substantial natural disturbances, MSs would not be able to exclude emissions. The application of this provision would be voluntary but requires solid and evidence-based justification[28]. In the rules laid down for the second commitment period under the Kyoto Protocol, a corresponding provision is set that includes the use of a background level to be calculated fro each party. The 3-5% mentioned above, can be seen as such a background level.

Carbon is stored in various "pools", primarily in above- and below-ground biomass, such as wood, leaves, roots, and in soils (see Matthews et al. (2011) for more details). But carbon is also stored in products made from harvested wood. In the KP rules emissions are accounted as if they occur at the time of harvest. However, harvesting does not generate emissions per se, it is a transfer of carbon from one pool (e.g. above-ground biomass) to another (harvested wood products). In accounting option (b) and (c), emissions would instead be accounted for when they occur, as also decided for the next KP commitment period by COP17/CMP7 at the Durban meeting in December 2011. In accounting option (b) and (c) and in the next commitment period, sawn wood, wood panels and paper would be accounted for on the basis of exponential decay (i.e. loss) or emission with default half-lives of 35, 25 and 2 years respectively. Wood that is used for energy production, which is generally combusted within a year, and wood put in land-fills would still be accounted for at the time of harvest. Net removals will occur as long as the transfer of carbon to the harvested wood products pool is greater than the loss from the pool. The Durban decision allows for substitution of the default half lives values, where transparent and verifiable country specific data are available.

4.4.1.3. Accounting option (c): UNFCCC+

This accounting option is based on the outcome in the UNFCCC negotiations in Durban (Accounting option (b)) but goes further in addressing the criticisms against the accounting rules under the first commitment period of the KP. In particular, the scope of accounting and coverage of emissions and removals would be extended to accounting for **cropland**

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28 In particular to determine the extent of the event (in terms of areas of land affected), estimate the GHG emissions resulting from disturbance of that land, formally declare the emissions as resulting from the disturbance, remove these emissions from the calculated GHG balance for the period, provided evidence can be presented to show that the emissions were beyond the control of MSs, demonstrate that actions are being taken to remediate the impacts of the event (e.g. restore carbon stocks on the affected land), and show that emissions associated with salvage logging were not excluded.

**management** (already accounted for by Denmark, Spain and Portugal) and **grazing land management** (accounted for by Denmark and Portugal) on a mandatory basis. Regardless of the outcome of the ongoing international negotiations, the EU (as a Party) is able to decide whether to account for all activities. Such a choice would be fully compatible with the international system.

### 4.5. Which options have been discarded at an early stage and why?

Annex V contains a description of discarded **accounting** options. In terms of defining the appropriate **policy context**, the annex summarises the key points for not considering the inclusion of LULUCF in the EU ETS in this impact assessment, as discussed in three earlier studies[29].

## 5. ANALYSIS OF IMPACTS

This section presents an analysis of the impacts related to the different options presented in Section 4. It is in the mandate of this impact assessment to address how LULUCF may be included in the EU's overall GHG reduction target. The environmental, macro-economic and social implications of, in particular, different accounting options depend on if and how LULUCF is linked to the overall climate change commitments. Therefore, this section brings together the analysis of accounting options and the steps for improving monitoring and reporting with the different overall policy options (cf. Figure 7) of (1) taking no action, (2) accounting for LULUCF in a separate framework I) *without mitigation targets* and II) *with mitigation targets*, and (3) including LULUCF in the ESD. As noted in Section 4, the analysis of sub-option 2.II, which sets mitigation targets for LULUCF, is preliminary and serves as a basis for discussion only.

Impacts are assessed relative to the reference scenario outlined in Section 2.4 (and elaborated in Annexes III and IV) as the most likely outcome in the absence of policy interventions.

### 5.1. Environmental implications

#### *5.1.1. Impact of the different options on GHG emissions*

5.1.1.1. Option 2.I – Separate framework for LULUCF (without mitigation targets)

The aim of this option is to introduce and improve accounting, monitoring and reporting methods in the EU's GHG reduction commitment without changing the agreed efforts already introduced under the Climate and Energy Package. In other words, it does not involve revising targets upwards or downwards and rather records emissions and removals as a memo item. This would prepare the ground for a more inclusive step-up of the EU-wide efforts in the pursuit of the long-term targets when conditions are right. Table 5 presents the expected credits and debits per year over the period 2013-20 in the reference scenario, i.e. without additional mitigation efforts. The level of credits is uncertain because of uncertainties in the

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[29] The three studies are: (1) Impact Assessment of the Directive of the European parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system. {COM(2008) 16 final}{SEC(2008) 53}, (2) Extended Impact Assessment on the Directive of the European Parliament and of the Council amending Directive establishing a scheme for greenhouse gas emission allowance trading within the Community in respect of the Kyoto Protocol's project based mechanisms {COM(2003) 403 final}{SEC(2003) 785}, and (3) Watterson et al. (2011).

emission inventories and in the projections in particular in relation to future wood demand (including the demand for biomass energy) and the possible role of natural disturbances (see Annex III for a description of uncertainties).

**Accounting option (a)** is expected to result in credits of around -79 $MtCO_2$ per year for the EU as a whole This adds up to credits of some 629 $MtCO_2$ over the whole commitment period. The main reason is that credits in existing forests are calculated without a benchmark, i.e. all net removals in the commitment period are converted into credits regardless of whether they are the result of changes in management practices or natural factors and then discounted by 85%. This approach would create credits which are largely unrelated to actual management practices, i.e. windfalls. It would also reduce the incentive for mitigation efforts in the sector as each tonne of $CO_2$ mitigation achieved at any price level would be discounted and, hence, made more expensive relative to mitigation measures in other sectors. Estimates show that accounting option (a) is expected to generate credits for most MSs or have hardly any impacts at all, see Table A4.4 in Annex IV for more details.

**Table 5. Estimated annual credits ($MtCO_2$ per year) in 2013-20 for the three accounting options**

| MS | Accounting option (a) | Accounting option (b) | | Accounting option (c) | |
|---|---|---|---|---|---|
| | Small changes | Outcome of the UNFCCC negotiations | | UNFCCC+ | |
| | | (I) | (II) | (I) | (II) |
| Annual average over commitment period | -78.7 | -14.5 | -85.8 | -35.0 | -106.3 |
| Cumulative 2013-20 | -629 | -116 | -686 | -280 | -850 |

Notes: Negative values denote net credits (and positive values net debits). Options take into account that some MS already have voluntary accounting of GM and FM in the baseline. Credits for Forest management are calculated in two different ways (in both cases, the impact of the cap on credits equal to 3.5% of base year emission is included):

(I) (modelled emissions and removals in reference scenario) - (modelled emissions and removals in baseline scenario)

(II) (modelled emissions and removals in reference scenario) - (forest management reference levels in LULUCF decision of CMP.7)

Differences between (I) and (II) reflect different assumptions or methods used in the models' projections as compared to country-specific projections.

Source: Calculations based on Böttcher et al. (2011) and JRC (2011b) and, for those MSs that based their submissions of reference levels on this work, have been adjusted following the expert review of forest management projections under the UNFCCC.

**Accounting option (b)** is expected to result in credits of around 10 $MtCO_2$ per year and 77 $MtCO_2$ cumulatively over the whole commitment period if credits are calculated using model projection for forest management reference levels ((b(I)). Credits would be nearly 86 $MtCO_2$ per year and 686 $MtCO_2$ cumulatively over the whole commitment period if the forest management reference levels agreed in UNFCCC decision CMP7 would be used (option b(I). For 10 countries the decision uses forest management reference levels projected by member states rather than model projections.Under option (b) credits are substantially smaller than option (a) because this option measures changes in emissions and removals relative to a reference level. In fact, debits are expected from forest management as a result of an increasing demand for wood for energy purposes. When provided for energy purposes such wood will avoid $CO_2$ emissions in the energy sector while substituting fossil fuels. The overall credits of the sector are explained by net removals from afforestation efforts since 1990 which exceed the expected emissions from deforestation. There are significant variations between Member States (see Table A4.4 in the Annex for details). For instance, estimates show that 17 countries (e.g. Germany, Poland, UK, Austria and France) would have credits whereas in ten countries (e.g. Italy, Spain and Romania) debits may arise.

**Accounting option (c)** (UNFCCC+) results in expected credits of 35 $MtCO_2$ per year with modelled projections (column I) and 106 Mt using the reference projections submitted to the UNFCCC (mix country and model projections). Overall credits are higher than in option (b) because this option includes the effects of mitigation achievements in cropland and grazing land management. The latter activity in particular is expected to lead to an increase in net removals compared to 1990. The cumulative credits for the commitment period would be 315 $MtCO_2$. The distribution of debits and credits amongst MSs is similar to that in option (b).

Contrary to option (a) which is based on discounting, both options (b) and (c) fully reflect changes in forest management practices (1 ton change = 1 ton accounted), here in response to the expected increase in demand for wood for energy purposes. The results also clearly illustrate the difference between accounting against a reference level, where only changes in management practices will count, and accounting for emissions and removals without any benchmark. In particular, option (b) and (c) ensure that the use of biomass in other sectors than LULUCF is mirrored in accounting and therefore provides a level playing field between different uses of biomass. The expected increase in the use of biomass for energy associated with reaching the RES-D targets is estimated to involve a reduction in net removals of on average about 15 $MtCO_2$ per year in the period 2013-2020 (based on the JRC LULUCF tool calibrating model results see JRC (2011b) and Böttcher et al, 2011, p.39). One should recall that such biomass allows to save GHG emissions in the energy sector while replacing fossil fuels. Finally, the effects of the more inclusive accounting in option (c) is reflected in the higher level of net removals (credits) compared to option (b).

The analysis shows that all accounting options are expected to generate a surplus of credits at the EU level and, in the absence of an explicit link to the EU's overall target or a sector target, this option would not per se create additional incentives to increase net removals or reduce net emissions compared to the reference scenario. In other words, the expected impact of this option on real GHG emissions compared to the reference scenario is zero but because of efforts that have already been undertaken some credits would arise, depending on the accounting option chosen. Option 2.I would mean that, for the time being, the net result of LULUCF accounting would be a memo item in the context of the existing overall commitment.

**Box 4. How have the illustrative targets been set?**

In Option 2.II the MS targets are based on two components; the estimated mitigation potential of LULUCF per MS at a carbon price of €5 per $tCO_2$[30] in the different accounting options (see Annex IV for details on MSs) plus the expected credits or debits generated in the reference scenario in the different accounting options (at zero cost).The sum of these components, i.e. the target, can then be expressed as a percentage of the total GHG emissions in 1990.

30 This carbon price is equal to the expected EU-wide carbon price of meeting the targets under the effort sharing decision, based on the analysis underlying Commission Staff Working Document (SEC(2010) 650 accompanying the Communication (2010) 265 final "Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage."

5.1.1.2. Option 2.II – Separate framework for LULUCF (with mitigation targets)

Box 4 explains how the target was simulated in Option 2.II. The impact on net emissions depends on the carbon price and on the accounting rules. Figure 9 shows the real abatement potential expected at different price levels in **accounting options (b) and (c)**. A target based on €5 per $tCO_2$ would generate an increase in net removals of about 5 $MtCO_2$ in 2020 compared to the reference scenario. Based on a target which includes the credits generated in the reference scenario plus the mitigation potential at €5 per tCO2 (see Box 5), this would correspond to a target of credits equal to -0.3% in accounting option (b) and -0.8% in accounting option (c) for the EU as a whole. The largest share of abatement potential is expected to come from changes in forest management practices followed by efforts to limit deforestation. Cropland management and afforestation play only a minor role. It should be noted that the difference between the two accounting options is small because no estimates were made of the mitigation potential through changes in grazing land management. Also, the modelling of mitigation measures in cropland management measures is limited. The mitigation potential of accounting option (c) may therefore be underestimated.

Figure 9 also shows the marginal cost of abatement efforts in **accounting option (a)**. In this case, mitigation efforts in forest management are discounted by 85%, which means that the accounted contribution to the overall target decreases at any given carbon price. To reach an (accounted) reduction in the EU of 5 $MtCO_2$, and a target of a credits equal to -1.5% (i.e. the credits in the reference scenario plus actual reductions of 7 $MtCO_2$) of total emissions in 1990, a carbon price of some €12 rather than €5/t $CO_2$ would be required.

Considering the current uncertainties related to incomplete and uncertain emission inventories and uncertainty in the projections (although they are partially addressed by calibrating the model results on the basis of reported data, see Annex III for details) it is premature to set quantitative national targets similar to ESD targets at this stage. Further analysis would be required because the differences in the LULUCF projections between the models and methods used are high compared to the potential mitigation potential of around 5 $MtCO_2$ that can be achieved at marginal costs of up to €5 per $tCO_2$. Fixing a quantitative target therefore carries a risk of under- and overshooting targets and therefore potentially of associated costs. Nevertheless, the preliminary analysis has been carried out to inform the discussion on target setting.

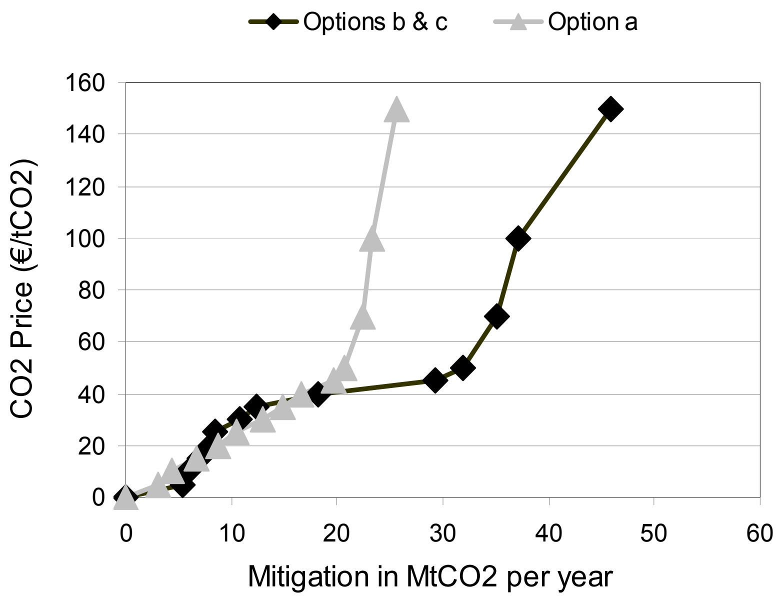
5.1.1.3. Option 3 – Inclusion of LULUCF in the ESD

In Option 3, the assumption is that MSs keep their current targets under the ESD and that any credits or debits generated by LULUCF count towards those targets. A redistribution of targets has not been considered under the current 20% commitments. The carbon price is assumed to be €5.3 per $tCO_2$ reflecting the price expected of transfers under the ESD to meet the national targets agreed under the Climate & Energy Package.

If the credits could be used to meet the national targets agreed under the ESD, **accounting option (a)** would have a significant impact. The credits generated in the reference scenario (Table 6) could be as high as 90% of the cumulative emission reduction needed between 2010 and 2020 under the ESD plus the mitigation efforts at the assumed carbon price. The accounting would therefore substantially reduce the actual emission reduction achieved in the ESD sectors compared to 2005 and compared to the efforts that have already been agreed in the Climate and Energy Package.

For **accounting options (b) and (c)** the impact would be smaller but not insignificant as the effect on the cumulative effort between 2010 and 2020 would be between 14 to 44% of the total required reductions in the ESD, see Table 6. The emission reduction in the ESD would be reduced rather than simply replaced by efforts in LULUCF because all accounting options allow for at least some degree of decrease in net removals whilst still generating credits; this is particularly the case for forest management under accounting option (a) for which credits are generated as long as forest management is a sink but also, although to a smaller extent, in accounting options (b) and (c) where no debits are awarded for forest management as long as the sink declines according to the reference level.

**Figure 9. Mitigation in the EU LULUCF sector in 2020 (MtCO$_2$ per year)**




Note: Effects measures that lead to increases in the HWP pool have not been considered.

Source: Böttcher et al. (2011), based on the G4M-EUFASOM models

### *5.1.2. Other environmental impacts*

The impact on land use change is expected to be minimal in the short term and at low carbon prices. In **Option 2.II combined with accounting options (b) and (c)**, the additional afforestation efforts and reduced deforestation are projected to have a limited effect on the forest area (an increase by some 0.05%) in 2020 compared to the reference scenario, and by about 0.15% in accounting option (a), see Table 6. Land use change is expected to be zero in all other options.

From a wider environmental perspective, a reduction of soil organic matter levels because of land use or land use change is a cause of concern not only for its link to climate change, but also because soil organic matter is a major contributor to wide environmental safeguards such as soil fertility as it binds nutrients to the soil, thus ensuring their availability to plants; it is the home for soil organisms, from bacteria to worms and insects, and allows them to transform plant residues. And it also maintains soil structure, thereby improving water infiltration, decreasing evaporation, increasing water holding capacity and avoiding soil compaction. Accounting for LULUCF is therefore likely to enhance these properties. Not including the sector in the commitments (**Option 1**) would discourage the protection and/or enhancement of soil and biomass carbon stocks directly or indirectly by not reflecting the effects of certain agricultural practices. Even simple monitoring and reporting would create meaningful incentives to reduce certain activities (e.g. the conversion of grassland to cropland, the cultivation of organic soils) that are generally undesirable both from a GHG and other environmental perspectives. **Accounting option (c)** would ensure that changes in soil organic matter would be taken into account throughout the EU whereas **accounting options (a) and (b)** would not as they allow MSs to account for agricultural activities (cropland and grazing land management) on a voluntary basis.

**Table 6. Environmental impacts of the options**

| | Option 1<br>No EU action | Option 2.I<br>Include LULUCF as a separate framework (No target) | | | Option 2.II<br>Include LULUCF as a separate framework (Target = 5 $MtCO_2$ accounted credits) | | | Option 3<br>Include LULUCF in the ESD<br>Assuming carbon price of €5 per $tCO_2$ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Accounting option* | *n/a* | *(a)* | *(b)* | *(c)* | *(a)* | *(b)* | *(c)* | *(a)* | *(b)* | *(c)* |
| $MtCO_2$/year | 0 | 0 | 0 | 0 | -7 | -5 | -5 | 80 | 13 | 39 |
| $MtCO_2$ from 2013-2020 ($MtCO_2$) | 0 | 0 | 0 | 0 | -54* | -43 | -43 | 642 | 102 | 315 |
| % of ESD effort in 2020 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 51% | 8% | 25% |
| % of ESD effort 2013-2020 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 90% | 14% | 44% |
| Land use change (forest area change as compared to reference scenario, %) | 0 | 0 | 0 | 0 | 0.15% | 0.05% | 0.05% | 0 | 0 | 0 |

Note: Option 2.II is based on a target of -5.4 $MtCO_2$ accounted credits. This equals a carbon price of €5 per $tCO_2$ for accounting options (b) and (c), as assumed for Option 3, but a carbon price of €12 per $tCO_2$ for accounting option (a) due to the discounting of forest management. Negative values denote net removals (and positive values net emissions). Source: Calculations based on updated version of Böttcher et al. (2011) and JRC (2011b), reflecting the UNFCCC review, and PRIMES-GAINS model results

### *5.1.3. Possible contributions to an EU target*

The possible contributions to the EU target will differ depending on the accounting option and the context in which LULUCF is accounted. As shown above, some credits will be generated also at a zero carbon price. In **Option 1** (No EU action) there will be no impact, and in **Option 2.I** (Separate framework without mitigation targets) the impact will be equal to that of the reference scenario which would be a memo item on top of the 20% target.

**Table 7. Possible contribution of options to the EU's GHG reduction target in 2020 for different accounting rules (based on the reference scenario)**

| Accounting options | Policy options | | | |
|---|---|---|---|---|
| | *Option 1* | *Option 2.I* | *Option 2.II* | *Option 3* |
| (a) Small changes to current rules | n/a | -1.4% | -1.5% | 0 |
| (b) Outcome in the UNFCCC (I) | n/a | -0.3% | -0.3% | 0 |
| (b) Outcome in the UNFCCC (II) | n/a | -1.5% | -1.6% | 0 |
| (c) UNFCCC+ (I) | n/a | -0.6% | -0.8% | 0 |

| | | | | |
|---|---|---|---|---|
| (c) UNFCCC+ (II) | n/a | -1.9% | -1.9% | 0 |

Note: A minus sign denotes credits and would contribute to reaching the EU's overall GHG reduction target. (I) relies only model results. (II) relies on a mix of model results and national submissions for forest management reference levels (see Table 5 for details) Source: Calculations based on Böttcher et al. (2011) and update of JRC (2011b)

**Option 2.II** (Separate framework with mitigation targets) with **accounting options (b) and (c)** would contribute about -0.3% to -1,6% and -0.8% to -1.9% (c) respectively. **Accounting option (a)** generates a higher target (-1.4%) due to windfall credits in the reference scenario. **In Option 3** (inclusion in the ESD), part of the efforts in other sectors would be replaced by LULUCF credits, which means that there would be no addition to the target and, indeed, the efforts in other sectors would decrease.

By way of sensitivity analysis, Table 8 shows the changes in emissions and removals resulting from a 10% change in the EU harvest rates. A decrease (increase) in the harvest rate compared to the reference scenario would result in credits (debits) of about 50 $MtCO_2$ per year (0.9% of total EU GHG emission in 1990) in accounting options (b) and (c). For accounting option (a) the accounted amount would be about 7.5 $MtCO_2$ as a result of discounting.

**Table 8. Impact on GHG emissions of changes in harvest rates**

| Change in harvest rate | Associated change in emissions (+) and removals (-), MtCO2 | Percent of EU total GHG emissions in 1990 |
|---|---|---|
| 10% increase | 52.5 | 0.9% |
| 10% decrease | -52.3 | -0.9% |

Source: Calculations based on Böttcher et al. (2011) and JRC (2011b)

**Box 5. Methodological note**

*Forest management*

Importantly, the methodology used to estimate the abatement potential (and, hence, costs and impacts) of forest management imply no direct changes in harvesting rates as models are set up to keep harvest close to the reference scenario when the carbon price increases. Whilst harvest rates remain unchanged, the geography of harvest changes and forest management parameters such as rotation length and the amount of wood removed through thinning are changed for different locations of forests to secure a given level of wood supply. This shifts harvest to more expensive and less productive sites. This approach is conservative compared to approaches which would involve reducing the harvest rate (and which would instead lead to the displacement of EU production to non-EU countries). Note that this does not mean that in the reference scenario wood production is constant over time. On the contrary, wood production for biomass and other uses is expected to be around 5% higher in 2020 than in 2005 (reflected in the decrease in net removals in the reference scenario).[31]

If, however, the increased costs of forest management would be reflected in increased timber prices the timber demand and harvest might however decrease slightly. Imports might increase and exports reduced (see section 5.2.2.2 for details). The effect is expected to be detectable only in Option 2.II with accounting option (a) where timber production might decrease by 0.1%. This might indirectly increase the LULUCF sink and reduce the efforts needed to meet quantitative reduction target.

Cropland and grazing land management

It should be noted that the mitigation potential of changes in grazing land management has not been modelled. Also, the modelling of cropland management measures is limited. The mitigation potential for agriculture may therefore be underestimated.

A detailed description of the modelled mitigation measures is given in Böttcher et al. (2011).

31 See Böttcher et al (2011), p.29 based on PRIMES results for energy and forest models for non-energy timber demand.

## 5.2. Economic implications

This section discusses the abatement costs for the EU as a whole and the costs for the most affected sectors (forestry and agriculture) and costs of monitoring and reporting. As noted in Section 2.3, this report does not attempt to assess the impact on individual businesses such as SMEs because legislation would involve an accounting framework at MS level rather than provide incentives directly to different sectors or companies. Subsequent choices on policy instruments will have to be made by MSs and the implications cannot be predicted at this stage. However, a brief mention is given to possible impacts by owner structure.

### *5.2.1. Direct abatement costs*

Abatement costs are only relevant for **Options 2.II and 3** as they are the only options which would provide additional mitigation incentives for LULUCF, see Table 9.

#### 5.2.1.1. Option 2.II – Separate framework with mitigation targets

The costs of setting a target for the LULUCF sector, based on a marginal cost of €5 per $tCO_2$ (= 5.4 $MtCO_2$ per year) for **accounting options (b) and (c)** are shown in Table 9. The annual costs are expected to be about €27 million per year. For **accounting option (a)** the costs would be higher since net removals in forest management are discounted by 85%. This increases the marginal costs to some €12 per $tCO_2$ to achieve the same accounted reduction of 5 $MtCO_2$. Consequently, annual costs would be higher and around €37 million per year. It should be noted that the costs of accounting option (a) would be significantly higher at higher mitigation targets. However, the results are uncertain (see Annex III) and this will affect the ability of MSs to achieve targets as well as the costs associated with reaching those targets.

