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LULUCF contribution to the 2030 EU climate and energy policy

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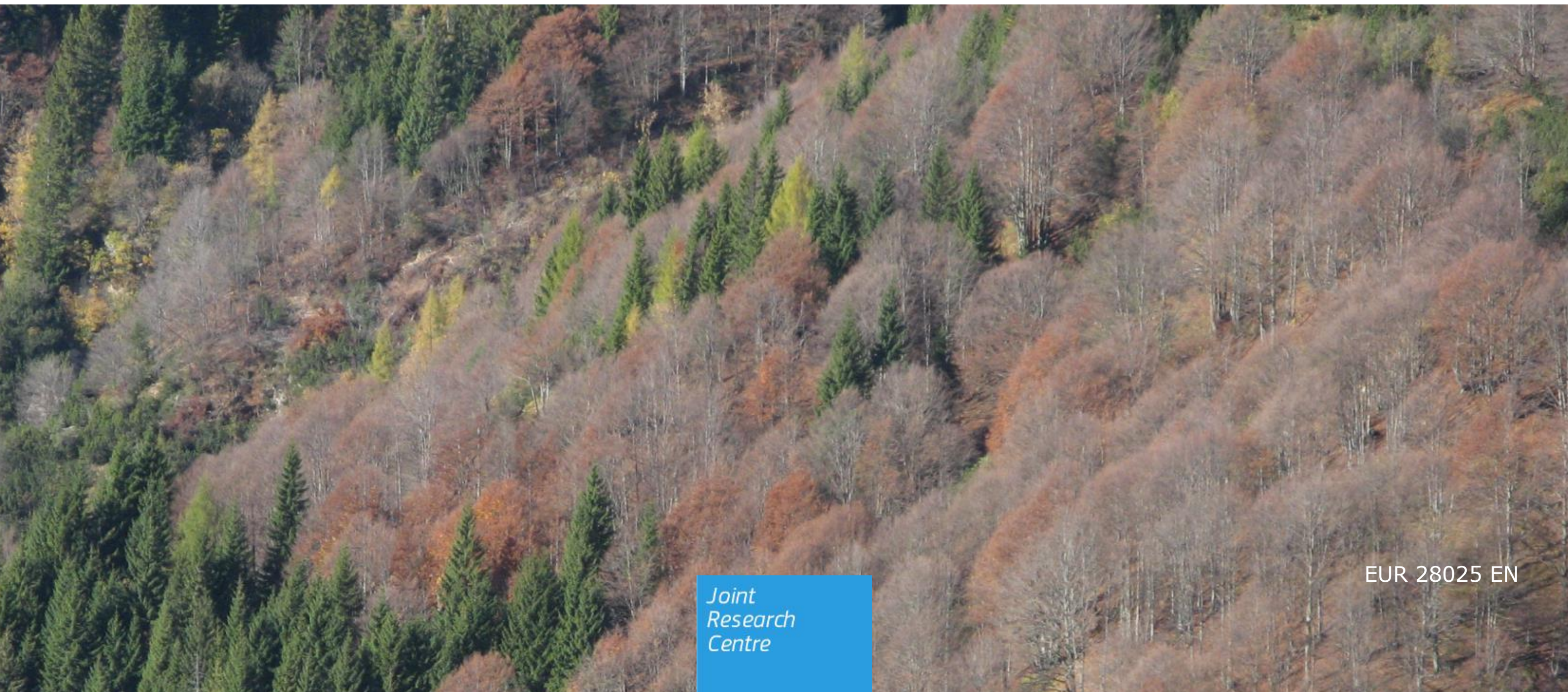

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Executive summary

The objective of this report is to present and discuss the results from the Administrative Arrangement (AA) "LULUCF 2030", aimed at supporting DG CLIMA on the following issues:

1) Implementation the EU LULUCF Decision 529/2013, especially with regard to evaluating the estimates reported by MS on carbon stock changes in CM and GM (to be reported for the first time in 2015) and elaborate recommendations to help MS on the gradual improvement in the reporting of emission estimates.
2) Contribution to specific elements of the Impact Assessment (IA) associated to a legislative proposal on the inclusion of the land use sector in the 2030 EU climate and energy policy.

Specifically, the work within this AA is organized along three main tasks:

1) Analysis of MS' reporting of estimates of emissions from Cropland and Grazing land Management (CM/GM)

2) Projections for LULUCF up to 2030 (for forest and agricultural activities)

3) Update of country-specific JRC Land Use factsheets.

For **Task 1**, we analysed CM and GM estimates reported by MS under Decision 529/2013 (and any available information on methods used), and elaborated a short assessment in terms of adherence to the reporting principles (accuracy, transparency, comparability, consistency, completeness). Then, recommendations have been elaborated to help MS improving their estimates. Detailed results of the analysis are presented in Annex 1.

Overall, the lack of a functioning version of the CRF Reporter heavily influenced all the GHG reporting for the year 2015 and 2016, including under the 529/2013 LULUCF decision. In 2015, the majority of MS included some quantitative estimate for CM and GM. During the year 2016, *most* of the MS have provided information on: (i) annual estimates of emissions and removals from CM and GM, (ii) methods and data used for these estimates, and, (iii) the system in place and being developed to estimates emissions and removals from these activities.

Despite the increase of the quantity of information, there are still significant differences among MS. Several issues have been identified and there is still the need to provide the information in a more harmonized way that allows a better assessment and comparability.

General recommendations for all the MS include: (i) to make use of the official channel for the provision of information pursuant the Decision 529/2013 and inform the Commission on when and what information is being submitted; (ii) to use the guidance for CM and GM developed under the project "LULUCF implementation guidelines and policy options", and other tools developed by the JRC (e.g. for estimating carbon stock changes in living biomass).

Task 2 is focused on producing new country-specific projections of carbon stock changes up to 2030 for the following LULUCF activities: Forest management (FM), Afforestation/Reforestation (AR), Deforestation (D), Cropland Management (CM) and Grazing land Management (GM).

Our **forest projections** up to 2030 for FM, AR and D have been done with the Carbon Budget Model (CBM). A short overview of the methods and the key results at EU level is included in section 3.1, with detailed country methods in Annex 2a and detailed country reports in Annex 2b. For FM, assumptions of future harvest rates are consistent with the "Reference scenario 2016" (based on Primes and IIASA's GLOBIOM/G4M modelling). For AR and D, assumptions of future forest land use change areas are derived from the "Reference scenario 2016" as modelled by GLOBIOM/G4M. Preliminary results for a sensitivity analysis for the key drivers (+/-10% FM harvest, and +/-50% AR/D area) are also provided.

Given the possibility that post-2020 LULUCF accounting will be based on land use categories (rather than activities), estimates are provided also for the land use subcategories corresponding to FM, AR and D (even if not originally foreseen in the AA), i.e. "forest remaining forest" (FL-FL), "land converted to forest" (L-FL, with 20-years transition period, or 30 years) and "forest converted to other land uses" (F-OL).

Overall, emissions/removals and accounting at EU level are shown in Figure 1, where we compare emissions (+) and removals (-) estimated for the period 2021-2030 for the KP activities (FM, AR, D) by G4M (IIASA – Reference scenario 2016) and by CBM (JRC); for CBM we also show results for the UNFCCC forest categories (FL-FL, L-FL with 20-years transition, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU forest "reference level") and *gross-net accounting* for AR / FL and D / FL-OL. More detailed EU-level results are included in section 3.1.2.

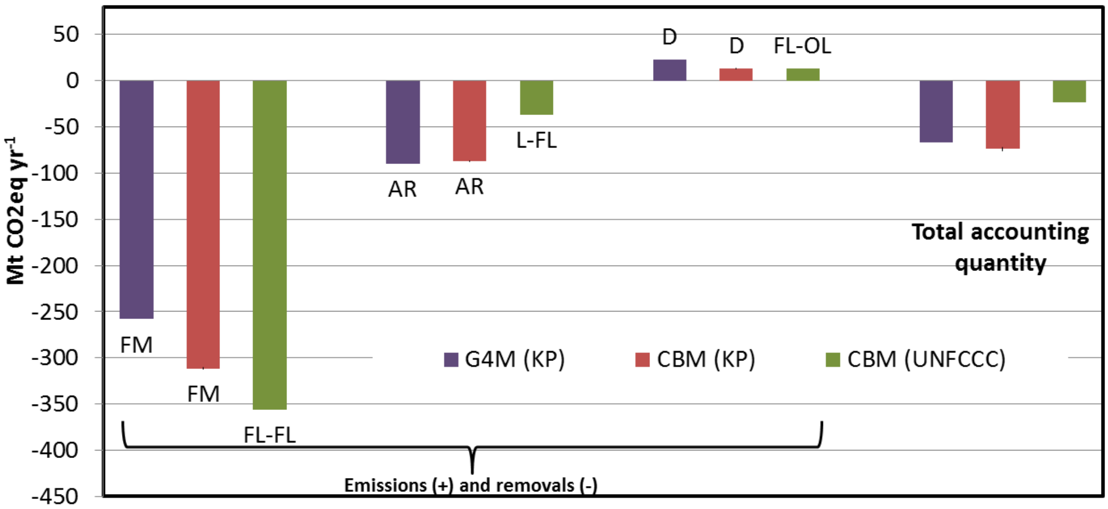


Figure 1: EU summary of emissions and removals and of accounting quantities for 2021-2030, using KP activities and UNFCCC land use categories. Here L-FL is assumed with a 20-years transition period.

Within task 2, we also developed a preliminary methodology, presented in section 3.2, for the future evolution of changes in forest areas estimated by the JRC, alternative to those from GLOBIOM/G4M but stemming from the same macroeconomic assumptions of the Reference Scenario. These estimates are obtained from the interaction between CBM and LUISA, including a preliminary simulation of the competition between agricultural and forest lands (based on the work initiated in the AA AFO-CC). This work represents an important step toward a more integrated LULUCF modelling framework. The focus has been on the methods, rather than on the results achieved, which therefore are to be considered very preliminary. EU-level results are included in section 3.2.2. Detailed results, country by country, are included in Annex 3.

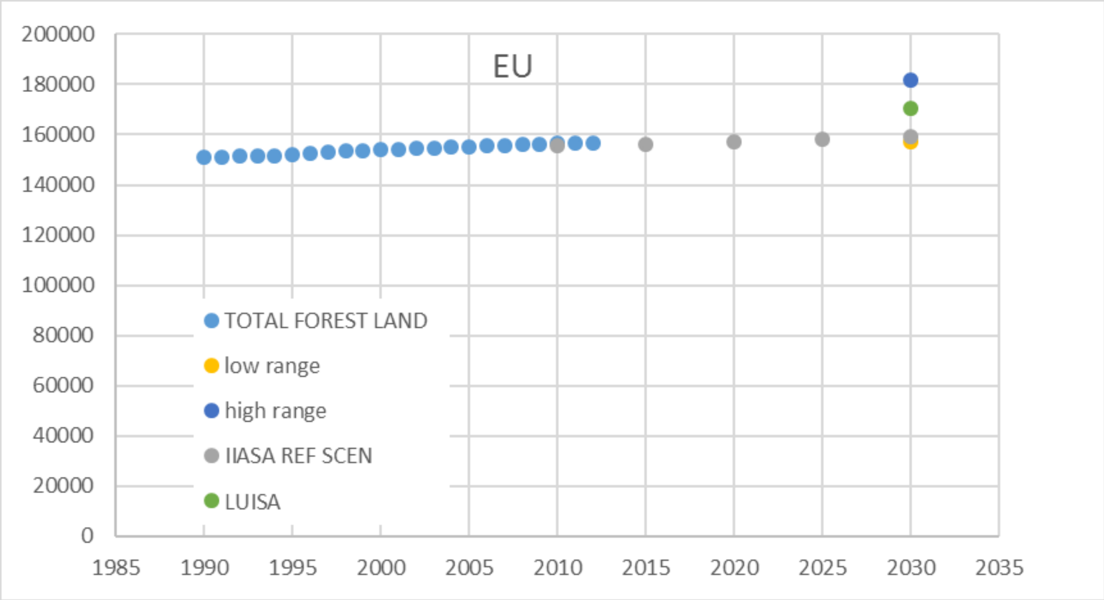


Figure 2: Historic evolution of EU forest land (in blue) compared with projected trends from the 2013 Reference Scenario (in grey) and with 2030 projections as elaborated with LUISA (in green). The graph also shows the range of variation that was allowed in LUISA for 2030 (yellow and dark blue).

Our **projections of carbon stock changes in CM and GM mineral soils** from 2010 to 2030 are based on the IPCC tier 1 method. For this assessment, we use future land use changes estimated by LUISA for the Reference Scenario, and assume continuation of current management/input based on statistics (this includes the projections of the carry-over effects of management/input changes in last 20yr). Emissions from cropland and from grassland are shown in Figure 3 and Figure 4, respectively. For this analysis, we show both the results in their original form and adjusted to the 2015 GHG inventories. Over 20 years the soil C-stock of all land areas decreases by 0.15%. A short overview of the methods and the key results at EU level is included in section 3.3, with the detailed results in Annex 4.

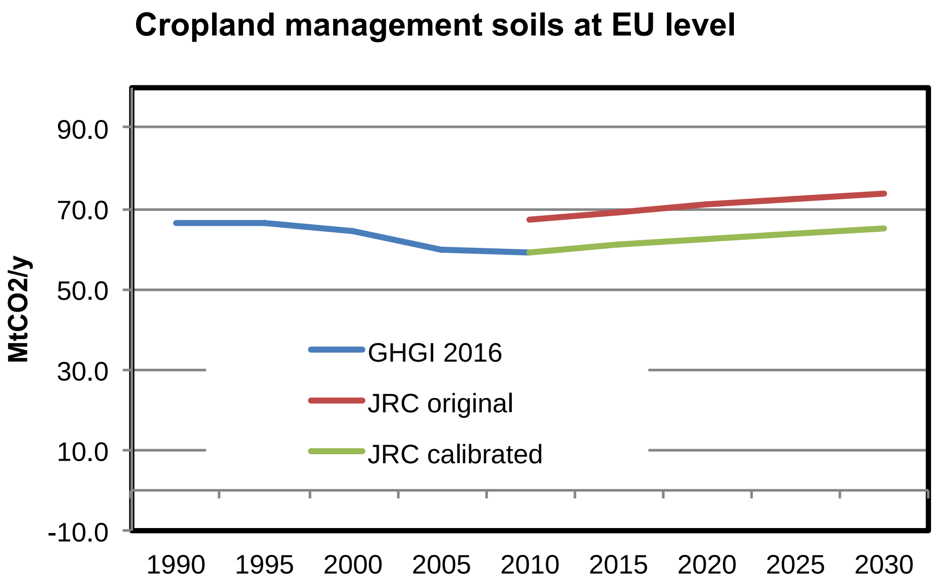


Figure 3: 2005-2030 emissions from Cropland soils at EU level.

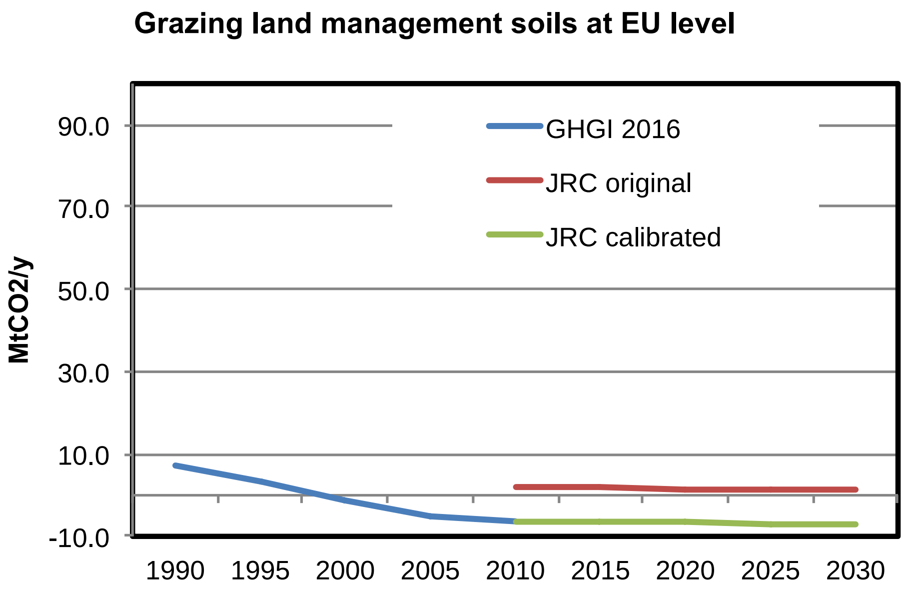


Figure 4: 2005-2030 emissions from Grassland soils at EU level.

A summary comparison of JRC and IIASA models' results, and data from countries' 2016 GHG inventories (GHGI), is shown for all activities/land uses in Figure 5. Models' results for FM, CM and GM are calibrated for the period 2000-2012 with the 2016 GHG inventories. Models' results for HWP, AR and D are *not* calibrated either because the difference with latest historical data from GHGI 2016 is small (HWP, AR, D for CBM) or because the calibration would produce meaningless results. Overall, both modelling frameworks (JRC and IIASA) suggest a very slight decline on future LULUCF sink. A more detailed summary of LULUCF projections and impact on accounting at EU level is included in section 3.4.

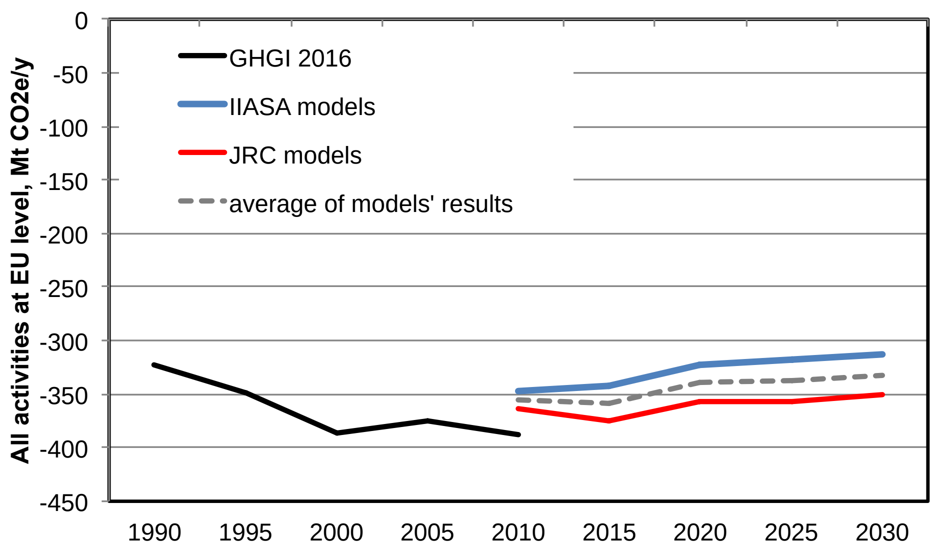


Figure 5: Sum of models results (JRC vs IIASA) for all activities and land uses shown in the previous figures (FM+HWP+AR+D+CM+GM). All data are 5-years averages.

Finally, **Task 3** updated the country-specific JRC land use factsheets with the latest available data, including the results of the present study. Section 4 includes the factsheet for the EU, and all the countries factsheets are in the Annex 5.

1 Introduction

At both the EU and global levels, the land use sector plays a significant role in greenhouse gas (GHG) emissions and removals. However, historically, the inclusion of Land Use, Land Use Change and Forestry (LULUCF) into climate targets has been complex and fragmented, mainly due to the methodological difficulties of this sector.

In the context of moving to a competitive low-carbon economy in 2050, the EU indicated that all land use should be considered in a holistic manner and LULUCF should be addressed within the Union's climate policy (COM/2011/0112).

Along this line, Decision 529/2013/EU broadened the coverage of LULUCF accounting (including emissions and removals from Cropland Management and Grazing Land Management among the mandatory activities to be assessed), and set up a plan for improving the Monitoring Reporting and Verification (MRV) process of GHG emission and removals, as first steps before the consideration of formal inclusion of LULUCF in the EU target.

In October 2014, in the 2030 EU energy and climate framework, EU leaders agreed to reduce GHG emissions by at least 40% by 2030 compared with 1990, and to establish the exact modality of including LULUCF "as soon as technical conditions allow and in any case before 2020". In mid-2016, the Commission intends to present a legislative proposal on the inclusion of LULUCF in the 2030 EU energy and climate framework, supported by a detailed Impact Assessment (IA).

At international level, in December 2015 the United Nation Framework Convention on Climate Change (UNFCCC) conference in Paris (COP-21) reached a historic global agreement for the post-2020. The EU LULUCF framework for post-2020 will therefore need to be consistent with the principles and goals of the Paris Agreement.

1.1 Aim and structure of the report

Taking into account the context above, the aim of the present AA LULUCF 2030 is to support DG CLIMA on the following issues:

3) Implementation the EU LULUCF Decision 529/2013, especially with regard to evaluating the estimates reported by MS on carbon stock changes in CM and GM (to be reported for the first time in 2015) and elaborate recommendations to help MS on the gradual improvement in the reporting of emission estimates.
4) Contribution to specific elements of the Impact Assessment (IA) associated to a legislative proposal on the inclusion of the land use sector in the 2030 EU climate and energy policy.

Specifically, the work within this is organized along three main tasks:

4) Analysis of MS' reporting of estimates of emissions from Cropland and Grazing land Management (CM/GM)

5) Projections for LULUCF up to 2030 (for forest and agricultural activities)

6) Update of country-specific JRC Land Use factsheets.

For **Task 1**, the aim is to analyse CM and GM estimates reported by MS under Decision 529/2013 (and any available information on methods used), and elaborate a short assessment in terms of adherence to the reporting principles (accuracy, transparency, comparability, consistency, completeness). Then, recommendations are elaborated to help MS improving their estimates, taking into account previous work done during the

AA 'LULUCF MRV' (2012-2014) and any useful information from the AA LULUCF Accounting. A short overview of key findings is included in section 2, with more detailed results in Annex 1.

Task 2 is focused on producing new country-specific projections of carbon stock changes up to 2030 for the following LULUCF activities: Forest management (FM), Afforestation/Reforestation (AR), Deforestation (D), Cropland Management (CM) and Grazing land Management (GM).

Projections up to 2030 for FM, AR and D have been assessed with the forest CBM model. A short overview of the methods and the key results at EU level is included in section 3.1, with detailed country methods in Annex 2a and detailed country reports in Annex 2b. For FM, assumptions of future harvest rates are consistent with the "Reference scenario 2016" (based on Primes and IIASA's GLOBIOM/G4M modelling). For AR and D, assumptions of future forest land use change areas are derived from the "Reference scenario 2016" as modelled by GLOBIOM/G4M. Preliminary results for a sensitivity analysis for the key drivers (+/-10% FM harvest, and +/-50% AR/D area) are also provided.

Given the possibility that post-2020 LULUCF accounting will be based on land uses (rather than activities), estimates are provided also for the land use subcategories corresponding to FM, AR and D (even if not originally foreseen in the AA), i.e. "forest remaining forest", "land converted to forest" (with 20 years transition period, or 30 yrs for the EU only) and "forest converted to other land uses".

Section 3.2 includes preliminary results for forest land use change areas estimated by the JRC, alternative to those from GLOBIOM/G4M but stemming from the same macroeconomic assumptions of the Reference Scenario. These estimates are obtained from the interaction between CBM and LUISA, including a preliminary simulation of the competition between agricultural and forest lands (based on the work initiated in the AA AFO-CC), and represent a step toward a more integrated LULUCF modelling framework. More detailed results are included in Annex 3.

Projections of carbon stock changes in CM and GM mineral soils from 2010 to 2030 are based on the IPCC tier 1 method. For this assessment, we use future land use changes estimated by LUISA for the Reference Scenario, and assume continuation of current management/input based on statistics (this includes the projections of the carry-over effects of management/input changes in last 20yr). A short overview of the methods and the key results at EU level is included in section 3.3, with the detailed results in Annex 4.

Finally, **Task 3** updated the country-specific JRC land use factsheets with the latest available data, including the results of the present study. Section 4 includes the factsheet for the EU, and all the countries factsheets are in the Annex 5.

The following sections 2-4 illustrate, for each Task, the main conclusions and/or the results at EU level. The corresponding detailed results at country level are included in the Annexes 1, 2a, 2b, 3, 4 and 5.

2 Task 1: analysis of MS' estimates of emissions from Cropland and Grazing land Management (CM/GM)

On top of the GHG emissions reporting requirements under UNFCCC and its Kyoto Protocol (KP), implemented at EU level through EU Reg 525/2013, the EU decision 529/2013 set new requirements for LULUCF for the period 2013-2020. In particular, Member States shall report emissions and removals also from Cropland management (CM) and Grazing land management (GM).

This task analysed CM and GM estimates reported by MS under Decision 529/2013, elaborated a short assessment in terms of adherence to the reporting principles (accuracy, transparency, comparability, consistency, completeness) and provided general recommendations to MS. Here the main conclusions are presented, while details results are in Annex 1.

Overall, the lack of a functioning version of the CRF Reporter heavily influenced all the GHG reporting for the year 2015 and 2016, including under the 529/2013 LULUCF decision. In 2015, the majority of MS included some quantitative estimate for CM and GM, but no one provided explanatory information on data and methods used to estimates emissions and removal (this was linked to the EU-level decision to skip KP submission in 2015).

During the year 2016, *most* of the Member States have provided information on: (i) annual estimates of emissions and removals from CM and GM, (ii) information on methods and data used for these estimates, and, (iii) the system in place and being developed to estimates emissions and removals from these activities. For France, it was not possible to find the 2016 submission of information under the 529/2013 in the EEA Central Data Repository, while for some other Member State the submission was incomplete in terms of some of the three elements.

Despite the increase of the quantity of information that has been submitted in 2016 (compared to 2015), there are still significant differences among Member States. Several issues have been identified related to the transparency, accuracy, consistency and completeness of the information, and there is still the need to provide the information in a more harmonized way that allows a better assessment and comparability of the information.

General recommendations for all the MS include: (i) make use of the official channel for the provision of information pursuant the Decision 529/2013 and to inform the Commission on when and what information is being submitted; (ii) to use the guideline for CM and GM developed under the project "LULUCF implementation guidelines and policy options", and any other tool developed by the JRC (e.g. for estimating carbon stock changes in living biomass).

The fact that in most of the cases Member States faced the reporting for CM and GM for the first time in 2015, and that new tables and guidelines have been introduced during the CP2, are the main reasons for the lack of a full adherence of the submissions to the reporting principles. Nevertheless, many Member States have provided information on on-going projects that, along with the experience and the result of supporting activities (e.g. LULUCF workshops, bilateral supporting projects), should result in significant improvements in the coming years.

3 Task 2: LULUCF projections up to 2030

The projections done in this AA (using CBM for forests, the IPCC tier 1 model for cropland/grazing management, and LUISA for land use changes) contribute to the broader aim of building a JRC capacity for integrated modeling, as suggested by DG CLIMA. In particular, the forest modeling and the links developed so far between CBM and LUISA represents an important step to meet the goals of building the integrated forest modeling framework (including energy/economic modeling) foreseen within the JRC Biomass project.

3.1 Projections of forest emissions and removals

New country-specific projections of carbon stock changes up to 2030 have been developed for Forest management (FM), Afforestation/Reforestation (AR), Deforestation (D), and for the corresponding land use categories, in 26 MS[1].

Projections are fully consistent with IPCC methods and include Harvested Wood products (HWP) and available information on natural disturbances (only for the historical period). For each MS, results include:

- Projections consistent with the "Reference scenario 2016" and the associated sectorial feedstock demand (e.g. harvest demand for energy and non-energy) as elaborated by GLOBIOM/G4M.
- Results including a sensitivity analysis on key drivers (harvest rate and forest land use change area).

Data and assumptions that have been formulated for each country, are documented in Annex 2a: CBM methods. Results for each country are described in Annex 2b: CBM country report. In this report, after a short description of the CBM model (2.1.1), we present the key results at EU level (2.1.2).

3.1.1 CBM model: a short description

The Carbon Budget Model (CBM), originally developed by the Canadian Forest Service (Kurz et al., 2009), is being used at IES-JRC since 2011 to simulate the stand- and landscape-level carbon dynamics of above- and belowground biomass, dead wood, litter and soil.

CBM is an inventory-based, yield-data driven model. In Figure 6 we show a schematic representation of the model structure, while in Table 1 we summarize the main input data used by the model. The spatial framework conceptually follows Reporting Method 1 (IPCC, 2003), where the spatial units are defined by their geographic boundaries and all forest stands are geographically referenced to a spatial unit. Within a spatial unit, each forest stand is characterized by age, area, and up to 10 classifier types[2] that provide administrative and ecological information, the link to the appropriate yield curves, and parameters defining the silvicultural system (such as forest composition, management strategy and other information provided by national forest inventories, NFIs).

During the model run, a library of yield tables defines the gross merchantable volume production by age class for each species. These yields represent the volume in the absence of natural disturbances and management practices. Species-specific stand-level equations (Boudewyn et al., 2007) convert merchantable volume production into

[1] For Malta and Cyprus insufficient data is available.
[2] As reported by Kurz et al. (2009), the classifiers are defined by the model user and typically describe characteristics of the land area such as site productivity, ownership, or leading species.

different aboveground biomass components. The belowground biomass, its increment and annual turnover are calculated using the equations provided by Li et al. (2003). Annual dead wood and foliage input is estimated as a percentage (i.e., turnover rate) applied to the standing biomass stock.

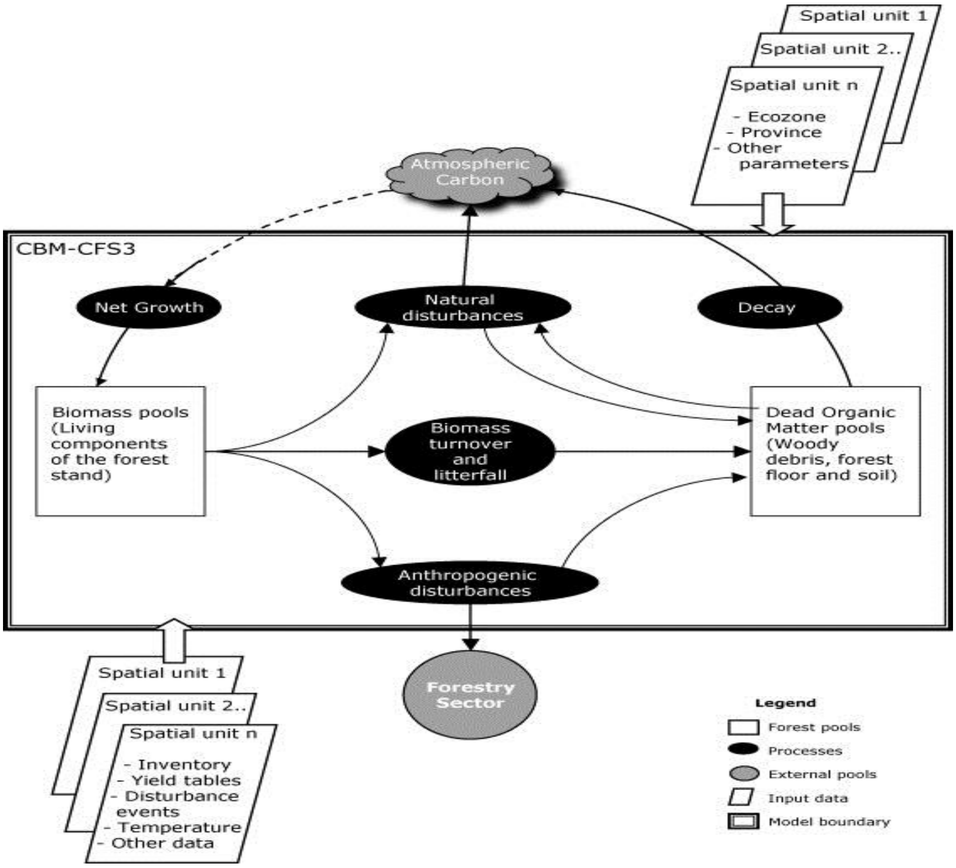


Figure 6: Simple schematic of CBM-CFS3.
Simulation of growth causes carbon to enter the forest ecosystem as living biomass. Simulation of turnover and disturbance processes causes the transfers of carbon from biomass to DOM pools. Natural disturbances can cause the loss of carbon from the ecosystem as gaseous emissions (e.g. in the smoke from a forest fire). Harvesting causes the loss of carbon from the ecosystem to the forestry sector. Carbon is also lost from the ecosystem due to decay of the DOM and soil organic C (from: Kurtz et al., 2009).

Table 1: CBM input data requirements. ESSENTIAL data are those needed to run the model: the model cannot be run without this information. REQUESTED data are also needed, but may be derived from the literature or from additional assumption, not necessarily from NFIs. USEFUL data are very useful to improve the model output. ADDITIONAL data can also be used to run the model.

IMPORTANCE	Input by NFI data	ESSENTIAL	REQUESTED	USEFUL	ADDITIONAL
ESSENTIAL	Area	Total Forest area	By age classes	By broadleaves / conifers and by regions (NUTS 2 level)	By main species and management types (MT, i.e. coppices/high forests
ESSENTIAL	Growing stock	Volume per ha at NUTS 1 level	By broadleaves /conifers	By main species	By age classes, regions and MT
ESSENTIAL	Increment	Increment per ha at NUTS 1 level	By broadleaves /conifers	By main species and age classes	By regions and MT
USEFUL	Total aboveground biomass			By main species and regions	By age classes
USEFUL	Natural disturbances			Area or biomass affected by natural disturbances by year	By main species and regions
ADDITIONAL	Silvicultural treatments				By main species and MT
ADDITIONAL	Harvest share (i.e., share of total harvest provided by …)				By main species and regions
ADDITIONAL	Aboveground biomass pools (i.e., merchantable, main branches, stumps)				By main species, regions and age classes

In order to correctly use the NFI parameters, namely the net annual increment (NAI), which represents the gross volume yield of each stand, and the standing volume, which reflects the impact of past silvicultural activities, during the model run, we use two yield curves libraries (Pilli et al., 2013). A historic yield curve library based on NFI volume data to obtain the standing volume at the start of the simulation, and a current yield curve library based on the NAI for the model runs. This is a relevant issue for the application of CBM and potentially of other yield-data driven models to European countries. Data were derived mainly from NFIs.

CBM allows for simulating the effect of any natural (storms, fires, pests, etc.) and human induced (i.e., silvicultural systems such as, partial-cutting, coppices, shelter-wood system, etc.) disturbance. In the simulation of stand- and landscape-level carbon dynamics, the user can define natural and anthropogenic disturbances such as fire, insects or storms and partial or clear-cut harvesting (Kull et al., 2011). The user defines the amount, type and intensity of each disturbance for each year and spatial unit. Eligibility criteria, such as forest type, age, or other classifier values can be used to define the eligible stands for each disturbance. Disturbance impacts are defined with a 'disturbance matrix' that describes the proportion of carbon transferred between pools, transferred to the forest product sector or released to the atmosphere for each disturbance type. Afforestation and deforestation can also be represented as disturbance types with their own disturbance matrices and transitions to and from forest land.

As output, the model returns annual predictions on carbon stocks and fluxes, such as the annual carbon transfers between pools, from pools to the atmosphere and to the forest product sector, as well as ecological indicators such as NPP and NEP.

Yield data-driven models, like CBM, cannot be directly applied to uneven-aged forests, where no yield tables are available. To overcome this limitation, we developed a novel approach based on volume and increment data provided by NFIs for uneven aged forests, and we adapted the default model design to the tree selection system (Pilli et al., 2013). Since uneven-aged forests cover about 30% of the forest area in Europe, addressing this issue is relevant for the application of the CBM to European countries.

It is also possible to run the model for a period of time antecedent to the reference NFI year, i.e. it is possible to reconstruct the age structure before the reference NFI year. This allows the validation of model results, through comparisons with historical data from other sources.

The main limitation of the current version of the CBM model is the difficulty in simulating the impacts of environmental changes (e.g. climate change) on forest growth because the model does not explicitly simulate the impacts of environmental variations on yields.

The model has been adapted to the European forests' characteristics and the applications and results of CBM have been published in several scientific papers. A first application on the model to Italy is described in Pilli et al. (2013). Italy presents a wide variety of forest types and silvicultural practices (including uneven-ages forest structures), and thus was a good case study for the subsequent application of CBM to all EU MS. Afforestation and reforestation activities in Italy and their contribution to carbon stock changes have been studied in Pilli et al. (2015).

The application of CBM to 26 EU countries is described in Pilli et al. (2016), where NFIs input data (Table 2) are used to estimate the forest carbon dynamic from 2000 to 2012, including the effect of natural disturbances and land use changes. Figure 7 summarizes the forest chain modelled by CBM for this historical period (i.e., assuming as main driver of the forest carbon dynamic, the historical harvest rate and natural disturbances) and the main links with the harvested wood products pool.

Table 2: NFI original reference year used by model; starting year for CBM application; base forest management (FM) area; additional natural disturbance events considered (F, fire; S storms and ice sleets; I insect attacks).

COUNTRY	Original NFI year	Time Step 0 (yrs)	CBM FM area (Mha)[2]	Natural Disturbances
Austria	2008	1998	3.2	**S + I**
Belgium	1999	1999	0.7	-
Bulgaria	2000	2000	3.2	-
Croatia	2006[1]	1996	2.0	**F**
Czech Republic	2000	2000	2.6	**-**
Denmark	2004	1994	0.5	**S**
Estonia	2000	2000	2.1	**S**
Finland	1999	1999	21.7	**S**
France	2008	1998	14.6	**S**
Germany	2002	1992	10.6	**S**
Greece	1992[1]	1992	1.2	**F**
Hungary	2008	1998	1.6	-
Ireland	2005	1995	0.5	**F**
Italy	2005	1995	7.4	**F**
Latvia	2009	1999	3.2	**S**
Lithuania	2006	1996	2.0	**S + F+I**
Luxembourg	1999	1999	0.1	**S**
Netherlands	1997	1997	0.3	**S**
Poland	1993	1993	8.9	**S**
Portugal	2005	1995	3.6	**F**
Romania	1985	1985	6.6	**-**
Slovakia	2000	2000	1.9	**S + F**
Slovenia	2000	2000	1.1	**S + F**
Spain	2002	1992	12.6	**F**
Sweden	2006	1996	22.6	**S**
United Kingdom	1997	1997	2.5	**S + F**
EU			137.9	21 countries

1: analysis based on data from Forest Management Plans.
2: FM area used by CBM at time step 0. According to KP rules, FM is the area of forest in 1990, decreased with any subsequent deforestation. The FM area is taken from the official submissions made by countries to UNFCCC/Kyoto Protocol (2014).

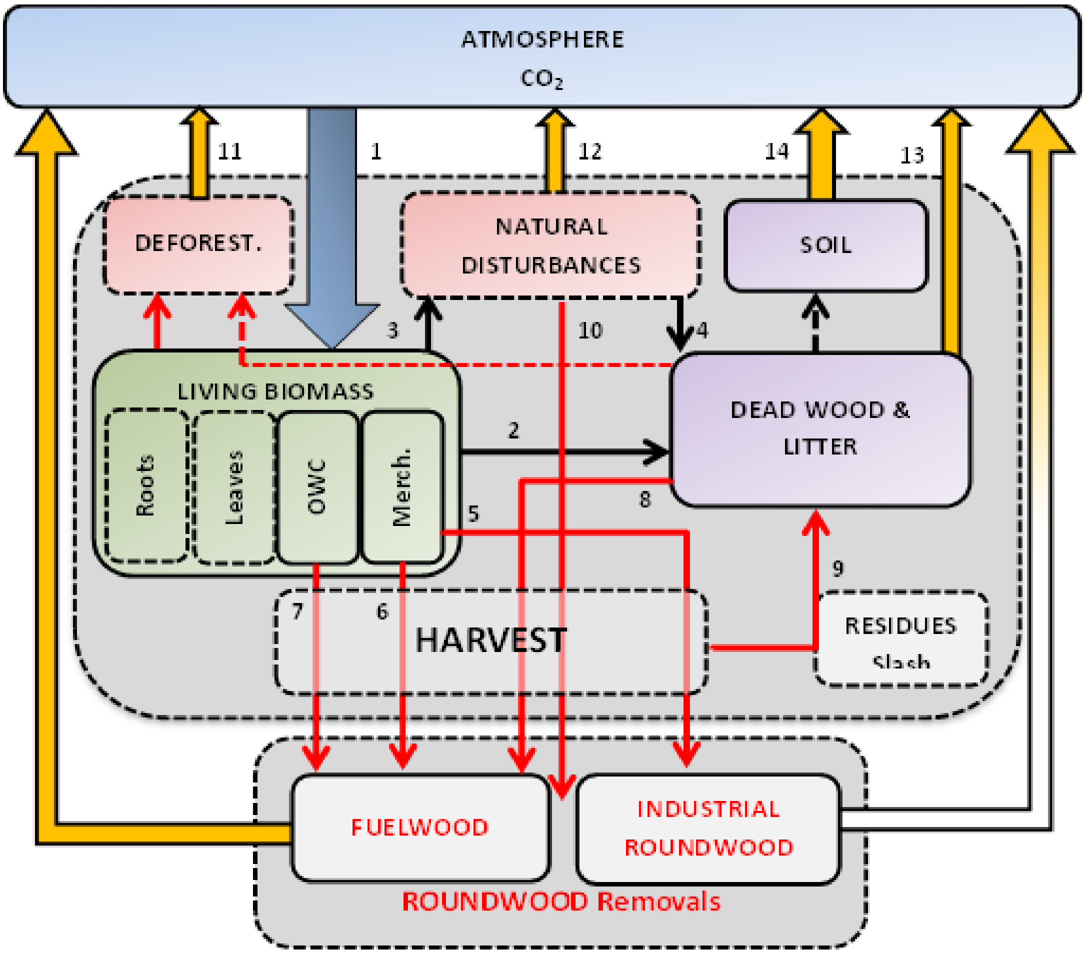


Figure 7: Forest chain modelled by CBM for the forest area (upper panel) and main links with the harvested wood products (HWP) pools (lower panel), further distinguished between industrial roundwood (IRW) and fuelwood (FW).
The figure highlights the main forest pools considered by our analysis: living biomass (LB) further distinguished between roots, leaves, merchantable tree portion and other wood components (OWCs, such as branches and tops), dead wood and litter pools (DOM) and soil. The C moves from the atmosphere to LB through photosynthesis (blue arrow number 1) and it naturally moves (black arrows) from LB to DOM because of litterfall and natural mortality (2) and natural disturbance events (i.e., in our study, fires and storms, highlighted by arrows 3 and 4). The red arrows highlight the main fluxes of C due to direct human activities. Due to the harvest, a fraction of the merchantable portion moves to IR (5) and to FW (6), part of the OWCs moves to FW (7) and a fraction of the standing dead trees may be collected as FW (8). A fraction of the living biomass will be left in the forest as forest residues moving from LB to DOM (9). In case of natural disturbance events, a fraction of C can move from the LB to IRW or FW, due to salvage logging (10). Due to the deforestation the C stocked by LB and DOM pools will be directly released (as highlighted by the orange arrows) to the atmosphere (11). Further releases are related to natural disturbances (12), and the decay rate of DOM (13) and soil (14) pools. The C used for energy (FW) is directly released to the atmosphere (i.e, immediate oxidation highlighted by the orange arrow) while the C stocked as IRW has a longer life cycle (highlighted by the gradient orange arrow). Please note that, as a prerequisite to provide this detailed chain the model requires detailed information on the harvest demand (i.e., coniferous/broadleaves and IRW/FW).

3.1.2 CBM assumptions and results at EU level

Assumptions

The basic assumptions on **areas** used in CBM for FM, AR and D at EU level are equal to what assumed in the Reference Scenario 2016 as modelled by IIASA (for 2015-2030). These assumptions are shown in Table 3 together with a comparison with the data reported by the country for 2010 (in the last column).

A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

Results include estimates for "Forest Land Remaining Forest Land (FL-FL, i.e. forest remained forest in the last 20 yrs)" and "Land converted to Forest Land" (L-FL, i.e. land converted to forests in the last 20-yrs.). "Forest converted to other land" (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

Table 3: Basic assumptions used in CBM for FM, AR and D and comparison with the data reported by the country for 2010 (see last column)

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		138,069	136,436	135,597	135,144	145,070 FM, FL
Aff/Ref. (AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	435	476	236	260	202	232
Deforest. (D)	Area of forest conversion to other land since 1990			145	127	62	37	97

FM Forest Management Area, if elected, otherwise FL

FL Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Concerning **harvest**, the following assumptions have been made (see Figure 8):

- The historical total harvest applied by G4M (Historical IIASA), further distinguished between Material wood (Material w IIASA) and Energy wood (Energy w IIASA).
- The historical total harvest applied by CBM in this study (Historical JRC), further distinguished between Material wood (Material w, reported both for the historical period and to 2030) and Energy wood (Energy w, reported both for the historical period and to 2030).
- The future total harvest demand applied by IIASA and used as input in this study (Projection IIASA), and the real amount of harvest provided by CBM ("CBM – Real harvest", excluding the harvest provided by AR).
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (IIASA +10% and IIASA -10%).

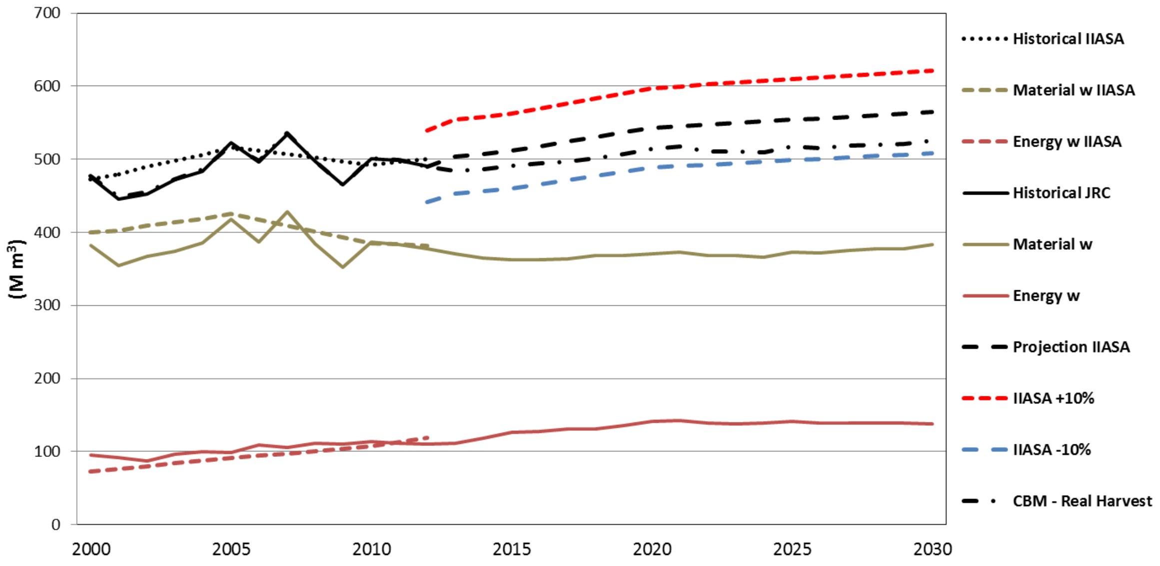


Figure 8: assumptions on total harvest at EU level.

Figure 9 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

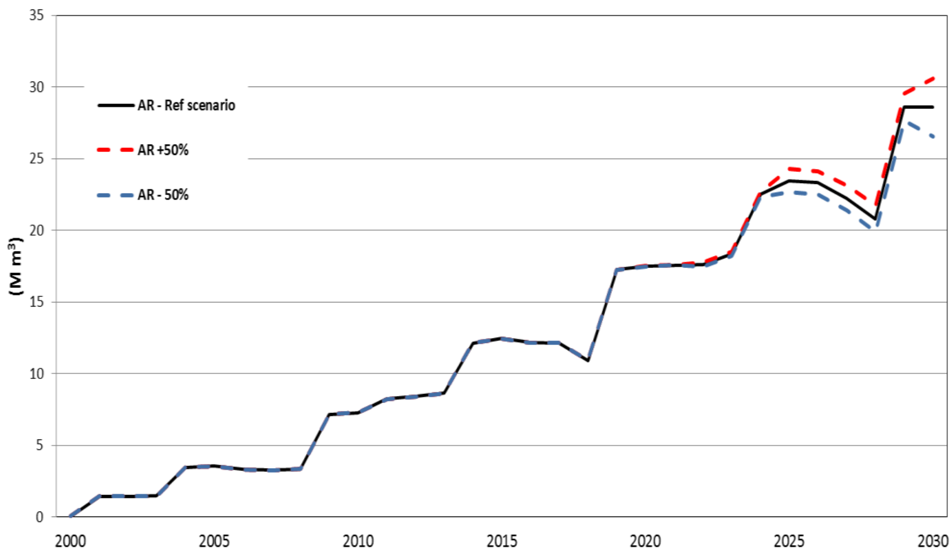


Figure 9: harvest from AR at EU level.

Results

In the following graphs, we describe the CBM model output at EU level, compare to countries' GHGI data and the result form IIASA's G4M model. Country-specific results are all documented in the Annex 2b.

Figure 10 compares for **Forest Management** the UNFCCC/KP countries' data (i.e. FM when available, or FL-FL) from 2015 GHGI inventories (<u>all available C pools</u>: living biomass, soil, DOM) with (i) the original estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

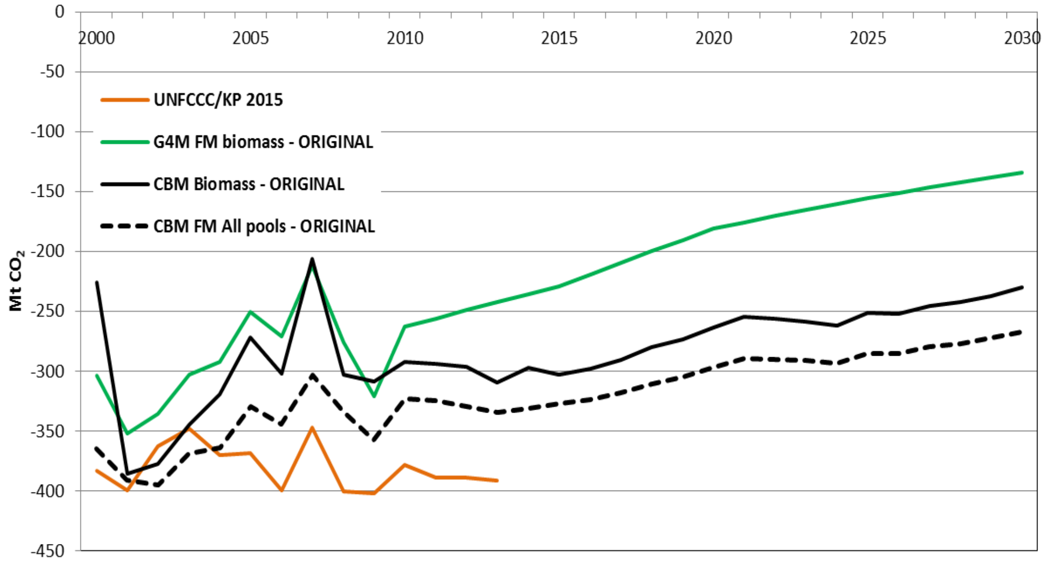


Figure 10: FM results of the original (i.e. not calibrated) CBM and G4M model results at EU level.

Figure 11 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[3] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

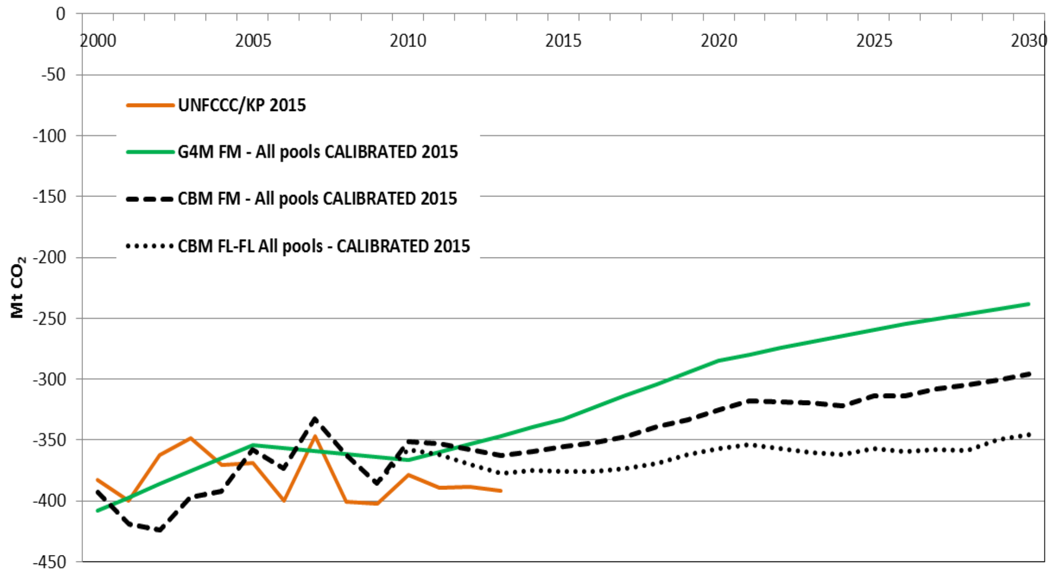


Figure 11: FM results of CBM and G4M calibrated with 2015 GHGI (as from the IA) at EU level.

[3] Calibrated means that models results are 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015. This facilitates the comparison with GHG inventories.

Figure 12 shows the preliminary results on the sensitivity analysis performed by CBM (+/-10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.

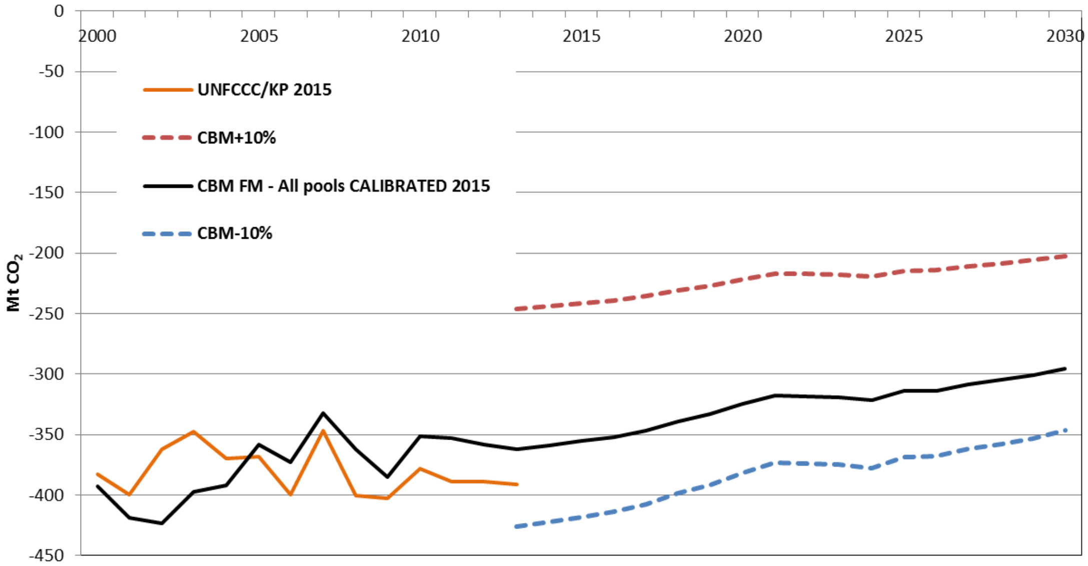


Figure 12: EU FM results for CBM (calibrated 2015 GHGI) and results of sensitivity analysis ±10% harvest

Concerning **Afforestation/Reforestation**, Figure 13 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

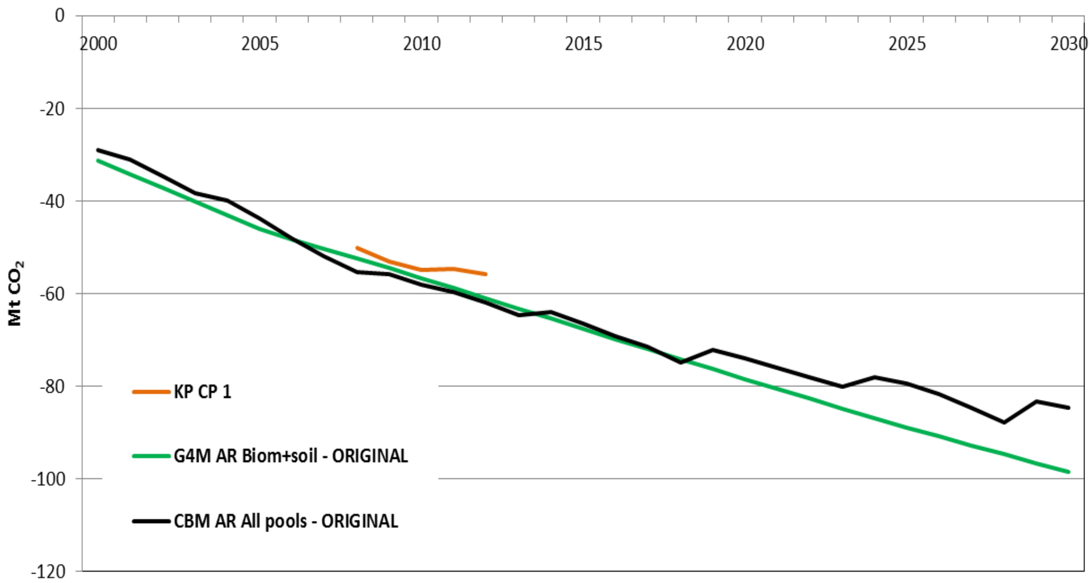


Figure 13: AR results for EU compared with AR from G4M.

Figure 14 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the total AR occurred since 1990 (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the Land converted to Forest Land" (L-FL, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

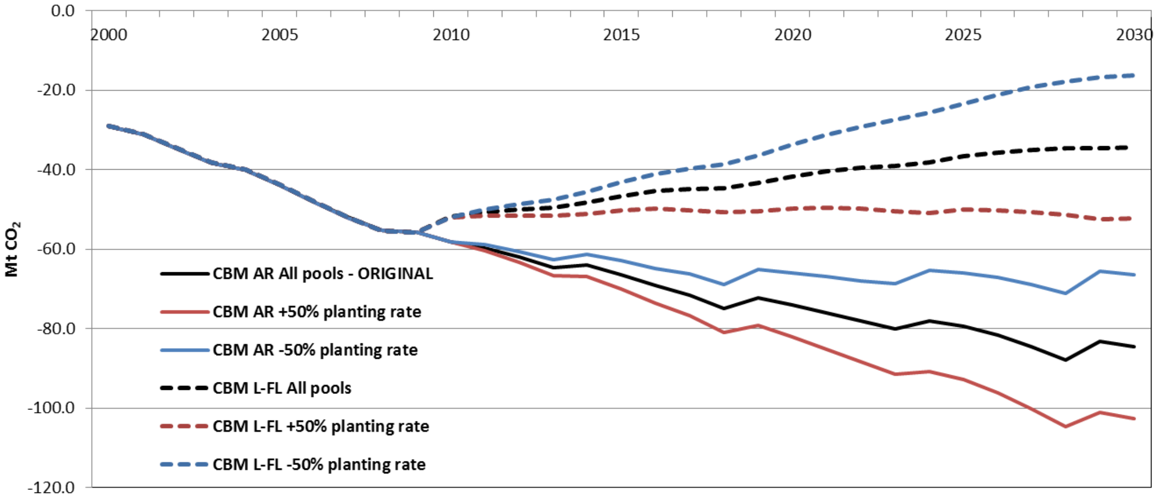


Figure 14: AR results for EU, including the sensitivity analysis.

For **Deforestation**, Figure 15 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

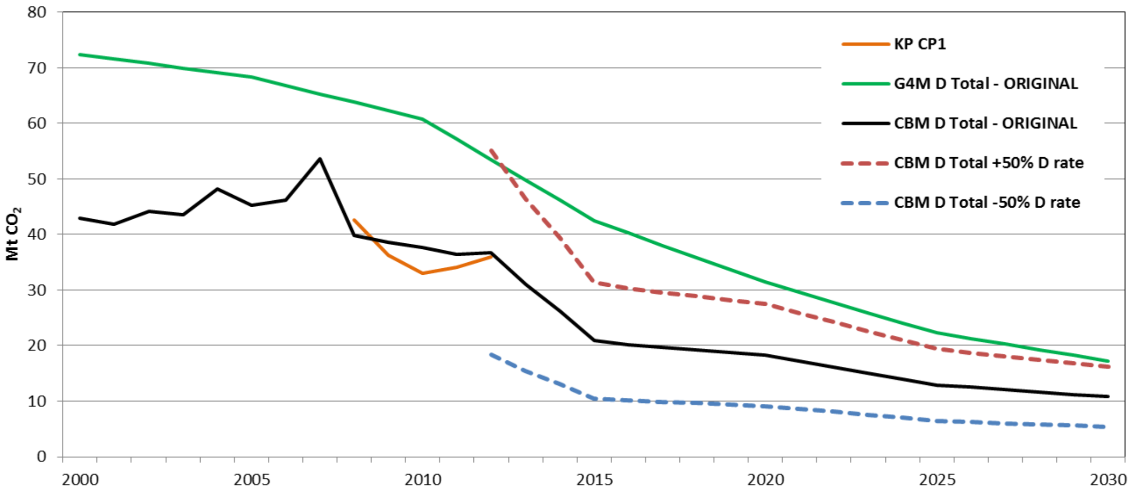


Figure 15: EU results for D, including the sensitivity analysis.

Finally, we show in Figure 16 the results for the **Harvested Wood Products (HWP)** estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[4]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

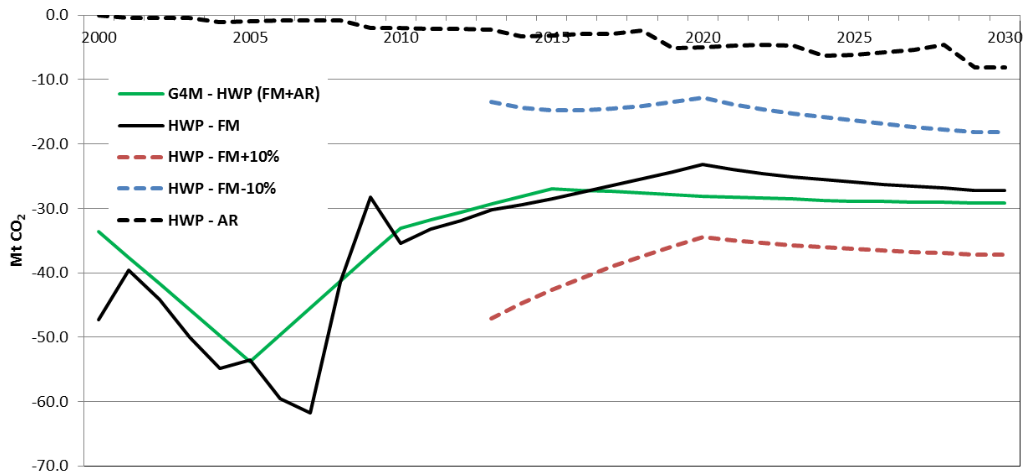
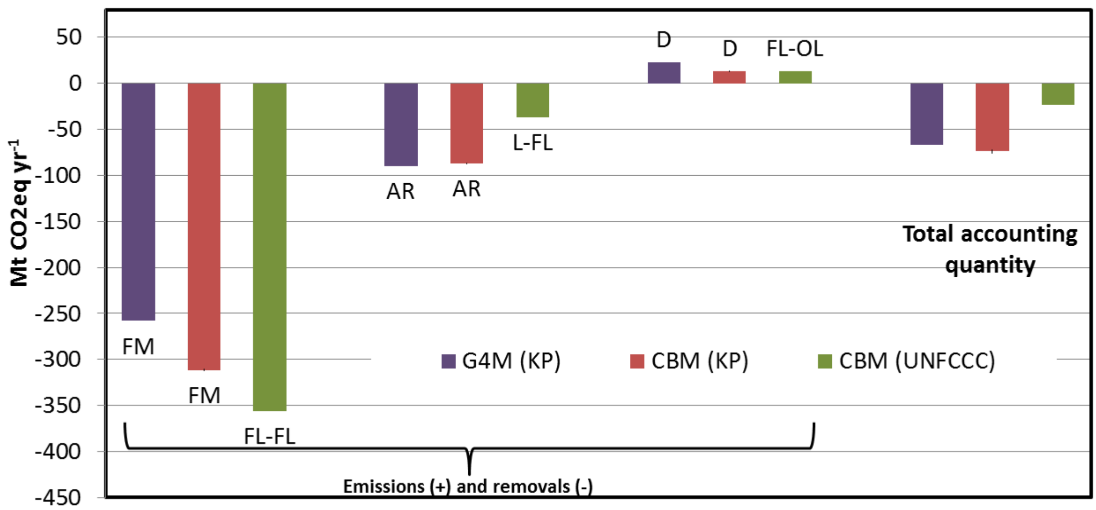


Figure 16: EU results for HWP, compared with G4M results.

Overall, emissions/removals and accounting at EU level are shown in Figure 17, where we report emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU forest "reference level") and *gross-net accounting* for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[5]; +/- 50% planting rate for AR; D/-50% D rate).



[4] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, unless explicitly suggested by country.
[5] Based on preliminary results.

Figure 17: EU summary of emissions and removals and of accounting quantities for 2021-2030.

The following comments on CBM runs and model assumptions can be drawn, also in relation of G4M model's results:

- Overall, at EU level, CBM applied an historical amount of harvest (2000-2012) similar to G4M (see Figure 8). However, in few countries the future harvest demand expected by IIASA could not be fully satisfied by CBM (see Figure 8 "CBM – Real harvest", and the specific county's reports for details). As a result, the amount of harvest applied by CBM on the FM area is 7% lower (in 2030) than the amount expected by IIASA for 2030 (-25%, -13% and -21% for Belgium, France and Poland, respectively). However, by adding the harvest amount potentially provided by AR, the total "real" harvest applied by CBM is only 3% lower than the total harvest demand by IIASA.

- The original (non-calibrated) biomass C sink estimated by CBM for 2030 is considerably higher than the estimates provided by G4M (+23% for the historical period 2000 – 2012, +71% in 2030) (see Figure 10). Both models report a lower C sink compared to the GHG inventory data.
- Calibrating both models on the 2015 GHGI data for the period 2000 – 2012, the total C sink estimated by CBM for FM is about 24% higher, in 2030, than the estimates reported by G4M (see Figure 11). This is mainly due to the lower "real" harvest implemented by CBM compared to G4M. In addition, other factors that may explain the difference between models are different assumptions on the increment, the age structure and the silvicultural treatments (e.g., the amount of harvest residues), and the treatment of natural disturbances (for historical period) and of non-biomass pools. In particular, in the period 2021-2030 CBM estimated a higher FM sink than G4M in Austria, Greece, Latvia, the Netherlands, Romania, Slovenia, Spain and Sweden. Despite possible differences on input data used by models (i.e., in case of Romania, CBM used new input data based on the last NFI), in many cases the differences on the final results were "amplified" by the calibration on the GHGI data (e.g. for Netherlands, Romania and Slovenia). In one case (Belgium), the sink by CBM is considerably lower (-48%) than the value reported by G4M. However, overall the match between G4M and CBM is quite good: for 17 out of 26 countries, the C sink provided by CBM is similar, both in the trend and in the level (for Croatia, Denmark, Estonia, Finland, France, Italy, Lithuania, Luxemburg and Slovakia), slightly higher (for Ireland and Portugal) or slightly lower (for Bulgaria, Czech Republic, Germany, Hungary and UK) than the estimates provided by G4M.
- The results reported for the sensitivity analysis performed on FM (Figure 12), assuming a ±10% variation on the future harvest demand, are very preliminary.
- The estimates for AR provided by both models are quite similar and fully consistent with the country KP data (see Figure 13). The sink estimated by CBM for L-FL (20 yrs transition) is significantly lower than the sink in AR (Figure 9).
- The emissions from D by CBM are consistent with the country KP data but generally lower than the emissions reported by G4M (Figure 10).
- The HWP C sink estimated by both the models is similar, with a C sink equal to about -30 Mt CO_2 yr^{-1} in 2030 (Figure 11).
- Overall, the removals estimated by CBM for the period 2021-2030 (reported on Figure 17) are about 20% higher for FM, 10% lower for AR and 40% lower for D than the estimates provided by G4M.

3.2 Steps in LULUCF model integration

Within the broader perspective of integrated modeling, in order to account for spatially explicit land use changes, in this AA we have addressed the integration of the LUISA platform (i) with CBM, for forest expansion and growth, and (ii) with IPCC tier 1 and a biophysical model for cropland/grazing management. These exercises aim at simulating the impacts of the macroeconomic assumptions behind the Reference scenario 2016 on land use changes and at assessing the LULUCF emissions that derive from such a scenario.

The line of work for integrating CBM and LUISA is part of a long collaboration that started with the AA AFOCC (Fiorese et al., 2015) and that is continuing both in the IES institutional work-programme "LUISA" and in the BIOMASS Project. Similarly, the IPCC Tier 1 has been applied to land uses as simulated by LUISA in several studies. The work performed within this AA is thus a step toward meeting the ambitious goal of developing a JRC framework capable of modelling the main land-based production sectors (forest and agriculture) in relation to the bioenergy and the wood product sectors.

Specifically, in this AA our aim is to model within LUISA the evolution of forest land under the reference scenario, distinguishing afforestation (AR) and deforestation (D). In this section, we briefly describe the assumptions behind the modelling and we present the results at EU level, while details and specific results for member states are in Annex 3. As for IPCC Tier 1, the aim is to develop and apply a method for estimating changes soil C-stocks resulting from modeled changes in land use as provided by LUISA. The methodology is briefly described in the section 0, while details are reported in Annex 4.

3.2.1 LUISA: a short description of the platform

The 'Land-Use-based Integrated Sustainability Assessment' modelling platform (LUISA) is a platform of inter-linked data, processes and models for the analysis of the evolution of European territories (macro-regions, countries, regions or urban areas) triggered by EU investments and policies. LUISA is equipped to measure the impact over time of national, regional and urban economic performance (e.g. GDP, sectoral production, employment, convergence, etc.) and allows for the mapping of access to services (e.g. to public structures, recreational and cultural sites, etc.) and infrastructures for housing, transport, energy, etc. Moreover, the LUISA platform permits the monitoring of the status of ecosystem services and their regional endowment.

LUISA is primarily used for the ex-ante evaluation of EC policies that have a direct or indirect territorial impact. Beyond a traditional land use model, LUISA adopts a new approach towards activity-based modelling based upon the endogenous dynamic allocation of population, services and activities.

LUISA can be configured to project a baseline (or reference) scenario, assuming official socio-economic trends (from ECFIN and EUROSTAT), and the effect of established European policies with direct and/or indirect territorial impacts. Variations to that reference scenario may be used to estimate impacts of specific policies, or of alternative macro-assumptions or sectorial investments.

LUISA is based upon the notion of land function – a new concept for cross-sector integration and for representing complex system dynamics. LUISA aims to contribute to the understanding, modelling and assessment of the impacts of land functions dynamics as they interact from local to global scales in the context of multiple and changing drivers. A land function can, for example, be societal (e.g. provision of housing, leisure and recreation), economic (e.g. provision of production factors - employment, investments, energy – or provision of manufacturing products and services – food, fuels, consumer goods, etc.) or environmental (e.g. provision of ecosystem services). Land functions are temporally and spatially dynamic, and are constrained and driven by natural, socio-economic, and techno-economic processes. The ultimate product of LUISA is a set of spatially explicit indicators that can be combined according to the 'function' of interest and/or to the sector under assessment.This is notably a wider notion of just "land use modelling" and of what so far has been referred to in literature.

One of the major milestones in the LUISA development plan is the implementation of a shared EC baseline (or reference) scenario. The shared baseline scenario includes the full scope of relevant policies assuring coherence among them since it should inform on future prospects in all sectoral domains that are affected by EU policies. Because of its benchmark function, the correct definition and implementation of such a baseline scenario is essential to correctly evaluate EC proposals. LUISA is configured to implement the Reference Scenario with annual up-dates, following major policies revisions and the setting of new socio-demographic projects.