**Table 9. Abatement costs per year in 2020 (€2008)**

| | **Option 2.II** Include LULUCF as a separate framework (Target) | | | **Option 3** Include LULUCF in the ESD | | |
|---|---|---|---|---|---|---|
| *Accounting option* | *(a)* | *(b)* | *(c)* | *(a)* | *(b)* | *(c)* |
| Marginal costs €/tCO2 | 12 | 5 | 5 | 0.3 | 3.8 | 1.0 |
| Abatement costs (mln€/yr) | 40 | 27 | 27 | -166 | -55 | -156 |
| (as % of GDP) | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

Source: PRIMES, GAINS and G4M model results

#### 5.2.1.2. Option 3 – Include LULUCF in the ESD

Meeting the targets under the ESD, whilst assuming unlimited transfers between MSs to offset debits, is expected to result initially in a market price of around €5 per $tCO_2$. Under Option 3 the price is affected in two ways. First, the accounting rules create credits that lower the need to reduce emissions in the ESD sectors. Secondly, the inclusion of LULUCF will create an incentive to undertake abatement also in the LULUCF sector, if the marginal costs of abatement are lower than in the ESD sectors. As a result, some abatement will be undertaken in the LULUCF sector. Both effects will lower the carbon price in the ESD sectors.

Table 9 shows that the impact is the biggest in **accounting option (a)** because of the large amount of LULUCF credits. As a result the price could drop to below €0.3 per $tCO_2$.[32] Depending on the price there is an additional supply of LULUCF reductions ranging from close to zero in **accounting option (a)** to around 4 $MtCO_2$ in **accounting option (b)**.

For **all options**, the macroeconomic implications will be insignificant since the changes in costs are small compared to the expected GDP in 2020.

### *5.2.2. Costs for the various sectors*

Following on from Section 5.2.1, costs are only relevant for **Options 2.II and 3** as they are the only options which would provide additional mitigation incentives for LULUCF.

The two sectors that would be directly affected by legislation are agriculture and, broadly defined, forestry. Table 10 shows the abatement costs for the sectors in 2020. The greatest contribution to mitigation is expected to come from forestry and forest management whereas the potential for cropland and grassland management is expected to be limited (see Box 5). As mentioned above, the abatement costs are uncertain since the projections are uncertain.

#### 5.2.2.1. Agriculture

Under **Option 2.II** and **accounting option (c)** agriculture can contribute to some degree by improved cropland management to enhance the sink and so faces some costs (€1 million per year)(see Böttcher et al. (2011). i.e. pp 10-11 and p. 47 for details). Under **accounting options (a) and (b)** costs would only arise if countries choose to account for agricultural activities (which are voluntary). The effect would be most significant for **accounting option (a)** since the carbon price is higher and therefore induces higher abatement also for cropland management. However, costs are expected to be small compared to the gross value added of the sector in 2020.

Under **Option 3** the costs for agriculture are negative. Any additional costs for cropland management are expected to be more than compensated by the cost savings of reducing non-$CO_2$ GHG emissions in agriculture under the ESD. If the marginal costs drop below €5 per $tCO_2$ (expected in all accounting options) several non-$CO_2$ abatement measures, e.g. reducing nitrous oxides from fertilizer application, do not appear to pay off anymore. Note, however, that the marginal costs of measures are country specific. Results might therefore differ between countries and the analysis on the impacts per sector which was made at an aggregate EU level. The credits and the inclusion of LULUCF options in the ESD (Option 3) would reduce the carbon price in the ESD sector and the need to reduce emissions in agriculture as well as other sectors. The costs for other sectors covered by the ESD are reduced the most, especially the energy sector that emits non-$CO_2$ GHGs. The impact on $CO_2$ reduction from energy is expected to be small.

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[32] The effect on the price of the ESD sectors was based on a set of dedicated runs of the PRIMES-GAINS models and are driven mainly by the expected marginal costs for reducing non-CO2 GHG emissions in the ESD sectors.

#### 5.2.2.2. Forestry

Impacts will differ between different options also in the forestry sector. In **Option 2.II** with **accounting option (a)** abatement efforts are estimated to lead to a cost increase of 0.2% relative to the production value in 2020. Elasticities of demand for timber vary by region and product between -0.3 and -0.6 (with an average of -0.5).[33] Subsequently, the indirect effects of passing on a cost increase of 0.2% in the timber price is estimated to lead to a reduction in demand of around 0.1% for this particular accounting option. If international markets are competitive relative to the EU market, part or all of the estimated decline in demand would instead be shifted to the international market (leakage). In **all other accounting options** in **Option 2.II** and **Option 3**, the additional cost for the forest sector are much smaller in absolute terms and relative to the value of production. Indirect effects are minimal.

**Table 10. Abatement costs per sector**

| | **Option 2.II** Include LULUCF as a separate framework (Target) | | | **Option 3** Include LULUCF in the ESD | | |
|---|---|---|---|---|---|---|
| *Accounting option* | *(a)* | *(b)* | *(c)* | *(a)* | *(b)* | *(c)* |
| Agriculture (€million/year) | 2* | 1* | 1 | -49 | -47 | -49 |
| Forestry (€million /year) | 38 | 26 | 26 | 0 | 16 | 1 |
| Other (ESD) Sectors (€million/year) | 0 | 0 | 0 | -117 | -24 | -108 |
| SUM (€million/year) | 40 | 27 | 27 | -166 | -55 | -156 |
| Agriculture (% of gross value added) | 0.00% | 0.00% | 0.00% | -0.03% | -0.02% | -0.03% |
| Forestry (% of gross value added) | 0.13% | 0.09% | 0.09% | 0.00% | 0.06% | 0.00% |

Note: * Assumes that MSs choose to account for cropland management where there is a mitigation potential at €5 per $tCO_2$.

Source: Calculations based on Böttcher et al. (2011), using the G4M&EUFASOM, PRIMES and GAINS. Numbers may not add up to rounding [34]

Whilst Table 10 presents all forest related impacts in terms of "forestry", the incidence is likely to be spread over different uses. Table 11 presents costs according to the projected market shares of energy (41%) and other wood uses (59%) in 2020. The latter group of uses consists of sawn wood, pulp wood and other industrial roundwood.

33 Based on the GLOBIOM model and consistent with UN/FAO data (Kangas and Baudin, 2003; p. 49-51).

34 Based on the detailed non-GHG cost curves for 2020 from the GAINS model, see http://ec.europa.eu/clima/documentation/docs/non_co2emissions_may2010_en.pdf

**Table 11. Costs by wood use (€ million per year)**

| Sector | Option 2.II Include LULUCF as a separate framework (Target) | | | Option 3 Include LULUCF in the ESD | | |
|---|---|---|---|---|---|---|
| *Accounting option* | *(a)* | *(b)* | *(c)* | *(a)* | *(b)* | *(c)* |
| Energy | 15 | 11 | 11 | 0 | 7 | 0 |
| Other wood uses | 22 | 15 | 15 | 0 | 9 | 1 |
| *Sawn wood* | *13* | *9* | *9* | *0* | *5* | *0* |
| *Pulp wood* | *8* | *6* | *6* | *0* | *3* | *0* |
| *Other industrial roundwood* | *1* | *1* | *1* | *0* | *1* | *0* |

Source: Calculations based on Böttcher et al. (2011) and Capros et al. (2010)

It should be noted that the extent to which accounting and hence the forestry sector is affected will depend on the rate of **change in the pool of harvested wood products**. An increased use of wood products would enhance the rate and generate credits which could potentially be recycled into industry. Rüter (2011) calculated changes in this pool for the years leading up to 2020 based on projections of harvest rates provided by Böttcher et al. (2011) and various country-specific models.[35] The current increase is expected to continue. As shown in Table 12, with a net pool increase estimated at approximately 52 $MtCO_2$ in 2020. However, emissions / removals fluctuate between single years and it may therefore be more appropriate to refer to the average of 2013-2020 of 55 $MtCO_2$. The HWP pool can increase in the short to medium term and may stabilise in the long term when removals from new wood products can compensate emissions from old wood products (i.e. inflow equals outflow).

**Table 12 Historic (up to 2009) and projected net emissions from the HWP pool ($MtCO_2$)*, ****

| | Year | | | | | Average |
|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2015 | 2020 | 2013-20 |
| EU total | -52.9 | -59.6 | -64.3 | -56.8 | -52.0 | -54.9 |

Note: * Negative values denote a pool increase. ** The calculations are subject to change following the UNFCCC review process of reference levels (incl. HWP) as submitted by MSs.

Source: Rüter (2011)

Another important factor to consider is the potential benefits in terms of GHG savings that can be achieved as a result of **substitution of materials and / or energy sources for biomass** that will appear in the accounting of other (non-LULUCF) sectors. These emission savings would be accurately reflected in accounting only once the related emissions are recorded in LULUCF. In a review of some 20 studies, Sathre and O'Connor (2010) found that the amount of carbon emissions avoided by the use of wood instead of non-wood material averaged at a

35 As noted in Box 3, MSs have submitted reference levels (excluding and including harvested wood products) to the UNFCCC for review in anticipation of a decision on accounting rules at the world climate summit in Durban later this year. Some 15 MSs base their harvest projections on Böttcher et al. (2011), the remaining MSs use national models (see submissions to the UNFCCC as requested by Decision 2/CMP.6, http://unfccc.int/meetings/ad_hoc_working_groups/kp/items/5896.php). Based on the harvest projections, the pool of HWP in use was calculated, following the approach suggested by FCCC/KP/AWG/2010/CRP.4/Rev.4 (p.31, paragraph 7).

factor of two. In other words, for each tC in wood products that substitute non-wood products, an average GHG emission reduction of 2.1 tC can be expected. The primary reason is that wood products generally require less total energy (in particular fossil fuel consumption) in manufacturing compared to products made from alternative materials. The energy recovery from biomass residues associated with wood products, e.g. wood processing residues, and the use of post-use wood products for energy purposes are also important.

5.2.2.3. Impacts by owner structure

Any positive direct costs of accounting for LULUCF (**Options 2.II and 3**) will mainly be borne by the forest sector. Some 46% of the forest is owned by individuals and families, some 11% is owned by forest industries and private institutions whereas local communities own 2% and the remaining 41% is public ownership (UNECE, 2011). Roughly half of any additional costs incurred for the forest sector (see Table 10) could therefore be borne by individual / family forest owners and 10% by private business entities and institutions (including SMEs and micro-firms), and another 40% by the public sector. Estimates suggest that the number of private forest owners might be around 15 million[36]. The most costly **Option 2.II** with **accounting option (a)** would involve an average additional cost per (private) forest owner of around €2 per year. **Accounting options (b) and (c)** would imply average costs of only some €1 per forest owner per year.

*5.2.3. Monitoring and reporting costs*

The implications of changes in monitoring and reporting requirements need to be assessed in two ways; some impacts stem from the administrative burden of changes in the scope of mandatory accounting and the accounting methods applied, and others relate to the additional efforts required by MSs to reach the objective defined in this impact assessment of reporting according to the IPCC GPG. The costs are the same for Options 2 and 3, although they vary depending on accounting option, and zero for Option 1.

5.2.3.1. Administrative burden of changing the scope and methods of accounting

Some reporting costs would arise as a result of changing the scope and modalities of accounting because the data needs for reporting on land use activities under the KP go beyond those for reporting on land use categories under the UNFCCC. The associated costs largely form part of the impact assessment of revising the Monitoring and Mechanism Decision (208/2004/EC) but are included also here for reasons of transparency, see Table 13.

No additional reporting requirements would be implemented for afforestation, reforestation and deforestation. Today, accounting for forest management is not mandatory, but 17 MSs have already chosen to account for associated emissions and removals. Making this a mandatory activity would involve additional efforts for 10 MSs at a total cost of about €0.4 million per year. Necessary updates of the data on forest management required for accounting options (b) and (c) is expected to be negligible (a total €20 thousand per year) and the mandatory reporting of changes in the HWP pool is estimated to cost roughly €0.3 million per year. There will be additional costs from the introduction of mandatory accounting and reporting of cropland and grazing land management activities in accounting option (c) at

[36] See http://www.micro-fuel.eu/about-the-project

approximately €0.7 million per year. Following the adoption of the 2006 IPCC GPG costs could become higher but are not estimated here.

**Table 13. Administrative burden of additional mandatory reporting requirements (€ million per year for the EU-27)**

| Reporting item | Accounting option (a)<br>*Small changes* | Accounting option (b)*<br>*Likely outcome in the UNFCCC negotiations* | Accounting option (c)*<br>*UNFCCC+* |
|---|---|---|---|
| Report emissions and removals from forest management activities on a mandatory basis | 0.35 | 0.35 | 0.35 |
| Report data on changes in the harvested wood products pool | - | 0.30 | 0.30 |
| Updating of forest management reference levels | - | 0.00 | 0.00 |
| Reporting emissions and removals for cropland and grazing land management | - | - | 0.70* |
| **EU total** | **0.35** | **0.65** | **1.35** |

Note: The cost of reporting items equal to accounting option (a) have been addressed in the impact assessment of the proposal for the revised Monitoring and Mechanism Decision (208/2004/EC) and related Commission Decision (2005/166/EC) and are included here for reasons of transparency. Note that an international agreement is likely generate the same additional administrative burden as accounting option (b). * This estimate is an approximation based on the estimated costs associated with reporting for rewetting and draining on land with organic soils.

Source: European Commission impact assessment of the proposed revision of the Monitoring and Mechanism Decision (208/2004/EC)

#### 5.2.3.2. Implications of improved monitoring and reporting

Whilst additional efforts will be required by MSs to improve the various aspects of monitoring and reporting, it must be noted that the related costs would not be the result of including LULUCF in the EU's GHG emission reduction commitments. MSs are already required to use higher tiers for key categories, corresponding to Steps 1 and 2 of improving monitoring and reporting as outlined in Section 4.3 (as a result of existing reporting obligations and commitments under the UNFCCC and the KP). However, since improvements will generally be required by MSs, estimates of the costs for improving the reporting on soils are presented here and in Annex I by way of illustration.

In tems of the first step, reporting on biomass in forest land is generally complete today, but many MSs do not report on soil in one or two of the sub-categories under forest land, cropland and grassland. Applying tier 1 requires compiling activity data (i.e. area disaggregated by broad climate and soil type and by broad management regime) from different sources in MSs and / or from European initiatives such as LUCAS[37] and CORINE

[37] The Land Use/Cover Area frame statistical Survey. The name reflects the methodology used to collect the information. Estimates of the area occupied by different land use or land cover types are computed on the basis of observations taken at more than 250 000 sample points throughout the EU rather than mapping the entire area under investigation. By repeating the survey every few years, changes to land use and land management can be identified (see

for recent years, to be combined with IPCC default values for carbon stock and stock changes. Some MS still have difficulties in tracking the history of land over time in order to calculate land conversion. While the effort needed to improve the completeness for mineral soils can be assumed to be reasonable, it must be understood that tier 1 reporting provides limited information about the effects of mitigation measures. On organic soils, and for land conversion, higher tiers need to be applied. However, as organic soils only make up 2% of the total surface, the additional efforts should be limited. This first essential step could be taken rather swiftly.

As regards the second step, MSs such as Sweden, the UK, Denmark, Finland and Germany, already apply high level tiers to the soil pool in all land categories, but most MSs use tier 1 or do not report at all on soil in at least one of the land categories. There is also a need for improved reporting on dead organic matter in forest land, although the significance varies and, in cropland and grassland, simpler methods are acceptable also under tier 2 (IPCC, 2003). Country-specific data are generally available in the EU-15, but less so for the EU-12. Finally, additional efforts may be needed for measuring stock changes in perennial vegetation in cropland and grassland. Data needed to calculate the soil emissions factors could be collected e.g. through repeated soil sampling campaigns in order to capture the annual rates of emissions and removals. Substantial work has already been carried out for the proposal of a European Soil Framework Directive and shows that there is capacity to build on (see e.g. Kibblewhite et al., 2008; Hiederer et al., 2011, EC, 2003). Activity data would have to be collected making use of existing data sources (IACS, FSS, FADN, crop statistics). More work is required to integrate existing data on soil types (e.g. EU soil map, LUCAS, national land surveys) with activity data on field management.

Annex I provides estimates of soil sampling costs resulting from the calculation of country-specific emission factors for soil, equivalent to Steps 1 and 2. However, the required frequency and scope of soil sampling will vary across MSs. If, for the purpose of GHG inventories, emission factors are developed through targeted research and combined with modelling tools, soil sampling will play the role of verifying, improving and calibrating the estimated data. Other methods, including eddy covariance measurements (used e.g. in CarboEurope) and chronosequencing[38] can contribute in providing the necessary inputs.

If all MSs require investments in soil monitoring to move to country specific data in reporting, the annual cost for the EU-27 are expected to amount to between €0.5-2.1 million per year using a sampling interval of eight years (which corresponds to the commitment period of 2013-20). However, and as shown in Table A1.10 in Annex I, a number of MSs already use country-specific data which means that the cost is likely to be lower, between €0.4-0.5 million per year at the EU level.

Arrouays et al. (2008) estimated the number of additional sampling sites needed to detect a relative decrease of 5% in soil organic carbon. If the same cost assumptions are applied to their estimate, the resulting costs would be €0.9-1.2 million per year, i.e. about double the

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http://epp.eurostat.ec.europa.eu/portal/page/portal/lucas/introduction for further information). In 2009, the survey was extended to include soil sampling on 22 000 sites across the Union.

38 Defined by IPCC (2003) as "…consisting of measurements taken from similar but separate locations that represent a temporal sequence in land use or management, for example, years since deforestation. Efforts are made to control all other between-site differences (e.g., by selecting areas with similar soil type, topography, previous vegetation). Chronosequences are often used as a surrogate for experimental studies or measurements repeated over time at the same location."

costs compared to the most conservative baseline assumption. On the other hand, a soil sampling campaign was carried out under LUCAS[39] in 2009 at an additional (soil-sampling specific) cost of only €1.2 million (or €0.2 million per year) which is much lower than any of the estimates given above. This shows that there are significant potential cost savings through the use of coordinated and systematic schemes. Although costs will vary between MSs and with the methods applied, the above estimates provide a cost interval with an average of €1.1 million per year of the additional investments required in MSs. The costs also depend vey nuch on the parameteres assessed and the depth of soil sampling. LUCAS was restricted to 0-30 cm and a reduced number of parameters. For example soil bulk density was not included which accounts for as sizeable part of the costs of soil survey. However, the parameters assessed may be sufficient for the purpose since change in soil carbon may only occur in the layer addressed for the time frame. On top of meeting the IPCC GPG standards, additional efforts to harmonise monitoring and reporting in the EU should be promoted (Step 3). It has not been possible to estimate the associated costs at this stage.

## 5.3. Social implications

In this section the social implications of Options 2.II and 3 are examined in terms of impacts on employment and the distribution of costs and cost savings (or revenues) over the MSs. Option 2.I is formulated such that the results of accounting are treated as a memo item to the EU's current overall GHG reduction target and there are therefore no distributional costs of this option. Similarly, costs are zero for Option 1.

### *5.3.1. Costs by Member States*

#### 5.3.1.1. Option 2.II – Separate framework with mitigation targets

In **Option 2.II** the distribution of cost per MS depends on the estimated mitigation potential. The target for each country is set on the assumption that all countries would face the same marginal costs of €5 per $tCO_2$. This is then translated into an amount to be reduced by each country over and above the credits generated in the reference scenario. The total amount to be reduced is some 5 $MtCO_2$ at the EU level on top of the credits generated in the reference scenario. It should be noted that uncertainties on the expected costs per MS are larger than uncertainties at the EU level.

Under **accounting option (a)** reductions from forest management are discounted by 85%. This means that more real reductions (around 14 Mt) are needed to meet the accounting target of around 5 $MtCO_2$ and this generates a higher carbon price of around €12 per $tCO_2$. Consequently, overall costs for the EU (€40 million per year in 2020) and for MSs are higher here than in the other accounting options. The illustrative targets are based on the mitigation potential at a given carbon price. The largest absolute costs would fall on the following MSs: Finland, Bulgaria, Rumania, Estonia, France and Italy (see Table A4.6 in Annex IV). Under **accounting options (b) and (c)** the total cost for the EU would be smaller at about €27 million in 2020. Most of the costs would fall on Finland, Bulgaria, Estonia, France and Italy (see Table A4.6).

[39] During the 2009 survey, soil samples were collected from more than 22 000 LUCAS point locations.

5.3.1.2. Option 3 – LULUCF included in the ESD

In Option 3 all MSs benefit from a reduction in the cost of meeting the ESD targets but some MSs benefit more than others. This is because there are net credits at an EU level that reduce the need to cut emissions for sectors covered by the ESD. In this case it is assumed that the price of ESD transfers is not fixed at €5.3 per $tCO_2$ (as expected to meet the agreed ESD targets) but is lowered for two reasons: the net LULUCF credits at EU level that lower total demand for emission reductions and the marginal costs and the additional supply of LULUCF sink enhancement measures induced by a positive carbon price in that sector. This is particularly relevant for **accounting option (a)** where credits are high (50% of the emission reduction needed in the ESD sectors in 2020, and 90% of the accumulated emission reduction over the period 2013-20) and the ESD price is reduced to less than €0.3 per $tCO_2$ in 2020 in the ESD sector. Total cost savings are estimated at €166 million, see Table A4.6 in Annex IV for MS results. Note that some MSs face additional costs since they have net debits rather than credits. Under **accounting option (c)** the net LULUCF credits are limited compared to the total reduction required under the ESD (around 10% of the reduction effort in 2020, and 15% of the accumulated emission reduction) so the impact on the carbon price and MSs abatement efforts is smaller. The costs savings of **accounting option (b)** are in between options (a) and (c).

*5.3.2. Employment*

Since the costs of the policy options are negligible in terms of share of GDP (see Table 9) the overall impacts on employment will be very small as well. Under **Option 2.II** combined with **accounting option (a)** costs are the highest and this is expected to lead to a loss of timber production in the EU in the forest sector of around 0.1%. For the two **other accounting options** output changes are even smaller at about 0.01-0.02%. Calculations (based on Eurostat (2009; p.37) show that **Option 2.II combined with accounting option (a)** could lead to a direct loss of some 175 (full-time) jobs in forestry. For **accounting options (b) and (c)** direct jobs losses are estimated at around 125 jobs.

However, any job losses will also be (partially) compensated by the additional demand for labour related to changes in forest management (e.g. increased thinning) to enhance the carbon sink. Based on the share of labour costs in forest management costs and the labour costs per person the number of jobs created in forest management could be around 210 for **Option 2.II** combined with **accounting option (a)** and around 180 for **accounting options (b) and (c)**. Whilst uncertainties are big, the assessment suggests that the overall impact on employment are very small and may be positive or neutral. For **Option 3** there could be job increases since costs are reduced in agriculture and other ESD sectors. Based on the analysis carried of options to move beyond 20% greenhouse reductions one can estimate the possible impacts.[40] Stepping up to 25% would entail additional cost of €33 billion and could create 160000 jobs or reduce 160000 jobs depending on how tax revenues would be used. Option 3 would reduce these costs by respectively 166 million in **accounting (a)**, 55 million (**option b**) and 156 million (**option c**), see Table 9. Depending on how tax revenues changes are used the number of (net) jobs by around 800, 760 or by around 270 jobs respectively. The impacts are hence very small.

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40 CEC (2010) Analysis of options to move beyond 20% greenhouse emission reductions and assessing the risk of carbon leakage, background information and analysis. Part II (COM (2010) 265) final. See page 46 and page 55 i.e.

## 6. COMPARING THE OPTIONS

This section provides a comparison of the extent to which the different options answer to the problem definition and operational objectives. The impact assessment shows how accounting for LULUCF can enhance the environmental integrity, policy coherence and economic efficiency of the EU's GHG emission reduction commitments, as defined in the problem definition.

### *6.1.1. Choosing the right policy context*

The analysis shows that only two broad options would meet the overall objective set out by the European Council and Parliament that all sectors should contribute to the EU's overall GHG reduction commitment; namely the inclusion of LULUCF in the EU's GHG reduction commitment via a separate framework (**Option 2**) or though the ESD (**Option 3**). The environmental, economic and social impacts of the options differ largely depending on the accounting rules applied, as shown in Section 5.