LUISA links specialized models and data within a coherent workflow. The resource-demand module uses outputs from demographic (EUROPOP 2008, 2010, 2013 and updates) and economic projections (from ECFIN and/or from models e.g.: CAPRI, GEM-E3, RHOMOLO, E3ME and others) to drive the allocation of activities and services. The allocation module uses a number of spatially explicit parameters at different resolutions (1 x 1 km, 100 x 100 m) in order to define an overall suitability for every modelled land use/cover type. These individual input are called factor maps. LUISA integrates factor maps related to accessibility measures (e.g. computed using the TRANSTOOLS network), soil characteristics and topography. In addition, the neighbourhood interactions between land use types are taken into account dynamically, as the land use patterns evolve and change through time. The definition of policy options requires the development of a range of parameters which take into account both location specific policies (e.g.: demand for each land use class, zoning maps, region-specific support measures, etc.) and the characteristics of land-use dynamics (e.g.: transition rules, conversion costs, neighbourhood effects, attractiveness etc.). The actual conversion from the land-use state in tn to a land use state in tn+1 for each location is based on the most suitable land use type for that specific location at that specific time. The land use state in t0 is given by a refined version of the CORINE Land Cover map of 2006 and will be soon up-dated with the refined CLC2012.

The land allocation module of LUISA requires a calibration which is based on the observed/historical land use/cover changes, as reported by the CORINE Land Cover set of maps (1990, 2000, and 2006). Verification is performed with detailed historical datasets on demographic census, transport networks and regional/urban digital maps.

In the current (2014) reference configuration, the allocation module runs from 2006, producing yearly results up to 2050. However, the runs can be extended 10 or 20 more years as long as demand is provided for the land use/cover types of interest.

The main direct outputs of LUISA are: 1) a simulated map of the land use/cover for a given year in the future; 2) projected population maps at high geographical resolution; 3) detailed accessibility maps. The combination of direct outputs with other data layers and with thematic models further allow the computation of a wide range of indicators, representing the simulated land functions.

3.2.2 LUISA and CBM integration: assumptions and results

The aim of linking LUISA and CBM is to assess how much forest biomass is available given the area for harvest and given the management of forests, currently and in future projections. LUISA simulates the spatial allocation of different land uses/covers over time. Specifically, the evolution of forest areas over time (expressed in ha/yr) is of interest in this context. The linkage between LUISA and CBM is based on the exchange of two variables: forest area available for wood supply (FAWS[6], from LUISA to CBM) and harvest from forest land (from CBM to LUISA).

LUISA simulates future land use allocation: the demand module provides an input for the land allocation module, specifying the required amount of land for different economic sectors, corresponding to the simulated land-use/cover classes. External models provide the inputs to derive land claims for different land use/cover classes; e.g. agricultural classes are derived from the CAPRI model. With regards to forestry, typically in LUISA afforestation is derived from the EUCLIMIT reference scenario, therefore from the coupling of PRIMES/G4M/GLOBIOM models. With the aim of building a modelling platform based on JRC models, we want to substitute future afforestation rates from the reference scenario with figures derived from JRC-based models. There are many possible factors that drive afforestation; we may assume that the most important ones are related to policy support to foster climate change mitigation, land abandonment and related forest natural expansion. Our aim is modelling future afforestation rates starting from JRC data collected for the UNFCCC or the KP reporting. We look for a relationship that can be extrapolated from historic data on afforestation and that can be used for the future.

To analyze past data of afforestation across EU-MS, we processed the data in order to have some comparability across EU. The idea behind this is that if a country has a high coverage of forests and a high AR rate, future AR will be lower with respect to a country with lower forest areas and lower AR rates. It is in fact possible to identify a relationship between the average AR rate and forest area: the larger the forest area, the smaller afforestation is. We defined two linear relationships that describe the relation between AR rates and forest area. We then used these linear relations to project into the future, up to 2030, the afforestation in each MS. For each country, we are able to provide a set of values that define the possible range of variation of future afforestation. This set of values is an input for the LUISA platform that is able to allocate land use changes into forest land in the future. The graph in Figure 18 shows results at EU level: it is possible to see the upper and lower ranges that are given to LUISA to simulate future AR. We also compare our results with future afforestation rates from the 2016 reference scenario estimated by G4M and GLOBIOM models. Details for each member states are provided in Annex 3.

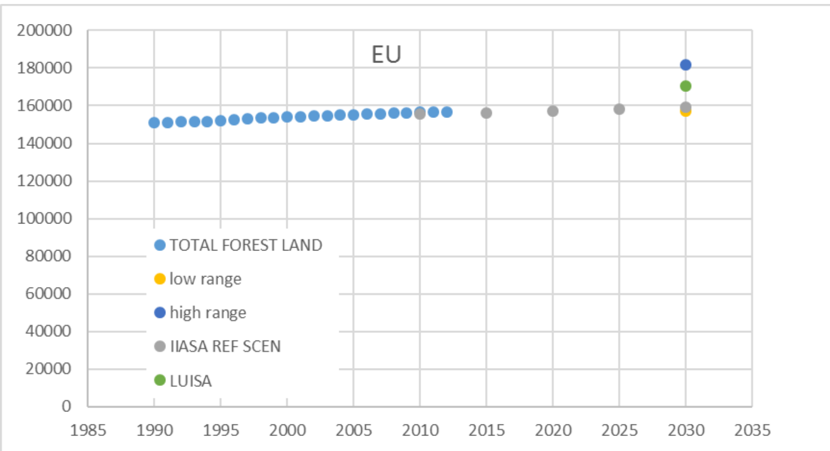


Figure 18: Historic evolution of EU forest land (in blue) compared with projected trends from the 2013 Reference Scenario (in grey) and with 2030 projections as elaborated with LUISA (in green). The graph also shows the range of variation that was allowed to LUISA for 2030 (yellow and dark blue).

[6] This is defined as a forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood. Note that we are always referring to data at national level. We are not capable of identify FAWS areas on a map.

3.3 Projections for cropland and grazing land management

Changes in land use and cover may cause significant changes in the amount of organic material in the soil, which is composed to 58% of carbon. The carbon of the soil organic material is exchanged with atmospheric carbon, mainly in form of carbon dioxide (CO_2). A method of estimating changes in CO_2 from the effect of changes in land use on *soil organic carbon* (SOC) stocks is detailed by the *Intergovernmental Panel on Climate Change* (IPCC, 2006). For estimating *greenhouse gas* (GHG) emissions resulting from anthropogenic activities leading to changes in land use and cover IPCC distinguishes three levels or Tiers with increasing complexity. The most generic method is defined by Tier 1.

The Tier 1 method for mineral soils is based on the supposition that the flux of carbon between the atmosphere and the soil has a propensity towards a state of equilibrium. Changes to this status of equilibrium lead to changes in C-stocks until a new stable level of C-stocks is reached. In the intermediate period soils may act as sources or sinks of atmospheric carbon. The Tier 1 method of estimating soil C-stocks and changes in mineral soils is implemented as a spatial database. Data are processed using a *Geographic Information System* (GIS). The spatial raster layers use a grid-spacing of 1 km.

Land use from 2010 onwards was projected based on an update of the Reference Scenario of the Roadmap to a Resource Efficient Europe (RREM) defined by DG ENER and DG CLIMA (Baranzelli *et al*., 2015). The update complies with the "EU Energy, Transport and GHG emission trends until 2050 – Reference Scenario 2013" (Lavalle *et al*., 2013). In the Reference Scenario land use is driven by demographic and economic trends. The update to the Reference Scenario includes additional measures, such as the greening measures under the *Common Agricultural Policy* (CAP), biodiversity or the habitat protection.

New runs fully consistent with the Reference Scenario 2016 could not be done due to the delay in the finalization of this scenario (i.e. we did not have in time the input macroeconomic data to be used). However, from the changes in the conditions it may be assumed with some confidence that the results presented here would not be significantly different from the Reference Scenario 2016.

The land use estimates were generated by the modeling platform *Land-Use-based Integrated Sustainability Assessment* (LUISA). These projected spatial data from LUISA provided the input parameters for the land use factor IPCC Tier 1 method for estimating CO_2 emissions and sinks from LULUCF.

Processing covered all land uses and land areas to allow an evaluation of CO_2 emissions and removals not only from CM and GM remaining that category, but also from changes between categories. The changes in soil C-stocks resulting from modeled changes in land use as provided by LUISA were assessed for 10-year periods, using 2010 as the base year. The year 2010 was used since this is the starting point of the Reference Scenario. It is assumed that after 2010 the changes in management and input for a land use category are stable.

Grazing land decreases in the scenario by 1.6% from 2010 to 2020 and 1.4% from 2020 to 2030. During the first decade over 90% of grazing land is converted to native ecosystem, i.e. abandoned (74% for the second period). Overall, the area of cropland increases over the decades with 2.2% for 2010 to 2020 and 0.6% from 2020 to 2030. A more detailed scrutiny of the changes by land use shows that the increase in area can be assigned to the emergence of energy crops on cropland. The area of long-term cultivated crops actually decreases by 1.1% over the first period and 1.2% over the second period.

Under the modelled land use changes of the Reference Scenario the area of artificial land use category increases over both periods (4.6% for 2010 to 2020 and 3.9 % for 2020 to 2030). Approximately 50% of the new artificial areas are located on former cropland.

For the period 2010 to 2030 annual C-emissions from cropland on organic soils were estimated at 17.2 Mt C yr^{-1} and 0.7 Mt C yr^{-1} for grazing land on organic soils. These C-emissions from drained organic soils amount to 90% of the emissions of mineral soils across all land use categories.

The area of grazing land contracts by 3.0% over 20 years while the soil C-stocks on grazing land decrease by 4.6%. The decrease of soil C-stock for grazing land is predominantly the result of the decrease in grazing land and to a minor degree the consequence of a conversion of less suitable land to grazing land.

Emissions from cropland and from grassland are shown in Figure 19 and Figure 20, respectively. For this analysis, we show both the results in their original form and adjusted to the 2015 inventory. Over 20 years the soil C-stock of all land areas decreases by 0.15%.

The increase of soil C-stock on cropland stems from the introduction of second generation energy crops. The crops are ligneous or herbaceous, but their enhancing effect on soil organic C-stocks is that they multi-annual. The areas under these crops are thus not ploughed and treated as grassland or agro-forestry. The increase in soil C-stocks under artificial surfaces is purely the consequence to the expansion of these areas at the expense of other areas.

It should be noted that the increases in soil C-stocks for cropland and artificial areas are the result of the assumptions made and targets set under the Reference Scenario. The changes in land use and subsequently soil C-stocks are more pronounced for the first decade than for the period 2020 to 2030 and apparent already in 2015. As a consequence, any comparison to data reported by EU Member States on changes in soil C-stocks should allow for the introduction of new energy crops under the Reference Scenario.

In the evaluation of the results the assumptions and targets of the Reference Scenario concerning energy crops were found to largely determine changes in soil C-stock on cropland, but not on grazing land. Without the stipulations of the Reference Scenario soil C-stocks may not develop in the same direction. The study also found that in order to provide comparative and complete emission estimates the changes in land use and soil C-stocks should cover all land areas and not be limited to cropland and grazing land. Otherwise methodological peculiarities in the treatment of areas over time may lead to biased results.

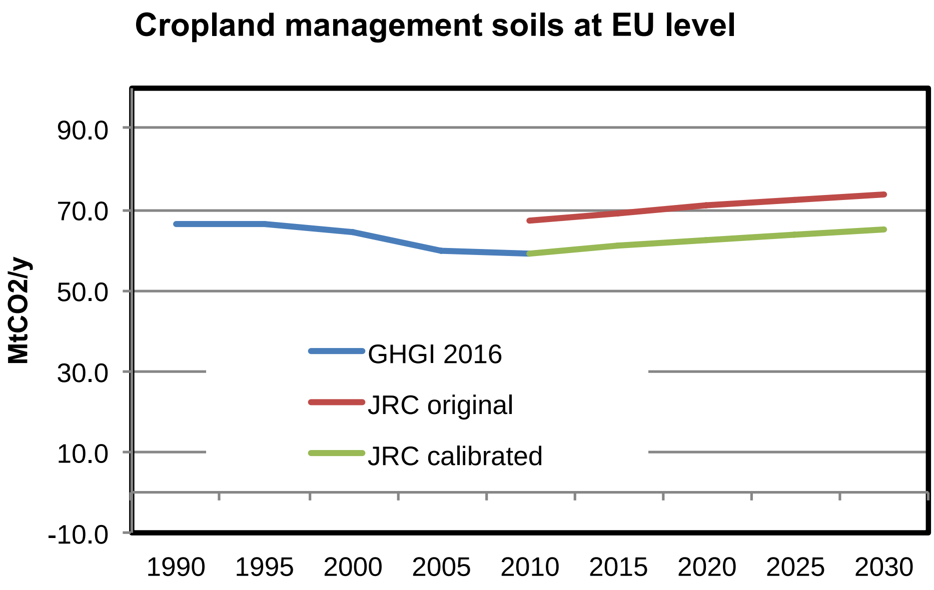


Figure 19: 2005-2030 emissions from Cropland soils at EU level.

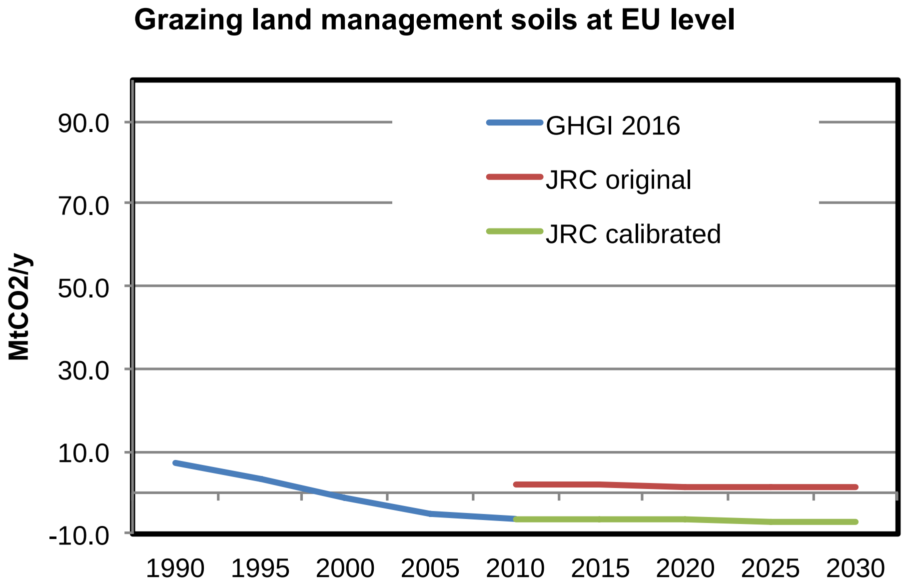


Figure 20: 2005-2030 emissions from Grassland soils at EU level.

3.4 Summary of LULUCF projections and impact on accounting

A summary comparison of JRC and IIASA models' results, and data from countries' 2016 GHG inventories (GHGI), are shown below for individual activities/land uses (Figure 21) and for all activities/land use (Figure 22). Models' results for FM, CM and GM are calibrated for the period 2000-2012 with the 2016 GHG inventories (the original JRC models' results for these activities are shown in figures 5 and 13). Models' results for HWP, AR and D are *not* calibrated either because the difference with latest historical data from GHGI 2016 is small (HWP, AR, D for CBM) or because the calibration would produce meaningless results (e.g. D for G4M).

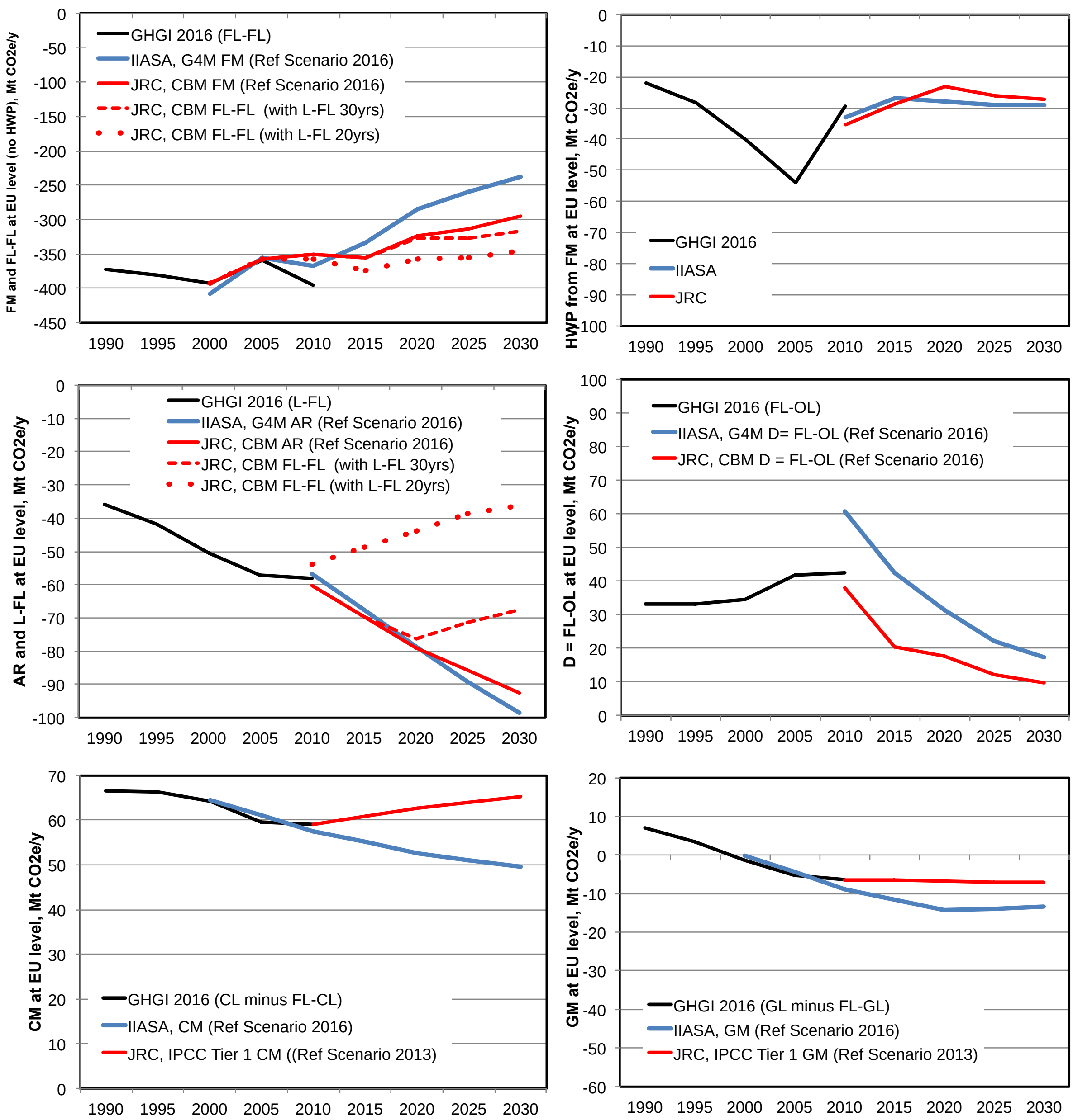


Figure 21: Summary comparisons of JRC and IIASA result for forest and agricultural activities, and data from countries' GHG inventories (GHGI). Models' results are calibrated with GHGI 2016 for FM, CM and GM only. HWP, AR and D are not calibrated. All data are 5-years averages.

Legend. FM: Forest management (forests existing in 1990). FL-FL: forest land remaining forest land (in the last 20 or 30 years); HWP: harvested wood products (production approach). AR: afforestation/Reforestation (after 1990). L-FL: forest converted to forest (in the last 20 or 30 years). D: Deforestation (since 1990) - the *difference with FL-OL (forest converted to other land uses) can be considered negligible. CM: cropland management (assumed equal to cropland minus forest land converted to cropland). GM: grazing land management (assumed equal to grassland minus forest land converted to grassland).*

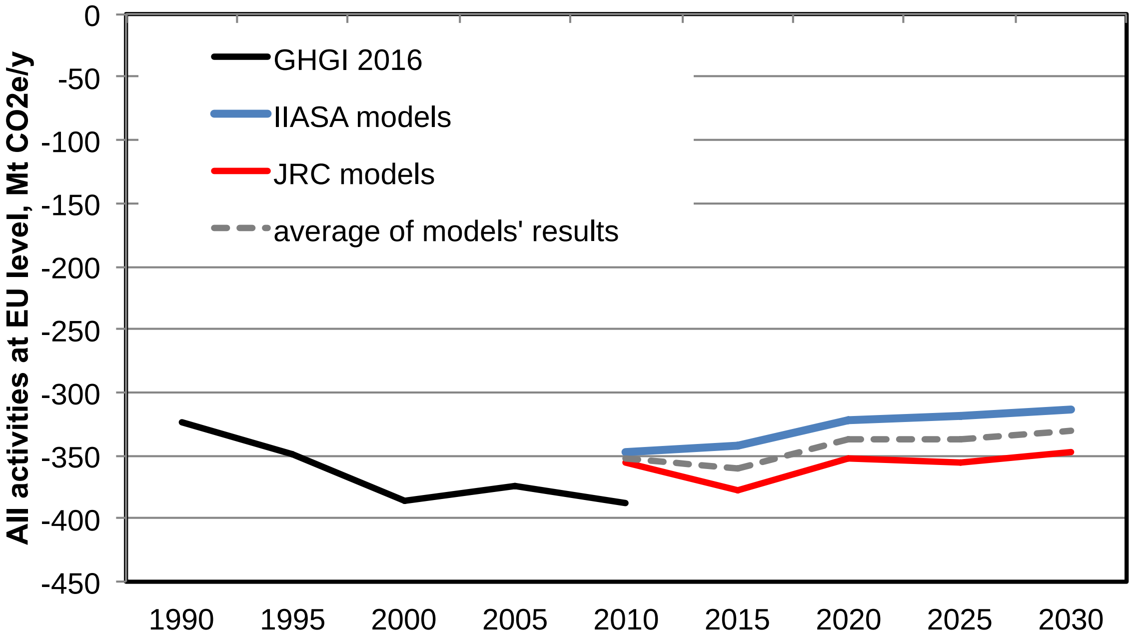


Figure 22: Sum of models results for all activities and land uses shown in the previous figure (FM+HWP+AR+D+CM+GM). All data are 5-years averages.

Table 4: Summary of models results and estimated impact in the accounting (in Mt CO_2e/y)

Activity or Land use	**GHGI 2016**		**Models results (average 2021-2030)**		**Impact on accounting (1), credits (-) or debits (+)**
	1990	**2005**	**JRC**	**IIASA**	
	Mt CO2e/y				
FM			-310	-259	Not estimated
FL-FL 20 yrs	-372	-359	-353		
FL-FL 30 yrs			-324		
HWP from FM or FL-FL	-22	-54	-26	-29	
AR since 1990			-86	-90	-88 (AR) -39 (L-FL 20 yrs) -71 (L-FL 30yrs)
L-FL 20 yrs	-36	-57	-39		
L-FL 30 yrs			-71		
D since 1990 (~FL-OL)	33	42	13	23	18
CM+GM	74	54	58	32	-9 (vs 2005) - 29 (vs 1990)
FM+HWP+AR+D+CM+GM	-323	-374	-349	-323	

(1) Estimated by comparing the average of models results for 2021-2030 with the relevant accounting rule: "gross-net" for AR and D, "net-net" (with 1990 or 2005 as base year) for CM and GM. Accounting for FM (or FL-FL) and for HWP is not estimated because it would require knowing the Forest Reference Level.

From Table 4 it can be seen that, overall, the **total sink from FM + HWP + AR + D + CM + GM** remains rather stable over time, i.e. from **-323 MtCO2e/y in 1990 and -374 MtCO2e/y in 2005** (GHGI 2016), to **-336 MtCO2e/y as average of models results for the period 2021-2030.** The total accounting quantity ranges from -29 MtCO2e/y (considering L-FL 20 yrs, D, and 2005 base year for CM and GM) to -96 MtCO2e/y (considering AR since 1990, D, and base year 1990 for CM and GM).

4 Task 3: JRC Land Use country-specific factsheets

According to task 3, the factsheets should synthesize available estimates on LULUCF and Agriculture from various research projects [7] and MS' sources (GHGI, National Communication, FMRL) into a summary document for each country. Values should also be translated into UNFCCC/KP accounting values for 2030. A first complete preliminary round of country Land Use factsheets (including historical data and projections for both the Agriculture and LULUCF sectors) has been delivered to DG CLIMA in December 2014.

In the following, we present the updated factsheet for the EU. Individual MS factsheets are included in Annex 5.

[7] E.g. JRC models (CBM, LUISA, CAPRI and IPCC-Tier1, CENTURY) and IIASA models (Recercene scenario 2016)

EUROPEAN UNION – JRC's AFOLU Fact sheet

Update: June 2016

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: Total agriculture emissions significantly decreased from 1990. Nitrogenous fertilizers are an important driver for these emissions, although current figures decreased by 30% from 1990. The emissions from livestock, and particularly ruminants, have also substantially decreased, and swine is the largest sector.

LULUCF: the total forested area across Europe increased by 4% between 1990 and 2014, reaching 165 kha or about 37% of the total EU-28 area. Six countries make up two thirds of the total forested area: Sweden, Spain, Finland, France, Germany and Italy. The area of land under agricultural use (cropland and grassland) decreased by approximately 5% between 1990 and 2014. France has the largest utilized agricultural area, followed by Spain, United Kingdom, Germany and Italy. The total sink from LULUCF slightly increased from 1990, mainly due an increase in the forest sink. Cropland is a rather stable source.

Fig. 1. Past trends of Agriculture and LULUCF (GHGI 2016)

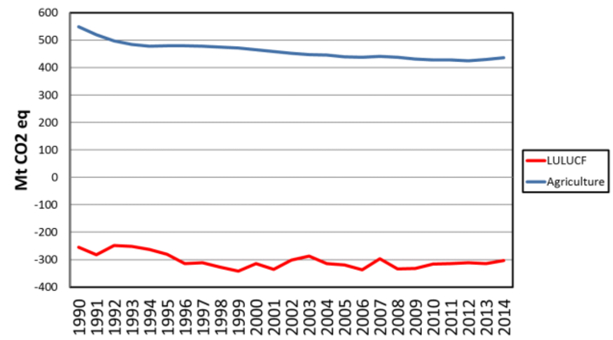


Fig. 2. Past trends of specific LULUCF categories (GHGI 2016)

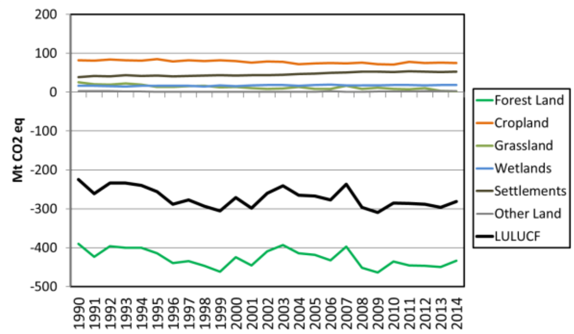


Table 1- state of play for LULUCF and Agriculture, and summary of available projections

EU28		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-361.2	(3)	-395.4	(3)	-309.0	-313.3	-347.5	(4)		-267.8	-322.0	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-57.9	(7)
	AR			-58.1			-78.6	-78.9	(5)		-98.7	-92.6	(5)		-78.8	(6)		-95.6	(6)		-18.0	(7)
	D			42.4			31.4	17.7	(5)	0.0	17.3	9.8	(5)		24.6	(6)	0.0	13.5	(6)		-6.4	(7)
	CM	66.3		59.0				70.9	(5)		0.0	73.4	(5)		4.6	(6)		-29.6	(6)			(7)
	GM	8.7		-6.4				1.6	(5)		0.0	1.2	(5)		-7.0	(6)		-8.1	(6)		0.0	(7)
	total (UNFCCC)	-281.9		-321.7		0.0	-360.5		(5)	0.0	-349.2		(5)									
Agriculture (2)	Soils N_2O	197.7	(3)	161.7	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	332.0		251.0					(5)				(5)			(6)			(6)			(7)
	total	548.8		428.9		464.4	434.0		(5)	464.0	432.6		(5)	-84.5	-114.8	(6)	-84.9	-116.2	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC)

AGRICULTURE: In recent years, environmental considerations including climate change mitigation have gradually been integrated into the EU's Common Agricultural Policy (CAP). The new CAP (covering the period 2014-2020) will further enhance the existing policy framework for sustainable management of natural resources, contributing to both climate change mitigation and enhancing the resilience of farming to the threats posed by climate change and variability. Furthermore, legislation (the Nitrates Directive) is in place, to contribute to decreasing CH_4 and N_2O emissions from agricultural activities. The European Soil Thematic Strategy also aims at preventing soil degradation and preserving soil as an important carbon pool.

EU-28 GHG emissions from the agricultural sector have shown a steady decrease over the past years. Changes in agricultural policy and farming subsidies as well as increased productivity have driven reduced animal numbers, reduced nitrogen fertilizer production and use and improved manure management, resulting in reduced emissions from agricultural soils and livestock. EU-28 GHG emissions from the agricultural sector are expected to continue decreasing up to 2020 in both WEM and WAM projections but at a slower pace than in previous decades. For the EU-28 under the WEM scenario, GHG emissions in the agricultural sector are projected to be 464.4 $MtCO_{2e}$ in 2020 and 463.9 Mt CO_{2e} in 2030. Considering additional policies and measures would reduce emissions to 460.4 $MtCO_{2e}$ in 2020 and 456.4 $MtCO_2$ e in 2030. In both the EU-28 WEM and WAM scenario, the second significant amount of absolute GHG emission reductions from 1990 to 2030 is projected to stem from the agricultural sector (140 $MtCO_{2e}$ and 148 $MtCO_{2e}$, respectively).

LULUCF: The new EU Forest Strategy provides a framework that coordinates and ensures coherence of forest-related policies and allows synergies with other sectors that influence forest management. MS are asked to consider the principles and goals of this strategy when setting up and implementing their action plans and national forest programmes. The new EU legislation on GHG accounting rules for LULUCF activities (going beyond forestry) lays down rules for the robust accounting in this sector. It will support the mitigation potential of this sector by improving the visibility and tracking progress of mitigation efforts.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 2.7 tCO_2/ha/yr), use of cover crops (0.6 tCO_2/ha/yr), straw incorporation and reduced tillage (0.6 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.32 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 1.13 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock resulting in 73.4 $MtCO_2$/yr for cropland and of 1.25 $MtCO_2$/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

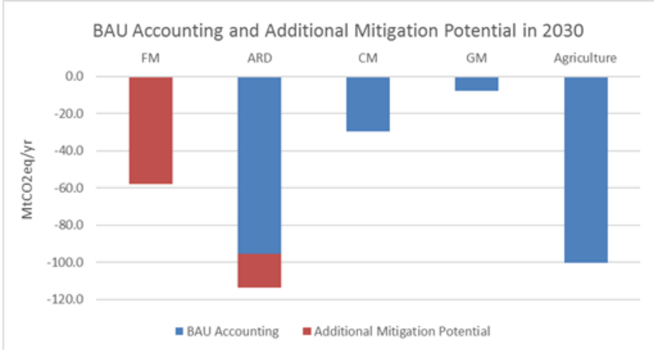
Forestry

The FMRL for CP2 was constructed with different approaches: 14 MS were modelled by IIASA/EFI/JRC, while the remaining MS applied their own model and approach. Overall, the sum of MS' FMRL led to an expected significant decrease of the FM sink, from about 370-380 $MtCO_{2e}$/y in 2010 to 260 $MtCO_{2e}$/y (without HWP) for the CP2. The latest available data (from GHGI 2016) shows that this decline is not happening, with the sink in 2013 still being around 120 $MtCO_{2e}$/y higher than the FMRL. When HWP is added, the known information on technical corrections considered, and the FM cap applied, the expected accounted quantity (for 2013-2014) would be ≈ 80 $MtCO_2$/yr. This large amount of credits, together with a clear lack of comparability of FMRL approaches among MS, suggests a profound revision of the criteria to set future Forest Reference levels.

On projections, using the harvest assumptions from Reference scenario 2016 (+15% from 2010 to 2030, mostly due to extra harvest for energy purposes), both CBM and G4M predict a decline of the sink in 2030 (-294 $MtCO_{2e}$/y and -238 $MtCO_{2e}$/y in 2030, without HWP, for CBM and G4M respectively). With a -10% harvest, CBM predicts an extra -58 $MtCO_{2e}$/y sink. The sink for HWP in 2030 is predicted to be around 25-30 $MtCO_2$/y (similar values for CBM and G4M).

For AR, the sink in 2030 is predicted to be around 90-100 $MtCO_2$/y (similar values for CBM and G4M). Assuming L-FL (20 or 30-years transition periods), CBM predicts smaller sink than AR (see section 3.4).

For D, the emissions in 2030 are predicted to be around 10 or 17 $MtCO_2$/y (for CBM and G4M, respectively).

Fig. 3. Marginal abatement cost curves for 2020 for agriculture No information available.	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).** For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red). *Base year (1990) country total GHGs (without LULUCF): 5664 $MtCO_{2eq}$/yr* 

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ANALYSIS OF MS' REPORTING OF ESTIMATES OF EMISSIONS FROM CROPLAND AND GRAZING LAND MANAGEMENT

ANNEX 1 of AA LULUCF 2030

Raul Abad Vinas, Tibor Priwitzer, Simone Rossi, Roland Hiederer

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Executive summary

On top of the greenhouse gas (GHG) emissions reporting requirements under the United Nation Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol (KP), implemented at EU level through EU Reg 525/2013, the EU decision 529/2013 has set new requirements for LULUCF for the period 2013-2020. In particular, Member States (MS) shall report emissions and removals also from Cropland management (CM) and Grazing land management (GM).

This Annex aims to fulfil task 1 of AA LULUCF 2030, i.e. "Analysis of MS' reporting of estimates of emissions from Cropland and Grazing land Management (CM/GM)", and in particular: (a) Analyse CM and GM estimates reported by MS, and elaborate a short assessment in terms of adherence to the reporting principles (accuracy, transparency, comparability, consistency, completeness); and (b) elaborate recommendations to help MS improving their estimates.

The lack of a functioning version of the CRF Reporter heavily influenced all the GHG reporting for the year 2015 and 2016, including under the 529/2013 LULUCF decision.

In 2015, the majority of MS included some quantitative estimate for CM and GM, but no one provided explanatory information on data and methods used to estimates emissions and removal (this was linked to the EU-level decision to skip KP submission in 2015).

During the year 2016, most of the Member States have provided information on: (i) annual estimates of emissions and removals from CM and GM, (ii) information on methods and data used for these estimates, and, (iii) the system in place and being developed to estimates emissions and removals from these activities. For France it was not possible to find the 2016 submission of information under the 529/2013 in the EEA Central Data Repository, while for some other Member State the submission was incomplete in terms of some of the three elements.

Despite the increase of the quantity of information that has been submitted in 2016 (compared to 2015), there are still significant differences among Member States. Several issues have been identified related to the transparency, accuracy, consistency and completeness of the information, and there is still the need to provide the information in a more harmonized way that allows a better assessment and comparability of the information.

General recommendations for all the MS include: (i) to make use of the official channel for the provision of information pursuant the Decision 529/2013 and to inform the Commission on when and what information is being submitted; (ii) to use the guideline for CM and GM developed under the project "LULUCF implementation guidelines and policy options", and any other tool developed by the JRC (e.g. for estimating carbon stock changes in living biomass).

The fact that in most of the cases Member States faced the reporting for these activities for first time in 2015 (i.e. only three and two Member States respectively selected to account for CM and GM during the CP1), and that new tables and guidelines have been introduced during the CP2, are the main reasons for the lack of a full adherence of the submissions to the reporting principles. Nevertheless, many Member States have provided information on on-going projects that, along with the experience and the result of supporting activities (e.g. LULUCF workshops, bilateral supporting projects), should result in significant improvements in the coming years.

Background information

The policy context

For the second commitment period of the KP, the EU committed to keep GHG emissions at an average of 20% below base-year levels over the whole period 2013-2020.

With a different scope, under the EU 2020 strategy, the EU also committed to a 20% reduction, by 2020, of total GHG emissions from its 28 Member States compared to 1990 levels.

Among others, the most significant difference between these commitments is that the Land Use, Land Use Change and Forestry (LULUCF) sector is not included in the domestic EU target, while MS may issue LULUCF credits under second commitment period (CP2) of the KP. However, in the context of moving to a competitive low-carbon economy in 2050, the EU also indicated that all land use should be considered in a holistic manner and LULUCF should be addressed within the Union's climate policy (COM/2011/0112).

To this end, in 2013 the European Commission proposed a legislative package for the inclusion of LULUCF within the EU target. Going beyond international obligations under the UNFCCC, the Decision 529/2013[8] established new provisions for the monitoring, reporting and accounting of various LULUCF activities during 2013-2020, as first steps before the consideration of formal inclusion of LULUCF in the EU target. In particular, the most significant novelty set by this decision is the mandatory reporting for Member States of emissions and removals from Cropland management (CM) and Grazing land management (GM)[9].

In October 2014, in the 2030 EU energy and climate framework EU leaders agreed to reduce GHG emissions by at least 40 % by 2030 compared with 1990, and to establish the exact modality of including LULUCF "as soon as technical conditions allow and in any case before 2020". In mid 2016, the Commission intends to present a legislative proposal on the inclusion of LULUCF in the 2030 EU energy and climate framework.

The 2015 will be remembered for the successful conclusion of a new global international climate agreement at the COP 21, held in Paris, to be implemented post-2020.

The GHG reporting context

National GHG inventories consist of quantitative estimates of GHG emissions and CO_2 removals reported in Common Reporting Format (CRF) tables, and descriptions of methods and data, used to derive such estimates, which are included in National Inventory Reports (NIR).

CRF tables should be prepared using the UNFCCC CRF Reporter software.

For the submissions of **GHG inventories for 2015**, following the adoption of the revised guidelines for reporting GHG inventories from Annex I Parties (Decision 24/CP.19[10]) the software had to be redesigned.

Decision 13/CP.20[11] recognized that the deadline, as set out in Decision 24/CP.19, for providing the redesigned version of the CRF Reporter to Annex I Parties was not met,

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

[9] Member States "shall, prior to 1 January 2022, provide and submit to the Commission by 15 March each year initial, preliminary and non-binding annual estimates of emissions and removals from cropland management and grazing land management using, where appropriate, IPCC methodologies".

[10] Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention

and that the CRF Reporter version available by that time was not functioning [12]. Accordingly, Decision 13/CP.20 reiterated that Annex I Parties in 2015 may submit their CRF tables after 15 April, but no longer than the corresponding delay in the CRF Reporter availability. But urged Annex I Parties to submit their CRF tables as soon as practically possible.

In this context, problems in the CRF Reporter caused a significant delay in the 2015 initial submissions of national GHG inventories to the Commission. However, in line with requirements under Decision 529/2013, the deadline of 15 March 2015 remained valid for the provision of quantitative information. On the other hand, it was agreed that explanatory information on methodologies and data used for the quantitative estimates should be provided, at the latest, as a separate annex, together with the submission of the NIR to the Commission.

In view of this situation, in order to facilitate Member States the compliance with the deadline for the provision of quantitative information, the Joint Research Centre (JRC) prepared a set of CRF tables to be filled manually that were used by most of the Member States. Additionally, a proposal on how to provide explanatory information on methodologies and data used was also presented during the WG-1[13] meeting held in Brussels in April 2015.

Finally, during the WG-I meeting held in Brussels in September 2015, it was acknowledged that the CRF Reporter version 10.0.0, available at that time, was not functioning due to a number of issues in relation to reporting requirements under the KP. Therefore, recalling the Decision 13/CP.20 that urged to submit the CRF tables as soon as practically possible, the WG-I agreed on the feasibility of provide official submissions for the year 2015 under the UNFCCC Convention and on the impossibility of provide official submissions under the Kyoto Protocol.

As a result, since Member States did not prepare official submissions of information under the KP, the separate annexes with information on methodologies and data used to derive annual estimates on CM and GM under the Decision 529/2013 were not submitted to the Commission in the year 2015.

With regards with information to be submitted in **GHG inventories for 2016**, the CRF Reporter remained not functional at the beginning of May, and there is still not clarity on whether Member States will submit official information under the KP to the UNFCCC. Nevertheless, the deadline for submitting information under the Decision 529/2013 to the Commission was not affected.

Additionally, following requirements set by the Article 3.2 of Decision 529/2013, starting in 2016, Member States must submit annually information on systems in place and being developed to estimate emissions and removals from CM and GM. Therefore, bearing in mind that March 2016 was the first year for submitting this information, the JRC prepared a guidance to facilitate the preparation and provision of such information that was circulated early this year to all the Member States.

Aim of the document

The aim of this document is to update a previous version of the report that covered the task 1a of the administrative arrangement LULUCF 2030, and that was circulated to the

[11] Guidelines for the technical review of information reported under the Convention related to greenhouse gas inventories, biennial reports and national communications by Parties included in Annex I to the Convention

[12] Functioning software means that the data on GHG emissions and removals are reported accurately both in terms of CRF tables and XML format.

[13] Working Group I – "Annual inventories" under the Climate Change Committee.

Commission at the end of 2015, with information submitted by Member States under Decision 529/2013 in 2016.

In addition, this report aims to cover, for first time, the requirement set by the Task 1b of the above-mentioned administrative arrangement.

Following the ToR document of the administrative arrangement, the following task are expected to be delivered to the Commission:

- Task 1a: involves the analysis of estimates reported by Member States for CM and GM under Decision 529/2013, (and any available information on methods used). The task also includes a short assessment of the adherence of Member States submissions to the five reporting principles of: transparency, accuracy, consistency, comparability and completeness.
- Task 1b: based on a), elaborate recommendations to help MS improving their estimates, taking into account previous work done during the AA 'LULUCF MRV' (2012-2014) and any useful information from the AA LULUCF Accounting.

1. Introduction

Decision 529/2013, hereinafter *"LULUCF Decision"*, requires Member States to prepare and maintain accounts of all emissions and removals resulting from Afforestation/reforestation, Deforestation, and Forest Management activities. For the accounting period beginning on 1 January 2021, and thereafter, Member States shall prepare and maintain also accounts of all emissions and removals resulting from CM and GM.

In addition, as regards the annual accounts for CM and GM during the accounting period from 1 January 2013 to 31 December 2020 MS shall:

- From 2016 to 2018, report to the Commission by 15 March each year on the systems in place and being developed to estimate emissions and removals from CM and GM.

- Prior to 1 January 2022, provide and submit to the Commission by 15 March each year initial, preliminary and non-binding annual estimates of emissions and removals from CM and GM.

Further, Regulation 749/2014[14] clarifies that:

- *Article 38*. *Avoidance of double reporting*. No duplication among the data submitted in the framework of the KP and the information to be sent to the Commission under the Decision 529/2013.

- *Article 39. Reporting requirements on systems for CM and GM*. Textual information on the systems in place and being developed to estimate emissions and removals from CM or GM including: (i) a description of the institutional, legal and procedural arrangements and, (ii) a description of the manner in which the systems implemented are consistent with the methodological requirements of the IPCC methodological guidelines.

- *Article 40. Reporting requirements on annual estimates of emissions and removals from CM and GM*. Starting in 2015, annual information including a complete set of all relevant CFR tables and explanatory information on methodologies and data used.

- *Article 42*. *Submission of information*. The information required in Articles 39, 40 (and 41) shall be submitted as a separate annex to the NIR included in the national GHG inventories.

Moreover, Article 4(2) of the LULUCF Decision requires Member States to ensure the transparency, accuracy, completeness, comparability and consistency of relevant information when estimating emissions and removals for the activities reported under this Decision.

The Decision 24/CP.19 adopted by the Conference of the Parties of the UNFCCC defines these reporting principles as follow:

- Transparency means that the assumptions and methodologies used for an inventory are clearly explained to facilitate replication and assessment of the inventory.

[14] Commission Implementing Regulation (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council.

- Accuracy is a relative measure of the exactness of an estimate. Estimates should be accurate in the sense that they are systematically neither over nor under estimated and that uncertainties are reduced as far as practicable.
- Consistency means that same methodologies and consistent data sets for all years are used. An inventory using different methodologies for different years can be considered to be consistent if it has been estimated in a transparent manner taking into account the IPCC good practices for time series consistency.
- Comparability means that the country used agreed methodologies and formats for estimating and reporting inventories.
- Completeness means that an inventory covers all sources and sinks and gases for the full geographic coverage of the Party.

2. Assessment of information submitted by Member States under the Decision 529/2013

At the time of writing this report, most of the Member States had submitted a set of CRF tables although with different level of completeness.

Overall, Member States focused their efforts on estimating CO2 emissions resulting from carbon stock changes on the pools considered in the LULUCF reporting, and to a lesser extent on the provision of non-CO2 emissions from other sources (e.g. biomass burning), as well as, on information reported on other cross-cutting tables.

Nevertheless, there are still a significant number of carbon pools (and additional information) that are reported with notation keys (NE-not estimated, NO-not occurring and NA- not applicable), or where empty cells where found. It is also important to note that some submissions included only estimates for the last year, rather than a complete set of tables (i.e.1990, 2013, 2014). For Bulgaria, France, and Malta, it was not possible to find the CRF tables in the corresponding EEA CDR folder[15].

With regards to requirement set by article 40.4.b of the Regulation 749/2014; 19 Member States provided information on methodologies and data used for reporting CM and GM, either as a separate document or included as part of the KP submission when the MS selected to account for these activities under the KP. For Belgium, Bulgaria, Cyprus, Estonia, Finland, France, Malta, Netherlands and Slovakia it was not possible to find a separate document containing such information. However, it should be noted that for some of these Member States a relatively detailed mention was included as part of the document related to the systems in place and being developed, stating that methods and data used for estimating CM and GM are the same than those used for reporting cropland and grassland to the UNFCCC Convention

Concerning requirement set by article 39.1 that requires, that starting in 2016, Member States must submit information on the systems in place and being developed to estimate emissions and removals from CM and GM, 23 Member States provided such information in a separate document. For France, Lithuania, Luxembourg, Netherlands, and Slovenia the information was not found in the corresponding EEA CDR folder.

An overview of the information submitted by Member States on activity data (kha) and emissions/removals (kt CO_2) from CM and GM for the base year and for the year 2014 is presented in

[15] Information under the Decision 529/2013 used in this report was collected from the European Environment Agency Central Data Repository (CDR). http://cdr.eionet.europa.eu/

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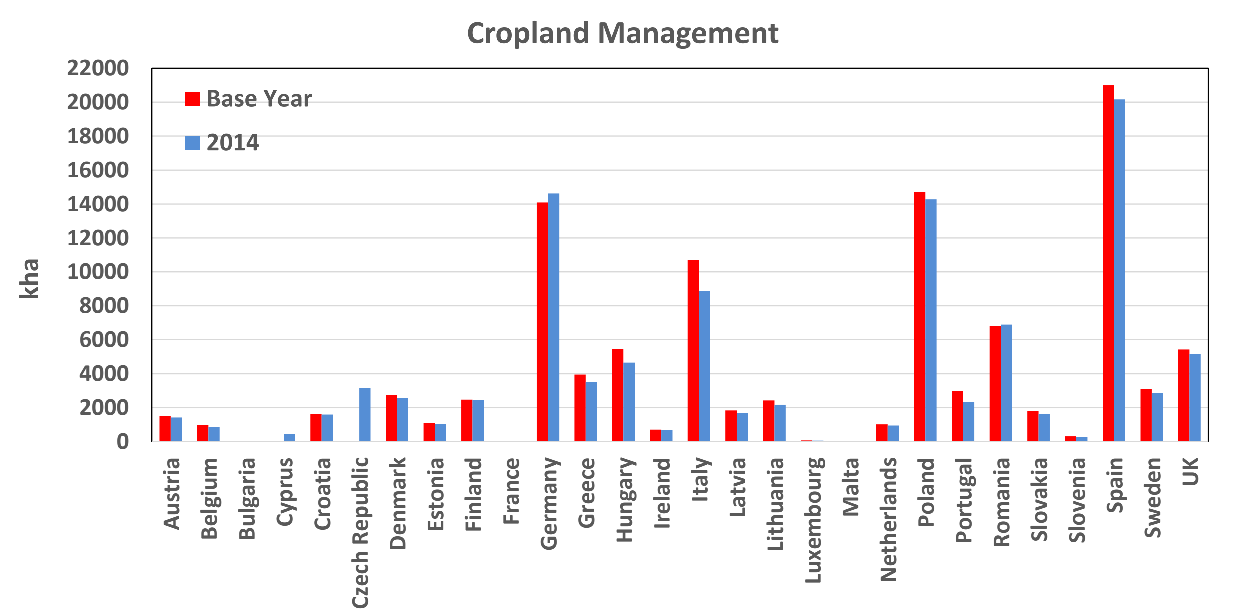
Cropland Management
kha
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Base Year
2014
Austria
Belgium
Bulgaria
Cyprus
Croatia
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Latvia
Lithuania
Luxembourg
Malta
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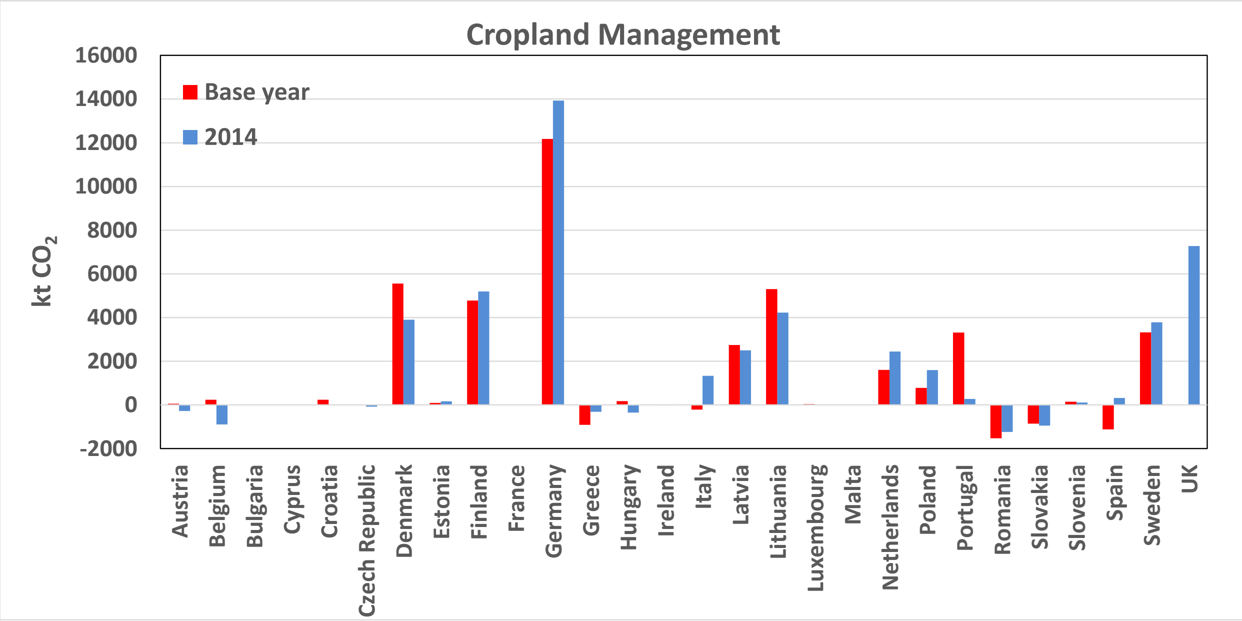
Cropland Management
kt CO_2
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Base year
2014
Austria
Belgium
Bulgaria
Cyprus
Croatia
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Latvia
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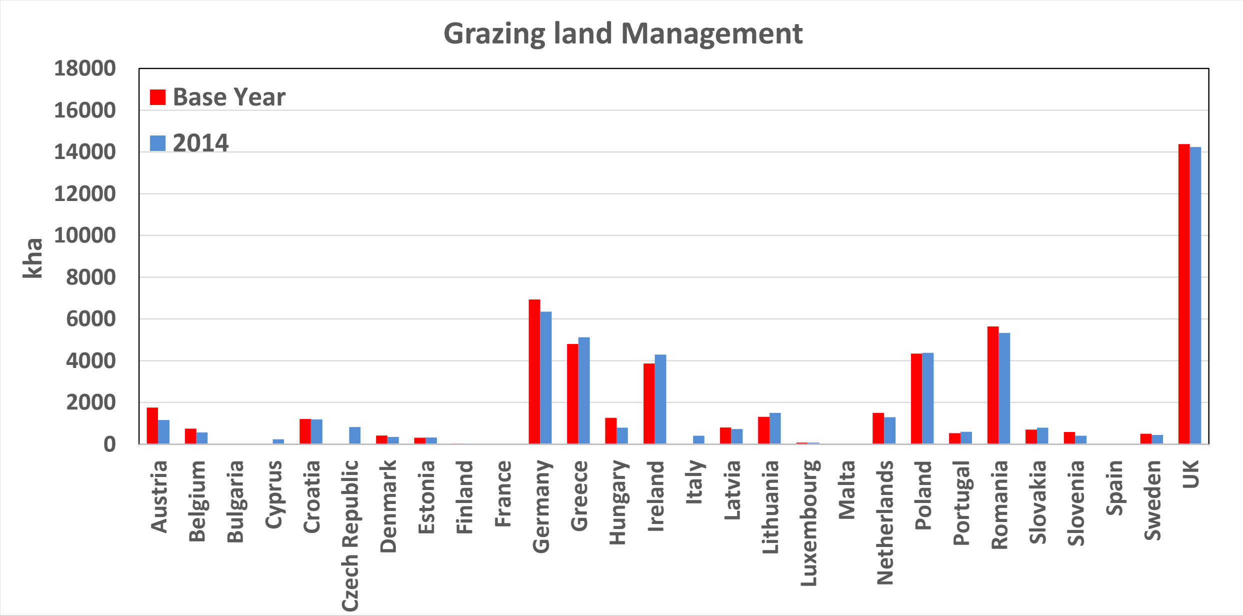
Luxembourg
Malta
Netherlands
Poland
Portugal
Romania
Slovakia
Slovenia
Spain
Sweden
UK



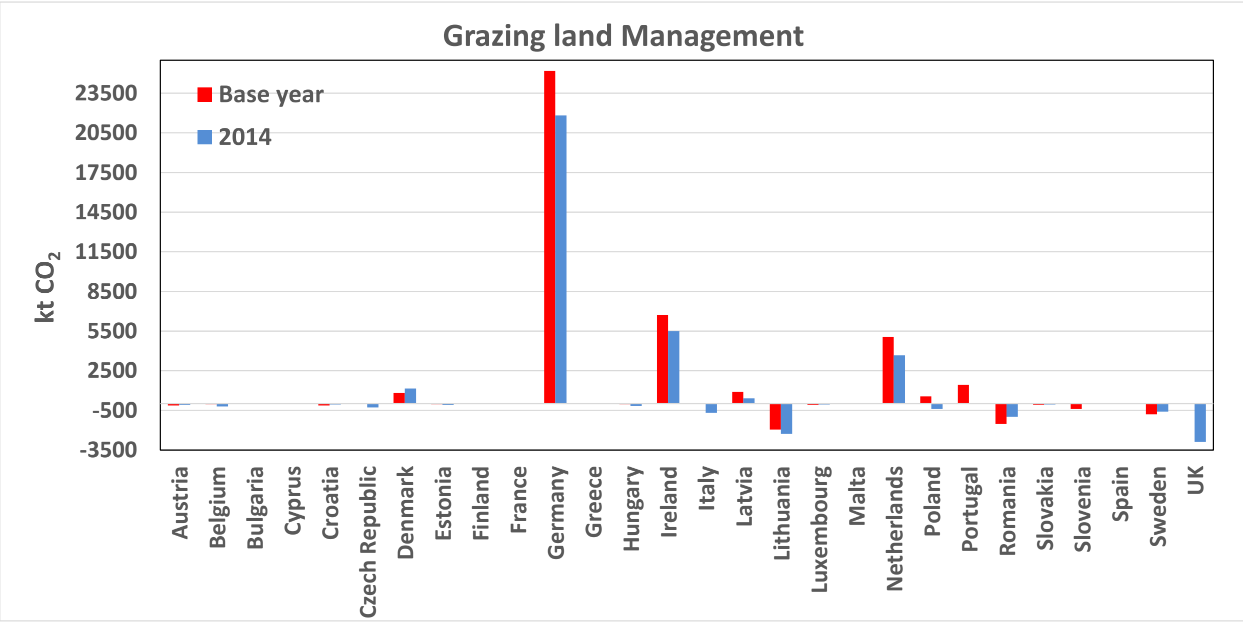


Figure 25: Summary of activity data (kha) and emissions/removals (kt CO_2) reported by Member States in tables 4(KP-I) B.2 /B.3.

Bearing in mind differences on extension and definitions of cropland and grassland areas, management practices, types of crops, areas of organic soils subject to management, and the methods and data implemented for estimating carbon stock changes, a comparison of CO_2 emissions/removals among Member States must be interpreted with some caution.

In spite of this, some significant differences arising when Member States with similar areas and presence of organic soils under Cropland and Grassland are compared, would require an in-depth analysis to clarify the reasons.

The following subheadings present a short assessment of the adherence of the information submitted under the LULUCF Decision to the five reporting principles.

2.1 Transparency

An inventory should be considered transparent if clear descriptions of methods, assumptions, and data used are provided that allow a full assessment of the information.

In this sense, although the majority of the MS provided information on methods and data used for reporting CM and GM under the LULUCF Decision, this information was not always transparent enough to assess the accuracy, consistency and comparability of the estimates.

For instance, often, Member States argued that the methods used under the LULUCF decision were the same than those used for estimating cropland and grassland under the Convention. While it is expected that methods used for estimating emissions and removals from CM and GM are in line with those used under the UNFCCC Convention for cropland and Grassland, in some instances, the information found was not clear enough to understand differences on emissions/removals among CM vs cropland and GM vs grassland.

In addition, some additional requirements exist when reporting information on CM and GM as compared with the reporting of associated land use categories, to the UNFCCC Convention. And in several instances, the information on methods and data provided was not enough to assess that these supplementary requirements were met. For instance, while under cropland and grassland some carbon pools can be assumed in balance (i.e. no net carbon stock change are expected) under Tier 1 methodologies, Member States are requested to demonstrate with verifiable and transparent information that those carbon pools are not a net source of emissions when reporting under the LULUCF activities (i.e. the simply assumption of consider the carbon pool in balance, is not enough to meet the requirement for the omission of a carbon pool)

2.2 Accuracy

The principle of accuracy stands for a relative measure of the exactness of an estimate. The accuracy of a final estimate is strongly associated with the completeness, however, while the completeness can be more easily assessed, the overall accuracy of an estimate relies on many other factors that cannot be easily assessed without a comprehensive review of methods, data and assumptions used.

Despite of this difficulty, having in mind that estimates of emissions and removals provided under the LULUCF Decision follow, overall, the methods, data and assumptions used for reporting agricultural activities to the UNFCCC Convention, the accuracy of such estimates needs to be seen as a moving target, toward which national inventories progress every year by implementing improvements.

It should be noted that national inventories are reviewed twice every year. Revisions are carried out during the QA/QC[16] checks implemented in the context of the EU GHG inventory, and by the official UNFCCC annual review, in order to assess their compliance with reporting principles. During these processes Member States are requested to provide information or implement changes whenever an inventory is found to be not in line with reporting principles.

Nevertheless, it should be also noted that reporting of carbon stock changes from soils under cropland and grassland remains among the main challenges for reporting LULUCF sector, and even more when estimates need to reported for the base year. Many

[16] Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC. Official Journal of the European Union L 165/13

Member States still rely on default IPCC values and default assumptions for reporting this pool, which in principle are associated to low accuracy as they barely reflect national circumstances that may impact the carbon content of the soils.

Indeed, one of the main challenge for reporting this carbon pool is the collection of country-specific data that capture the carbon stock in soils under constant management practices and the fate of this carbon on soils subject to land use or management changes. With the lack of this information, Member States often implement IPCC assumptions that aim to demonstrate that carbon stock change under Cropland and Grassland are not a net source of emissions (e.g. the intensity of soil management practices that impact the carbon content has decreased constantly on time) and therefore the omission of quantitative estimated can be accepted, however, in many instance such argumentation is considered not enough and not in line with requirements.

Moreover, challenges relates also to the need to collect proper data on areas subject to CM and GM for the base year and for every year of the accounting period. The reporting of carbon stock changes in soils for the base year requires information on activity data since 1970, which may be very challenging. In addition, the land representation systems should be able to provide information in such a way that allows to track lands along the years of the time series. While some national systems are not yet capable to collect proper information on activity data, some alternatives, discussed in the context of other administrative arrangements ("LULUCF MRV", "LULUCF Accounting"), are available to fulfil reporting requirements.

2.3 Consistency

Consistency means that same methodologies and consistent data sets are used across the years. If not, Member States should implement IPCC good practices to ensure time series consistency. Moreover, consistency needs to be ensured also among the data reported in different sections of the submissions (e.g. annex with explanatory information and CRF tables).

As with the previous reporting principles, any attempt to assess the consistency of the submissions should be based on an in-depth analysis of data and methods used to derive annual estimates. Since, so far, data submitted only cover information for the base year and the 1^{st} and 2^{nd} year of the accounting period, it is difficult to carry out a full assessment of consistency of the time series.

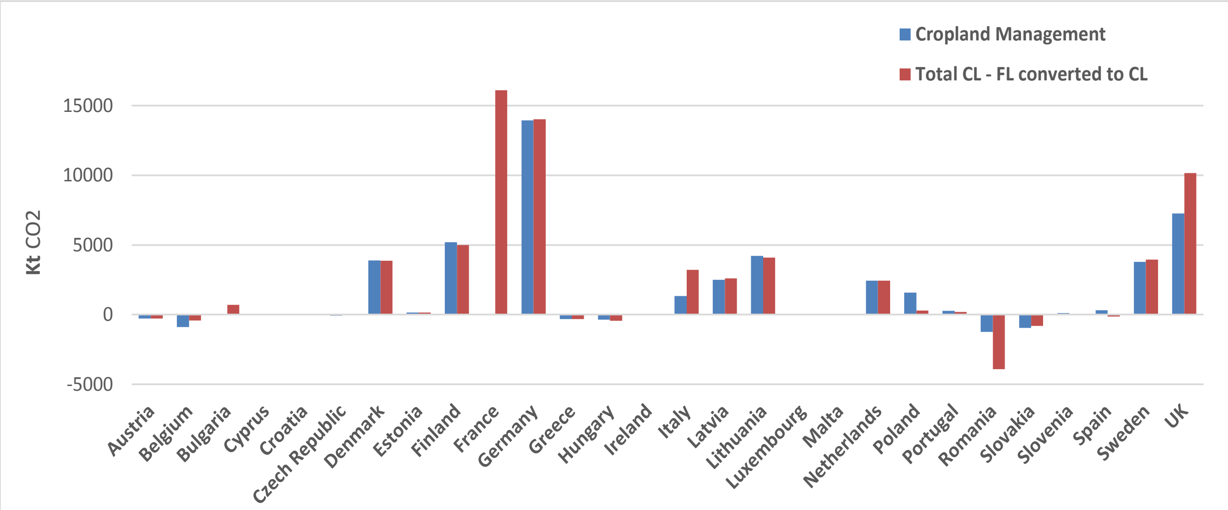
Nevertheless, a comparison among data submitted to the UNFCCC Convention and data submitted under the LULUCF Decision may help to provide a preliminary assessment of the consistency, and to identify potential discrepancies.

In this regard, we compare emissions and removals from Croplands submitted to the Convention, with those from CM submitted under the LULUCF Decision. It should be noted that, although these data are not expected to be equal, in overall, they are expected to be comparable after the exclusion from Cropland, emissions related with deforestation (i.e. Forest land converted to Cropland). Also, it is important to take into account that, a more complex analysis is required when a Member State account, under the KP, for voluntary activities under the Article 3.4 of the KP. In this case, it may also be necessary to exclude emissions and removals from some other conversions to Cropland.

The same reasoning can be also implemented for the comparison of Grassland and GM data, however, larger differences should be expected due to the inclusion of unmanaged grassland areas in the submissions to the Convention.

In any case, it is important to bear in mind that mismatches cannot be, in every instance, directly associated with inconsistencies.

Figure 26 provides a comparison of emissions and removals reported for CM and GM under the LULUCF Decision with those reported for Cropland and Grassland to the Convention after subtract the emissions related to deforestation.



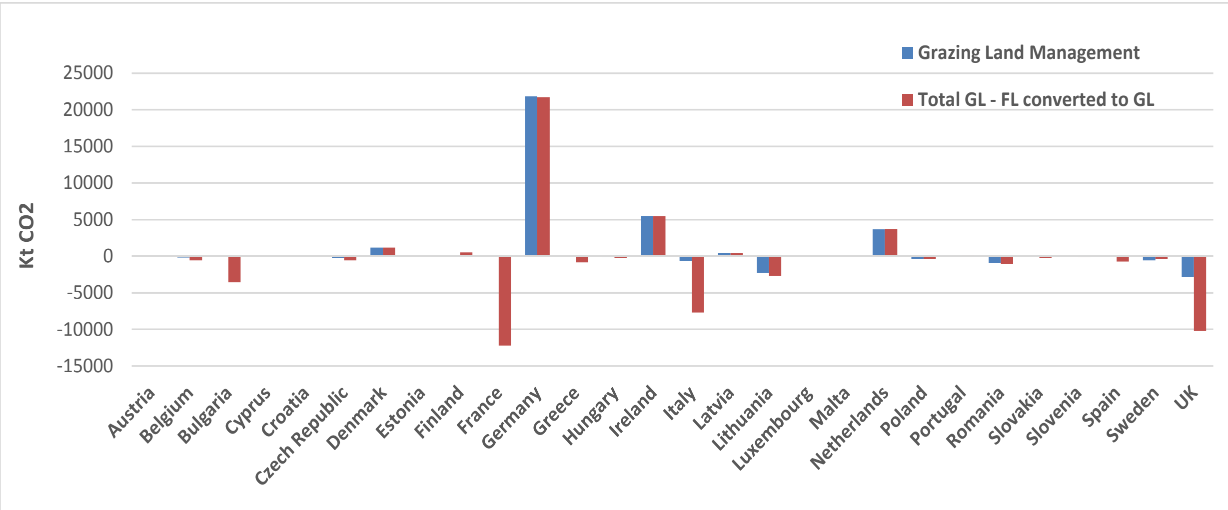


Figure 26: Comparison of emissions/removals (kt CO_2) reported by Member States in tables 4(KP-I) B.2 /B.3 under the LULUCF Decision with those reported to the Convention in tables 4B/4C for the year 2014 (March submissions).

Finally, potential inconsistencies arises also when a Member State reports quantitative estimates from a carbon pool only for one of the years of the time series (see Figure 27), although some circumstances may justify this fact.

2.4 Comparability

This principle refers to the use of common and agreed methodologies and formats for the provision of information. On this regard, the information submitted by Member States under the LULUCF Decision can be considered comparable, since this information was always provided in the form of the CRF tables, and because Member States implemented methodologies, which even if not always transparent and or accurate; they have been reviewed, and, in principle, accepted during the reviews.

Despite of this, some issues affecting the comparability may arise if finally the information is considered incomplete, inconsistent or inaccurate.

2.5 Completeness

Completeness means that the submissions report information for all sources, sinks and gases with full geographic coverage for each year of the time series.

Overall, the information on methods provided by Member States does not provide explicit statements that ensure that emissions are reported for the full national coverage, but the fact that information on CM and GM is based on the same land representation system used under the UNFCCC convention ensures that the whole national territory is assessed when reporting CM and GM information pursuant the LULUCF Decision.

Concerning the completeness of reporting on carbon pools, Figure 27 presents the number of Member States that provide quantitative estimates (different than cero) of carbon stock changes for each carbon pool under CM and GM.

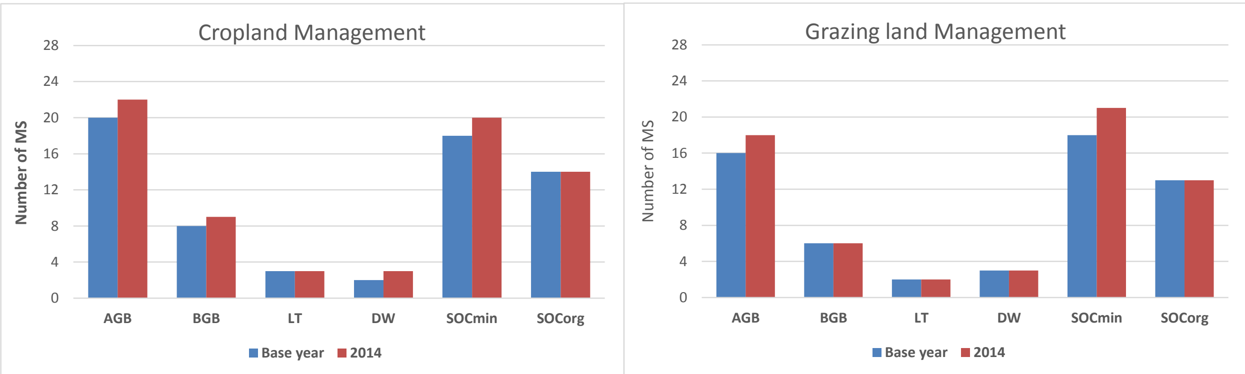


Figure 27: Completeness reporting of carbon stock changes by carbon pools reported in tables 4 (KP-I) B.2/B.3 for the base year and 2014.
AGB-aboveground biomass; BGB-belowground biomass; LT-litter; DW-dead wood; SOCmin-soil organic carbon in mineral soils; SOCorg-soil organic carbon in organic soils.

It is important to note that in many cases the lack of quantitative estimates relies on the use of notation keys. In this respect, while the use of NE (i.e. not estimated) is often directly associated with an incompleteness issue; unless the concept of –insignificant[17]- applies. For the use of the notation keys NO (i.e. not occurring) or NA (i.e. not applicable), it is expected the provision of verifiable information demonstrating that the carbon pool does not result in a net source of emissions, otherwise, an incompleteness issue arises.

While, in this cases the lack of quantitative estimates should not be directly associated to an incomplete reporting issue before to analyse the explanations on the use of the notation keys, an incomplete reporting is associated directly when Member States reported blank cells or they do not report the set of CRF tables.

[17] See revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention.

To this regards, we could not find the 2016 submission under the LULUCF Decision for Bulgaria, France and Malta, while other Member States provided only information for the year 2014 and empty cells for the base year.

Related to non-CO2 gases, issues on completeness were found also because some Member States do not provide information (i.e. notation keys or quantitative estimates) on additional sources of emissions in the corresponding CRF tables, however this issue is expected to improve in the coming years, as it was also subject to a depth assessment during the EU QA/QC checks.

3. General recommendations to help Member States improving their estimates

As a general recommendation to improve the collection of information submitted in the context of the LULUCF Decision, all the MS are encouraged to make use of the official channel for the provision of such information and to inform the Commission, via e-mail, when and what information is being submitted. So far, information has been submitted via the EEA CDR repository, however not all the Member States used the specific folder allocated there for the submission of the information. In some cases, it was difficult to find the documents related to LULUCF Decision since they were included in different folders. On the other hand, we also noted that some Member States resubmitted the information without informing the Commission that a new version of the submission was being sent, therefore it exist a potential risk of missing the most updated estimates submitted.

Concerning the transparency of the information, all the Member States are suggested to make used of the guidance, prepared by the JRC, for the provision of information on data and methods used for the preparation of estimates under CM and GM, as well as, for the provision of information on the systems in place and being developed to estimate emissions and removals from CM and GM. The use of such guidance would improve the transparency of the information, and increase the assessment of the completeness and comparability of such information.

Furthermore, many Member States reported information on on-going activities being developed to collect specific and more accurate information on land subject to cropland and grassland and on carbon stock changes, mainly in soils, under agricultural activities. In this sense, all the MS are encouraged to assess the potential utility that available EU datasets have for the provisions of explicit information on areas and parameters needed for carbon stock change estimation, since early 1990's.

Preliminary assessments of these European initiatives (e.g. LPIS, IACS, LUCAS), along with the experience of those Member States that are already making use of such data, have shown that they could contribute to: (i) increase the accuracy of the reporting; (ii) reduce the uncertainty by shortening the gap-filled period with the geo-spatial information provided, (iii) increase the completeness of the reporting, tracking land use changes for all the land use categories; and (iv) verify the accuracy of the reported data by comparing own data with EU datasets.