The objective to limit the impact of the high inter-annual variability of emissions and removals in LULUCF and their inherent reversibility on compliance poses an important challenge for the inclusion in the policy frameworks that currently regulate the EU's reduction targets. The ESD (**Option 3**) is based on annual compliance and requires MSs to decrease (or limit increases in) emissions according to a linear trajectory. This is a key feature to ensure that the targets are met in 2020 and to limit the cumulative emissions in the commitment period. However, there is a significant compliance risk associated with applying this approach to LULUCF. Annual compliance would be difficult to apply where, over the period 1990 to 2008, many MSs experienced variability in net emission between two adjacent years of around 20% (Sweden, Austria and Portugal), 40% (Finland), 50% (Latvia) or 60% (Estonia) compared to their total ESD emissions in 2008. This and the frequent and significant recalculations of reported data clearly pose a challenge for annual compliance with a linear trajectory and would in many cases greatly exceed the flexibilities of the ESD. In addition, the long lead-time of many measures in LULUCF means that annual accounting is not as meaningful as in other sectors, and a linear trajectory with required emission reductions each year will generally not be relevant. **Option 2** (a separate framework) would be able to address these issues by averaging emissions and removals over the commitment period and therefore meet the objective related to inter-annual variability. Another issue to note associated with **Option 3**, particularly as long as the EU's emission reduction target remains at 20%, is that the inclusion of LULUCF would reduce the agreed efforts for the sectors that are already part of the existing commitments and so effectively reduce the EU's commitment. **Option 2** would avoid this issue.Ensuring robust accounting.

The objectives of accounting are to ensure an extensive coverage of emissions and removals, thereby providing a level playing field between mitigation options, and to ensure that non-permanence is reflected in accounting and to prevent large natural disturbances from negatively affecting the compliance risk of MSs. Three options were considered to meet the objectives: (a) small changes to the rules under the KP's first commitment period, (b) rules which correspond to the expected outcome in the UNFCCC negotiations, and (c) rules which correspond to the expected outcome of the UNFCCC but with an improved scope of the emissions and removals accounted for. Table 14 provides a summary assessment of the extent to which the different accounting options meet the objectives.

**Table 14. Performance of the different accounting options**

| Objectives | Extent to which the objectives are met by the different accounting options | | |
|---|---|---|---|
| | **Accounting option (a)**<br>*Small changes* | **Accounting option (b)**<br>*Likely outcome in the UNFCCC negotiations* | **Accounting option (c)**<br>*UNFCCC+* |
| Provide a level playing field between different mitigation options | X | ● | ●● |
| Ensure extensive coverage of emissions and removals | ● | ● | ●● |
| Ensure that non-permanence is reflected in accounting | X | ● | ●● |
| Prevent large natural disturbances from negatively affecting the compliance risk of MSs | ● | ●● | ●● |

Notation key: x Objective not or insufficiently addressed by option, ● Objective partially addressed by option, ●● Objective sufficiently addressed by option

As regards providing a level playing field between different mitigation options, the most important activity is forest management. This is treated differently in the different accounting options. Table 5 shows that **accounting option (a)** generates substantial credits, about 80 $MtCO_2$ per year between 2013 and 2020. These are largely a "windfall" (free) as they include removals that would have occurred without any change in management activities. Any mitigation efforts will be discounted by 85% and this will make mitigation very expensive and so limit incentives for additional mitigation efforts. It would also allow for substantial decreases in net removals and increases in net emissions without any real economic impacts. Finally, it would not meet the objective of ensuring that non-permanence is reflected in accounting because no emissions and removals related to agricultural activities, and only a fraction of those related to forest management, will be accounted.

**Accounting options (b) and (c)** allow for a change in the sink due to natural saturation and existing policies without generating debits or credits. They do so to factor out changes in emissions and removals that are not human-induced. However, for forest management they require full accounting for any deviations from the "reference level". In practice, this means that in the reference scenario all abatement options and uses, whether sequestration or additional use of biomass for energy production (e.g. for reaching the RES-D targets) or material substitution, will face the same opportunity cost and this will ensure a level playing field between different mitigation options. In line with the agreement in Durban is the cap on credits from forest managment. An additional dimension to accounting for forest management is to put a quantitative limitation ("cap") on the emissions and removals accounted. The cap limits the undue benefits (credits) related to the uncertainty associated with the projections which underpin the "reference levels". Annex II describes the impact on accounting of the cap on credits of 3.5% agreed in Durban.

In terms of ensuring extensive coverage of emissions and removals in accounting and that non-permanence is reflected in accounting, only **accounting option (c)** requires MSs to account for emissions and removals in both agriculture and forestry on a mandatory basis whereas both accounting options (a) and (b) allow accounting for agriculture to be voluntary. Voluntary accounting may put the credibility of the EU's commitment at risk as the choice of which activity to account for can be perceived as opportunistic. A wider scope of accounting would increase the consistency between MSs as some account for these activities under the first commitment period of the KP and others not. It is important that all sectors in all MSs are recognised as contributing to reaching the targets of the "Europe 2020" strategy, both to secure a level playing field for business and MSs and a fair distribution of efforts, and to ensure a consistent treatment of agriculture, forestry and industry within the EU's internal market, i.e. to provide a level playing field. In the longer term, a more inclusive accounting would also be conducive to increasing the cost-efficiency in reaching any given overall target.

As regards the objective of reducing the impact of natural disturbances on compliance risk, **accounting options (b) and (c)** would include provisions for accounting for large natural disturbances and so limit the risk of non-compliance with GHG reduction targets if emissions occur as a result of large natural disturbances which are beyond the control of MSs. Annex II provides more details on the effects on accounting of different thresholds for excluding emissions from accounting. However, the application of the provisions is likely to be limited to a handful of MSs and to have only a small impact on accounting for the EU as a whole. If the emissions beyond 5% of the total emissions of a MS in 1990 were to be used the impact on the EU's overall accounting would be negligible whilst at the same time provide the necessary safeguards for those MSs most affected (in particular Portugal).

### *6.1.2. Improving monitoring and reporting*

This impact assessment outlines a three-step approach to meet the objective of ensuring that monitoring and reporting comply with IPCC methodological guidance. A first step would involve achieving complete reporting using at least simple methodologies. This first essential step could be taken rather swiftly. A second step would mean increasing the accuracy of the reported data using more sophisticated methods. Essential progress is expected during the first commitment period of the KP but efforts will have to continue also during the commitment period 2013-20. Lastly, further improvements of the comparability between MSs can be achieved by harmonising monitoring, reporting and related nomenclature. Although important steps towards harmonisation have already been taken and is part of compliance with the IPCC guidelines (steps 1 and 2), further efforts will be required over the next commitment period.

The above steps would essentially form part of the Commission's proposal for a revised Monitoring Mechanism Decision, see separate proposal and impact assessment, but are included here for illustrational purposes. It should be noted also that MSs are generally obliged to take the first two steps as part of their commitments under the UNFCCC and the KP and the cost of introducing the requirements in EU legislation are therefore close to zero. This said, further improvements are generally needed in MSs but could be achieved at low costs. Changes in the scope and methods of accounting would however generate additional but small administrative / reporting costs, estimated at approximately €0.4 million to €1.4 million per year for the EU as a whole, with the more extensive **accounting option (c)** at the upper end of the interval.

## 6.2. Concluding comments

There were two important reasons for initially leaving LULUCF out of the EU's climate change commitments. Firstly, the deficiencies of existing accounting rules under the KP needed to be addressed. Secondly, the expectation was that the Copenhagen world climate summit in 2009 would deliver an international agreement on climate change, including revised accounting rules for LULUCF which could then be adopted by the EU. This did not happen, and despite the progress achieved through the Copenhagen Accord and the Cancun

Agreements there is still not an agreement in place. It is clear that the views of both developed and developing countries are converging and there is widespread support for the EU's favoured options on the key remaining issues. But LULUCF is only one part of wider and very complex discussions. As a result, an accounting framework for LULUCF risks being further delayed.

There are good reasons to include LULUCF in the EU's GHG emission reduction commitments to improve the policy coherence, environmental integrity and economic efficiency of the EU's GHG emission reduction commitment. But the inclusion requires that the special features of LULUCF and circumstances of MSs are suitably addressed. It is therefore important to ensure that robust accounting rules and monitoring and reporting are in place.

In terms of accounting, **accounting option (c)** involves inclusive accounting of emissions and removals from both forestry and agricultural activities and gives equal weight to mitigation efforts whether undertaken in the forestry, agriculture, industry or energy sectors. This is conducive to cost-efficiency and will ensure a level playing field for both MSs and the different sectors of the EU's internal market. It will also provide a framework in which mitigation efforts by farmers and foresters and industry are incentivised, visible and correctly reflected. A wide coverage of emissions and removal will also ensure that potential reversals are reflected in accounting.

Monitoring and reporting needs to be improved in support of the accounting framework and of indicators for progress in agriculture and forestry. The Commission proposes to achieve this through separate legislation, i.e. a revision of the Monitoring Mechanism Decision. For reasons of both comparability and cost-efficiency, better use should be made of EU wide monitoring instruments such as LUCAS and CORINE.

Robust accounting and monitoring are important steps, but not sufficient. For strong incentives to be provided, the results of efforts by sectors need to count towards the EU's GHG emission reduction commitments. This will only be possible if the right policy context for LULUCF is established. The high variability of emissions and removals in forests means that annual emissions reduction targets that apply to other sectors are unsuitable. The long lead times needed for mitigation measures to take effect also set LULUCF apart from most other sectors. The results of this impact assessment suggest that a separate framework would be best suited to address the special circumstances of LULUCF.

However, the EU has already committed to reducing greenhouse gas emissions by 20% by 2020 compared to 1990 through efforts in other sectors and is on track to reach that commitment without the contribution of LULUCF. Before the level of ambition is increased beyond 20% conditions need to be right. The sector should therefore be formally included in the target only once the EU decides to increase the level of ambition (**Option 2.I**). This does not mean that mitigation action should be put on hold. National action plans could be prepared to provide a strategy and outlook for LULUCF as well as an intermediate step towards the full inclusion of the sector and its integration with current policies.

## 7. MONITORING AND EVALUATION

Reporting will be reviewed and monitoring will be carried out as part of the existing requirements and arrangements under the UNFCCC and successor to the KP in terms of:

- Completeness, accuracy and consistency of monitoring and reporting (in line with the relevant IPCC methodological guidance),
- The correct application of accounting rules

As appropriate, monitoring and evaluation will also be ensured through the proposed amendments of the Monitoring Mechanism Decision (280/2004/EC) and related Commission Decision (2005/166/EC).

# 8. ANNEXES

## 8.1. Annex I – Monitoring, reporting and verification

With the exception of Section 8.2.8, this Annex has been authored by the Joint Research Centre and is referred to in the main text as JRC (2011a).

### *8.1.1. Introduction*

The following text presents an overview of the status of monitoring, reporting and verification of GHGs in LULUCF in the EU-27,[41] By *monitoring* is meant activities that are carried out to estimate emissions and removals, by *reporting* the inclusion of information collected during the monitoring phase in the national annual GHG inventory[42], and by *verification* the comparison of the emissions/removals estimates reported in the GHG inventory with estimates derived from independent assessments. The assessment focuses on four aspects of monitoring and reporting, namely completeness of land categories/activities and carbon pools reported, accuracy of estimates, consistency of estimates over time and comparability of estimates among MSs. A brief discussion on existing verification activities is also provided. A more detailed compilation of data from the UNFCCC and KP reporting can be found in the annual European Union greenhouse gas inventory 1990 – 2008 and inventory report 2010 (http://www.eea.europa.eu/publications) and in the JRC LULUCF tool (http://afoludata.jrc.ec.europa.eu/index.php/models/detail/7).

### *8.1.2. Completeness*

#### 8.1.2.1. Convention reporting

Reporting under the convention is mandatory for the land categories for which IPCC GPG exists, i.e. forest land, cropland and grassland, and all land use changes (for all land categories). According to IPCC GPG-LULUCF, emissions and removals from key categories[43] should be estimated with higher-tiers methods (i.e. tier 2 or 3) [44]. Table A1.1

41 Based on the 2010 GHG inventories submitted to UNFCCC. Note that Cyprus and Malta are not yet Annex-I countries and thus do not submit GHG inventories to UNFCCC. The information collected here for these countries come from the GHG reporting under the EU monitoring mechanism.

42 The GHG inventory includes the Common Reporting Format (CRF) tables, containing the estimates of emissions/removals, and the National Inventory Report (NIR), containing the description of how the estimates were obtained along with other information (e.g., on uncertainties, QA/QC, time-series consistency, recalculations, verification, etc.).

43 The IPCC's GPG and Uncertainty Management in National Greenhouse Gas Inventories (IPCC GPG, 2000) identifies a key category as “one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of the

gives a detailed account of the reporting requirements associated with land use categories, either with tier 1 or tier 2 methods. It should, however, be noted that Cyprus and Malta are not part of Annex I to the Convention and therefore not obliged to report in the same way. It is therefore relevant to discuss the 25 MSs that are obliged to report.

Table A1.2 shows reported emissions (E) and removals (R) as well as the key categories (shaded cells) for the three main UNFCCC land categories ("wetlands", "settlements" and "other" have been omitted). Reporting by the 25 MS obliged to report under the UNFCCC for the various land and sub categories shows complete coverage for forest remaining forest and nearly complete coverage (24 MS) for land converted to forest. Coverage is reasonably good also for cropland (22 MS reported cropland remaining cropland and 18 MS land converted to cropland) and grassland (corresponding numbers are 18 and 22). Whilst the coverage of categories was significantly improved in 2008, especially for land use changes, likely due to the first reporting under the KP, there are still some gaps in the reporting of mandatory categories.

Table A1.3 shows reported emissions (E) and removals (R) by carbon pools[45]. Note that in some cases the assumption of no C stock change is allowed by IPCC [46]. Reporting for biomass is by far the most complete across land categories, in particular for forest land, and less so for soil and dead organic matter. However, for grasslands soils are more important and this is reflected in reporting. Most of the EU-12 reported less sub-categories and pools than the EU-15 MS. This difference is not only because of lack of national data, but also because

absolute level of emissions, the trend in emissions, or both". The approaches to determine key categories in LULUCF are described in Chapter 5.4 of IPCC GPG-LULUCF. In the context of the Kyoto Protocol, each activity under Articles 3.3 and 3.4 (if elected) is a category. Furthermore, it is good practice to evaluate possible further disaggregation into subcategories (e.g. forest land converted to cropland) for purposes of choosing appropriate methods and prioritizing resources. In this regard, it is good practice to identify any subcategory as "key" if it accounts for 25-30% of the overall emissions or removals of the corresponding category.

44 For each C pool, IPCC GPG-LULUCF provides methods according to 3 Tiers of increasing complexity and certainty in estimates.

45 Under the Convention reporting the C pools to be reported are: Living Biomass (above- and below-ground), Dead Organic Matter (DOM, including litter and dead wood) and Soil (including mineral and organic soils).

46 IPCC GPG-LULUCF assumes no change in C stocks for the following cases: (i) Tier 1 for DOM and mineral soils in FLrFL, for DOM in LcFL, and for Biomass in GLrGL; (ii) Tier 1 and 2 for DOM in CLrCL and GLrGL. See table A1.1 for more details.

of lack of resources for processing the existing data (e.g. available from national statistics) and to adapt and develop it according to the UNFCCC/IPCC reporting needs.

**Table A1.1 Mandatory categories and carbon pools to be reported under the Convention, using tier 1 or tier 2 methods (tier 2 is mandatory if the category is "key category")**

| | | TIER 1 | Forest land | | Cropland | | Grassland | | Wetlands | | Settlement | | Other land | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FLrFL | LcFL | CLrCL | LcCL | GLrGL | LcGL | WLrWL | LcWL | SLrSL | LcSL | OLrOL | LcOL |
| TIER 1 | LB | AB | Y | Y | Y[1] | Y[2] | | Y[2] | | Y[2] | | Y[2] | | Y[2] |
| | | BB | | Y | | Y[2] | | Y[2] | | Y[2] | | Y[2] | | Y[2] |
| | DOM | DW | | | | X[2] | | X[2] | | | | | | |
| | | L | | | | X[2] | | X[2] | | | | | | |
| | SOM | mineral | | Y | Y | Y | Y | Y | | Y | | | | Y[3] |
| | | organic | Y | Y | Y | Y | Y | Y | | Y | | | | |
| | $CO_2$ | liming | | | Y | Y | Y | Y | | | | | | |
| | $N_2O$ | fertilization | | | T[4] | [4] | [4] | [4] | | | | | | |
| | | conversion | | | | Y | | Y | | | | | | |
| | | drainage | Y | Y | [4] | [4] | [4] | [4] | | | | | | |
| | | fires | Y | Y | [4] | [4] | Y[5] | Y[5] | | | | | | |
| | $CH_4$ | fires | Y | Y | [4] | [4] | Y[5] | Y[5] | | | | | | |
| TIER 2 | LB | AB | Y | Y | Y[1] | Y | Y | Y | | Y | | Y | | Y |
| | | BB | Y | Y | | Y | Y | Y | | Y | | Y | | Y |
| | DOM | DW | Y | Y | | X[2] | | X[2] | | | | | | |
| | | L | Y | Y | | X[2] | | X[2] | | | | | | |
| | SOM | mineral | Y | Y | Y | Y | Y | Y | | Y | | | | Y |
| | | organic | Y | Y | Y | Y | Y | Y | | Y | | | | |
| | $CO_2$ | liming | | | Y | Y | Y | Y | | | | | | |
| | $N_2O$ | fertilization | Y | Y | [4] | [4] | [4] | [4] | | | | | | |
| | | conversion | | | | Y | | Y | | | | | | |
| | | drainage | | | [4] | [4] | [4] | [4] | | | | | | |
| | | fires | Y | Y | [4] | [4] | Y[5] | Y[5] | | | | | | |
| | $CH_4$ | fires | Y | Y | [4] | [4] | Y[5] | Y[5] | | | | | | |

Notation keys:

FLrFL: forest land remain forest land; LcFL: land converted to forest land (and so on for the other categories)

| | |
|---|---|
| LB | Living biomass (AB: Above ground biomass; BB: Below ground biomass) |
| DOM | Dead organic matter (DW: Dead wood; L: Litter) |
| SOM | Soil organic matter |
| Y | Mandatory |
| X | To be mandatorily reported only in the conversion year (from forest) |
| blank | Non mandatory (or IPCC assumes no change in carbon stock) |
| 1 | Perennial woody crops, only |
| 2 | To be reported as instantaneously oxidized in the year of conversion |
| 3 | To be reported fully oxidized in conversion |
| 4 | To be reported under the agriculture sector |
| 5 | Savanna burning shall be reported under the agriculture sector |

**Table A1.2. Completeness of reporting in each MS by land use categories (data for the year 2008, from the GHG inventory 2010). In each land use category, first column (e.g. F-F) identifies a land remaining in the same category, while second column (e.g. L-F) identifies a land converted to a new category.**

| | Reporting category | | | | | |
|---|---|---|---|---|---|---|
| | Forest land | | Cropland | | Grassland | |
| | 5.A.1. | 5.A.2. | 5.B.1. | 5.B.2. | 5.C.1. | 5.C.2. |
| Party | FLrFL | LcFL | CLrCL | LcCL | GLrGL | LcGL |
| Austria | R | R | R | E | R | E |
| Belgium | R | R | E | E | E | E |
| Denmark | E | E | E | R | E | E |
| Finland | R | E | E | E | E | R |
| France | R | R | | R | | R |
| Germany | R | R | E | R | E | R |
| Greece | R | R | R | | | |
| Ireland | R | E | R | E | E | R |
| Italy | R | R | R | | R | R |
| Luxembourg | R | R | E | E | | E |
| Netherlands | R | R | | E | E | E |
| Portugal | R | R | R | E | | R |
| Spain | R | R | R | | | R |
| Sweden | R | R | E | E | R | R |
| UK | R | R | E | E | E | R |
| Bulgaria | R | R | E | E | | R |
| Cyprus | R | | | | | |
| Czech Rep. | R | R | R | E | R | R |
| Estonia | R | R | E | E | R | R |
| Hungary | R | R | R | E | E | R |
| Latvia | R | R | E | E | E | |
| Lithuania | R | R | | | | |
| Malta | R | | R | | | |
| Poland | R | R | E | | E | R |
| Romania | R | | | | | |
| Slovakia | R | R | R | E | | R |
| Slovenia | R | R | E | E | E | E |

Notation key: R= Removals, E = Emissions. The first column of each category denotes land remaining in the same land category whereas the second column denotes land converted to that land category. Shaded area indicates that the category is a key category. Note that Cyprus and Malta do not have the same reporting obligations under the UNFCCC.

**Table A1.3. Completeness of reporting in each MS by pools for main land use categories (data for the year 2008, from the GHG inventory 2010). For transparency, the soil pool is separated into mineral and organic soil.**

| | Forest land | | | | | | | | Cropland | | | | | | | | Grassland | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FL-FL | | | | L-FL | | | | CL-CL | | | | L-CL | | | | GL-GL | | | | L-GL | | | |
| | Biomass | DOM | SOM Min | SOM Org | Biomass | DOM | SOM Min | SOM Org | Biomass | DOM | SOM Min | SOM Org | Biomass | DOM | SOM Min | SOM Org | Biomass | DOM | SOM Min | SOM Org | Biomass | DOM | SOM Min | SOM Org |
| **AT** | R | R | | | R | R | R | | E | | R | | R | E | E | | | | R | ie | E | E | E | |
| **BE** | R | R | R | | R | | R | | | | E | | E | | E | | | | E | | E | | E | |
| **DK** | R | E | | E | E | R | E | E | E | | R | E | R | E | R | ie | E | | E | E | E | E | R | E |
| **FI** | R | ie | R | E | R | ie | E | E | R | | R | E | R | R | E | E | | | R | E | R | R | R | E |
| **FR** | R | R | | | R | R | R | | | | | | R | R | R | | | | | | E | E | R | |
| **DE** | R | R | | E | R | R | R | E | R | ie | R | E | R | R | R | E | R | ie | | E | R | ie | R | E |
| **GR** | R | | | | R | | | | R | | R | E | ie | | | | | | | | | | | |
| **IE** | R | R | | R | E | R | E | R | | | R | | | | E | | | | | E | R | | R | E |
| **IT** | R | R | R | | R | R | R | | R | R | R | E | | | | | R | R | R | | E | | R | |
| **LU** | R | | | | R | | R | | E | | | | E | E | E | | | | | | E | E | R | |
| **NL** | R | R | | | R | | | | | | | ie | E | E | | | | | | E | E | E | | |
| **PT** | R | E | R | | R | E | R | | R | E | E | | E | E | E | | | | | | E | E | R | |
| **ES** | R | | | | R | | R | | R | | R | | | | | | | | | | | | R | |
| **SE** | R | R | R | E | R | R | R | E | R | E | E | E | E | E | E | E | R | R | R | E | R | E | R | E |
| **UK** | R | R | R | R | R | R | R | R | R | | Ie | E | E | ie | E | ie | | | | | E | ie | R | ie |
| **BG** | R | | | | R | | E | | E | ie | R | | R | | E | | | | | | E | | R | |
| **CY** | R | | | | | | | | | | | | | | | | | | | | | | | |
| **CZ** | R | | | | R | | R | | R | | R | | E | E | E | | | | R | | E | E | R | |
| **EE** | R | R | | E | R | ie | | E | | | | E | | | | E | R | E | | E | R | | | E |
| **HU** | R | | | | R | | | | E | | R | | R | ie | E | | | | E | | R | ie | R | |
| **LV** | R | | | E | R | | | E | | | | E | ie | E | | ie | | | | E | | | | ie |
| **LT** | R | R | R | E | R | | | | | | | | | | | | | | | | | | | |
| **MT** | R | | | | | | | | R | | | | | | | | | | | | | | | |
| **PL** | R | | R | | R | R | R | | R | R | E | E | | | | | | R | | E | | R | | |
| **RO** | R | | | | | | | | | | | | | | | | | | | | | | | |
| **SK** | R | | | | R | | R | | R | | | | E | E | E | | | | | | R | E | R | |
| **SI** | R | R | | | R | R | R | | R | | E | E | E | | E | | | | | E | E | | R | |

R, E - carbon pools changes result in either Removal or Emissions; "ie" means "included elsewhere"; empty cells show either "not estimated" (reported in CRF as "NE" alone or in combination with other keys), assumed as "no C stock change" (following IPCC tier 1), or assumed as "not occuring" (notation keys used "NO" and/or "NA")

### 8.1.2.2. Kyoto Protocol reporting

Table A1.4 shows activities accounted for by MSs and key categories for the EU-25. Reporting and accounting of LULUCF eligible activitites are mandatory for afforestation and reforestation (AR) and deforestation (D) under Art 3.3, and optional for forest management (FM), cropland management (CM), grazing land management (GM) and revegetation (RV) under Art 3.4. Forest activities, in particular AR and FM, are key categories for most MSs.

**Table A1.4 Activities accounted for by MSs (white cells) and key categories (K)**

| Member State | AR | D | FM | CM | GM | RV |
|---|---|---|---|---|---|---|
| Austria | K | K | | | | |
| Belgium | | | | | | |
| Denmark | K | | K | K | | |
| Finland | K | K | K | | | |
| France | - | - | - | | | |
| Germany | K | K | K | | | |
| Greece | K | | K | | | |
| Ireland | K | | | | | |
| Italy | | | K | | | |
| Luxembourg | | | | | | |
| Netherlands | K | K | | | | |
| Portugal | K | K | K | K | | |
| Spain | K | | K | K | | |
| Sweden | | | K | | | |
| UK | K | K | K | | | |
| Bulgaria | K | | | | | |
| Czech Republic | | | K | | | |
| Estonia | K | K | | | | |
| Hungary | K | | K | | | |
| Latvia | K | | K | | | |
| Lithuania | | | | | | |
| Poland | K | K | K | | | |
| Romania | | | | | | |
| Slovakia | K | K | | | | |
| Slovenia | | | K | | | |

All MSs except one reported on all mandatory activities, and all but two reported on elected voluntary activities. In general, biomass carbon stock changes are directly estimated whereas the three other pools are frequently included elsewhere (IE) or not reported (NR). Under the KP, a country must always provide transparent and verifiable information that any non-reported pool, for mandatory and elected activities, is not a source (in which case the notation key NR should be used). Although most MSs reported most of the carbon pools, the completeness of reporting will need to improve in subsequent inventories.

The supplementary reporting required under the KP as compared to the Convention reporting was submitted for the first time in 2010 (for the first year of the commitment period 2008-12) and, inevitably, certain areas were problematic the first time around. The expert reviews show that the key difficulties appear to be to provide information which demonstrates that:

- units of lands are identifiable (i.e. that relevant *units of land* or *lands* are precisely identified and can be traced in the future)
- non-reported pools (SOM, DOM) are not sources
- afforestation/reforestation activities are of a direct, human-induced nature

See Appendix 1 to this Annex and the Annual European Union GHG inventory 1990 – 2008 and inventory report 2010 (Technical report No 6/2010) for more information.

**Table A1.5. Completeness on reporting pools on KP forest activities**

| | Aff/Reforestation | | | | | Deforestation | | | | | Forest management | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Change in Cpool reported | | | | | Change in Cpool reported | | | | | Change in Cpool reported | | | | |
| | Above-ground biomass | Below-ground biomass | Litter | Dead wood | Soil | Above-ground biomass | Below-ground biomass | Litter | Dead wood | Soil | Above-ground biomass | Below-ground biomass | Litter | Dead wood | Soil |
| Austria | R | R | IE | NO | R | R | R | IE | IE | R | NA | NA | NA | NA | NA |
| Belgium | R | R | R | NR | R | R | R | R | R | R | NA | NA | NA | NA | NA |
| Denmark | R,R | R,R | R,IE | R,R | R,NR | R,NO | R,NO | R,NO | R,NO | R,NO | R,R | R,R | R,IE | R,R | R,NR |
| Finland | R | IE | IE | IE | R | R | IE | IE | IE | R | R | IE | IE | IE | R |
| France | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| Germany | R | R | R | NO | R | R | R | R | R | R | R | R | NO | R | R |
| Greece | R | R | NR | NR | NR | R | R | NR | NR | NR | R | R | NR | NR | NR |
| Ireland | R | R | R | R | R | R | R | R | R | R | NA | NA | NA | NA | NA |
| Italy | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| Luxemburg | R | IE | IE | NO | R | R | IE | IE | R | R | NA | NA | NA | NA | NA |
| Netherlands | R | R | NR | NR | NR | R | R | R | R | NR | NA | NA | NA | NA | NA |
| Portugal | R | R | NE | NE | NE | R | R | NE | NE | NE | R | R | NR | NR | NR |
| Spain | R | R | NR | NR | NR | R | IE | NR | NR | NR | R | IE | NR | NR | NR |
| Sweden | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| United Kingdom | R | IE | R | IE | R | R | IE | IE | IE | R | R | IE | R | IE | R |

| | Change in Cpool reported | | | | | Change in Cpool reported | | | | | Change in Cpool reported | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Above-ground biomass | Below-ground biomass | Litter | Dead wood | Soil | Above-ground biomass | Below-ground biomass | Litter | Dead wood | Soil | Above-ground biomass | Below-ground biomass | Litter | Dead wood | Soil |
| Bulgaria | R | IE | IE | NO | R | R | IE | IE | R | R | NA | NA | NA | NA | NA |
| Czech Republic | R | R | IE | R | R | R | R | IE | R | R | R | R | NR | R | NR |
| Estonia | R | R | IE | NO | R | R | R | IE | IE | R | NA | NA | NA | NA | NA |
| Hungary | R | R | NR | NR | NR | R | R | NR | NR | R | R | R | NR | NR | NR |
| Latvia | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| Lithuania | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Poland | R | R | R | R | R | R | R | IE | R | R | R | R | R | R | R |
| Romania | R | IE | R | IE | NR | R | R | R | IE | R | R | R | NR | NR | R |
| Slovakia | R | IE | NR | NR | R | R | IE | NR | NR | R | NA | NA | NA | NA | NA |
| Slovenia | NO | NO | NO | NO | NO | R | R | NR | R | R | R | R | NR | R | NR |

R (reported), NR (not reported), IE (included elsewhere) , NO (not occurring), NA (not applicable)

### 8.1.2.3. Concluding comments

The tables above suggest that:

- for the coverage of land categories reported under the UNFCCC: despite significant improvements in recent years, further efforts are required from some MS (especially from the EU-12) to report GHG emissions from all the "mandatory" categories under the Convention (i.e. forest land, cropland, grassland and all land use changes; the other categories are considered "voluntary" under the Convention). One particular aspect where further improvements are needed is that areas of all land use categories should be reported, and the sum should be constant over time and match the total area of the country.

- for the coverage of activities under KP: all MSs except one (Lithuania) reported the mandatory activities (AR, D); however, other two countries (Portugal and Spain) did not report data for 1990 for elected activities. Given the stringent mandatory nature of KP reporting, it is expected that these gaps will be filled in the next 1 or 2 years.

- for the coverage of C pools: under both the UNFCCC and the KP, the assumption of no change in C stock can only be used in specific cases[47]. Furthermore, beyond these specific cases, under the KP a country may omit the accounting of a pool (for a mandatory or any elected activity) provided that transparent and verifiable information is given showing that the pool is not a source (in this case, the notation key "NR", not reported, should be used). As a matter of fact, many MSs apply the assumption of no change in C stock even when it should not be applied, e.g. if forest land remaining forest land (or forest management under the KP) is a "key category", the tier 1 method (assuming no change in C stock) cannot be used for DOM and mineral soil. Under the KP, this approach represents a problem if it is not accompanied by transparent and verifiable information which shows that the pool is not a source. In the first year of reporting under the KP, the UNFCCC reviews raised this problem for several MS (see later sections).

### *8.1.3. Accuracy*

Accuracy is defined by the IPCC GPG as "a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, so far as can be judged, and that uncertainties are reduced so far as is practicable. Appropriate methodologies conforming to guidance on good practices should be used to promote accuracy in inventories."[48] In this sense estimates should be accurate so long as GPG is followed. However the degree of accuracy may differ according to the approaches and methodologies applied.

GHG emissions/removals on land are estimated as AD x EF, where AD is activity data ("area" in LULUCF), and EF is emission factor (derived either as C stock change).

IPCC (2003) recommends three approaches for consistent land representation as basis for activity data estimation at national level:

APPROACH 1: BASIC LAND-USE DATA: area datasets likely to have been prepared for other purposes such as forestry or agricultural statistics. Frequently, several datasets will be combined to cover all land classifications and regions of a country. There is no information on land use changes.

APPROACH 2: SURVEY OF LAND USE AND LAND-USE CHANGE consists in a national or regional-scale assessment of not only the losses or gains in the area of specific land categories but what these changes represent (i.e., changes from and to a category). Thus, it includes more information on changes between categories. Tracking land-use changes in this explicit manner will normally require estimation of initial and final land-use categories.

APPROACH 3: GEOGRAPHICALLY EXPLICIT LAND USE DATA requires spatially explicit observations of land use and land-use change. The data may be obtained either by sampling of geographically located points, a complete tally (wall-to-wall mapping) or a combination of the two.

47 IPCC GPG-LULUCF assumes no change in C stocks for the following cases: (i) Tier 1 for DOM and mineral soils in FLrFL, for DOM in LcFL, and for Biomass in GLrGL; (ii) Tier 1 and 2 for DOM in CLrCL and GLrGL. See table A1.1 for more details.

48 IPCC GPG for LULUCF, Annex A: Glossary, p. G.2.

The quality of GHG estimates is reflected by the methodological tiers used. IPCC LULUCF GPG 2003 introduces three methodological tiers:

The Tier 1 approach employs the basic method provided in the *IPCC Guidelines* (Workbook) and the default emission factors provided in the *IPCC Guidelines* (Workbook and Reference Manual) with updates in this chapter of the report. For some land uses and pools that were only mentioned in the *IPCC Guidelines* (i.e., the default was an assumed zero emissions or removals), updates are included in this report if new scientific information is available. Tier 1 methodologies usually use activity data that are spatially coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps.

Tier 2 can use the same methodological approach as Tier 1 but applies emission factors and activity data which are defined by the country for the most important land uses/activities. Tier 2 can also apply stock change methodologies based on country-specific data. Country-defined emission factors/activity data are more appropriate for the climatic regions and land use systems in that country. Higher resolution activity data are typically used in Tier 2 to correspond with country-defined coefficients for specific regions and specialised land-use categories.

At Tier 3, higher order methods are used including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution activity data and disaggregated at sub-national to fine grid scales. These higher order methods provide estimates of greater certainty than lower tiers and have a closer link between biomass and soil dynamics. Such systems may be GIS-based combinations of age, class/production data systems with connections to soil modules, integrating several types of monitoring. Pieces of land where a land-use change occurs can be tracked over time. In most cases these systems have a climate dependency, and thus provide source estimates with inter-annual variability. Models should undergo quality checks, audits, and validations.

Behind the approaches and tiers there are various datasets and methods, used separately or in combination, to meet the GPG requirements for estimation and reporting of GHG. Estimates from country-specific data and methods (if calculated in accordance with GPG) are likely to be more accurate than if they were prepared using default methods and aggregated data sets.

8.1.3.1. Underlying methods used to estimate activity data

Given the heterogeneity of ecological and socio-economic conditions in the EU-27, and for historical reasons, there is no unique definition of different land uses across MSs. For the EU-15 the activity data is estimated using approaches 2 or 3 (national forest inventories (NFI), earth observation methods (EO) and land surveys (LS)) while some EU-12 MS still use approach 1 (national statistics (NS)), see Table A1.6. Nevertheless, data is provided through various official sources and may be underpinned by several methods.

**Table A1.6. Data sources for activity data in National Inventory Reports (NIR) 2010**

| **MS** | **Reporting categories** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **5A Forest land** | | | **5B Cropland** | | **5C Grassland** | | **Other LU categories** |
| | 5.A.1 | 5.A.2 | Disturbances | 5.B.1 | 5.B.2 | 5.C.1 | 5.C.2 | |
| Austria | NFI | NFI | NS | NS | NS | NS | NS | NS |
| Belgium | EO | EO | | EO, NS | | EO, NS | | NS |
| Denmark | NS, NFI | NS,NFI | | NS, EO | | NS, EO | | NS, EO |
| Finland | NFI | NFI | NS | NS | | NFI, NS | | NFI, NS |
| France | NFI, LS | NFI | NS | NFI, LS | NFI, LS | NFI, LS | NFI, LS | NFI, LS |
| Germany | NFI | NFI | NS | NS, NM, EO | NS, NM, EO | NS, NM, EO | NS, NM, EO | NS, NM, EO |
| Greece | NS | NS | NS | NS | | NS | | NS |
| Ireland | NFI, NS | NS, NM, EO | NS | NS | NM | NS | NM, EO | NS, EO |
| Italy | NFI, NS | NS | NS | NS | NS | NS | NS | NS, EO |
| Luxembourg | EO | EO | NS | EO | EO | EO | EO | EO |
| The Netherlands | NFI, NM | NFI, NM | | NM | NM | NM | NM | NM |
| Portugal | NFI, EO | EO, NS | NS | EO | EO | EO | EO | EO |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Spain | NFI, EO, NM | NS | NS | EO, NS | EO | EO | EO | EO |
| Sweden | NFI | NFI | NFI | NFI | NFI | NFI | NFI | NFI |
| United Kingdom | NS | NS | NS | NS | NS | NS | NS | NS |
| Bulgaria | NS | NS | NS | NS | NS | NS | NS | NS |
| Czech Republic | NS | NS | NS | NS | NS | NS | NS | NS |
| Estonia | NS | NS | NS | NS | NS | NS | NS | NS |
| Hungary | NS | NS | NS | NS | NS | NS | NS | NS |
| Latvia | NFI, EO | NFI, EO | NS | NS | NS | NS | NS | NS |
| Lithuania | NS, NFI | NS, NFI | NS | NS | NS | NS | NS | NS |
| Poland | NS | NS | NS | NS | NS | NS | NS | NS |
| Romania | NS | NS | NS | NS | NS | NS | NS | NS |
| Slovakia | NS | NS | NS | NS | NS | NS | NS | NS |
| Slovenia | EO, NS | EO, NS | | EO, NS | EO, NS | EO, NS | EO, NS | EO, NS |

Notation keys: NFI – National Forest Inventory; NS – National Statistics (agricultural and forest statistics, management plans, cadastral data); EO – Earth Observation methods (i.e. Corine Land Cover); LS –Land Survey (i.e. permanent grid); NM – National Maps; and Empty cells –No information reported/no reported pool.

Land area

Underlying methods used to determine the “activity data” (i.e. *land area*) could be grouped according their characteristics, as follows:

- National statistics: for *forest land* data is provided by ground measurement of area via stand-wise management plans of forests, updated cyclically. Specifically data refers only to a certain type of land class (i.e. usually forest and from/to conversions) and thus do not fully cover the country territory. Data is then aggregated bottom up, but could be heterogeneous in accuracy. National statistics provide data of areas at the end of year, thus additional information on conversions must be derived from underlying sectoral statistics with additional effort, e.g. the forest or land census. Data is presented in tabular form, under various possible aggregations. For *cropland and grassland* national statistics refers to datasets that are collected via census or surveys on farms/land owners/administrators or public authorities, based on questionnaires. In general, the method implies partial sampling every year and a complete survey every 5-10 years. Data could be only presented as registry or tabular, under various aggregations. Under cropland it covers the information on land use and crops type, management approaches.

- Systematic grids: data is provided by complex mathematic-statistical procedure derived from geo-referenced systematic grids (i.e. NFI, Land surveys) that cover entire/partial territory of the country. The method offers the possibility to recalculate previous cycles with improved approaches or tools for example geo-referenced virtual grids (without field sampling points). The grid design differs from country to country, as well as the number of cycles achieved. Data are presented in tabular form with the option of mapping by additional effort.

- Earth Observation: data are provided by mapping of land cover or changes with successive images (satellite, aerial). The resolution is different through time, with 1990 or earlier less accurate. Data is mapped, with the option to develop tables and interoperate with other instruments.

- Cadastral systems: “wall-to-wall” databases with ground measurement of the land area. Additional methods are used for land classification (remote sensing, field checks). Data covers all type of land categories within the national territory. Measurements methods implement homogenous accuracy standards. Data is both mapped and in tabular format, possible to enhance by use of other instruments.

Methods are combined in different ways from one MS to another for each land sub-category, see Table A1.7, however, approach 2 and 3 are most prevalent.

**Table A1.7. Methods used to determine the "activity data" for forestland ($_{FL}$), cropland ($_{CL}$) and grassland ($_{GL}$) and category and their characteristics (N= no. of MS reporting under respective method)**

| Main datasets/source | Main characteristics of the method | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Land definition | Land identi-fication | Land classi-fication risk | Land conversion detection | Land traceability | Timing of data collection | Coverage of land category | Uncer-tainty |
| National statistics ($N_{FL}$=5) ($N_{CL,GL}$=8) | LU | Non explicit | High | Low | Non traceable | Annual/ Periodic | Partial/ Total | Low |
| Systematic grids ($N_{FL}$=11) ($N_{CL,GL}$=6) | LC/LU | Explicit | Low | High | Traceable | Periodic | Total | Low-Medium |
| Earth Observation ($N_{FL}$=5) ($N_{CL,GL}$=6) | LC | Explicit | High | High | Traceable | Periodic /Annual | Total | Medium-High |
| Cadastral systems ($N_{FL}$=4) ($N_{CL,GL}$=5) | LC/LU | Explicit | Low | High | Traceable | Annual | Total | Low |

Soil type distribution

The activity data (area) of each subcategory requires to be further disaggregated by main soil types (e.g. mineral vs. organic soils). The available information on the methods used to determine the area of mineral and organic soils suggest the following distinction:

- Associations of soil characteristics with land cover or administrative units (regions, provinces, national) - expert judgement association of land cover with certain soil type (especially used for organic soils) or link to the soil databases with regional or national administrative boundary (in order to derive unique values of reference C stocks at such level for each land categories). Data are presented in a tabular format.

- Soil maps - digital or digitized maps of soils at various scales and mapping precisions. They may be very old (now digitized) and time change of soil classification systems may affect their accuracy. Data could be presented on various aggregation of soils (i.e. types, subtypes) and mapping scales at certain moment in time (they could be very old). Data is presented in map format and optionally in tabular format.

- Systematic grids - data are collected via a systematic grid or networks of permanent or temporary geo-referenced sampling points, with repetitive sampling. The grid may cover total or partial territory of the country (e.g. NFIs) and sampling points serve for other data collection too. Data could be presented on type and subtype of soils in tabular formats, with optional mapping (i.e. GIS).

MSs more frequently apply approach 2 or 3, but several MS do not determine activity data for different soil types at all.

**Table A1.8. Synthesis of the datasets/methods used to determine the "activity data" for SOILS and their characteristics (N= no. of MS reporting under respective method). To note that not reporting MS, i.e. assuming no change in SOM pools (N= 8)**

| Main source/datasets | Main characteristics | | | | |
|---|---|---|---|---|---|
| | Soils definition | Soil type mapping | Traceability of sampling | Interopera-bility | Uncertainty |
| Association with the land use/ cover/administrative data ($N_{FL}$= 6) | Low | Low | Low | Low | High |
| Soil maps ($N_{FL}$= 8) | High | High | Low | High | Low/Medium |
| Systematic grids ($N_{FL}$= 3) | High | High | High | High | Low/Medium |

<u>Determination of "activity data" for disturbance on forest land</u>

Major forest disturbances in the EU-27 are forest fires and windstorms, with characteristic random occurrence in time and space. Adequate information on the methods used to detect disturbances is not always transparently and explicitly reported in National Inventory reports (NIRs); often the CO2 loss from these events is included in the annual biomass loss and therefore is not quantified separately. Nevertheless, accurate reporting of the underlying data (i.e. area) is an essential requirement for KP reporting.

**Table A1.9. Synthesis of the datasets/methods used to determine the "activity data" for disturbance and their characteristics (N= no. of MS reporting under respective method)**

| Datasets | Comments on methods |
|---|---|
| Data not estimated ($N_{FL}$=3) | Data not available or reported as "NO" |
| Sectoral statistics ($N_{FL}$=19) | Either affected area or volume is usually (rarely both) measured or estimated by ground measurement or visual assessment and made available in sectoral (not national) statistics |
| National Forest Inventory ($N_{FL}$=3) | Area affected by disturbances is either directly derived by mathematic-statistical procedure in geo-referenced grids, often with the help of remote sensing datasets |

### *8.1.4. Underlying methods used to estimate emission factors*

Methods used by MSs to estimate emissions and removals in the categories 5A, 5B and 5C in biomass, soil and dead organic matter pools vary from default (Tier 1) to country specific (Tiers 2 and 3).

Common Reporting Format (CRF) tables in GHG inventories include a summary with methods and factors used. However, the aggregation of this information (only by land use category and gas) is not appropriate for a detailed analysis involving specific C pools. Therefore, the detailed table A1.10 below has been elaborated by JRC taking into account more specific information provided by each MS in its 2010 National Inventory Report (NIR). "NE" is this tables indicates a reporting which is not complete according to the IPCC methods and to the key category analysis done by the MS. Note that it is often difficult to assign the method used for a pool to a specific tier, and this table is subject of change upon improvements in time.