Moreover, in the context of the project "LULUCF implementation guidelines and policy options", funded by DG Climate action (CLIMA.A2/2013/AF3338), two guidelines were developed to support Member States on the implementation of the LULUCF Decision. Specifically on reporting and accounting for: (i) Cropland and Grassland management in accordance with Article 3(2) of the LULUCF Decision[18], and (ii) Revegetation and Wetland

[18] Weiss P, Freibauer A, Gensior A, Hart K, Korder N, Moosmann L, Schmid C, Schwaiger E, Schwarzl B (2015), Guidance on reporting and accounting for cropland and grassland management in accordance with Article 3(2)

Drainage and Rewetting Activities in accordance with Article 3(3) [19]. Information contained in these guidelines should serve to guide Member States in developing the information and systems needed to fulfil their reporting obligations under the LULUCF Decision. Therefore, Member States are encouraged to consult these documents when preparing the reporting of information under CM and GM.

With regards to the estimation of carbon stock changes in living biomass of woody crops (e.g. olives trees, vineyards, etc.), it has been noted that many Member States rely on default emissions factor, which along with a non-proper implementation of the Tier 1 methodology result in a systematic overestimation of the sink from this carbon pool. Specifically, some MS report this pool by assuming an annual biomass accumulation rate of 2.1 tn C ha^{-1}, (2006 IPCC GL) which is higher than the one implemented in forest vegetation; moreover, in some case this rate is implemented to the whole area of woody crops without take into account that, as described in the IPCC method, perennial woody crops accumulate carbon for a finite period after which they are removed. Therefore, Member States that implement the IPCC tier 1 method are encouraged to re-check the correct implementation of the IPCC method, and when possible to consider the option of making use of specific data collected by neighbouring countries with similar ecological conditions. Alternatively, the JRC prepared in 2013 a simple model that Member States could use to eliminate the impact of this erroneous interpretation of the method, and that would help to meet requirements.

Finally, with the entry into force of the CP2, the structure and content of some CRF tables covering the reporting of non-CO_2 emissions has changed. On the other hand, new methods have also become available for estimating such emissions during the CP2. With this context, it was noted during the EU QA/QC check that some Member States experienced difficulties to provide accurate, complete and consistent estimates of such emissions. Therefore, all the Member States are encouraged to verify that emissions of non-CO2 gases from CM and GM activities are properly reported and allocated, so there is no risk of double-counting, or omissions, of such emissions.

4. Conclusions

The lack of a functioning version of the CRF Reporter heavily influenced all the GHG reporting for the years 2015 and 2016, including under the 529/2013 LULUCF decision. Among others, this was the main reason for the lack of explanatory information on data and methods used to estimates emissions and removal for CM and GM in 2015.

During the year 2016, the EU mechanism for monitoring and reporting GHG inventories has been also affected by the status of the CRF Reporter. For instance at the time of writing this report there is still not clarity on whether there will be official submissions of KP information to the UNFCCC. Despite of this, following the deadline of 15 of March, most of the Member States provided information on: (i) annual estimates of emissions and removals from CM and GM, (ii) information on methods and data used for these estimates, and, (iii) the systems in place and being developed to estimates emissions and removals from these activities.

From the analysis of this information significant differences emerge, among Member States, on the status and adherence of these submissions with the five reporting

of EU Decision 529/2013/EU, Task 3 of a study for DG Climate Action: 'LULUCF implementation guidelines and policy options', Contract No CLIMA.A2/2013/AF3338, Institute for European Environmental Policy, London.

[19] Freibauer A, Gensior A, Hart K, Korder N,Moosmann L, Schmid C, Schwaiger E, Schwarzl B, Weiss P (2015), Guidance on reporting and accounting for Revegetation and Wetland Drainage and Rewetting Activities in accordance with Article 3(3) of EU Decision 529/2013/EU, Task 4 of a study for DG Climate Action: 'LULUCF implementation guidelines and policy options', Contract No CLIMA.A2/2013/AF3338, Institute for European Environmental Policy, London.

principles. Several issues have been identified related to the transparency, accuracy, consistency and, to an important extent, to the completeness of the information. This suggests the need to implement additional efforts to fulfil the reporting obligations. But also, there is need to enhance the system for collecting information from Member States.

The fact that in most = cases Member States faced the reporting of these activities for first time in 2015 (i.e. only three and two Member States respectively selected to account for CM and GM during the CP1), and that new tables and guidelines have been introduced during the CP2 for reporting and accounting for emissions from these activities, appear to be the main reasons for the lack of a full adherence of the submissions to the reporting principles.

Finally, despite of inherent difficulties for the reporting of CM and GM, it is expected an overall enhancement on the reporting for agricultural activities under LULUCF Decision in the coming years, as result of the significant number of dedicated projects that are currently ongoing.

List of figures

CBM METHODS
ANNEX 2a of AA LULUCF 2030

Contract n° 33920-2015 NFP

Administrative agreement

340202/2015/705777/CLIMA.A.2

Roberto Pilli, Giulia Fiorese, Giacomo Grassi
Coordination by Giacomo Grassi

2016

Joint
Research
Centre

Table of contents

1 Introduction

The general aim of the subtasks ***a*** ("Projections of FM") and ***b*** ("Projections of AR") of the AA is providing projections consistent with the IPCC methods, for each MS, from 2000 to 2030, including:

- Forest Management (FM) and natural disturbances.
- Harvested Wood products (HWP).
- Forest land use change, i.e., Afforestation/Reforestation (AR) and deforestation (D).
- A sensitivity analysis on harvest rate and on land use change.

To this aim, the Carbon Budget Model (CBM) developed by the Canadian Forest Service (Kurz et al., 2009) was used, as part of a broader effort for a comprehensive modelling framework for the forest sector. During the last years, the CBM was successfully adapted to specific forest management conditions in Europe (e.g. uneven-aged forests, Pilli et al., 2013), validated at regional and country level (Pilli et al., 2014a; Pilli et al., 2016a) and successfully applied to 26 MSs to estimate the C balance for FM (Pilli et al., 2016a) and AR (Pilli et al., 2014b and Pilli et al., 2016b).

This annex describes the methods applied by this AA, in order to analyze the forest C sink and HWP mitigation potential of EU MS.

The first section of this annex focuses on the general methodological assumptions applied to this AA (i.e., CBM general description, main assumptions applied to HWP sector, and natural disturbances, historical and future model assumptions); the second section reports in details the specific methodological assumptions applied to each MS.

1.1 General Methodological assumptions

1.1.1 The Carbon Budget Model (CBM-CFS3) and the main input data

The CBM is an inventory-based, yield-data driven model that simulates the stand- and landscape-level C dynamics of above- and below-ground biomass, dead organic matter (DOM: litter and dead wood) and mineral soil (Kurz et al., 2009). The model, developed by the Canadian Forest Service[20], was recently applied to the Italian forests, in order to test the CBM for different European silvicultural systems, proposing a novel approach to include uneven-aged forest structures (Pilli et al., 2013).

Because this work applies the same general assumptions used in the Italian case study, we provide only a short description of the model, highlighting the specific methodological assumptions related to the present study. Further details of the model can be found in Kurz et al. (2009), and its applications to European countries are found in Pilli et al. (2013, 2016).

The spatial framework applied by the CBM conceptually follows Reporting Method 1 (IPCC 2006) in which the spatial units are defined by their geographic boundaries and all forest stands are geographically referenced to a spatial unit (SPU). We considered 26 MSs[21] (i.e., as reported by Tab. 1) and 35 climatic units (CLUs, as defined by Pilli, 2012) for a total of 910 SPUs. The CLU's mean annual temperatures, range from -7.5 to +17.5°. Each SPU was linked to a CLU through the information provided by Corine Land Cover.

[20] The model description is available to the following URL: http://www.nrcan.gc.ca/forests/climate-change/carbon-accounting/13107)

[21] Two EU countries excluded from the analysis are Cyprus (no NFI data available) and Malta (very small forest area, mainly covered by shrub lands).

Within a SPU, each forest stand is characterized by age, area and 7 classifiers that provide administrative and ecological information, the link to the appropriate yield curves, and parameters defining the silvicultural system such as forest composition and management type (MT), and the main use of the harvest provided by each SPU, as fuelwood or industrial roundwood. For each country, these parameters were mainly derived by NFIs. According to country-specific information, MTs may include even-aged high forests, uneven-aged high forests, coppices and specific sylvicutural systems such as clear-cuts (with different rotation lengths for each FT), thinnings, shelterwood systems, partial cuttings, etc.

Species-specific, stand-level equations (Boudewyn et al., 2007) convert merchantable volume production into aboveground biomass, partitioned into merchantable stemwood, other (tops, branches, sub-merchantable size trees) and foliage components (Kurz et al., 2009). Where additional information provided by NFIs or by literature was available (see last column in Tab. 1), country-specific equations were selected to convert the merchantable volume into aboveground biomass (Pilli et al. 2013). If no data were available, we used the same equations selected for other countries and similar forest types (FTs, defined according to the main species). Belowground biomass is calculated using the equations provided by Li et al. (2003) and the annual dead wood and foliage input is estimated as a pool-specific turnover rate (percentage) applied to the standing biomass stock (Kurz et al., 2009).

Forest inventories typically contain no or only insufficient data on stocks in DOM and soil C pools. The model therefore uses an initialization process to estimate the size of all DOM pools at the start of the simulation and then, following IPCC guidance, links DOM dynamics to biomass dynamics. Inputs from biomass to DOM pools result from biomass litterfall and turnover as well, as natural and human-caused disturbances. The DOM parameters were first calibrated on the Italian cases study (see Pilli et al., 2013, Appendix E for further details), then validated on a specific study at regional level (Pilli et al., 2014) and, if necessary, further modified for specific countries, such as Finland and Sweden.

We use two sets of yield tables (YT) in these analyses (Pilli et al. 2103). Historical YTs derived from the standing volumes per age class reported by the NFI represent the impacts of growth and partial disturbances during stand development. Current YTs derived from the current annual increment reported in country NFIs represent the stand-level volume accumulation in the absence of natural disturbances and management practices.

Tab. 1: summary of the main parameters applied by CBM model for each country. The table reports the NFI original reference year; the year since the model was applied; the average harvest rate used by model from 2000 to 2012; the countries where specific equations to convert the merchantable volume into aboveground biomass were selected. Two countries were not modeled: Cyprus (no NFI data available) and Malta (very small forest area, mainly covered by shrub lands).

COUNTRY	Original NFI year	Time Step 0 (yr.)	Harvest rate (av. 2000-2012, Mm^3)	County specific biomass equations
Austria	2008	1998	22.9	X
Belgium	1999	1999	4.3	
Bulgaria	2010	2000	5.3	
Croatia	2006[1]	1996	4.6	
Czech Republic	2000	2000	17.0	X
Denmark	2004	1994	2.3	
Estonia	2000	2000	7.9	
Finland	1999	1999	55.0	
France	2008	1998	54.9	
Germany	2002	1992	74.7	X
Greece	1992[1]	1992	1.6	
Hungary	2008	1998	6.2	X
Ireland	2005	1995	2.8	X
Italy	2005	1995	10.2	X
Latvia	2009	1999	15.8	X
Lithuania	2006	1996	7.7	
Luxembourg	1999	1999	0.3	
Netherlands	1997	1997	1.2	
Poland	1993	1993	37.8	
Portugal	2005	1995	12.2	X
Romania	2010	1990	22.5	X
Slovakia	2000	2000	9.0	
Slovenia	2000	2000	3.3	
Spain	2002	1992	16.8	
Sweden	2006	1996	79.5	
United Kingd.	1997	1997	9.8	
EU			485.6	9 countries

1: analysis based on data from Forest Management Plans.

To implement the CBM to uneven-aged FTs (when this forest structure was relevant at the country level), all the uneven-aged forest area was allocated to a reference age class with the average volume, reported by the NFI for uneven-aged stands. Starting from this age class, and assuming a continuous application of silvicultural treatments to the uneven-aged forest stands, a decreasing percentage increment was applied to the subsequent (older) age classes and stands disturbed by non-stand replacing disturbances were moved back to the reference age class (Pilli et al., 2013).

In order to provide a comparable dataset for all the EU countries, covering the period 2000 – 2012, when the NFI reference year was after the year 2000 (see Tab. 1), the original NFI age-class distribution (for even-aged forests) was rolled back by 10 years (see Pilli et al., 2013 for further details).

1.1.2 Harvest rate

To provide a consistent estimate of the harvest demand for all 26 EU countries, historical data (until 2012) on harvest were obtained from FAO statistics (FAOSTAT, 2013). For some countries, the original FAOSTAT data were slightly modified to ensure consistency with other information provided by countries under the KP. The country-specific modifications applied to the original FAOSTAT data (in most cases due to different treatment of the bark fraction) are described in Pilli et al., 2015.

FAOSTAT data (modified where necessary) were further distinguished, at the country level, between four compartments: Industrial Roundwood (IRW, i.e., the portion of roundwood used for the production of wood commodities) and Fuelwood (FW, i.e., wood for energy use) and between coniferous and non-coniferous (i.e., for our analysis, broadleaved) species groups. For each compartment, in CBM we defined: (i) the FTs (i.e., broadleaved species for IRW and FW broadleaved species, and coniferous species for IRW and FW coniferous species), (ii) the MTs (for example coppices for FW from broadleaved species) and (iii) the silvicultural practices (for example thinnings for FW from coniferous species) providing the total amount of wood expected each year (the harvest target).

We assumed that the harvest rate was entirely satisfied by the FM area, considering that the possible amount of harvest provided by lands afforested or reforested (AR) since 1990 was generally negligible (Pilli et al., 2014b), with the exception of Ireland and Portugal (see the country specific information for details).

1.1.3 Natural disturbances

For each country, the historical effect of the storms and ice (16 countries), fires (11 countries) and insect attacks (i.e., bark beetles' attacks, for 2 countries) were analyzed (see Tab. 2 for details). We assumed that all natural disturbances occurred on the FM area, excluding possible disturbances on the afforested area.

The effect of storms was evaluated using the data reported by the FORESTORMS database (Gardiner et al., 2010) provided by the European Forest Institute and by specific additional information available at the country level. Depending on the available information, the effect of each event was modelled according to (i) the amount of forest biomass damaged by storm and eventually salvage logged and/or (ii) the amount of area affected by the disturbance event. In the first case, we mainly modified the 'disturbance matrix' that describes the proportion of C transferred between pools and to the forest product sector or released to the atmosphere (Kurz et al. 2009), in order to be consistent with the disturbance impact reported by the FORESTORMS database. In the second case, we verified that the amount of forest area affected by the disturbance event was consistent with the area reported by this database (in some cases, both these criteria were verified).

Fire disturbances were modelled according to the amount of area affected by fire, as reported by national statistics, proportionally distributed between different FTs or according to further information provided by literature (mainly, the National Inventory Reports) The disturbance matrix associated with fires was modified according to specific country-level information, to account for salvage of logging residues, commonly applied in some Mediterranean countries. When relevant, we also included the burning of harvest residues after a clearcut.

More specific information on the methodological assumptions applied to represent storms and insect attacks are reported in the country's methodological description).

Tab. 2: overview of countries with natural disturbance events simulated by the CBM (F, fire; S storms and ice sleets; I insect attacks), with information on input data used for storms (country data, National Inventory Reports, NIR or the FORESTORMS database, Gardiner et al., 2010) and the average burned area.

COUNTRY	Natural Disturb.	Storms, ice and insect disturbances		Fires
		Source	Vol. affected[1] (Mm^3 yr^{-1})	Area burned[2] (kha yr^{-1})
Austria	**S + I**	Vol. based on country data	4.1	-
Belgium	**-**			-
Bulgaria	**S**	Area based on country data	< 0.0	-
Croatia	**F**			2.3
Czech Rep.	**F**			0.5
Denmark	**S**	Vol. based on country data	0.5	-
Estonia	**S**	Area and vol. based on NIR	0.7	-
Finland	**S**	Vol. based on FORESTORMS	0.6	-
France	**S**	Area and vol. based on FORESTORMS	18.3	-
Germany	**S**	Vol. based on FORESTORMS	6.2	-
Greece	**F**			6.0
Hungary	**-**			-
Ireland	**F**			0.4
Italy	**F**			35.0
Latvia	**S**	Vol. based on FORESTORMS	0.7	-
Lithuania	**S+F+I**	Vol. based on the NIR + FORESTORMS	0.2	0.3
Luxembourg	**S**	Vol. based on FORESTORMS	<0.1	-
Netherlands	**S**	Vol. based on FORESTORMS	<0.1	-
Poland	**S**	Vol. based on FORESTORMS	0.4	-
Portugal	**F**			49.1
Romania	**-**			-
Slovakia	**S + F**	Vol. based on FORESTORMS + country data	0.8	0.6
Slovenia	**S + F**	Vol. based on country data	<0.1	0.1
Spain	**F**			35.3
Sweden	**S**	Vol. based on FORESTORMS + country data	7.1	-
United K.	**S + F**	Vol. based on FORESTORMS	<0.1	3.5
	23 countries		39.6*	134.0

[1] average volume affected by storms, ice and insects between 2000-2012, as reported by the input data used by model. The interannual variations of these disturbances can vary considerably among countries (i.e., in many cases disturbances are concentrated in few big events). In some cases, further damages were considered before 2000.

[2] average area affected by fires between 2000-2012, mainly based on the data reported by National Inventory Reports * A more detailed analysis of the effect of storms at EU level is reported in Pilli et al., 2016b

During the model run, when considered for the historical period 2000 - 2012, a constant amount of area affected by fire was applied from 2013 to 2030, equal to the average burned area applied to the historical period.

1.1.4 Future model assumptions (2013 – 2030)

Each country's model run includes an historical part, from 2000 to 2012 and a future part, from 2015 to 2030 (the period 2013 – 2014 is a "transition period"). The historical part, is based on country's specific methodological assumptions developed by the JRC (reported in the following section) on all the main input data considered by this AA, and in particular:

- The FM area in 2000 and its evolution until 2012.
- The historical rate of AR and D, as reported by each country in the 2015 CRF tables.
- The main disturbance events reported by literature until 2012[22]
- The historical amount of harvest further distinguished between IRW and FW and between coniferous and broadleaves.

From 2015 to 2030, in order to be consistent with the "reference scenario 2030", the model applies the input data provided by IIASA, on the following parameters (see appendix 2b for details):

- The future AR and D rates
- The future amount of harvest, further distinguished between IRW and FW.

For the transition period 2013 - 2014, we applied an average harvest, AR and D rates, between the two periods described above.

1.2 Country's methodological description

This section reports in details the following information, for each EU Member State:

1. **NFI data and model assumptions**: this section describes the main input data used by CBM for modelling the forest area:
   a. the National Forest Inventory input data, including the assumptions on the forest area, the base year (i.e., the time step zero used for the model run), the main forest types considered by our study, the silvicultural systems (i.e., the minimum rotation length, the thinnings, etc.).
   b. The equations applied to convert the volume to biomass (based on country-specific assumptions or derived from other countries) and the assumptions applied for the selection of the yield tables applied to each country (including the values applied for the historical and the current yield tables).
   c. A description of the natural disturbances applied to each country (i.e., fires, storms, insect attacks) during the model run

2. **Harvest assumptions and HWP analysis: this second section describes the main analyses on the harvest wood product sector, including:**
   a. A summary of the analysis performed, for each country, on the main input data applied to HWP in order to estimate the future HWP mitigation potential.

[22] In one case we also considered a disturbance event occurred in 2013.

b. A review, updated with the last available data, on the historical harvest rate reported by different data sources (i.e., FAOSTAT, FRA 2010 Country Report, NIR, etc.).

c. The share of harvest applied by model, further distributed between industrial roundwood (IRW) and fuelwood (FW) and distinguished between conifers and broadleaves. The total amount of felling was further distributed according to the proportion of FW (i.e., the amount of harvest used for energy) and IRW (i.e., the amount of harvest for non-energy use) reported by FAO statistics at country level. The resulting IRW and FW amounts were distributed between different forest types (FTs) and management types (MT), according to their proportion in the total forest area and to country-specific assumptions. We further assumed that a fraction of the fuelwood was provided by branches and dead standing trees (also coming from species used for industrial roundwood production) and by wood collected on the area affected by natural disturbances (i.e., through salvage logging).

d. The historical domestic production estimated by our analysis for each HWP commodity (i.e., Sawnwood, Wood based Panels and Paper and Paperboard).

Austria[23]

NFI data and model assumptions

The analysis was based on the data provided by NFI 2007-2009. Assuming 2008 as NFI reference year, all data were brought back to 1998. The total forest area was distributed between 9 administrative regions and 12 Climatic units (Figure 28).

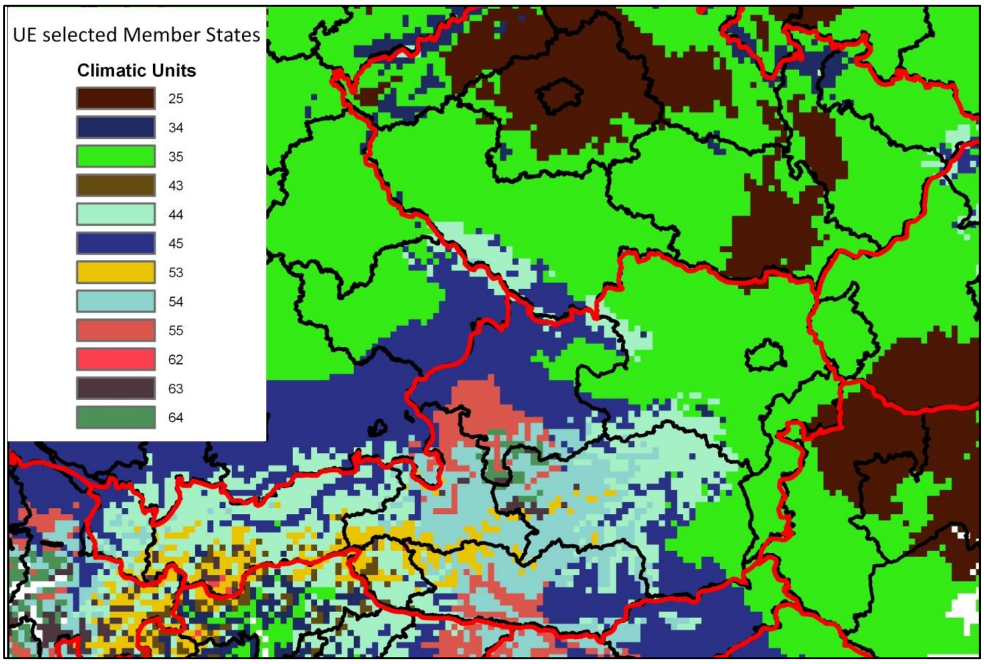


Figure 28: administrative regions defined at NUTS2 level and CLUs applied to Austria

According to the information provided by the NFI, the following management compartments were considered:

(i) Productive forests (WiWa[24])
(ii) Protective and productive forests (SWie[25])
(iii) Coppices[26]

TOTAL Productive forests[27] 3,380 kha

(iv) Protective and other not productive forests(Swae[28]±HBae[29]) 597 kha

TOTAL 3,977 kha

For (i) and (ii): the age class distribution by species and regions was downloaded by the NFI web site.

For (iii): the age total class distribution by regions was downloaded by the NFI web site.

[23] A specific analysis on case study is reported by Pilli et al., 2016.
[24] Wirtschaftswald.
[25] Schutzwald im Ertrag.
[26] Ausschlagwald.
[27] According to the National Submission of information on forest management reference level (2011) the total FM area in 2000 was 3,370 kha.
[28] Schutzwald außer Ertrag (***U****navailable*, excluded by harvest activities).
[29] Holzboden außer Ertrag.

For (iv): the age class, species and regional distribution was argued according to the proportion of area assigned to (i)

All age classes were made uniform to 10 years' time-span.

According to the 2014 CRF Tables (Tab. 5.a), the 1990 FL remaining FL area was equal to 3,224 kha of productive forests plus the forests out of yield equal to 407 kha. Based on the last NIR (2014, pag. 354), "*the calculations of C-losses and C-gains for FL remaining FL consider only the area of* ***productive forest (forest in yield)****. The assumption for the exclusion of carbon stock changes in nonproductive forests is the following: There is a balance between C-losses due to decay and C gains due to biomass increment. There is no extraction of biomass due to the missing access to these forests, but the opposite, planting measures are carried out (for maintaining the essential protective function of these forests)*".

Therefore, we scaled the total "Productive Forest area" to 3,224 kha, assumed as FM area, according to the following assumptions:

1. The difference between the Productive Forest area reported by NFI and the FM area, equal to 156,915 ha, was assumed as new forest area (AR), established between 1990 and 2008 (i.e., 18 years).
2. About 55% (i.e., 10/18) of this forest expansion was assigned to the first age class (≤ 10 yrs.), referred to new forest stands less than 10 years old. The area of the first age class was therefore reduced of 87,175 ha.
3. The remaining fraction (i.e., 8/18) was assigned to the second age class (between 11 and 20 yrs.) and it is referred to new forest stands older than 10 years The area of the first age classes was therefore reduced of 69,740 ha.
4. Each even-aged high forest stand (excluding any expansion on coppices) belonging to the first and the second age class was proportionally reduced according to the previous assumptions.
5. The final area was further decreased to about 3,198 kha, to account for the amount of deforestation occurred between 1990 and 1998 (equal to 3,260 ha yr^{-1}).

Protective and other not productive forests" were not considered by the present analysis.

In order to select species-specific equations, we considered the total aboveground volume reported by NFI and we estimated the biomass through the following assumptions:

a. Vol/ha = Tot Volume/ forest area
b. Wood density (WD): 0.39 for conifers 0.53 for broadleaves

   BEFs (default IPCC values): 1.3 for conifers

   1.4 for broadleaves

   Tot aboveground biomass =Vol/ha * DB * BEFs

Tab. 2 reports the original species from which were derived the equations selected for each forest type. For black pine and other conifers, due to the low number of observations, the same equations selected for spruce were applied.

Tab. 2: the table reports the original species from which were derived the equations selected for each forest type, according to the methodological assumptions previously defined. The acronym applied to each FT was also reported. For PN and OC, due to the low number of observations, the same equations selected for PA were applied. The mean percentage difference and the standard deviation between the average aboveground total biomass estimated by the selected equations and the reference country-specific biomass values were also reported.

Acronym	**Forest type**	**Species selected by default CBM database**	**Mean Δ**	**St dev.**
PA	Spruce	Eastern white cedar (Thuja occid.)	1.87	6.95
AA	Fir	Eastern white pine (P. strobus)	-0.66	3.17
LD	Larch	Red pine (P. resinosa)	2.35	2.11
PN	Black pine	Eastern white cedar (Thuja occid.)	-	-
OC	Other conifers	Eastern white cedar (Thuja occid.)	-	-
FS	Beech	White ash (Fraxinus americana)	2.88	2.54
QR	Oaks	Black cherry (Prunus serotina)	9.02	4.00
OH	Other hardwoods	Largetooth aspen (Populus grandidentata)	1.63	3.89
OB	Other broadl.	Basswood (Tilia americana)	3.65	6.59

Species-specific YTs were selected using the average volume and increment reported by NFI. According to Gschwantner et al. (2010[30]), both the volume and increment are referred to trees with Dbh≥ 5.0 cm over bark. Thus a common correction factor equal to 1.05 was applied to these values to account for the amount of trees under this threshold. An example is reported by Tab. 4.

[30] Gschwantner, T., Gabler, K., Schadauer,K., Weiss, P. in: Tompoo, E., Gschwantner, T., Lawrence, M., McRoberts, R.E., 2010, in: National Forest Inventories. Pathways for Common Reporting. Springer, Heidelberg, Dordrecht, London, New York.

Tab. 3: the table reports an example of the YTs applied by CBM model for Austria, region AT22, high forests with productive function. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Region	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	AA	AT22	3.1	12.2	17.9	19.0	17.3	14.6	11.6	9.0	6.8	5.1	3.7	2.7	2.0	1.5
Current	FS	AT22	0.5	3.0	6.0	8.0	8.8	8.6	7.9	6.9	5.8	4.8	3.9	3.1	2.4	1.9
Current	LD	AT22	0.9	3.7	6.1	7.6	8.3	8.4	8.1	7.5	6.8	6.0	5.2	4.5	3.9	3.3
Current	OH	AT22	4.9	4.8	4.6	4.4	4.2	4.0	3.8	3.7	3.5	3.3	3.2	3.0	2.9	2.8
Current	OS	AT22	1.5	4.4	6.4	7.4	7.6	7.4	6.9	6.2	5.5	4.8	4.2	3.6	3.0	2.6
Current	PA	AT22	2.1	7.9	12.3	14.5	15.0	14.3	12.9	11.4	9.7	8.2	6.8	5.6	4.6	3.7
Current	PC	AT22	0.3	2.1	4.9	7.3	9.1	9.9	10.1	9.7	9.0	8.1	7.1	6.2	5.3	4.5
Current	PS	AT22	1.8	8.4	13.2	14.4	13.4	11.3	9.0	6.9	5.2	3.9	2.8	2.0	1.5	1.1
Current	QR	AT22	0.2	1.1	2.3	3.5	4.4	5.1	5.5	5.6	5.5	5.3	5.0	4.6	4.3	3.9
Historic	AA	AT22	45.3	154.8	277.4	387.0	475.4	542.9	592.8	628.8	654.5	672.6	685.4	694.3	700.6	704.9
Historic	FS	AT22	5.4	36.2	93.0	163.4	235.5	301.8	358.9	405.9	443.5	472.9	495.6	512.9	526.1	536.0
Historic	LD	AT22	19.5	72.0	145.3	229.6	318.0	405.7	489.7	568.2	640.3	705.6	764.0	816.0	861.9	902.3
Historic	OH	AT22	1.4	11.2	34.7	72.7	123.3	183.2	248.8	317.2	385.6	452.2	515.5	574.6	629.1	678.6
Historic	OS	AT22	20.4	75.7	153.3	243.0	337.2	431.1	521.2	605.7	683.5	754.1	817.5	874.1	924.2	968.2
Historic	PA	AT22	2.2	16.2	47.9	97.1	160.8	234.8	314.8	397.4	479.4	558.6	633.7	703.6	767.9	826.3
Historic	PC	AT22	4.3	13.7	26.3	41.2	57.7	75.3	93.6	112.4	131.3	150.2	168.9	187.4	205.4	223.1
Historic	PS	AT22	14.0	100.0	240.7	385.4	505.7	595.2	657.7	699.7	727.3	745.2	756.7	764.0	768.7	771.7
Historic	QR	AT22	10.2	79.4	202.2	337.2	456.2	549.4	617.4	665.1	697.7	719.6	734.2	743.8	750.1	754.3

Belgium

The original increment values reported by NFI are referred to the increase of tree stem volume over bark between two inventories, excluding harvested trees and natural trees that have died from natural causes (Gschwantner et al., 2010). In order to estimate the net growth including the amount of harvested trees, the following equations were applied:

$$Pi = \frac{I_{NFI}}{V_{NFI}}$$

$$CAI = (V_{NFI} + D) \times Pi$$

where, P_i is the percentage increment estimated on the original net increment (I_{NFI}) and volume (V_{NFI}) reported by NFI; *CAI* is the current net annual increment and *D* (drains) consists of the stem volumes of cut trees and trees that have disappeared from the collective of sample trees due to mortality or natural causes. The total amount of drains (by regions and species) reported by the Austrian NFI, was divided by the total amount of productive forest area, in order to estimate the amount of drains by hectares and species.

In Tab. 4 are reported the main species grouped by each forest types and the minimum rotation length applied to clear cuts. Part of the harvest demand (on average, about 45%) was also provided by thinnings (removing between 15 – 30% of the merchantable biomass, depending by FTs and MTs).

Tab. 4: forest types applied by CBM model, the corresponding species reported by NFI and the minimum rotation length applied to clear cuts for the Productive high forests (H) and coppices (C) management types.

CBM Forest Types	Manag. Type	Minimum rotation length (yrs)	Species reported by NFI
PA	H	110 - 120	Fichte (P. abies)
AA	H	110	Tanne (A. alba)
LD	H	120	Larch (L. decidua)
PN	H	80 - 100	Schwarzkiefer (P. nigra)
OC	H	80	Sonstiges Nadelholz (other conifers)
FS	H	110 - 120	Buche (F. sylvatica)
QR	H	80	Eiche (Quercus sp.)
OS	H	30 - 40	Weichlaub (Other broadl. i.e Betula, Populus, Alnus)
OH	H	70	Sonstiges Hartlaub (hardwood broadl. i.e Fraxinus, Acer)
OH	C	30	Broadleaves hardwoods
PS	H	80 - 90	Weisskiefer (P. sabiniana)
PC	H	110 - 120	Zirbe (P. cembra)

Belgium

We considered the effect of natural disturbance events due to storms, snow and insects' attacks affecting the Austrian forests. The amount of merchantable volume damaged by storms and snow between 1998 and 2007 was derived by the 2008 Austrian Forest Report[31] (Tab. 5). The amount of merchantable volume damaged between 2008 and 2012 was estimated as the average of the previous period.

Tab. 5: merchantable volume (M m^3) damaged by forest storms and snow between 1998 and 2008 and by bark beetle between 1998 and 2007 (all values were derived by figures reported by pg. 23 of the 2008 Austrian Forest Report). From 2007 to 2012 the average amount of volume damaged in the previous period was estimated and applied during the model run.

Step	Year	Vol. damaged by Storm and snow	Vol. damaged by Bark beetle
1	1998	1.2	0.8
2	1999	1.3	0.7
3	2000	1.2	0.6
4	2001	0.4	0.7
5	2002	6.1	0.8
6	2003	1.2	2.0
7	2004	1.1	2.4
8	2005	0.8	2.5
9	2006	2.8	2.4
10	2007	5.0	2.3*
11	2008$^+$	2.1$^+$	1.4$^\wedge$
12	2009	2.1$^+$	1.4$^\wedge$
13	2010	2.1$^+$	1.4$^\wedge$
14	2011	2.1$^+$	1.4$^\wedge$
15	2012	2.1$^+$	1.4$^\wedge$
* Average 2003 - 2006			
$^+$ Average 1998 - 2007			
$^\wedge$ Average 1998 - 2006			

The effect of these disturbances was modelled through four different disturbance events applied to model run: (i) a stand replacing-storm (and snow) disturbance event; (ii) a widespread-storm (and snow) disturbance; (iii) a specific disturbance event for modelling the bark beetle attack and (iv) a disturbance event for modelling salvage of logging residues after

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[31] Sustainable Forest Management in Austria – Austrian Forest Report, 2004 and 2008. Available at www.lebensministerium.at

widespread-storms and bark beetle attacks. The analysis was based on the following assumptions:

(i) For the stand-replacing storm and snow disturbance event:

a. We assumed that a fraction of the forest area reported by the first age class (i.e., < 10 yrs., assumed as clear-cut forest area) in the original age class distribution (i.e., referred to 2008) was affected by stand replacing-storm between 1998 and 2008.
b. Comparing the annual amount of damaged volume (Vol_{St}) with each harvest compartment (IRW conifers, IRW Broadleaves, FW conifers and FW broadleaves) we highlighted that the amount of damaged harvested trees was only related to the IRW conifers (IRW_C) compartment.
c. We estimated the share of IRW conifers potentially provided by trees damaged by storms and snow, named Storm factor (*SF*) and equal to:

$$SF = \frac{Vol_{St}}{IRW\_C}$$

d. We assumed that the amount of forest area affected by stand replacing-storm each year was equal to the clear-cut forest area of the *i*-year multiplied by the Storm Factor.
e. We assumed that this disturbance only affected spruce forests (i.e., the main coniferous species in Austria) with an average age between 70 and 80 years (i.e., the average age of the spruce Austrian forests according to NFI data).
f. Storms and snows disturbances were simulated as a clear-cut, stand replacing, disturbance events, assuming that 95% of the merchantable living biomass was moved to the products pool (i.e., harvested after the disturbance event and therefore not accounted under DOM pool) and the other merchantable living biomass components were moved to dead wood and litter pools.

(ii) For the widespread storm and snow disturbance event:

a. After a preliminary run, based on the assumption reported above, we estimated the amount of merchantable biomass (in tons of C) damaged by stand-replacing storm ($V\_St_{St\_Repl}$).
b. The biomass affected by widespread disturbance events ($V\_St_{St\_W}$) was estimated as the difference between the total merchantable biomass (expressed as tons of C) damaged by storm (see Tab. 6) and $V\_St_{St\_Repl}$.
c. Assuming that: (i) even this event was mainly affecting spruce; (ii) it was affecting 40% of the merchantable biomass pool and (iii) considering the area affected by the stand-replacing disturbance (provided by preliminary runs), we estimated the amount of area requested, in order to satisfy the expected amount of biomass damaged (i.e., $V\_St_{St\_W}$).

Tab. 6: the table summarizes the assumptions made to distribute the total amount of biomass damaged by storm and snow disturbances, between stand-replacing disturbance events and widespread disturbances. In this last case, after a preliminary run we estimated the amount of biomass (in tons of C) affected by stand-replacing disturbance events (column C); the difference between this amount and the total amount of biomass damaged by storm (column B), is the amount of biomass damaged by widespread disturbances (column D); the area was estimated through some further preliminary runs as the amount of area providing the values expected in column D.

Year	Total Storm & snow damage		Stand Repl. Dist.	Widespread Dist.	
	Tot_Vol (**M m^3**)	B= (Tot_Vol/2)*0.40*10^6 (tons C)	C=CBM Output (tons C)	**D=B-C** (tons C)	**Area*** **(ha)**
1998	1.2	240,000	151,353	88,647	3,911
1999	1.3	260,000	162,810	97,190	4,214
2000	1.2	240,000	152,314	87,686	3,886
2001	0.4	80,000	51,204	28,796	1,300
2002	6.1	1,220,000	758,154	461,846	19,485
2003	1.2	240,000	144,103	95,897	3,757
2004	1.1	220,000	127,419	92,581	3,553
2005	0.8	160,000	95,818	64,182	2,608
2006	2.8	560,000	325,822	234,178	9,293
2007	5.0	1,000,000	533,900	466,100	15,917
2008$^+$	2.1	422,000	224,420	171,710	6,792
2009	2.1	422,000	216,626	171,710	6,792
2010	2.1	422,000	222,452	171,710	6,792
2011	2.1	422,000	222,414	171,710	6,792
2012	2.1	422,000	229,696	171,710	6,792

* The final area was estimated after some preliminary simulation, in order to satisfy the expected amount of biomass damaged (column D).

d. We assumed that there was no direct salvage of logging residues associated with the widespread storm, i.e., 40% of the living biomass was moved to DOM pool.

(iii) For the bark beetle attacks on spruce forests:

a. The merchantable volume damaged (reported in Tab. 5) was converted to tons of C (assuming an average wood density equal to 0.4 for spruce) and divided by the average merchantable spruce biomass per ha estimated through a preliminary run. This value (i.e, t C ha-1) was finally multiplied for a constant factor equal to 0.05, assuming that 5% of the living biomass was affected by this disturbance event (see Tab. 7).

Tab. 7: the table summarizes the assumptions made to estimate the spruce (PA) area affected by bark beetles: (i) the total volume (column A) was converted to tons of C (column B, assuming a wood density equal to 0.4 for spruce); dividing this amount by the average merchantable biomass per ha (referred to spruce and provided by a preliminary run) we estimated the total area potentially affected by this disturbance (column D); reducing by 0.05 the average merchantable biomass per ha (i.e., assuming that bark beetles attack 5% of the living biomass), we estimated the final area affected by this disturbance (column E)

Year	Vol damaged (M m3)	t C PA	Avg Merch Biom PA (t C ha-1)	Area (ha)	Area Assuming 5% damage (ha)
COLUMN	**A**	**B=**A*10^6*0.5*0.4	**C**	**D=**B/C	**E=**B/(C*0.05)
1997	1	200,000	48	4,169	83,386
1998	0.8	160,000	49	3,254	65,089
1999	0.7	140,000	50	2,780	55,597
2000	0.6	120,000	52	2,324	46,488
2001	0.7	140,000	53	2,648	52,970
2002	0.8	160,000	54	2,955	59,093
2003	2	400,000	55	7,265	145,310
2004	2.4	480,000	56	8,580	171,608
2005	2.5	500,000	57	8,799	175,975
2006	2.4	480,000	58	8,331	166,612
2007	2.3	465,000	58	7,964	159,272
2008	1.4	286,667	58	4,909	98,189
2009	1.4	286,667	58	4,909	98,189
2010	1.4	286,667	58	4,909	98,189
2011	1.4	286,667	58	4,909	98,189
2012	1.4	286,667	58	4,909	98,189

b. We assumed that there was no direct salvage of logging residues associated with this event, i.e., 5% of the living biomass was moved to DOM pool.

(iv) Salvage of logging residues after the widespread storms and insect attacks, was simulated through specific events, moving biomass from the stem snags pools to the product pool. We assumed that salvage of logging residues was done on the same amount of area and age classes affected by these events, starting from the year after the disturbance. We also prioritized the removals of harvest residues, from the stands having the highest stem snag carbon amount[32].

[32] As suggested by the CBM's User Guide, the Sort type of this disturbance event was modified (Sort type 7) in the project database file.

Harvest and HWP analysis

The historical FAO statistics are complete and cover the period starting from 1961. The historical harvest reported by FAOSTAT has the same trend of the drain reported by the last NIR[33] but it is, on average, about 27% lower than NIR's data (Figure 29). These last data derive from relative indices applied to national statistics on harvest and based on the average annual drain estimated by different NFI's cycles for 1991, 1997 and 2005 (black markers in Figure 29). This drain includes not only the harvest (also reported by FAOSTAT data) but also biomass losses due to natural mortality (about 10% of the total biomass drain, not reported by FAOSTAT) and any additional natural disturbance event (such as storms or insect attacks) and it is referred to the category "Forest Land (FL) remaining FL" + all Land Use Change subcategories from and to FL (i.e., not only the FM area). The estimates reported by FAOSTAT are consistent with the information reported by the FRA 2010 Country Report[34]. According to this document, the IRW and FW removals reported by FAOSTAT are referred to the volume under bark and a correction factor equal to 1.15 can be used to estimate the total amount of removals over bark. Therefore the difference between FAOSTAT and the NIR may be related to (i) the bark's fraction (estimated using a correction factor and reported as *FAOSTAT Corr* in Figure 29), (ii) the harvest residues and natural mortality, (iii) to different methodological assumptions on the area and (iv) to a possible underestimate of the amount of harvest provided as salvage logging after the major disturbance events (not reported by FAOSTAT data). Indeed, adding to *FAOSTAT Corr* the amount of biomass removed as salvage logging after storms, snow and insect attacks (i.e., the total amount of volume damaged, reported in Tab. 5, minus the biomass not removed as salvage of logging residues), we derive the *FAOSTAT Corr* data including natural disturbances (red dotted line in Figure 29). This amount is still, on average 3% lower (between 1998 and 2007) than the drain reported by NIR, but this difference may be due to different assumptions on the area and to natural turnover rate (excluded disturbance events). The final trend of this line is similar to the drain reported by NIR, but in 2002 and 2007 we estimate a slightly higher amount of harvest (+5% in 2002 and +2% in 2003) due to the high amount of biomass damaged by storms (6.1 and 5.0 million m3 in 2002 and 2007, respectively). Since the drain reported by NIR is based on relative indices based on the average annual drain estimated by different NFI's cycles, these inter-annual variations may be reported differently. From 2009 to 2012, the NIR reports a constant average value equal to 25,888 km^3, not comparable with our assumptions.

[33] Austria's National Inventory Report, 2014.
[34] FRA 2010 – Country Report, Austria (pag. 49)

Belgium

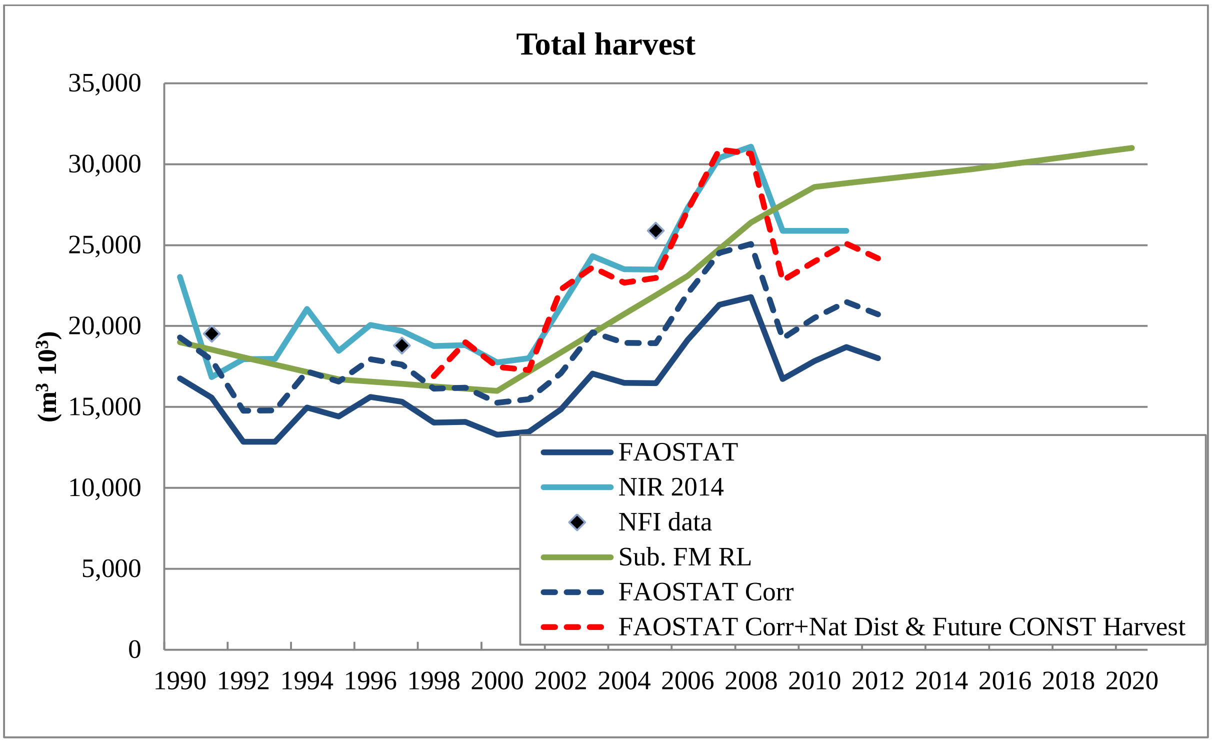

Figure 29: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (under bark), the NIR 2014 (drain, including natural mortality), the NFI data (average drain of different NFI's cycles), and the National Submission for FM Reference Level (Sub. FMRL). Assuming a correction factor equal to 1.15 to account for the bark's fraction, we also reported the FAOSTAT estimates corrected for bark (FAOSTAT Corr) and, adding to these estimates the amount of biomass damaged by storms, snow and insect attacks (reported in Tab. 5) we estimated the FAOSTAT Corr including Natural disturbances (dotted red line).

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 30. The following analysis (such as the figure) on the HWP domestic production and mitigation potential does not consider the amount of harvest provided by salvage logging, since this is not reported by FAOSTAT.

Belgium

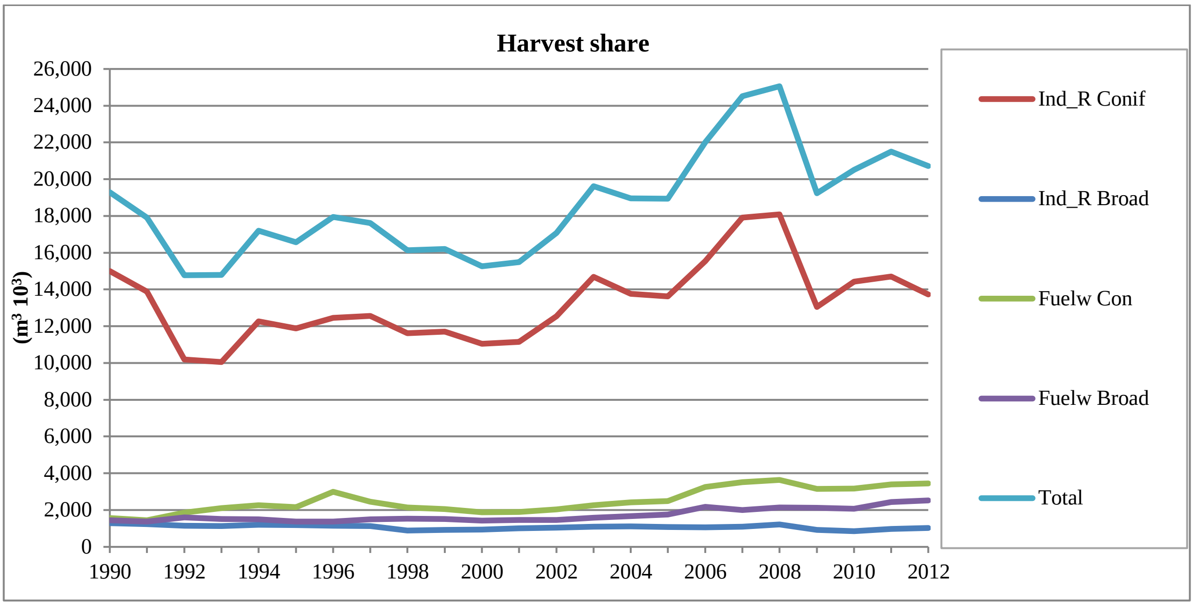

Figure 30: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The IRW amount of harvest provided by conifers is further distinguished (from 1998) between the amount reported by FAOSTAT estimates (corrected for bark) and the total amount, including the harvest provided by salvage logging after natural disturbances.

The historical fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is shown in Figure 31. For the historical period, our estimates are based on the data reported in Figure 30, excluding the amount of harvest provided by natural disturbances, and are consistent with the data reported by the country's submission for FMRL for the SW and the WP while we slightly underestimated the PP country's production. This may suggest that even the estimates provided by country were based on the same input data applied by our analysis.

Belgium

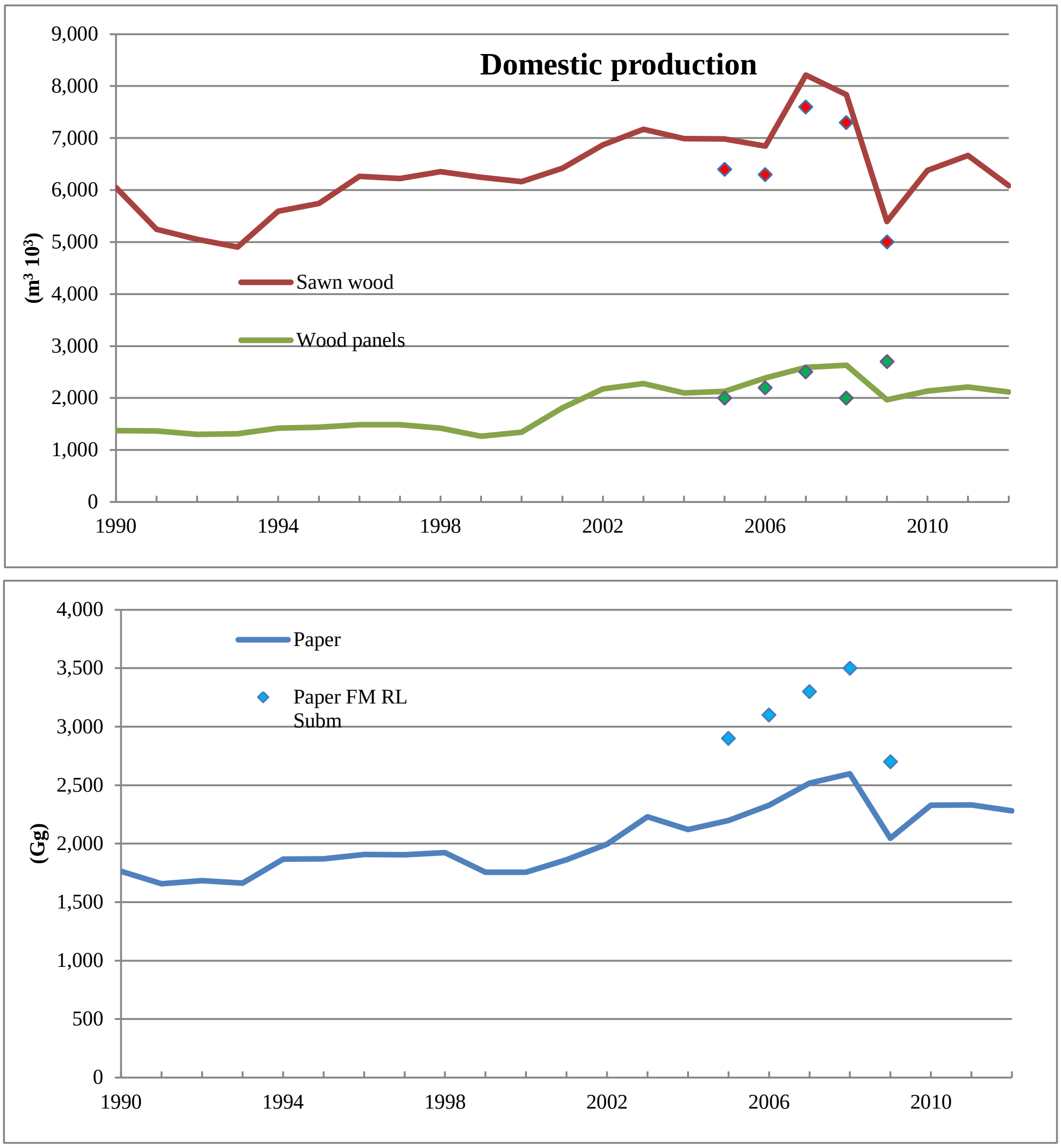

Figure 31: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Belgium

NFI data and model assumptions

The analysis was based on data reported by Official report of the 2000 Walloon Inventory (Lecomte et al., 2003)[35] integrated with additional data provided by the country for the Flanders region. Since the original data were referred to 1999, they were not scaled back of 10 years. Due to the lack of detailed information on the age class distribution, the total forest area was distributed between 2 administrative regions and 3 Climatic units, as reported by Figure 32.

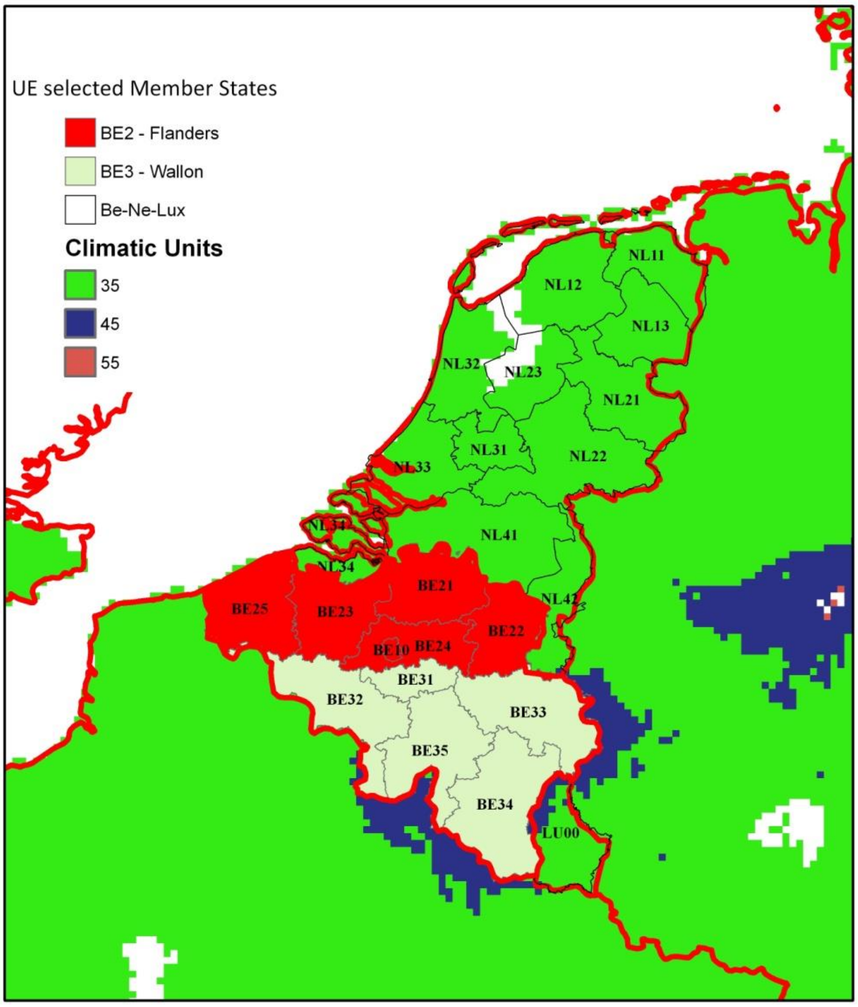

Figure 32: administrative regions defined at NUTS2 level and CLUs applied to Belgium, Luxembourg and the Netherlands.

The total forest area reported by the original NFI data, equal to about 586 kha, was scaled to the FM area reported by the Submission on forest management reference level of Belgium, equal to 700 kha for 2000 (i.e., no further correction to account for deforestation is needed).

[35] Available at: http://environnement.wallonie.be/dnf/inventaire/indgen.htm

Belgium

The main species reported by the NFI were grouped in 10 forest types, reported in Tab. 8. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the minimal age for final felling reported by the Report of the technical assessment of the forest management reference level submitted by Belgium in 2011[36].

Tab. 8: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	Acronym	Min. rotation length (yrs)
Betula sp.	**BT**	**60**
Pseudotsuga menziesii	**DF**	**50**
Fagus sylvatica	**FS**	**120**
Other broadleaves	**OB**	**60**
Other conifers	**OC**	**40**
Picea abies	**PA**	**50**
Pinus nigra	**PN**	**60**
Pinus sylvestris	**PS**	**60**
Pinus sylvestris	**PS**	**60**
Populus sp.	**PT**	**15**
Quercus sp.	**QR**	**110**

The harvest criteria applied by CBM for Belgium are reported in Tab. 9.

Tab. 9: main parameters defining the harvest criteria applied by CBM for Belgium, including the age classes affected by each silvicultural treatment and the total amount of harvest provided by each treatment.

Silvicultural treatment	Criteria	Harvest share
20% Commercial Thinnings	> 20 yrs.	9%
30% Commercial Thinnings	> 20 yrs.	21%
Clearcut (95% commercial thinning)	Depending by species	70%

[36] Available at: http://unfccc.int/documentation/documents/advanced_search/items/6911.php?priref=600006464#beg

Belgium

Since no specific data on biomass stock was available at national level, the same equations selected for Germany, Italy and Latvia were applied to Belgium, according to the assumptions reported in Tab. 10.

Tab. 10: association between the Belgian forest types and the default species provided by the original CBM database, based on the selection applied to Germany, Italy and Latvia.

FT	Species selected by default CBM database	Germany (DE), Italy (IT) or Latvia (LV)	Correspondence with the German, Italian or Latvian FTs
BT	Red pine (P. resinosa)	LV	Birch (LV)
DF	Red pine (P. resinosa)	DE	DF
FS	Sugar Maple	DE	FS
OB	Eastern white pine (P. strobus)	IT	OB
OC	Red pine (Pinus resinosa)	IT	OC
PA	Norway Spruce	DE	PA
PN	Red pine (Pinus resinosa)	IT	PN
PS	Eastern white-cedar	DE	PS
PT	White spruce (P. glauca)	LV	Aspen (LV)
QR	Ironwood (Ostria virginiana)	DE	QR

Species-specific YTs were selected using the average volume and increment reported at national level. Since the original NFI data report the gross annual increment of all trees with a Dbh>6.5 cm, we applied a correction factor equal to 1.05 to the original data on volume and no correction factor to the original data of increment (assuming a compensation between the natural mortality included by the inventory data and the trees with Dbh<6.5 cm). The current library and the historical library applied by CBM model are reported in Tab. 11.

No natural disturbance event was considered for Belgium.

Belgium

Tab. 11: Yield tables applied by CBM model for Belgium. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Region	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	BT	BE2	4.8	3.4	2.4	1.6	1.1	0.8	0.5	0.4	0.2	0.2	0.1	0.1	0.1	0.0
Current	DF	BE3	23.0	24.4	24.2	23.2	22.0	20.6	19.2	17.8	16.4	15.1	13.9	12.7	11.6	10.6
Current	FS	BE2	25.5	21.5	18.2	15.3	12.9	10.9	9.2	7.8	6.6	5.5	4.7	3.9	3.3	2.8
Current	FS	BE3	24.2	19.8	16.1	13.2	10.8	8.8	7.2	5.9	4.8	3.9	3.2	2.6	2.1	1.7
Current	LD	BE2	17.0	16.6	12.1	7.8	4.8	2.8	1.6	0.9	0.5	0.3	0.1	0.1	0.0	0.0
Current	OB	BE2	21.3	10.3	5.0	2.4	1.2	0.6	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Current	OB	BE3	9.2	7.8	6.6	5.6	4.7	4.0	3.4	2.8	2.4	2.0	1.7	1.4	1.2	1.0
Current	OC	BE2	18.2	17.8	13.9	10.0	6.8	4.5	2.9	1.8	1.2	0.7	0.5	0.3	0.2	0.1
Current	OC	BE3	21.8	20.6	19.0	17.3	15.7	14.3	12.9	11.7	10.5	9.5	8.6	7.7	6.9	6.2
Current	PA	BE3	21.8	20.6	19.0	17.3	15.7	14.3	12.9	11.7	10.5	9.5	8.6	7.7	6.9	6.2
Current	PN	BE2	28.6	30.3	26.8	21.9	17.2	13.1	9.8	7.3	5.3	3.9	2.8	2.0	1.4	1.0
Current	PS	BE2	19.0	20.0	16.8	12.8	9.2	6.5	4.4	3.0	2.0	1.3	0.9	0.6	0.4	0.2
Current	PS	BE3	15.4	14.6	13.8	13.0	12.3	11.7	11.1	10.5	9.9	9.4	8.9	8.4	8.0	7.6
Current	PT	BE2	30.6	20.6	12.7	7.6	4.4	2.6	1.5	0.8	0.5	0.3	0.2	0.1	0.1	0.0
Current	PT	BE3	26.8	24.6	22.5	20.7	19.0	17.4	16.0	14.7	13.5	12.4	11.3	10.4	9.5	8.8
Current	QR	BE2	11.3	9.1	7.3	5.9	4.8	3.8	3.1	2.5	2.0	1.6	1.3	1.0	0.8	0.7
Current	QR	BE3	1.5	1.6	1.7	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0
Historic	BT	BE2	1.5	11.8	34.3	67.3	107.1	149.9	192.5	233.1	270.1	303.2	332.1	356.9	378.0	395.8
Historic	DF	BE3	4.1	25.9	63.0	106.3	148.2	184.9	215.2	239.0	257.4	271.3	281.6	289.3	294.9	299.0
Historic	FS	BE3	5.9	43.2	119.4	223.3	339.8	456.6	565.5	662.4	745.7	815.6	873.2	920.1	957.9	988.2
Historic	FS	BE2	6.8	37.5	84.9	136.3	183.3	222.6	253.5	277.1	294.7	307.5	316.8	323.5	328.3	331.7

Belgium

Library	FT	Region	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Historic	LD	BE2	8.0	38.0	87.8	151.7	224.1	300.3	376.8	451.1	521.4	586.8	646.8	701.2	750.0	793.6
Historic	OB	BE3	1.0	7.3	21.4	43.4	72.3	106.7	144.7	184.9	225.9	266.6	306.1	344.0	379.7	413.0
Historic	OB	BE2	1.0	10.2	33.6	71.7	120.7	176.0	233.1	288.8	340.9	388.1	429.9	466.2	497.3	523.7
Historic	OC	BE3	18.4	68.0	136.6	214.5	295.1	373.7	447.9	516.1	577.7	632.6	681.1	723.4	760.3	792.1
Historic	OC	BE2	15.1	55.4	108.0	163.6	216.7	264.6	306.1	341.4	370.8	394.9	414.6	430.5	443.4	453.7
Historic	PA	BE3	20.9	99.6	207.2	313.2	403.0	473.2	525.4	563.0	589.7	608.4	621.3	630.3	636.4	640.6
Historic	PN	BE2	18.3	85.3	195.3	335.0	491.7	655.1	817.6	973.9	1120.7	1256.2	1379.4	1490.3	1589.2	1676.8
Historic	PS	BE3	3.7	22.9	59.2	107.6	161.8	216.9	269.4	317.5	360.1	397.0	428.5	455.0	477.0	495.3
Historic	PS	BE2	3.0	34.1	108.4	210.5	318.2	415.9	497.2	561.1	609.4	645.0	670.9	689.5	702.7	712.1
Historic	PT	BE3	18.3	85.3	195.3	335.0	491.7	655.1	817.6	973.9	1120.7	1256.2	1379.4	1490.3	1589.2	1676.8
Historic	PT	BE2	15.8	95.5	233.0	397.4	562.5	712.7	841.1	946.6	1030.9	1097.0	1148.1	1187.2	1217.0	1239.5
Historic	QR	BE3	4.3	13.7	26.3	41.2	57.7	75.3	93.6	112.4	131.3	150.2	168.9	187.4	205.4	223.1
Historic	QR	BE2	4.4	18.0	38.3	62.6	89.0	115.8	142.1	167.0	190.2	211.4	230.7	248.0	263.4	277.0

Harvest and HWP analysis

The historical FAO statistics provide data only from 2000. Due to the lack of data before 2000, in many cases the input data were estimated as constant average values.

The total amount of harvest reported by FAOSTAT is generally higher than the harvest demand reported by the NIR[37] (Figure 33). These last numbers (referred to the volume over bark) are equal to the values reported in the Submission for FMRL. The estimates reported by FAOSTAT are also higher than the information reported by the FRA 2010 Country Report[38]. These last figures, however, are fully consistent with the data reported by the NIR and by the Submission for FMRL. The difference with FAOSTAT may be due to the lack of data on harvest from private forests, not directed accounted by the FRA country's report, and to different accounting methods since the volume reported by the country's report is defined as "commercial volume". According to the FRA country's report, the data should include the fraction of bark, therefore no further correction on FAOSTAT will be applied to account for the bark. The Submission for FMRL estimated a constant harvest demand to 2020 equal to about 4 million m^3.

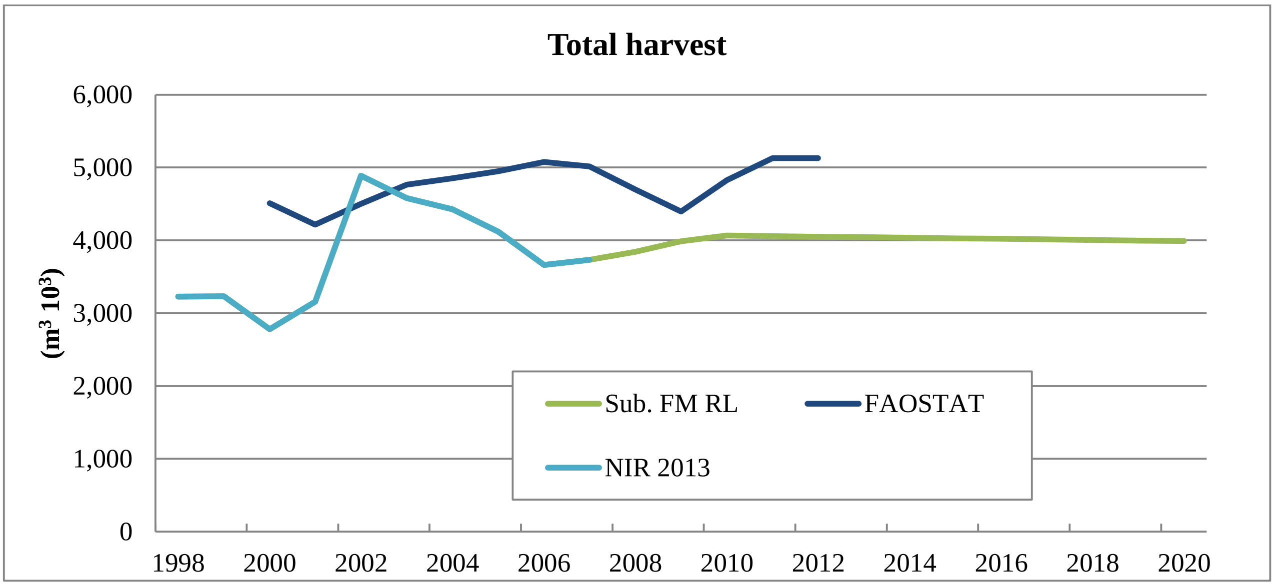

Figure 33: the figure reports the total amount of harvest provided from different data sources for the period 1998 – 2012 (historical data): FAOSTAT, the NIR 2013 and the National Submission for FM Reference Level (Sub. FMRL, reporting the same data of the NIR). The future harvest demand (i.e., from 2013) is shown for the National Submission for FM Reference Level.

The historical and future (assuming a constant harvest rate) share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 34. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

[37] Belgium National Inventory Report, 2013 (pag 169).
[38] FRA 2010 – Country Report, Belgium (pag. 51)

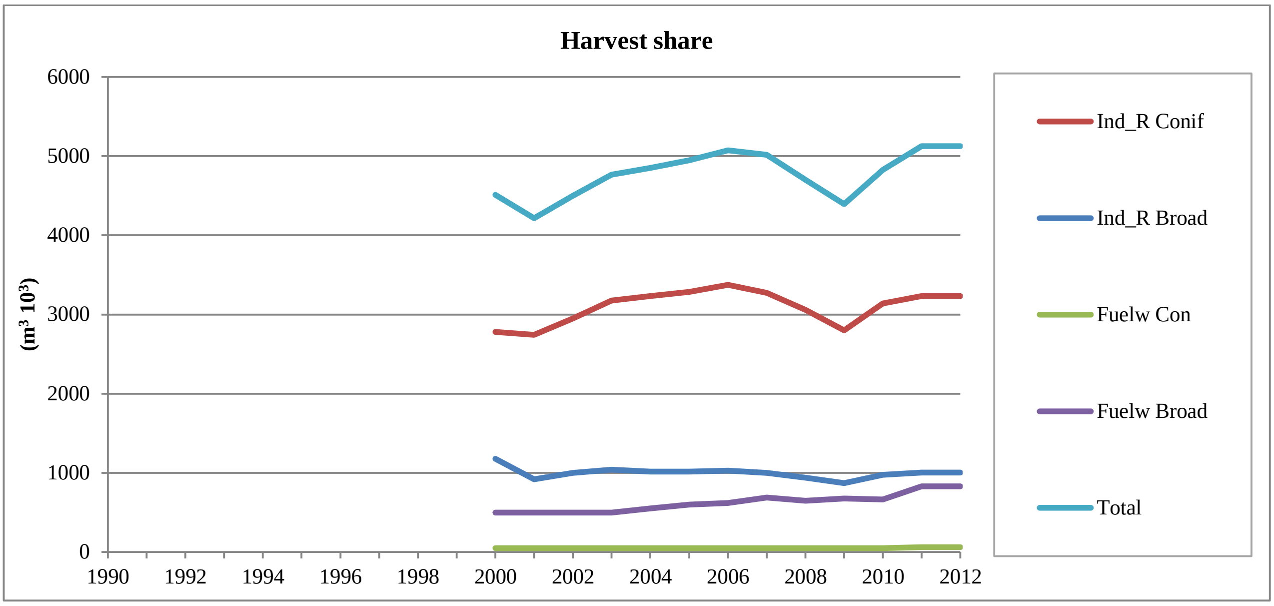

Figure 34: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 35. No data is reported by the country's submission for FMRL.