**Table A1.10. Analysis of methods and data used for reporting C pools (based on NIR 2010 and CRF tables 2011 for the year 2009). Analysis carried out by JRC, March 2011.**

| | Forest land | | | | | | | | Cropland | | | | | | | | Grassland | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FLrFL | | | | LcFL | | | | CLrCL | | | | LcCL | | | | GLrGL | | | | LcGL | | | |
| | Biomass | DOM (1) | SOM Min | SOM Org (2) | Biomass | DOM | SOM Min | SOM Org (2) | Biomass | DOM | SOM Min (3) | SOM Org (2) | Biomass (4) | DOM | SOM Min | SOM Org (2) | Biomass | DOM | SOM Min (3) | SOM Org (2) | Biomass | DOM | SOM Min | SOM Org (2) |
| **AT** | CS | CS,D | D | NO | CS | CS | CS | NO | D | D | CS,CS | NO | CS,CS | CS | CS | NO | D | D | CS,CS | CS | CS | CS | CS | NO |
| **BE** | CS | CS,D | CS | NO | CS | D | CS | NO | NE | D | CS | NO | CS,NO | NE | CS | NO | D | D | CS | NO | CS | NE | CS | NO |
| **DK** | CS | CS,D | D | CS | CS | CS | CS | CS | CS | D | CS | CS | CS,CS | CS | CS | CS | CS | D | CS | CS | CS | CS | CS | CS |
| **FI** | CS | CS | CS | CS | CS | CS | CS | CS | CS | D | CS,D | CS | CS,NE | CS | CS | CS | D | D | CS,D | CS | CS | CS | CS | CS |
| **FR** | CS | CS,D | D | NO | CS | CS | CS | NO | CS | D | NE | NO | CS,NE | CS | CS | NO | D | D | NE | NO | CS | CS | CS | NO |
| **DE** | CS | CS,D | D | CS | CS | CS | CS | CS | D | D | CS | CS | CS,CS | CS | CS | CS | CS | CS | NE | CS | CS | CS | CS | CS |
| **GR** | CS | D | D | NO | CS | D | D | NO | CS | D | D,D | CS | CS,NE | NE | NE | NO | D | D | NO | NO | NE | NE | NE | NO |
| **IE** | CS | CS,D | D | CS | CS | CS | CS | CS | NO | D | CS,D | NO | NO,NE | NO | CS | NO | D | D | NE | CS,D | CS | NE | CS | CS |
| **IT** | CS | D,CS | CS | NO | CS | CS | CS | NO | CS | CS | CS | CS | NO,NO | NO | NO | NO | CS | CS | CS,D | NO | CS | NE | CS | NO |
| **LU** | CS | D | D | NO | CS | D | CS | NO | CS | D | NE | NO | CS | CS | CS | NO | D | D | NE | NO | CS | CS | CS | NO |
| **NL** | CS | CS | D | NE | CS | D | NE | NE | NE | D | NE | CS | CS,NE | CS | NE | NE | D | D | NE | CS | CS | CS | NE | NE |
| **PT** | CS | CS | CS | NO | CS | CS | CS | NO | CS | CS | CS | NO | CS,CS | CS | CS | NO | D | D | NE | NO | CS | CS | CS | NO |
| **ES** | CS | D | D | NO | CS | D | CS | NO | CS | D | CS | NO | NO,NO | NO | NO | NO | D | D | NE | NO | NE | NE | CS | NO |
| **SE** | CS | CS | CS | CS | CS | CS | CS | CS | CS | CS | CS | CS | CS,CS | CS | CS | CS | CS | CS | CS | CS | CS | CS | CS | CS |
| **UK** | CS | CS | CS | CS | CS | CS | CS | CS | CS | D | CS | CS | CS,CS | CS | CS | CS | D | D | NE | NO | CS | CS | CS | CS |
| **BG** | CS | D | D | NO | CS | D | CS | NO | CS | CS | CS | NO | CS,D | NE | CS | NO | D | D | NE | NO | CS | NE | CS | NO |
| **CY** | CS | D | D | NE | NE | D | NE | NO | NE | D | NE | NO | NE | NE | NE | NO | D | D | NE | NO | NE | NE | NE | NO |
| **CZ** | CS | D | D | NO | CS | D | CS | NO | CS | D | CS,D | NO | CS, D | CS | CS | NO | D | D | CS,D | NO | CS | CS | CS | NO |
| **EE** | CS | CS,D | D | CS,D | CS | CS | NE | CS,D | NE | D | NE | CS,D | NO,NO | NO | NO | CS,D | CS,D | CS | NE | CS,D | CS | NE | NE | CS,D |
| **HU** | CS | D | D | NO | CS | D | D | NO | CS | D | D,D | NO | CS,D | CS | D | NO | D | D | D,D | NO | CS | CS | D | NO |
| **LV** | CS | D | D | CS | CS | D | NE | CS | D | D | NE | CS | CS,NO | CS | NE | CS | D | D | NE | CS | NE | NE | NE | CS |
| **LT** | CS | CS | CS | CS | CS | D | NE | NE | NE | D | NE | NE | NE,NE | NE | NE | NE | D | D | NE | NE | NE | NE | NE | NE |
| **MT** | CS | D | D | NE | NO | NO | NO | NO | CS | D | NE | NO | NE | NE | NE | NO | D | D | NE | NO | NO | NE | NE | NO |
| **PL** | CS | D | CS | NE | CS | CS | CS | NE | CS | CS | CS | CS | NE,NO | NE | NE | NE | D | CS | NE | CS | NE | CS | NE | NE |
| **RO** | CS | D | D | NE | NE | D | NE | NE | NE | D | NE | NE | NE,NE | NE | NE | NE | D | D | NE | NE | NE | NE | NE | NE |
| **SK** | CS | D | D | NO | CS | D | CS | NO | CS | D | NE | NO | CS,D | CS | CS | NO | D | D | NE | NO | CS | CS | CS | NO |
| **SI** | CS | CS | D | NO | CS | CS | CS | NO | CS | D | CS | CS | CS,D | NE | CS | NO | D | D | NE | CS | CS | NE | CS | NO |

Notation key: DOM: dead organic matter; SOM: soil; Min = mineral; Org: organic; "CS" country specific data, associated either with IPCC method (tier 2) or country-specific method (tier 3, if data are highly disaggregated). Note that sometimes not all parameters involved in the estimation are truly "CS" (e.g. root/shoot ratio and BEF are often taken by IPCC). However it is expected that if "CS" is reported, the most important parameters are truly "CS". "D" means that the default IPCC emission factors are used in the estimation. D is tipically associated with IPCC default method (tier 1). If the heading is in grey, D means that NO change in C stock is assumed. "NE" means either country assumes the emission/removal is negligible or not enough data is available for estimation. "NO" means emissions or removals "not occuring" in a country (it includes also "NA" - not applicable).

Black heading means that for these pools the IPCC allows the assumption of no change in C stock under tier 1 (note that if the category is a key categroy, in theory higher tiers should be used). For DOM in CL and GL, the assumption of no C stock change is also valid under tier 2.

Grey cells denote key categories according to either level or trend analysis done by the country (FR, DK, LT did not yet perform a key category analysis, as of March 2011). In general, key categories should be reported using higher tiers. However note that, when reviewers assess the adequacy of the methodological choice (tiers) in relation to key categories, should also consider "national circumstances" (i.e. the availability of data/resources/capacity in the country). This means that in some cases tier 1 may be also accepted for key categories.

Notes: (1) for DOM under "FLrFL" the 2 notations separated by a comma mean: first one refers to DW (dead wood), second to LT (litter); (2) for organic soil "NE" is used if the country reports some area of organic soil but no emissions are associated to it; (3) for mineral soil on CL and GL the 2 notation keys separated by comma mean that the country uses IPCC default method (i.e. tier 1 if associated with D data, or tier 2 if associated with CS data); in this case, the first notation key refers to "reference C stock", and second to "C stock change factor" (see IPCC-GPG for details). A cell with a single "CS" indicate a country-specific method and data (i.e. tier 3 if data are highly disagreagated); and (4) for biomass under L c CL, "conversion to cropland", the 2 notation keys used mean: first one refers to FLcCL and second to GLcCL.

When comparing the absolute levels or trends of Implied Emission Factors (IEFs) across MS, much caution should be used. Indeed, in some cases, large differences may be attributable to the different estimating or reporting methodology and they do not truly reflect the different intensity of emissions and removals. For example, some IEFs may be significantly affected by new areas entering a given category. Furthermore, the fact that not all countries use the 20-year IPCC default transition period for land use change categories means that the corresponding emission factors are not fully comparable across all MSs.

Determination of "C stock change factors" for Forest Land

Based on MS' NIRs, information on underlying methods used to determine the C stock change factors in forest land is generally available for biomass, but less for SOM and DOM.

- Biomass: Information on C stock change in the biomass pool is the most complete in NIRs, with rich information on the underlying method used for collection (Table A1.11). In fact, all MS apply Tier 2 or 3 methods.

**Table A1.11. Synthesis of the datasets/methods used to determine the "C stock change factors" for BIOMASS and their characteristics (N= no. of MS reporting under respective method)**

| Data source | Method | Comments on method |
|---|---|---|
| National Forest Inventory<br>($N_{FL}$=17) | Statistical procedures in geo-referenced grid | Data obtained by complete and repetitive field measurements in permanent and/or temporary plots. Proxy parameters are the dimensions of individual trees in the sampling plots. |
| Stand wise forest inventory<br>($N_{FL}$=6) | Partial sampling of stands | Data is obtained by both field measurements (i.e. old stands) and derived from yield tables (i.e. for young stands). Proxy parameters are the stand descriptive characteristics. |
| Various statistics<br>($N_{FL}$=2) | Modeling | Source data could be NFI or combination of other data (i.e. afforestation data, yield tables, wood harvest) |

Despite the few basic methods, there is a lot of heterogeneity on implementation characteristics of each method across MS (i.e. grid density, plot characteristics, sampling procedures).

- Dead organic matter: Information on underlying methods C stock change in this pool is rather poor in the NIRs, still with many MS not reporting. The majority of MSs does not report a change (Tier 1), see Table A1.12.

**Table A1.12. Synthesis of the datasets/methods used to determine the "C stock change factors" for DEAD ORGANIC MATTER and their characteristics (N= no. of MS reporting under respective method)**

| Data source | Method | Comments on method |
|---|---|---|
| Not reported<br>($N_{FL}$=16) | NA | Reporting according Tier 1 IPCC (no change) |
| National Forest Inventory<br>($N_{FL}$=7) | Statistical procedure in geo-referenced grids | Usually only dead wood data is collected (not the litter). Annual estimates are derived by mass or C stock difference over successive cycles and interpolation |
| Various data<br>($N_{FL}$=4) | Modeling (process based or bookkeeping models) | Source data could be NFI, other statistics (i.e. afforestation, harvest, yield tables) or simple regressions based on other data (i.e. stand aboveground biomass) |

- Mineral soils: It is rarely clear from NIRs what soil classification systems are used and how data is processed, while the method to collect data is provided (Table A1.13). For land conversion to/from forest the most used method is that of "reference C stocks" which allows an annual constant linear change between "initial" and "final" C stocks. More than half of MS apply Tier 1 (no change in C stock) in forest remaining forest.

**Table A1.13. Synthesis of the datasets/methods used to determine the "C stock change factors" for MINERAL SOIL and their characteristics (N= no. of MS reporting under respective method)**

| Data source | Method | Comments on method |
|---|---|---|
| Not estimated ($N_{FL}$=13) | NA | Reporting according Tier 1 IPCC (no change) |
| IPCC default values ($N_{FL}$=1) | IPCC default values | Unique national reference C stocks assumed equal to IPCC default value |
| National Forest Inventory and soils databases ($N_{FL}$=11) | Statistical procedure in geo-referenced grids | Time difference and annual interpolation based on repetitive sampling (i.e. national soil database, NFI, ICP Forests, research projects) |
| National Forest Inventory and other various data ($N_{FL}$=5) | Process based or bookkeeping modeling | Source data could be NFI, or other statistics (i.e. afforestation, harvest, yield tables) or simple regressions |

- Organic soils: The definition of soil C pool differs across MS in terms of the threshold between organic and mineral soils and the treatment of peatland and drained areas with organic soils. There are only a few methods used for estimation of organic soils (Table A1.14). Tier 1 is the most used method for organic soils.

**Table A1.14. Synthesis of the datasets/methods used to determine the "C stock change factors" for ORGANIC SOIL and their characteristics (N= no. of MS reporting under respective method)**

| Data source | Method | Comments on method |
|---|---|---|
| Not estimated ($N_{FL}$=18) | NA | Not reporting or not occurring or (in disagreement with IPCC GPG LULUCF) assumed neutral |
| IPCC default emission factor ($N_{FL}$=4) | IPCC default values | Reporting under Tier 1 |
| National Forest Inventory or other data ($N_{FL}$=3) | Modeling | Process based modeling with inputs from NFI or other data (i.e. afforestation, harvest, yield tables) |

- Emission factors for disturbances on forest land: The main source of data are the NFIs or stand wise forest inventories, combined with specific statistics managed by forest authorities. The wood volume lost in disturbance events is usually measured or estimated by ground measurement or visual assessment and provided in statistics. Another method considers the average estimate of standing stock (derived from NFIs database).

Determination of "C stock change factors" for cropland and grassland

Information on C stock change factors in cropland is rather poor in NIRs. The basic underlying methods do not differ significantly between cropland and grassland on C stock change in soils.

- Biomass: On cropland, only C stock change in woody permanent crops is estimated (i.e. orchards, vineyards, olive groves). Annual biomass is only computed by few MS, and sometimes it is done with the purpose to assess the organic matter input into soils (which drives a model for soil emissions). Changes in biomass are mainly reported as not occurring on grassland (following IPCC tier 1), and default values are also commonly applied to cropland (Tier 1).

**Table A1.15. Datasets/methods used to determine the "C stock change factors" for BIOMASS (N= no. of MS reporting under respective method on CL or GL)**

| Datasets | Comments on method |
|---|---|
| Not reported<br>($N_{CL}$= 8)<br>($N_{GL}$= 22) | Not yet estimated or assumed "no change" |
| IPCC default values<br>($N_{CL}$=10)<br>($N_{GL}$=0) | IPCC default factors. 2 MS included here report CS data for bioenergy/biomass plantations |
| Basic country specific data<br>($N_{CL}$= 5)<br>($N_{GL}$=0) | National data available (i.e. from research). 2 MS included here report some type of permanent crops by modeling |
| Various inputs to models<br>($N_{CL}$=2)<br>($N_{GL}$=3) | Process based modeling with various inputs (i.e. non-forest NFI sampling, research data) |

- Mineral soils: Reporting of this pool is still rather poor because of lack of consistent and adequate data. Also, the methodological information in the NIRs is not always adequate. Where available, the data is often provided by heterogeneous databases (i.e. various methodologies, sampling year). Tier 1 is applied by four MS; Tier 2 or 3 methods are applied by about half MS.

**Table A1.16. Datasets/methods used to determine the "C stock change" for MINERAL SOILS (N= no. of MS reporting under respective method on CL or GL)**

| Datasets for C stock in mineral soils | Comments on method |
|---|---|
| Not reporting<br>($N_{CL}$= 8)<br>($N_{G}$L= 11) | Not yet estimated or assumed (in discordance with IPCC LULUCF GPG) "no change" for CL |
| IPCC C stock default values<br>($N_{CL}$= 4)<br>($N_{GL}$= 4) | IPCC default values |
| Country specific reference C stocks<br>($N_{CL}$= 9)<br>($N_{GL}$= 6) | C stock reference is developed on each land use either on province or national scale from soil database |
| Various inputs to models<br>($N_{CL}$= 4)<br>($N_{GL}$= 4) | Process based modeling with various inputs (i.e. NFI, agricultural data; research data for GL) |
| Adjustment factors data<br>($F_{lu}$, $F_{mngm}$, $F_{i}$) | |
| Expert based adjustment of IPCC default values | Only 1 MS developed own factors based on time series of field measurements |

- Organic soils: while few MS report emission from organic soils under cropland or grassland, the emissions are usually relevant. On grassland, reporting of organic soils is particularly poor because of lack of consistent and adequate data. Lack of transparency and explicit information characterizes this issue in NIRs.

**Table A1.17. Datasets/methods used to determine the "emission factors" for ORGANIC SOILS (N=no. of MS reporting under respective method on CL or GL)**

| Datasets/source | Comments on method |
|---|---|
| Not reporting<br>($N_{CL}$= 12)<br>($N_{GL}$= 12) | Not yet estimated or assumed "no occurring" |
| IPCC default values<br>($N_{CL}$= 7)<br>($N_{GL}$= 8) | Emission factor provided by the IPCC GPG |
| Country specific data<br>($N_{CL}$= 6)<br>($N_{GL}$= 5) | Data from research used for reporting either based on CS emission factors (i.e. heterotrophic respiration) or by modeling (i.e. input from NFI) |

### *8.1.5. Uncertainties*

This section presents the estimated uncertainties at EU-15 level, based on the (often incomplete) information available in MS' NIRs. Uncertainties for AD and EF are reported as simple averages of MS' reported data, while uncertainties for GHG emission/removals are estimated based on the aggregation (by error propagation) of MS estimates. In general, these estimates at EU-15 level can be considered broadly valid also for the whole EU. More infomation can be found in the EU NIR 2010.

The uncertainty of the *activity data (AD)* varies across MS and land (sub)categories within the MSs. The uncertainty level depends on the original purpose of datasets, land use definitions and their consistent use in time, spatial resolution, reference years as well as land data processing techniques which usually introduce additional uncertainty in GHG estimations. For forest land remaining forest land the uncertainty at EU-15 level is estimated to be about 12%, as a simple average, with the lowest value reported by Germany and the UK (~1%). For lands under conversion to forest land, MS reported very different values, with an overall simple average of 15% and the highest value reported by Italy (75%). For all other land categories, the average uncertainty is around 20% for lands remaining the same land and apparently less than 20% for lands under conversion.

The uncertainty associated with the *emission factors/C stock change factors(EF)* is in the order of 60–85%, as a simple average, for all GHG and land uses in the EU-15, and a little higher on lands under conversion. It also shows a rather high fluctuation among MSs, because of the generally high number of parameters involved in its calculation and the variety of the methodological approaches. Again, the direct comparability among MS is low as often it reflects combined uncertainty with the activity data. The uncertainty of the EF is higher for the land subcategories in the territories of MS with high disturbance levels like forest fires (i.e. Portugal and Greece) or organic soils (i.e. Finland).

The aggregated estimated uncertainty of the annual EU-15 emissions and removals is 32% for forest land, grassland and cropland combined; however, it ranges from 25% in land converted to forest to 105% in cropland remaining cropland (see Table A1.18). For the new 10 MS (i.e. excluding Malta and Cyprus) similar ranges of uncertainty of activity data can be expected, but higher levels for C stock change factors (JRC 2010a).

**Table A1.18. Uncertainty across the EU-15 by subcategories and GHG in 2008 (half of 95 % confidence interval of averages, by error propagation with individual MS E/R)**

| Inventory category | Category uncertainty for EU (%) | Total estimated emission (+)/ removal (-) in 2008 (Gg $CO_2$) | Uncertain amount ($GgCO_2$) |
|---|---|---|---|
| FL r.FL (5A1) | 30% | -276,794 | 81675 |
| LcFL (5A2) | 25% | -49,779 | 12446 |
| CLrCL (5B1) | 105% | 19,184 | 20216 |
| LcCL (5B2) | 30% | 45,341 | 13484 |
| GLrGL (5C1) | 87% | 11,923 | 13756 |
| LcGL (5C2) | 49% | -22,077 | 10796 |
| *Total*** | *32%* | *-280,018* | *88590* |
| | | | |
| Forest land (5A) | 26% | -326,573 | 84761 |
| Cropland and grassland (5B+5C) | 63% | 46,555 | 31784 |

*It should be noted that estimates of the aggregated EU-15 level uncertainties may slightly vary also depending on the method used to aggregate the available information at MS level. Subcategory uncertain amounts do not sum up to the overall EU 15's unceratin amount due to compensation over the error propagation procedure. Uncertainty is computed as two standard deviations (2σ for 95 % confidence interval).

** This estimate excludes Wetland, Settlements and Other land. Taking these land categories into account, the total uncerainty estimate amounts to 35%.

Notes: Much care should be used when comparing uncertainties of specific LULUCF categories with others sectors. While all the other sectors are sources of GHG, LULUCF may either be a source or a sink. This may profoundly affect the estimate of % uncertainty, depending at which level the analysis is done. E.g. If the subcategory "cropland remaining cropland" is a sink of -50 MtCO2 +/-10%, and "land converted to cropland" is a source of +55 MtCO2 +/-10%, the whole cropland category will be a source of +5 MtCO2 with a level of uncertainty close to 100%.

By way of comparison, Table A1.19 shows the uncertainty related to estimates in the agricultural sector (non-$CO_2$ GHG). Uncertainty in this sector is 68% on average but varies from 12% (enteric fermentation) and 156% (agricultural soils). Table A1.20 shows the overall uncertainty estimates for other sectors, based on the magnitude of emissions. It is clear that the level of uncertainty in LULUCF is relatively large compared to e.g. fuel combustion (1.5%), transport (6%), industrial processes (5%) and waste (21%), but is similar to that of fugitive emissions (32%) and smaller than the uncertainty in the agriculture sector. All sectors other than LULUCF are already part of the EU's GHG reduction commitment.

**Table A1.19. Uncertainty across the EU-15 by subcategories and GHG in 2008 (half of 95 % confidenceinterval of averages, by error propagation with individual MS E/R)**

| Inventory category | GHG | Category uncertainty for EU (%) |
|---|---|---|
| Enteric fermentation (4A) | CH4 | 12% |
| Manure management (4B) | CH4 | 26% |
| Manure management (4B) | N2O | 61% |
| Rice cultivation (4C) | CH4 | 20% |
| Agricultural soils (4D) | CH4 | 50% |
| Agricultural soils (4D) | N2O | 156% |
| | | |
| *Total* | *CH4+N2O* | *68%* |

Source: Leip (2010)

**Table A1.20. Uncertainty estimates of EU-15 GHG emissions and removals**

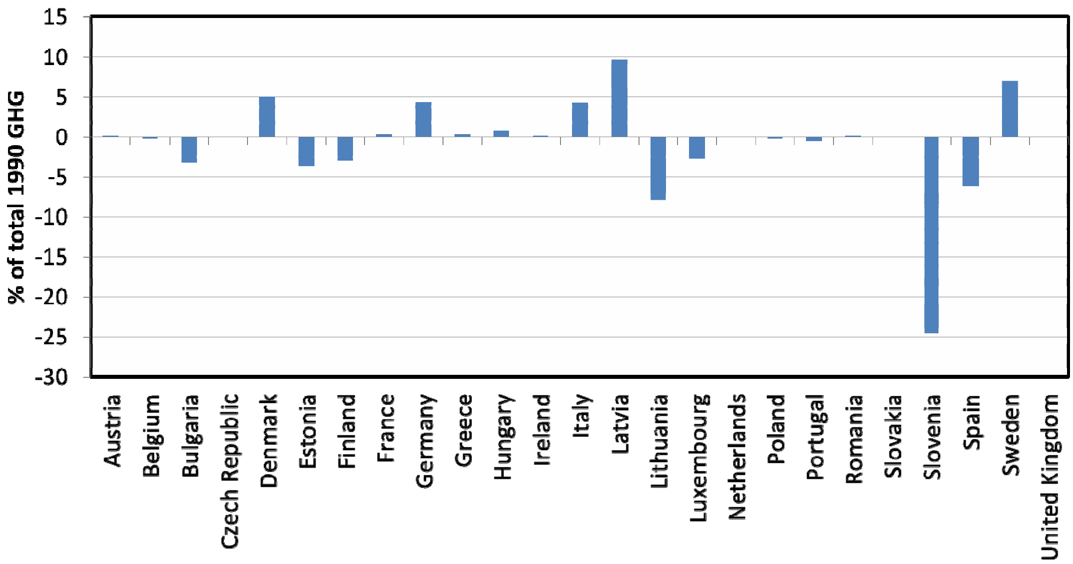
| Source category | Gas | Emissions 1990 | Emissions 2008 | Emission trends 1990-2008 | Level uncertainty estimates based on MS uncertainty estimates | Trend uncertainty estimates based on MS uncertainty estimates |
|---|---|---|---|---|---|---|
| Fuel combustion stationary | all | 2,458,079 | 2,311,118 | -6% | 1.5% | 0.5 |
| Transport | all | 698,421 | 861,374 | 23% | 6% | 3.4 |
| Fugitive emissions | all | 97,527 | 49,936 | -49% | 32% | 23.3 |
| Industrial processes | all | 374,779 | 329,992 | -12% | 5% | 12.2 |
| Agriculture | all | 430,533 | 377,803 | -12% | 68% (45%-102%) | 8.4 |
| LULUCF | all | -212,334 | -251,002 | 18% | 35% | - |
| Waste | all | 171,257 | 103,923 | -39% | 21% | 10.7 |
| **Total (incl LULUCF)** | **all** | **4,018,264** | **3,783,144** | **-6%** | **7.4% (5.6%-10.7%)** | |
| **Total (excl LULUCF)** | **all** | **4,230,597** | **4,034,145** | **-5%** | **6.9% (4.8%-10.2%)** | **1.7** |

Source: EEA (2010)

### *8.1.6. Recalculations*

A large number of countries carried out important recalculations in the last GHG inventory. Recalculation are usually due to change in methods (e.g. from stock change to gain-loss), new C pools reported for the first time, or new data (e.g. new NFI). Recalculations are an inherent characteristic of the LULUCF sector and are generally more significant than in other sectors. This is illustrated by Figure A1.1 which shows differences between 2009 and 2010 amounting to five, ten and 25% of MSs' 1990 GHG emissions. This has implications for the possibility of including LULUCF in existing policy frameworks to the extent that they require annual compliance with emission limits as well as corrective action when a MS's (under the ESD) or installation's (under the EU ETS) emissions exceed its limit.

**Figure A1.1. Extent of recalculations for the year 2007 in "forest remaining forest" (difference 2010-2009 submissions), expressed as % of total 1990 GHG emission of each MS.**



### *8.1.7. Time-series consistency and comparability between MSs*

Comparability can be looked in at least two ways; within a MS over time ("time-series consistency") and between different MSs. The former can be generally considered scarcely a problem and the following sections therefore focus on some of the factors that affect comparability between MS. It follows from earlier sections that there is diversity in estimation methods amongst MS. This is highlighted by e.g. Lawrence et al. (2010) who also note that variations in definitions make direct comparability difficult. Some of the differences in definitions are discussed below.

#### 8.1.7.1. Definitions

Forest definition

The parameters used to define forest under the KP are presented in Table A1.21. Definitions vary across MSs. While consistency within the country in terms of time and space is achieved by most MS, direct comparability accross the MSs is currently not possible as the parameters vary across minimum crown cover, minimum hieght, minimum area and minimum width. Although diversity in methods inevitably contributes to differences in estimates, if forest area sampling and estimators are unbiased, then detrimental effects on harmonised reporting as a result of their diversity are minimal (Lawrence et al., 2010).