Belgium

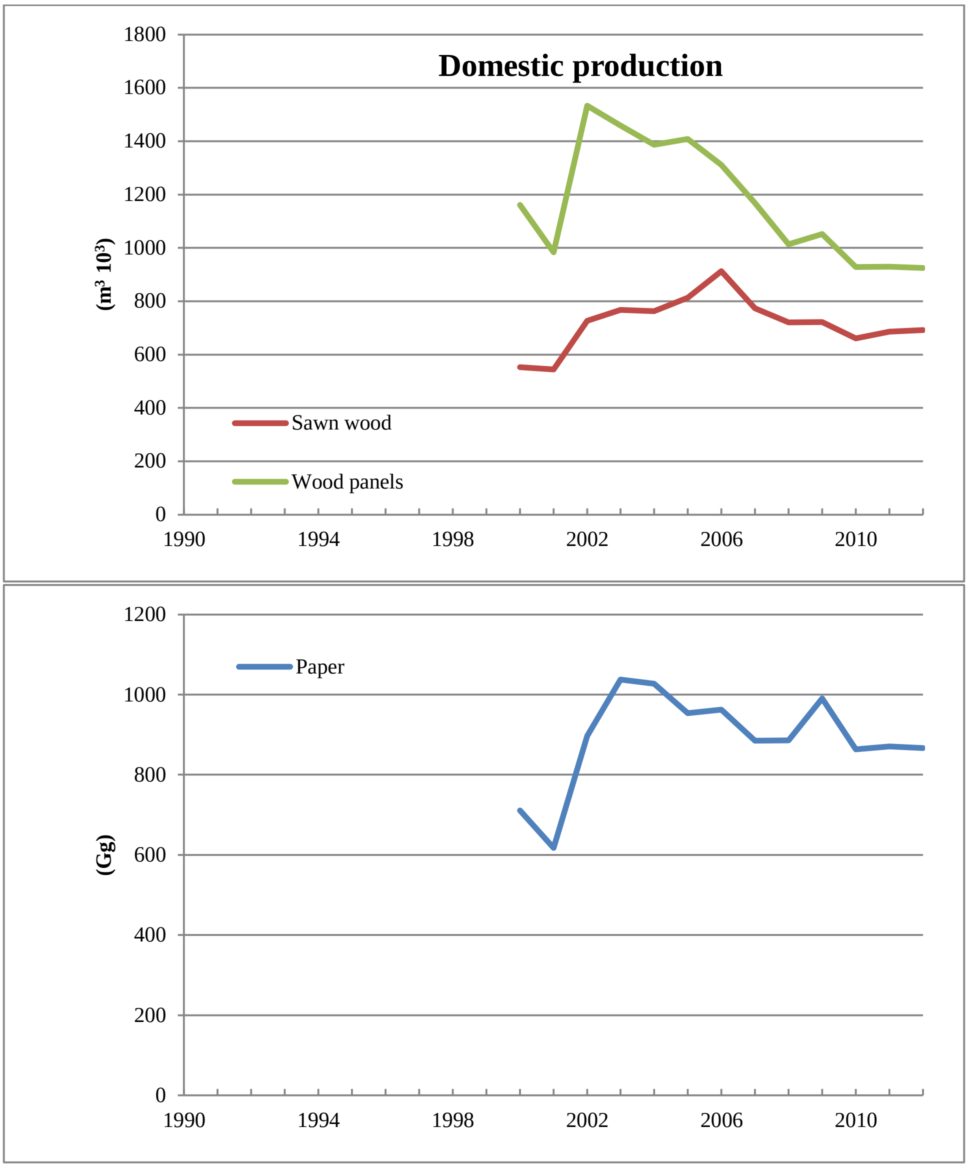

Figure 35: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Bulgaria[39]

NFI data and model assumptions

The analysis was based on data provided by country based on the last NFI 2010, reporting a total forest area equal to 3,737 kha. The original age class distribution was scaled back to 2000, considering a total forest area equal to 3,632 kha at time step zero. The analysis was performed at country level, distributing the original forest area between 6 CLUs, reported in Figure 36.

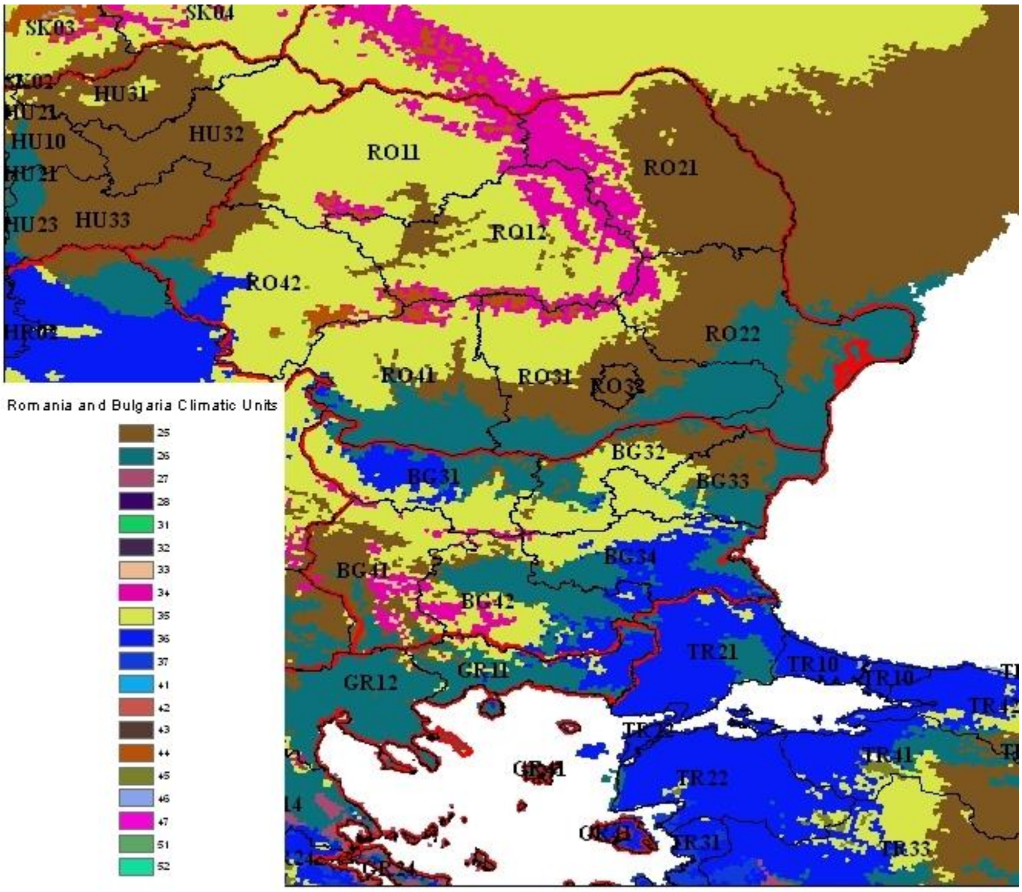

Figure 36: Administrative regions defined at NUTS2 level and CLUs applied to Romania and Bulgaria.

The main species reported by the Bulgarian NFI were distributed between 11 forest types (FT) and 3 management types (MT, including high forests, coppices and the so called "restoration MT"[40]) as reported in Tab. 12. Specific rotation lengths were applied for each FT, taking into account the information provided by the country's experts. Coppices were further distinguished between even-aged management strategy and coppices for transformation to high forests.

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[39] Data directed provided by the country (January-March, 2016); contact person: Lora Petrova, *Senior Expert, Emissions Inventory Department, Monitoring and Assessments of Environment Directorate. Executive Environment Agency*

[40] "Restoration" forests are either composed of unsuitable species or are of such a poor state that is impossible to regenerate. They have to be clear-cut within 30 years regardless of their age

Bulgaria

Tab. 12: main species grouped by forest types (FTs) and management types (MTs) applied to Bulgaria. The minimum rotation length applied to high forests (H), restoration forests (R) and coppices (C) is also reported.

Main species	FT	MS	Min. rotation length (yrs)	
			High forest	Coppices/Rest.
Fir	**AA**	**H**	**120**	**-**
Ash	**FO**	**H**	**50**	**-**
Beech	**FS**	**H/C**	**110**	**40-50**
Beech	**FS**	**R**	**-**	**20**
Other deciduous (poplar, aspen, maple, birch, chestnut, etc.)	**OB**	**H**	**40**	
Common hornbeam, oriental hornbeam, linden coppices, other coppices	**OB**	**C**	**-**	**40-50**
Beech, Hornbeam, other deciduous	**OB**	**R**	**-**	**20**
Other conifers	**OC**	**H**	**30**	**-**
Spruce	**PA**	**H**	**100**	**-**
Black pine	**PN**	**H**	**30**	**-**
Sylver pine	**PS**	**H**	**40**	**-**
Q. cerris	**QC**	**H/C**	**40**	**40-50**
Other oaks	**QR**	**H/C**	**30**	**40-50**
Other Oaks	**QR**	**R**	**-**	**20**
Black locust	**RF**	**C**	**-**	**20**

The main parameters defining the harvest criteria applied by CBM for Bulgaria and the average share of harvest provided by thinnings and clearcut are reported on Tab. 13.

Tab. 13: main parameters defining the harvest criteria applied by CBM for Bulgaria, including the age classes affected by each silvicultural treatment and the average share of harvest provided by each treatment during the historical period (2000 – 2012).

Silvicultural treatment	Criteria	Harvest share
15% Commercial Thinnings	> 30 yrs.	1%
20% Commercial Thinnings	> 10 - 40 yrs.	17%
30% Commercial Thinnings	> 80 yrs.	4%
Clearcut (95% commercial thinning)	Depending by species	78%

Bulgaria

Since no specific data on biomass stock was available at national level, the same equations selected for Italy were applied to Bulgaria, according to the assumptions in Tab. 14.

Tab. 14: association between the Bulgarian forest types and the default species provided by the original CBM database, based on the selection applied to the Italian case study (the correspondence with Italian FTs is also reported).

FT	Species selected by default CBM database	Correspondence with the Italian FTs
FO	Eastern white pine (P. strobus)	Other broadleaves
FS	Gray birch	Beech
OB	Eastern white pine (P. strobus)	Other broadleaves
OC	Red pine	Other conifers
PA - AA	Red pine	Spruce
PN	Red pine	Black pine
PS	Red pine	Scots pine
QC	Largetooth aspen (Populus grandidentata)	Holm oak
QR	Basswood (Tilia americana)	Other oaks
RF	Red pine	Riparian forests

Species-specific YTs were selected using the average volume and increment reported by NFI. The historical library (i.e. the YTs applied during the stand-initialization procedure) and the current library (i.e. the YTs applied during the model run) are reported in Tab. 15.

Bulgaria

Tab. 15: Yield tables applied by CBM model for Bulgaria, distinguished between forest types (FT), management types (MT) and management strategies (MS). The historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure; the current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run. Age classes with a 10 years span were assumed (i.e., Age10 -> age class 1 to 10 years; Age20 → age class 11 to 20 years, etc.).

Library	FT	MT	MS	Age10	Age20	Age30	Age40	Age50	Age60	Age70	Age80	Age90	Age100	Age110	Age120
Historical	AA	H	E	23	90	181	275	359	425	470	495	502	495	476	450
Historical	FO	H	E	53	102	143	176	202	220	234	242	247	248	246	243
Historical	FO	H	E	80	136	178	209	232	247	257	262	264	262	258	252
Historical	FS	C	E	20	79	176	311	484	694	941	1,226	1,548	1,906	2,302	2,734
Historical	FS	C	T	0	2	19	75	197	404	699	1,070	1,487	1,919	2,329	2,689
Historical	FS	H	E	71	130	178	218	249	273	291	304	312	317	319	318
Historical	FS	R	E	34	43	50	55	58	62	64	66	68	70	71	72
Historical	OB	C	E	0	5	32	107	253	480	784	1,148	1,546	1,949	2,330	2,664
Historical	OB	C	E	0	9	50	151	331	592	922	1,297	1,687	2,063	2,402	2,683
Historical	OB	C	E	0	2	15	51	123	238	393	579	782	985	1,173	1,335
Historical	OB	C	T	0	3	19	59	134	247	398	577	775	979	1,176	1,356
Historical	OB	C	T	0	1	4	13	33	65	109	163	223	283	340	388
Historical	OB	C	T	1	9	33	82	163	277	425	605	813	1,043	1,291	1,550
Historical	OB	C	T	1	7	23	52	96	156	233	326	434	557	693	840
Historical	OB	H	E	69	113	145	168	185	196	203	206	207	206	203	198
Historical	OB	H	E	60	102	134	160	180	195	206	214	219	222	222	222
Historical	OB	H	E	109	137	153	163	170	175	177	178	178	178	176	174
Historical	OB	H	E	61	100	132	158	180	199	215	228	239	248	255	261
Historical	OB	H	E	56	115	167	210	244	271	290	303	311	314	313	309
Historical	OB	H	E	12	44	81	117	145	164	174	177	174	166	155	142
Historical	OB	H	E	38	72	97	116	128	135	138	138	136	131	126	119
Historical	OB	H	E	0	1	9	32	75	134	199	257	300	322	324	308
Historical	OB	H	E	29	48	64	79	92	105	117	129	140	151	161	171
Historical	OB	R	E	20	43	58	65	66	64	59	52	46	39	33	27

Bulgaria

Library	FT	MT	MS	Age10	Age20	Age30	Age40	Age50	Age60	Age70	Age80	Age90	Age100	Age110	Age120
Historical	OB	R	E	12	18	20	20	19	18	16	14	12	10	8	7
Historical	OB	R	E	83	75	68	61	55	50	45	41	37	33	30	27
Historical	OC	H	E	168	258	332	397	455	510	561	610	656	701	743	785
Historical	OC	H	E	28	108	202	279	327	346	340	318	285	248	211	175
Historical	OC	H	E	85	132	166	193	213	230	242	252	259	264	267	268
Historical	PA	H	E	53	132	211	281	337	380	410	428	436	436	429	416
Historical	PN	H	E	99	174	229	268	294	310	317	318	314	306	296	283
Historical	PN	H	E	12	50	105	167	228	283	328	362	384	397	400	395
Historical	PN	H	E	0	3	21	67	144	240	338	419	473	496	488	457
Historical	PS	H	E	100	169	220	258	284	302	313	319	320	318	312	305
Historical	QC	C	E	0	5	27	87	199	366	581	826	1,082	1,327	1,544	1,719
Historical	QC	C	T	4	22	58	114	192	296	426	584	771	988	1,238	1,520
Historical	QC	H	E	39	71	96	116	132	144	152	158	161	162	162	161
Historical	QR	C	E	0	3	18	64	157	306	511	759	1,033	1,310	1,571	1,797
Historical	QR	C	T	0	3	14	43	95	173	275	397	530	669	803	928
Historical	QR	H	E	46	77	101	119	133	145	153	159	163	166	167	167
Historical	QR	R	E	111	103	97	90	84	79	73	68	64	60	56	52
Historical	RF	C	T	0	13	95	284	517	686	731	664	534	390	263	167
Current	AA	H	E	4.6	5.9	6.4	6.5	6.3	6.0	5.6	5.2	4.7	4.3	3.8	3.5
Current	FO	H	E	3.8	4.2	4.3	4.1	3.8	3.5	3.2	2.8	2.5	2.2	2.0	1.8
Current	FO	H	E	5.6	5.7	5.3	4.9	4.4	3.9	3.5	3.1	2.7	2.4	2.1	1.8
Current	FS	C	E	5.2	4.7	4.3	3.9	3.5	3.2	2.9	2.6	2.4	2.2	2.0	1.8
Current	FS	C	T	4.2	3.7	3.3	2.9	2.6	2.3	2.0	1.8	1.6	1.4	1.2	1.1
Current	FS	H	E	5.1	5.5	5.3	5.1	4.7	4.3	3.9	3.6	3.2	2.9	2.6	2.3
Current	FS	R	E	2.6	2.2	1.8	1.5	1.3	1.1	0.9	0.7	0.6	0.5	0.4	0.4
Current	OB	C	E	3.5	3.8	3.8	3.6	3.3	3.0	2.7	2.4	2.2	1.9	1.7	1.5
Current	OB	C	E	5.6	5.0	4.5	4.1	3.7	3.3	3.0	2.7	2.4	2.2	2.0	1.8
Current	OB	C	E	4.5	3.2	2.3	1.7	1.2	0.9	0.6	0.5	0.3	0.2	0.2	0.1

Bulgaria

Library	FT	MT	MS	Age10	Age20	Age30	Age40	Age50	Age60	Age70	Age80	Age90	Age100	Age110	Age120
Current	OB	C	T	2.0	2.2	2.2	2.1	1.8	1.6	1.4	1.2	1.0	0.8	0.7	0.6
Current	OB	C	T	2.5	1.2	0.6	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Current	OB	C	T	13.7	7.2	3.8	2.0	1.0	0.5	0.3	0.1	0.1	0.0	0.0	0.0
Current	OB	C	T	6.8	3.7	2.0	1.1	0.6	0.3	0.2	0.1	0.1	0.0	0.0	0.0
Current	OB	H	E	4.8	4.8	4.5	4.0	3.6	3.2	2.8	2.4	2.1	1.8	1.6	1.4
Current	OB	H	E	5.3	4.7	4.2	3.8	3.4	3.0	2.7	2.4	2.2	2.0	1.8	1.6
Current	OB	H	E	9.0	7.1	5.6	4.4	3.5	2.7	2.1	1.7	1.3	1.0	0.8	0.6
Current	OB	H	E	4.6	4.3	4.0	3.7	3.4	3.1	2.9	2.7	2.5	2.3	2.1	1.9
Current	OB	H	E	3.5	4.6	4.9	4.9	4.7	4.4	4.0	3.6	3.2	2.9	2.5	2.2
Current	OB	H	E	3.1	3.1	2.9	2.7	2.5	2.2	2.0	1.8	1.6	1.4	1.3	1.1
Current	OB	H	E	3.0	3.1	2.9	2.7	2.4	2.1	1.8	1.6	1.4	1.2	1.0	0.9
Current	OB	H	E	4.3	3.4	2.7	2.1	1.7	1.3	1.0	0.8	0.6	0.5	0.4	0.3
Current	OB	H	E	3.3	2.9	2.6	2.4	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.0
Current	OB	R	E	3.0	2.4	1.9	1.5	1.2	0.9	0.7	0.6	0.4	0.3	0.3	0.2
Current	OB	R	E	2.7	1.2	0.6	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Current	OB	R	E	15.7	6.3	2.5	1.0	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0
Current	OC	H	E	12.7	12.0	11.0	10.0	9.0	8.1	7.2	6.4	5.7	5.1	4.5	4.0
Current	OC	H	E	8.5	7.5	6.6	5.8	5.1	4.4	3.9	3.4	2.9	2.6	2.2	2.0
Current	OC	H	E	4.0	5.2	5.4	5.2	4.8	4.2	3.7	3.1	2.6	2.2	1.8	1.5
Current	PA	H	E	4.4	5.8	6.3	6.4	6.2	5.8	5.4	4.9	4.4	3.9	3.5	3.1
Current	PN	H	E	8.0	7.6	7.0	6.2	5.5	4.8	4.2	3.7	3.2	2.7	2.4	2.0
Current	PN	H	E	2.3	3.2	3.7	4.0	4.1	4.0	4.0	3.8	3.6	3.4	3.2	3.0
Current	PN	H	E	0.0	0.4	1.1	2.1	3.0	3.7	4.1	4.2	4.1	3.7	3.3	2.8
Current	PS	H	E	8.6	7.6	6.7	6.0	5.3	4.7	4.1	3.6	3.2	2.8	2.5	2.2
Current	QC	C	E	4.4	3.7	3.1	2.6	2.2	1.8	1.5	1.3	1.1	0.9	0.8	0.6
Current	QC	C	T	6.2	4.6	3.5	2.6	1.9	1.4	1.1	0.8	0.6	0.4	0.3	0.2
Current	QC	H	E	1.8	2.6	2.8	2.9	2.7	2.5	2.2	2.0	1.7	1.5	1.2	1.1
Current	QR	C	E	2.4	2.3	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.3

Bulgaria

Library	FT	MT	MS	Age10	Age20	Age30	Age40	Age50	Age60	Age70	Age80	Age90	Age100	Age110	Age120
Current	QR	C	T	1.2	1.6	1.6	1.4	1.2	0.9	0.7	0.6	0.4	0.3	0.2	0.2
Current	QR	H	E	2.6	3.0	3.1	2.9	2.7	2.5	2.2	2.0	1.7	1.5	1.3	1.1
Current	QR	R	E	10.0	6.1	3.7	2.2	1.3	0.8	0.5	0.3	0.2	0.1	0.1	0.0
Current	RF	C	T	4.5	3.6	2.9	2.3	1.9	1.5	1.2	1.0	0.8	0.6	0.5	0.4

Bulgaria

According to the information reported by the country, the effect of the following storms was considered during the model run:

year	area affected by Storm (ha)	salvage logging (m^3)
2006	102,887	23,499
2007	88,090	19,746
2008	97,177	24,095
2009	86,259	15,496
2010	128,066	11,229

Each disturbance event was simulated as a "widespread storm" (i.e., as a not-stand replacing event), using as main input data the area affected by storm (as reported in the previous table) and assuming that: (i) the total forest area affected by storm, each year, was distributed proportionally to the area covered by each FT; (ii) 10% of the living biomass was damaged by this disturbance; (iii) 5% of this biomass was removed as salvage logging; (iv) the remaining 95% moved to the DOM pools.

Harvest and HWP analysis

The historical FAO statistics are complete and cover the period starting from 1961. The total amount of harvest reported by FAOSTAT is consistent with the data reported in the country's submission for FMRL, even if FAOSTAT shows a higher inter-annual variability, probably due to a higher detail of information reported by these last data (Figure 37). No data are reported by the NFI, but new data were recently provided by the country (see the red line on Figure 37) and applied by CBM as input data for the historical period until 2012. The estimates reported by the country's submission are fully consistent with the information reported by the FRA 2010 Country Report[41], already including the fraction of bark. The future harvest demand estimated by the Submission for FMRL shows a decreasing trend, with a final amount of harvest equal to about 5.7 million m^3 for 2020

[41] FRA 2010 – Country Report, Bulgaria (pag. 35), reporting the volume over bark.

Bulgaria

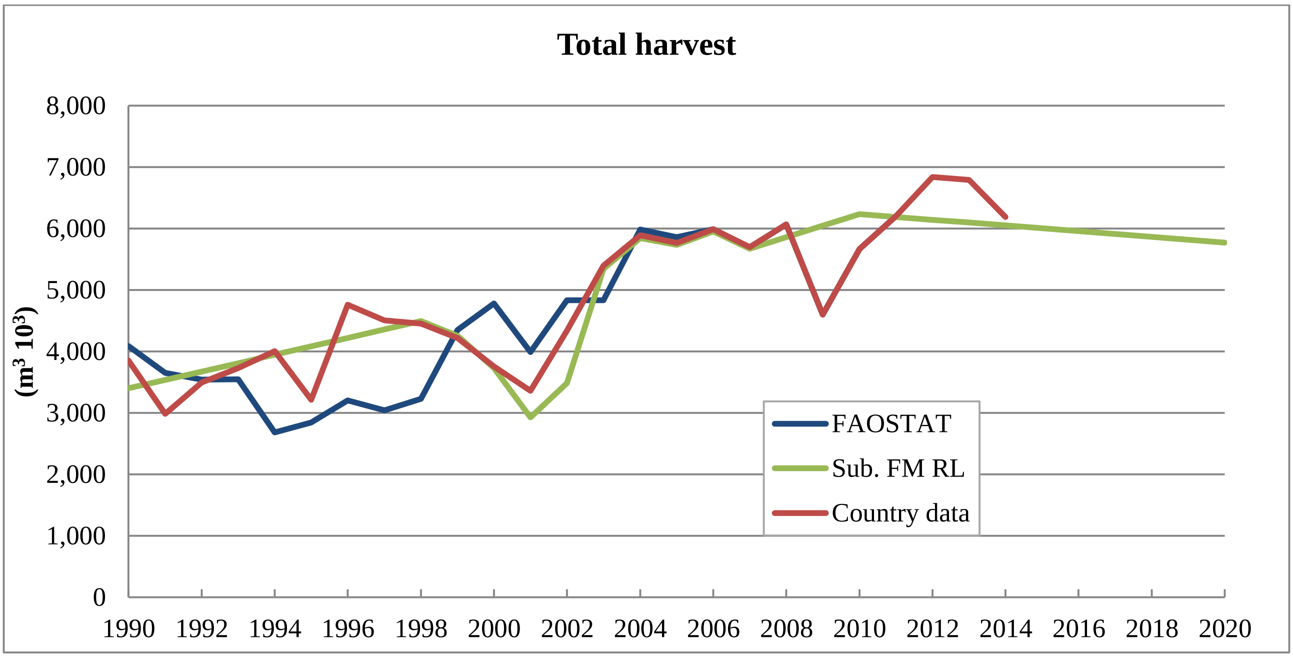

Figure 37: the figure reports the total amount of harvest from different data sources for the period 1990 – 2014 (historical data): FAOSTAT (2013), the National Submission for FM Reference Level (Sub. FMRL) and specific data directly provided by the country. The future harvest demand (i.e., from 2013) is reported according to the National Submission for FM Reference Level.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 38. These data, corrected to account for the OWCs can be used by CBM as input.

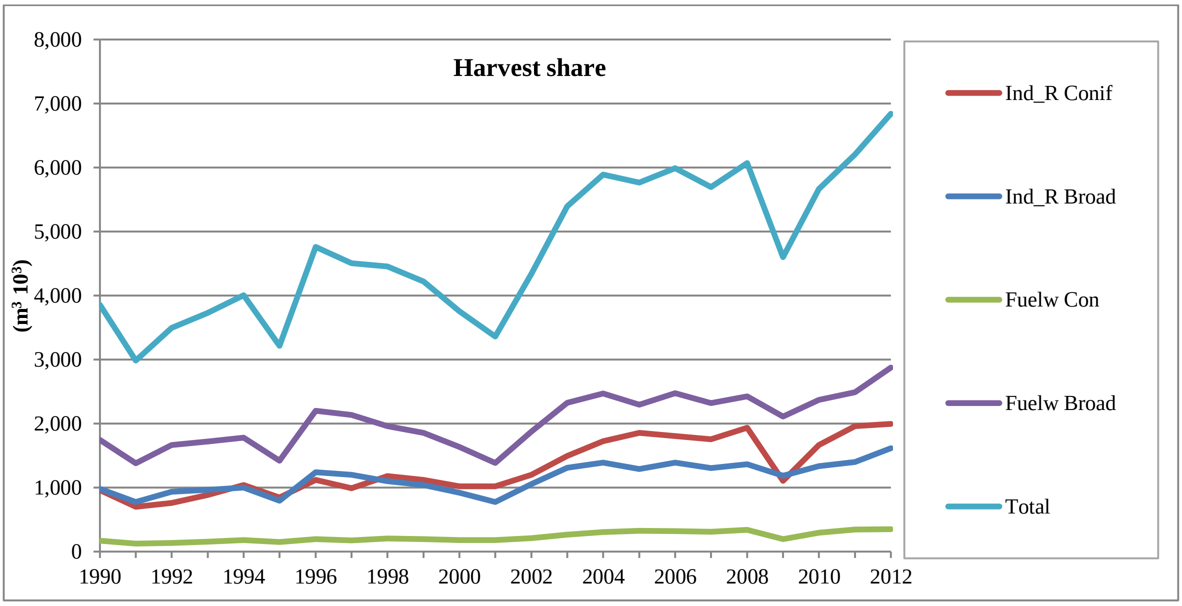

Figure 38: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest up to 2012 is equal to the FAOSTAT estimates, corrected for bark.

Bulgaria

The fraction of domestic production estimated by our analysis for the three main HWP categories (according to FAOSTAT data[42]), using the Tier 2 method proposed by IPCC is reported in Figure 39. No data is reported by the country's submission for FMRL.

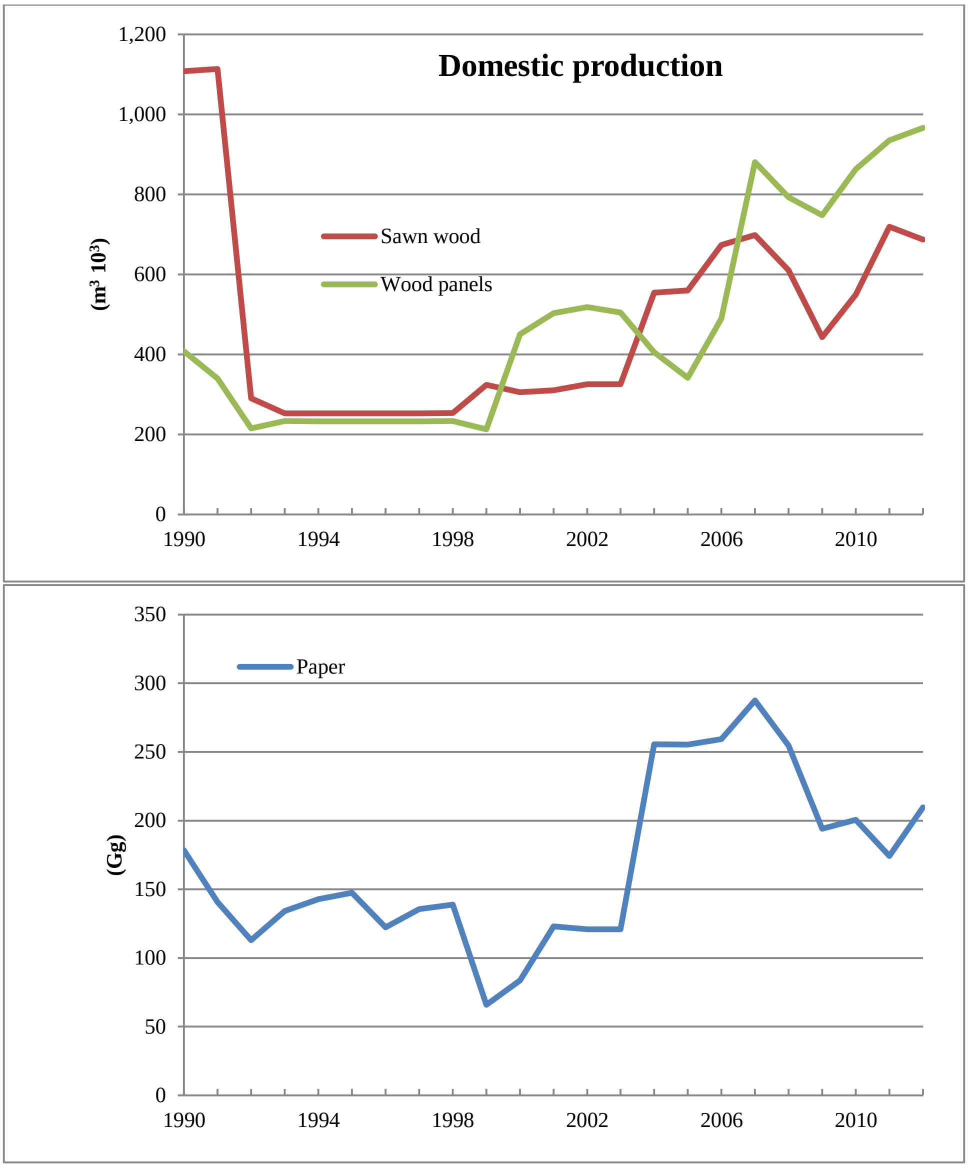

Figure 39: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FRL.

[42] This data source was not corrected to account for the new data on total harvest recently provided by the country.

Croatia[43]

NFI data and model assumptions

The analysis was based on specific data provided by Croatia. According to the NIR, Croatia's forest management area is covered by 16 forest management districts under whose administration are more than 600 forest management units. Corresponding forest management plans (FMAP) are developed for the majority of units. Data available in Forest management plan for the whole Republic of Croatia (period 1986-1995, 1996-2005, 2006-2015), have already been used to estimate the information reported on the Forest Land category by the NIR. The data reported by last FMAP (2006-2015), provide the input data required by CBM, assuming the year 2005, scaled back to 1995. We scaled the original area reported by FMAP to the "FL remaining FL" area reported by the last NIR (2014), equal to 2,019 kha for 1990. This amount was further corrected to account for the total amount of deforestation occurred until 1995 (i.e., about 600 ha yr^{-1}). The final area was equal to about 2,016 kha. Due to the lack of specific information, the total forest area was aggregated at national level (i.e. without any regional distribution) and it was distributed between 10 Climatic units (Figure 40).

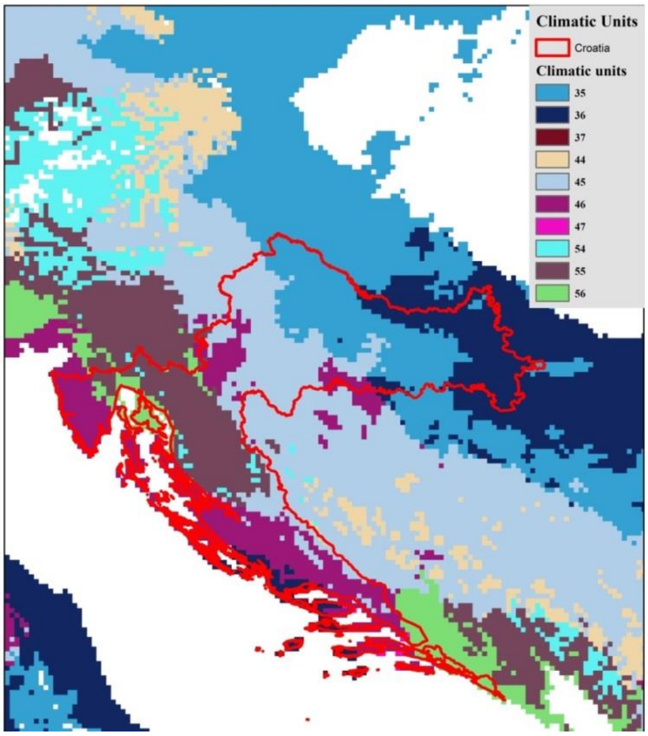

Figure 40: CLUs applied to Croatia.

We considered 7 forest types (FT, i.e. groups of species as reported by Tab. 16), further distinguished between two management types (MT, high forests and coppices) and management strategies (MS, even-aged and uneven-aged). The mixed uneven-aged high forest area reported by the original data (equal to about 206 kha) was further distinguished between fir and beech.

Since no specific data on biomass stock was available at national level, the same equations selected for Italy were applied to Croatia, according to the assumptions reported by Tab. 16.

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43 Specific information were provided by country's expert, in the context of the AA 071201/2011/611111/CLIMA.A2 (Analysis of and proposals for enhancing, monitoring, reporting and verification of land use, land use change and forestry in the EU - LULUCF MRV).

Croatia

Tab. 16: main species (i.e., FT) considered by CBM and "reference species", based on the Italian case study, used to convert the volume to tons of carbon. The last column reports the basic wood density (based on IPCC, 2006) used to convert the volume to dry biomass, to estimate the harvest demand.

Main species	**Acronyms**	**Reference species based on Italian case study**	**Wood density** (t dry matter/m^3 fresh volume)
Other broadleaves	OB_HR	*Fagus sylvatica*	0.60*
Other conifers	OC_HR	*Pinus nigra*	0.49*
Beech	FS_HR	*Fagus sylvatica*	0.58
Peduncolate Oak	QR_HR	*Quercus sp.*	0.58
Sessile Oak	QP_HR	*Quercus sp.*	0.58
Common hornbeam	CB_HR	*O. carpinifolia* and *C. betulus*	0.63
Fir	AA_HR	*Abies alba*	0.40
* average values of the other species			

Based on the silvicultural treatments reported by the country, we defined a set of specific silvicultural rules applied to each FT. The main parameters defining each treatment are reported in Tab. 17.

Croatia

Tab. 17: the table summarizes the main parameters defining the model assumptions for each forest type (FT, as defined by Tab. 16), management type (MT: high-forest (H) and coppice (C)) and management strategy (MS: even-aged (E) and uneven-aged (U)). The silvicultural treatments applied to each FT, MT and MS, are defined through a set of CBM treatments criteria, based on (i) the amount of merchantable aboveground biomass removed by each treatment (i.e., 20%, 30%, 35%, 95%), (ii) the minimum (Min age) and maximum (Max age) age where each CBM treatment can be applied and (iii) the minimum interval of time between two consecutive treatments. The last column (HWP Group) reports the final use assigned to the biomass provided by each CBM treatment, distinguished between industrial roundwood IRW and fuel wood (FW) and between broadleaves (B) and conifers (C).

FT	MT	MS	Silvicultural treatments	CBM treatments	Min age (yrs)	Max age (yrs)	Min since last disturbance (yrs)	HWP Group
FS	H	E	Shelterwood	20% thinning	20	60	10	IRW_B
				35% thinning	60	80	10	IRW_B
				Final cut (95%)	100	210	15	IRW_B
	C	E	Selective	30% thinning	10	210	12	FW_B
QR	H	E	Shelterwood	20% thinning	20	100	10	IRW_B
				35% thinning	100	120	10	IRW_B
				Final cut (95%)	140	210	15	IRW_B
	C	E	Selective	30% thinning	10	210	10	FW_B
QP	H	E	Shelterwood	20% thinning	20	80	10	IRW_B
				35% thinning	80	100	10	IRW_B
				Final cut (95%)	120	210	15	IRW_B
	C	E	Selective	30% thinning	10	210	10	FW_B
CB	H	E	Shelterwood	20% thinning	20	30	10	IRW_B
				35% thinning	30	50	10	IRW_B
				Final cut (95%)	70	210	15	IRW_B
	C	E	Selective	30% thinning	10	210	10	FW_B
OB	H	E	Shelterwood	20% thinning	30	100	10	IRW_B
				35% thinning	100	120	10	IRW_B
				Final cut (95%)	140	210	15	IRW_B
	C	E	Selective	30% thinning	10	210	12	FW_B
OC	H	E	Shelterwood	20% thinning	20	30	10	IRW_C
				35% thinning	30	50	15	IRW_C
				Final cut (95%)	70	210	20	IRW_C
AA	H	U	Selective	20% removal	29	210	12	IRW_C
FS				20% removal	29	210	12	IRW_B
OC				20% removal	29	210	12	IRW_C
OB				20% removal	29	210	12	IRW_B

Croatia

Based on the previous methodological assumptions, a preliminary test was performed on the three most common silvicultural systems: (i) the shelterwood system (considering the beech even-aged high forest as representative case study); (i) the selective coppice system (considering the beech coppice as representative case study); (iii) the selective system applied to uneven-aged high forests (considering the fir as a representative species). The results reported in Figure 41, highlight the general pattern of each silvicultural system on a long time evolution (120 years) for each test.

Croatia

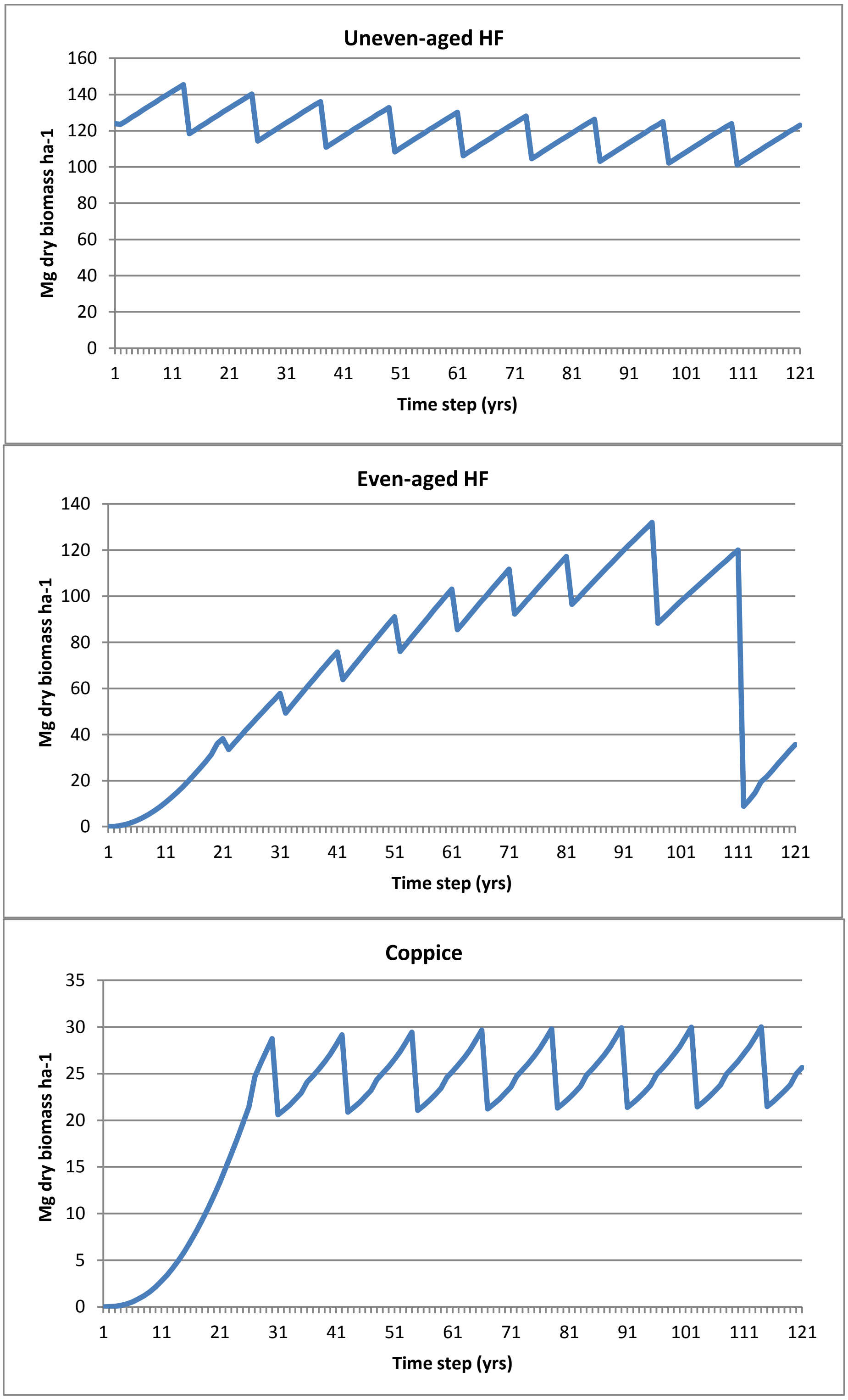

Figure 41: the figure reports the theoretical long term evolution (considering a period of 120 yrs) of the aboveground merchantable biomass (in Mg dry matter ha-1), for 1 ha of pure forest stand managed through the following silvicultural systems: (i) the shelterwood system applied to beech even aged high forest; (ii) the selective coppice system applied to beech coppices and (iii) the selective tree system applied to uneven-aged fir high forest.

Species –specific yield tables (Tab. 18) were selected using the data of volume (for the "Historical YTs") and increment (for the "Current" YTs) provided by Croatia for each FT.

Croatia

Tab. 18: Yield tables applied by CBM model for Croatia. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

FT	Library	MT	MS	Vol0	Vol1	Vol2	Vol3	Vol4	Vol5	Vol6	Vol7	Vol8	Vol9	Vol10	Vol11	Vol12
AA	Historical	H	U	0	312.2	319.2	326.1	394.0	459.8	521.7	578.5	629.6	674.6	713.8	747.6	776.4
CB	Historical	C	E	0	17.5	42.2	67.3	90.8	112.0	130.8	147.1	161.2	173.3	183.6	192.3	199.7
CB	Historical	H	E	0	10.4	34.9	66.2	99.9	133.4	165.0	194.0	220.1	243.1	263.2	280.7	295.7
FS	Historical	C	E	0	24.3	71.2	111.1	138.4	155.3	165.4	171.3	174.6	176.6	177.7	178.3	178.6
FS	Historical	H	E	0	13.9	49.6	94.8	141.3	184.7	223.1	255.8	283.1	305.4	323.5	338.0	349.6
FS	Historical	H	U	0	312.2	319.2	326.1	394.0	459.8	521.7	578.5	629.6	674.6	713.8	747.6	776.4
OB	Historical	C	E	0	10.1	36.3	56.7	67.8	73.1	75.6	76.7	77.2	77.4	77.5	77.5	77.5
OB	Historical	H	E	0	1.2	10.3	30.7	59.7	92.9	126.3	157.2	184.4	207.4	226.4	241.8	254.1
OB	Historical	H	U	0	197.5	202.6	207.6	257.6	307.2	354.9	399.3	439.8	475.9	507.7	535.2	558.8
OC	Historical	H	E	0	5.7	18.3	34.4	52.0	70.0	87.6	104.3	120.0	134.4	147.5	159.3	170.0
OC	Historical	H	U	0	193.9	199.3	204.8	259.5	314.8	368.8	419.8	466.7	509.0	546.4	579.0	607.0
QP	Historical	C	E	0	25.5	76.0	117.9	145.2	161.5	170.7	175.8	178.6	180.2	181.0	181.4	181.7
QP	Historical	H	E	0	16.4	41.5	70.4	101.2	133.1	165.2	197.3	229.1	260.2	290.5	320.1	348.6
QR	Historical	C	E	0	63.4	139.9	196.5	233.8	257.2	271.5	280.2	285.4	288.5	290.4	291.5	292.2
QR	Historical	H	E	0	5.5	23.1	50.5	85.1	124.2	165.9	208.4	250.6	291.7	330.9	368.0	402.7

Croatia

FT	Library	MT	MS	Vol0	Vol1	Vol2	Vol3	Vol4	Vol5	Vol6	Vol7	Vol8	Vol9	Vol10	Vol11	Vol12
OC	Current	H	U	0	19.39	0.55	0.55	5.47	5.54	5.40	5.10	4.69	4.22	3.74	3.26	2.81
QP	Current	C	E	0	0.06	0.57	1.69	3.16	4.58	5.65	6.24	6.36	6.09	5.56	4.87	4.14
QP	Current	H	E	0	1.24	3.25	5.17	6.72	7.81	8.46	8.73	8.70	8.43	8.00	7.46	6.86
QR	Current	C	E	0	0.73	2.51	4.54	6.29	7.53	8.21	8.40	8.20	7.73	7.08	6.34	5.57
AA	Current	H	U	0	31.22	0.69	0.69	6.79	6.58	6.19	5.68	5.10	4.51	3.92	3.38	2.88
CB	Current	C	E	0	0.53	2.18	3.95	5.09	5.45	5.19	4.56	3.77	2.98	2.27	1.69	1.22
CB	Current	H	E	0	2.31	4.60	6.34	7.51	8.18	8.46	8.44	8.20	7.81	7.31	6.76	6.19
FS	Current	C	E	0	0.51	1.45	2.47	3.40	4.15	4.70	5.07	5.25	5.30	5.22	5.05	4.81
FS	Current	H	E	0	1.91	4.07	5.83	7.13	7.98	8.45	8.61	8.53	8.27	7.89	7.42	6.90
FS	Current	H	U	0	31.22	0.69	0.69	6.79	6.58	6.19	5.68	5.10	4.51	3.92	3.38	2.88
OB	Current	C	E	0	0.72	1.55	2.26	2.80	3.18	3.42	3.55	3.57	3.52	3.41	3.26	3.09
OB	Current	H	E	0	2.66	5.18	6.99	8.11	8.66	8.79	8.60	8.19	7.65	7.03	6.38	5.73
OB	Current	H	U	0	19.75	0.50	0.50	5.00	4.96	4.77	4.44	4.05	3.61	3.17	2.75	2.36
OC	Current	H	E	0	1.49	3.14	4.40	5.21	5.64	5.77	5.67	5.41	5.05	4.63	4.19	3.75
QR	Current	H	E	0	5.79	7.93	9.13	9.82	10.15	10.24	10.17	9.97	9.68	9.33	8.95	8.53

The effect of Fire disturbance events were considered based on the following assumptions: data on the amount of burned area for the period 2005 – 2012 were directly provided by the country; for 1995-2004 we assumed a constant average amount of burned area equal to 2,297 ha yr^{-1} (Figure 42). After 2012, we assumed a constant average amount of burned area equal to 2,297 ha yr^{-1}, equal to the 2005-2012 average. Fire disturbances were simulated assuming that fire affected 50% of the living biomass, with salvage of 15% of logging residues. Fires were distributed proportionally to the forest area of each FT, MT and MS.

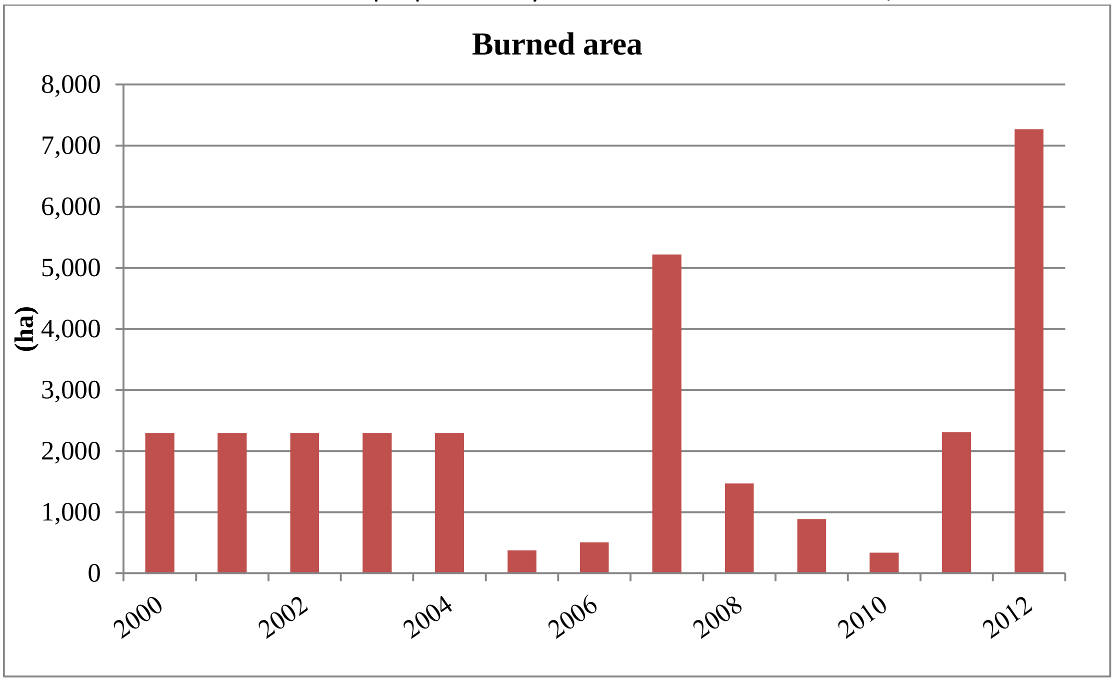

Figure 42: amount of area burned between 1996 and 2012 (based on data reported by NIR, 2014).

Harvest and HWP analysis

The historical FAO statistics cover the period starting from 1992. The total amount of historical harvest reported by FAOSTAT is consistent (after 1994) with the data reported by the country's submission for FMRL. FAOSTAT shows a higher inter-annual variability, probably due to a higher detail of information reported by this source. These data are, on average, 20% lower than the submission's data, probably because of the amount of forest residues and bark (Figure 43). No data are reported by the NFI and the FRA 2010 Country Report[44] only reports data for the state-owned forests. From 2010 on, the Submission for FMRL reports an increasing trend, with a final amount of harvest equal to about 8.0 million m^3 for 2020 (see Figure 43).

[44] FRA 2010 – Country Report, Croatia (pag. 57).

Croatia

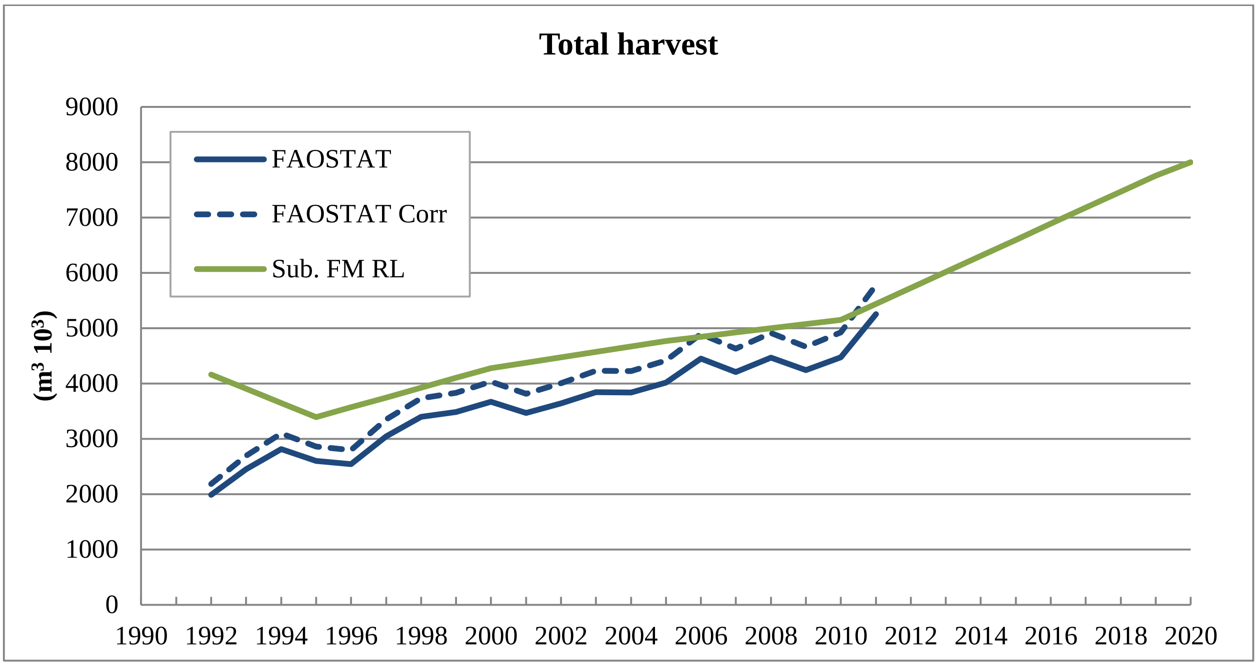

Figure 43: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (under bark) and the National Submission for FM Reference Level (Sub. FMRL). No data is reported by the last NIR. Assuming a correction factor equal to 1.1 to account for the bark's fraction, we also reported the FAOSTAT estimates with bark (FAOSTAT Corr). The future harvest demand reported bt the National Submission for FM Reference Level, is also highlighted.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 44. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

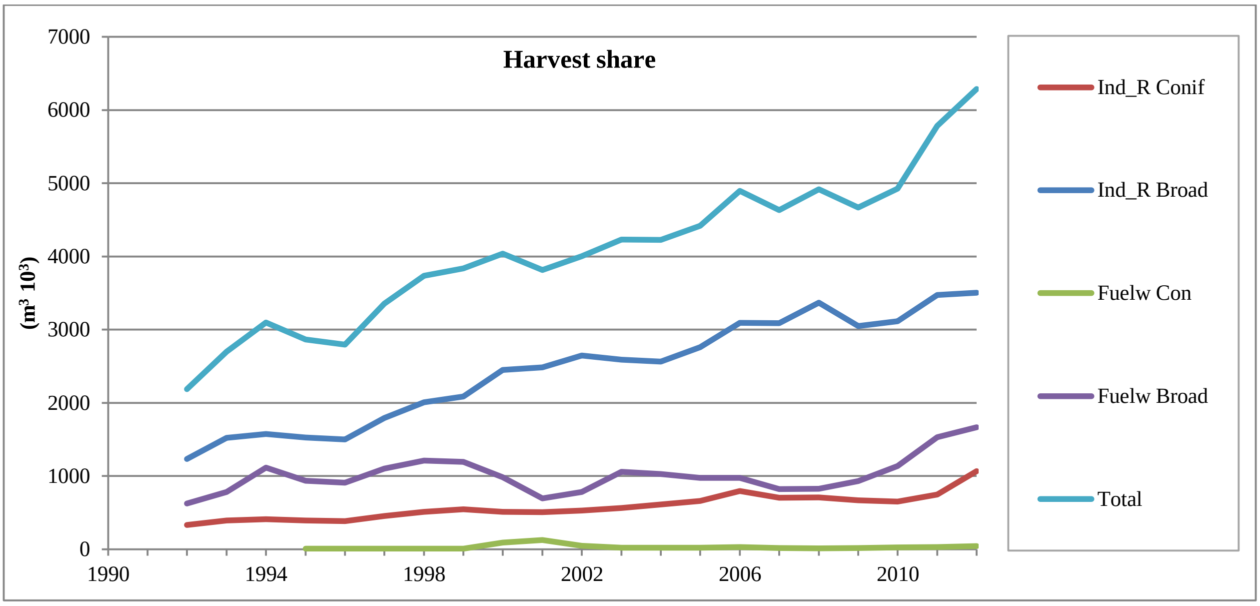

Figure 44: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated in our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 45. No data is reported by the country's submission for FMRL.

Croatia

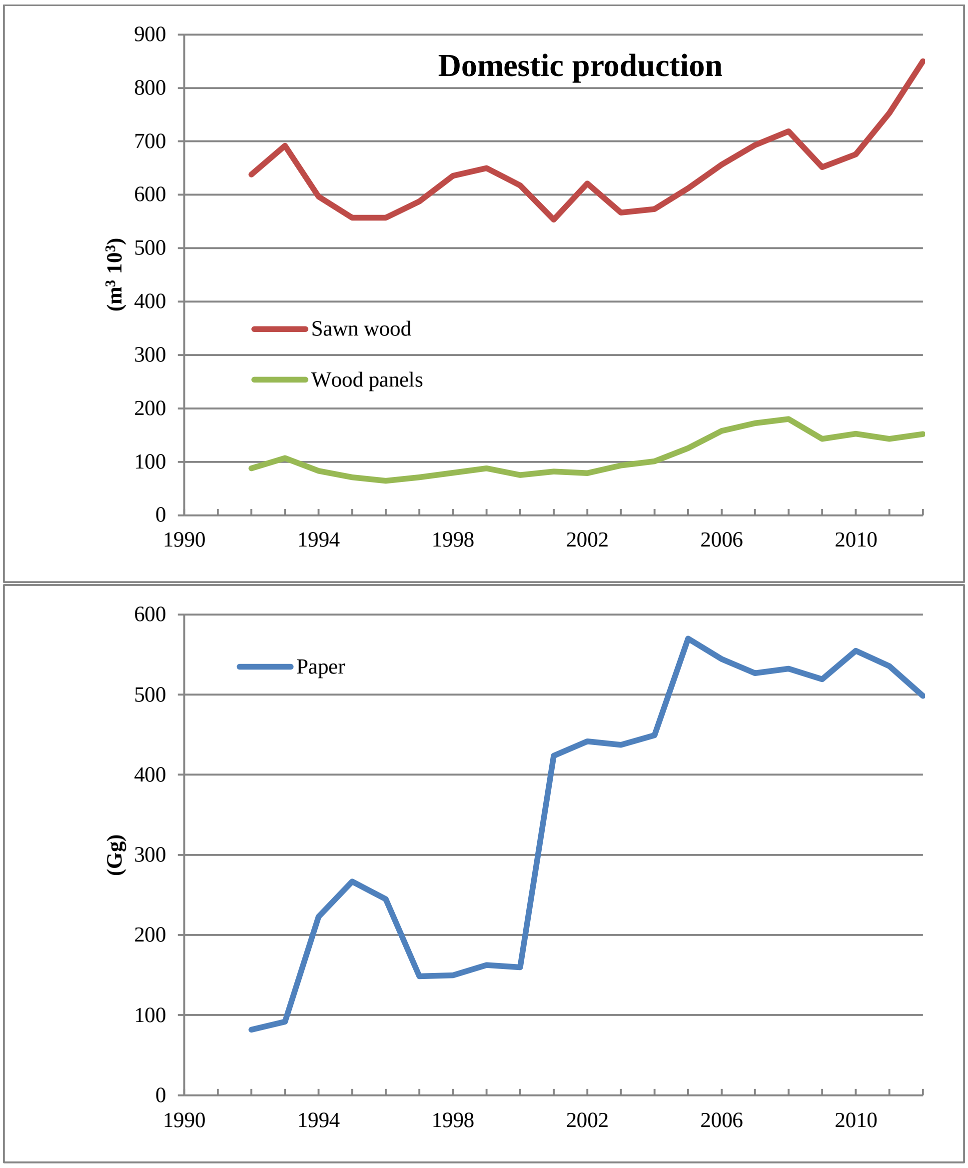

Figure 45: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Czech Republic

NFI data and model assumptions

The analysis was based on data reported by the EFI database. Since the original data were referred to 2000, they were not scaled back of 10 years. The total forest area was distributed between 6 Climatic units (CLUs 25, 34, 35, 44, 45, 54), as reported in Figure 46. For the final analysis, all input data were regrouped at national level. The total forest area reported in the original NFI data, equal to about 2,493 kha, was scaled to the FM area referred to 2005 (equal to 2,565 kha, as reported by the Submission on forest management reference level of Czech Republic[45]).

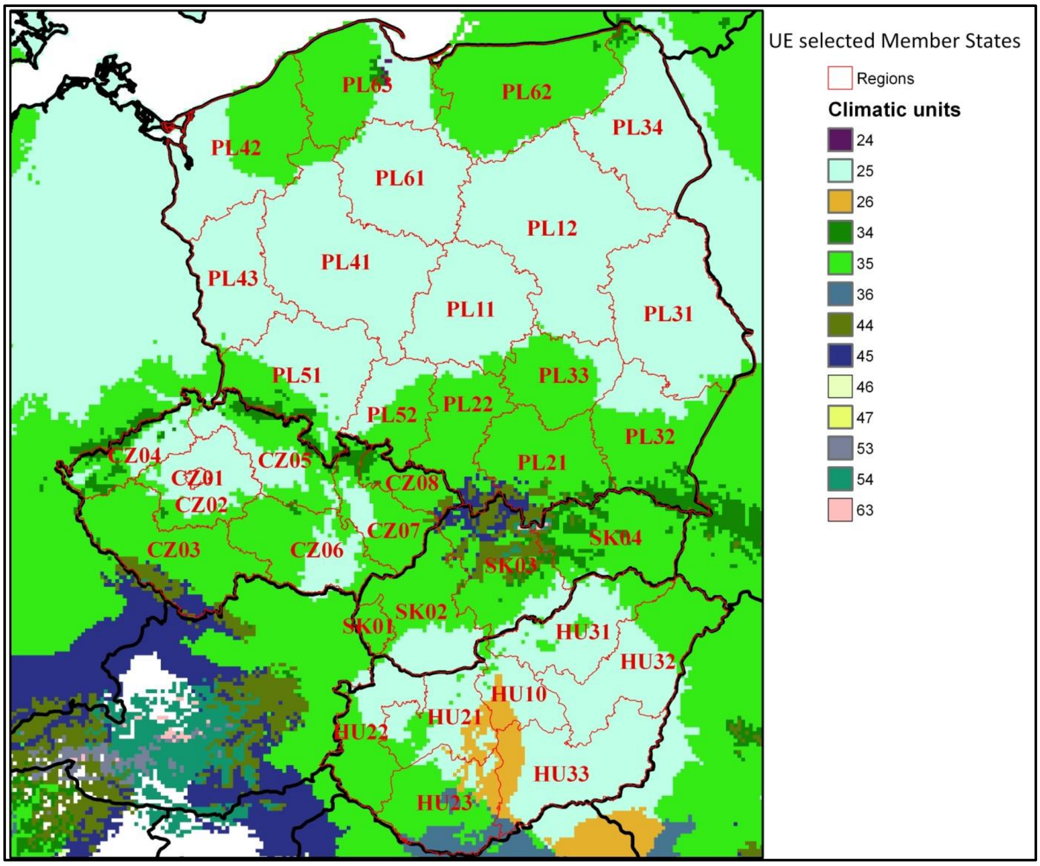

Figure 46: Administrative regions defined at NUTS2 level and CLUs applied to Poland, Czech Republic, Slovakia and Hungary.

The main species reported by the NFI were grouped in 8 forest types, reported in Tab. 19. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the information reported in the literature46.

[45] No further correction to account for deforestation (i.e., about 610 ha yr^{-1}) is needed.
[46] Report of the technical assessment of the forest management reference level submitted by Czech Republic in 2011

Tab. 19: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	Acronym	Min. rotation length (yrs)
Abies alba	**AA**	**100**
Fagus sylvatica	**FS**	**110**
Larix deciduas	**LD**	**90**
Other broadleaves	**OB**	**60**
Other conifers	**OC**	**40**
Picea abies	**PA**	**90**
Pinus sylvestris	**PS**	**100**
Quercus sp.	**QR**	**90**

The main parameters defining the harvest criteria applied by CBM are reported on Tab. 20.

*Tab. 20: main parameters defining the harvest criteria applied by CBM for Czech Republic, including the age classes affected by each silvicultural treatment and the total amount of harvest provided by each treatment. *

Silvicultural treatment	Criteria	Harvest share
20% Commercial Thinnings	> 20 yrs.	14%
30% Commercial Thinnings (only applied to conifers)	> 20 yrs.	36%
Clearcut (95% commercial thinning)	Depending by species	50%

In order to select species-specific equations, the total aboveground volume per age class reported in the NFI was multiplied for the default wood density reported by the IPCC Guidelines (2006)[47] and for the species- and age-specific BEFs reported by Cienciala et al. (2006)[48] for spruce, pine and beech. The average aboveground total biomass by species and regions was compared to the original set of equations provided by Boudewin et al. (2007) for Quebec, selecting the equations reported on Tab. 21. Since no specific data on the biomass stock was available for the other species, the same equations selected for Austria were applied to the Czech Republic (Tab. 21)

Tab. 21: association between the Czech forest types and the default species provided by the original CBM database, based on the selection applied to Germany, Italy and Latvia.

FT	Species selected by default CBM database	Austrian (AT) or country specific selection (CZ)	Correspondence with the Austrian FTs
AA	Eastern white pine (*P. strobus*)	AT	Fir (AT)
FS	Sugar maple (*A. saccharum*)	CZ	
LD	Red pine (*P. resinosa*)	AT	Larch (AT)

[47] Available at: http://www.ipcc-nggip.iges.or.jp/

[48] *Data provided by the AFOLU database on Allometric, Biomass and Carbon factors (Somogiy, Z., et al. (2008), available at: http://fi.jrc.it/BEF_selection.cfm*

OB	Basswood (*Tilia americana*)	AT	OB_AT
OC*	Red spruce (*P. rubens*)	CZ	
PA	Red spruce (*P. rubens*)	CZ	
PS	White spruce (*P. glauca*)	CZ	
QR	Black cherry (*Prunus serotina*)	AT	Oak (AT)
* the same equation selected for spruce and pine was applied to the other conifers			

Tab. 22 reports the percentage difference between the average aboveground total biomass estimated by the selected equations and the country-specific values of biomass.

Tab. 22: the table reports the mean percentage difference and the standard deviation between the average aboveground total biomass estimated by the selected equations and the country-specific biomass values.

Acronym	Forest type	Mean Δ	St dev.
PA	Spruce	1.76	2.22
PS	Scots pine	0.41	4.49
FS	Beech	-2.94	4.84

Species-specific and regional-specific YTs were selected using the average volume and increment reported at national level. Since the original NFI data report the gross annual increment of all trees with a Dbh>7.0 cm, we applied a correction factor equal to 1.07 to the original data on volume and increment. The current library and the historical library applied by CBM model are reported in Tab. 23.[49]

[49] Because the final analysis was performed at national level, we applied the average volume by age class for each FT.

Czech Republic

Tab. 23: Example of the yield tables applied by CBM model for one region (CZ03) of Czech Republic. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.). Because the final analysis was performed at national level, we applied the average volume by age class for each FT.

Library	FT	Region	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	AA	CZ03	1.4	4.7	8.3	11.2	13.0	13.7	13.6	12.8	11.7	10.3	8.9	7.5	6.3	5.2
Current	FS	CZ03	1.1	3.7	6.7	9.2	11.0	12.1	12.6	12.5	12.0	11.2	10.2	9.1	8.1	7.1
Current	LD	CZ03	2.7	6.4	9.4	11.4	12.4	12.5	12.1	11.3	10.3	9.2	8.1	7.0	5.9	5.0
Current	OB	CZ03	1.4	3.8	6.2	8.0	9.1	9.6	9.6	9.3	8.6	7.9	7.1	6.2	5.4	4.6
Current	OC	CZ03	3.0	8.7	13.6	16.5	17.5	16.9	15.5	13.5	11.3	9.3	7.5	5.9	4.6	3.5
Current	PA	CZ03	2.2	6.4	10.3	13.0	14.3	14.6	14.0	12.9	11.5	10.0	8.5	7.1	5.9	4.8
Current	PS	CZ03	1.4	4.2	7.0	9.1	10.3	10.8	10.5	9.9	9.0	7.9	6.9	5.9	4.9	4.1
Current	QR	CZ03	1.6	4.8	7.9	10.1	11.3	11.6	11.2	10.3	9.2	8.0	6.8	5.7	4.7	3.8
Historic	AA	CZ03	10.6	46.8	99.9	159.7	219.0	273.7	321.8	362.9	397.3	425.5	448.5	467.0	481.8	493.7
Historic	FS	CZ03	7.3	40.0	90.6	145.5	196.2	238.8	272.7	298.7	318.2	332.6	343.1	350.7	356.2	360.1
Historic	LD	CZ03	9.7	35.6	70.9	110.4	150.6	189.5	225.7	258.5	287.9	313.8	336.4	355.9	372.8	387.2
Historic	OB	CZ03	1.2	6.6	16.9	32.1	51.5	74.5	100.2	127.9	157.0	186.9	217.1	247.2	276.8	305.8
Historic	OC	CZ03	1.2	6.6	16.9	32.1	51.5	74.5	100.2	127.9	157.0	186.9	217.1	247.2	276.8	305.8
Historic	PA	CZ03	27.1	81.2	142.6	202.1	255.8	302.2	341.2	373.6	400.0	421.4	438.6	452.4	463.4	472.1
Historic	PS	CZ03	5.2	31.6	75.6	126.1	174.5	216.6	250.9	277.9	298.6	314.1	325.7	334.2	340.4	344.9
Historic	QR	CZ03	6.5	26.7	55.3	87.5	119.6	149.6	176.5	200.0	220.1	237.0	251.1	262.7	272.2	280.0

The effect of natural fire disturbances was considered in the model. Data on the amount of burned area were taken from the literature[50] for the historical period, 2000-2012 (Figure 47). After 2012, the 2000-2012 average burned area was used. Fire disturbances were simulated assuming that fire affects 50% of the living biomass, with salvage of 15% of logging residues.

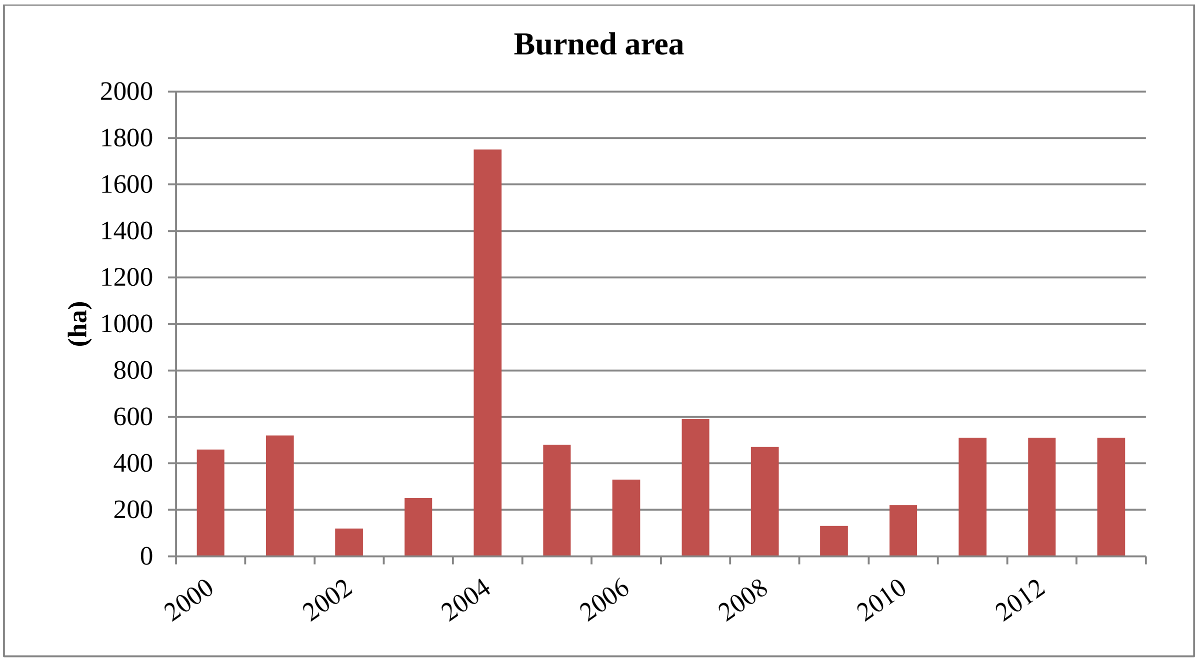

Figure 47: amount of area burned between 2000 and 2012 (based on literature).

Harvest and HWP analysis

The historical FAO statistics cover the period since 1993. The total amount of historical harvest reported by FAOSTAT is consistent with the data reported by the country's submission for FMRL. FAOSTAT shows a higher inter-annual variability, probably due to a higher resolution of the information reported by this source. These data are, on average, 13% lower than the submission's data, probably because of the amount of forest residues and bark (Figure 48). Indeed, the FRA 2010 Country Report[51] reports the same data provided by FAOSTAT, highlighting that these values are referred to the volume "under bark". The last NIR does not report details about the amount of harvest but only a figure that is consistent with the other data sources. After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to about 20.6 million m^3 for 2020.