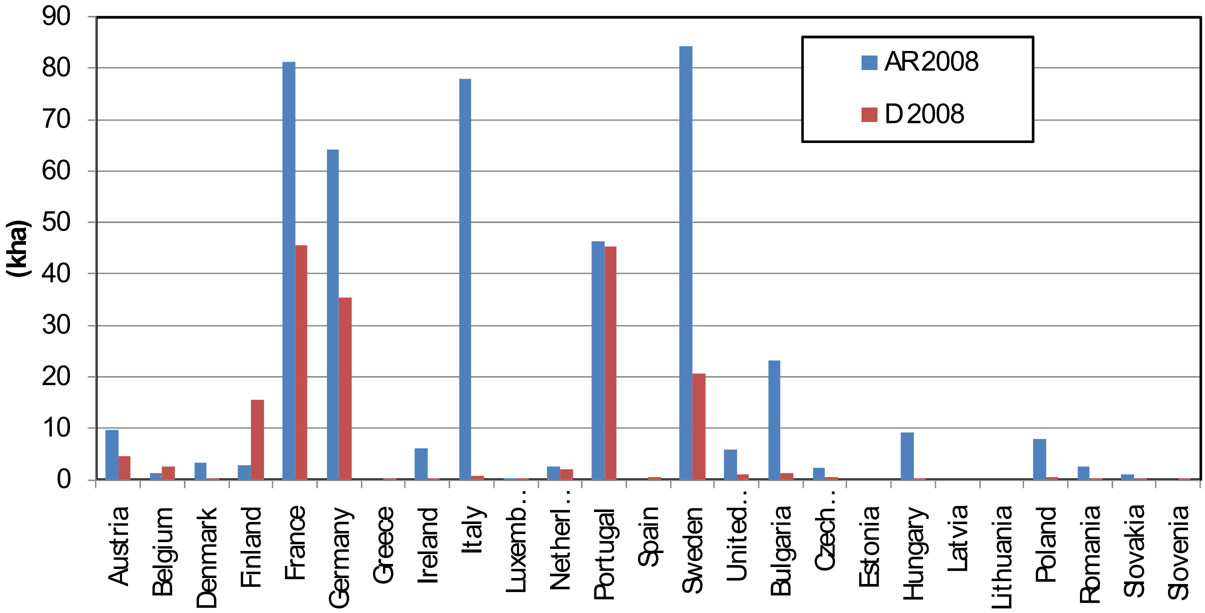
**Table A1.21. Selection of parameters for defining "forest" under the Kyoto Protocol**

| | Minimum crown cover (%) | Minimum height (m) | Minimum area (ha) | Minimum width (m) |
|---|---|---|---|---|
| Austria | 30 | 2 | 0.05 | 10 |
| Belgium | 20 | 5 | 0.5 | - |
| Denmark | 10 | 5 | 0.5 | 20 |
| Finland | 10 | 5 | 0.5 | 20 |
| France | 10 | 5 | 0.5 | 20 |
| Germany | 10 | 5 | 0.1 | - |
| Greece | 25 | 2 | 0.3 | 30 |
| Ireland | 20 | 5 | 0.1 | 20 |
| Italy | 10 | 5 | 0.5 | - |
| Luxemburg | 10 | 5 | 0.5 | - |
| Netherlands | 20 | 5 | 0.5 | 30 |
| Portugal | 10 | 5 | 0.1 | 20 |
| Spain | 20 | 3 | 1.0 | 25 |
| Sweden | 10 | 5 | 0.5 | - |
| United Kingdom | 20 | 2 | 0.1 | 20 |
| Bulgaria | 10 | 5 | 0.1 | - |
| Czech Republic | 30 | 2 | 0.05 | 20 |
| Estonia | 30 | 1.3 | 0.5 | - |
| Hungary | 30 | 5 | 0.5 | 10 |
| Latvia | 20 | 5 | 0.1 | 20 |
| Lithuania | 10 | 5 | 0.1 | 10 |
| Poland | 10 | 2 | 0.1 | 10 |
| Romania | 10 | 5 | 0.25 | 20 |
| Slovakia | 20 | 5 | 0.3 | - |
| Slovenia | 30 | 2 | 0.25 | - |

Definition of land use changes

Definitions of land use changes may differ among MS, and this introduces some difficulty in comparing estimates. For example, some MS define deforestation based on specific documentation (e.g. permissions), while other MSs consider that if after a given lapse of time from harvest (e.g. 5 or 10 yrs) regeneration did not occur, than it is deforestation. Data on AR and D areas suggest there may be a problem of comparability among MS (e.g. France has D area hundreds times that of Italy, Portugal hundreds times that of Spain). It is clear that for some MS data for AR and D are still preliminary. Many MS noted the difficulty of reporting on land use changes, because they are usually small and scattered events.

**Figure A1.2. Comparison of ARD area in the EU-27**




Definitions of carbon pools

The wide variation of definition of the pools amongst MSs (aboveground and belowground biomass, soil organic matter, dead organic matter) is notable. The effect on overall accuracy of the estimation of carbon stock changes and other GHG emissions related to various pools definition is likely low, but also difficult to assess in quantitative terms (i.e. for non-considered part of the pools, like trees under the threshold diameter). The variation in definitions affects the comparability amongst MS but likely not the completeness, to the extent that the share of pools which is reported by one MS under some category is reported by others under a different category. Nevertheless, a pool reported under other pools may introduce higher uncertainty in the estimation (caused mainly by the different turnover), but it can be duly justified for practical reasons (i.e historical data availability, measurement errors). For example, the minimum DBH (breast height diameter) for trees measurement in NFI varies from 0 cm for 5 MS, < 5 cm for 3 MS and < 10 cm for 5 MS. Also, soil organic matter (SOM) is estimated for different depth (30 cm to 100 cm) across MS. Dead organic matter pool (DOM, litter and dead wood) also differs in terms of type (standing, laying), threshold diameter and height, and duration since laying down (which defines the decomposition period).

### 8.1.8. *Verification activities*

Currently, there is poor implementation of, or at least little information on, verification activities by EU MS. Despite IPCC GPG LULUCF provides a number of possible specific approaches for verification, several MS included verification activities in the Quality Assurance (QA)/Quality Control (QC) process and only focus on double checks of input data used for the estimation of GHG. There are few specific cases of verification of the outputs (e.g. C stocks changes): Germany reports on the calculation of the C stocks and C-stock changes in biomass for forestland by two different forestry institutes and estimates are in "good agreement". Italy reports on current implementation of an interregional project to carry out atmospheric emission inventories at local scale, with a module on the estimation of forest land related emission/removals (in 7 out of the 20 Italian regions), the results of which will allow the validation of both methodology and estimates at country level. Finland reports the establishing of a network for GHG monitoring of drained organic soils. The UK implements a number of research projects on the effect of afforestation, effect of cultivation and re-sampling in the framework of National Soil Inventory as part of GHG inventory programme. Sweden confirms the trend of estimated removals by implementing the default method with own data. Also, it reports that process based models and field measurements agreed on organic matter and soil organic carbon in forests. Denmark performs field collecting samples in order to check the outputs of the model which is used for reporting.

In terms of disturbances, Forest fire - EFFIS (European Forest Fire Information System, http://effis.jrc.ec.europa.eu/) is a potential candidate for verification at the continental scale. It is a tool for rapid damage assessment and active fire detection which may be assessed in the way of verification of emissions from fires. Practically all the data are delivered in a harmonized scheme and in the standard European spatial reference system ETRS-LAEA which ensures the most recent MODIS coverage of Europe.

In conclusion, although verification activities are clearly a key element for ensuring inventory quality and increasing confidence on results, currently there is still poor implementation of, or at least little information on, verification activities at EU level. It is expected that more attention will be paid on verification in coming years, and that a larger role in this context will be played by models.

### 8.1.9. *Costs of improving monitoring*

Reporting under the UNFCCC is mandatory for land categories for which IPCC GPG exists, i.e. forest land, grassland and cropland, and all land use changes (for all land categories). In addition, the KP requires reporting for a number of mandatory and elected activities and adds obligations to the UNFCCC reporting. This requires action by MSs. Tier 1 should be applied as a minimum in reporting but it is good practice to use tier levels 2 or 3 for key categories.[49] The objective for monitoring and reporting set out in this impact assessment is that MSs comply with the IPCC GPG. More efforts are required to meet this objective.

A two-step approach was used in order to estimate the associated costs (see discussion in Section 4.2 of the main text):

[49] Both IPCC GPG-LULUCF and UNFCCC guidelines for reviewing GHG inventories recommend to consider national circumstances when evaluating the methodological choice (i,e. tier level) in relation to the key category analysis, This means assessing the resources and capacities needed to improve the GHG inventory in relation to the Party's possibilities.

- Step 1 – Achieving completeness in the reporting of all mandatory categories and pools at a minimum level of tier 1,

- Step 2 – Increasing the accuracy of the reported key categories and pools to a minimum of tier 2.

It is, however, a challenge to estimate the related costs and the following limitations should be borne in mind when interpreting the results:

- There is no unique way of reaching the objective because the IPCC GPG allows for different methodologies and approaches to be applied according to national circumstances. A number of tools exist for representing land areas (e.g. use of existing data, remote sensing and ground-based surveys) and for deriving emission factors (e.g. default values, literature, measurements and models), and these can be combined in a number of ways. For the purpose of this assessment, repeated soil sampling campaigns were simulated to derive country specific emission factors for soils (required for tier 2) and that can be combined with largely existing activity data.

- It is a complex task to establish the current monitoring capacity, or the baseline, in MSs. Here the information on methodologies and approaches reported by MSs to the UNFCCC in 2010, and analysed by JRC (2011a), was used, see Table A1.3 (completeness of reporting) and Tables A1.6 and A1.10 (type of approaches and methodologies).

- The availability of literature on monitoring costs is limited. A mixture of sources, based on actual experience and studies, was used to obtain the necessary assumptions to derive an interval indicating the potential costs.

#### 8.1.9.1. Step 1 – Achieving completeness in the reporting of categories and pools at a minimum level of tier 1

Reporting on biomass in forest land is generally complete. Only a few MSs did not report (in 2010) on this pool in one of the sub-categories under forest land. On the contrary, most MSs did not report on soil in one or both of the sub-categories under forest land, cropland and grassland.

The cost of improving the completeness to a minimum of tier 1 level of accuracy is, however, assumed to be reasonable, both for biomass and for soils; whilst it requires compiling activity data from different sources, the data is generally available in MSs and/or from European initiatives (e.g. LUCAS[50] and CORINE) and can be combined with IPCC default values (tier 1).

[50] The Land Use/Cover Area frame statistical Survey. The name reflects the methodology used to collect the information. Estimates of the area occupied by different land use or land cover types are computed on the basis of observations taken at more than 250,000 sample points throughout the EU rather than mapping the entire area under investigation. By repeating the survey every few years, changes to land use and land management can be identified.

### 8.1.9.2. Step 2 – Increasing the accuracy of the reported key categories and pools to a minimum of tier 2

This step focuses on improving the level of accuracy of monitoring and reporting of stock changes in soils in forest land, cropland and grassland as this is where the most significant gaps in reporting exist, see Table A1.10. SE, DK, FI, DE and the UK apply high level tiers to the soil pool in all land categories but most MSs use tier 1 or do not report at all on soil in at least one of the land categories.

On the basis of what is required by the IPCC GPG (2003), it is assumed that activity data from different sources available in MSs and/or from European initiatives (e.g. updates of LUCAS and CORINE) would provide sufficient information and spatial resolution to be used for tier 2 and that the cost for this component therefore is low. For the purpose of simulating the cost of increasing the level of accuracy and to derive country-specific emission factors it is assumed that the required data would be collected through repeated soil sampling campaigns in order to capture the annual rates of emissions and removals, calculated as the difference in stocks over time divided by the inventory time period. A comprehensive review of the soil inventory and monitoring activities in the EU was carried out under ENVASSO[51] and evaluated the extent to which existing soil monitoring networks adequately represent European soil typological units, land use/cover, specific soil criteria such as soil organic carbon and bulk density (which are needed to measure changes in carbon stocks). It also detailed the existing national networks, their purpose, sampling strategy, analytical methods used and number of monitoring sites (around 35 000 for soil organic carbon). Procedures and protocols appropriate for inclusion in a European soil monitoring system were identified and documented and, finally, a soil monitoring system was defined that comprises a network of geo-referenced sites at which qualified sampling process is being or could be conducted. In addition, the BioSoil demonstration project (Hiederer et al., 2011) is one of several studies under Forest Focus[52] and was initiated to develop the monitoring scheme by means of studies, experiments, demonstration projects and testing on a pilot basis and establishment of new monitoring activities.

The following steps were taken:

1. The sampling density was determined based on a review of plot sizes ranging between 6 400 ha, 18 000 ha (LUCAS), 19 600 ha (Forest Focus and Biosoil) and 30 000 ha (which is the EU median density, Arrouays et al., 2008) per plot. Although it should be noted that the number of plots also depends on the desired level of certainty and the sampling interval (Mäkipää et al., 2008). A consideration for monitoring and estimating soil organic carbon is that it may be desirable to stratify mineral and organic soils and sample within those strata to obtain sufficient data for the organic soils.

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[51] The ENVironmental Assessment of Soil for mOnitoring (ENVASSO) project was funded 2006-08 as Scientific Support to Policy under the European Commission 6th Framework Programme of Research.

[52] Regulation (EC) No 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community, now funded via LIFE+, provides for measures to e.g. promote harmonised collection, handling and assessment of data; improve data evaluation at Community level; improve the quality of data and information gathered; and develop forest monitoring activities.

2. The number of samples per plot was set at 1 composite soil carbon sample (consisting of 2-4 soil samples) and 1 composite sample for bulk density (IPCC, 2003).

3. Case studies show that the cost per sample ranges between €6-16 as regards the laboratory cost (Stolbovoy et al., 2007) which constitutes about 25% of the total cost (Mäkipää et al., 2008), i.e. total cost per sample amounts to €24-64. Mäkipää et al. (2008) found that the cost per sample was €47 but estimated a fixed cost per plot at €230.

4. The number of sites needed per MS was determined by dividing the total area of forest land, cropland and grassland by the sampling plot density where the land area is a key category.

5. The cost per MS was calculated by multiplying the number of sites with the total cost per site, divided by the time interval between two different sampling campaigns, ranging between 20 years for tiers 1 and 2 (IPCC, 2003), 10 years (Arrouays et al., 2008) and 3-5 years for tier 3 (IPCC, 2003).

   However, the cost obtained from 1-5 above assumes that all MSs would require investments in soil monitoring. As shown in A1.10 this is not the case, neither for all MSs nor for all land categories. Therefore an additional step was taken:

6. The cost related to those land categories for which MSs already apply tier 2 or 3 methodologies was deducted from the cost obtained in 1-5.

As noted above, MSs are required to report to report under the UNFCCC and the KP, using tier 1 as a default and tiers 2 or 3 for all key categories. The cost of meeting these criteria should therefore be attributed to the ratification of the Convention and the KP and the adoption of the IPCC GPG, and not the potential inclusion of LULUCF in the EU's GHG reduction commitment.

The fixed costs of monitoring a network of plots were not assessed, but it is assumed that use could be made of existing networks, as shown by Kibblewhite et al. (2008), and so limiting or cancelling the cost of additional plots. Additional reporting costs (e.g. to adapt UNFCCC data to KP format) are also judged to be negligible given the current reporting requirements under the UNFCCC and the KP.

8.1.9.3. 3 – Harmonisation

In addition to the IPCC GPG, additional efforts to harmonise monitoring and reporting in the EU should be promoted and this would require resources. The associated costs have not been estimated. Great effort has already gone into harmonizing forest and soil surveys. The findings from BioSoil (EC, 2003) clearly ask for better harmonization of methods to allow arriving at comparable results between national surveys, but also to provide temporal consistency. Otherwise differences in methods overshadow changes in the field and cannot be separated to estimate C stocks and GHG emissions.

Table A1.22 summarises the assumptions made for two cost scenarios, one low and one high.

**Table A1.22 Summary of assumptions about sampling parameters**

| Parameter | Value | | |
|---|---|---|---|
| | Low cost | | High cost |
| Sampling density | 19 600 ha | | 6 400 ha |
| Number of samples per plot | 2 composite samples (1 soil carbon, 1 bulk density) | | 2 composite samples (1 soil carbon, 1 bulk density) |
| Sample cost | €24 | | €64 |
| Fixed cost per plot | €238 | | €238 |
| Sampling interval | 20 years | 8 years | 4 year |

### 8.1.9.4. Results

Table A1.23 shows the results of Step 2, using two different assumptions about the baseline. If all MSs require investments in soil monitoring to move from tier 1 to tier 2 or 3, the annual cost for the EU-27 would be between 0.5 and 2.1 mln €/year, assuming a sampling interval of 8 years. However, and as shown in Table A1.10, a number of MSs already have the required capacity which means that the additional cost is likely to be lower, between 0.4 and 0.5 mln €/year. As noted above, MSs are already obliged to use tier 2 or 3 for key categories in UNFCCC and KP reporting. Hence, whilst the costs to MSs of improving monitoring are positive, the cost of the policy objective is zero.

Arrouays et al. (2008) estimated the number of additional sites needed to detect a relative decrease of 5% of the national mean of topsoil organic carbon contents according to national statistics on variances. If the same cost assumptions are applied to their estimate, the resulting costs would be €0.9 to 1.2 mln per year with an 8 year sampling interval. On the other hand, soil sampling was carried out under the auspices of LUCAS[53] in 2009 at an additional cost of only €1.2 mln (€0.2 mln per year). This shows that significant cost savings to be had through coordinated and systematic schemes.

**Table A1.23. Indicative costs of improving the level of accuracy of MRV**

| Frequency of sampling* | Annual cost for EU-27 (mln €/yr) | |
|---|---|---|
| | Low | High |
| | *Baseline assumption: all MSs require investments in soil monitoring* | |
| every 4 yrs | 1,1 | 4,2 |
| every 8 yrs | 0,5 | 2,1 |
| every 20 yrs | 0,2 | 0,8 |
| | *Baseline assumption: some MSs (based on Table A1.9) require investments in soil monitoring* | |
| every 4 yrs | 0,7 | 0,9 |
| every 8 yrs | 0,4 | 0,5 |

53 During the 2009 survey, soil samples were collected from more than 22,000 LUCAS point locations.

| | | |
|---|---|---|
| every 20 yrs | 0,1 | 0,2 |
| **Cost of policy requiring improved MRV according to IPCC GPG standard under both baseline assumptions**** | **0** | **0** |
| Cost of harmonisation | Not estimated | Not estimated |

Notes: *According to Arrouays et al. (2008) a time interval of about 10 years would enable the detection of some simulated large changes in soil organic carbon in most European countries. IPCC uses 20 years as a default (tiers 1 and 2) and 3-5 years for tier 3. An 8 year interval is used here as the central scenario to match the compliance period of 2013 to 2020. ** The cost of the policy is what would be required in addition to the meeting the obligations under the UNFCCC and KP; MSs are already required to apply tier 2 or 3 for key land categories, but only some MS comply.

### *8.1.10. Appendix 1 – Overview of problems emerged during 2010 review and answers by MS*

The EU QA/QC and UNFCCC review 2010 revealed several issues related to achievement of the reporting requirements under the KP:

- To demonstrate that a non-reported C pool is not a source. This is a problem for soil C, especially for land remaining in the same category (e.g. forest remaining forest).
- To identify and track LUC over time ("land identification")
- To estimate appropriate EF for organic soils

A summary is provided in Table A1.24. MSs have since provided more detailed explanations for the issues raised. It is likely that at least in part the problems are related to transparency in reporting (i.e. not enough background explanations provided).

**Table A1.24. LULUCF issues raised in the review of the 2010 submission for the Kyoto Protocol**

| MS | Main issues | Specific issues | Likely impact on reporting and accounting<br><br>*Notation key:*<br>*Small < 1 $MtCO_2eq$.*<br>*Medium 1-5 $MtCO_2eq$.*<br>*Large > 5 $MtCO_2eq$.* |
|---|---|---|---|
| Austria | AR | Land identification | Medium |
| Denmark | ARD, FM, CM, GM | "C pool not reported" w/o demonstrating that it is not a source (ABG, BGB, LT, DW, SOM) | Small |
| | AR | "C pool not reported" w/o demonstrating that it is not a source (SOM –organic soils) | Small |
| | AR | "C pool not reported" w/o demonstrating that it is not a source (LT) | Small |
| | CM, 1990, 2008 | SOM | Probably medium |
| | GM, 1990, 2008 | SOM | Probably medium |
| Finland | No issues | No issues | |
| France | AR | Land identification | Large |
| | FM | Emissions from fires | Small-Medium |
| | D | "C pool not reported" w/o demonstrating that it is not a source (DW) | Small |
| | D | Lime application | Small |
| Germany | ARD, FM | National system - land identification | Difficult to assess |
| Greece | D | Incomplete land coverage | Probably small |
| | ARD, FM | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Small |
| Ireland | D | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Small |
| Italy | No issues | No issues | |
| Netherlands | AR,D | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Small |
| Portugal | CRF table 1990 | Only notation keys | Difficult to assess |
| | ARD, FM | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Small |
| Spain | AR | "C pool not reported" w/o demonstrating that it is not a source (SOM) | Medium |
| | FM | "C pool not reported" w/o demonstrating that it is not a source (SOM) | Medium |
| | CL, 1990 | SOM, ABG, BGB | Probably medium |

| | | | |
|---|---|---|---|
| Sweden | No issues | No issues | |
| UK | D | Incomplete land coverage | Probably small |
| | D | Information that demonstrates that deforestation activities began on or after 1 January 1990 | Probably small |
| | D | Emissions from wildfires on deforestation lands | Small |
| Czech Republic | AR, FM | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Small |
| Estonia | ARD | Land identification | Probably small |
| | ARD | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Small |
| | D | Distinguishing of harvesting/forest disturbance from deforestation | Potentially large |
| Hungary | KP tables | National system | Difficult to assess |
| Latvia | AR | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Small |
| | D | "C pool not reported" w/o demonstrating that it is not a source (ABG, BGB, LT, DW, SOM) | Probably small |
| | FM | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Small |
| Poland | ARD, FM | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Medium |
| Romania | KP tables | National system | Difficult to assess |
| | AR | Land identification | Probably small |
| | AR | "C pool not reported" w/o demonstrating that it is not a source (LT, DW,SOM) | Medium |
| | FM | "C pool not reported" w/o demonstrating that it is not a source (LT, DW, SOM) | Medium |
| | FM | Land areas | Unknown |
| Slovakia | ARD, FM | National System | Difficult to assess |
| | ARD | "C pool not reported" w/o demonstrating that it is not a source (LT, DW) | Small |
| Slovenia | D | "C pool not reported" w/o demonstrating that it is not a source (LT) | Small |
| Luxemburg | ARD | KP tables not submitted in time | Likely small |
| Lithuania | ARD, FM | National system | Difficult to assess |
| Bulgaria | ARD | Land identification and "direct human induce" | Medium |
| | ARD | "C pool not reported" w/o demonstrating that it is not a source (DW) | Small |

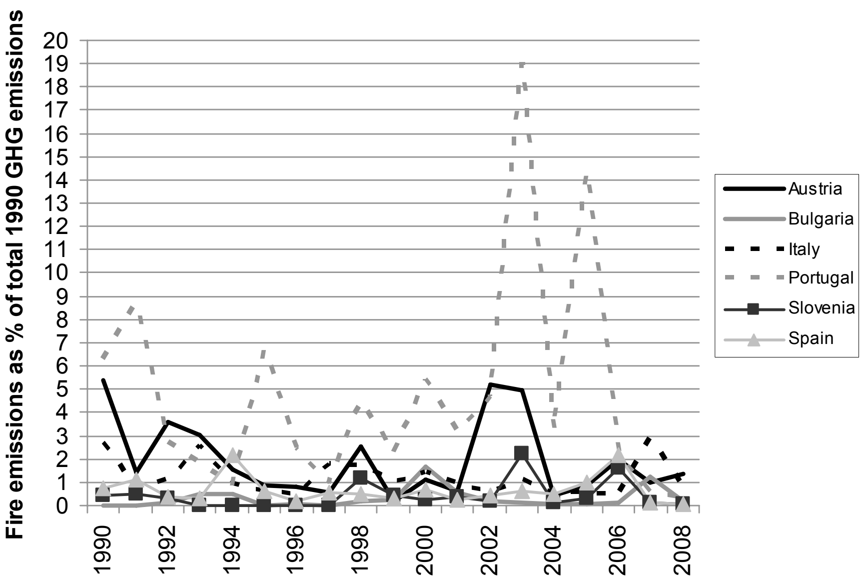
Notation keys: ABG – Above ground biomass; BGB – Below ground biomass; LT – Litter; DW – Deadwood; and SOM – Soil organic matter.