[50] Comparative Analysis of the Forest Fire Situation in Central-Eastern Europe. Master thesis by Albers, J (2012). University of Natural Resources and Life Sciences (BOKU) Vienna, Austria.
[51] FRA 2010 – Country Report, Czech Republic (pag. 45), reporting the volume under bark.

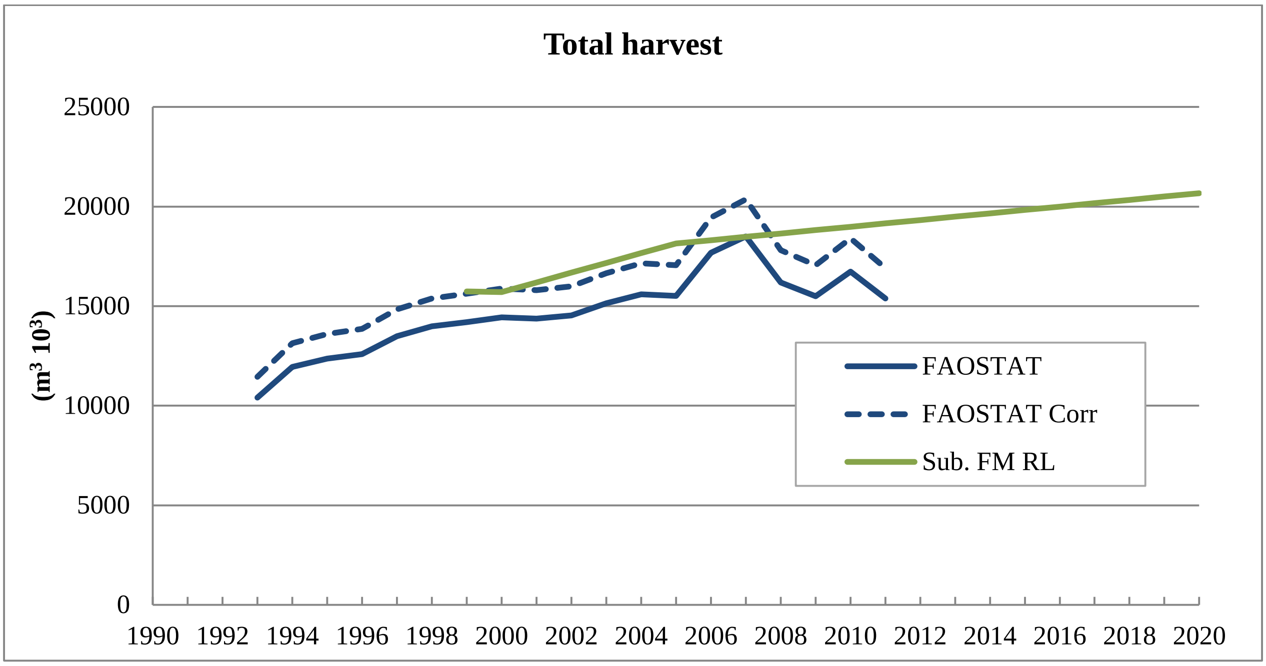

Figure 48: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (under bark) and the National Submission for FM Reference Level (Sub. FMRL). No data is reported by the last NIR. Assuming a correction factor equal to 1.1 to account for the bark's fraction, we also reported the FAOSTAT estimates with bark (FAOSTAT Corr). The future harvest demand (i.e., from 2013) is reported according to the National Submission for FM Reference Level.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is in Figure 49. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

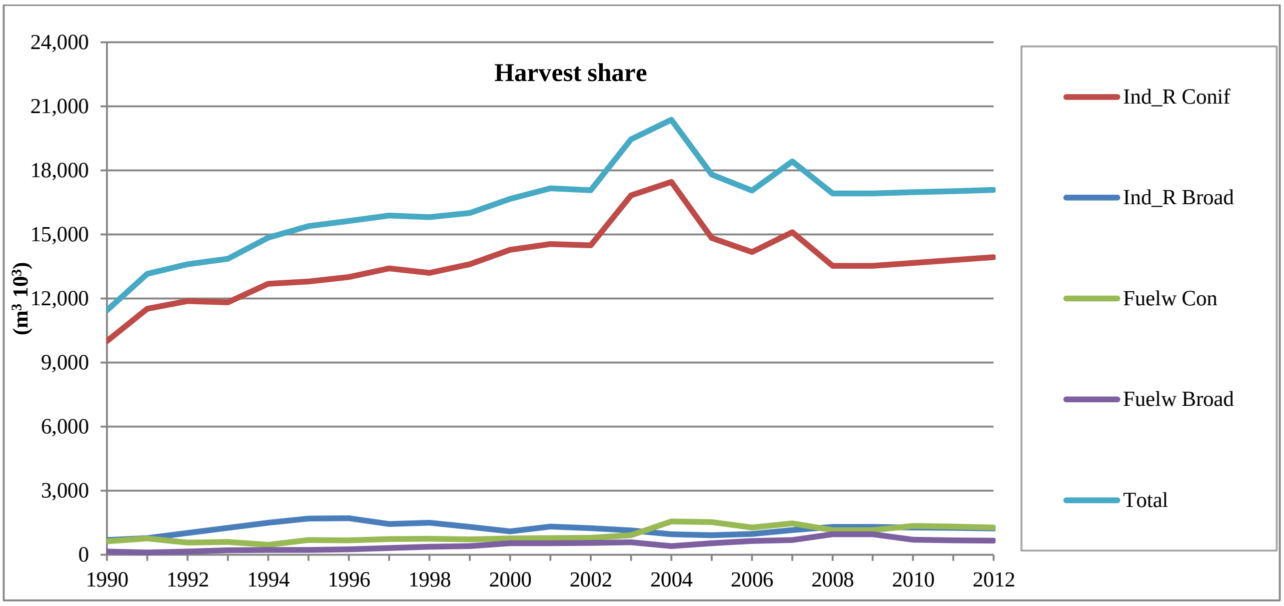

Figure 49 share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 50.

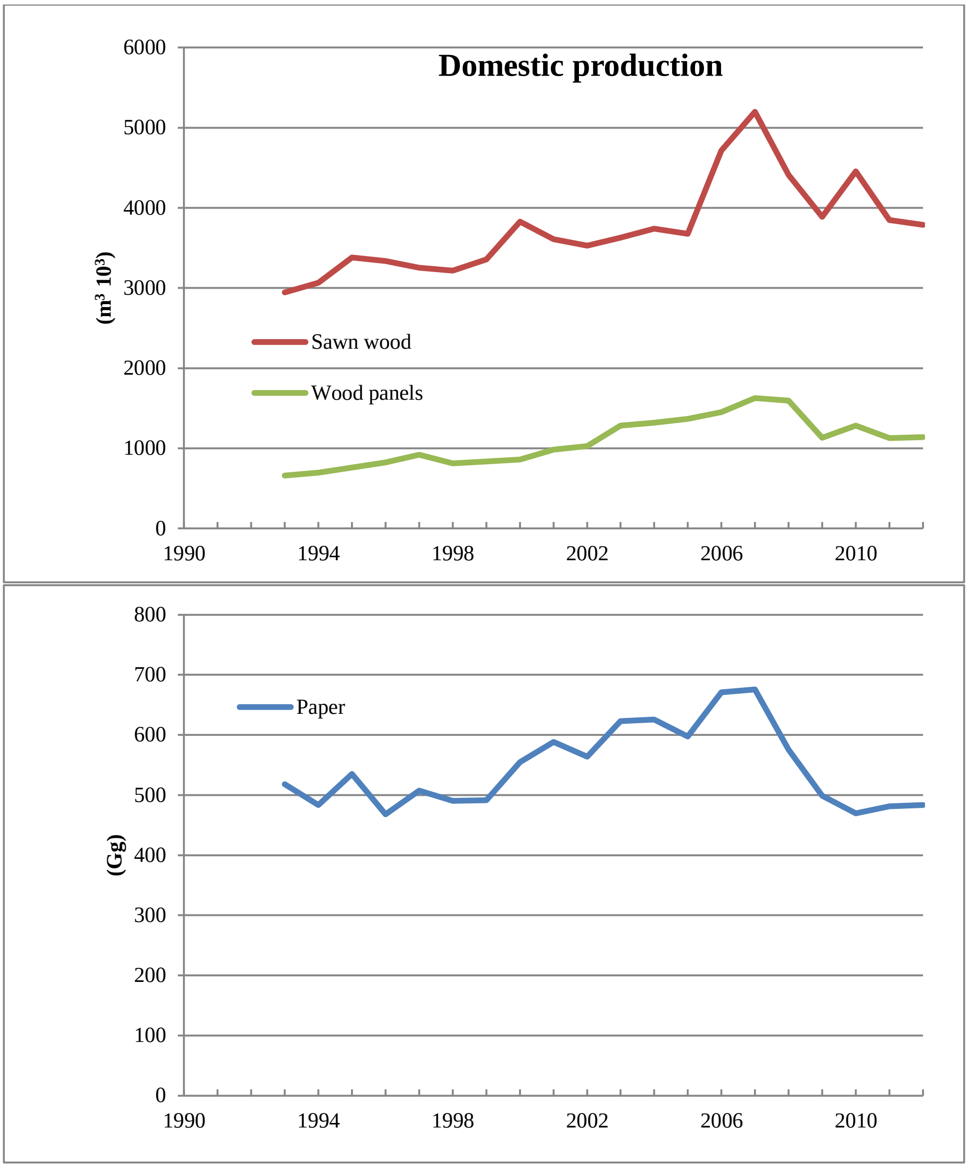

Figure 50: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Denmark

NFI data and model assumptions

The analysis was based on the data provided by the last NFI (2002-2006, referred to 2004)[52] for the age class distribution, forest composition and volume[53]. The original forest area, equal to about 570 kha, was scaled to 540 kha (assumed as FM area[54]), according to the following assumptions:

1. The difference between the NFI forest area and the FM area, equal to 30,800 ha, was assumed as new forest area (AR), established between 1990 and 2004 (i.e., 14 years).
2. About 35% (i.e., 5/14) of this forest expansion was assigned to the first age class (≤ 10 yrs.), referred to new forest stands less than 10 years old.
3. The remaining fraction (i.e., 9/14) was assigned to the second age class (between 11 and 20 yrs.) and it is referred to new forest stands older than 10 years.
4. Each even-aged high forest stand belonging to the first and the second age class was proportionally reduced according to the previous assumptions.

Five administrative regions at NUTS 2 level and 2 CLUs were considered (Figure 24):

- 5 regions at NUTS_2 level: DK01, DK02, DK03, DK04, DK05
- 2 Climatic units: CLU 25 and CLU 35

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[52] Submission of information on forest management reference levels by Denmark (Kvist Johannsen et al., 2011).

[53] Thomas Nord-Larsen kindly provided Danish forest inventory data and he expressed the wish to be acknowledged and to contribute to the scientific analyses & publications of the results: *"As a final note, in supplying these data we would ask you to consider including us in some of the work on EFISCEN. [...] This because Forest and Landscape both do national analyses of both energy and carbon in the forests as well as is responsible for the Danish data submissions to Kyoto, UNFCCC and FAO - to mention a few. We hope that some agreement can be reached on both the way data are referred to (to give credit to us - and other data providers) and how we can contribute to the scientific analyses & publications of the results*."

[54] This figure is consistent with the forest area reported by Kvist Johannsen et al. (Submission of information on forest management reference level by Denmark) ranging between 540 kha and 562 kha.

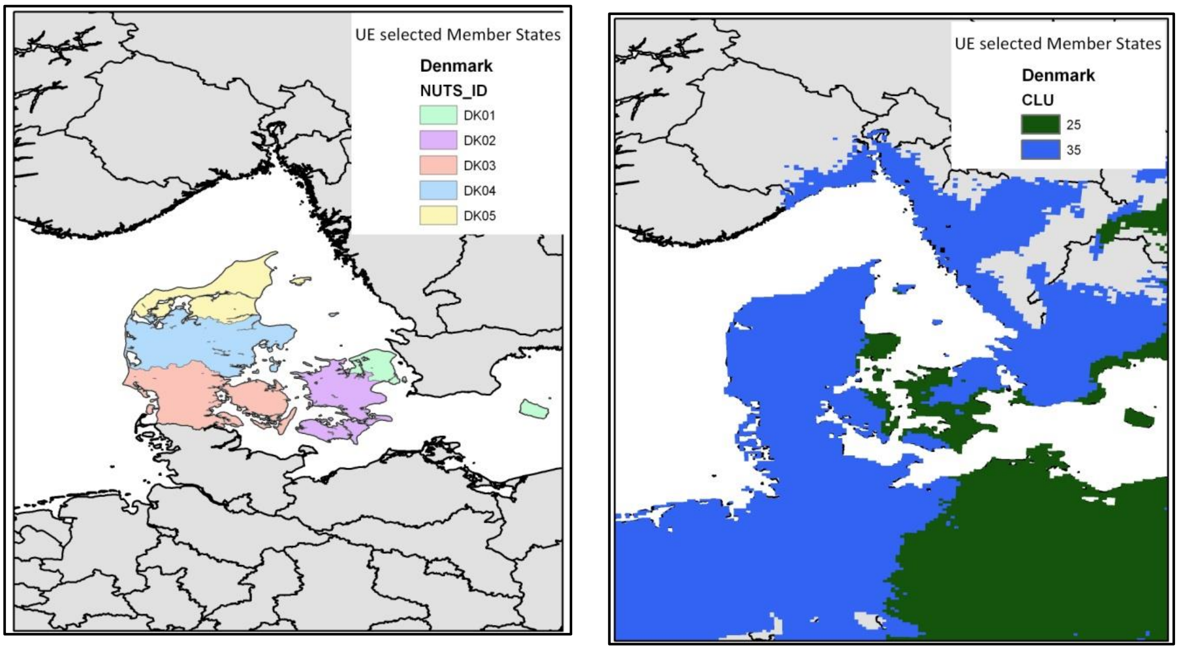

Figure 51: Administrative regions defined at NUTS2 level and CLUs applied to Denmark

The main species reported by the Danish NFI were grouped in 7 forest types, as in Tab. 24. All species were managed as high forests. Specific rotation lengths were applied for each FT. A fraction of the harvest demand (on average, about 25%) was also provided by thinnings (removing between 20 – 30% of the merchantable biomass, depending by FTs); the remaining amount was provided through clearcut.

Tab. 24: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	**Acronym**	**Min. rotation length (yrs)**
Spruce (*P. abies* and *P. sitchensis*)	**PA**	**50 - 60**
Pine (*Pinus* spp.)	**PS**	**60**
Fir (*A. normanniana*, *A. procera*, other *Abies* spp.)	**AA**	**40 - 60**
Other conifers	**OC**	**40 - 50**
Oaks (*Quercus* spp.)	**QR**	**70**
Beech (*F. sylvatica*)	**FS**	**80**
Other broadleaves. (Ash, Maples, etc.)	**OB**	**50**

Since no specific data on biomass stock was available at national level, the same equations selected for Latvia were applied to Denmark, according to the assumptions reported in Tab. 25.

Tab. 25: association between the Danish forest types and the default species provided by the original CBM database, based on the selection applied to the Latvian case study.

FT	Species selected by default CBM database	Correspondence with the Latvian FTs
PA	White spruce (P. glauca)	Spruce
PS	Red pine (P. resinosa)	Scots pine
AA	White spruce (P. glauca)	Spruce
OC	White spruce (P. glauca)	Spruce
QR	Red pine (P. resinosa)	Other broadleaves
FS	White spruce (P. glauca)	Aspen
OB	Red pine (P. resinosa)	Other broadleaves

Species-specific YTs were selected using the average volume and increment reported at national level. The historical YTs were directly derived by the volume reported by NFI, defined at NUTs 2 level. Since NFI does not report data on increment, these data were derived by the EFISCEN database[55]. The average increment estimated by this database (8.6 m^3 ha^{-1} yr^{-1}), defined species by species at national level, was previously compared with the average increment reported at country level by the Submission of information on Forest Management Reference Levels by Denmark (Kvist Johannsen et al., 2011) equal to 8.4 m^3 ha^{-1} yr^{-1} (for 2008-2009). The historical library (i.e., the YTs applied during the stand-initialization procedure) and the current library (i.e., the YTs applied during the model run) are reported in Tab. 26.

[55] http://www.efi.int/databases/efiscen/index.php

Tab. 26: Yield tables applied by CBM model for Denmark. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	Region	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
Current	DK00	AA	4.0	10.0	13.3	14.7	14.9	14.4	13.4	12.1	10.8	9.4	8.2	7.0	6.0	5.0	4.2	3.5
Current	DK00	FS	1.6	5.9	9.4	11.6	12.6	12.8	12.3	11.4	10.4	9.2	8.0	6.9	5.9	5.0	4.2	3.5
Current	DK00	OB	2.5	5.8	7.5	8.2	8.2	7.9	7.3	6.7	5.9	5.2	4.6	3.9	3.4	2.9	2.4	2.0
Current	DK00	OC	4.1	8.4	9.9	9.9	9.1	8.0	6.8	5.7	4.7	3.8	3.0	2.4	1.9	1.5	1.2	0.9
Current	DK00	PA	2.5	7.6	11.2	13.1	13.7	13.4	12.6	11.5	10.2	9.0	7.7	6.6	5.6	4.7	3.9	3.2
Current	DK00	PS	0.2	1.5	3.2	4.5	5.1	5.1	4.6	4.0	3.3	2.6	2.1	1.6	1.2	0.9	0.6	0.4
Current	DK00	QR	1.8	4.9	6.9	8.0	8.4	8.4	8.0	7.5	6.8	6.1	5.4	4.8	4.2	3.6	3.1	2.7
Historic	DK01	FS	11.6	71.7	152.5	237.4	318.2	391.5	455.7	510.9	557.6	596.8	629.4	656.4	678.5	696.7	711.6	723.8
Historic	DK02	OB	1.5	51.9	202.5	421.0	655.1	869.6	1048.9	1190.5	1298.2	1378.2	1436.7	1478.9	1509.1	1530.7	1546.0	1556.8
Historic	DK03	QC	0.6	18.1	71.7	156.5	257.7	361.7	459.3	545.6	619.1	679.8	729.0	768.4	799.4	823.8	842.7	857.4
Historic	DK04	QR	16.6	82.2	164.0	250.2	335.4	416.5	492.1	561.6	624.7	681.6	732.7	778.2	818.6	854.5	886.1	914.0
Historic	DK05	RF	5.7	41.0	97.8	168.4	247.2	330.5	415.4	499.9	582.4	662.0	738.0	809.9	877.6	940.9	999.8	1054.5
Historic	DK01	FO	0.2	9.3	43.8	105.8	187.1	276.7	365.6	448.0	520.8	583.1	635.1	677.7	712.2	739.9	761.9	779.3
Historic	DK02	FS	2.8	21.9	54.9	98.8	151.2	210.2	274.2	341.9	412.3	484.3	557.3	630.6	703.6	776.0	847.3	917.2
Historic	DK03	OB	0.7	14.2	50.2	105.5	173.2	246.0	318.7	387.7	450.8	507.0	556.1	598.5	634.5	665.0	690.5	711.7
Historic	DK04	OC	6.2	44.5	101.3	164.4	227.2	286.0	339.1	385.7	426.1	460.7	489.9	514.5	535.0	552.1	566.3	578.0

Denmark

Library	Region	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
Historic	DK05	PA	1.9	25.7	72.5	129.5	186.8	238.9	283.3	319.9	349.1	372.2	390.1	403.8	414.4	422.4	428.4	433.0
Historic	DK01	PN	1.0	15.5	49.8	101.8	167.2	241.1	319.7	399.6	478.3	554.2	625.9	692.7	754.4	810.7	861.8	907.9
Historic	DK02	PS	1.6	20.6	58.9	109.5	165.7	222.4	276.5	326.2	370.5	409.4	442.9	471.6	495.8	516.2	533.2	547.4
Historic	DK03	QR	1.6	20.6	58.9	109.5	165.7	222.4	276.5	326.2	370.5	409.4	442.9	471.6	495.8	516.2	533.2	547.4
Historic	DK04	OB	0.0	2.1	17.6	57.6	121.3	199.3	280.6	357.4	424.9	481.7	527.8	564.4	592.9	614.9	631.6	644.3
Historic	DK05	AA	0.8	9.7	29.6	58.6	94.6	135.2	178.4	222.6	266.6	309.5	350.6	389.4	425.8	459.6	490.7	519.2
Historic	DK01	AA	0.4	14.5	61.7	145.3	257.5	386.9	522.9	657.3	784.4	900.9	1005.0	1096.5	1175.7	1243.6	1301.2	1349.8
Historic	DK02	AA	4.3	41.2	106.1	185.7	270.0	352.7	429.9	499.7	561.5	615.3	661.5	700.9	734.2	762.2	785.6	805.1
Historic	DK03	AA	2.4	31.3	86.6	152.5	217.4	275.3	324.0	363.5	394.6	418.8	437.3	451.4	462.0	470.0	476.0	480.5
Historic	DK04	AA	10.5	91.6	206.2	316.5	407.9	478.3	530.3	567.6	594.0	612.5	625.3	634.2	640.3	644.5	647.4	649.3
Historic	DK05	FS	0.3	9.2	38.7	88.7	152.5	222.2	291.5	356.4	414.5	465.0	508.0	543.8	573.4	597.6	617.3	633.1
Historic	DK01	FS	9.5	62.2	136.5	217.3	296.6	370.3	436.5	494.7	545.0	588.1	624.6	655.4	681.2	702.7	720.7	735.5
Historic	DK02	FS	0.2	13.4	71.0	179.0	319.0	467.9	608.8	732.5	835.7	919.0	984.5	1035.2	1073.9	1103.2	1125.3	1141.8
Historic	DK03	FS	1.1	19.7	65.3	132.5	212.0	296.1	378.8	456.4	526.8	589.2	643.5	690.1	729.7	763.1	791.0	814.3
Historic	DK04	FS	0.5	18.8	72.0	146.6	223.7	291.9	346.9	388.9	419.9	442.2	458.0	469.2	476.9	482.3	486.1	488.7
Historic	DK05	OB	1.8	26.3	80.2	153.4	235.0	317.0	394.2	463.8	524.7	577.0	621.1	657.9	688.3	713.3	733.6	750.2
Historic	DK01	OB	0.0	2.1	13.3	39.5	82.3	139.5	207.0	280.2	355.1	428.4	497.8	562.0	620.0	671.8	717.4	757.1
Historic	DK02	OB	1.0	23.8	87.4	184.1	298.5	416.5	528.7	629.7	717.5	791.6	853.1	903.4	944.1	976.7	1002.8	1023.5

Denmark

Library	Region	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
Historic	DK03	OB	0.3	6.1	23.1	50.9	86.8	127.4	169.6	211.4	251.0	287.5	320.6	350.0	375.8	398.2	417.5	434.1
Historic	DK04	OB	0.0	3.7	25.7	70.9	128.9	186.9	237.5	277.7	308.2	330.3	346.1	357.1	364.7	370.0	373.6	376.1
Historic	DK05	OC	0.0	1.5	6.4	15.5	28.6	44.8	63.1	82.6	102.3	121.7	140.2	157.7	173.8	188.6	201.9	213.8
Historic	DK01	OC	1.4	20.7	62.1	117.3	178.1	238.4	294.7	345.0	388.7	425.9	457.1	482.9	504.2	521.5	535.6	546.9
Historic	DK02	OC	4.3	29.4	67.9	113.6	162.8	212.7	261.7	308.7	353.0	394.3	432.4	467.3	499.0	527.7	553.6	576.8
Historic	DK03	OC	1.0	20.8	67.3	129.1	193.9	254.0	305.7	348.2	382.1	408.5	428.7	444.1	455.7	464.4	470.9	475.8
Historic	DK04	OC	5.5	31.1	65.0	101.4	137.4	171.6	203.1	231.6	257.1	279.6	299.5	316.8	331.9	345.0	356.3	366.0
Historic	DK05	PA	1.0	11.3	30.9	56.2	84.2	112.6	139.9	165.3	188.2	208.6	226.5	242.1	255.5	266.9	276.7	284.9

The effects of the two main storms affecting Danish forests in 1999-2000 and 2005 were also considered, assuming that about 3,819 Mm^3 and 1,985 Mm^3 fall in 1999-2000 and 2005, respectively (Kvist Johannsen et al., 2011). We assumed that about 30% of this volume was harvested as industrial roundwood and that:

a. A fraction of the forest area reported by the first age class (i.e., < 10 yrs., assumed as clear-cut forest area) in the original age class distribution (i.e., referred to 2004) was affected by storms between 1994 and 2004.
b. Comparing the annual amount of damaged volume (Vol_{St}) with each harvest compartment (IRW conifers, IRW Broadleaves, FW conifers and FW broadleaves) we highlighted that the amount of damaged harvested trees was mainly related to the IRW conifers (IRW_C) compartment.
c. We estimated the share of IRW conifers potentially provided by trees damaged by storms, named Storm factor (SF) and equal to:

$$SF = \frac{Vol_{St}}{IRW\_C}$$

d. The amount of forest area affected by storms each year was equal to the clear-cut forest area of the *i*-year multiplied by the Storm Factor.
e. Storms only affected coniferous FTs with an average age between 50 and 60 years (i.e., the average age of conifers).
f. Storm disturbances were simulated as a clear-cut, stand replacing, disturbance events, assuming that 100% of the merchantable living biomass was moved to the products pool (i.e., harvested) and the other merchantable living biomass was moved to dead wood and litter pools.

Harvest and HWP analysis

The historical FAO statistics are complete and cover the period starting from 1961. The total amount of harvest reported by FAOSTAT to 1997 is about 16% higher than the data reported by the country's submission for FMRL (Figure 52); between 1998 and 2005 these data are, on average, 14% lower than the submission; between 2005 and 2007 they are equal. After 2008, FAOSTAT data are again higher than the submission's data. The FRA 2010 Country Report[56] reports the same data reported by the submission. According to this document, data are referred to the total fellings, over bark, excluding, for the industrial roundwood, forest residues (i.e., tops, branches and stumps). Therefore, we can assume that FAOSTAT reports the volume over bark and the differences with the data reported by the submission and by FRA country's report are related to FW residues. The last NIR does not report further data. After 2010, the Submission for FMRL reports a decreasing harvest demand, with a final amount of harvest equal to about 2.6 million m^3 for 2020.

[56] FRA 2010 – Country Report, Denmark (pag. 49), reporting the volume over bark.

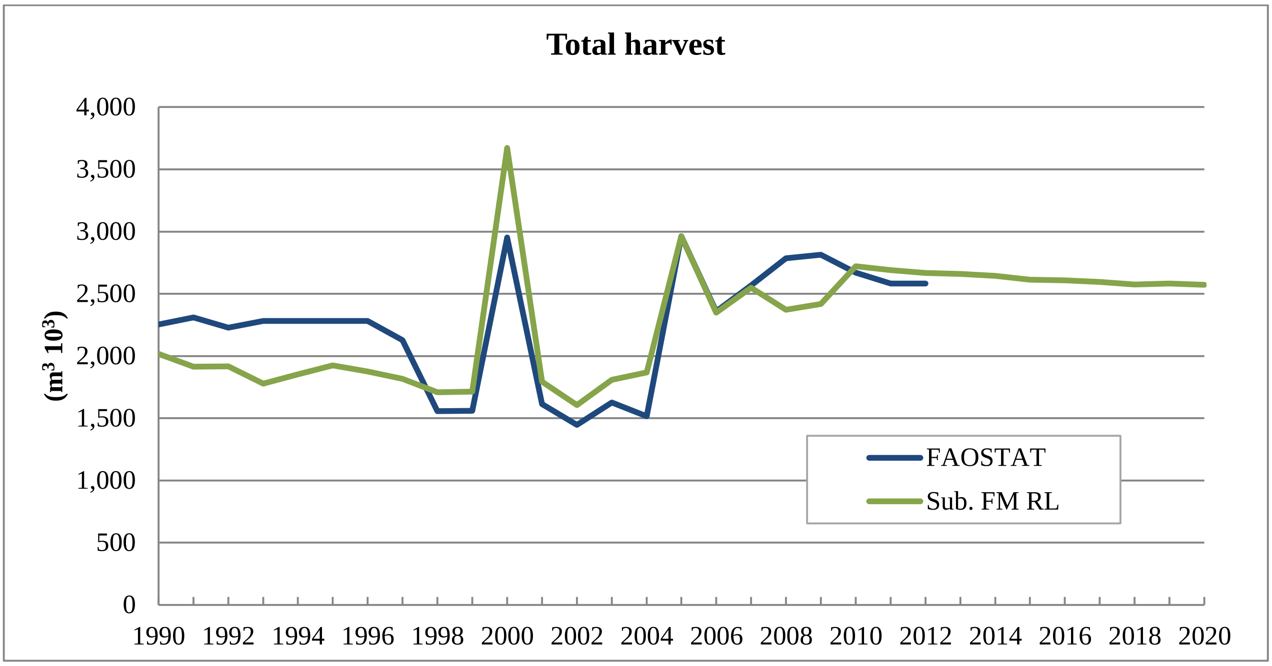

Figure 52: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (over bark) and the National Submission for FM Reference Level (Sub. FMRL). No data is reported by the last NIR. The future harvest demand (i.e., since 2013) is reported according to the National Submission for FM Reference Level.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 53. These data, corrected to account for the OWCs (see materials and methods) were applied to CBM as input.

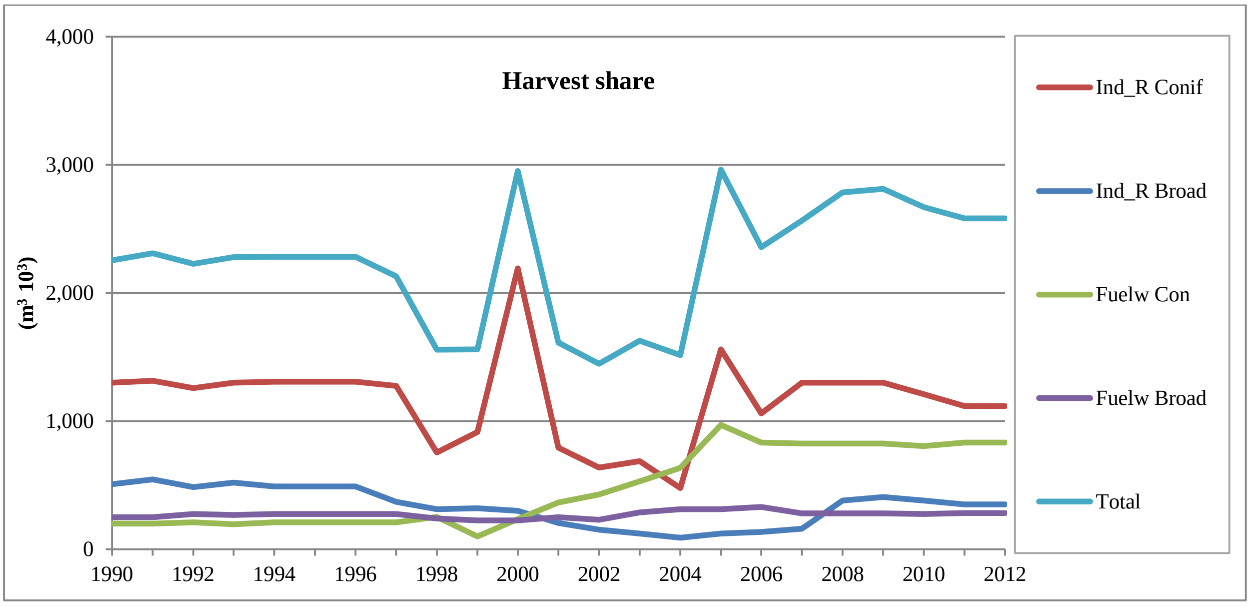

Figure 53: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest is equal to the FAOSTAT estimates, corrected for bark.

Denmark

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 54. No data is reported by the country's submission for FMRL.

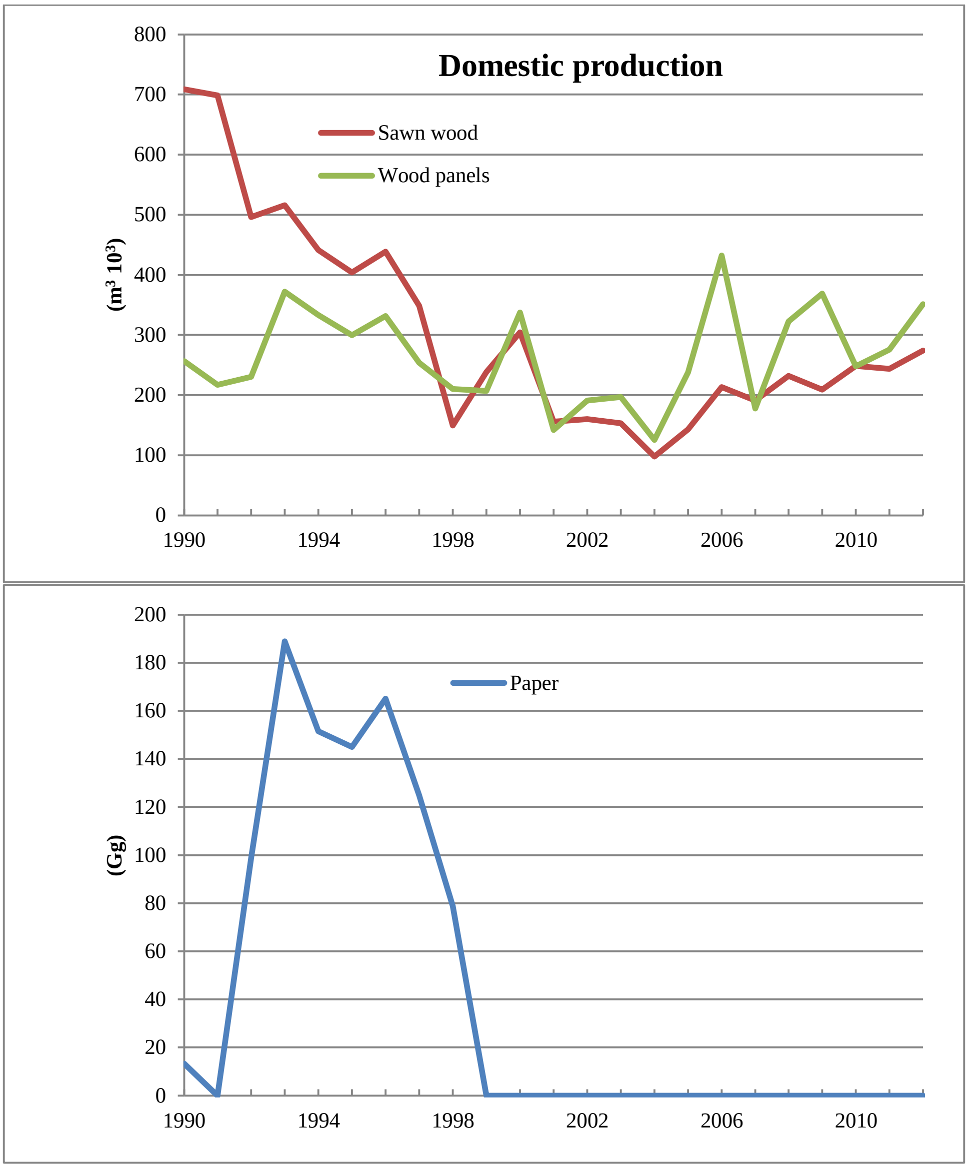

Figure 54: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Estonia[57]

NFI data and model assumptions

Analysis based on data provided by the last NFI (2000), reporting the area (distinguished by age classes and species), volume and increment (by species). The original area reported by NFI was first scaled to the 1990 FM area, equal to 2,081 kha; this amount was further corrected to account for the total amount of deforestation occurred until 2000 (i.e., about 720 ha yr^{-1}). The final area was equal to about 2,074 kha, distributed between 2 CLUs (the entire county is included into one administrative region, see Figure 55).

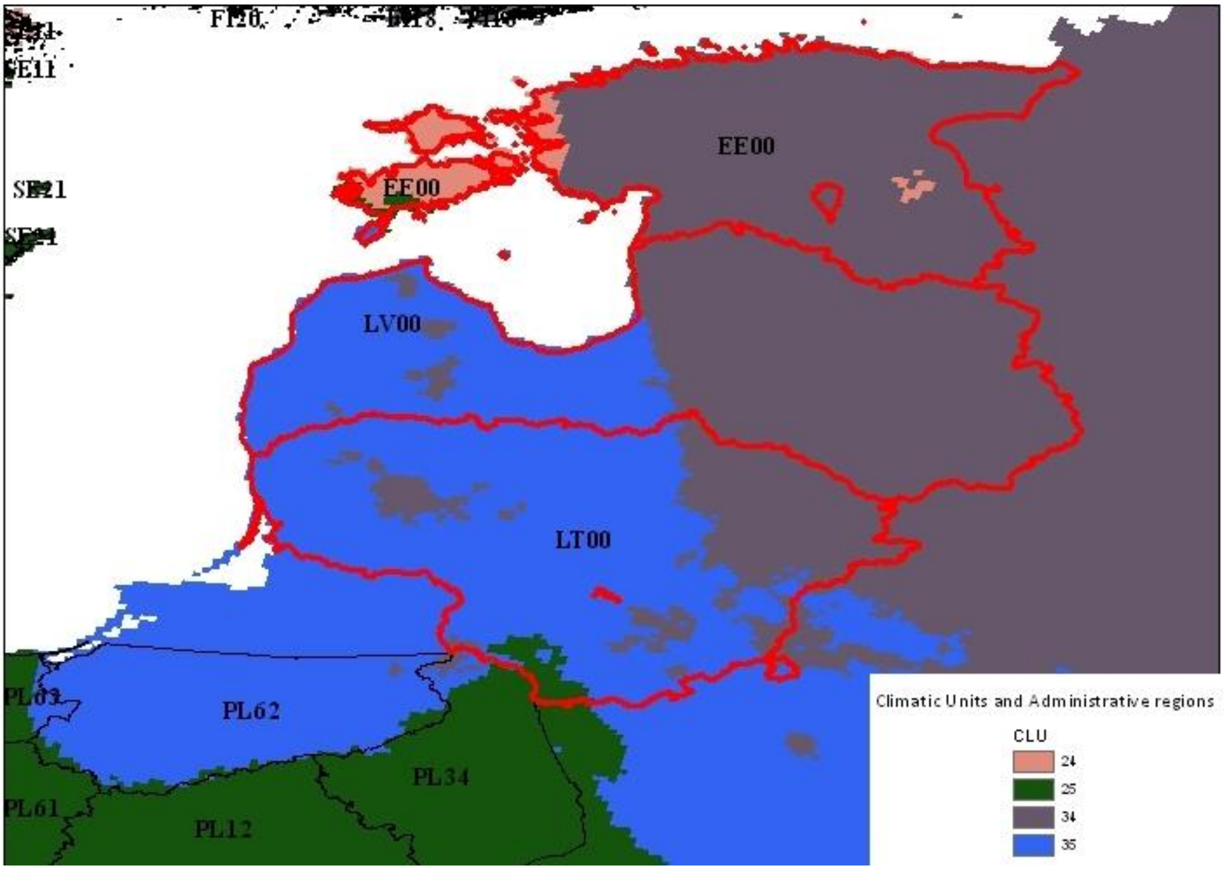

Figure 55: the figure reports the geographical distribution of the CLUs applied by CBM model for Latvia, Lithuania and Estonia and the administrative regions considered by model.

The main species reported by NFI were assigned to 7 forest types, reported in Tab. 27. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the most probable time for final felling reported by the Submission of information for forest management reference levels by Estonia (2011). After 2012, a constant reduction (equal to 0.9) of the default minimum rotation length was allowed during the model run.

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[57] Specific information were provided by country's expert, in the context of the AA 071201/2011/611111/CLIMA.A2 (Analysis of and proposals for enhancing, monitoring, reporting and verification of land use, land use change and forestry in the EU - LULUCF MRV).

Estonia

Tab. 27: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	Acronym	Min. rotation length (yrs)
Alnus glutinosa	**AG**	**60**
Alnus incana	**AI**	**30**
Betula sp.	**BT**	**60**
Other Broadleaves	**OB**	**50**
Picea abies	**PA**	**80**
Pinus sylvestris	**PS**	**90**
Poplar sp.	**PT**	**50**

The main parameters defining the harvest criteria applied by CBM for Estonia are reported on Tab. 28.

Tab. 28: main parameters defining the harvest criteria applied by CBM for Estonia, including the age classes affected by each silvicultural treatment and the relative share of harvest provided by each treatment (average for the historical period).

Silvicultural treatment	Criteria	Harvest share
20% Commercial Thinnings	40 – 80 yrs	16%
30% Commercial Thinnings*	20 - 70 yrs.	3%
Clearcut (95% commercial thinning)	Depending by species	71%
Salvage logging after storm events	Depending by specific events	≈ 10%
* only applied to PA		

Since no specific data on biomass stock was available at national level, the same equations selected for Latvia were applied to Estonia, according to the assumptions reported in Tab. 29.

Estonia

Tab. 29: association between the Estonian forest types and the default species provided by the original CBM database, based on the selection applied to the Latvian case study.

FT	Species selected by default CBM database	Correspondence with the Latvian FTs
AG	Eastern white pine (P. strobus)	Black alder
AI	Red pine (P. resinosa)	Grey alder
BT	Red pine (P. resinosa)	Birch
PA	White spruce (P. glauca)	Spruce
PS	Red pine (P. resinosa)	Scots pine
PT	White spruce (P. glauca)	Aspen
AG	Eastern white pine (P. strobus)	Black alder

Species-specific YTs were selected using the average volume and increment reported at national level. Since the NFI does not report data on increment by age classes, the current library was directly derived by the UBALD database, with the same approach applied to the historical library. A correction factor equal to 1.5% was applied to original volume data, to account for the minimum Dbh threshold equal to 7 cm applied by NFI (Tomter et al., 2012). The historical library[58] (i.e., the YTs applied during the stand-initialization procedure) and the current library (i.e., the YTs applied during the model run) are reported in Tab. 30.

[58] Compared to the previous CBM runs (performed in 2013) the values applied to YT library were revised.

Estonia

Tab. 30: Yield tables applied by CBM model for Estonia. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	AG	2.2	5.9	7.8	8.3	7.9	7.1	6.2	5.3	4.4	3.6	2.9	2.4	1.9	1.5
Current	AI	4.5	10.2	12.4	12.5	11.6	10.3	8.8	7.4	6.1	5.0	4.1	3.3	2.7	2.1
Current	BT	0.6	2.3	4.1	5.3	6.1	6.4	6.4	6.2	5.8	5.3	4.8	4.3	3.7	3.3
Current	OB	0.6	2.5	4.4	5.9	6.7	7.0	6.9	6.6	6.1	5.5	4.9	4.3	3.8	3.3
Current	PA	0.6	3.2	6.5	9.1	10.5	11.1	10.9	10.2	9.3	8.2	7.2	6.2	5.2	4.4
Current	PS	0.1	1.7	4.8	7.7	9.1	9.1	8.2	7.0	5.6	4.4	3.4	2.6	1.9	1.4
Current	PT	4.3	10.8	12.9	12.3	10.6	8.7	6.9	5.3	4.0	3.0	2.3	1.7	1.2	0.9
Historic	AG	8.1	38.7	82.9	129.5	8.1	207.8	236.4	258.6	275.5	288.1	297.4	304.3	309.3	312.9
Historic	AI	1.2	10.3	30.7	59.7	1.2	126.3	157.2	184.4	207.4	226.4	241.8	254.1	263.8	271.4
Historic	BT	1.2	10.3	30.7	59.7	1.2	126.3	157.2	184.4	207.4	226.4	241.8	254.1	263.8	271.4
Historic	OB	1.2	10.3	30.7	59.7	1.2	126.3	157.2	184.4	207.4	226.4	241.8	254.1	263.8	271.4

Estonia

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Historic	PA	10.4	34.9	66.2	99.9	10.4	165.0	194.1	220.1	243.1	263.3	280.7	295.7	308.5	319.4
Historic	PS	3.4	18.3	44.1	77.4	3.4	152.8	189.8	224.4	256.0	284.1	308.7	330.2	348.6	364.3
Historic	PT	24.2	63.9	105.8	145.2	24.2	210.8	236.5	258.1	275.9	290.6	302.6	312.5	320.4	326.9

Estonia

The effect of Storm disturbance events was considered based on the following assumptions:

1. The amount of area affected by storm (reported in Tab. 31) was directly inferred by the last NIR (2014). Moreover, the NIR also report some specific information on the volume of clear cutting and sanitary cutting due to storm damages occurred in 2001, 2002 and 2005.

Tab. 31: the table reports: the amount of area affected by storm (column A) and the salvage of logging residues (column B), inferred by the last NIR (2014, Figure 7.11); the volume removed per ha based on the previous data (in m^3 ha^{-1} yr^{-1}, column C); the volume removed per ha (column D), estimated applying Eq. (1) and using the area affected by storm as independent variable (see Figure 56); the total volume that, based on our assumptions, is "directly" removed through salvage of logging residues (column E).

Data directly provided by NIR (2014)			Values estimated		Salvage Logging on STAND-REPLACING Ev.
Year	**Affected Area (ha)**	**Salvage logging (m^3)**	**Salvage logging per ha (m^3 ha^{-1} yr^{-1})**	**Estimated* Salv. logging per ha (m^3 ha^{-1} yr^{-1})**	**Total Salvage logging (m^3 yr^{-1})**
	A	**B**	**C = B/A**	**D = based on Eq.(1)**	**E = A*D**
2000	4,000			41.4	165,724
2001	29,000	908,000	31.3*	31.3*	908,000
2002	41,000	808,000	19.7*	19.7*	808,000
2003	15,000			35.9	538,965
2004	10,000			38.4	384,310
2005	70,000	666,000	9.5*	9.5*	666,000
2006	52,000			17.4	906,412
2007	15,000			35.9	538,965
2008	40,000			23.4	937,240
2009	34,000			26.4	898,654
2010	74,000			6.4	475,894
2011	54,000			16.4	887,274
2012	12,000			37.4	449,172
* Original values based on NIR data and used to estimate parameters on Eq. (1)					

2. Based on the information directly provided by NIR (columns A and B, Tab. 31), we estimated the amount of damaged volume removed per ha (columns C, Tab. 31) after the disturbance events occurred in 2001, 2002 and 2005. Using these values, we derived a linear model to estimate the amount of volume per ha (y) removed on the remaining years, according to the following equation, where we used the amount of area affected by storm as independent variable (x):

$$y = a + bx \qquad \text{Eq. (1)}$$

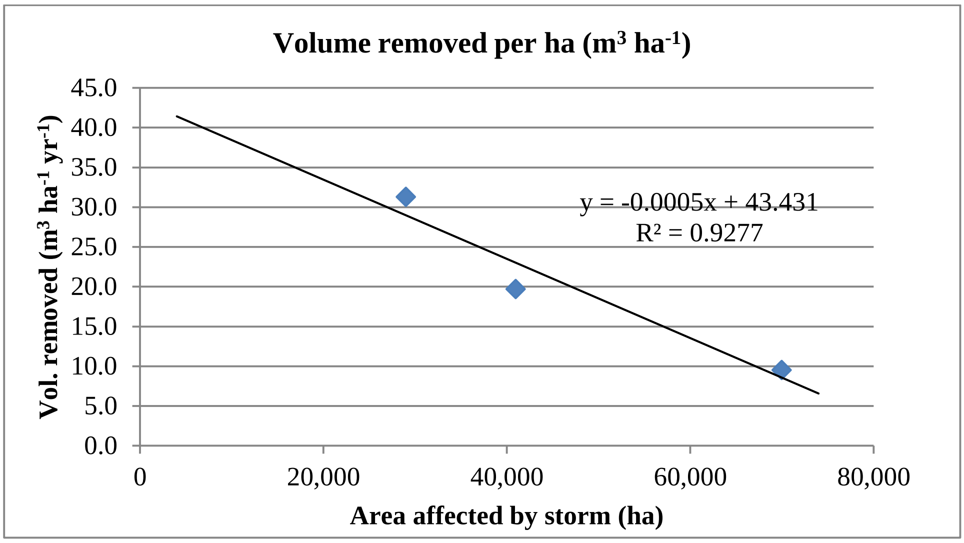


Figure 56: linear regression model (based on Eq, (1)) applied to estimate the amount of volume per ha (in m^3 ha^{-1} yr^{-1}) removed by direct salvage logging after the storm events. The values of the parameters a and b, such as the coefficient of determination (R^2) are also reported.

3. We assumed that the volume estimated by previous step (column E, Tab. 31) is removed on forest areas affected by stand-replacing disturbance events, affecting 65% of the living biomass. The salvage of logging residues was simulated assuming that 30% of the merchantable biomass moves to product pools. This event will have a direct effect on the age class distribution (i.e., after the event and the salvage of logging residues, the area affected by storm will be "moved" to the first age class). The effect of this event was equally distributed between all the main species (excluded OB) according to the proportion of area of each FT.
4. A second, widespread disturbance event related to storms was simulated assuming that only 30% of the living biomass was disturbed, without any salvage of logging residues. In this case the area affected by the disturbance will remain on the current age class. The amount of area affected by this second disturbance event was estimated (after a preliminary run) as the difference between the total amount of area affected by storm (column A, , Tab. 31) and the amount of area affected by stand-replacing disturbance event described by the previous step.

Harvest and HWP analysis

The historical FAO statistics cover the period starting in 1992. The total amount of historical harvest reported by FAOSTAT to 2002 is considerably lower (on average -42%) than the data reported by the country's submission for FMRL; since 2003, the two sources are more consistent (Figure 57). The FRA 2010 Country Report[59] only reports complete data for 2000 and 2005. These figures, referred to the volume over bark, are generally higher than FAOSTAT but lower than the submission's values. Therefore, we assumed that FAOSTAT reports the volume under bark and the differences with the data reported by the submission are related to forest residues, even if some inconsistency should be further clarified. The last NIR reports the same values reported by the country's submission, based on corrections applied to national statistics. After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to about 10.8 million m^3 for 2020.

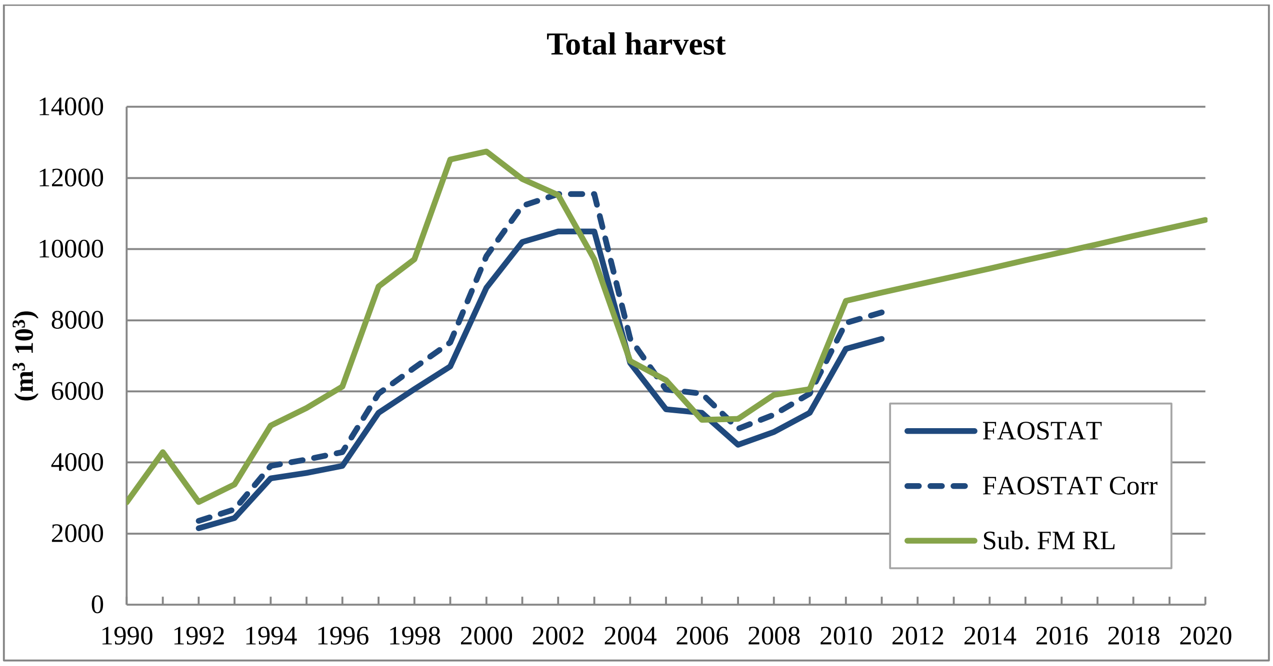


Figure 57: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (over bark) and the National Submission for FM Reference Level (Sub. FMRL). No data is reported by the last NIR. The future harvest demand (i.e., since 2013) is reported according to the National Submission for FM Reference Level.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 58. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

59 FRA 2010 – Country Report, Estonia (pag. 41), reporting the volume over bark.

Estonia

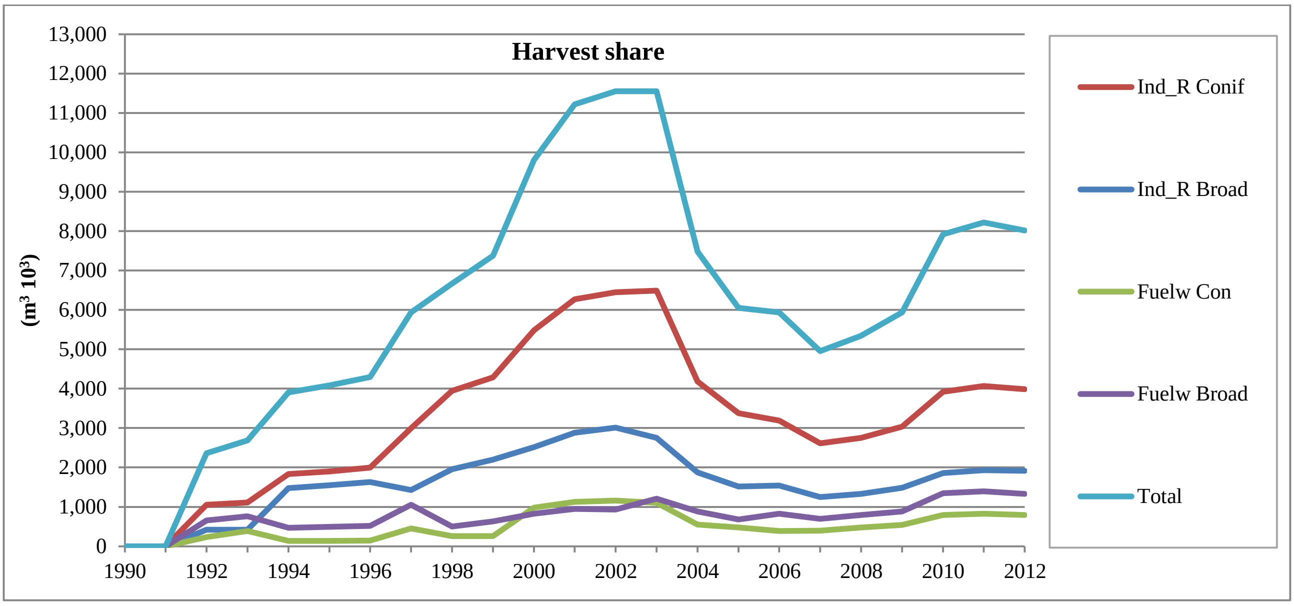


Figure 58: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2010 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated in our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 59.

Estonia

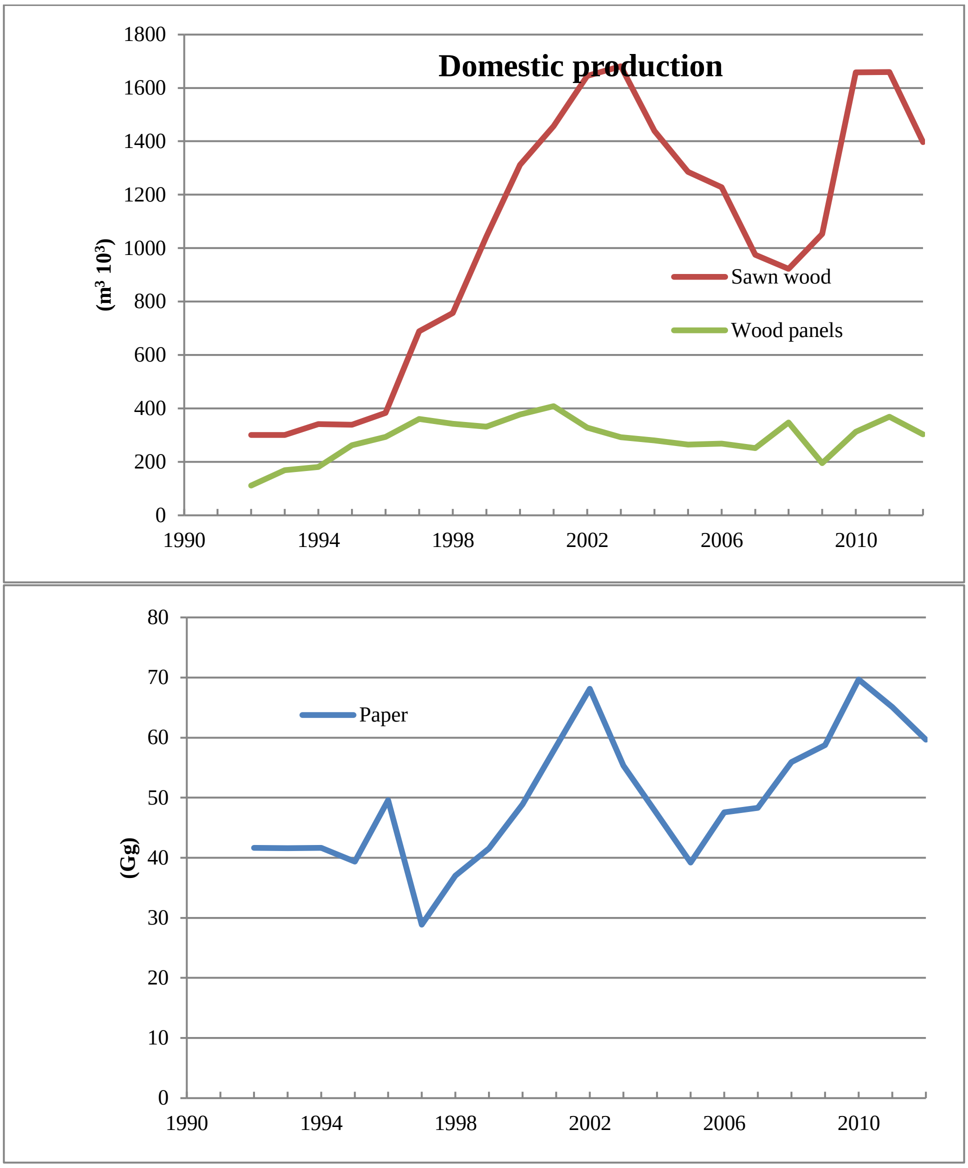


Figure 59: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Finland

NFI data and model assumptions

The analysis was based on data provided by NFI 9 (1996-2003, assuming as reference year the 1999) for the age class distribution, the forest composition and increment (Tompoo et al., 2008).[60] Since the period covered by this NFI was quite large, data were not scaled back to 1989. The total forest area, equal to 21,873 kha was distributed between 4 CLUs and it was corrected to account for the total amount of deforestation occurred until 1999 (i.e., about 14,810 ha yr^{-1}, with a final forest area equal to 21,740 kha for 1996 (see Figure 60 and Figure 61).

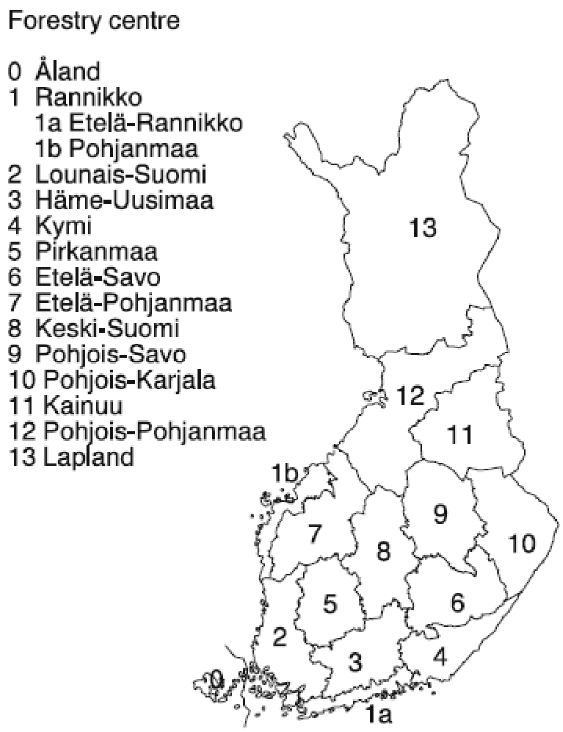


Fig. 1.1 Forestry centres 1.1.2007. Digital map data: ©National Land Survey of Finland, licence No. 363/MML/08.

Figure 60: forestry center's map, as reported by Tompoo et al., 2008. Because Forestry centers (FCs) and administrative regions at NUTS2 level did not overlap exactly, the following assumptions were made: FC0 was assigned to region FI20, FCs 1a, 3 and 4 were assigned to region FI18, FCs 2, 5, 7, 1b and 8 were assigned to region FI19, FCs 6, 9, and 10 were assigned to region FI13 and FCs 12 and 13 were assigned to region FI1A.

[60] Tomtoo, E., Haakana, M., Katila, M., Peräsaari, J, 2008. Multi-Source National Forest Inventory. Methods and Applications. Springer.

Finland

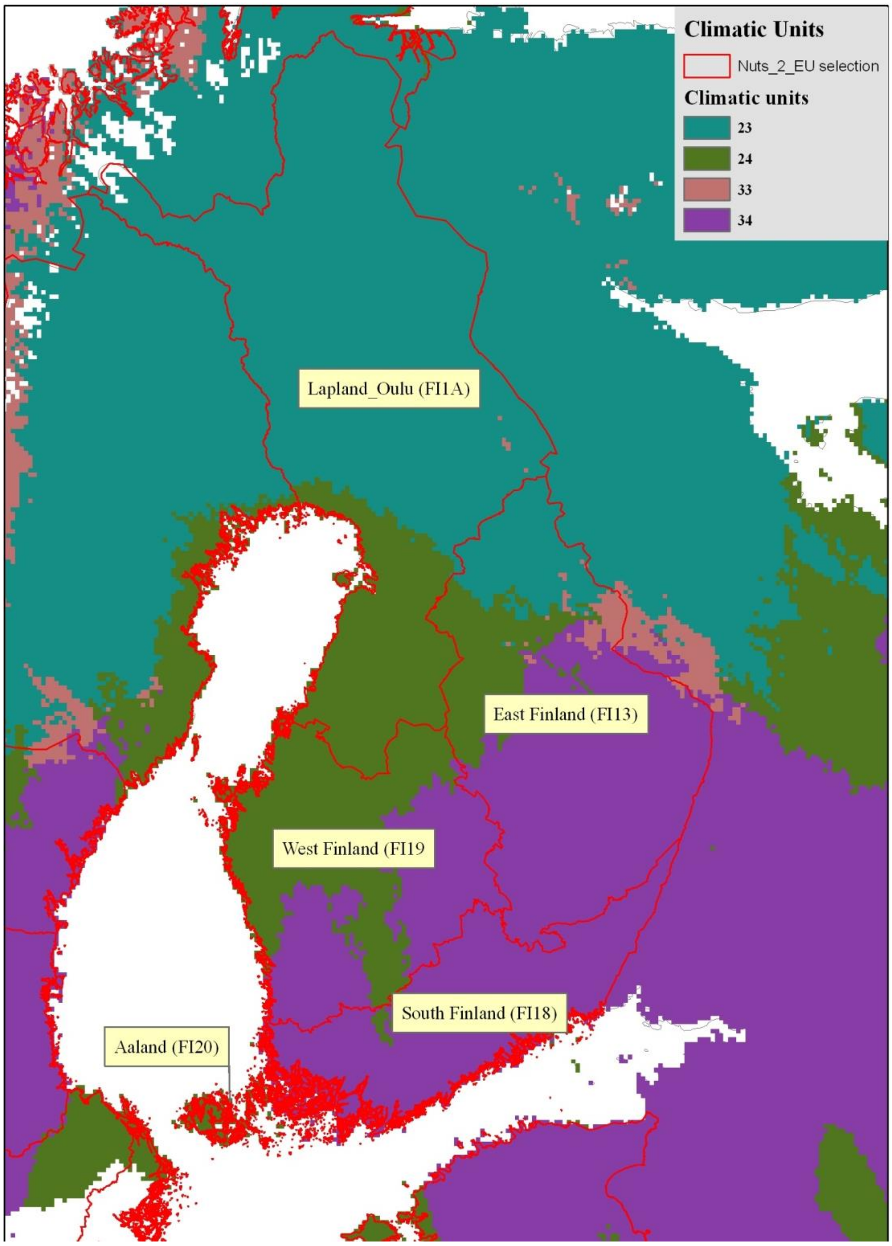


Figure 61: regional borders defined at NUTS 2 level and climatic borders assumed by CBM model. For the final analysis, all input data were regrouped at national level.

In Tab. 32 is reported the minimum rotation length applied to each FT.

Tab. 32: forest types and minimum rotation length applied to clear cutting.

FT	Acronyms	Min. rotation length (yrs)
Spruce	PA	70

Finland

Pine	PS	70
Birch	BT	60
Other broad.	OB	50

The main parameters defining the harvest criteria applied by CBM for Finland are reported on Tab. 33.

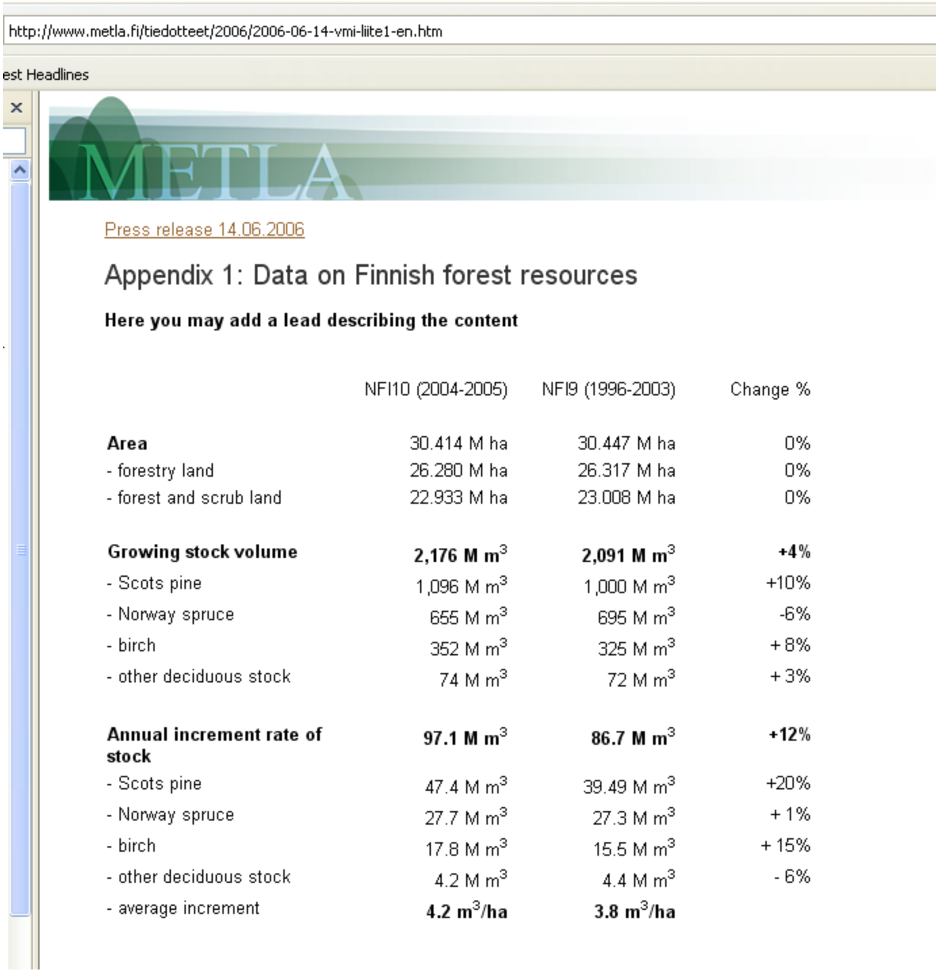
Tab. 33: main parameters defining the harvest criteria applied by CBM for Finland, including the age classes affected by each silvicultural treatment and the relative share of harvest provided by each treatment (average for the historical period).

Silvicultural treatment	Criteria	Harvest share
15% Commercial Thinnings	> 20 yrs	2%
20% Commercial Thinnings	> 20 yrs	10%
30% Commercial Thinnings*	20 - 70 yrs.	4%
Clearcut (95% commercial thinning)	Depending by species	84%
* only applied to PA		

Due to the lack of country-specific data published by literature, we applied the same set of equations selected for Latvia. Species-specific YTs were selected using the total volume and increment reported in Figure 62 combined with the information provided by NFI 9 (Tab. 34).

Tab. 34: volume (m^3 ha^{-1}) and annual increment (CAI, in m^3 ha^{-1} yr^{-1}) derived by country specific data combined with additional information provided by NFI.

FT	Country data	
	Volume	CAI
BT	196.38	8.90
OB	209.91	12.19
PA	147.77	5.51
PS	72.79	2.73



http://www.metla.fi/tiedotteet/2006/2006-06-14-vmi-liite1-en.htm

est Headlines

METLA

Press release 14.06.2006

Appendix 1: Data on Finnish forest resources

Here you may add a lead describing the content

	NFI10 (2004-2005)	NFI9 (1996-2003)	Change %
Area	30.414 M ha	30.447 M ha	0%
- forestry land	26.280 M ha	26.317 M ha	0%
- forest and scrub land	22.933 M ha	23.008 M ha	0%
Growing stock volume	**2,176 M m^3**	**2,091 M m^3**	**+4%**
- Scots pine	1,096 M m^3	1,000 M m^3	+10%
- Norway spruce	655 M m^3	695 M m^3	-6%
- birch	352 M m^3	325 M m^3	+ 8%
- other deciduous stock	74 M m^3	72 M m^3	+ 3%
Annual increment rate of stock	**97.1 M m^3**	**86.7 M m^3**	**+12%**
- Scots pine	47.4 M m^3	39.49 M m^3	+20%
- Norway spruce	27.7 M m^3	27.3 M m^3	+ 1%
- birch	17.8 M m^3	15.5 M m^3	+ 15%
- other deciduous stock	4.2 M m^3	4.4 M m^3	- 6%
- average increment	**4.2 m^3/ha**	**3.8 m^3/ha**	

Figure 62: data reported by METLA web site for NFI 10 (data used by EFISCEN) and NFI 9 (data on increment used by CBM in this study).

Species-specific YTs were selected at national level using the average volume and increment reported by NFI (see Tab. 35 for details).

Finland

Tab. 35: Yield tables applied by CBM model for Finland. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	**Age 1**	**Age 2**	**Age3**	**Age4**	**Age5**	**Age6**	**Age7**	**Age8**	**Age9**	**Age1 0**	**Age1 1**	**Age1 2**	**Age1 3**	**Age1 4**	**Age1 5**	**Age1 6**	**Age1 7**	**Age1 8**
Current	BT	2.0	8.0	12.8	15.1	15.5	14.7	13.2	11.4	9.7	8.0	6.6	5.3	4.3	3.4	0.0	0.0	0.0	0.0
Current	OB	1.3	7.2	13.6	18.1	20.1	20.2	19.0	17.1	15.0	12.8	10.8	9.0	7.4	6.0	0.0	0.0	0.0	0.0
Current	PA	0.8	3.0	5.0	6.4	7.2	7.6	7.7	7.4	7.0	6.5	6.0	5.4	4.9	4.4	0.0	0.0	0.0	0.0
Current	PS	0.6	2.0	2.9	3.5	3.8	3.9	3.8	3.6	3.3	3.0	2.7	2.4	2.1	1.9	0.0	0.0	0.0	0.0
Historic	BT	3.9	23.5	57.7	99.1	140.9	179.3	212.5	239.9	262.1	279.5	293.2	303.7	311.7	317.8	317.8	317.8	317.8	317.8
Historic	OB	6.3	25.8	55.1	90.4	128.6	167.2	204.7	240.2	273.0	302.9	329.8	353.7	375.0	393.6	393.6	393.6	393.6	393.6
Historic	PA	4.4	18.0	38.3	62.6	89.0	115.8	142.1	167.0	190.2	211.4	230.7	248.0	263.4	277.0	277.0	277.0	277.0	277.0
Historic	PS	1.1	6.1	15.0	26.9	40.8	55.7	70.8	85.6	99.7	112.9	125.0	135.9	145.8	154.5	154.5	154.5	154.5	154.5

Finland

The effect of a big storm affecting Finland in 2001 was considered. Based on the information reported by the FORESTORMS[61] database, about 7 million m^3 were damaged; we assumed that: (i) this amount was distributed between PA and PS, according to their proportion in the total forest area; (ii) 15% of the living biomass was damaged by this disturbance (i.e., this was a widespread disturbance event); (iii) all the merchantable biomass damaged by this event was removed as salvage logging; (iv) there was a direct salvage of logging residues, moving 10% of the merchantable biomass to the product sector (i.e., 5% of the living biomass moved to the DOM pools).

Harvest and HWP analysis

The historical FAO statistics are complete since 1961. The total amount of harvest reported by FAOSTAT to 2010 shows the same trend reported by other data sources (Figure 63) but it is, on average, 14% lower than the country's submission for FMRL and 27% lower than the data reported by the last NIR (2013). The differences with the country's submission may be due to the bark fraction while the data reported by the last NIR, may include: (i) bark fraction, (ii) forest residues and non-commercial removals not reported by other statistics. This last fraction will not be considered. The FRA 2010 Country Report[62] only reports complete data for 1990, 2000 and 2005. These figures, referred to the volume over bark, are generally higher than FAOSTAT but lower than the values reported by the last NIR. Therefore, we assumed that FAOSTAT reports the volume under bark and the differences with the data reported by the submission are related to forest residues, even if some inconsistency should be further clarified. After 2010, the Submission for FMRL reports a slightly increasing harvest demand, with a final amount of harvest equal to about 66.1 million m^3 for 2020.

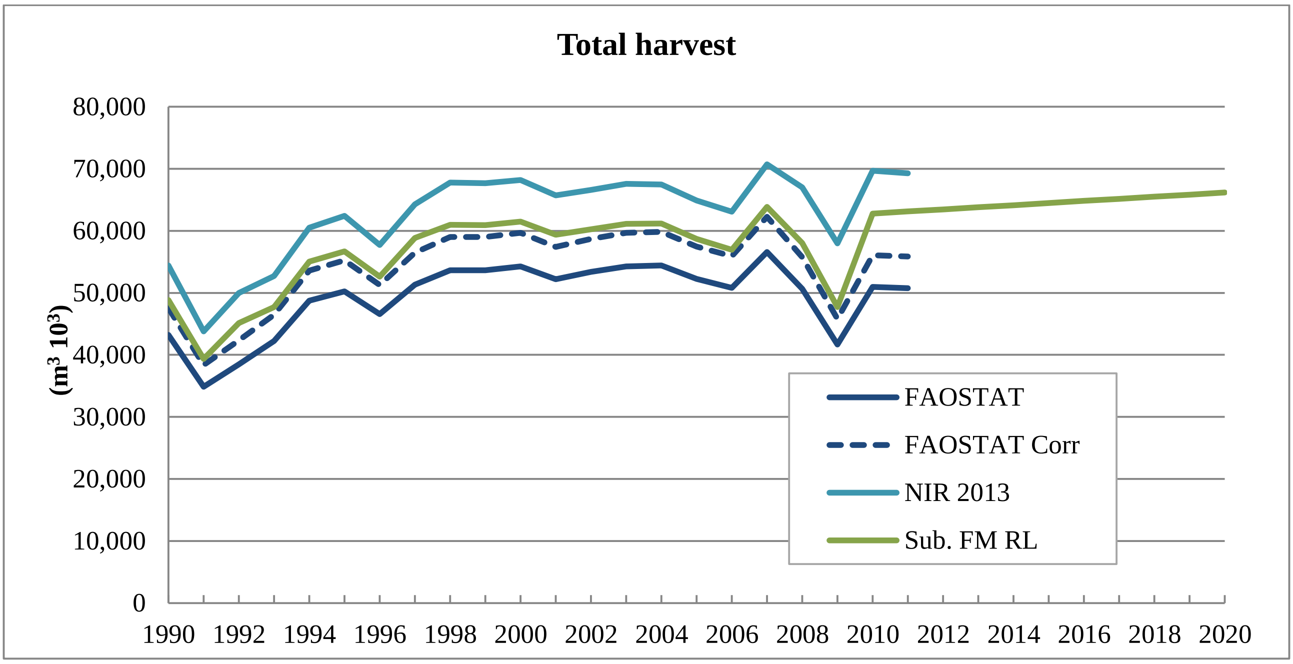


Figure 63: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (under bark), National Submission for FM Reference Level (Sub. FMRL) and the NIR 2013. Assuming a correction factor equal to 1.1 to account for the bark's

[61] http://www.efiatlantic.efi.int/portal/databases/forestorms/

[62] FRA 2010 – Country Report, Finland (page 42), reporting the volume over bark.

fraction, we also reported the FAOSTAT estimates with bark (FAOSTAT Corr). Future harvest demand (i.e., since 2013) is reported according to the National Submission for FM Reference Level.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 64. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

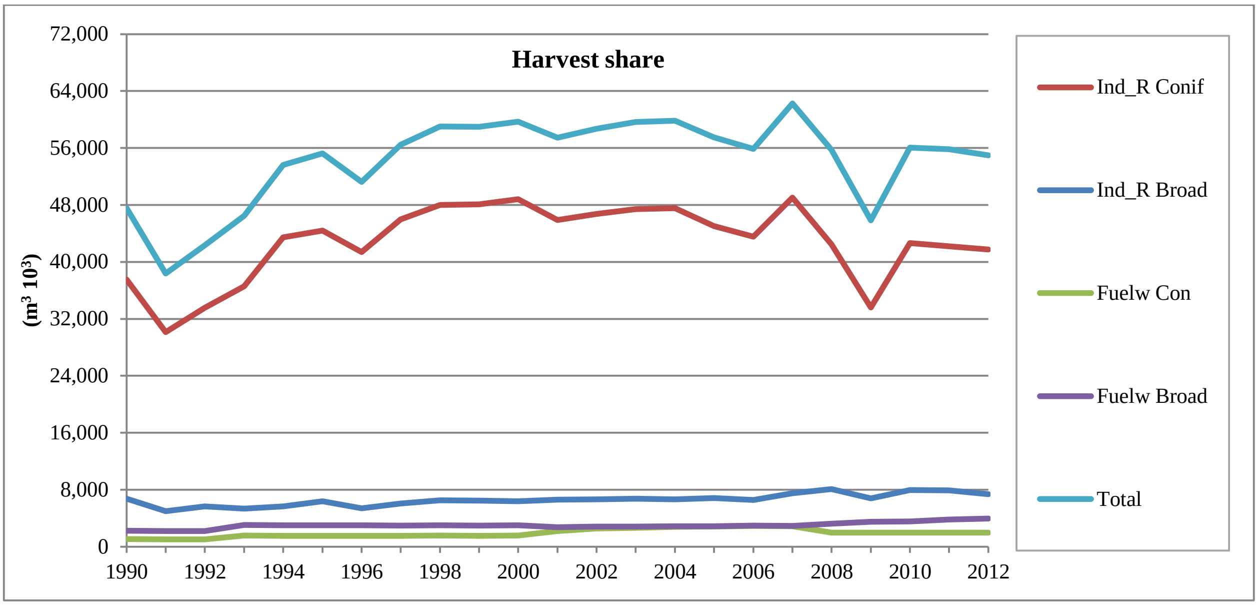


Figure 64: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2012 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 65.

Finland

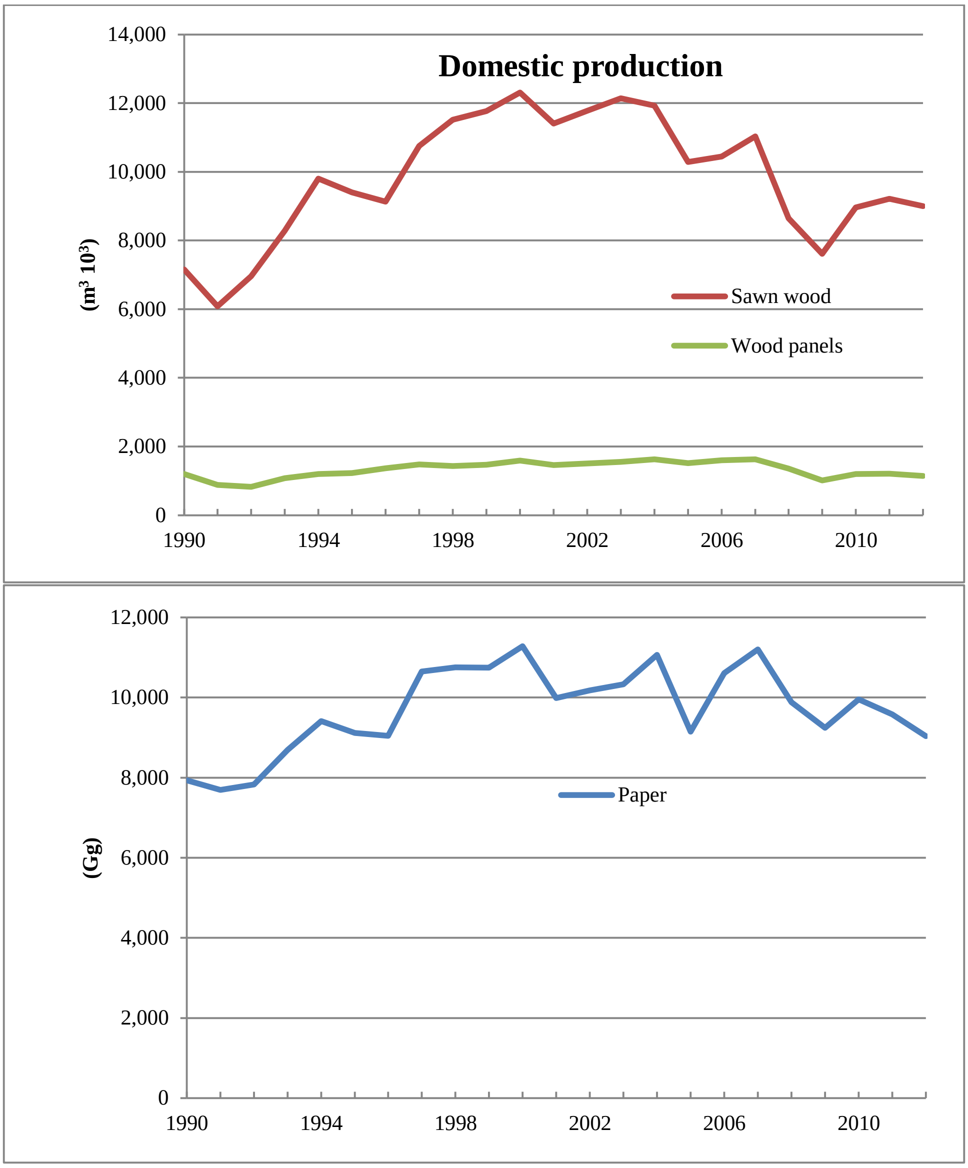


Figure 65: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

France

NFI data and model assumptions

The analysis was based on data provided by NFI 2006-2010[63], reporting a total forest area (referred to the productive forests) equal to about 15,500 kha. In order to apply the CBM model to the original NFI data, the following elaboration was performed:

1. The national age class distribution of the main species (i.e. 14 species) was downloaded by the NFI website (these data are not fully available at regional level). The area not classified for the age (estimated as the difference between the total forest area reported for each species and the area classified according to the age) was distributed between each age class, according to the proportion of area reported by each age class and species.
2. The national age class distribution of the main species according to the main management types (MTs) applied to the France forests (i.e. high forests, coppices and mixed[64] forests) was downloaded. Based on these data the three main MTs cover the following amount of area: 5,988 kha of high forests, 3,135 kha of mixed forests and 897 kha of coppices (i.e., a total of about 10,000 kha). Since, according to the NFI data, the total forest area classified as mixed forest was equal to 4,351 kha and the total forest area classified as coppice was equal to 1,693 kha, a correction factor (equal to 1.88 and 1.38 for coppices and mixed forests, respectively) was applied to the original age class distribution. The national age class distribution by species and MT was therefore defined, maintaining a total forest area of 15,406 kha. All age classes were made uniform to 10-year span.
3. The NFI forest area was scaled to 14,931 kha, i.e., the forest management area reported by the Submission of information on forest management reference level (2011) for 1990.
4. Assuming the year 2008 as NFI reference year, all data were brought back to 1998 and the total amount of FM area was further decreased to 14,586 kha, assuming an annual rate of deforestation equal to 43,000 ha, applied from 1990 to 1998.

Figure 66 shows a summary of the previous steps. The final forest area was distributed between 15 CLUs, as reported in Figure 67. To simplify the model run, input data were aggregated at NUTS 0 (i.e., national) level.

[63] http://www.ifn.fr/spip/?rubrique18

[64] This group includes forests where the coppice and the high forest system are applied on the same area, using different species in a two-stratified forest. The forests having an irregular structure (i.e., about 725 kha) and the forest area not classified for this parameter were not considered and they were distributed between the other MTs.

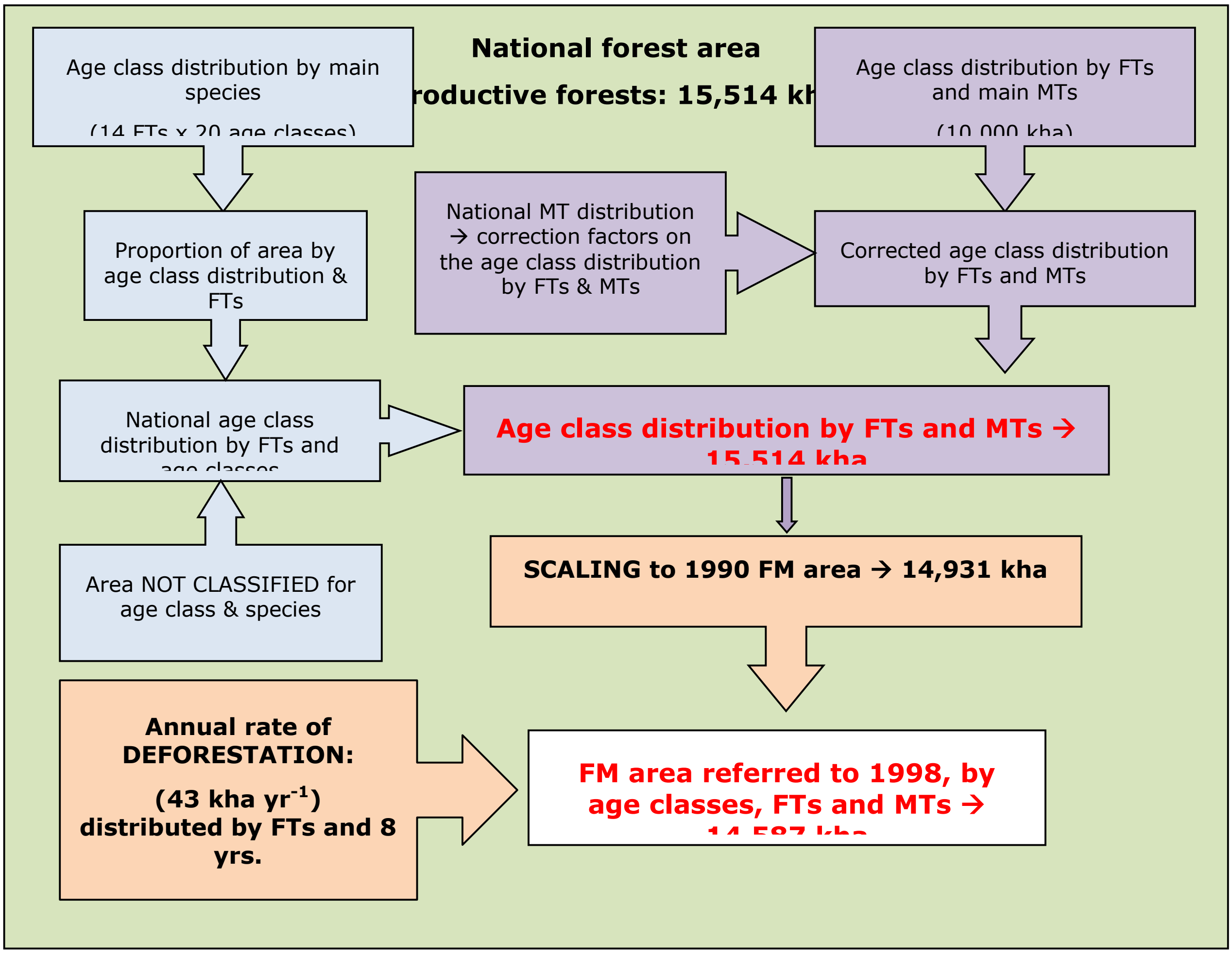


Figure 66: main elaboration steps applied to the original NFI data, in order to distribute the total national forest area between the main species (FTs), age classes and MTs. The NFI forest area was finally scaled to the 1990 FM area and corrected to account for the annual rate of deforestation occurred until 1998 (i.e., the time step 0 assumed by CBM).

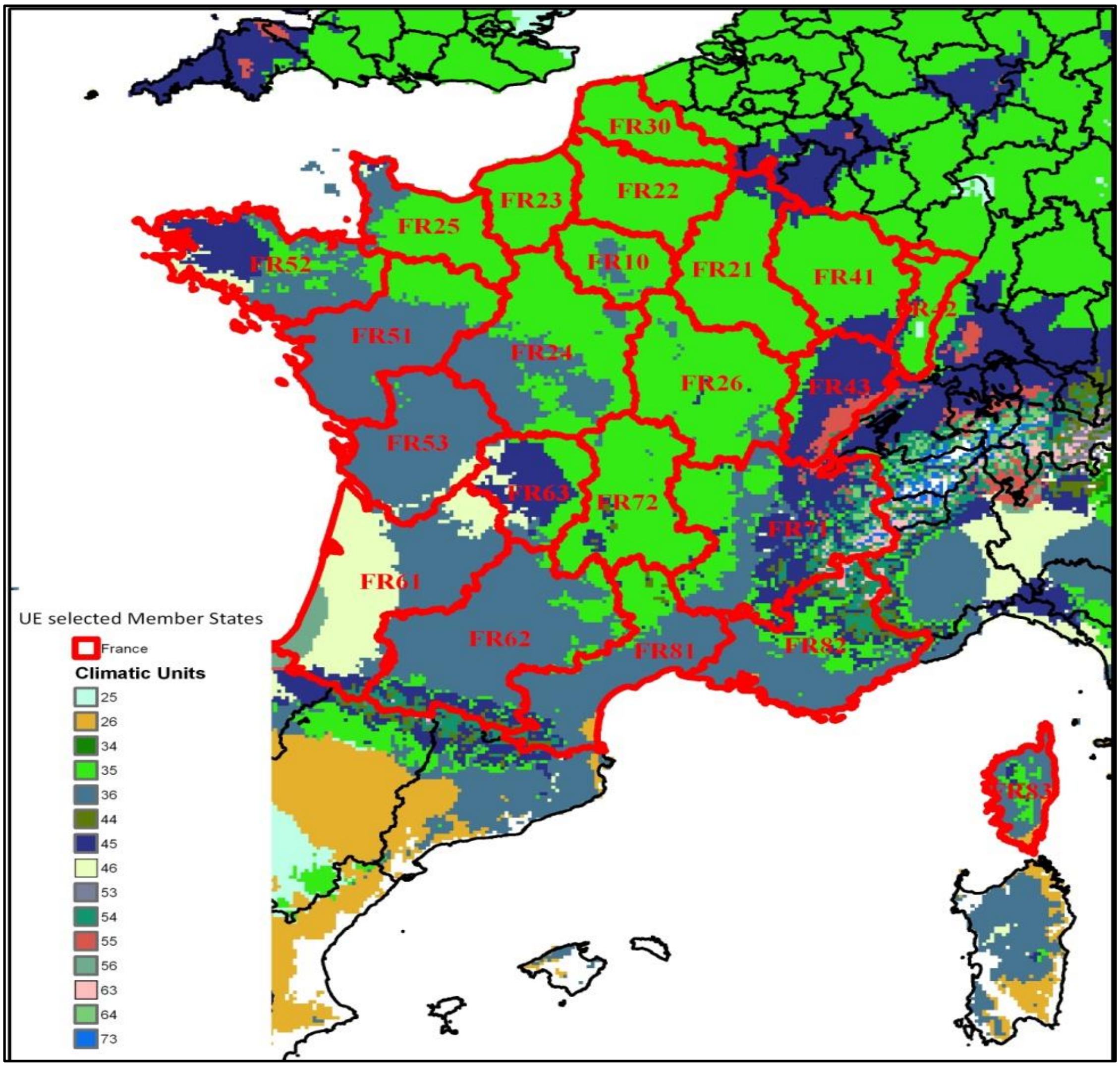


Figure 67: Administrative regions defined at NUTS2 level and CLUs applied to France. To simplify the analysis, input data were aggregated at NUTS 0 (i.e., national) level.

The main species reported in the French NFI were distributed between 10 forest types (see Tab. 37) and the following management types:

1. High forests: according to the data reported by literature and inferred by the NFI, we assumed that:
    a. OB: managed through a simple clearcut regeneration system, applying a minimum rotation length between 90 (until 2008) and 72 years.
    b. QR and FS: managed through a shelterwood regeneration system, applying a final removal cut at the minimum rotation length reported by Tab. 37, and a preliminary cut (i.e., the establishment cut to prepare the seed bed and to create a new age class) 20 years before the final cut. This last cut was simulated through a 30% commercial thinning, while the final cut was simulated through a clearcut[65].

[65] In order to bring back the 1998 age class distribution, applying the Shelterwood system, we assumed that only the species where the original NFI data reported an amount of area with an age > 20 yrs (i.e., where no area was reported for the age class 1 and 2), could be affected by the final cut during the previous 20 years. For these species, the amount of area reported on

c. AA, OC, PA, PM, PS [66] (i.e., coniferous FTs): managed through a clearcut regeneration system applied to small patches (i.e., group clearcutting system). This system was simulated assigning to each FT a percentage (*X*) of merchantable biomass to be removed at the minimum rotation length (*x*) assigned to each FT. *X* was defined as the ratio between the average volume reported by yield tables for the minimum rotation length *x* (V_x) and the volume reported for the minimum age class reported by NFI for each FT (V_y). After each event, a fraction equal to the amount of biomass removed by each stand is moved to the *y* -age class. Further details are reported in Tab. 36.

Tab. 36: main parameters used to define the percentage of biomass removed by group clearcutting applied to coniferous high forests: the minimum rotation length assigned to each FT (x), the minimum age class reported by NFI (y), the average volume reported by yield tables for each age class. The last column reports the fraction of stand-area moved to the y-age class after disturbance.

FT	Min rotation length (x)	Min NFI age class (y)	Average volume ≥ age class x (V_x)	Volume age class y (V_y)	% of merch. biomass removed ≈ (1-V_y/ V_x)*100	Fraction moved to age class y
AA	100 yrs.	40 yrs.	400 m^3	222 m^3	≈ 50%	50%
OC	50 yrs.	20 yrs.	300 m^3	70 m^3	≈ 75%	75%
PA	60 yrs.	30 yrs.	400 m^3	200 m^3	≈ 50%	50%
PM	60 yrs.	20 yrs.	250 m^3	75 m^3	≈ 70%	70%
PS	60 yrs.	30 yrs.	175 m^3	70 m^3	≈ 60%	60%

2. Mixed forests: according to data reported by NFI, this MT was applied to FS, CS, CB, OB and QR. The rotation length applied to the coppice stratum was set to a minimum period of 15 - 20 years and the rotation length applied to the high forest stratum is reported by Tab. 37. Since the data available, did not allow providing separate yield tables for these two strata, during the simulation run they were considered together, applying a 30% commercial thinning to simulate the final cut on the coppice stratum and a 70% commercial thinning to simulate the final cut on the high forest stratum.
3. Coppices: according to the data reported by NFI, this system was applied to CS, OB and QR. We applied a minimum rotation length equal to 20 years.

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the age class 3 (i.e., between 21–30 yrs), was bring back to the final clearcut age reported on Tab. 37, according to the same assumptions proposed for the simple clearcut system.

[66] The minimum age class reported by NFI for these species is 20 yrs. (for OC), 30 yrs. (for PA and PS) and 40 yrs. (for AA). This suggests that no clearcut (at least on wide areas) was applied to these species during the previous 20 – 40 years.

Tab. 37: main species grouped by forest types and management strategies applied to France. The minimum rotation length applied for high forests and mixed forests are also reported.

Main species	FTs	Min. rotation length (yrs)	
		High forests	Mixed forests
Fir	**AA**	**70**	**-**
Hornbeam tree	**CB**	**80**	**80**
Chestnut	**CS**	**80**	**80**
Beech	**FS**	**90* - 72**	**90**
Other broadleaves[67]	**OB**	**90 - 72**	**90**
Other conifers[68]	**OC**	**80**	**-**
Spruce	**PA**	**70***	**-**
Maritime pine	**PM**	**50**	**-**
Scots pine	**PS**	**100***	**-**
Quercus ps (*Q. petrea, Q. pubescens, Q. robur*)	**QR**	**80* - 64**	**80**
*** values referred to the final removal cut applied to the Shelterwood system.**			

After 2012, a reduction of the minimum default rotation length was allowed during the model run.

The main parameters defining the harvest criteria applied by CBM for France are reported on Tab. 38. The table also highlights the distribution of the total harvest demand between the different MTs and silvicutural treatments.

[67] This group also includes *Fraxinus excelsior.*
[68] This group also includes *Pseudotsuga menziesii*.

Tab. 38: main parameters defining the harvest criteria applied by CBM for France, and average amount of harvest provided by each treatment for the historical period (i.e., 2008 – 2013), according to the different management types reported on the last column.

Silvicultural treatment	Harvest share	MT
20% Commercial Thinnings	5%	HF
30% Commercial Thinnings	28%	MF - C
70% Commercial Thinnings	20%	MF
50% - 75% Commercial Thinnings	31%	HF (conifers)
Clear cut	11%*	HF(broadl.)
Salvage logging after Nat. disturbances	5%	
* the harvest share provided by the clearcut on the high forests (including both the cleacut and the Shelterwood system) is strictly related to the original age class distribution provided by the NFI data for the period 1998 – 2008.		

Since no specific data on biomass stock was available at national level, the same equations selected for Italy were applied to France, according to the assumptions reported in Tab. 39.

Tab. 39: association between the France forest types and the default species provided by the original CBM database, based on the selection applied to the Italian case study (the correspondence with Italian FTs is also reported).

FT	**Species selected by default CBM database**	**Correspondence with the Italian FTs**
AA	White spruce (P. glauca)	Fir
CB	Black spruce (Picea mariana)	Hornbeam
CS	Balsam poplar (Populus balsamifera)	Chestnut
FS	Gray birch (Betula populifera)	Beech
OB	Eastern white pine (P. strobus)	Other broadleaves
OC	Red pine (Pinus resinosa)	Other conifers
PA	Red pine (Pinus resinosa)	Spruce
PM	Red pine (Pinus resinosa)	Maritime pine
PS	Red pine (Pinus resinosa)	Scots pine
QR	Basswood (Tilia americana)	Oaks

Species-specific YTs were selected using the average volume and increment reported by NFI. Given that both the volume and increment are referred to trees with Dbh≥ 7.5 cm over bark, a correction factor equal to 1.05 was applied to the first age class to account for the amount of trees under this threshold. No further correction was applied to the original data, since the increment reported by NFI (equal to about 81 million m^3) was consistent with the total gross annual increment (83 million m^3) reported by the NFI's web site[69]; this last figure includes the increment of living biomass and the harvest (as expected by CBM) and excluding the standing dead trees.

Both the historical and the current library applied the high forests and the mixed forests, were directly derived by the average volume (for the historical YTs) increment (for the current YTs) values reported by NFI for each species and age classes, using a combined exponential and power function. This approach ensured a greater consistency between the NFI's original values and the figures applied by CBM. The YTs applied to coppices were derived by the UBALD database, comparing the original data on volume (for the historical YTs) and increment (for the current YTs) reported for each species at national level with the average values reported by the UBALD database. The historical and current libraries are reported in Tab. 40.

To account for the effect of the periodic silvicultural practices applied to coppices (i.e., a 30% commercial thinning) on the DOM pools (i.e., litter and dead wood), we reduced to 5% the mortality on the roots components.

[69] http://inventaire-forestier.ign.fr/spip/IMG/pdf/production.pdf

France

Tab. 40: Yield tables applied by CBM model for France. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	MT	Age1	Age2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16	Age17
Current	AA	H	5.33	8.85	11.04	12.26	12.77	12.78	12.44	11.87	11.14	10.34	9.49	8.64	7.82	7.03	6.29	5.60	4.97
Current	CB	H	7.35	7.03	6.72	6.43	6.15	5.89	5.63	5.39	5.16	4.93	4.72	4.51	4.32	4.13	3.95	3.78	3.62
Current	CS	H	6.88	8.41	8.82	8.69	8.27	7.70	7.06	6.41	5.76	5.15	4.58	4.05	3.57	3.14	2.75	2.41	2.10
Current	DF	H	2.88	10.38	16.09	17.65	16.02	12.91	9.57	6.68	4.45	2.86	1.79	1.09	0.65	0.38	0.22	0.13	0.07
Current	FE	H	4.11	5.34	6.00	6.35	6.51	6.53	6.46	6.32	6.13	5.92	5.68	5.43	5.17	4.91	4.65	4.39	4.14
Current	FS	H	5.73	6.52	6.82	6.90	6.84	6.70	6.51	6.28	6.04	5.78	5.52	5.26	5.00	4.75	4.50	4.25	4.02
Current	OB	H	8.69	8.01	7.20	6.41	5.67	5.00	4.40	3.87	3.40	2.98	2.61	2.28	2.00	1.75	1.53	1.33	1.16
Current	OC	H	4.67	6.49	6.98	6.76	6.17	5.44	4.67	3.94	3.27	2.69	2.19	1.77	1.43	1.14	0.91	0.72	0.57
Current	PA	H	4.81	9.94	13.19	14.59	14.62	13.76	12.39	10.82	9.22	7.70	6.34	5.15	4.14	3.30	2.61	2.04	1.60
Current	PP	H	7.07	7.98	7.97	7.57	7.00	6.36	5.71	5.08	4.49	3.95	3.46	3.02	2.62	2.28	1.97	1.70	1.47
Current	PS	H	6.05	5.75	5.47	5.21	4.95	4.71	4.48	4.26	4.05	3.85	3.67	3.49	3.32	3.15	3.00	2.85	2.71
Current	QP	H	1.49	1.96	2.23	2.38	2.46	2.49	2.49	2.45	2.40	2.33	2.26	2.17	2.08	1.99	1.90	1.81	1.72
Current	QR	H	5.26	5.60	5.70	5.69	5.62	5.51	5.38	5.24	5.09	4.93	4.77	4.61	4.45	4.29	4.13	3.98	3.82

France

Library	FT	MT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16	Age17
Current	QT	H	5.26	5.60	5.70	5.69	5.62	5.51	5.38	5.24	5.09	4.93	4.77	4.61	4.45	4.29	4.13	3.98	3.82
Current	CB	M	7.35	7.03	6.72	6.43	6.15	5.89	5.63	5.39	5.16	4.93	4.72	4.51	4.32	4.13	3.95	3.78	3.62
Current	CS	M	3.95	5.83	6.84	7.30	7.40	7.27	6.97	6.58	6.14	5.66	5.19	4.72	4.27	3.84	3.44	3.08	2.74
Current	FE	M	4.43	6.12	6.85	7.03	6.87	6.53	6.07	5.56	5.04	4.52	4.02	3.56	3.14	2.75	2.41	2.09	1.82
Current	FS	M	5.73	6.52	6.82	6.90	6.84	6.70	6.51	6.28	6.04	5.78	5.52	5.26	5.00	4.75	4.50	4.25	4.02
Current	OB	M	6.90	7.16	6.89	6.43	5.90	5.35	4.83	4.33	3.86	3.44	3.05	2.70	2.39	2.11	1.86	1.64	1.44
Current	QP	M	1.49	1.96	2.23	2.38	2.46	2.49	2.49	2.45	2.40	2.33	2.26	2.17	2.08	1.99	1.90	1.81	1.72
Current	QR	M	5.26	5.60	5.70	5.69	5.62	5.51	5.38	5.24	5.09	4.93	4.77	4.61	4.45	4.29	4.13	3.98	3.82
Current	QT	M	5.26	5.60	5.70	5.69	5.62	5.51	5.38	5.24	5.09	4.93	4.77	4.61	4.45	4.29	4.13	3.98	3.82
Current	CB	C	4.73	5.48	5.70	5.79	5.82	5.81	5.77	5.71	5.65	5.57	5.48	5.39	5.30	5.21	5.11	5.01	4.91
Current	CS	C	7.38	9.57	10.16	10.30	10.20	9.98	9.67	9.32	8.94	8.54	8.14	7.74	7.35	6.96	6.59	6.23	5.88
Current	FE	C	0.79	4.68	8.88	11.27	11.80	11.07	9.69	8.12	6.59	5.24	4.10	3.17	2.43	1.86	1.41	1.07	0.81
Current	FS	C	22.06	28.24	14.28	5.87	2.26	0.85	0.32	0.12	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Current	OB	C	4.54	18.91	17.63	10.25	5.01	2.28	1.01	0.44	0.19	0.08	0.04	0.02	0.01	0.00	0.00	0.00	0.00
Current	QP	C	5.18	9.30	7.72	5.23	3.25	1.93	1.13	0.65	0.37	0.21	0.12	0.07	0.04	0.02	0.01	0.01	0.00

France

Library	FT	MT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16	Age17
Current	QR	C	6.53	26.18	23.65	13.42	6.42	2.87	1.25	0.54	0.23	0.10	0.04	0.02	0.01	0.00	0.00	0.00	0.00
Current	QT	C	22.73	34.32	12.51	3.37	0.85	0.21	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Historic	AA	H	0	36.5	97.2	162.0	222.8	275.9	319.6	353.7	378.5	394.8	403.6	405.8	402.6	394.9	383.7	369.6	353.5
Historic	CB	H	0	41.6	75.3	102.9	125.3	143.3	157.4	168.2	176.2	181.7	185.1	186.7	186.9	185.7	183.5	180.4	176.6
Historic	CS	H	0	40.4	91.9	138.4	175.7	203.4	221.9	232.5	236.5	235.2	229.7	221.1	210.3	198.1	184.9	171.4	157.8
Historic	FS	H	0	17.8	45.3	75.5	105.7	134.4	161.1	185.1	206.4	224.8	240.4	253.3	263.6	271.6	277.4	281.1	283.1
Historic	OB	H	0	37.9	65.1	91.4	115.6	137.0	155.1	169.8	181.1	189.2	194.5	197.3	197.9	196.6	193.9	189.9	184.9
Historic	OC	H	0	16.8	72.5	160.1	245.4	301.4	320.8	310.0	280.7	243.5	205.8	171.9	143.2	119.8	101.2	86.3	74.4
Historic	PA	H	0	40.6	114.1	192.7	264.2	323.2	367.7	398.1	415.5	421.7	418.8	408.5	392.7	372.8	350.3	326.1	301.3
Historic	PM	H	0	31.9	75.3	118.1	156.8	189.8	216.9	238.1	253.8	264.6	271.0	273.6	273.0	269.7	264.2	257.0	248.3
Historic	PS	H	0	14.2	41.1	71.8	102.1	129.7	153.3	172.5	187.1	197.6	204.1	207.1	207.2	204.7	200.2	194.0	186.5

France

Library	FT	MT	Age1	Age2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age9	Age1 0	Age1 1	Age1 2	Age1 3	Age1 4	Age1 5	Age1 6	Age1 7
Historic	QR	H	0	18.0	41.4	65.7	89.3	111.2	131.0	148.5	163.5	176.3	186.7	195.1	201.6	206.3	209.5	211.3	211.9
Historic	CB	M	0	58.0	85.1	105.3	121.7	135.3	146.8	156.8	165.4	172.9	179.3	185.0	189.8	194.0	197.6	200.7	203.3
Historic	CS	M	0	27.0	74.3	122.6	164.4	196.4	218.4	230.9	235.4	233.3	226.3	215.5	202.3	187.6	172.1	156.4	141.1
Historic	FS	M	0	0.4	4.8	19.0	44.5	79.0	117.4	154.5	185.8	208.6	222.0	226.2	222.2	211.9	196.9	178.9	159.4
Historic	OB	M	0	35.4	68.5	97.0	120.4	138.7	152.4	162.0	167.9	170.8	171.1	169.3	165.8	161.0	155.2	148.6	141.6
Historic	QR	M	0	46.6	68.4	89.3	108.7	125.9	140.7	153.0	163.0	170.6	176.3	180.1	182.4	183.3	183.2	182.1	180.2
Historic	CB	C	0	27.4	60.4	84.3	99.8	109.2	114.9	118.3	120.3	121.4	122.1	122.1	122.1	122.1	122.1	122.1	122.1
Historic	CS	C	0	32.8	71.7	102.1	123.6	138.1	147.7	154.0	158.1	160.8	162.5	162.5	162.5	162.5	162.5	162.5	162.5
Historic	FE	C	0	11.5	38.8	62.2	77.4	86.2	90.9	93.5	94.8	95.5	95.9	95.9	95.9	95.9	95.9	95.9	95.9
Historic	FS	C	0	27.4	60.4	84.3	99.8	109.2	114.9	118.3	120.3	121.4	122.1	122.1	122.1	122.1	122.1	122.1	122.1
Historic	OB	C	0	38.8	57.8	60.2	60.4	60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5
Historic	QP	C	0	14.8	32.5	44.6	51.8	55.9	58.2	59.4	60.1	60.5	60.7	60.7	60.7	60.7	60.7	60.7	60.7

France

Library	FT	MT	Age1	Age2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age9	Age1 0	Age1 1	Age1 2	Age1 3	Age1 4	Age1 5	Age1 6	Age1 7
Historic	QR	C	0	21.6	52.3	67.0	72.4	74.2	74.9	75.1	75.1	75.2	75.2	75.2	75.2	75.2	75.2	75.2	75.2
Historic	QT	C	0	44.4	79.1	86.5	87.8	88.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0

France

The effect of three main disturbance events due to wind storms were included in the model run, according to the following assumptions:

- <u>1999 Wind storm</u> (so called *Lothar*): according to the data reported by the European Storms Catalogue[70], the storm affected about 968,000 ha of forests (no specific data was available on the spatial distribution of this disturbance) and about 176 Mm^3. During the model run, the effect of this event, occurred between 26th and 28th December 1999, was directly shifted to 2000. The following drivers were considered:
    - The original age class distribution reported by NFI for 2008 does not report any significant amount of area in the first age class (i.e., < 10 yrs); we therefore assumed that the event had an impact on a large area (i.e., about 1 million of hectares of forests) but was not a "stand -replacing" disturbance event.
    - The disturbance matrix assigned to this event was modified to ensure that the final amount of area affected by the storm was equal to about 960 kha and the total amount of living biomass damaged was equal to about 176 million m^3, as reported by literature (see Tab. 41). We finally assumed that about 25% of the living biomass moved to the DOM pool and about 4.5% of the merchantable biomass was directly moved to the HWP pool as direct salvage logging applied in 2000.
    - Looking in detail to the HWP demand, we highlighted that in 2000 both the conifers and broadleaves industrial roundwood demands were considerably higher than in 1999. The average amount of harvest reported by statistics for 1999 (i.e., the year before any salvage logging on the trees damaged by the storm) and 2003 (i.e., 3 years after the disturbance event, when we assumed that the salvage of logging residues was negligible), was assumed as average amount of harvest provided by common silvicultural practices applied to conifers (i.e., 18.08 million m^3) and broadleaves (i.e., 10.61 million m^3). The difference between these values and the amount of harvest reported by statistics for 2000 (i.e., 26.31 and 13.17 million m^3 for conifers and broadleaves, respectively) was assumed as provided by a direct salvage logging applied in 2000. This amount, equal to 8.23 and 2.56 million m^3 for conifers and broadleaves, respectively was further converted to t of C, assuming an average wood density equal to 0.40 and 0.55 for conifers and broadleaves, respectively. The resulting C amount was distributed proportionally to the FT's area.
    - A further amount of harvest is collected in 2001, 2002 and 2003 through a second salvage logging treatment, assuming that each year a proportion of the total forest area damaged by the storm (i.e., about 968 kha) is treated by a second salvage logging. The final amount of harvest provided through these treatments was not directly defined as amount of merchantable C but is a consequence of the salvage of logging residues transferred by the merchantable to the dead wood steam pools during the storm and of the amount of area (i.e., δ in Tab. 41) affected by the salvage logging ((i.e, the final amount of harvest is $\gamma=f(\delta)$)). We assumed that 55% of the C stocked into this last pool was moved to the HWP pool during the second salvage logging treatment[71] .
- <u>2009 Wind storm</u>: according to the data reported by the Appendix 3 of the final report of the project "Destructive Storms in European Forests: Past and Forthcoming Impacts", this event affected about 684,000 ha of which about 234,000 ha had more than 40% damaged trees. The total damaged volume (about 43 million m^3) was mainly represented by maritime pine in the age class 20-40 yrs. old. To account for the effect of this storm the following drivers were considered:

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[70] http://w3.pierroton.inra.fr/IEFC/bdd/storm/storm_liste.php

[71] Since the Spatial Units affected by the storm disturbance event during the model run were sorted randomly, the final amount of area affected by this event and the amount of harvest removed by the second salvage logging could slightly vary between different model runs.

- As for the previous case, we assumed that the event had an impact on a large area but was not "stand -replacing".
- Based on the additional information provided by literature about 200,000 ha of maritime pine in the age class 20 -40 yrs were affected by the disturbance event and about 40% of the damaged trees were represented by these stands. A similar volume - according to literature - and - based on our assumptions - a similar area (i.e., 200,000 ha) belongs to other coniferous FTs disturbed by this storm. The remaining 20% of the damaged trees was represented by other broadleaves FTs, distributed, - based on our assumptions - over about 84,000 ha. The total forest area affected by the disturbance event, represented by a disturbance matrix affecting about 30% of the living biomass, is equal to 484,000 ha, i.e., about 60% of the entire area disturbed (i.e., 684,000 ha). This is a compromise between the area affected by high damages (i.e., 234,000 ha, where 40% of the standing volume was damaged) and the area affected by low damages (i.e., about 200,000 ha). The amount of harvest provided by direct salvage logging in 2009, is function of the share of area affected by the disturbance event (i.e., according to Tab. 41 δ_4), assuming that about 4.5% of the merchantable biomass was moved to the HWP pool.
- A further amount of harvest is collected in 2010, 2011 and 2012 through a second salvage logging treatment, assuming that each year a proportion of the total forest area damaged by the storm (i.e., about 484 kha) is treated by a second salvage logging. The final amount of harvest provided through these treatments (i.e., γ) was not directly defined as amount of merchantable C but is a consequence of the salvage of logging residues transferred by the merchantable to the dead wood steam pools during the storm event. As for the previous case, we assumed that 55% of the C stocked into this last pool was moved to the HWP pool during the second salvage logging treatment[72] .

2010 Wind storm: according to the data reported by the European Storms Catalogue[73], the storm damaged about 0.26 Mm^3. As for the previous disturbances, we assumed that about 5% of the merchantable biomass was directly moved to the HWP sector. Further amount of biomass may be removed in 2011 and 2012 through salvage of logging residues, modelled as in the previous case study.

[72] Since the Spatial Units affected by the storm disturbance event during the model run were sorted randomly, the final amount of area affected by this event and the amount of harvest removed by the second salvage logging could slightly vary between different model runs.
[73] http://w3.pierroton.inra.fr/IEFC/bdd/storm/storm_liste.php

Tab. 41: area (in kha) and volume (m3 106) affected by storms in 1999 and 2009, compared with the total amount of industrial roundwood removals reported by FAO statistics for conifers and broadleaves. The columns on model assumptions report the amount of harvest (in m3 106 distinguished between conifers and broadleaves) removed (according to our assumptions) by common management practices and by salvage of logging residues (this amount was also estimated as t C in 2000). The last columns report the amount of area (in kha) affected by a second salvage logging (after the year of disturbance).

	STATISTICS				MODEL ASSUMPTIONS							
Year	STORMS		FAOSTAT Harvest		Conifers removed by			Broadleaves removed by			Second-Salvage logging	
	Area	Vol	Conif	Broad	Ma. Pract.	Salv. logging		Man. Pract.	Salv. logging		% of area with salv. logging	Area (δ)
	kha	Volume (m^3 10^6)			Volume (m^3 10^6)		t C 10^3	Volume (m^3 10^6)		t C 10^3		Kha
1998	0	0.00	17.94	11.48	17.94	0.00	0	11.48	0.00	0		
1999	968	176.0	18.18	11.68	18.18	0.00	0	11.68	0.00	0		
2000	"	"	26.31	13.17	18.08	8.23	1,645	10.61	2.56	705		
2001	0	0.00	22.90	10.89	22.90- γ_1	$\gamma_1=f(\delta_1)$		10.89- γ_1	$\gamma_1=f(\delta_1)$		30%	$\delta_1=293$
2002	0	0.00	19.85	9.54	19.85- γ_2	$\gamma_2=f(\delta_2)$		9.54-- γ_2	$\gamma_2=f(\delta_2)$		25%	$\delta_2=244$
2003	0	0.00	17.98	9.48	17.98- γ_3	$\gamma_3=f(\delta_3)$		9.48	0.00	0	20%	$\delta_3=195$
2004	0	0.00	18.57	9.62	18.57	0.00	0	9.62	0.00	0		
…	0	0.00	…	….	….	…	0	…	…	0		
2009	684	43.10	20.92	8.16	20.92- γ_4	$\gamma_1=f(\delta_4)$		8.16	0.00	0		$\delta_4=484$*
2010	-	0.26	21.26	8.37	21.26- γ_5	$\gamma_5=f(\delta_5)$		8.37	0.00	0	30%	$\delta_5=88$
2011	0	0.00	19.59	8.80	19.59- γ_6	$\gamma_6=f(\delta_6)$		8.80	0.00	0	25%	$\delta_6=61$
2012	0	0.00	21.48	8.32	21.48- γ_7	$\gamma_7=f(\delta_7)$		8.32	0.00	0	20%	$\delta_7=39$

* *Total amount of area affected by storm in 2009 (based on model's assumptions) and by the direct salvage logging*

Harvest and HWP analysis

The historical FAO statistics are complete since 1961. The total amount of harvest reported by FAOSTAT to 2010 is consistent with the data reported in the country's submission for FMRL. The data reported by the FRA 2010 Country Report[74] are consistent (even if not the same) with FAOSTAT and they are referred to the volume over bark. We therefore assumed that even FAOSTAT reports the volume over bark and the differences with the country's submission are

[74] FRA 2010 – Country Report, France (pag. 83), reporting the volume over bark.

mainly due to forest residues. The data reported by the last NIR (2013), are, on average, 40% lower than the data reported by the other sources.

After 2010, the Submission for FMRL reports a slightly increasing harvest demand, with a final amount of harvest equal to about 63.3 million m^3 for 2020.

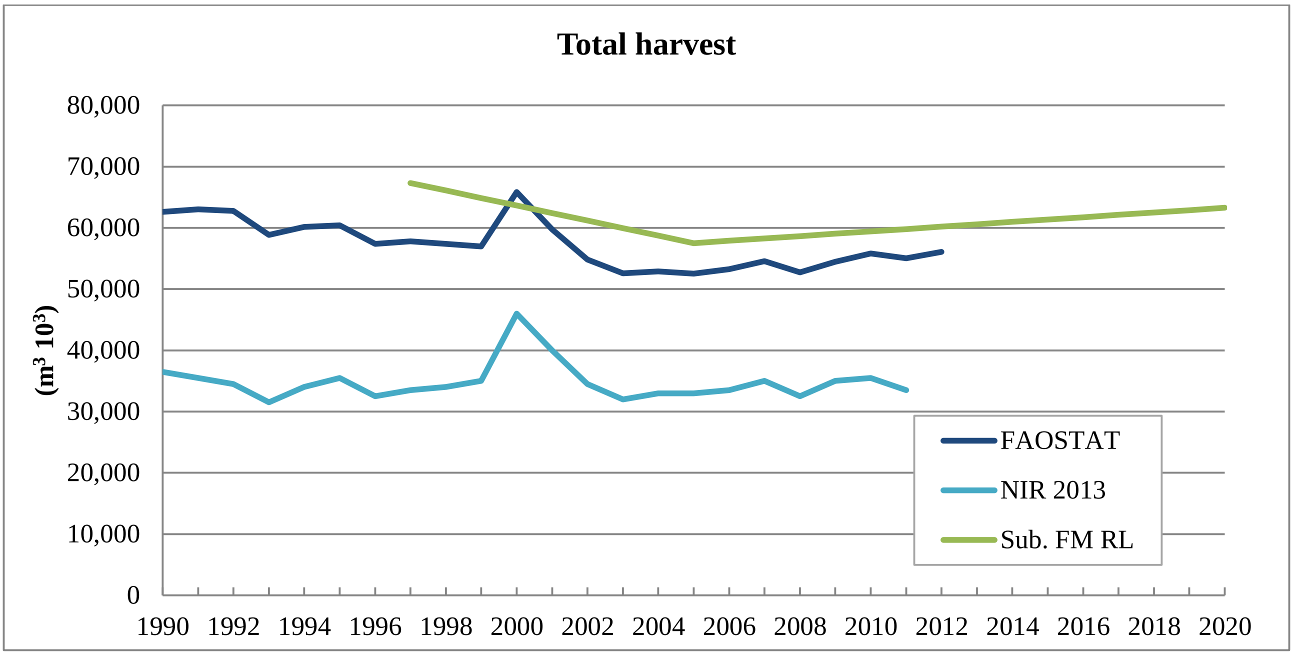


Figure 68: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (over bark), the National Submission for FM Reference Level (Sub. FMRL) and the NIR 2013. The figure also reports the future harvest demand for the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is in Figure 69. These data, corrected to account for the OWCs (see materials and methods) can be used as input by CBM for the historical period (i.e., until 2012).

France

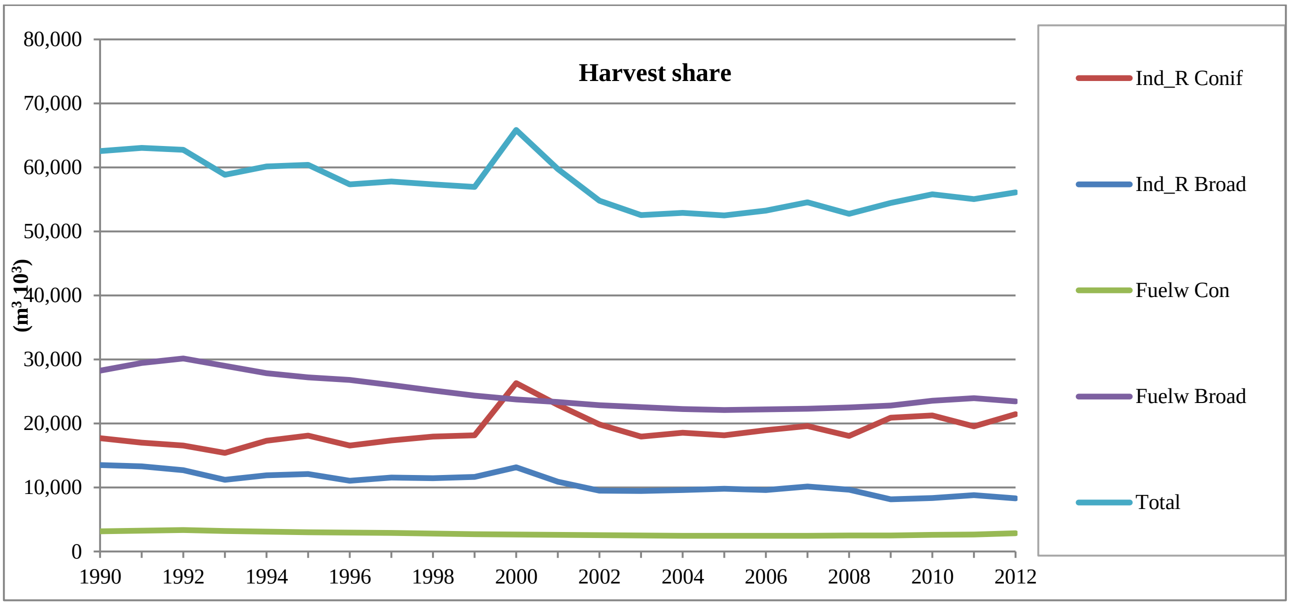
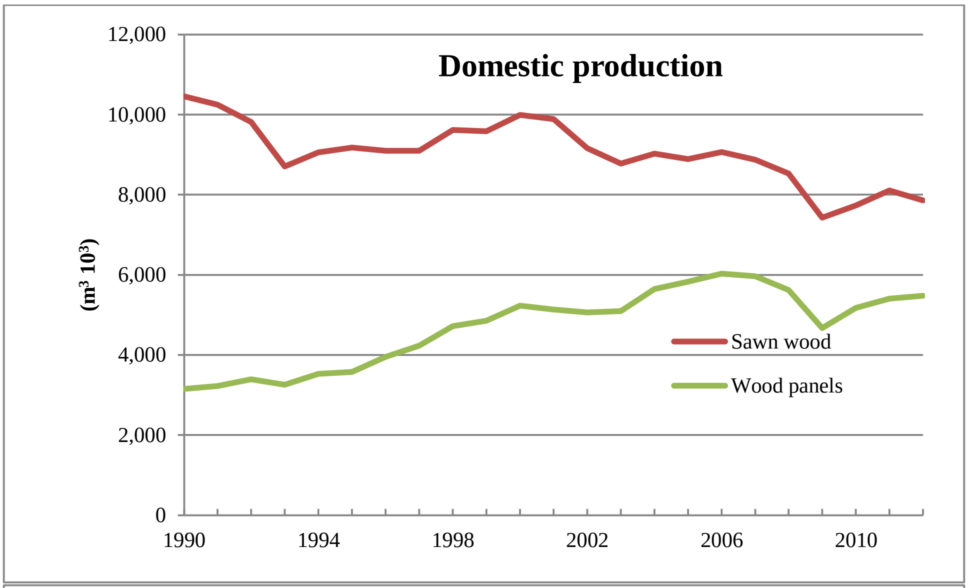


Figure 69: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 70.

France



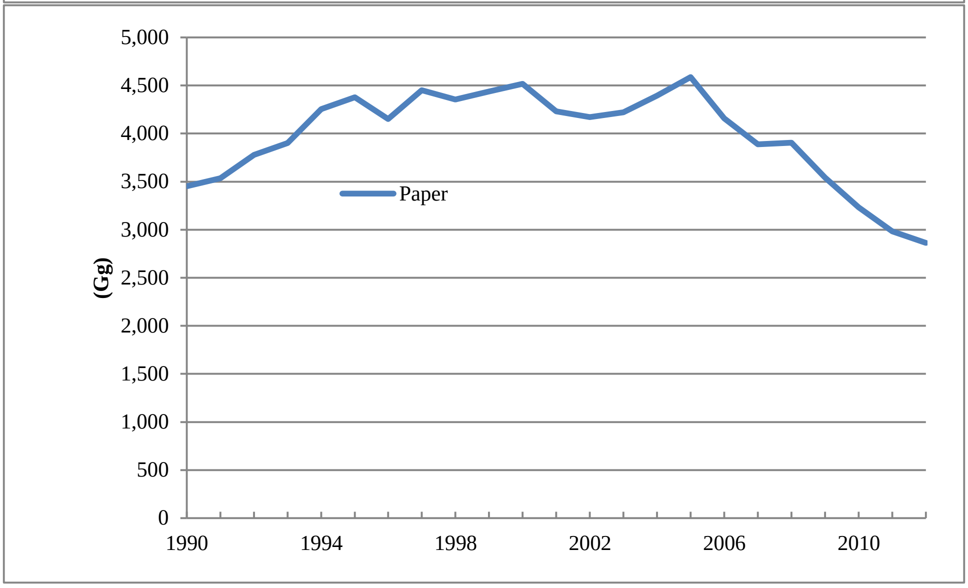


Figure 70: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Germany[75]

NFI data and model assumptions

The analysis was based on data provided by the German NFI 2 (referred to 2002). The total area reported by NFI, equal to 10,320 kha, was scaled to the 1990 FM area reported by Germany (i.e. 10,651 kha). All data were brought back to 1992 and the total amount of FM area was further decreased to about 10,629 kha, assuming an annual rate of deforestation equal to 11,170 ha yr^{-1}, applied from 1990 to 1992. All age classes were made uniform to 10 years. The total forest area was aggregated at national level and distributed between 16 Climatic units (Figure 71):

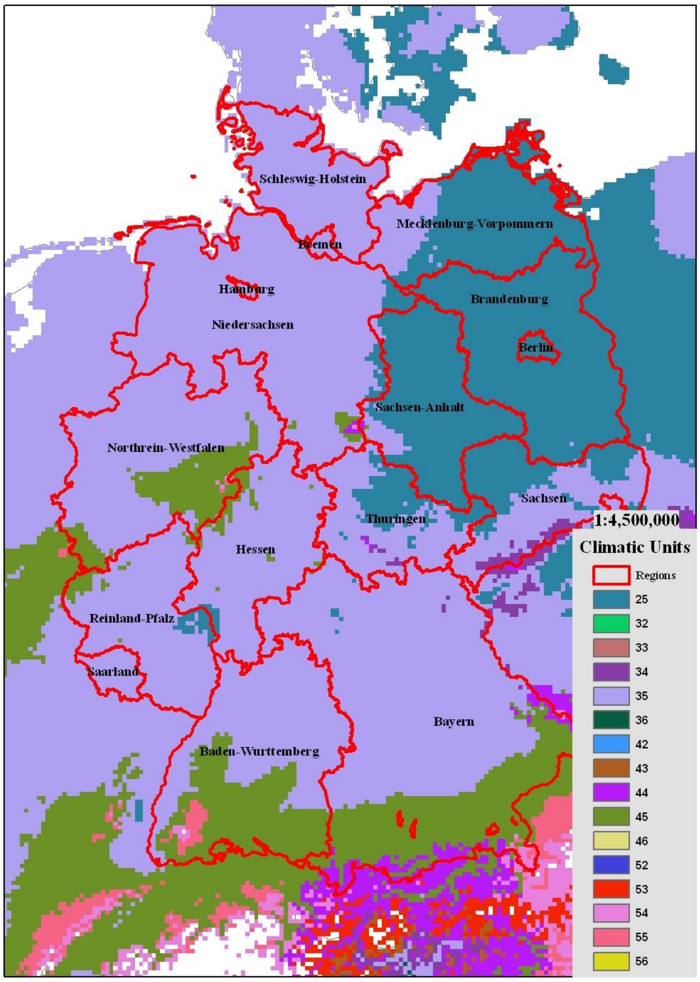


Figure 71: the figure reports the geographical distribution of the CLUs applied by CBM model for Germany. The analysis was performed at country level.

In order to select specific equations, species–specific equations from the literature (Zianis, et al, 2005; Wirth et al., 2004, and other equations76) were applied to the average volume

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[75] A specific analysis on case study is reported by Pilli et al., 2016a

[76] Zianis, D., Muukkonen, P., Mäkipää, R., Mencuccini, M., 2005. Biomass and stem volume equations for tree species in Europe. Silva Fennica 4.

Wirth, C., Schumacher, J., Schulze, E.D., 2004. Generic biomass functions for Norway spruce in Central Europe. A meta-analysis approach toward prediction and uncertainty estimation. Tree Physiology 24, 121-139.

reported by NFI. This allowed to estimate the total aboveground biomass stock for each FT and to select the equation that minimizes the difference between the figures derived by NFI and the ones provided by the default CBM dataset (Tab. 42).

Tab. 42: Forest types (FT) applied to Germany, equations selected by the default CBM database (the original Canadian species are reported) and clearcut rotation length applied to each FT.

Forest type	Acronym	Species selected by default CBM database	Rotation length (yrs)
Fir	**AA**	Pinus banksianae	**100 - 160**
Beech	**FS**	Acer saccharum	**140 - 160**
Larch	**LD**	Larix laricina	**100 – 160**
Other deciduous short life	**OB_S**	Salix nigra	**40 - 180**
Other deciduous long life	**OB_L**	Acer negundo	**80 - 180**
Spruce	**PA**	Picea abies	**80 - 160**
Pseudotsuga menziesii	**PsM**	Pinus resinosa	**100 - 160**
Scots pine	**PS**	Pinus contorta	**130 - 160**
Oak	**QR**	Ostria virginiana	**150 - 200**

All forests were reported as even-aged high-forests and assumed as pure forests. The silvicultural system was based on clear-cut and thinnings. The minimum rotation lengths (Tab. 42) were based on data reported by the Germany's NIR. After 2010, a 10% reduction of the default rotation length was allowed during the model run.

The main parameters defining the harvest criteria applied by CBM for Germany are reported on Tab. 44.

Tab. 43: main parameters defining the harvest criteria applied by CBM for Germany, including the age classes affected by each silvicultural treatment and the relative share of harvest provided by each treatment (average for the historical period).

Silvicultural treatment	Criteria	Harvest share
20% Commercial Thinnings	15 – 120 yrs	7%
30% Commercial Thinnings	30 - 150 yrs.	9%

Germany

35% Commercial Thinnings*	> 45 yrs.	38%
Clearcut (95% commercial thinning)	Depending by species	39%
Salvage logging after storm events	Depending by specific events	≈ 4%
* Clearcut applied to small areas, only applied to PA		

Species-specific YTs were selected using the average volume and increment reported by NFI (see , Tab. 44). Figure 72 reports a comparison between the CAI (in mc ha^{-1} yr^{-1}) applied by CBM model for the current YTs and the CAI reported by NFI. These last values were corrected to account for the amount of young plants that do not reach the minimum *Dbh* threshold (7 cm) during one year (Tomter et al., 2012).

Germany

Tab. 44: Yield tables applied by CBM model for Germany. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16	Age17	Age18
Current	**AA**	6.9	12.2	16.2	18.9	20.7	21.7	22.2	22.0	21.7	20.9	20.1	19.1	18.0	16.9	15.7	14.6	13.6	12.4
Current	**PsM**	11.0	18.2	22.9	26.2	28.0	28.9	29.2	28.8	28.0	27.0	25.8	24.3	23.0	21.5	20.0	18.5	17.2	15.8
Current	**FS**	2.8	6.1	9.2	11.6	13.5	14.8	15.5	16.0	16.1	15.8	15.4	14.8	14.1	13.3	12.5	11.6	10.9	9.9
Current	**LD**	5.8	10.6	13.8	15.7	16.6	16.6	16.1	15.4	14.2	13.1	11.9	10.6	9.5	8.4	7.4	6.4	5.6	4.9
Current	**OL**	3.3	6.8	9.8	12.0	13.7	14.7	15.1	15.3	15.1	14.6	14.0	13.3	12.5	11.6	10.8	9.9	9.1	8.2
Current	**OS**	3.3	6.4	8.6	10.2	11.2	11.8	12.1	11.9	11.7	11.2	10.7	10.1	9.4	8.8	8.1	7.4	6.8	6.2
Current	**PA**	6.8	12.7	16.8	19.7	21.4	22.1	22.3	21.7	21.0	20.0	18.7	17.4	16.1	14.7	13.4	12.2	11.0	9.9
Current	**PS**	5.5	8.3	10.0	10.9	11.3	11.5	11.3	11.0	10.6	10.0	9.4	8.9	8.2	7.7	7.1	6.5	6.0	5.4
Current	**QR**	3.4	5.8	7.5	8.8	9.6	10.3	10.5	10.7	10.7	10.6	10.4	10.0	9.8	9.3	8.9	8.5	8.1	7.6
Historic	**AA**	2	23	72	145	232	322	408	486	553	610	658	696	727	752	771	787	799	808
Historic	**PsM**	16	61	124	197	274	352	427	498	563	623	677	725	768	807	840	870	896	918
Historic	**FS**	11	47	100	160	219	274	322	363	397	426	448	467	482	494	503	510	516	521
Historic	**LD**	7	33	76	129	186	244	299	349	395	435	470	501	527	549	568	583	596	608

Germany

Historic	**OL**	3	17	43	79	122	169	217	264	309	352	391	426	458	487	512	535	554	571
Historic	**OS**	16	42	70	101	133	165	197	229	260	291	320	349	376	403	428	453	476	499
Historic	**PA**	16	57	116	183	254	324	391	453	510	562	608	649	685	717	744	768	789	807
Historic	**PS**	25	73	126	177	223	264	299	328	352	372	388	402	413	421	428	434	439	443
Historic	**QR**	28	78	132	181	224	259	288	310	328	342	353	362	368	373	377	380	382	384

Germany

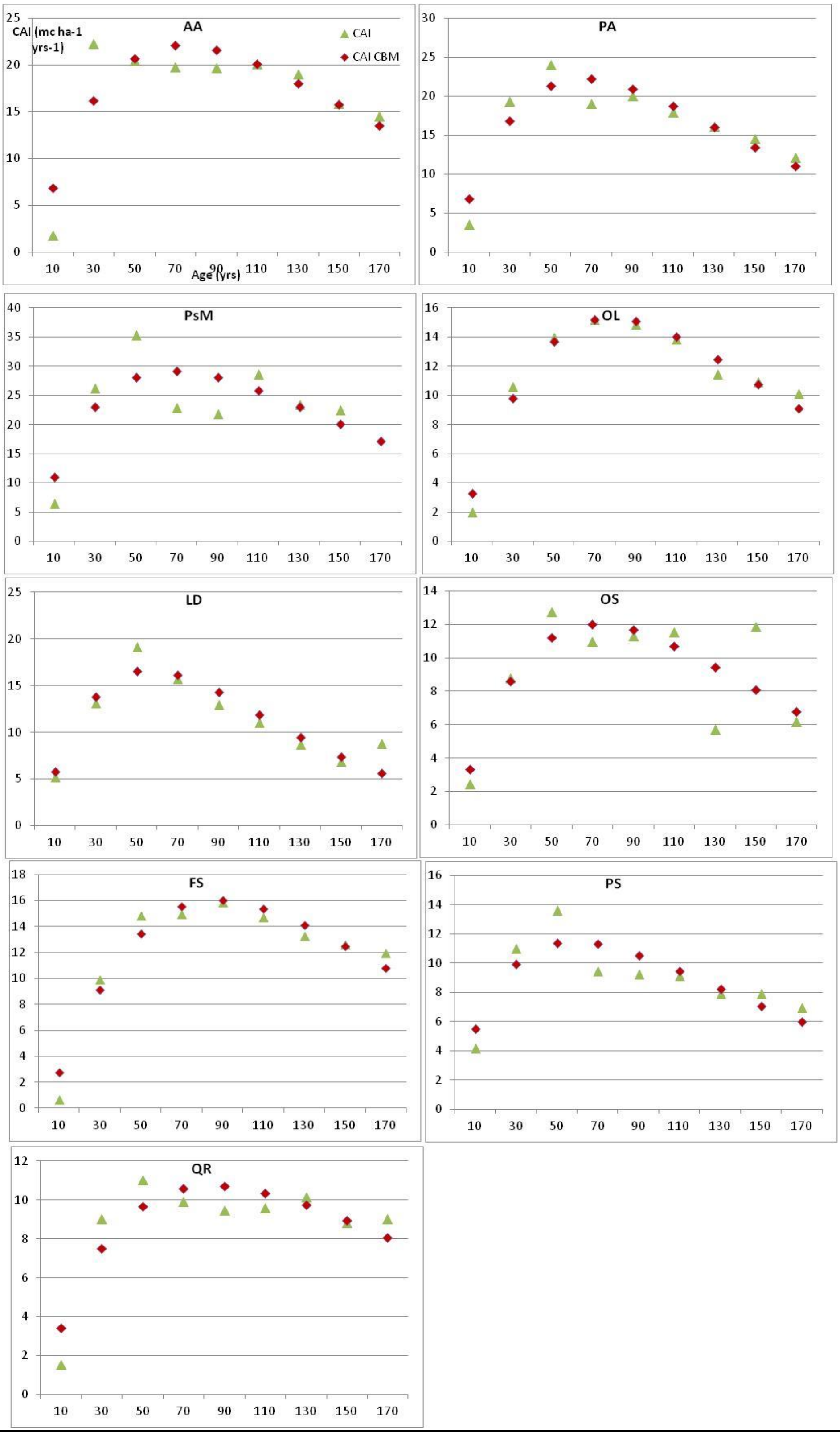


Figure 72: comparison between the CAI (in mc ha^{-1} yr^{-1}) applied by CBM model for the current YTs and the CAI reported by NFI.

The effects of the main disturbance events due to wind storms were included in the model run (Tab. 45).

Germany

Tab. 45: volume damaged by storms, according to information reported by FORESTORMS database[77].

Year	Volume damaged
1992	-
1993	-
1994	2,680,000
1995	1,330,000
1996	-
1997	900,000
1998	-
1999	34,290,000*
2000	-
2001	-
2002	-
2003	-
2004	-
2005	-
2006	-
2007	37,000,000
2008	-
2009	-
2010	3,590,000
* The effect of this storm, occurred on December 1999 was postponed to 2000	

Comparing the amount of primary damaged volume reported by the FORESTORMS database with the total harvest amount per year, we can apply the following assumptions (see also Figure 73):

a. Considering that the storms in 1999 and 2007 had a clearly identified effect on the annual amount of harvest referred to conifers industrial roundwood (HWP at year T= 2000 for storm 1999 and 2007 for storm 2007), we estimated the average amount of harvest excluding salvage logging in year T (Hwp_T^*), as:

$$Hwp_T^* = HWP_{T-1} - HWP_{T+1}$$

b. The difference between HWP_T (i.e. the original harvest demand) and Hwp_T^*, estimated for the disturbance events of 2000 and 2007 (for the other storms no effect on the total amount of harvest can be highlighted) represents the amount of salvage logging, i.e., about 17.6 Mm^3 and 14.8 Mm^3, removed in 2000 and 2007, respectively.

[77] http://www.efiatlantic.efi.int/portal/databases/forestorms/

c. From these two events, we estimated the average percentage amount of salvage logging, equal to 46% of the volume damaged and we applied this percentage to the other disturbance events.

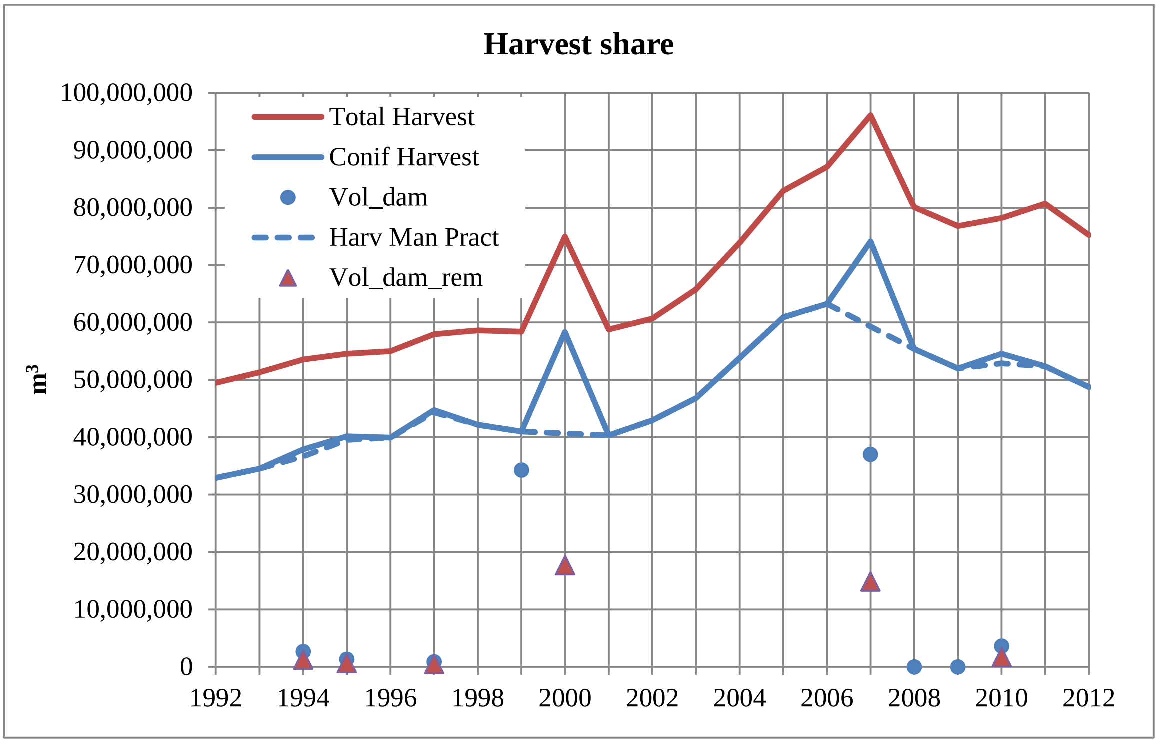


Figure 73: total harvest demand (in m^3) applied to Germany (Total Harvest) between 1992 and 2012, further distinguished between: the total amount of harvest provided by conifers (Conif Harvest), the amount of harvest damaged (Vol_dam, as reported in Tab. 45), the volume removed as salvage of logging residues (Vol_dam_rem) and the volume provided by usual management practices (Harv Man Pract).