### 8.2. Annex II – Impacts on accounting of threshold values (natural disturbances) and caps (forest management)

#### *8.2.1. Implications of different triggers for the application of provisions for large natural disturbances*

A key point in the discussions on provisions for large natural disturbances is what would trigger their application. Discussions have centred on a trigger set on the basis of total GHG emissions of parties in 1990 (excl. LULUCF), i.e. as a percentage of 1990 emissions. This makes sense because, in the absence of methods for separating natural and human induced effects (IPCC, 2010), the cap would relate to and limit compliance risk. As noted above, events of large disturbances could result from major grass or forest fires, storms and pest/disease outbreaks. Reporting on the related effects on emissions is currently scarce, which would suggest that the application of the provisions may be limited unless monitoring and reporting is improved. Also, in cases where wood can be salvaged, for instance following storms, the related emissions would be spread out over a number of years (up to 35 years) if MSs can account for changes in the HWP pool. However, wildfire is a common and big source of natural disturbance emissions and for which reported data are more frequently available. Figure A2.4 shows that only some six countries in the EU had fire related emissions in the period 1990-2008 that exceeded one percent of total 1990 GHG emissions, and only Portugal and Austria had emissions that at some point exceeded five percent.

**Figure A2.4 Fire related emissions (Mt$CO_2$eq.) in the period 1990-2008 as % of 1990 GHG emissions**




Projections of natural disturbances are difficult (or impossible). However, for the sake of illustration reported data in 1990-2008 can be used to estimate the impact on accounting. If, during this period, a trigger of one percent had been used, on average 5.5 Mt$CO_2$ per year would have been excluded from accounting at the EU level, see Table A2.2, whereas a trigger of five percent would have excluded about 1 Mt$CO_2$ per year on average.

**Table A2.2 Fire emissions that would have been excluded from EU accounting per year as a result of different trigger values in the period 1990-2008**

| Trigger values (set as % of a MS's 1990 GHG emissions excl. LULUCF) | Emissions that would have been excluded from accounting per year in the period 1990-2008 ($MtCO_2eq.$) | | |
|---|---|---|---|
| | Average | min | max |
| 1% | 5588 | 276 | 15474 |
| 2% | 2992 | 0 | 12459 |
| 3% | 1737 | 0 | 11037 |
| 4% | 1327 | 0 | 9663 |
| 5% | 980 | 0 | 8325 |

### *8.2.2. Caps on credits and debits in forest management and their implications*

Given that there is always a degree of uncertainty associated with projections, some parties have called for quantitative limitations ("caps") on credits and debits generated by forest management. Whilst technical corrections of reference levels and provisions for big natural disturbances should eliminate most of the risks of setting "erroneous" reference levels, some uncertainty remains (projections inherently involve a degree of uncertainty). Caps could be put in place to ensure that credits are not issued beyond a reasonable level of expected mitigation potential relative to the projected emissions and removals, or indeed that debits are not issued beyond a reasonable level of a potential deterioration in the sink.

Such caps could be designed in a number of ways; similar to the current cap on forest management, developing countries have called for a cap on credits only, whereas the EU has expressed a preference for caps on both credits and debits, albeit with a higher degree of stringency on the credit side than on the debit side.[54] Discussions have centred on caps set on the basis of total GHG emissions of parties in 1990 (excl. LULUCF), i.e. as a percentage of 1990 emissions. As in the case of natural disturbances this makes sense because the cap relates to compliance (risk). Also, base year emissions are fixed and not subject to changes due to recalculations. A possible disadvantage of the construction is that countries with low total GHG emissions and large forest areas are likely to be more affected by caps than countries with high total emissions. The Durban negotiations in December 2011 settled with a 3.5% credit cap only, applying no cap on debits.

Different cap levels have been discussed previously in the EU, e.g. 4-6% on credits and 8-12% on debits. Table A2.3 shows the impact on accounting of different caps.[55] The calculations are based on a 10% change in the harvest rate compared to the forest management reference level which should be regarded as a conservative approach given that the reference scenario (including reaching the renewable energy targets in the RES-D) in this impact assessment is expected to lead to an increase in the harvest rate of about 4%.

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54 See the March 2011 Environment Council Conclusions.

55 Based on Böttcher et al. (2011) and JRC (2011b) who also provide the forest management reference levels for 15 MSs.

**Table A2.3 Possible debits and credits arising from a 10% change in the harvest rate**

| MS | Possible debits | Possible credits |
|---|---|---|
| | Resulting from a 10% *increase* in the harvest rate (in % of total MS GHG emissions in 1990) | Resulting from a 10% *decrease* in the harvest rate (in % of total MS GHG emissions in 1990) |
| Netherlands | 0% | 0% |
| Greece | 0% | -1% |
| Belgium | 0% | 0% |
| United Kingdom | 0% | 0% |
| Luxembourg | 0% | -1% |
| Denmark | 0% | -1% |
| Italy | 0% | 0% |
| Ireland | 1% | -1% |
| Romania | 1% | -1% |
| Bulgaria | 1% | -1% |
| Germany | 1% | -1% |
| Poland | 1% | -1% |
| Slovakia | 1% | -2% |
| Spain | 1% | -1% |
| Hungary | 1% | -1% |
| Lithuania | 1% | -1% |
| Czech Republic | 1% | -1% |
| France | 1% | -2% |
| Austria | 2% | -2% |
| Slovenia | 2% | -2% |
| Portugal | 2% | -2% |
| Estonia | 2% | -2% |
| Latvia | 5% | -5% |
| Sweden | 9% | -10% |
| Finland | 11% | -9% |

Source: Calculations based on Böttcher et al. (2011) and JRC (2011b)

If the harvest rate is decreased by 10%, only Latvia, Sweden and Finland would exceed a cap on credits of 3% by some 0.5, 5 and 4 Mt respectively (see Table A2.4). Only Sweden and Finland would exceed a cap of 5% by some 3.6 and 2.6 Mt respectively.

**Table A2.4 Possible net removals excluded from accounting at different cap values, arising from a 10% decrease in the harvest rate**

| | Emissions excluded from accounting per year at different caps on credits ($MtCO_2$) | | |
|---|---|---|---|
| | 3% | 3.5% | 4% |
| Latvia | 0.5 | 0.4 | 0.3 |
| Sweden | 5.1 | 4.7 | 4.4 |
| Finland | 4.0 | 3.6 | 3.3 |
| *EU* | *9.6* | *8.8* | *8.0* |

Source: Calculations based on Böttcher et al. (2011) and JRC (2011b)

With the Durban decision all increases in harvest beyond the expected levels in the Forest Management reference level would be accounted for in full.

## 8.3. Annex III – Methodology (models and calibration)

### *8.3.1. Description of the models, their linkages and their use*

The core models used to project emissions and removals from afforestation, deforestation and forest management are G4M (from IIASA) and EFISCEN (from the European Forest Institute, EFI). The EUFASOM model is used to project emissions and removals from cropland and grassland. Table A3.1 and Figure A3.1 below provide the essential features of the main models involved and an overview of the modelling architecture. This section first describes the models and then explains how they have been linked to generate projections. Details can be found in Böttcher et.al. (2011).

EFISCEN (European Forest Information SCENario) is developed and applied by the European Forest Institute (EFI). It is a large-scale forest scenario model that projects forest resource development on regional to European scales. EFISCEN describes the state of the forest as an area distribution over age- and volume-classes based on national forest inventory data. Transitions of areas during simulations represent different natural processes influenced by management regimes and changes in forest area. Management scenarios are specified at two levels in the model. First, a basic management regime defines the period during which thinnings can take place and a minimum age for final fellings. These act as constraints for total harvest levels. Second, the demand for wood is specified for thinnings and final fellings and EFISCEN may fell the demanded wood volume if available. Harvest residues from thinning and final fellings can also be extracted. EFISCEN projects stem wood volume, increment, age-class distributions, removals, forest area, natural mortality and deadwood for every five year time-step. With the help of biomass expansion factors, stem wood volume is converted into whole-tree biomass and subsequently to carbon stocks. EFISCEN is used for projecting the net emissions due to forest management, afforestation and reforestation activities. During the last years initial forest inventory have been updated with new inventory data for a number of countries. The model was used to project the forest carbon sinks.

G4M (Global Forest Model) estimates the annual above ground wood increment and harvesting costs. By comparing the income of managed forest (difference of wood price and harvesting costs and income by storing carbon in forests) with income by alternative land use on the same place a decision of afforestation or deforestation is made. G4M is spatially explicit (currently on a 30"x30" resolution). The model can use external information (like wood prices, prescribed land-use change) from other models or data bases, which guarantee food security and land for urban development or account for disturbances. As outputs, G4M produces estimates of land-use change, carbon sequestration/emissions in forests, impacts of carbon incentives (e.g., avoided deforestation), and supply of biomass for bio-energy and timber. The model includes age classes with one year width. Afforestation and disasters cause an uneven age-class distribution over a forest landscape. The model performs final cuts so that all age classes have the same area after one rotation period. During this age class harmonization time the standing biomass, increment and amount of harvest is fluctuating due to changes in age-class distribution and afterwards stabilizing. The main forest management options considered are species selection, variation of thinning and choice of rotation length. G4M does not model species explicitly but a change of species can be emulated by adapting net primary productivity (NPP), wood price and harvesting costs. The rotation length can be individually chosen but the model can estimate optimal rotation lengths to maximize increment, maximize stocking biomass or maximize harvestable biomass. The model was used to project the forest carbon sinks and the carbon sink enhancement potential and costs (forest management, afforestation and deforestation.

EUFASOM simulates detailed land use and land management adaptations, commodity market and trade equilibrium adjustments, and environmental consequences in response to political, technical, societal, and environmental change scenarios related to agriculture, forestry, and nature conservation. EUFASOM represents the Member States of the European Union but also includes commodity supply and demand functions for non-EU regions covering the entire globe. Likely land use impacts are determined through constrained welfare maximization. The objective function maximizes the net economic surplus from all agricultural and forestry markets and includes the impact of policy incentives and disincentives. Technological opportunities, physical resource endowments, production capacities, inter-temporal relationships, and political regulations form important constraints of EUFASOM. Model output consists of optimal land use allocations and associated management intensities, related environmental impacts, regional resource usage, commodity supply, equilibrium market prices, and trade volumes of the agricultural and forest commodities covered in the model. Technological options include agricultural and forest management alternatives, livestock production, bioenergy and forest industry processing. The objective function incorporates all major drivers for these changes, i.e. cost coefficients for land use and commodity processing alternatives, adjustment costs for major land use changes, market price changes for commodities and production factors, trade costs, political incentives and disincentives, and terminal values for standing forests. EUFASOM was used to project the net emissions from cropland and grassland for each EU country and to assess the potential and costs for increasing the agricultural carbon sink.

**Table A3.1. Essential features of the core models involved in the projection of LULUCF emissions and removals and estimates of potential sink enhancement and their cost.**

| Model | Description |
|---|---|
| G4M | The Global Forest Model (G4M) provides spatially explicit estimates of annual above- and belowground wood increment, development of above- and belowground forest biomass and costs of forestry options such as forest management, afforestation and deforestation by comparing the income of alternative land uses. |
| EFISCEN | The European Forest Information Scenario Model (EFISCEN) is a large-scale model that assesses the supply of wood and biomass from forests and projects forest resource development on regional to European scale, based on forest inventory data. EFISCEN provides projections on basic forest inventory data (stemwood volume, increment, age-structure), as well as carbon in forest biomass and soil. |
| EUFASOM | EUFASOM simulates detailed land use and land management adaptations, in this project limited to cropland and grazing land management. The model represents the Member States of the European Union in detail. Land use impacts are determined through constrained welfare maximization. Crop yields, water and fertilizer requirements, and environmental impacts are simulated with the Environmental Policy Integrated Climate (EPIC) model. |

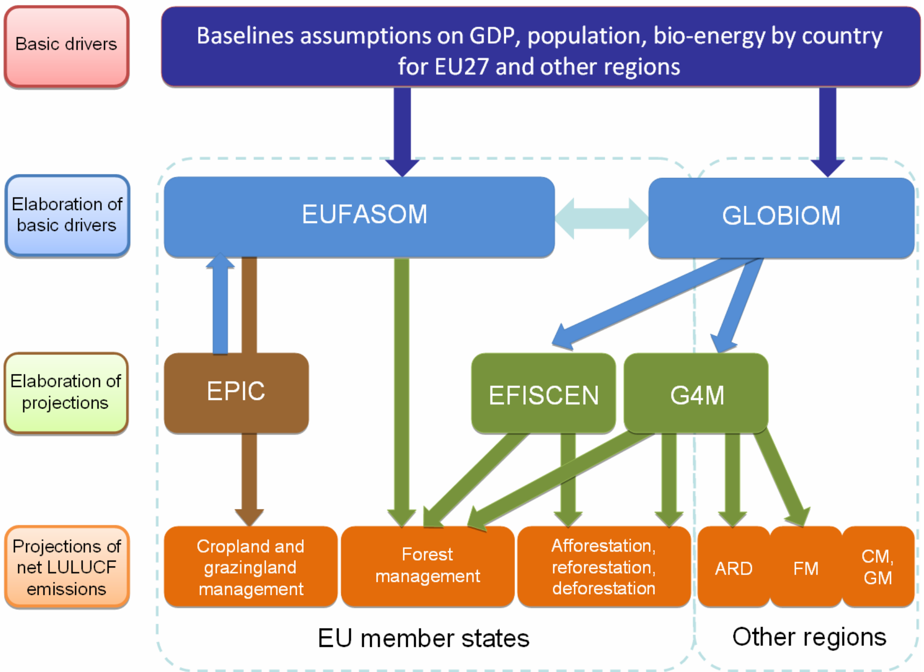
The projections build on macro projections of GDP and population which are exogenous to the models used and consistent with PRIMES information (see Figure A3.1 below). They reflect the recent economic downturn, followed by sustained economic growth resuming after 2010. The GLOBIOM[56] model uses these projections to translate them into demand for timber.[57] Bio-energy demand and supply was projected by the PRIMES biomass model and

56 GLOBIOM is a global static partial equilibrium model integrating the agricultural, livestock, bioenergy and forestry sectors with the aim to give policy advice on global issues concerning land use competition between the major land-based production sectors.

57 See main assumptions in Capros et al. (2010) .

other timber demand by GLOBIUM combined with EFISCEN and G4M.[58] The EU biomass supply model is consistent with the baseline and reference scenarios of the PRIMES large scale energy model for Europe.[59] It is an economic supply model that computes the optimal use of resources and investment in secondary and final transformation, so as to meet a given demand of final biomass energy products, driven by the rest of sectors as in PRIMES model. The primary supply of biomass and waste has been linked with resource origin, availability and concurrent use (land, forestry, municipal or industrial waste etc). The total primary production levels for each primary commodity are restricted by the technical potential of the appropriate primary resource.

**Figure A3.1. Flowchart of information exchange between models**




For the baseline and reference scenarios, the economic land use models (G4M and GLOBIOM) project domestic production and consumption, net exports and prices of wood products and changes in land use for EU member states and other world regions. The sector specific information from the economic models is used by the forest models (EFISCEN and G4M) to project GHG emissions and removals. This requires a complex interaction between models for different sectors with different geographical resolutions and degrees of detail (see Figure) Data exchange from EFISCEN to EU-FASOM includes: areas and volumes by age class, species, owner for 2005, rotation lengths and theoretical harvest potentials. EFISCEN delivers to G4M data on wood densities as weighted average by country. GLOBIOM receives from G4M data on forest management parameters, initial NPV of agricultural land and initial wood prices. After baseline calculations in GLOBIOM to integrate global competition of world regions for different commodities the model provides country level total wood demand to the two detailed forestry models G4M and EFISCEN. In addition, G4M

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58 See http://www.e3mlab.ntua.gr/e3mlab/PRIMES%20Manual/THE_NEW_PRIMES_BIOMASS_MODEL.pdf

59 See http://www.e3mlab.ntua.gr/e3mlab/PRIMES%20Manual/The_PRIMES_MODEL_2008.pdf

receives from GLOBIOM information on the development of land and wood prices. Finally, G4M sends data on the areas of afforestation and deforestation to EFISCEN.

### *8.3.2. Description of uncertainties in the modelling results*

The original model results for each MS are shown in Böttcher et al. (2011). That report also provides a detailed overview of the original model-based predicted impacts, their influences and the underlying assumptions and data. The major elements that affect the uncertainty and sensitivity of the results can be summarized as follows (see Böttcher et al. (2011) for more details). The modelling approach used is to a large degree data-driven. Hence, the quality of the results presented depends heavily on the quality of the datasets that were used. Efforts were made to harmonise data on forest area, basic national forestry inventory data (area, age-class structure, growing stock, increment), wood density, biomass expansion factors and wood removals between models and where possible with estimates and data from member states in number of bilateral meetings and e-mail exchanges with MSs. Harmonisation with datasets used by MSs was not always possible in all cases and differences in datasets used explain differences in reported and projected emissions and removals. For instance, historical roundwood removals were used to initialize the forest models and to estimate the future roundwood removals. A comparison of FAO data on historical wood removals with national statistics included in the EU submission to UNFCCC showed significant differences. Sensitivity analysis indicated that projections were rather sensitive to the assumed harvest rates. Hence, such differences can have substantial impacts on the projected $CO_2$ emissions or removals. Given these uncertainties in the national inventories and differences between models and inventories, the setting of absolute targets (in relation to a past year) such as done for the ESD runs the risk that targets are not met (while infeasible) or costs are higher (or lower) than expected.

Furthermore, the evolution of the future forest management sink in MSs depends on several elements. It is uncertain which role biomass will play in the EU's energy portfolio. For 2020 MSs have presented their views and projections in their National Renewable Action Plans. For 2030 (and also 2020) the demand for 2030 depends to some degree on the economic viability of second generation type of technologies that would utilize wood in an efficient way and the share of other renewable and non-renewable energy sources. Total wood demand depends further on the degree other wood uses will grow and this demand change might also be negative if the increased wood demand for bio-energy would result in higher overall wood prices. Improving resource efficiency through increased recycling rates can also contribute to limit the growth in demand of wood. The impact on the EU forest carbon stocks depends on whether the demand growth will be met by internal production or increased imports. Whether there is an impact on the forest sink or not depends further on whether increased production is achieved through changes in forest management or rather through increased afforestation. Given the relatively high baseline afforestation rates MSs and rather long rotations in new forests including species with rather moderate growth rates, significant additional supply from afforestation is negligible.

In addition, future roundwood production is based on projections by GLOBIOM and PRIMES. The projection by these two models depends on the same macro-economic developments. Furthermore, it was ensured that GLOBIOM reproduced the same numbers on bio-energy production. However, the development of the forest sector was not harmonized between the models. This could lead to discrepancies in the availability of e.g. black liquor and/or wood waste between GLOBIOM and PRIMES. Further harmonisation between PRIMES and GLOBIOM could change the projections of $CO_2$ emission or removals by forests. The GLOBIOM model projected future wood production for the entire EU. In doing so it was assumed that production of wood for material use in all EU countries will increase by the same factor. However, the rate is likely to vary between countries. For some countries "ceilings" on maximum wood removals might have be built in to constrain the production of wood to reflect environmental, technical, social and economical constraints that limit wood supply. The models EFISCEN and G4M have been developed mainly for even-aged forests and application of the models to situations other than even-aged forests should be done with great care. For shorter periods, simulation of increment and growing stock are probably reasonable, but the age-class distribution will be unreliable and this will influence growth rates and growing stocks at the longer term.

Finally, the impact of growth changes and large-scale disturbances due to environmental and/or climate change on the estimated $CO_2$ emissions and removals were not included. Growth may decrease in Southern Europe due to reduced water availability, whereas growth in Northern regions may increase much more. This will affect in changes in future $CO_2$ removals and emissions. Disturbances were also not included in the analysis, but could have an important impact. The impact of growth changes and large-scale disturbances on the development of the LULUCF sector is difficult to model. The model approach does not account for natural forest disturbance, i.e. losses through fire, storm and insects. Especially in boreal and Mediterranean forest ecosystems fire plays a major role in the carbon cycle. By omitting fire losses, both terms might be biased: forest productivity and net carbon storage. To account for fire implies also a consideration of likely management-fire feedbacks. Management can both enhance and suppress the natural fire regime, through anthropogenic ignition, fire suppression and fire management by timber exploitation and debris abandonment. This does not allow a simple ex-post calibration or correction for fire losses. Storm events and insect damage affect the carbon balance in a different way. The biomass is not lost but timber quality drops and harvest schedule is shifted. At the regional level however, shifts in the harvest schedule re likely to be balanced through market mechanisms. More intense harvest in the affected area is thus compensated by reduced timber extraction in intact regions.

### *8.3.3. Description of the calibration method used*

To align differences between models and inventories the original model results were calibrated. The calibration was carried out by the JRC and is referred to as JRC (2011b) in the main text and is consistent with the EU's submission of forest management reference levels to the UNFCCC.[60]

In order to ensure consistency between models' results and historical data on net GHG emissions reported to the UNFCCC by countries, the emissions and removals estimated by the models for the entire time series (up to 2020) were "calibrated" (i.e. adjusted) using historical data from the country for the period 2000-2008 (for which we had both data from the GHG inventories and data projected by the models). To this end, an "offset" was calculated for two components:

- biomass: offset calculated as difference between the average of a country's emissions and removals from biomass for the period 2000-2008 and the average of the models' estimated emissions and removals from biomass for the period 2000-2008

60 See http://unfccc.int/meetings/ad_hoc_working_groups/kp/items/5896.php .

- non-biomass pools and GHG sources: offset calculated as the sum of non-biomass pools and GHG sources as reported by the country for the period 2000-2008, and not estimated by models.

The calibrated average of the models, which is used for the setting of the reference level (for the credit calculation), is obtained by adding the total offset (biomass offset + non-biomass pools and GHG sources offset) to the models' average. In other words, models' results were adjusted to match the average historical data provided by each country for the period 2000-2008. This ensures consistency between country data and models' data in terms of: (i) absolute level of emissions and removals from biomass, i.e. the calibration „reconciles" differences in estimates which may be due to a large variety of factors, including different input data, different parameters, different estimation methods (e.g., some country uses a "stock-change approach", while the models use a "gain-loss approach"); (ii) coverage of non-biomass pools and GHG sources. The calibration procedure automatically incorporates into the projections the average rate (for the period 2000-2008) of the GHG impact of past disturbances, not estimated by the model (e.g. emissions from fires).

The future trend of emissions and removals up to 2020 as predicted by the underlying models is not affected (but the absolute level is affected) by this calibration procedure, but only by the current forest characteristics (e.g. age structure) and the expected future harvest demand (be it for materials or energy purposes.

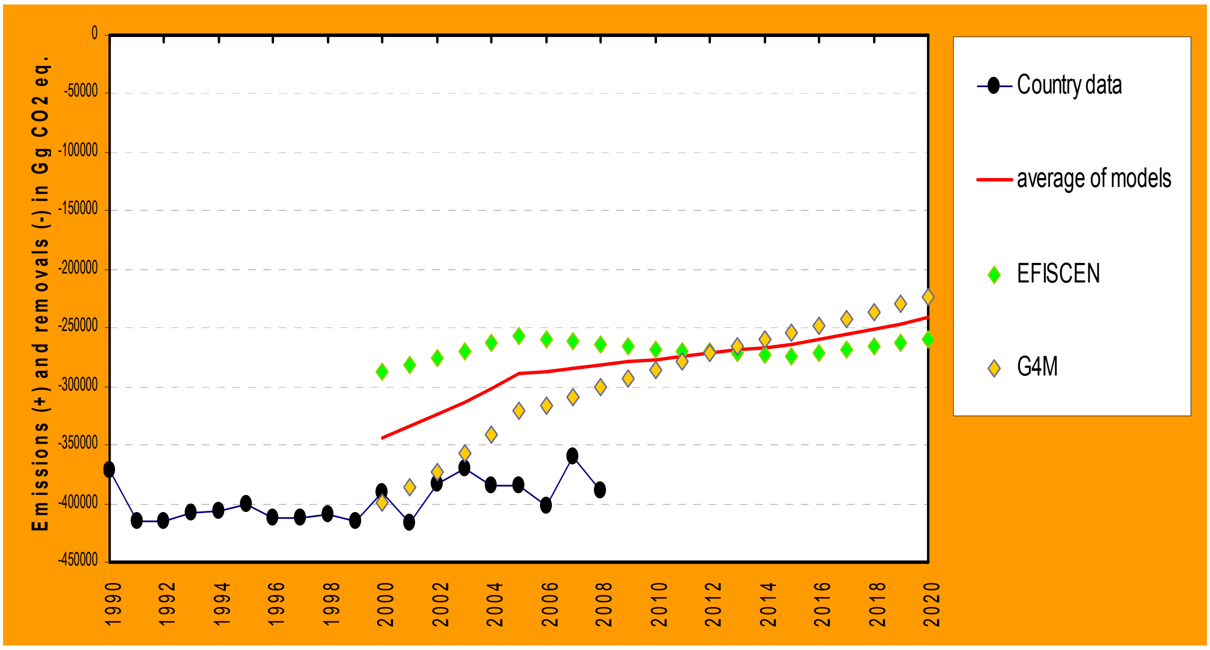
This way of calibration implies that model projections are now more consistent with reported emission inventories (2000 to 2008). The uncertainty in the emission inventory itself (around 35%) still exists and the fact that national emission inventories do not cover all sources is also not resolved. Adjusted in this way the model results are closer to reported data (EEA, 2011) and the difference is less than 5% in 2005 for forest management. The calibrated G4M model estimates the EU's forest management sink at 378 Mt$CO_2$, EFISCEN estimates 387 Mt$CO_2$ and the reported data suggest 394 MtCO2 for 2005. For afforestation and deforestation uncertainty is also less than 5%.For grazing land management uncertainty is higher (10%) but not all countries report this.