The effect of storms was modelled through three different disturbance events applied to model run: (i) a stand replacing-storm disturbance event; (ii) a widespread-storm disturbance event and (iii) a specific disturbance event for salvage of logging residues during the 3 years following the storm.

a. In the stand replacing-storm disturbance event, we assumed that on average 46% of the aboveground merchantable biomass moved to the HWP pool (salvage logging) and the remain part to DOM pool; this disturbance has a direct effect on the age class distribution and was modelled taking into account the evolution of the age class distribution in the first 10 years, i.e., according to the total area reported in the first age class of the original age class distribution for spruce. We assumed that this event affected spruce forests between 70 and 80 yrs old (i.e., the average age of spruce forests in 2002). This assumption allowed to reconstruct the age class distribution expected in 2002, starting from 1992, considering that part of the area reported into the first age class in 2002 was also affected by a storm.
b. The widespread-storm disturbance event, was modelled assuming that only 50% of the existing living biomass is disturbed; also in this case, 46% of the aboveground merchantable biomass (i.e., about 23% of the total aboveground biomass) moves to the HWP pool and the remaining 54% (i.e., about 27% of the total aboveground biomass) moves to DOM pools. This event was applied into the same *i*-year of the stand replacing-storm but to a different area and it does not affect directly the age class distribution. While the stand replacing-storm was set based on the area (i.e., hectares), the effect of the widespread-storm (DSL_W_i directly expressed as tones of carbon) was estimated as

the difference between the total amount of biomass expected to be removed by direct salvage logging in the *i*-year (DSL_T_i) and the amount of biomass already provided by the stand-replacing storm in the same year (DSL_R_i):

$$DSL\_W_i = DSL\_T_i - DSL\_R_i$$

c. A further amount of harvest can be provided during the 3 years following the storm event, moving 60% of the stem snag biomass (coming from the widespread-storm) to the HWP pool. This salvage-logging disturbance has no effect on living biomass and it was set as a maximum amount of forest area affected by this disturbance per year, equal to 50,000 ha yr^{-1} (i.e., about 1/3 of the maximum forest area affected by the widespread-storm events in 2000 and 2007)

The storm occurred in December 1999 was directly applied to the year 2000.

Harvest and HWP analysis

The historical FAO statistics are complete since 1961. FAOSTAT reports the same amount of harvest reported by the last NIR (2013) to 2010 (Figure 74). The data, however, are on average 48% lower than the data reported by the country's submission for FMRL. Based on additional information provided by the country's experts (Joachim Rock, pers. com.) we assumed that data reported by the submission for FMRL represent the net harvest removals from forests, excluding residues. According to the additional information reported by the submission and by the NIR, official statistics should exclude the bark's fraction (10%), harvesting losses (about 10%) and forest wood residues remaining on the forest site, which are generally assumed as 15% of the total amount of harvest. These three compartments may justify about 35% of the difference detected between the submission and FAOSTAT. The remaining amount, equal on average to 13% of the total amount of harvest reported by FAOSTAT, may be related to a general underestimation of FAOSTAT, also reported by the NIR (2013). The FRA 2010 Country Report [78] also highlight that official statistics are underestimated; the values reported by this document are 33%, 11% and 38% higher than FAOSTAT, for 1991, 2000 and 2010, respectively. Considering all these issues, we applied to the original data a year by year correction factor for the period 1991 – 2009 (i.e., the historical period reported by the country's submission), equal to the ratio between the values reported by FAOSTAT and by the submission (this ensured a full consistency between the two datasets for this period) and an average CF equal to 1.44 to the previous (i.e., before 1991) and following (i.e., since 2010) periods, in order to account for bark the general underestimation of FAO statistics.

After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 104.0 million m^3 for 2020.

[78] FRA 2010 – Country Report, Germany (pag. 42), reporting the volume over bark.

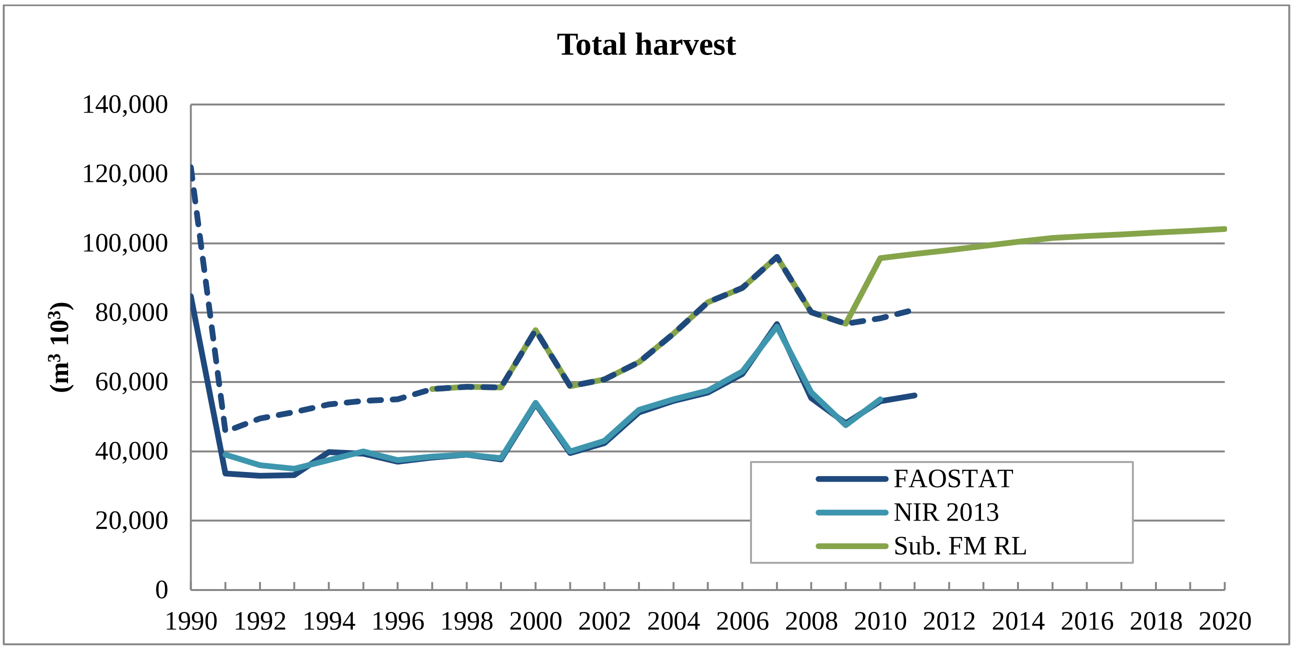


Figure 74: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (under bark), the National Submission for FM Reference Level (Sub. FMRL) and the NIR 2013. Assuming a year by year CF for the period 1991 – 2009 and an average CF equal to 1.44 for the following period to account for the bark's fraction and for the general underestimation of FAO statistics, we estimated the FAOSTAT corrected estimates (FAOSTAT Corr). The figure also reports the future harvest demand as from the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 75. These data, corrected to account for the OWCs (see materials and methods) can be used as input by CBM.

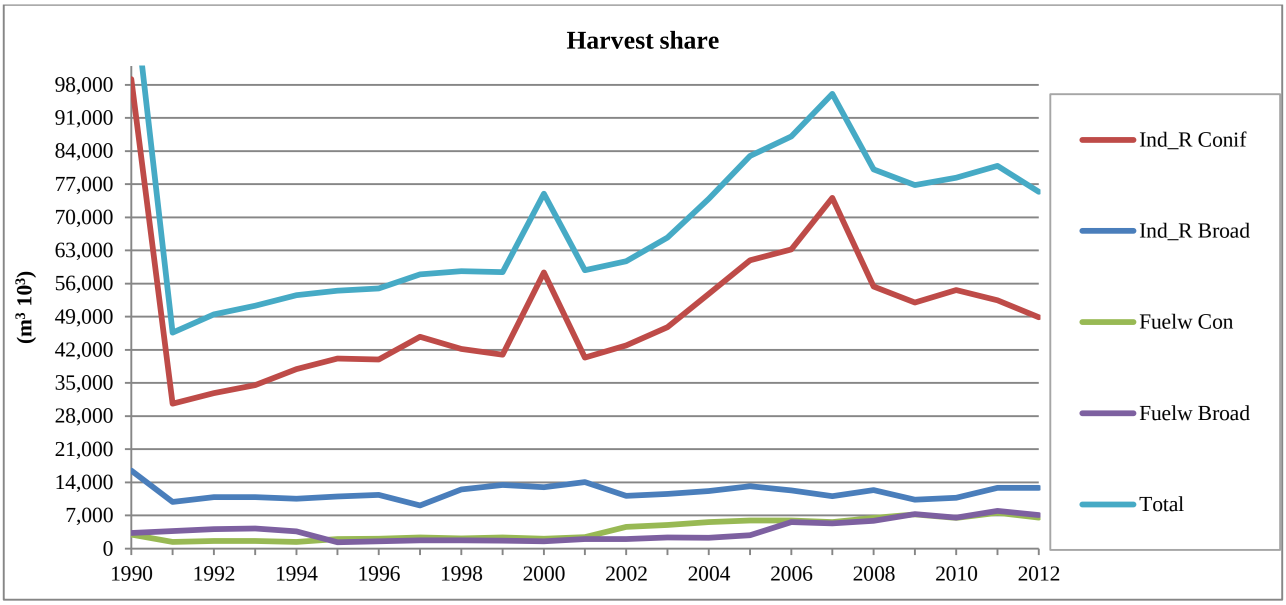


Figure 75: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest is equal to the FAOSTAT estimates, corrected for bark.

Germany

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 76. Please note that no correction was applied to these data to account for possible underestimation of official FAO statistics.

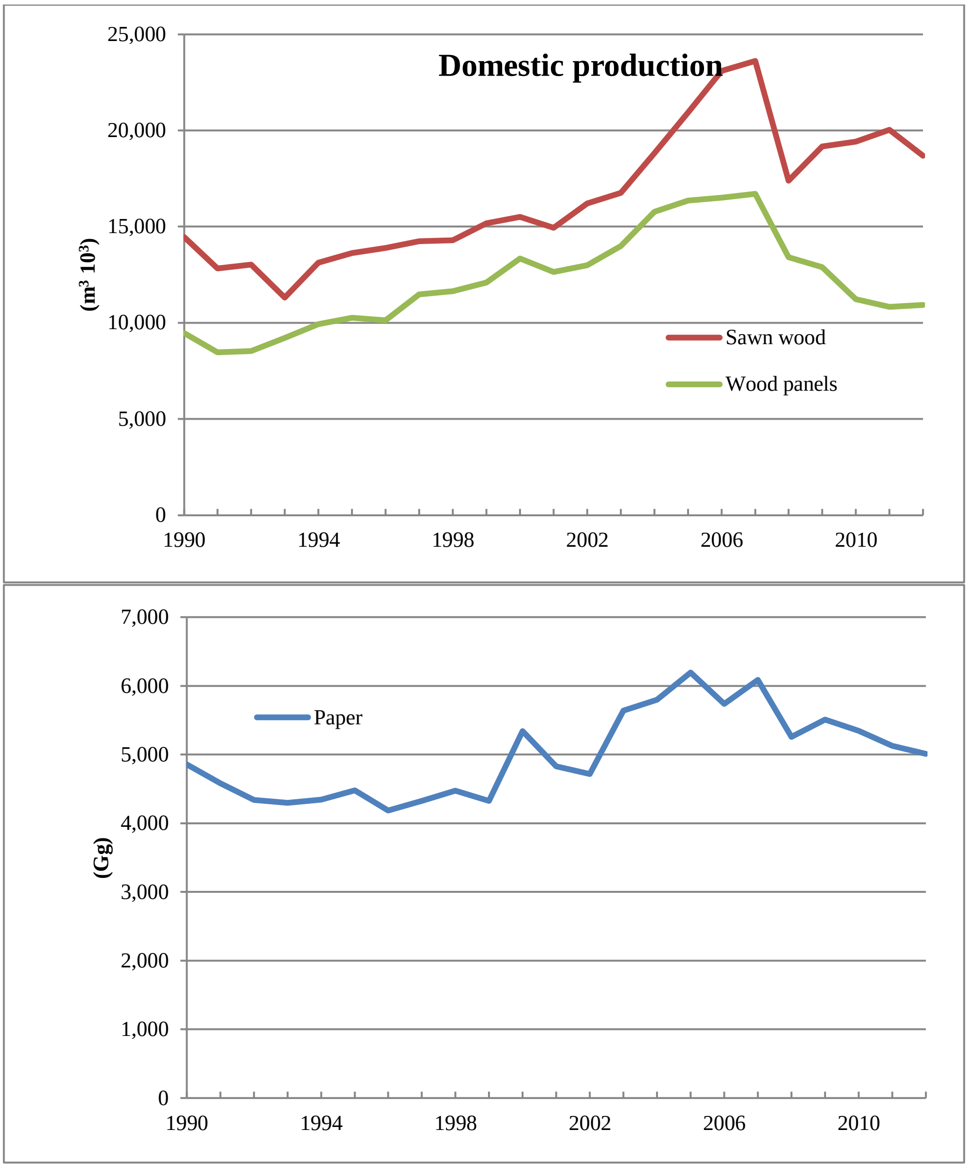


Figure 76: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Greece[79]

NFI data and model assumptions

The analysis was based on data directly provided by the country. The forest area was distributed between 13 Climatic units as reported by Figure 77, without any further distribution at regional level.

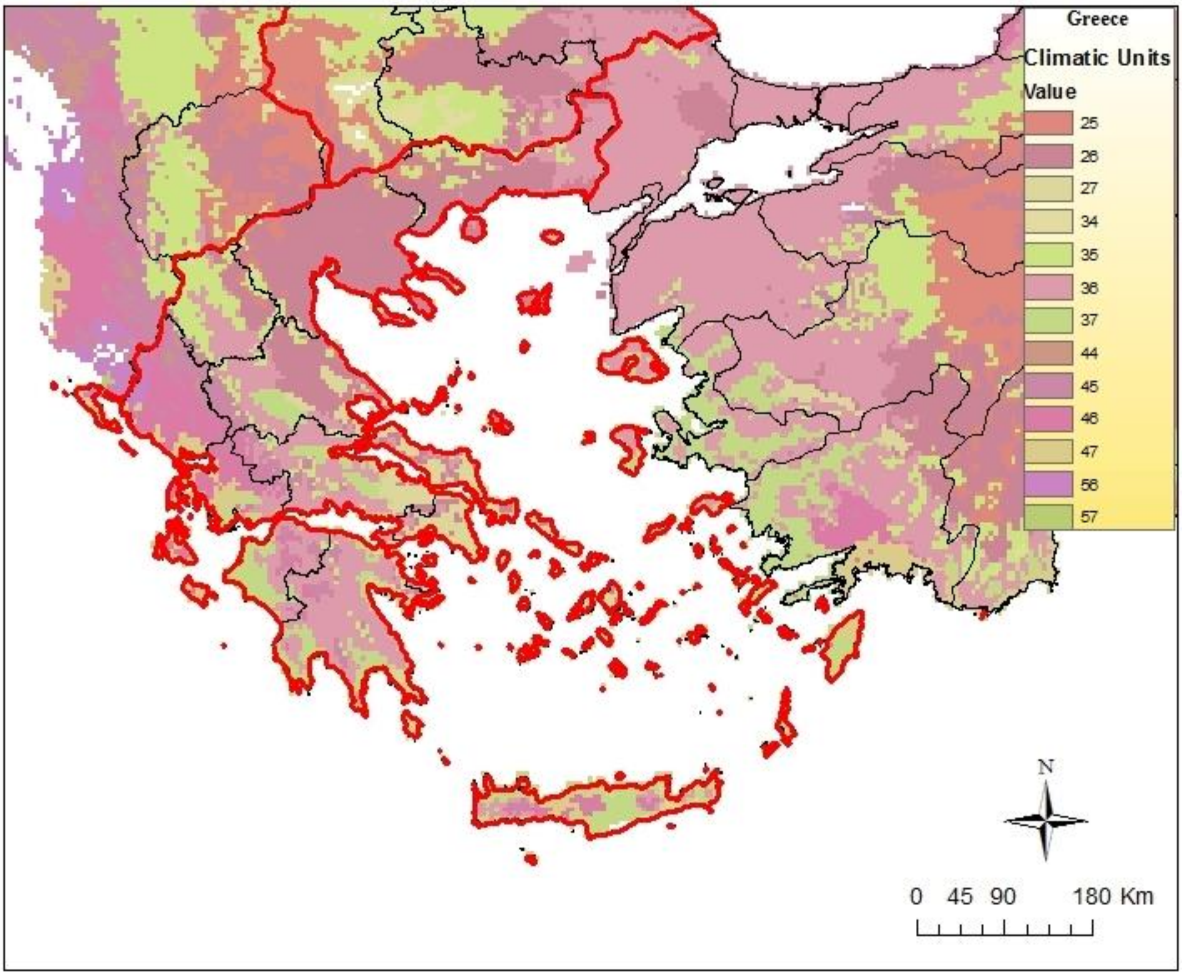


Figure 77 Administrative regions defined at NUTS2 level and CLUs applied to Greece. Please note that the analysis was performed at country level.

Since the Forest Management area (equal to about 1,219 kha) is fully covered by Management Plans, the model requirements were derived from these plans, according to the following assumptions:

a. Forest area: Since the most common silvicultural practices are based on partial-cuts treatments, the forest area can be assumed as uneven-aged. The model used as input data the total forest area distinguished between the main forest types (i.e., the main species) at country level.
b. Volume and increment data were collected by FM plans. Using for both parameters the same set of plans, it was estimated, for each forest type, the average volume

[79] The analysis was developed in collaboration with Iordanis Tzamtzis who provided specific information for this country. Greece highlighted that all the data provided may be used only by the JRC and only in the context of the cooperation in order to run the CBM model for Greece.

and increment per ha, using the total forest area of each forest type as weighting factor. No further distinction between regions was considered for the increment and the volume data.

c. Reference year: since the model needs a reference year as time step zero, the average (using the total forest area of each plan as weighting factor) of the years assigned to each plan as "field measurement year" was used as reference to run CBM.
d. Historical fire disturbances were considered, distributing the total burned area between managed/unmanaged forests.
e. Harvest: data on the total (i.e., at country level) amount of harvest per year were provided by the country

The assumptions on the input data are summarized in Tab. 46.

Tab. 46: the table summarizes some additional information provided by Greece and further assumptions by JRC.

Input data	Additional information provided by country	Further assumptions by JRC.
Volume and Increment data	They were estimated using the total forest area of each forest type as weighting factor	
Reference year	It was estimated using the total forest area of each plan as weighting factor	
Fires data	They are provided at country level, since no further information are available. They are referred to the total forest area (FM + area not managed). No data on the amount of biomass burned per ha is available.	
Harvest	The data are referred to the net amount of harvest (i.e., excluding forest residues left into the forest) and they include the bark fraction	We assumed that they are referred to the FM area, since they are considerably lower than the data reported by FAO statistics and by the Submission for FM RL
Increment data	The data are referred to the net annual increment and the minimum Dbh threshold is 10 cm	

Greece

The original data (Tab. 47) based on the Forest Management plans were scaled to the FM area reported by NIR (2013), equal to 1,219 kha minus 2 times the annual rate of deforestation reported by Greece, equal to 2.3 kha yr^{-1} (i.e., the final area was equal to 1,214 kha). Assuming the 1992 as reference year for the information reported by forest plans, the model was run between 1992 and 2030. All the forests types (FTs) were assumed as uneven-aged high.

Greece

Tab. 47: the table reports the original input data provided by Greece: the total forest area reported by forest management plans (ha), the average volume per ha (m^3 ha^{-1}) and the net annual increment (m^3 ha^{-1} yr^{-1}). All values are distributed between regions and the main species. The first column reports the CBM forest types (FTs) assigned to each species. The last row reports the total area and the average volume and increment values.

Input parameters		**Original forest area reported by Forest Plans (ha)**										**Vol.**	**Increment**
CBM FTs	**NUTS 2** / **Main Species**	**GR11**	**GR12**	**GR13**	**GR14**	**GR21**	**GR23**	**GR24**	**GR25**	**GR41**	**Total**	(m^3 ha^{-1})	(m^3 ha^{-1} yr^{-1})
AA	**Abies sp.**	409	353	625	77,396	11,250	0	123,875	50,827	0	264,736	202	4.32
PA	**Picea abies**	978	0	0	0	0	0	0	0	0	978	442	5.59
PN	**Pinus sp .**	54,596	29,103	53,016	15,087	18,880	3,885	33,500	3,790	1,441	213,299	154	6.58
FS	**Fagus sp.**	50,515	79,364	62,605	43,459	12,416	0	1,132	0	0	249,492	200	7.19
QI	**Quercus sp.**	336,939	190,267	82,837	103,774	20,769	7,963	32,794	1,960	0	777,305	50	2.33
OB	**Other Deciduous**	14,355	4,972	815	737	282	0	445	40	0	21,646	39	1.38
CS	**Castanea sativa**	0	4,350	0	481	18	332	620	0	0	5,801	75	4.29
PO	**Populus sp.**	0	1,632	0	0	0	0	0	0	0	1,632	110	7.60
TOTAL & AVERAGE VALUES		457,793	310,042	199,898	240,935	63,615	12,180	192,366	56,617	1,441	1,534,888	115*	4.06*

* Average weighting values, estimated using the area as weighting factor

Greece

In order to convert the volume to biomass, each FT was linked to a set of equation (named "reference species", reported by Tab. 48), based on a preliminary selection performed on the Italian case study (Pilli et al., 2013).

Tab. 48: main species (i.e., FT) considered by CBM and "reference species", based on the Italian case study, used to convert the volume to tons of carbon. The last columns reports the basic wood density (based on IPCC, 2006) used to convert the volume to dry biomass (to estimate the harvest demand).

Acronyms	Reference species based on Italian case study	Wood density (t dry matter/m^3 fresh volume)
AA	*Abies alba*	0.40
PA	*Picea abies*	0.40
PN	*Pinus nigra*	0.42
FS	*Fagus sylvatica*	0.58
QI	*Quercus ilex*	0.58
OB	*Other broadleaves*	0.50*
CS	*Castanea sativa*	0.48
PO	*Other broadleaves*	0.35
* average values of the other species		

Species-specific yield tables (YTs) were selected using the data of volume and increment provided by Greece for each FT. Since these data were referred to a minimum Dbh threshold equal to 10 cm, a general correction factor equal to 1.07 was applied.

Due to the major importance of forest fires in Greece, these were taken into consideration as the main natural disturbance in the country. Assuming that the total forest area in Greece is equal to about 3,354 kha and the FM area is equal to 1,219 kha, we scaled the total amount of forest area affected by fires to 36%, as reported by Figure 78. The burned area was finally distributed between different FTs according to the relative amount of area. The effect of fires was simulated through a *Not-Stand Replacing* disturbance event, i.e. the forest area was only partially affected by fire and the stand maintains the current age class after the disturbance event. In this case, we assumed that 50% of the living biomass was burned and, taking into account the information directly provided by the country, salvage of logging residues was <1% of the merchantable biomass. The remaining merchantable biomass (i.e., about 99%) moves to the DOM pool.

After 2012, we assumed a constant average amount of burned area equal to the 2005-2012 average.

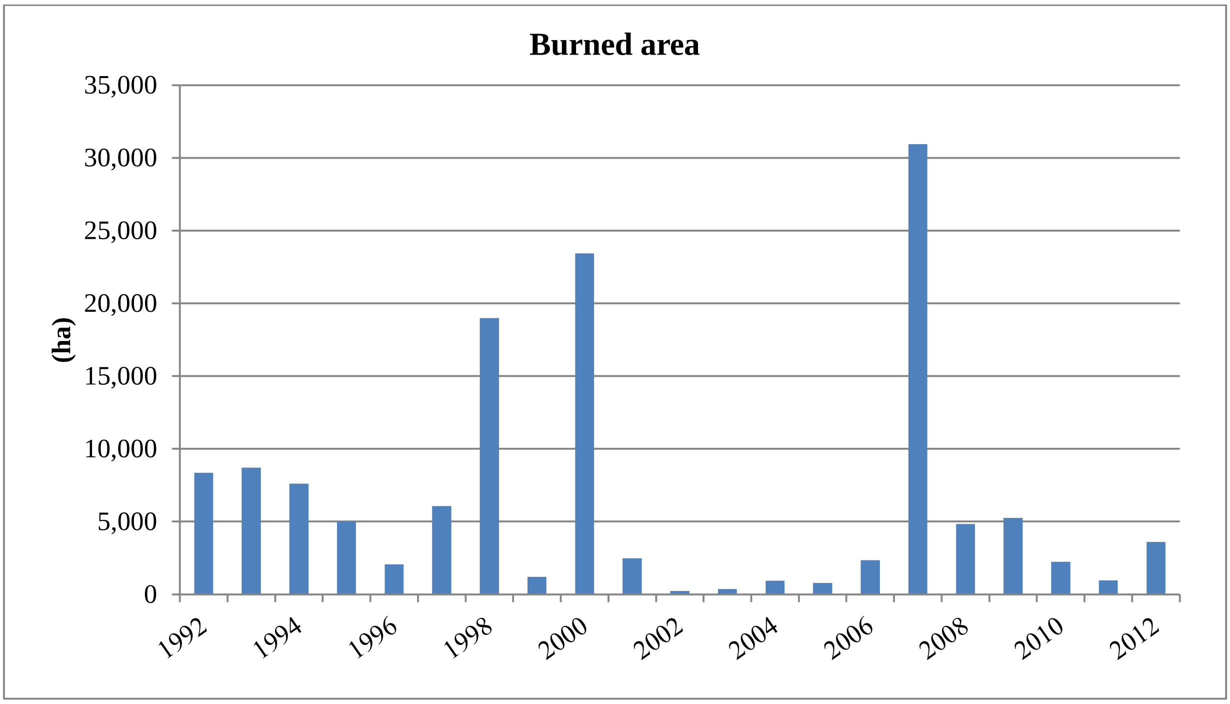


Figure 78: area affected by forest fires in Greece.

Harvest and HWP analysis

The historical FAO statistics are complete since 1961 but they report constant values for all the data since 2007. The amount of harvest reported by FAOSTAT (Figure 79) is generally about 15% lower than the values reported by the country's submission for FMRL. However, according to the FRA 2010 Country Report[80], FAOSTAT reports the volume under bark. Applying to the original FAO statistics a correction factor equal to 1.15, suggested by the report, the resulting amount of harvest is consistent with the country's submission. The NIR does not report additional information. After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 3.0 million m^3 for 2020.

Assuming a constant harvest rate, equal to the average historical value estimated for the previous period (2000-2012, based on the FAOSTAT data corrected), we estimated an average amount of harvest equal to about 2.0 million m^3. This is the total roundwood removal applied by CBM, assuming a constant harvest scenario.

[80] FRA 2010 – Country Report, Greece (pag. 28), reporting the volume over bark.

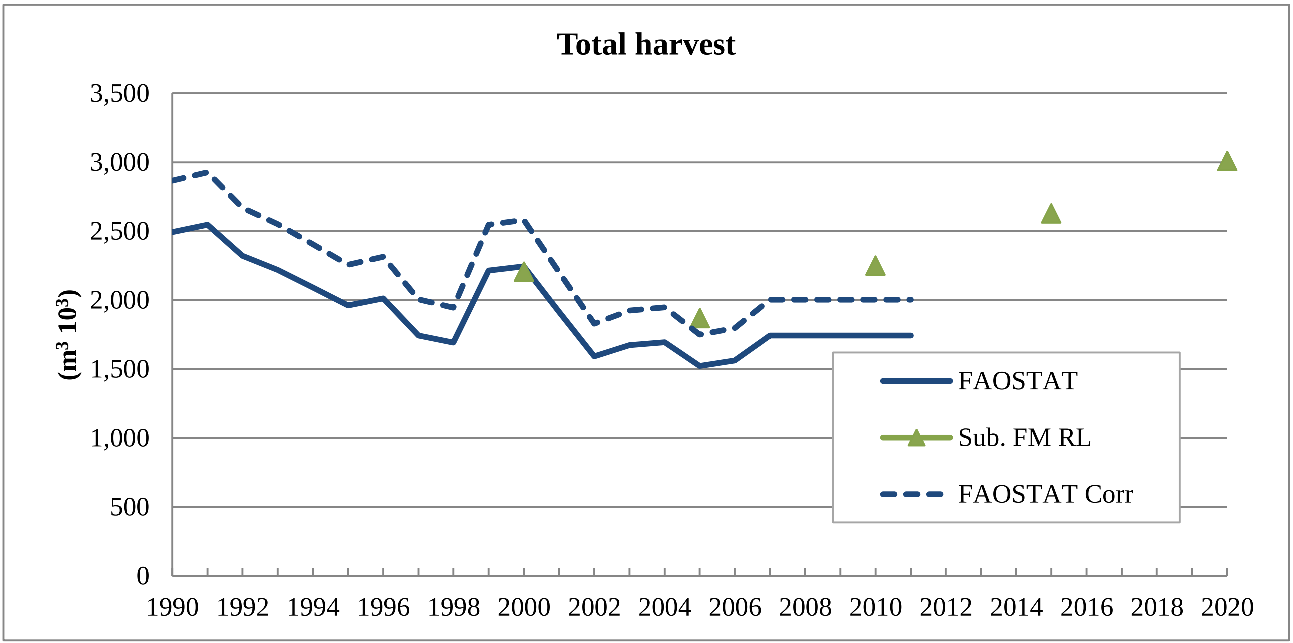


Figure 79: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (under bark) and the National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a correction factor equal to 1.15 to account for the bark's fraction. The graph also reports the future harvest demand (i.e., from 2013) according to the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 80. These data, corrected to account for the OWCs (see materials and methods) can be used as input by CBM.

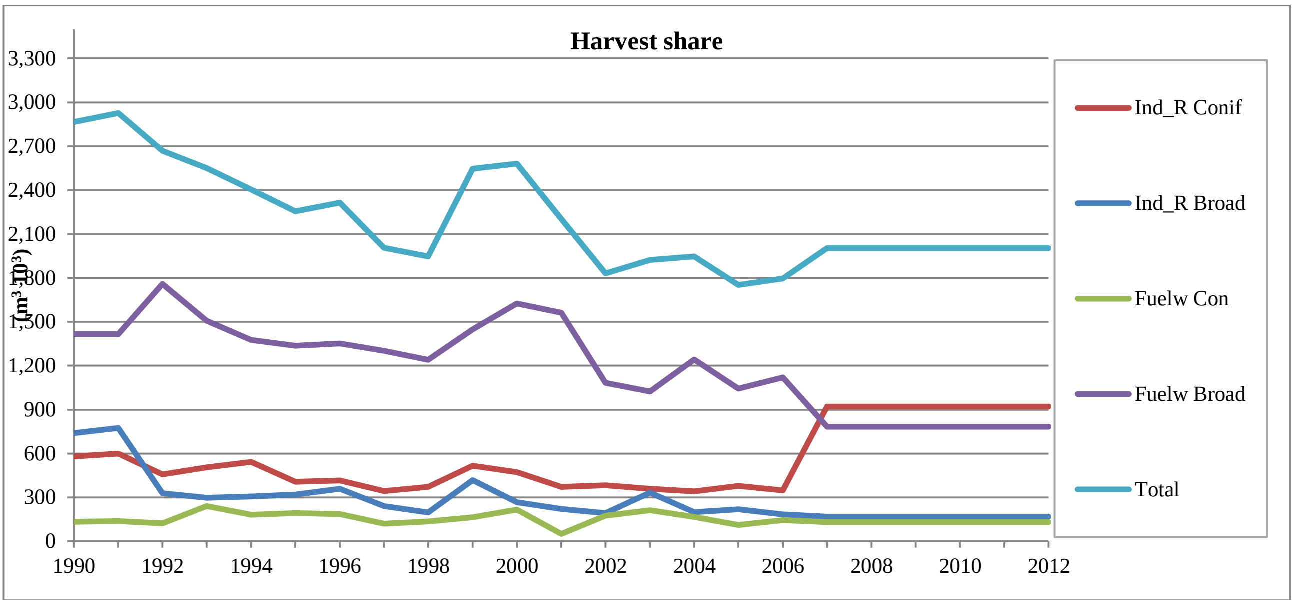


Figure 80: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 81. According to our analysis, after 2012, assuming a constant harvest scenario, we estimated with both our approaches: (i) for WP an increasing domestic production (above all until 2020); (ii) for SW a constant domestic production; (iii) for PP both our approaches estimated an increasing domestic production, however, since no DP is reported in Greece since 2000, these estimates are probably unrealistic. No data is reported by the country's submission for FMRL.

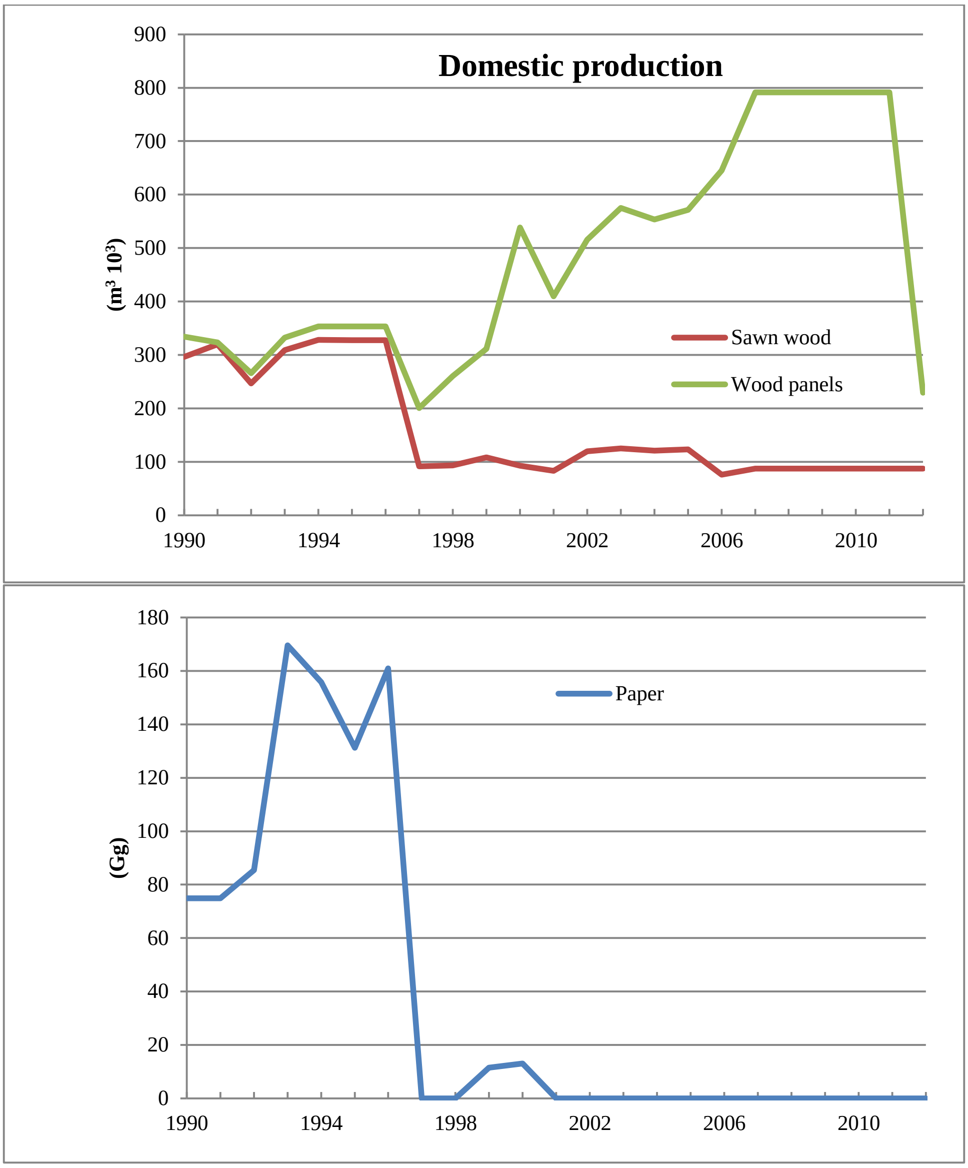


Figure 81: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Hungary

NFI data and model assumptions

The analysis was based on data reported by the country in the Submission of information for forest management reference levels by Hungary (2011), referred to 2008. The original age class distribution (1,542 kha) was therefore scaled back to 1998, with a total forest area equal to 1,644 kha. This amount was further corrected to account for the total amount of deforestation occurred until 1998 (i.e., about 450 ha yr^{-1}, with a final forest area equal to 1,640 kha for 1998. The total forest area was distributed between 4 Climatic units (CLUs 25, 26, 35, 36), as reported by Figure 46 for the Czech Republic. For the final analysis, all input data were regrouped at national level.

The main species reported by the NFI were grouped in 8 forest types (Tab. 49), according to the country-specific values of wood density of each species, as reported by the National Inventory Report of Hungary (NIR, 2012). All species, except *Robinia pseudacacia*, were managed as high forests. Specific rotation lengths were applied for each FT, according to the values reported by literature. After 2009 a reduction factor equal to 0.9 of the default minimum rotation length was applied during the model run.

Tab. 49: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	**Acronym**	**Min. rotation length (yrs)**
Picea abies and *other conifers*	PA	**90**
Pinus silvestris, Pinus nigra and *Larix deciduas*	PS	**110**
Fagus sylvatica	FS	**100**
Other broadleaves hardwoods (Carpinus betulus, Acer sp., Ulmus sp., Fraxinus sp.)	OH	**70**
Other broadleaves softwoods (Alnus sp., Tilia sp.)	OS	**70**
Poplar spp., Salix spp.	PT	**20**
Quercus spp.	QR	**110**
Robinia pseudacacia	RP	**30**

The main parameters defining the harvest criteria applied by CBM for Hungary are in Tab. 50.

Hungary

Tab. 50: main parameters defining the harvest criteria applied by CBM for Finland, including the age classes affected by each silvicultural treatment and the relative share of harvest provided by each treatment (average for the historical period).

Silvicultural treatment	Criteria	Harvest share
20% Commercial Thinnings	> 20 yrs.	21%
30% Commercial Thinnings	> 30 yrs.	35%
Clearcut (95% commercial thinning)	Depending by species	44%

Species-specific equations were selected using the total aboveground volume per age class reported by NFI multiplied for the default wood density reported by NIR (2012). Since, all wood volume values in Hungary are "estimated and expressed as total volume of trees aboveground including stem, all branches and bark", no biomass expansion factor had to be applied[81].The average aboveground total biomass by species and age classes was compared with the values provided by the original set of equations reported by Boudewin et al. (2007) for Quebec. The equations reported on Tab. 51 were finally applied for Hungary.

Tab. 51: association between the Hungarian forest types and the default species provided by the original CBM database.

FT	Species selected by default CBM database
PA	Eastern white-cedar (Thuja occid.)
PS	Eastern white-cedar (Thuja occid.)
FS	Basswood (Tilia americana)
OH	Red pine (P. resinosa)
OS	Eastern white-cedar (Thuja occid.)
PT	Willow (Salix)
QR	Balsam poplar (Populus balsamifera)
RP	Red pine (P. resinosa)

[81] See page 191, NIR 2012

Tab. 52 reports the percentage difference between the average aboveground total biomass estimated by the selected equations and the country-specific values of biomass.

Tab. 52: the table reports the mean percentage difference and the standard deviation between the average aboveground total biomass estimated by the selected CBM equations and the country-specific biomass values (the mean and the standard deviations were estimated considering the values reported by FT and age class)

FT	Mean Δ	St dev.
FS	43.4	78.7
OH	16.5	21.8
OS	44.7	69.4
PA	55.2	69.9
PS	41.7	53.1
PT	73.3	78.9
QR	37.4	64.7
RP	9.9	12.6

Species-specific YTs were selected using the average volume and increment reported at national level, estimated by additional information on the total volume and increment, directly provided by the country[82]. No correction factor was applied to the original data. The current library and the historical library applied by CBM model are reported in Tab. 53.

[82] Data provided by Somogyi Zoltán.

Hungary

Tab. 53: Yield tables applied by CBM model for Hungary. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied by time step 0 to 22 (i.e., during the model run); the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	FS	8.4	9.1	9.4	9.4	9.3	9.1	8.9	8.7	8.4	8.2	7.9	7.6	7.3	7.1
Current	OH	7.3	9.0	8.8	7.8	6.6	5.4	4.3	3.4	2.6	2.0	1.5	1.2	0.9	0.7
Current	OS	5.4	7.5	8.4	8.6	8.3	7.8	7.1	6.5	5.8	5.1	4.5	3.9	3.4	2.9
Current	PA	8.8	11.5	12.1	11.7	10.7	9.5	8.3	7.1	6.0	5.1	4.2	3.5	2.9	2.4
Current	PS	7.7	9.1	8.8	7.8	6.6	5.5	4.4	3.5	2.8	2.2	1.7	1.3	1.0	0.8
Current	PT	8.7	10.1	9.0	7.1	5.3	3.9	2.7	1.9	1.3	0.9	0.6	0.4	0.2	0.2
Current	QR	7.8	9.4	9.5	8.8	7.8	6.7	5.7	4.8	3.9	3.2	2.6	2.1	1.7	1.4
Current	RP	6.7	8.2	7.3	5.7	4.1	2.8	1.9	1.2	0.8	0.5	0.3	0.2	0.1	0.1
Historic	FS	7.3	40.0	90.6	145.5	196.2	238.8	272.7	298.7	318.2	332.6	343.1	350.7	350.7	350.7
Historic	OH	18.7	51.3	88.2	125.4	161.0	193.9	223.8	250.6	274.3	295.2	313.4	329.2	329.2	329.2
Historic	OS	19.0	67.3	130.5	198.2	264.3	325.5	380.2	427.9	468.8	503.5	532.7	557.0	557.0	557.0
Historic	PA	35.3	113.0	204.9	295.8	378.6	450.6	511.4	561.6	602.6	635.7	662.2	683.3	683.3	683.3
Historic	PS	11.7	63.1	140.7	223.0	297.0	357.8	405.1	440.6	466.7	485.5	499.0	508.6	508.6	508.6
Historic	PT	25.9	86.5	166.4	255.8	348.3	439.7	527.4	609.7	685.8	755.5	818.5	875.3	875.3	875.3
Historic	QR	12.9	42.5	80.8	122.8	165.5	206.9	245.9	281.9	314.6	344.0	370.2	393.4	393.4	393.4
Historic	RP	47.4	102.6	119.4	123.3	124.2	124.4	124.5	124.5	124.5	124.5	124.5	124.5	124.5	124.5

No natural disturbance was included in our model run. According to the last NIR (2014): "*no major disturbances or other processes have occurred that could have resulted in substantial emissions from the above three pools".* The amount of controlled burning and forest fires reported by NIR was assumed as negligible.

Harvest and HWP analysis

The historical FAO statistics are complete since 1961. The amount of harvest reported by FAOSTAT (Figure 82) is on average 31% lower than the values reported by the country's submission for FMRL (the last NIR reports the same values reported by the submission). According to the FRA 2010 Country Report[83], original data should include the bark fraction for the FW removals and they should report the volume under bark for the IRW. Therefore, we applied an average correction factor to the original FAO statistics, only for the IRW component. The correction factor was estimated as the average of the conversion factors reported by the FRA 2010 Country Report and it was equal to 1.20. Even applying this correction, the values reported by FAOSTAT are considerably lower than the values reported by the submission and by NIR, probably because of the amount of forest residues. After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 7.7 million m^3 for 2020.

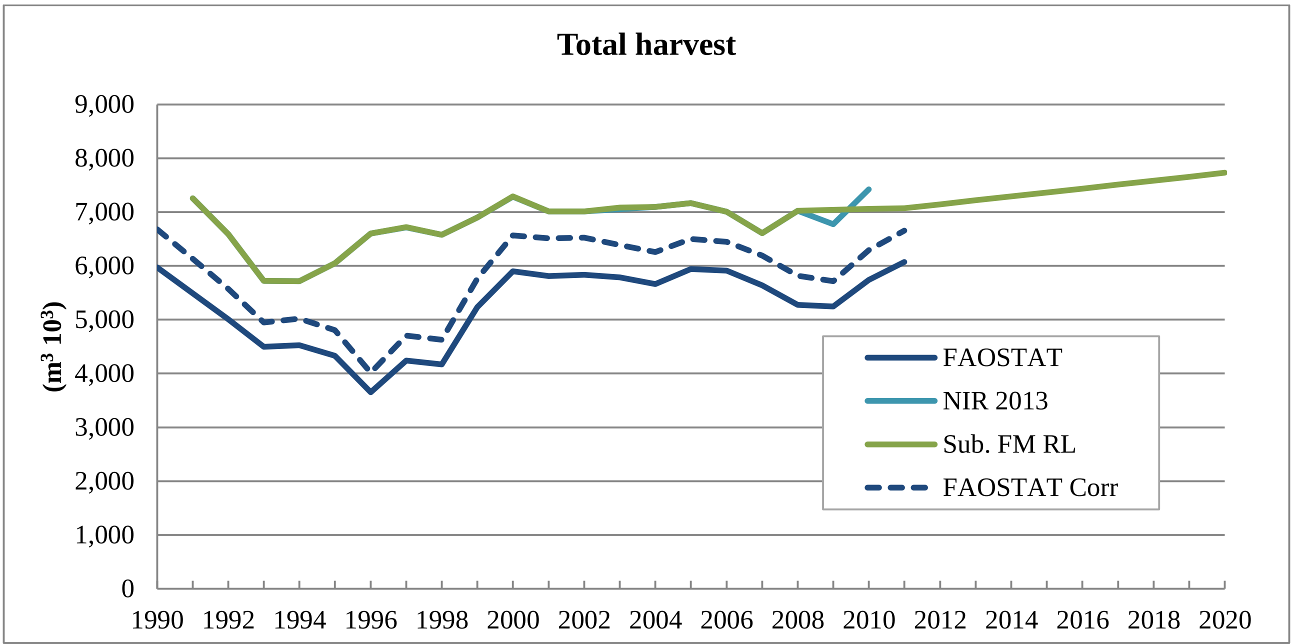


Figure 82: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (under bark) and National Submission for FM Reference Level (Sub. FMRL). We also show the FAOSTAT corrected estimates (FAOSTAT Corr), based on a correction factor equal to 1.2 to account for the bark's fraction. The future harvest demand (i.e., since 2013) is reported according to the National Submission for FM Reference Level.

[83] FRA 2010 – Country Report, Hungary (pag. 40), reporting the volume over bark.

Hungary

The historical share of harvest between IRW and FW production and between conifers and broadleaves is shown in Figure 83. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

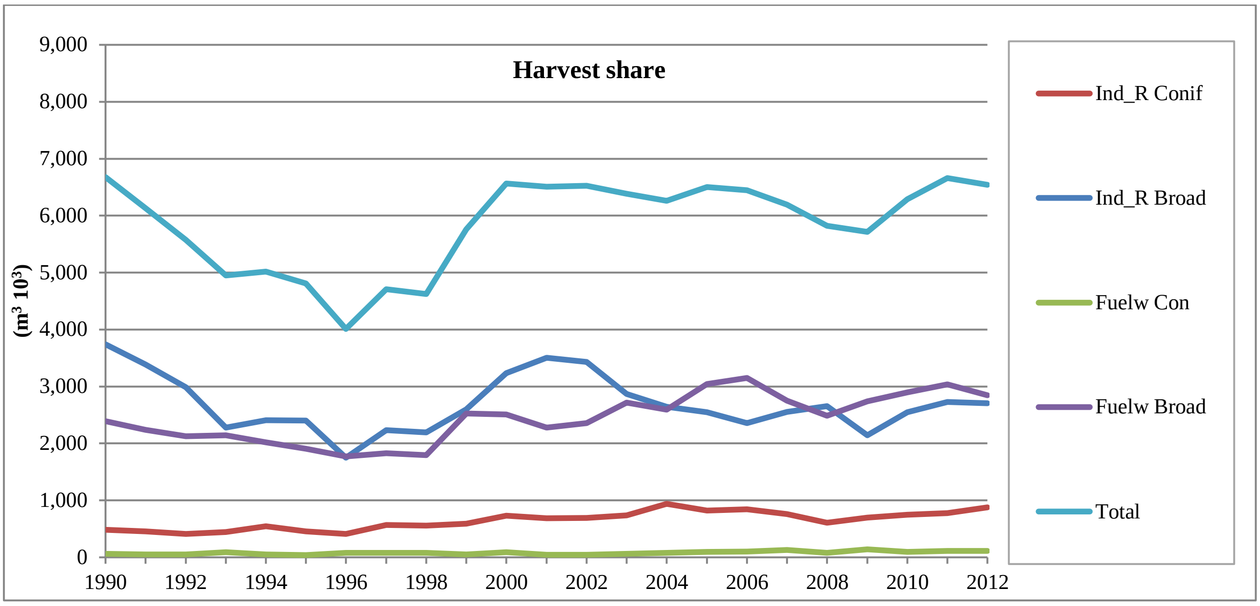
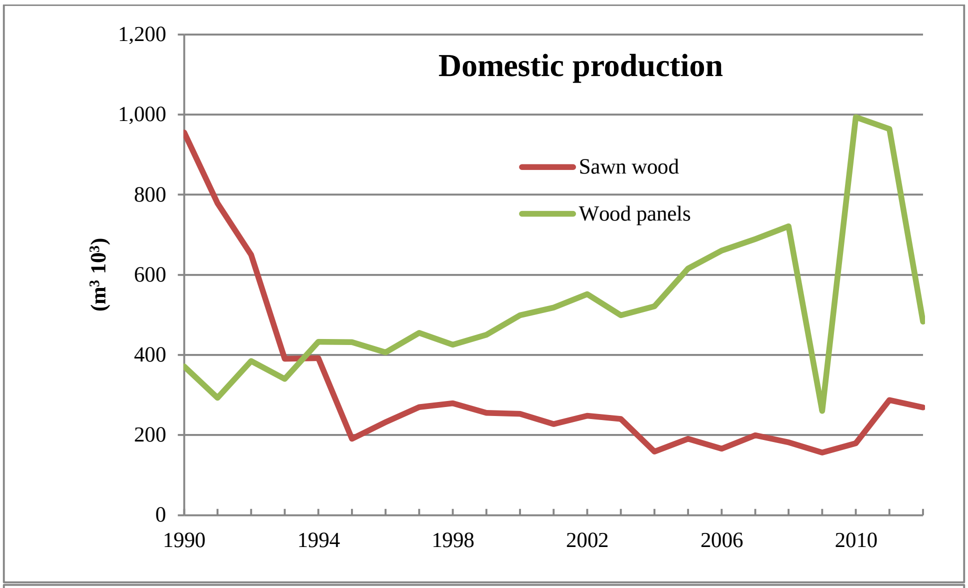


Figure 83: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2012 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 84.



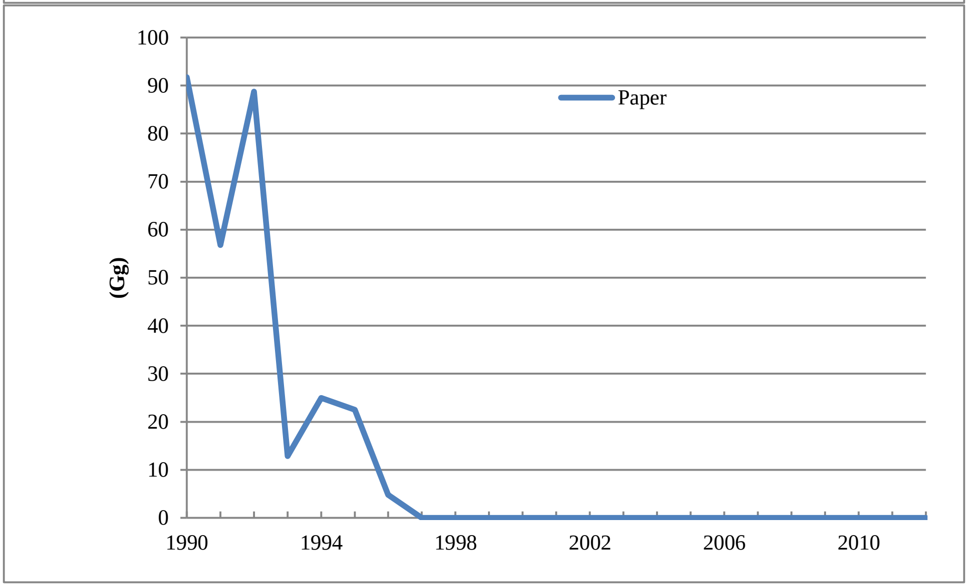


Figure 84: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Ireland[84]

NFI data and model assumptions

The analysis was based on data directed provided by the country and referred to the 2004-2006 NFI. The original age class distribution, referred to 2005, (i) was scaled back to 1995; (ii) was corrected to a total forest area equal to 454 kha, in order to consider the deforestation occurred from 1995 to 2005; (iii) was distributed among 4 Climatic units, as reported by Figure 85 and between 5 fertility classes (i.e., site indexes), as suggested by the country.

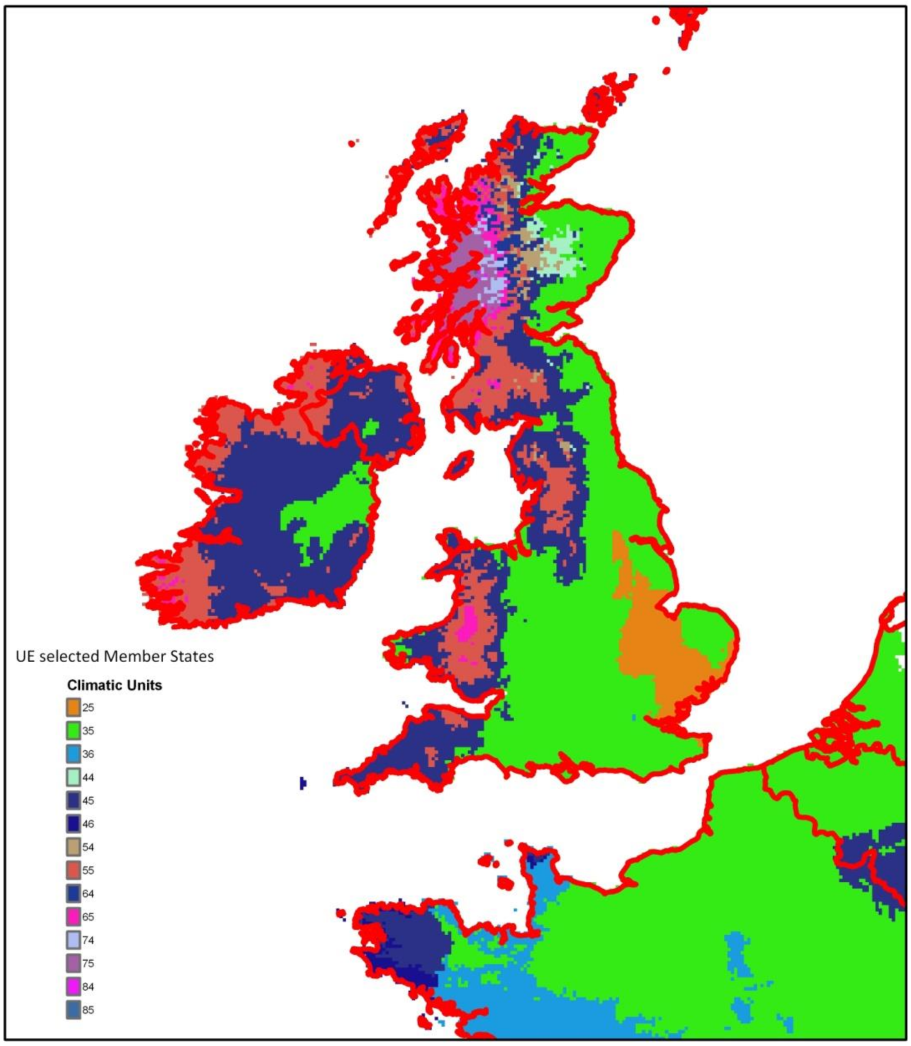


Figure 85: administrative regions defined at NUTS2 level and CLUs applied to Ireland and the United Kingdom.

[84] The analysis was based on data specifically provided by the country (November 2015), in order to be applied to the CBM. Contact person: Kevin Black, Forest Ecologist, Director FERS Ltd

Ireland

The main species reported by the NFI were grouped in 6 forest types, reported in Tab. 54.

Tab. 54: main species grouped by forest types and minimum rotation length applied by CBM model.

Main species	FTs	Min. rotation length (yrs)
Alnus sp.	AG	**40**
Fagus sylvatica and Quesrcus sp.	FS	**70**
Other broadleaves (Acer sp., Fraxinus sp. and Other broadleaves)	OB	**40**
Other conifers (Larix spp.,, Psudotsuga menziesii and Other conifers)	OC	**40**
Picea abies and Picea sitchensis	PA	**30 -50***
Pinus sylvestris and Pinus spp.	PS	**30**
* depending by the site index		

All species were managed as high forests. Specific rotation lengths were applied for each FT, but, according to the information reported by the country, we assumed that, on average, for the historical period (i.e., before 2012) about 95% of the harvest was provided by coniferous species (60% directly from Sitka spruce), while the amount of harvest provided by broadleaves was negligible (see Tab. 55). As suggested by the country, the amount of Other Wood Components (i.e., branches and snags) removed with the default silvicultural treatments was considerably reduced.

Tab. 55: main parameters defining the harvest criteria applied by CBM for Ireland, including the age classes affected by each silvicultural treatment and the total amount of harvest provided by each treatment.

Silvicultural treatment	Criteria	Harvest share
30 -35% Commercial Thinning	10 – 50 yrs	65%[85]
Clearcut on Conifers (mainly PA)	Depending by sp. and site ind.	55%

[85] According to the information provided by the country, the share of harvest provided by clearcut is considerably higher (on average 78% from 2006 to 2012) than the amount of harvest provided by thinnings. These proportions were modified, to run back the original age class distribution to 1995. However, further model runs from 2006 on, were performed, full consist with the data provided by the country.

Ireland

Salvage logging after fire disturbances	Depending by years	< 1%

Country –specific data on volume and biomass were used, in order to derive new biomass equations for the main FTs according to the assumptions reported in Tab. 56.

Tab. 56: the table reports the original species from which were derived the equations selected for each forest type, according to the methodological assumptions previously defined. For OB, due to the low number of observations, the same equations selected for FS and AG were applied. The mean percentage difference and the standard deviation between the average aboveground total biomass estimated by the selected equations and the reference country-specific biomass values were also reported.

Forest type	Species selected by default CBM database	Mean Δ	St dev.
PA	Pin cherry (Prunus pennsylvanica)	7.12	17.72
PS	Black spruce (Picea mariana)	27.53	72.65
OC	Eastern white pine (P. strobus)	-11.42	16.46
AG	Eastern white pine (P. strobus)	-8.49	64.39
FS	Eastern white pine (P. strobus)	-86.06	8.72
OB	No input data available		

Species-specific YTs were selected using the average volume and increment reported at national level, distinguished by FTs and site indexes. No further correction factor was applied to the original data. The current library and the historical library applied by CBM model are reported by Tab. 56.

Ireland

Tab. 57: Yield tables applied by CBM model for Ireland, further distinguished between forest types (FT) and site indexes (SI). The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	SI	Age1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12
Current	AG	E	2.27	8.48	11.78	10.92	8.11	5.23	3.06	1.67	0.86	0.43	0.20	0.09
Current	FS	E	1.02	3.60	6.12	7.73	8.30	8.04	7.26	6.21	5.11	4.08	3.17	2.42
Current	OB	E	2.35	8.47	11.69	10.89	8.18	5.36	3.20	1.78	0.94	0.48	0.23	0.11
Current	OC	E	2.03	11.55	21.04	24.07	21.33	16.09	10.86	6.75	3.95	2.20	1.17	0.61
Current	PA	A	0.86	6.86	14.75	18.52	17.33	13.45	9.19	5.71	3.30	1.81	0.94	0.47
Current	PA	B	3.01	14.42	24.17	26.34	22.69	16.83	11.27	7.00	4.10	2.30	1.24	0.65
Current	PA	C	3.88	17.43	27.59	28.51	23.32	16.45	10.48	6.20	3.46	1.85	0.95	0.48
Current	PA	D	6.35	23.89	34.05	32.61	25.12	16.86	10.29	5.85	3.16	1.64	0.82	0.40
Current	PS	E	4.42	11.21	15.33	16.27	15.03	12.73	10.14	7.73	5.70	4.09	2.87	1.98
Historical	AG	E	19	48	82	120	161	205	252	301	352	405	460	517
Historical	FS	E	66	108	142	171	196	219	240	258	275	290	304	316
Historical	OB	E	46	77	103	127	150	171	192	211	231	249	267	285
Historical	OC	E	29	137	274	389	456	474	454	409	352	292	235	185
Historical	PA	A	5	50	146	262	360	416	427	402	354	297	238	184
Historical	PA	B	1	42	233	490	608	540	382	228	119	57	25	10
Historical	PA	C	16	98	283	600	1074	1729	2584	3661	4977	6551	8400	10541
Historical	PA	D	89	251	461	710	992	1304	1643	2008	2396	2807	3238	3690
Historical	PS	E	11	74	163	225	239	215	174	129	90	60	38	23

The effect of Fire disturbance events were considered based on the following assumptions (Figure 86): data on the amount of burned area for 1995-2013 were derived by NIR (2014). Fire disturbances were simulated assuming that fire affects 50% of the living biomass, with salvage of 15% of logging residues. Fires were distributed proportionally to the forest area of each FT, MT and MS. A constant amount of burned area, equal to the average amount 2000 – 2012 was applied from 2013 to 2030.

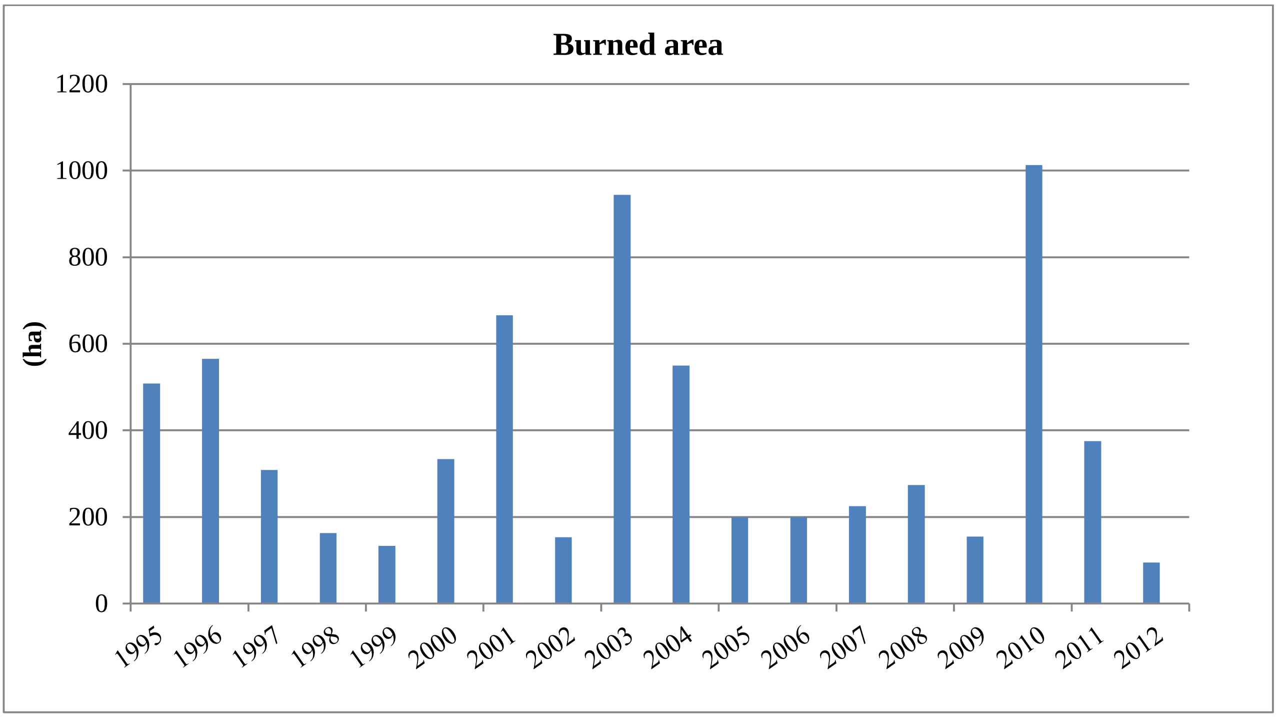


Figure 86: amount of area burned between 1995 and 2012 (based on data reported by NIR, 2014).

Harvest and HWP analysis

The historical FAO statistics are complete since 1961. The amount of harvest reported by FAOSTAT (Figure 87) is on average 11% lower (until 2007) than the values reported by the country's submission for FMRL and 9% lower than the values reported by the NIR (2014) and by the country. Comparing these data with the FRA 2010 Country Report[86], we assumed that FAOSTAT report the volume under bark and we applied an average correction factor equal to 1.09, ensuring a full consistency between FAOSTAT, NIR and country-specific data. After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 3.2 million m^3 for 2020.

[86] FRA 2010 – Country Report, Ireland (pag. 39), reporting the volume over bark.

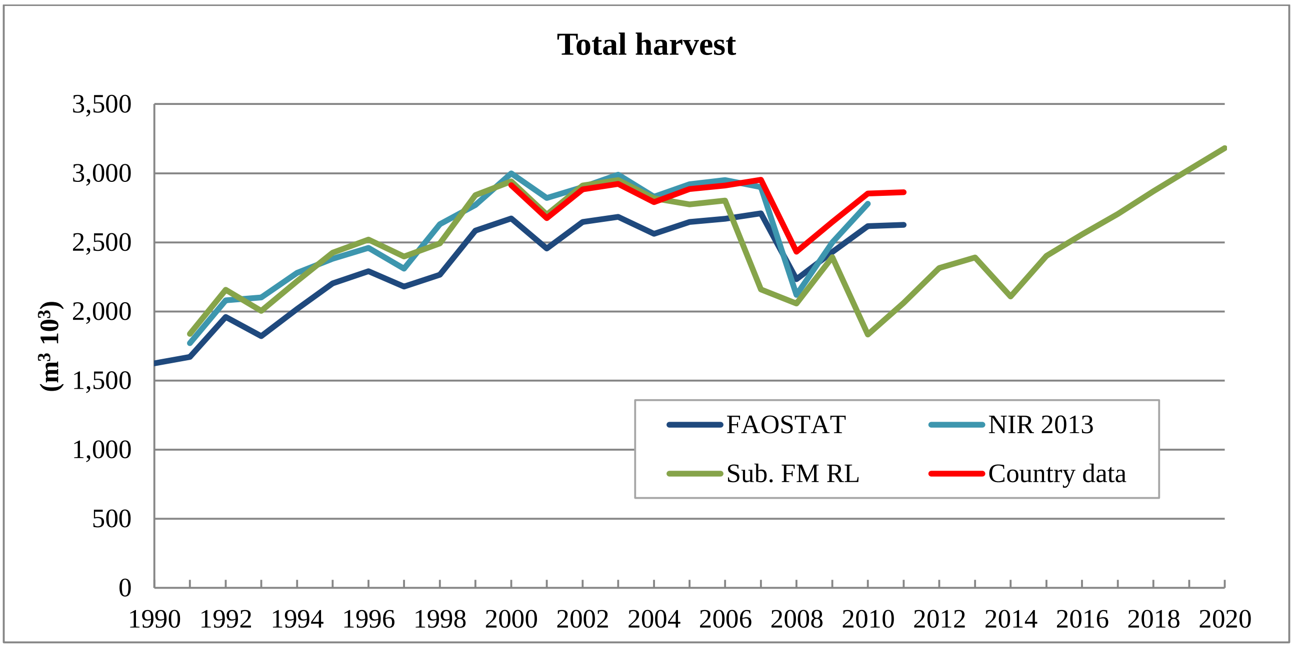


Figure 87: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (under bark), the National Submission for FM Reference Level (Sub. FMRL) and the NIR (2013) and specific data provided by the country. We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a correction factor equal to 1.09 to account for the bark's fraction. The figure also shows future harvest demand according to the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 88. These data, corrected to account for the OWCs (see materials and methods) can be used as input by CBM.

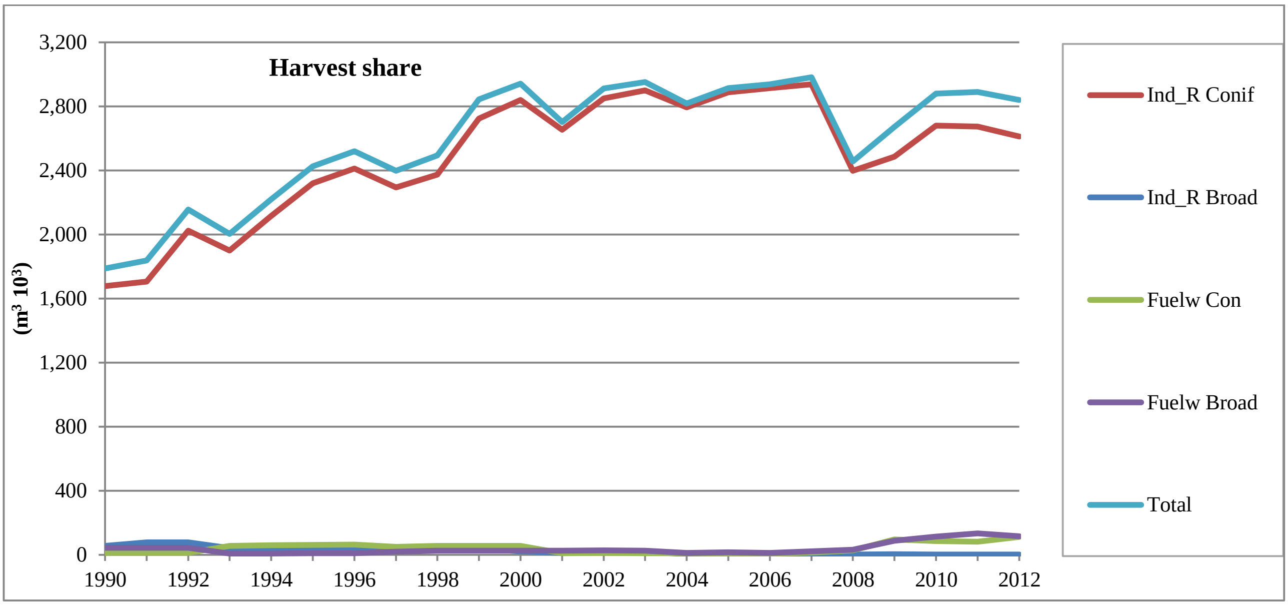


Figure 88: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 89.