Still, as with any projections there is uncertainty. This can best be illustrated for forest management, the most significant activity. The calibrated G4M model projects a sink of -297 Mt$CO_2$ in 2020 in the EU. The EFISCEN model projects -378 Mt$CO_2$. The average is -338 Mt$CO_2$. For the UNFCCC process 10 MSs also made their own projections.[61] Combining these 10 estimates with the model projections for the other countries (average of G4M and EFISCEN model) gives a FM sink of -253 MtCO2 (the sum of FM reference levels without HWP). The result of these 3 projections is a mean of -313 Mt$CO_2$ and an uncertainty of +/- 58 MtCO2 (standard deviation). The uncertainty is a factor ten higher than the reduction of 5.4 Mt$CO_2$ that could be expected from setting a reduction target for the EU on the basis of €5 per t$CO_2$. Given this uncertainty at an EU level the setting of absolute targets at an EU level runs the risks of not meeting the target or meeting the target at higher costs than expected certainly when the majority of the sink enhancement is expected to come from forest management in 2020. Agreeing on a reduction of 5 Mt$CO_2$ could then imply doing nothing (if the sink is 58 Mt$CO_2$ higher than expected) or having to increase the sink by 63 Mt$CO_2$ in 2020 which is not feasible or would require very high marginal costs (above €150/t $CO_2$), see Böttcher et al. (2011).

[61] http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_eu_2011_rev.pdf

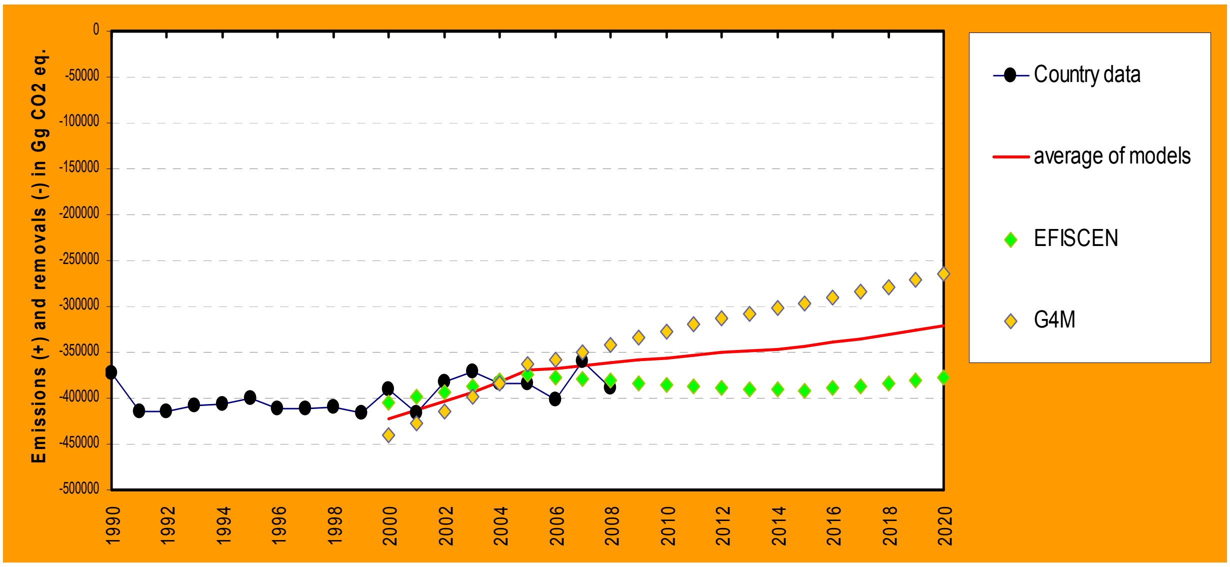
The figure below shows the results of the models for forest management before calibration.

**Figure A3.2. Model results for forest management before calibration**




The figure below shows the results after calibration to fit data for the period 2000-2008.

**Figure A3.3. Model results for forest management after calibration**




## 8.4. Annex IV – Model results: projected emissions / removals and abatement costs

### *8.4.1. Projected emissions and removals (Reference scenario)*

This annex presents the model predictions of emissions and removals in the "reference scenario" for the period leading up to 2020. A description of the assumptions underpinning the scenario is given by Böttcher et al. (2011), see also Capros et al (2010). The models and their calibration are explained in Annex III to this report and in Böttcher et al. (2011).

### 8.4.1.1. Models average

**Table A4.1. Net emissions and emissions for the EU-27 in the reference scenario (models average) ($KtCO_2$/year)**

| Activity | 2005 (reported) | 2010 | 2015 | 2020 | Average 2013-20 |
|---|---|---|---|---|---|
| Afforestation/reforestation | -40569 | -43267 | -50727 | -60128 | -53559 |
| Deforestation | 25237 | 18056 | 23990 | 26954 | 24617 |
| Forest management | -383469 | -363818 | -347351 | -325996 | -340721 |
| Cropland management | 66089 | 59038 | 58282 | 54609 | 56961 |
| Grazing land management | -30872 | -33081 | -33081 | -33081 | -33081 |
| **Total LULUCF** | **-363584** | **-363072** | **-348887** | **-337641** | **-345782** |

Note: A minus sign denotes net emissions and plus sign net removals.

Source: Böttcher et al. (2011) and JRC (2011b)

### 8.4.1.2. G4M and EUFASOM

**Table A4.2. Net emissions and emissions for the EU-27 in the reference scenario (G4M + EUFASOM) ($KtCO_2$/year)**

| Activity | 2005 (reported) | 2010 | 2015 | 2020 | Average 2013-20 |
|---|---|---|---|---|---|
| Afforestation/reforestation | -40569 | -43267 | -50727 | -60128 | -53559 |
| Deforestation | 25237 | 18056 | 23990 | 26954 | 24617 |
| Forest management | -383469 | -343959 | -313983 | -285295 | -305759 |
| Cropland management | 66089 | 59038 | 58282 | 54609 | 56961 |
| Grazing land management | -30872 | -33081 | -33081 | -33081 | -33081 |
| **Total LULUCF** | **-363583** | **-343213** | **-315518** | **-296940** | **-310820** |

Note: A minus sign denotes net emissions and plus sign net removals.

Source: Böttcher et al. (2011) and JRC (2011b)

### 8.4.1.3. EFISCEN and EUFASOM

**Table A4.3. Net emissions and emissions for the EU-27 in the reference scenario (EFISCEN + EUFASOM) ($KtCO_2$/year)**

| Activity | 2005 (reported) | 2010 | 2015 | 2020 | Average 2013-20 |
|---|---|---|---|---|---|
| Afforestation/reforestation | -40569 | -43267 | -50727 | -60128 | -53559 |
| Deforestation | 25237 | 18056 | 23990 | 26954 | 24617 |
| Forest management | -383469 | -383677 | -380718 | -366696 | -375682 |
| Cropland management | 66089 | 59038 | 58282 | 54609 | 56961 |
| Grazing land management | -30872 | -33081 | -33081 | -33081 | -33081 |
| **Total LULUCF** | **-363583** | **-382931** | **-382254** | **-378341** | **-380743** |

Note: A minus sign denotes net emissions and plus sign net removals.

Source: Böttcher et al. (2011) and JRC (2011b)

### 8.4.1.4. Accounting results for individual MSs and the EU-27(models average)

See table on next page

**Table A4.4. Credits ($KtCO_2$ per year) for three accounting options**

| **Accounting option** | Accounting option (a)<br>Small changes | Accounting option (b)<br>Likely outcome in the UNFCCC negotiations | | Accounting option (c)<br>UNFCCC+ | |
|---|---|---|---|---|---|
| | | (I) models | (II) mix | (I) models | (II) mix |
| Austria | -3953 | -1258 | -5083 | -1363 | -5188 |
| Belgium | -671 | -652 | -651 | -726 | -726 |
| Bulgaria | 284 | 2830 | 944 | 3766 | 1881 |
| Cyprus | -1 | -4 | 155 | -4 | 155 |
| Czech Republic | -114 | 1309 | 1310 | 761 | 762 |
| Denmark | -92 | -1041 | -1481 | -1041 | -1481 |
| Estonia | -1326 | -2199 | -2199 | -3171 | -3171 |
| Finland | -4155 | -1564 | -1833 | -1457 | -1726 |
| France | -13763 | -4253 | -4253 | -6834 | -6834 |
| Germany | -10542 | -3687 | -42780 | -4217 | -43310 |
| Greece | -570 | -274 | -415 | -760 | -901 |
| Hungary | 349 | 961 | 961 | 1053 | 1052 |
| Ireland | -2989 | -2576 | -3603 | -2678 | -3705 |
| Italy | -7946 | 7008 | 7008 | -3887 | -3888 |
| Latvia | -2167 | 1051 | -678 | 888 | -841 |
| Lithuania | -274 | 67 | 95 | -232 | -204 |
| Luxembourg | -28 | 35 | -90 | 53 | -72 |
| Malta | 0 | 0 | 49 | 0 | 49 |
| Netherlands | -184 | 10 | -74 | -54 | -139 |
| Poland | -7409 | -7495 | -18867 | -8307 | -19679 |
| Portugal | -4292 | -4969 | -5645 | -4969 | -5645 |
| Romania | -1251 | 2483 | 1487 | 3817 | 2821 |
| Slovakia | -16 | -390 | -390 | -308 | -308 |
| Slovenia | 247 | 2112 | 761 | 2324 | 972 |
| Spain | -6984 | 1457 | 1586 | 684 | 813 |
| Sweden | -7519 | -2833 | -2833 | -3990 | -3990 |
| UK | -3292 | -617 | -9263 | -4307 | -12953 |
| **EU27** | **-78658** | **-14487** | **-85781** | **-34958** | **-106253** |
| **Cumulative (2013-2020)** | **-6292666** | **-115892** | **-686248** | **-279667** | **-850023** |

Note: A minus sign denotes net credits and a plus sign net debits. Credits for forest management are calculated in two different ways. In both cases the impact of the cap on credits of 3.5% of base year emissions is included:

(1) ( Modeled emissions and removals in reference scenario) – (modeled emissions and removales in the baseline scenario)

(2) ( Modeled emissions and removals in reference scenario) – (forest management reference levels in LULUCF decision CMP.7).

Source: Calculations based on Böttcher et al. (2011) and JRC (2011)

Differences between columns (I) and (II) are mainly due to different assumptions in future harvest rates between model projections and the country's projections used to set forest management reference levels. Some MS (e.g., Germany, Poland, Slovenia, Austria, United Kingdom) used in their forest management reference levels higher future harvest rates than assumed by the G4M and Efiscen models. Differences between option (c) and option (b) reflect the impact of cropland and grazing management. The large difference between option (c) and option (b) for Italy reflects the potential credits from grassland management, essentially due to the fact that Italy reported a large increase of the sink in grassland from 1990 to now (more than 15 MtCO2 increase). While part of this increase is explainable by the increased area of other wooded lands since 1990 (which Italy reports under grassland), further checks may reveal the need for some corrections. Abatement costs and emission reductions per Member State

**Table A4.5. Emission reductions and annual costs in 2020 by Member States at various carbon prices**

| MS | Emissions reduction (MtCO2) at different prices | | | Annual cost (mln €) at different prices | | |
|---|---|---|---|---|---|---|
| | €5/t$CO_2$ | €15/t$CO_2$ | €30/t$CO_2$ | €5/t$CO_2$ | €15/t$CO_2$ | €30/t$CO_2$ |
| Austria | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 6.1 |
| Belgium | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 4.1 |
| Bulgaria | 1.3 | 1.3 | 2.4 | 0.6 | 0.6 | 4.1 |
| Cyprus | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Czech Rep. | 0.3 | 0.4 | 0.4 | 1.7 | 2.2 | 2.2 |
| Denmark | 0.1 | 0.1 | 0.1 | 0.6 | 0.6 | 4.1 |
| Estonia | 0.7 | 0.7 | 0.9 | 3.7 | 3.7 | 7.3 |
| Finland | 1.3 | 1.9 | 2.3 | 6.7 | 15.7 | 24.2 |
| France | 0.3 | 0.6 | 0.6 | 1.3 | 6.9 | 6.9 |
| Germany | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 16.3 |
| Greece | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Hungary | 0.1 | 0.1 | 0.4 | 0.3 | 0.3 | 6.3 |
| Ireland | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Italy | 0.5 | 0.5 | 0.5 | 2.4 | 2.4 | 2.4 |
| Latvia | 0.2 | 0.3 | 0.3 | 1.1 | 2.4 | 2.4 |
| Lithuania | 0.2 | 0.2 | 0.2 | 0.9 | 0.9 | 0.9 |
| Luxembourg | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Malta | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Netherlands | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Poland | 0.0 | 0.0 | 0.2 | 0.0 | 0.4 | 5.9 |
| Portugal | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 3.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Romania | 0.0 | 0.5 | 0.5 | 0.0 | 4.8 | 4.8 |
| Slovakia | 0.2 | 0.2 | 0.3 | 1.0 | 1.0 | 3.7 |
| Slovenia | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Spain | 0.1 | 0.1 | 0.1 | 0.4 | 0.4 | 0.4 |
| Sweden | 0.0 | 0.0 | 0.4 | 0.0 | 0.2 | 11.4 |
| UK | 0.1 | 0.1 | 0.2 | 0.6 | 0.6 | 4.1 |
| **EU27** | **5.4** | **7.0** | **10.7** | **26.4** | **58.2** | **150.9** |

Note: Costs are in €2008.

Source: Böttcher et al. (2011).

### *8.4.2. Distribution of costs*

**Table A4.6. Distribution of (net) abatement costs (in million € in 2008 prices)**

| | **Option 2.II** | | | **Option 3** | | |
|---|---|---|---|---|---|---|
| | **Include LULUCF as a separate framework (Target)** | | | **Include LULUCF in the ESD** | | |
| *Accounting option* | *(a)* | *(b)* | *(c)* | *(a)* | *(b)* | *(c)* |
| Austria | 0 | 0 | 0 | -8 | -5 | -5 |
| Belgium | 0 | 0 | 0 | -1 | -3 | -3 |
| Bulgaria | 6 | 6 | 6 | 0 | 12 | 15 |
| Cyprus | 0 | 0 | 0 | 0 | 0 | 0 |
| Czech Rep. | 2 | 2 | 2 | 0 | 6 | 4 |
| Denmark | 0 | 0 | 0 | 0 | -1 | -4 |
| Estonia | 4 | 4 | 4 | -3 | -14 | -17 |
| Finland | 11 | 7 | 7 | -9 | -7 | -6 |
| France | 4 | 1 | 1 | -29 | -24 | -32 |
| Germany | 0 | 0 | 0 | -22 | -16 | -17 |
| Greece | 0 | 0 | 0 | -1 | -1 | -3 |
| Hungary | 0 | 0 | 0 | 1 | 4 | 4 |
| Ireland | 0 | 0 | 0 | -6 | -11 | -11 |
| Italy | 2 | 2 | 2 | -16 | 29 | -17 |
| Latvia | 2 | 1 | 1 | -1 | 11 | 10 |
| Lithuania | 1 | 1 | 1 | -2 | -3 | -4 |
| Luxembourg | 0 | 0 | 0 | 1 | 2 | 2 |
| Malta | 0 | 0 | 0 | 0 | 0 | 0 |
| Netherlands | 0 | 0 | 0 | 0 | 0 | 0 |
| Poland | 0 | 0 | 0 | -15 | -32 | -33 |
| Portugal | 0 | 0 | 0 | -9 | -17 | -20 |
| Romania | 5 | 0 | 0 | -8 | 8 | 7 |
| Slovakia | 1 | 1 | 1 | 0 | -1 | -1 |
| Slovenia | 0 | 0 | 0 | 1 | 9 | 9 |
| Spain | 0 | 0 | 0 | -14 | 19 | 3 |
| Sweden | 0 | 0 | 0 | -16 | -18 | -21 |
| UK | 1 | 1 | 1 | -7 | -3 | -17 |
| **EU-27** | 40 | 27 | 27 | -166 | -55 | -156 |

Source: Calculations based on an updated version of Böttcher et al. (2011), JRC (2011b) reflecting the UNFCCC review mid 2011 and results of the PRIMES-GAINS models.

## 8.5. Annex V – Discarded options

This annex outlines the policy and accounting options that have not been considered in detail in this impact assessment and the reasons why.

### *8.5.1. Discarded policy options*

The option of including LULUCF in the EU ETS has not been considered in detail in this impact assessment. It has already been the subject of two studies by the Commission.[62] Both argue against including LULUCF in the EU ETS for the following reasons (applicable to the use of LULUCF for project off-sets such as CDM and/or as a fully included sector):

- There are considerable risks related to the temporary and reversible nature of LULUCF activities in a company-based trading system designed to handle permanent emissions reductions. No modalities have been developed to mitigate the impacts of non-permanence, high uncertainties (including the likelihood of necessary recalculations), jeopardising the environmental effectiveness of the EU ETS.

- Simplicity, transparency and predictability of the EU ETS would be reduced considerably.

- The inclusion of LULUCF in the EU ETS would require land holdings to be subject to monitoring rules. This would require a quality of monitoring and reporting at the holding level that is comparable to the monitoring and reporting of emissions from the installations currently covered by the system. The currently available guidance for monitoring LULUCF (IPCC, 2003; IPCC, 2006) has been designed for national inventory systems and are not applicable to monitoring at the farm/land holding level. This has three major implications:

    (1) A whole new monitoring system and protocol would need to be developed for use on all types of land, a resource and time demanding process.

    (2) As LULUCF monitoring systems and approaches are scale-dependent, the compatibility/consistency of farm/holding level estimates with those of national data could not be guaranteed, and therefore would require a separate system to handle the unavoidable discrepancies.

    (3) Because of the much higher resolution of monitoring, the cost of the system (both monitoring and administrative) would be orders of magnitude more expensive than that of a national inventory, and significantly higher than monitoring and transaction costs in the current EU ETS sectors (see e.g. Annex I for a comparison of uncertainties between sectors).

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62 Impact Assessment of the Directive of the European parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system. {COM(2008) 16 final}{SEC(2008) 53} and Extended Impact Assessment on the Directive of the European Parliament and of the Council amending Directive establishing a scheme for greenhouse gas emission allowance trading within the Community in respect of the Kyoto Protocol's project based mechanisms {COM(2003) 403 final}{SEC(2003) 785}

- Because of the relatively high variability of credits/debits potentially affecting the system (and quantity in the case of project off-sets), the functioning of the carbon market might be undermined.

These findings have subsequently been confirmed by an additional review (Watterson et al., 2011) which, based on the EU ETS legislation, looked at implications of incorporating LULUCF directly within the scheme. An overview of the key features of the legislation and related difficulties in integrating LULUCF is also provided in that report.

8.5.1.1. Splitting LULUCF according to activities for the inclusion in different policy frameworks

The mandate requires the Commission to see if and how the sector can be included in the EU's GHG reduction commitment. It may be possible to argue that different LULUCF activities could be addressed under different frameworks just like the energy and industry sectors are currently divided between the ETS and the ESD. For instance, new guidance on reporting has been produced by the IPCC (2006) in which non-$CO_2$ GHG emissions from agriculture and GHG emissions from LULUCF are merged into one sector. However, this guidance has yet to be adopted by the UNFCCC and the EU has advocated for continued reporting according to the present sub-sectors. As no compelling reason for dividing the sector has been found, this option was not considered further.

*8.5.2. Discarded accounting options*

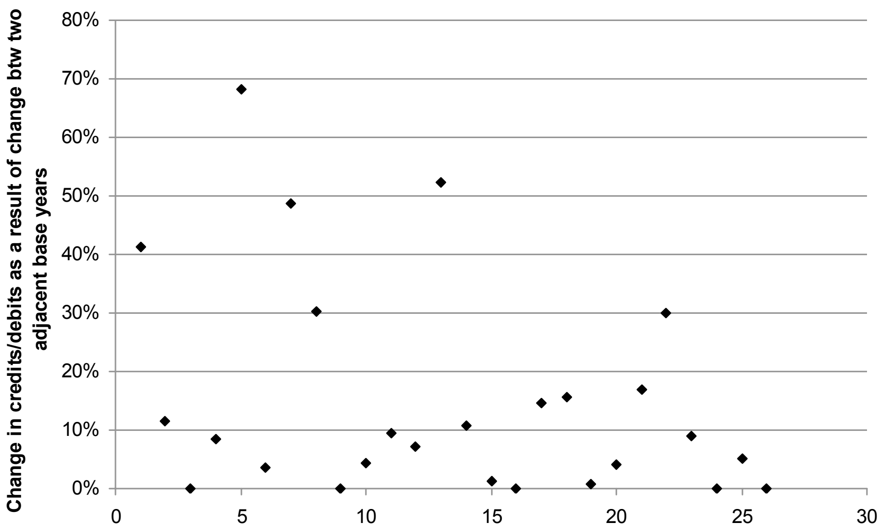
The following accounting options have been discarded for the reasons given below:

- *Gross/Net accounting without constraints or with a cap*. As in the case of the current KP rules, this accounting approach does not reflect anthropogenic emissions and removals as it involves accounting emissions and removals that occur naturally in the commitment period without comparison to a reference year/period. The accounting results therefore represent a windfall and limits the incentives for mitigation efforts since the noise from natural factors is too large for human interventions to be detected. Such incentives would be further limited with the addition of a cap beyond which no changes will register in the accounting.

- *Net/Net accounting for forest management for relative to a single base year or historical period.* As noted above, emissions and removals in forests depend on a number of natural (regional/geographical) circumstances such as variations in growing conditions (temperature, precipitation and droughts) and natural disturbances (storms, fires) as well as past and present management practices (rotation lengths, which affect the distribution of age classes in forest stands and therefore the rate of removals). A single base year or historical period is not able to reflect these factors and resulting cyclical impacts on emissions and removals or their inter-annual variations (see Figure 3 in the main text). Instead, such an approach would create a random impact on accounting. Figure A5.1 illustrates this point by showing the effects on accounting of forest management for a fictive commitment period of 1990-2008 (reported data) by changing the base year from 1990 to 1991. The effects of management practices are limited between two years, yet the differences in accounting would be as high as 70% in terms of debits / credits.

- *Inclusion of wetland or rewetting and drainage on land with organic soil.* The activity relating to wetland management was defined in the negotiations under the KP in Durban in December 2011, but the IPCC Guidance (IPCC, 2006) on reporting of Wetlands has not yet been adopted by Parties to the UNFCCC (earlier IPCC guidance does not fully address Wetland). In addition, a mandatory inclusion of agricultural and forestry activities (and their soils) would implicitly cover around 90% of emissions from organic soils in the EU (JRC, 2011a). The activity should however be considered for mandatory inclusion in subsequent commitment periods.

**Figure A5.1. Illustration: Impact on accounting of changing from 1990 to 1991 as a base year (using reported data in 1990 to 2008 as a fictive commitment period)**




Note: Each observation shows the impact on accounting for a MS.

Source: Based on EEA (2011)

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