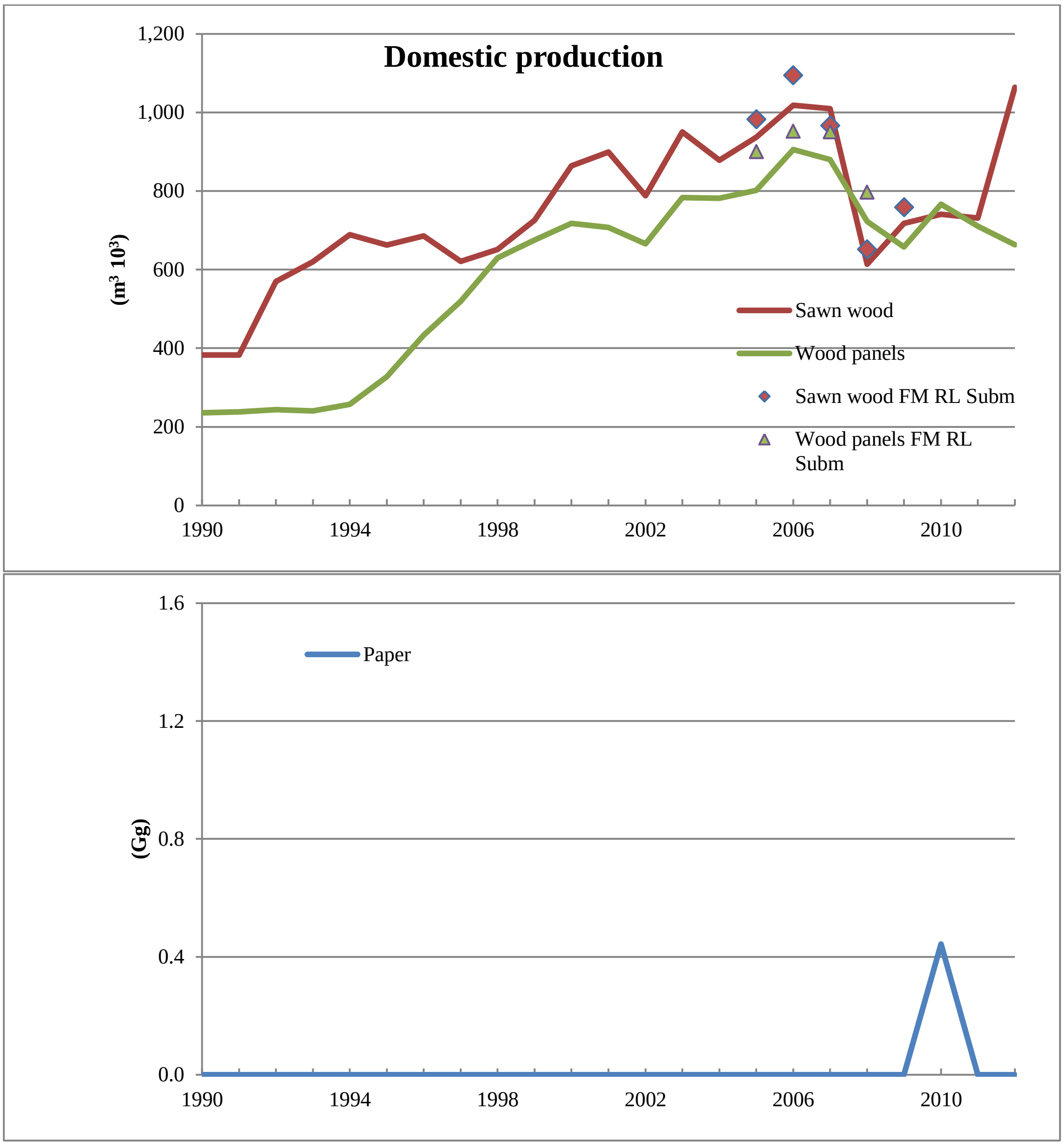


Figure 89: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Based on the information provided by the country, an increasing amount of harvest was provided by Sitka spruce plantations (see the results, on Annex 2b for further information).

Italy[87]

NFI data and model assumptions

The analysis was based on data reported by the last NFI, referred to 2005. The original age class distribution was therefore scaled back to 1995, considering a total forest area equal to 7,450 kha distributed between 21 Climatic units, as showed in Figure 90. All data were aggregated at national level and the total amount of FM area was further decreased to about 7,444 kha, assuming an annual rate of deforestation equal to 1,220 ha yr^{-1}, applied from 1990 to 1995.

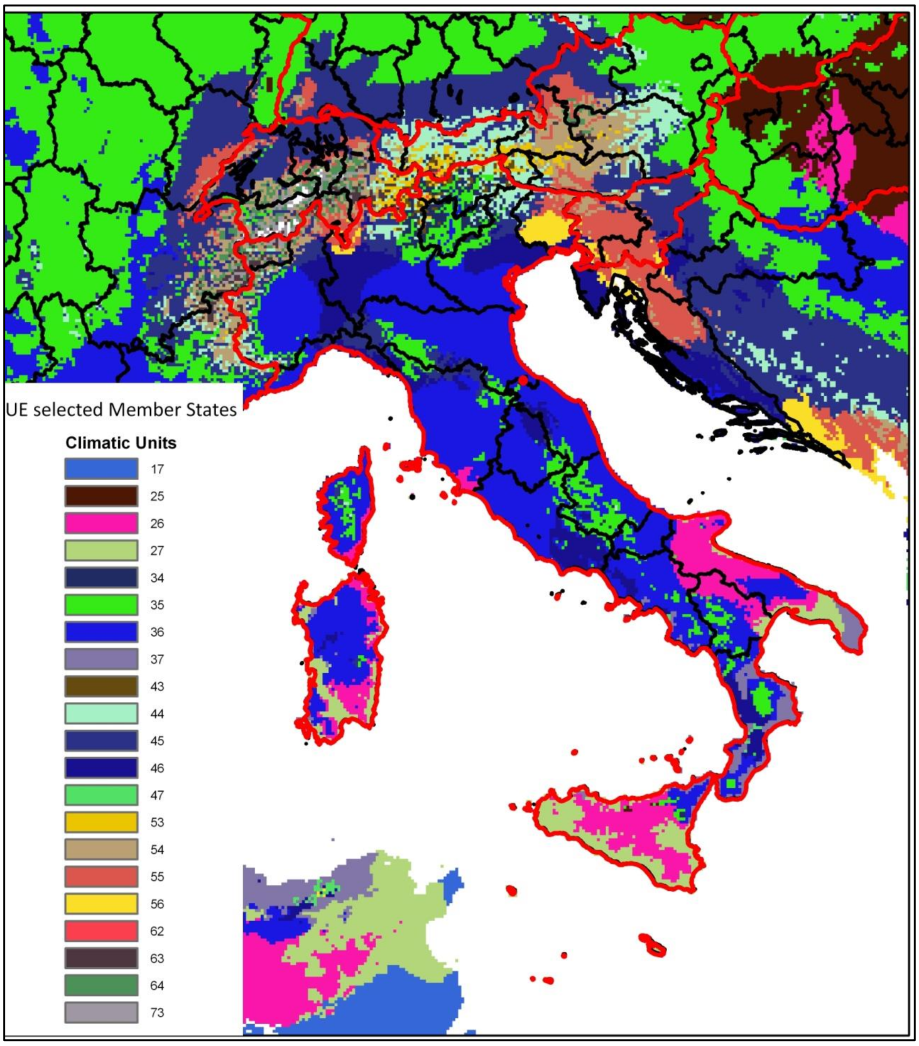


Figure 90: the figure reports the geographical distribution of the CLUs applied by CBM model for Italy. The analysis was performed at country level.

The main species reported by the NFI were grouped in 17 forest types (Tab. 58) and in 3 main management types: even-aged high forest, uneven-aged high forests (equal to about 30% of the total forest area and also including not classified and irregular forests) and coppices (only for broadleaves). The rotation length applied to the even-aged high forests and to coppices is

[87] Specific information was provided by country's expert, in the context of the AA 071201/2011/611111/CLIMA.A2 (Analysis of and proposals for enhancing, monitoring, reporting and verification of land use, land use change and forestry in the EU - LULUCF MRV). See also Pilli et al., 2013 for further information.

shown in Tab. 58. A 15%-20% commercial thinning with a cutting cycle of 12-25 years was applied to the uneven aged forests. After 2011 a reduction factor equal to 0.9 of the default minimum rotation length was applied during the model run.

Tab. 58: main species grouped by forest types and minimum rotation length applied by CBM model to even aged high forests (first number) and coppices (second number).

Forest Type (FT)	Acronym	Min. rotation length (yrs)
Oak forests	QR	110/20
Oak forests with *Q. cerris*	QC	130/20
Mixed deciduous broadleaved	OB	100/15
Beech forests	FS	110-130/20
Chestnut forests	CS	40/20
Hornbeam forests	OCa	40/20
Norway spruce forests	PA	100
Holm oak forests	QI	60/20
Larch and stone pine forests	LD	130
Mediterranean pine forests	PM	60
Riparian forests	RF	40/20
Black pine forests	PN	90
Cork oak forests	QS	20 only for coppices
Scots pine and Mountain pine	PS	110
Silver Fir forests	AA	100
Other evergreen forests	OE	110/20
Other coniferous forests	OC	60

The main parameters defining the harvest criteria applied by CBM for Italy are reported in Tab. 59.

Tab. 59: main parameters defining the harvest criteria applied by CBM for Italy, including the minimum age classes affected by each silvicultural treatment and the relative share of harvest provided by each treatment (average for the historical period).

Silvicultural treatment	Criteria	Harvest share
20% Commercial Thinnings	> 15 yrs.	28%
30% Commercial Thinnings*	> 20 yrs.	55%
Clearcut (95% commercial thinning)	Depending by species	13%
Salvage logging after fire disturbance	Depending by years	4%
* including group selection system applied to uneven-aged forests		

Italy

Species-specific equations were selected using the total aboveground biomass, the values of stem plus branches and of stumps reported by NFI (see Pilli et al., 2013). The equations reported in Tab. 60 were finally applied to Italy.

Tab. 60: association between the Italian forest types and the default species provided by the original CBM database.

FOREST CATEGORIES	Species selected by default CBM database
AA	White spruce
BP	Red pine
CP	Red pine
CS	Balsam poplar
FS	Gray birch
LD	Eastern white-cedar
OB	Eastern white pine
OC	Red pine
OE	Red pine
Oca	Black spruce
PA	Red pine
PM	Red pine
PN	Red pine
PS	Red pine
QC	Largetooth aspen
QI	White elm
QR	Basswood
QS	White elm
RF	Red pine
QI	White elm

Figure 91 reports the percentage difference between the average biomass estimated by the selected equations and the country-specific values of biomass for each FT.

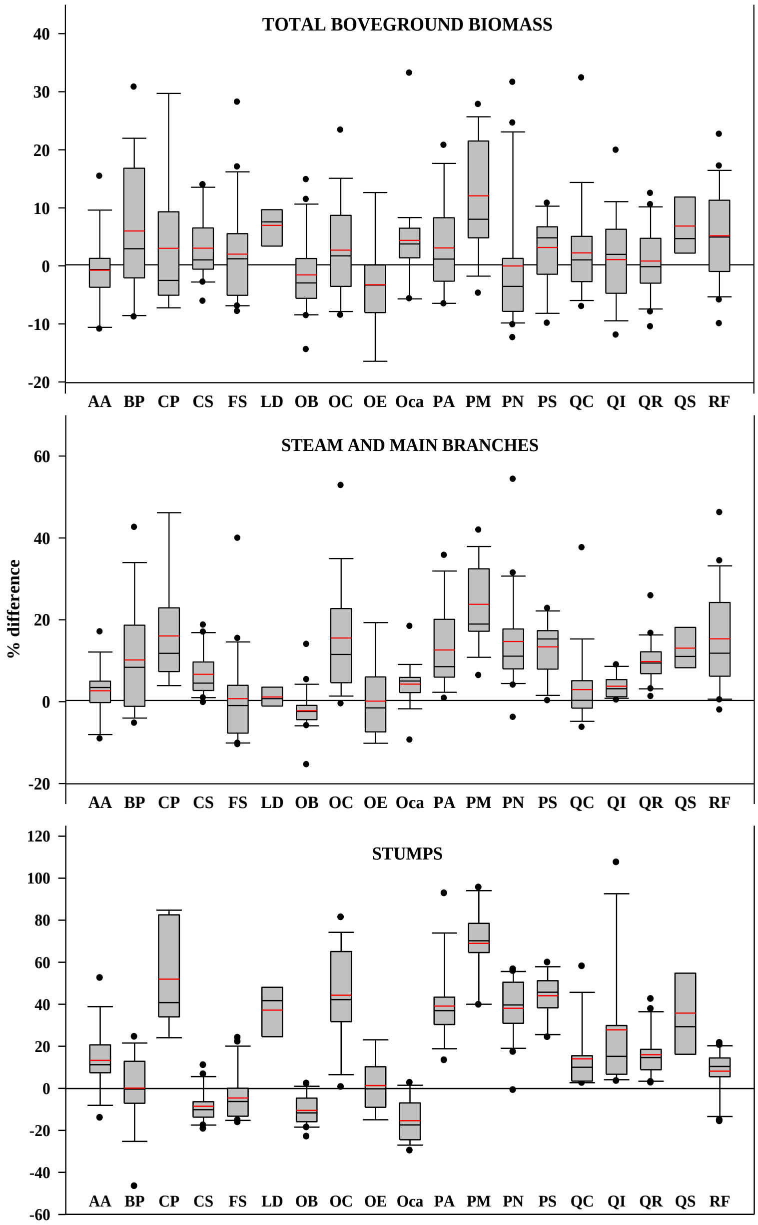


Figure 91: percentage differences scatter plots (between the total aboveground biomass estimated through the selected volume to biomass equations and the biomass reported by the INFC) for total aboveground biomass, stem and main branches and stumps, for each forest type, based on the selected species. The mean percentage difference (red line, inside the box plot), median (black line inside the box plot), 25th and 75th percentile (boundaries of the box), 10th and 90th percentile (error bars) and outlying points are reported.

Species-specific YTs were selected using the average volume and increment by region, FT and age class, reported by NFI data (see Pilli et al., 2013 for details). A comparison between the original data of CAI reported by NFI for each even aged FT and the data applied by the current YTs, is reported by Figure 92 and Figure 93. Because the final analysis was performed at national level, for each FT we calculated the average volume by age class, using as weighting factor the area occupied by each FT at regional level.

Italy

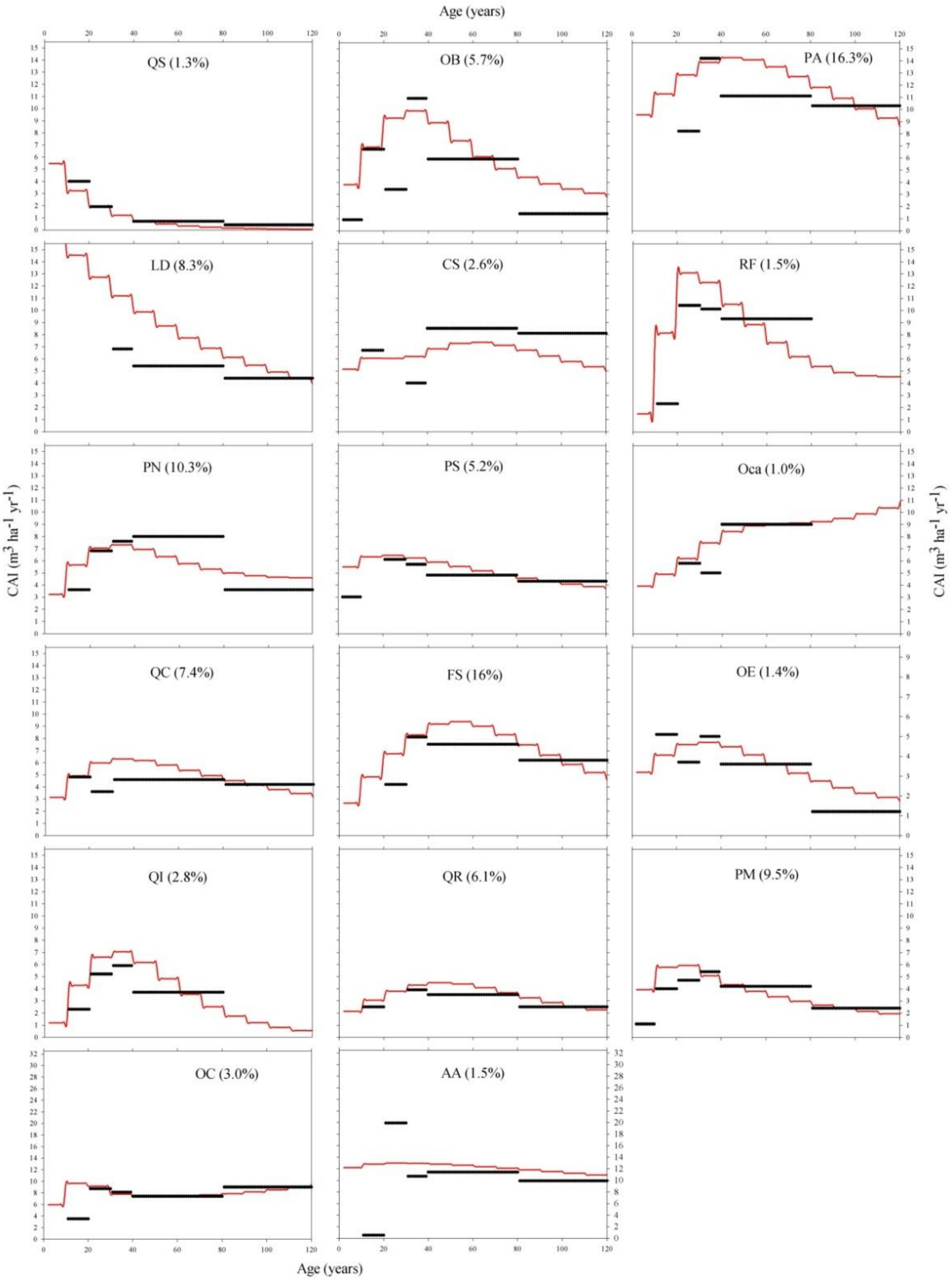


Figure 92: average CAI (m^3 ha^{-1} yr^{-1}) estimated for each FT (red lines) based on the CAI derived by NFI data. The figure reports the theoretic evolution of this parameter on undisturbed EVEN-AGED HIGH FORESTS and the average CAI inferred by NFI for each FT (black lines) according to the following age classes distribution: 0-10 years, 11-20 years, 21-30 years, 31-40 years, 41-80 years and 80-120 years. For some FTs and age classes, where no forests were detected by NFI, no data was provided by the inventory. FTs are reported according to acronyms listed in Tab. 58 with the share of area covered by each FT (expressed as percentage on the total even-aged high forest area reported by NFI).

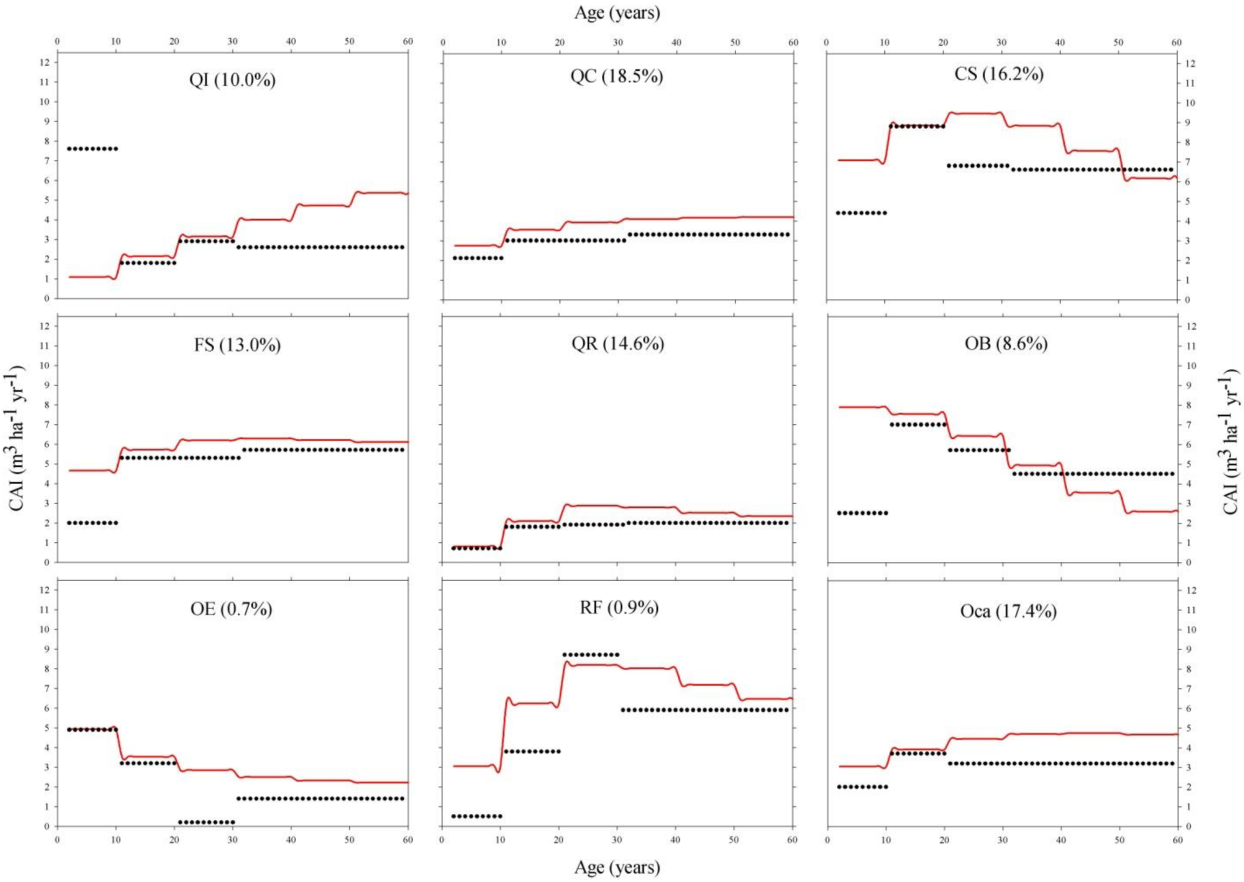


Figure 93: average CAI (m^3 ha^{-1} yr^{-1}) estimated for each FT (red lines) based on the CAI derived by NFI data. The figure reports the theoretic evolution of this parameter on undisturbed COPPICES and the average CAI inferred by NFI for each FT (black lines) according to the following age class distribution: 0-10 years, 11-20 years, 21-30 years, 31-40 years, 41-80 years and 80-120 years. For some FTs and age classes, where no forests were detected by NFI, no data was provided by the inventory. FTs are reported according to acronyms listed in Tab. 58 with the share of area covered by each FT (expressed as percentage on the total even-aged high forest area reported by NFI).

The effect of fire disturbance events were considered (Tab. 45); data on the amount of burned area for the period 1995-2013 were derived by national statistics[88]. Fire disturbances were simulated assuming that fire affects 50% of the living biomass, with salvage of 15% of logging residues. Fires were distributed proportionally to the forest area of each FT, MT and MS. A constant amount of burned area, equal to the average amount 2000 – 2012 was applied from 2013 to 2030.

[88] Incendi Boschivi 2011 – Corpo Forestale dello Stato, Ministero Politiche Agricole Alimentari e Forestali. Incendi Boschivi per Regione – dati provvisori anno 2013 – Corpo Forestale dello Stato Ispettorato Generale Divisone 3°

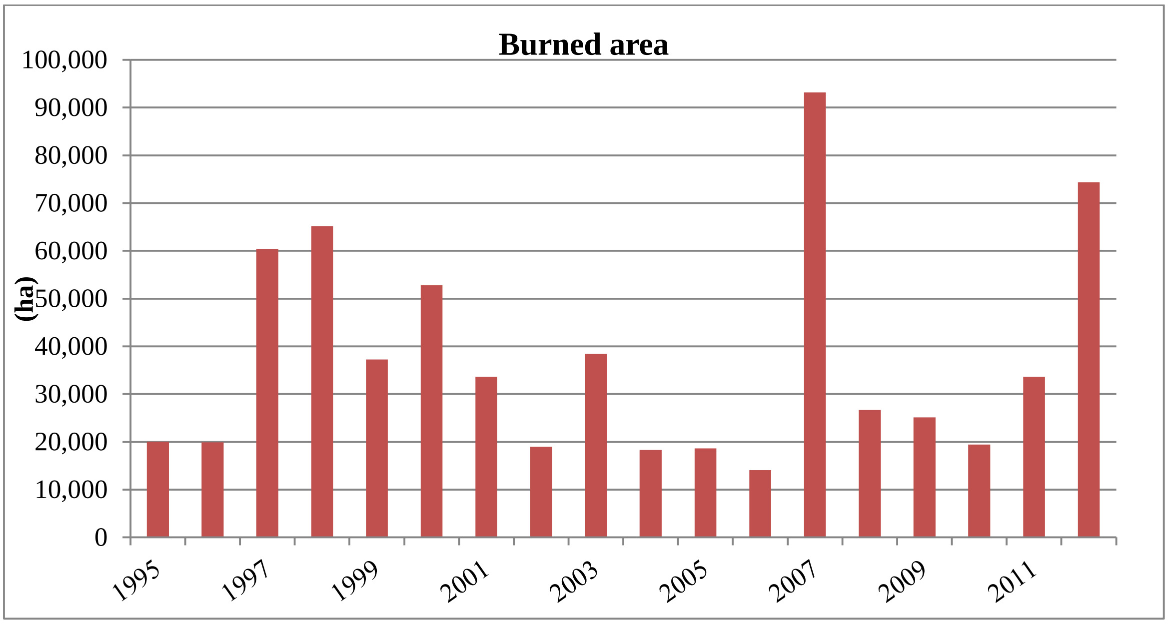


Figure 94: amount of area burned between 1995 and 2012 (based on country data).

Harvest and HWP analysis

The historical FAO statistics are complete since 1961. The amount of harvest reported by FAOSTAT is shown in Figure 95. Until 2009, the values are, on average, 80% lower than data reported by the country's submission for FMRL (no value is reported by the last NIR). The values reported by the FRA 2010 Country Report[89], are consistent with FAOSTAT. According to the last NIR (2013) and as highlighted by literature (Pilli et al., 2013) Italian statistics are strongly underestimated. The last NIR suggested to use an average correction factor, based on the data collected by the last Italian NFI and equal to 1.57, to account for (i) the general underestimation of official statistics, (ii) forest residues (i.e., the amount of wood left in the forest) and (iii) the bark's fraction. We corrected FAO statistics applying a constant correction factor equal to 1.5, reducing the resulting amount of 15%, to account for forest residues.

[89] FRA 2010 – Country Report, Italy (pag. 50).

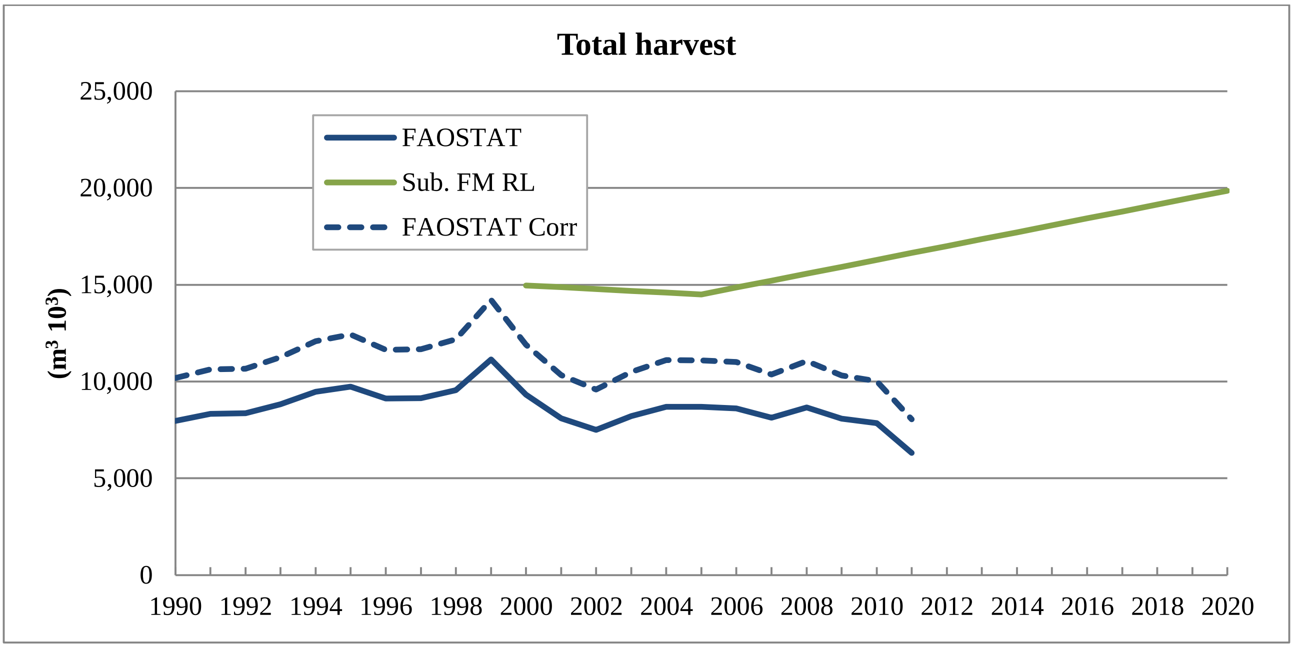


Figure 95: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (under bark) and the National Submission for FM Reference Level (Sub. FMRL). We also report the FAOSTAT corrected estimates (FAOSTAT Corr), based on a general correction factor equal to 1.5, reduced by 15% to account for forest residues. The figure also shows the future harvest demand as from the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 96. These data, corrected to account for the OWCs (see materials and methods) can be used as input by CBM.

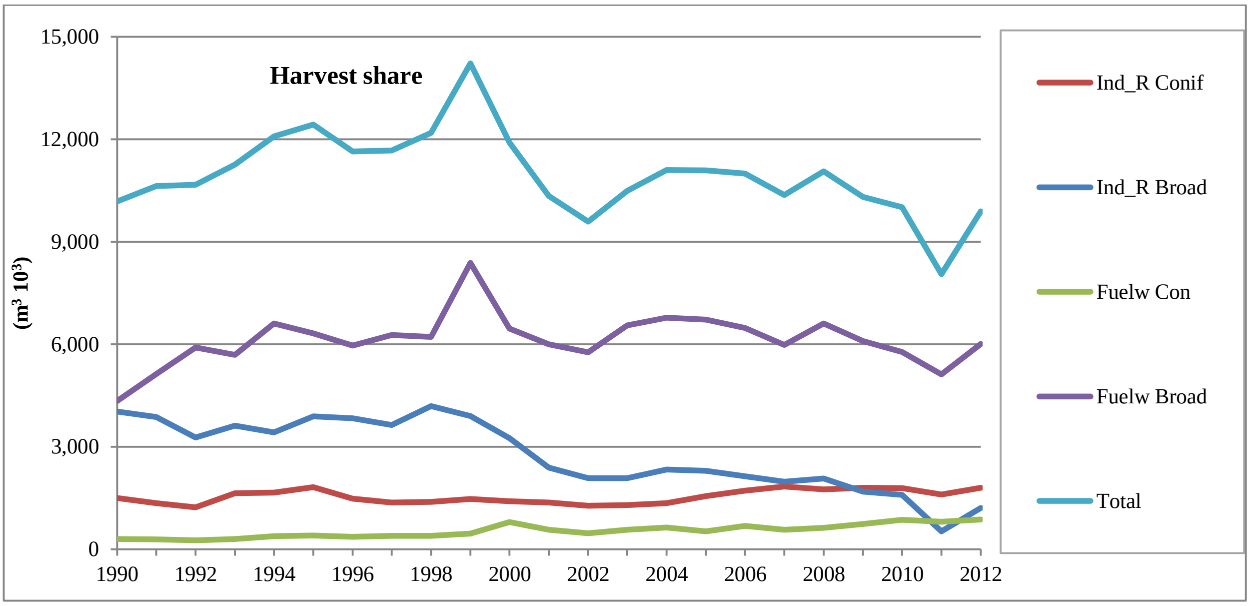


Figure 96: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 97.

Figure 97: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in $m^3\ 10^3$) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Latvia[90]

NFI data and model assumptions

The analysis was based on data collected by NFI 2009, combined with additional information directly provided by the country and scaled back to 1999[91]. The total forest area, equal to 3,220 kha was corrected to account for the total amount of deforestation occurred until 1999 (i.e., about 1,800 ha yr^{-1}, with a final forest area equal to 3,204 kha for 1999) and it was distributed between 2 CLUs (the entire county is included into one administrative region, see Figure 55 reported for Estonia).

Country-specific equations to be used by CBM model were selected. based on data on volume and growing stock provided by the country for each species, combined with biomass data, estimated applying to the volume BEFs-equations provided by literature (Lethonen et al., 2004).[92] For Latvia, the selection was based both on the total aboveground biomass and on the stem + branches biomass compartment. The comparison was performed on age classes > 10 yrs. Tab. 61 reports the original species from which were derived the equations selected for each FT.

Tab. 61: the table reports the original species from which were derived the equations selected for each forest type, according to the methodological assumptions previously defined. The acronym applied to each FT was also reported. The table also reports the mean percentage difference and the standard deviation between (i) the average total aboveground biomass estimated by the selected equations and the reference country-specific biomass values and (ii) the average stem+branches biomass values estimated by the selected equations and the reference country-specific values.

Forest type	Acronym	Species selected by default CBM database	Mean % diff. on biomass	
			Tot. Biomass	Stem + br.
Spruce (P. abies)	PA	White spruce (P. glauca)	8.53 ± 33.27	7.70 ±15.50
Pine (P. sylvestris)	PS	Red pine (P. resinosa)	8.49 ±19.41	7.90±19.33
Birch (Betula sp)	BT	Red pine (P. resinosa)	7.62 ± 13.59	0.73 ± 11.36
Black alder (A. glutinosa)	AG	Eastern white pine (P. strobus)	11.49 ± 15.32	3.20 ±8.04
Grey alder (A. incana)	AI	Red pine (P. resinosa)	12.00 ± 11.18	5.43 ± 9.10
Aspen (P. tremula)	PT	White spruce (P. glauca)	10.70 ± 21.02	2.51 ± 13.41
Other broadl. (Oak,	OB	Red pine (P. resinosa)	12.48 ±	4.43 ± 16.55

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[90] Specific information was provided by country's expert, in the context of the AA 071201/2011/611111/CLIMA.A2 (Analysis of and proposals for enhancing, monitoring, reporting and verification of land use, land use change and forestry in the EU - LULUCF MRV).

[91] Both the age class distribution (i.e., the Inventory table used by CBM) and the yield tables used as input by CBM were considerably revised, compared with the previous model runs.

[92] Lehtonen, A., Mäkipää, R., Heikkinen, J., Sievänen, R., Liski, J., 2004. Biomass expansion factor (BEFs) for Scots pine, Norway spruce and birch according to stand age for boreal forests. For. Ecol. Man., 188: 211-224.

Ash)			20.54	

Tab. 62 shows the minimum rotation length applied to each FT. The minimum rotation length applied after 2009 were based on the information provided by the country. After 2010 a 20% reduction of the default minimum rotation length was allowed during the model run. According to the last NIR (2014), incineration of harvesting residues after clearcut is still quite common in Latvia and, during the period 2007-2010, about 18% of harvesting residues were incinerated. We therefore assumed that about 18% of the area affected by clearcut each year was also affected by incineration of harvest residues.

Tab. 62: forest types, minimum rotation length applied to clear cutting and wood density based on specific values reported by NIR (2014).

FT acronyms	Min. rotation length (yrs)	Wood density (tons m^3)
PA	90	0.36
PS	110	0.38
BT	80	0.47
AG	80	0.41
AI	40	0.41
PT	60	0.40
OB	90	0.41

The main parameters defining the harvest criteria applied by CBM for Latvia are in Tab. 63.

Tab. 63: main parameters defining the harvest criteria applied by CBM for Latvia, including the age classes affected by each silvicultural treatment and the relative amount of harvest provided by each treatment (estimated as the average amount of harvest provided between 1999 and 2012).

Silvicultural treatment	Criteria	Harvest share
15% Commercial Thinnings	> 10 yrs	<3%
30% Commercial Thinnings	> 20 yrs	41%
Clearcut (90-97% commercial thinning, including clearcut with slash-burned)	Depending by species	56%

Latvia

Species-specific YTs were selected using the average volume and increment reported at national level. The historical library (i.e., the YTs applied during the stand-initialization procedure) and the current library[93] (i.e., the YTs applied during the model run) are in Tab. 67.

[93] Compared to the previous CBM runs (performed in 2013) the values applied to YT library were revised.

Latvia

Tab. 64: Yield tables applied by CBM model for Latvia. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	AG	2.13	5.40	8.20	10.08	11.06	11.29	10.94	10.24	9.32	8.28	7.24	6.23	5.30	4.45
Current	AI	1.41	5.99	10.09	11.63	10.88	8.93	6.69	4.68	3.13	2.00	1.23	0.75	0.44	0.26
Current	BT	1.30	4.14	6.98	9.06	10.20	10.48	10.11	9.34	8.32	7.20	6.11	5.09	4.17	3.37
Current	OB	0.67	2.57	4.89	6.96	8.44	9.24	9.45	9.19	8.58	7.78	6.87	5.96	5.08	4.25
Current	PA	1.48	4.45	7.41	9.66	11.01	11.55	11.42	10.83	9.93	8.88	7.78	6.69	5.68	4.76
Current	PS	1.10	3.41	5.83	7.80	9.14	9.84	10.00	9.72	9.15	8.40	7.55	6.67	5.80	4.99
Current	PT	3.05	7.73	11.68	14.25	15.48	15.61	14.96	13.82	12.40	10.89	9.39	7.96	6.68	5.55
Historic	AG	2.0	16.0	51.0	106.0	178.0	260.0	347.0	435.0	519.0	597.0	668.0	732.0	789.0	838.0
Historic	AI	5.0	30.0	82.0	151.0	230.0	310.0	386.0	456.0	518.0	570.0	615.0	653.0	684.0	709.0
Historic	BT	2.0	17.0	44.0	81.0	121.0	160.0	195.0	226.0	252.0	273.0	290.0	304.0	315.0	323.0
Historic	OB	1.0	10.0	34.0	72.0	121.0	176.0	233.0	289.0	341.0	388.0	430.0	466.0	497.0	524.0
Historic	PA	4.0	19.0	44.0	76.0	115.0	155.0	197.0	239.0	279.0	316.0	351.0	384.0	413.0	440.0
Historic	PS	2.0	15.0	42.0	83.0	134.0	189.0	247.0	303.0	356.0	405.0	449.0	488.0	523.0	553.0
Historic	PT	6.0	36.0	86.0	144.0	203.0	258.0	305.0	344.0	376.0	402.0	422.0	438.0	450.0	460.0

Latvia

The effect of Storm disturbance events was considered according to the following assumptions:

1. Based on the information reported by the FORESTORMS[94] database, two main storms affected Latvia between 1999 and 2012 (Tab. 65). The total volume damaged by these disturbances was equal to 7.8 and 0.5 million m^3 in 2005 and 2007, respectively.
2. Considering the amount of harvest by species reported by the last NIR (2014), we highlighted that in 2005 and 2007 there was a considerable increase on the amount of harvest provided by PA and PS (see Tab. 65). For these FTs, we estimated the total amount of salvage of logging residues (*SL*), as the difference between the average amount of harvest referred to the year before (HWP_{t-1}) and after (HWP_{t+1}) the storm and the amount of harvest in the year affected by the disturbance event (HWP_t see columns C and D, Tab. 65):

$$SL = HWP_t - \frac{(HWP_{t-1} + HWP_{t+1})}{2}$$

3. The effect of these disturbances was modelled through (i) a stand replacing-storm and (ii) a widespread-storm disturbance.
   (i) For the stand-replacing storm:

a. We assumed that a fraction of the forest area reported by the first age class (i.e., < 10 yrs., assumed as clear-cut forest area) in the original age class distribution (i.e., referred to 2009) was affected by stand replacing-storms in 2005 and 2007.
b. The disturbance event was simulated assuming that 65% of the living biomass was damaged and, on this amount, about 40% of the damaged merchantable biomass (i.e., 30% of the total) was moved to the products pool (i.e., harvested after the disturbance event) and the other living biomass components were moved to dead wood and litter pools.

(ii) For the widespread storm:

a. After a preliminary run, based on the assumptions reported above, we estimated the amount of merchantable biomass (see columns F and G, Tab. 65) damaged by stand-replacing storm ($V\_St_{St\_Repl}$).
b. The biomass affected by the widespread disturbance event ($V\_St_{St\_W}$) was estimated as the difference between the total merchantable biomass damaged by storm (i.e., columns C and D in Tab. 65) and $V\_St_{St\_Repl}$.
c. We assumed that this event affected 30% of the merchantable biomass pool, with a 15% of salvage logging.

4.

[94] http://www.efiatlantic.efi.int/portal/databases/forestorms/

Tab. 65: the table reports the total volume damaged by storms in Latvia according to the FORESTORMS database (in m^3 10^3); the total amount of harvest reported by the NIR (columns A and B) for spruce (PA) and pine (PS); the total amount of salvage logging estimated as the difference between the average amount of harvest referred to the year before and after the storm and the amount of harvest in the year affected by the disturbance event (see columns C and D); the amount of salvage logging provided from stand-replacing disturbance events, estimated through a preliminary run (see columns F and G); the amount of salvage logging to be further provided from widespread disturbance events, estimated as the difference between the total salvage logging and the amount provided by the previous disturbance a preliminary run (see columns H and I)

Year	**Vol dam.** (m^3 10^3)	**Tot Harvest NIR (m^3 10^3)**		**Estimated Salv Log (m^3 10^3)**			**Salv. Log. Stand-replacing From prel. run (m^3 10^3)**		**Salv Log. widespread storm To be further provided (m^3 10^3)**	
		PA	**PS**	**PA**	**PS**	**Tot**	**PA**	**PS**	**PA**	**PS**
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H=C-F**	**I=D-G**
2000	0	4,258	4,296	-	-	0	-	-	-	-
2001	0	4,045	4,684	-	-	0	-	-	-	-
2002	0	4,218	4,945	-	-	0	-	-	-	-
2003	0	3,668	5,117	-	-	0	-	-	-	-
2004	0	3,456	4,901	-	-	-	-	-	-	-
2005	7,800	4,087	5,377	1,047	694	1,741	100,000	70,000	947,000	624,000
2006	0	2,624	4,465	-	-	-	-	-	-	-
2007	500	2,775	4,109	371	0	371	20,000	17,000	351,500	-
2008	0	2,183	4,209	-	-	-	-	-	-	-
2009	0	2,373	5,622	-	-	-	-	-	-	-
2010	0	2,639	5,891	-	-	-	-	-	-	-
2011	0	3,047	6,517	-	-	-	-	-	-	-
2012	0	2,384	3,473	-	-	-	-	-	-	-

Harvest and HWP analysis

The historical FAO statistics provide data only from 1992. Until 1998, the values reported by FAOSTAT are consistent with the values reported by the last NIR (2014)[95] but they are, on average, 10% lower; since 1999, these differences considerably increase and the data reported by the NIR shows a higher inter-annual variability, probably due to natural disturbances and salvage of logging residues (Figure 98). According to the FRA 2010 Country Report[96], FAOSTAT report the volume under bark and a country specific correction factor equal to 1.12 can be applied. Assuming the NIR as the best source of data on forest harvest, a further correction factor (varying year by year) was applied to the original FAOSTAT data, in order to make them fully consistent with the values reported by the last NIR.

After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 12.3 million m^3 for 2020. Assuming a constant harvest rate, equal to the average historical value estimated for the previous period (2000-2012, based on the FAOSTAT Corrected data), we estimated an average amount of harvest equal to 15.6 million m^3. This is the total roundwood removal applied by CBM, assuming a constant harvest scenario.

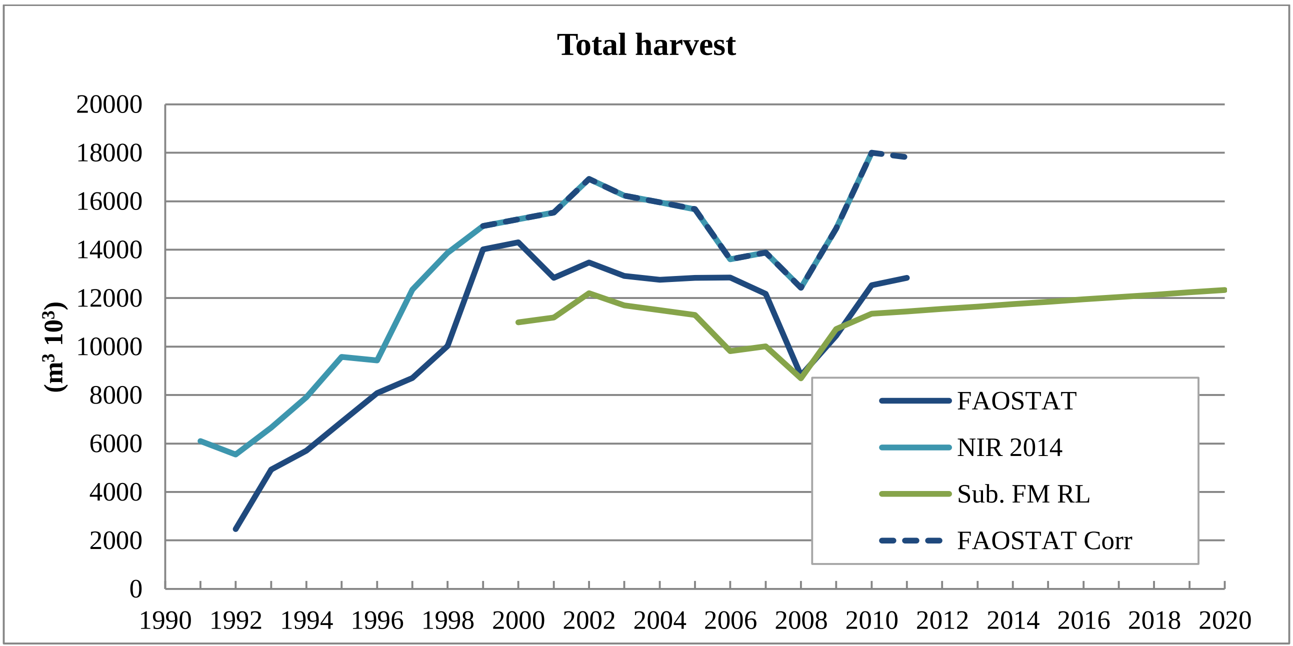

Figure 98: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (under bark), the last NIR (2014) and the National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a general correction factor equal to 1.12 to account for the bark and a further correction, varying year by year, based on the ratio between FAOSTAT original estimates and NIR's values. The future harvest demand (i.e., since 2013) is reported according to the National Submission for FM Reference Level.

[95] The NIR clearly defines this harvest amount as total felling excluding deforestation.
[96] FRA 2010 – Country Report, Latvia (pag. 46).

Latvia

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 99. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

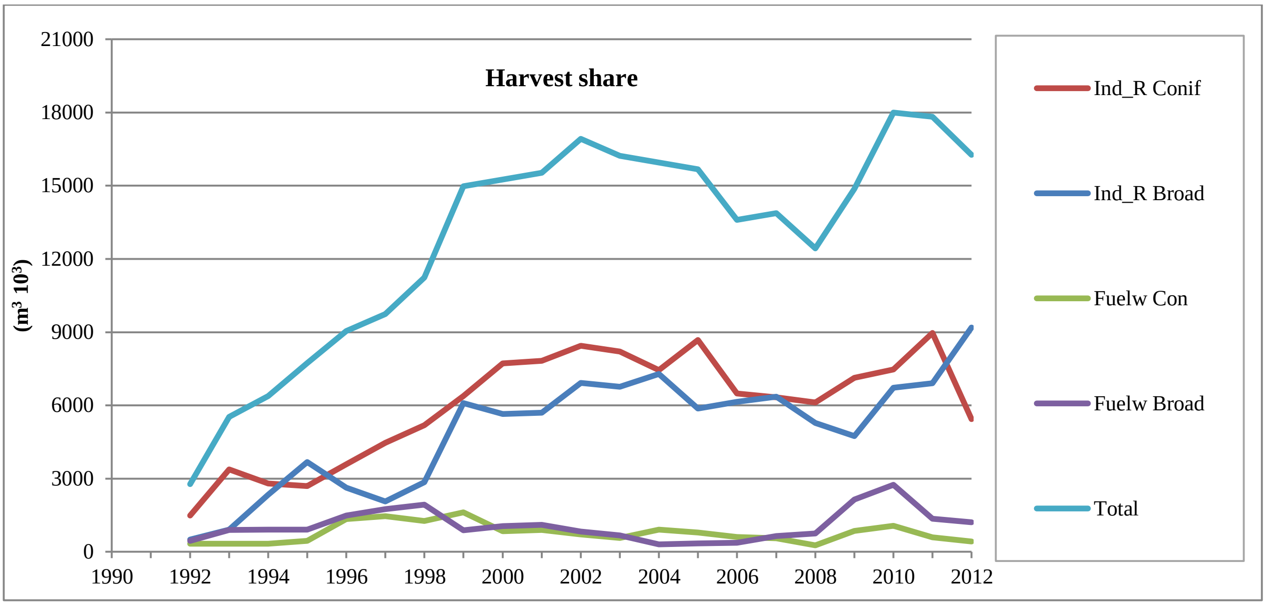

Figure 99: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest is equal to the FAOSTAT estimates, corrected for bark.

Latvia

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is shown in Figure 100. Note that no correction was applied to these data to account for possible underestimation (i.e., the difference with the values reported by NIR) of official FAO statistics.

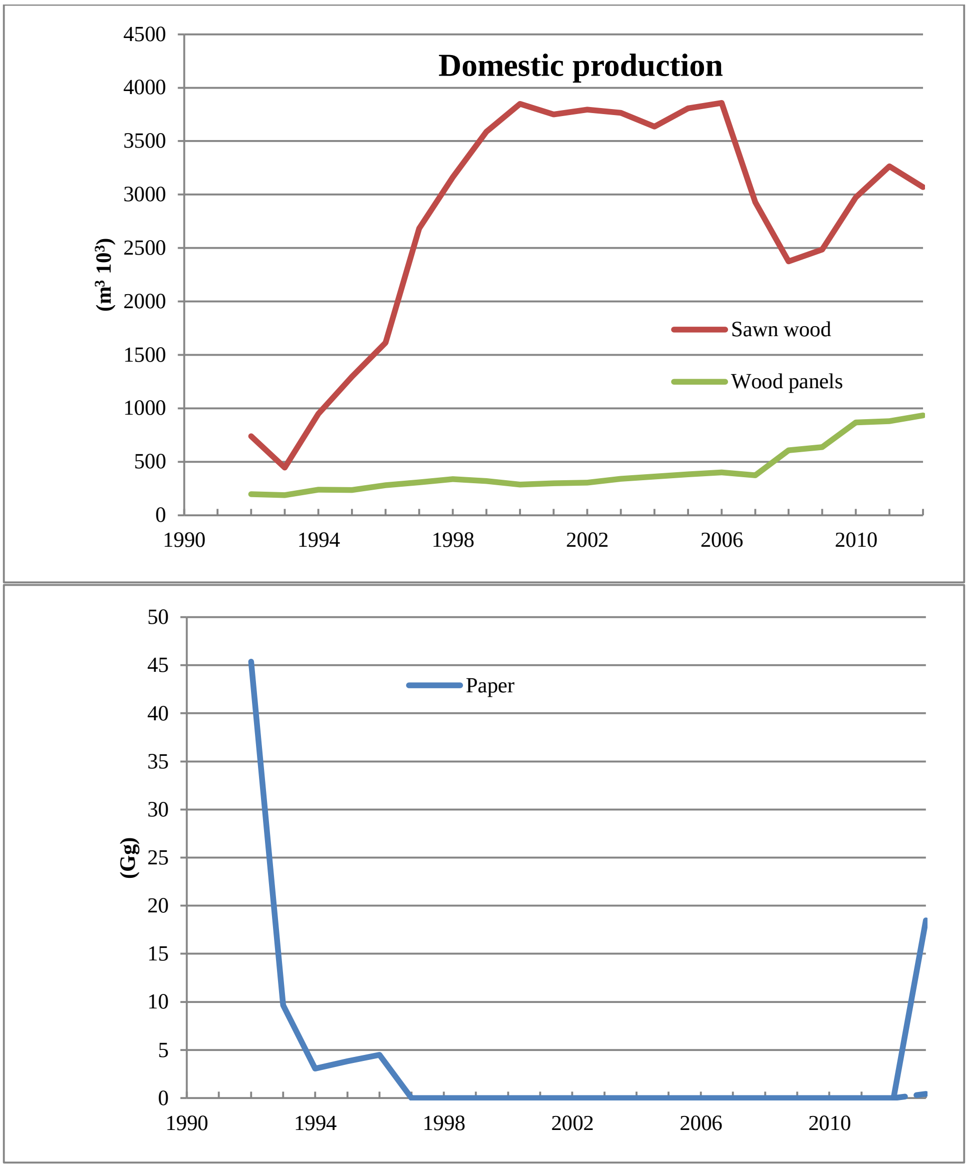

Figure 100: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL

Lithuania[97]

NFI data and model assumptions

The analysis was based on data collected by NFI 2004-2008 (referred to 2006), scaled back to 1996. The total forest area, equal to 2,000 kha was corrected to account for the total amount of deforestation occurred until 1996 (i.e., about 53 ha yr^{-1}) and distributed between 3 CLUs (the entire county is included into one administrative region, see Figure 55 reported for Estonia).

The main species reported by the NFI were grouped in 7 forest types, reported in Tab. 66. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the minimal age for final felling reported by the Report of the technical assessment of the forest management reference level submission of Lithuania submitted in 2011[98]. After 2012 a constant reduction (equal to 0.9) of the default minimum rotation length was allowed during the model run.

Tab. 66: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	FT Acronym	Min. rotation length (yrs)
Alnus glutinosa	**AG**	**60**
Alnus incana	**AI**	**30**
Betula sp.	**BT**	**60**
Other Broadleaves(including Oaks and Ash)	**OB**	**110**
Picea abies	**PA**	**70**
Pinus sylvestris	**PS**	**100**
Poplar sp.	**PT**	**40**

The harvest criteria applied by CBM for Lithuania are reported on Tab. 67.

[97] A specific validation of CBM on the Lithuania's case study is reported by Pilli et al., 2016.
[98] Available at: http://unfccc.int/documentation/documents/advanced_search/items/6911.php?priref=600006460#beg

Tab. 67: main parameters defining the harvest criteria applied by CBM for Lithuania, including the age classes affected by each silvicultural treatment and the relative amount of harvest provided by each treatment (estimated as the average amount of harvest provided between 1996 and 2012).

Silvicultural treatment	Criteria	Harvest share
15% Commercial Thinnings	From 10-15 to 40-60 yrs depending by species	8%
30% Commercial Thinnings	From 10-60 to 40-125 yrs depending by species	26%
Clearcut (90-95% commercial thinning)	Depending by species	66%

Since no specific data on biomass stock was available at national level, the same equations selected for Latvia were applied to Lithuania, according to the assumptions reported in Tab. 68.

Tab. 68: association between the Lithuanian forest types and the default species provided by the original CBM database, based on the selection applied to the Latvian case study.

FT	Species selected by default CBM database	Correspondence with the Latvian FTs
AG	Eastern white pine (P. strobus)	Black alder
AI	Red pine (P. resinosa)	Grey alder
BT	Red pine (P. resinosa)	Birch
PA	White spruce (P. glauca)	Spruce
PS	Red pine (P. resinosa)	Scots pine
PT	White spruce (P. glauca)	Aspen
AG	Eastern white pine (P. strobus)	Black alder

Species-specific YTs were selected using the average volume and increment reported at national level. Since the NFI[99] reports the gross annual increment (GAI), including the volume of dead trees by species and age classes, original NFI data were corrected to account for natural mortality (see Tab. 69) and estimate the net annual increment (NAI).

[99] Lithuanian national forest Inventory 2004-2008. Forest resources and their dynamic. Forest Statistics.

Lithuania

Tab. 69: Average Gross annual increment (GAI) reported at national level, average dead wood and average Net annual increment (NAI) used in the CBM model (all values in mc ha^{-1}).

FT	GAI	Dead wood	NAI
AG	8.5	2.0	6.5
AI	7.5	2.8	4.7
BT	6.5	1.8	4.7
PA	5.7	2.8	2.9
PS	7.7	1.4	6.3
PT	8.4	1.3	7.1
AG	8.6	3.1	5.5

To highlight the effect that this correction would produce on the selection of the current YTs, Figure 101 reports the CAI estimated by a selection of yield tables based on GAI and on NAI. Current library (derived by this last parameter) and historical library (based on the average volume reported by NFI for each species) applied by CBM are reported in Tab. 70.

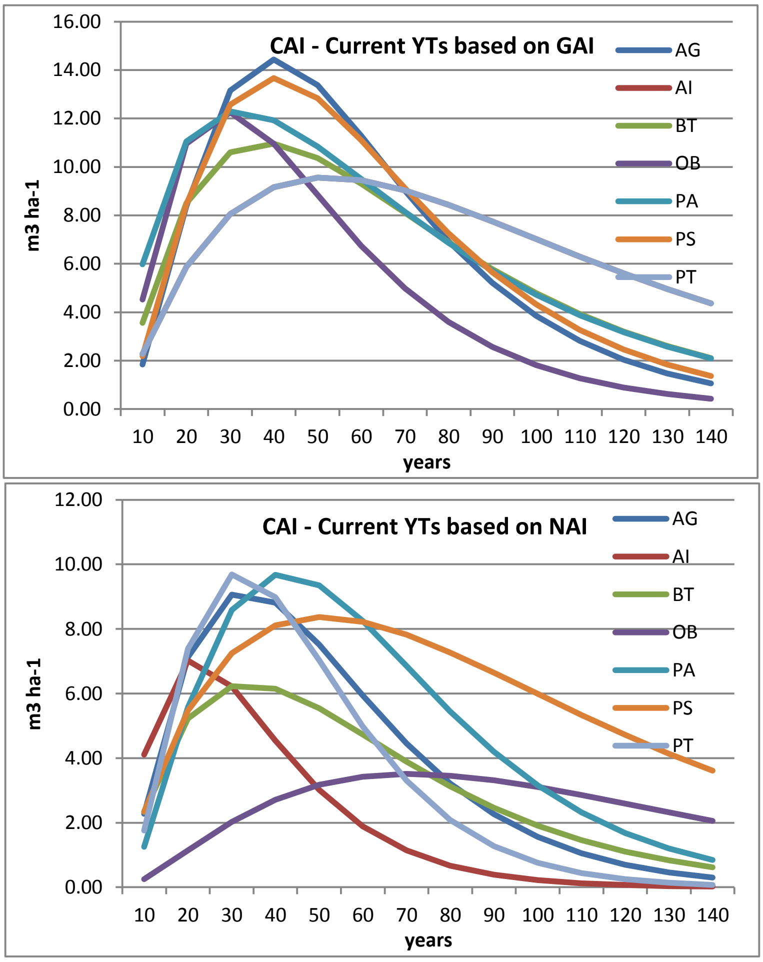

Figure 101: Current annual increment based on GAI and NAI (the acronyms are reported on Tab. 66).

Lithuania

Tab. 70: Yield tables applied by CBM model for Lithuania. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	**AG**	2.27	7.13	9.06	8.81	7.52	5.94	4.45	3.22	2.26	1.56	1.05	0.70	0.46	0.30
Current	**AI**	4.10	7.02	6.22	4.54	3.01	1.89	1.14	0.67	0.39	0.22	0.12	0.07	0.04	0.02
Current	**BT**	2.33	5.23	6.23	6.15	5.54	4.73	3.89	3.12	2.46	1.90	1.46	1.11	0.83	0.62
Current	**OB**	0.25	1.14	2.02	2.71	3.17	3.43	3.51	3.46	3.31	3.10	2.85	2.59	2.32	2.06
Current	**PA**	1.25	5.57	8.59	9.67	9.35	8.25	6.85	5.45	4.20	3.15	2.32	1.68	1.20	0.85
Current	**PS**	2.34	5.47	7.25	8.11	8.37	8.22	7.82	7.27	6.64	5.99	5.34	4.72	4.14	3.61
Current	**PT**	1.75	7.39	9.68	8.98	7.03	4.98	3.30	2.08	1.27	0.75	0.44	0.25	0.14	0.08
Historic	**AG**	3.7	18.5	44.1	77.4	115.2	155.0	194.6	232.7	268.4	301.2	330.9	357.5	381.0	401.7
Historic	**AI**	1.2	10.3	30.7	59.7	92.9	126.3	157.2	184.4	207.4	226.4	241.8	254.1	263.8	271.4
Historic	**BT**	6.5	26.7	55.3	87.5	119.6	149.6	176.5	200.0	220.1	237.0	251.1	262.7	272.2	280.0
Historic	**OB**	10.4	34.9	66.2	99.9	133.4	165.0	194.0	220.1	243.1	263.2	280.7	295.7	308.5	319.4
Historic	**PA**	9.0	30.0	58.0	89.9	123.6	157.5	190.7	222.5	252.5	280.6	306.5	330.3	352.1	371.9
Historic	**PS**	10.2	43.0	89.5	140.7	190.5	235.7	275.0	308.2	335.7	358.0	376.1	390.5	402.0	411.1
Historic	**PT**	9.0	30.0	58.0	89.9	123.6	157.5	190.7	222.5	252.5	280.6	306.5	330.3	352.1	371.9

<u>The effect of three different natural disturbances was considered</u>:

1. <u>Storms</u>: based on the information reported by NIR (2014), various storms damaged Lithuanian forests between 2000-2005. According to data reported by the FORESTORMS[100] database, the following information were collected (Tab. 71):

Tab. 71: the table reports the volume damaged by the main storms, as reported by EFISTORM database (in million m^3 reported as Model INPUT); the volume and area (in ha) directly affected by each disturbance event according to model's assumptions (reported as Model OUTPUT).

Model INPUT		Model OUTPUT	
Year	**Vol damaged (M m^3)**	**Vol affected by storm (M m^3)**	**Area affected by storm (ha)**
1996			
1997			
1998			
1999			
2000*	400,000	373,733	1,160
2001			
2002			
2003			
2004			
2005	1,000,000	1,028,814	2,904
2006			
2007	300,000	307,401	870
2008			
2009			
2010			
2011			
2012			
* "Lothar", Dec 1999, assumed as occurred in 2000			

We assumed that the disturbance event was stand-replacing, affecting spruce forests[101] and moving 80% of the living biomass to snags pools, without any direct salvage of

[100] http://www.efiatlantic.efi.int/portal/databases/forestorms/

logging residues (i.e., this means that we also assumed that a fraction of the area reported in the first age class for spruce in 2006, was not directly clearcut but affected by storm).
Salvage of logging residues after natural disturbances, was simulated through specific events, moving biomass from stem snags pools to product pools. These events were further distinguished between two treatments, assuming that products were used as fuelwood or industrial roundwood and prioritizing, in some cases, the removals of harvest residues, from the stands having the highest stem snag carbon amount[102].

2. Fires: data on the amount of burned area were directly taken from the NIR (2014) for the historical period (1996-2012, Figure 102). A constant amount of burned area, equal to the average amount 2000 – 2012 was applied from 2013 to 2030.

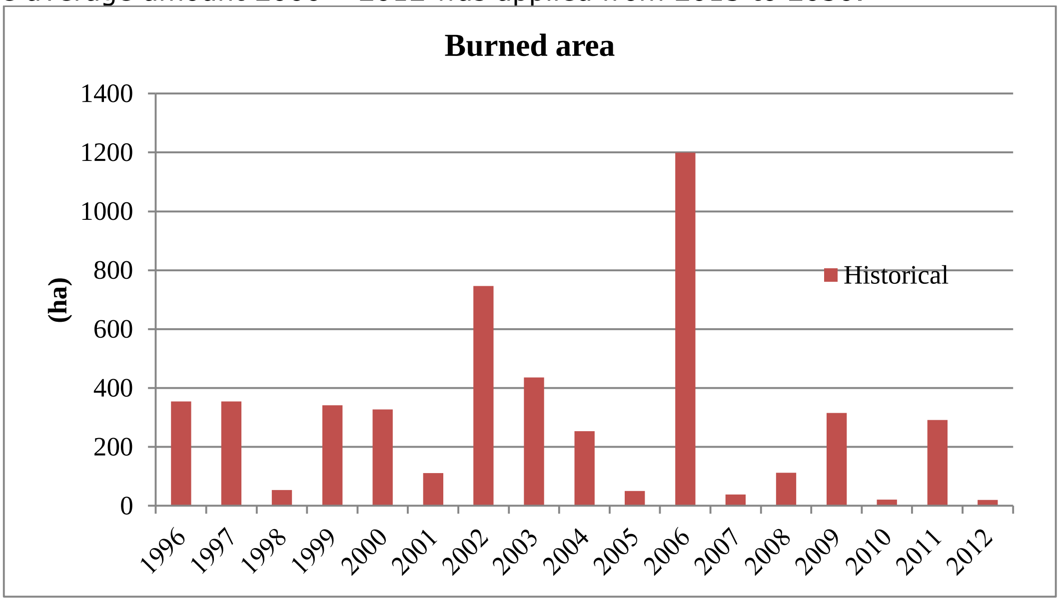

Figure 102: amount of area burned between 1996 and 2012 (based on data reported by NIR, 2014).

Fire disturbances were simulated assuming that fire affect 50% of the living biomass, with salvage of 15% of logging residues.

3. Insects: according to NIR (2014) a spruce dieback, caused by the bark beetle *Ips typographus*, affected at least 13 milion m^3 of spruce between 1994 and 1997. Since no specific information about this attack is reported by the EFI database on Forest Disturbances in Europe (DFDE[103]), we first assumed that about 30,000 ha yr^{-1} of spruce were disturbed in 1996 and 1997 (with a mortality of 5% of the living biomass on the area affected by disturbance). Secondly, considering that insects' attacks largely affected all coniferous species between 1994 and 1997 (according to DFDE database pines were also affected by other insects' attacks from *Dendrolimus pini*), we assumed that these disturbances largely decreased the growth potential of coniferous species in 1996 and 1997. This was simulated applying a growth multiplier correction factor equal to 0.01 to spruce and pine forest area in 1996 and 1997.
As for storms, salvage of logging residues after these disturbances was simulated through specific events, moving biomass from stem snags pools to product pools. These

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[101] To simplify model assumptions (above all for reconstructing the age class distribution before 2006), we assumed that the effect of storm was concentrated between the age classes 70 – 80 yrs., i.e. the average age of spruce forests in Lithuania.
[102] As suggested by the CBM's User Guide, the Sort type of this disturbance event was modified (Sort type 7) in the project database file.
[103] http://dataservices.efi.int/dfde

events were further distinguished between two treatments, assuming that products were used as fuelwood or industrial roundwood.

The 2014 NIR reports specific assumptions both on the living biomass and the dead tree stems volumes, based on two specific studies performed at national level, which can be used to validate model's results. For this reason, further assumptions were considered to model the dead wood pool:

1. We distinguished coniferous and broadleaves FTs (assuming different Climatic Units with the same mean annual temperature and precipitation), in order to apply different stem annual turnover rates and snag fall rates for conifers and broadleaves.
2. Different stem annual turnover rates and snag fall rates were applied to the initialization process and during the model run.

The final values applied to DOM turnover parameters (Tab. 72) were based on a preliminary calibration (as suggested by Pilli et al., 2013), taking into account the model output and the values provided by NIR (2014).

Tab. 72: CBM DOM turnover rates applied to Lithuania during the Initialization Process and the Model run, for coniferous and broadleaves species (further details on the meaning of these parameters are reported by Kull et al., 2011)

CBM stage	**Initialization Process**		**Model run**	
DOM Turnover parameters	Stem annual turnover rate	Stem snag fall rate	Stem annual turnover rate	Stem snag fall rate
Conifers	0.001	0.028	0.003	0.009
Broadleaves	0.002	0.028	0.028	0.018

Harvest and HWP analysis

Data from the historical FAO statistics are available only from 1992. The amount of harvest reported by FAOSTAT is on average 12% lower than the values reported by the country's submission for FMRL (Figure 103). According to the FRA 2010 Country Report[104], FAOSTAT reports the volume under bark; the same correction factor applied to Latvia, equal to 1.12, was applied to Lithuania. Further data are reported in the last NIR (2014, Figure 7-23) but they are, on average (for the period 1996-2009) 44% higher than the FAOSTAT data corrected for bark. This may be due to forest residues, included in the total amount of felling reported by NIR, and wood used for fuel, not fully accounted by FAOSTAT data (as highlighted by FRA Country Report, pag. 43). Therefore, the following assumptions were considered to estimate the final amount of harvest removals (Figure 103, NIR Corrected):

1. Based on the 2008 NFI results[105], forest residues account, on average to 16% of the total amount of harvest. We therefore decreased the amount of total fellings of living trees (Figure 7-23, NIR 2014) by 16%, to estimate the total removals. Due to this correction, the difference between NFI data and FAOSTAT data was reduced on average to 21% for the period 1996 – 2009.
2. We assumed that the largest amount of harvest reported by NIR for the period 1996-2009, was due to wood for fuel not reported by FAOSTAT data and we proportionally distributed this amount between coniferous and broadleaves fuelwood.

[104] FRA 2010 – Country Report, Lithuania (pag. 41).
[105] Forest Statistics, 2008 (pag. 81).

3. Between 2010 and 2012, due to the corrections applied to point 1, the amount of removals estimated by NIR data was slightly lower (on average -13%) than the total amount of harvest estimated by FAOSTAT. We therefore reduced the industrial and fuelwood amount, according to this correction.

After 2010, the Submission for FMRL reports a decreasing harvest demand, with a final amount of harvest equal to 6.2 million m^3 for 2020.

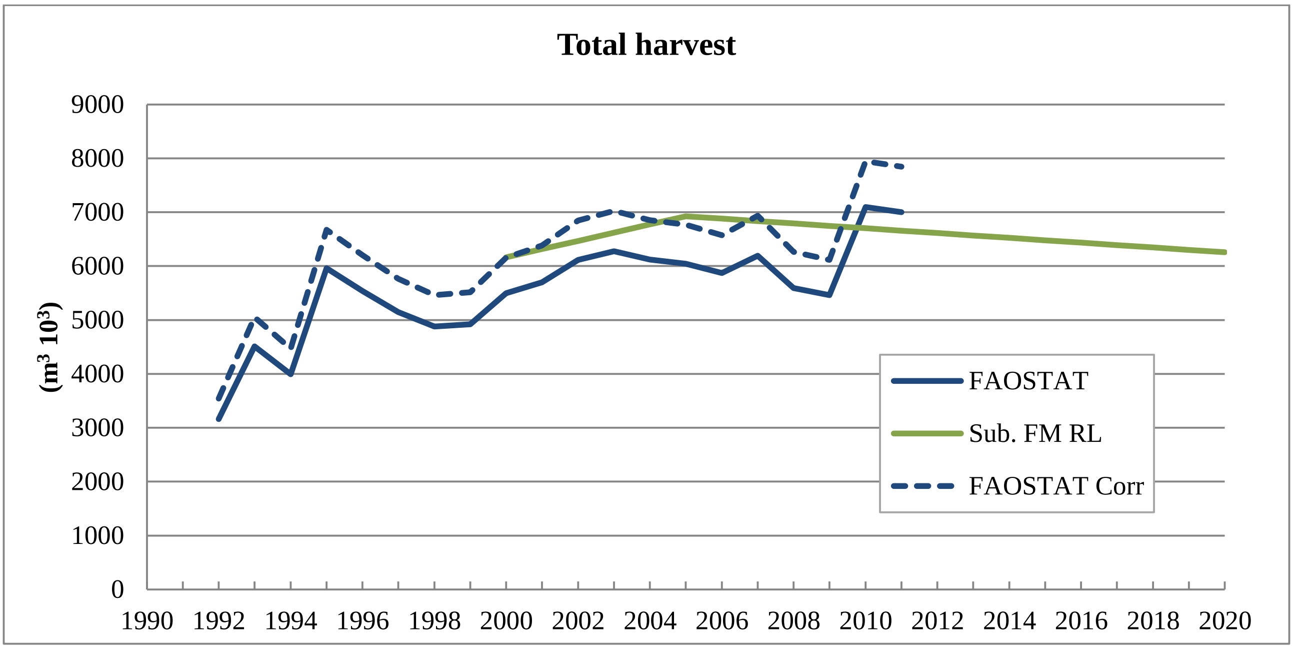

Figure 103: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (under bark) and the National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a general correction factor equal to 1.12. The figure also reports the future harvest demand (i.e., since 2013) reported by the National Submission for FM Reference Level.

The historical and future (assuming a constant harvest rate) share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 104. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

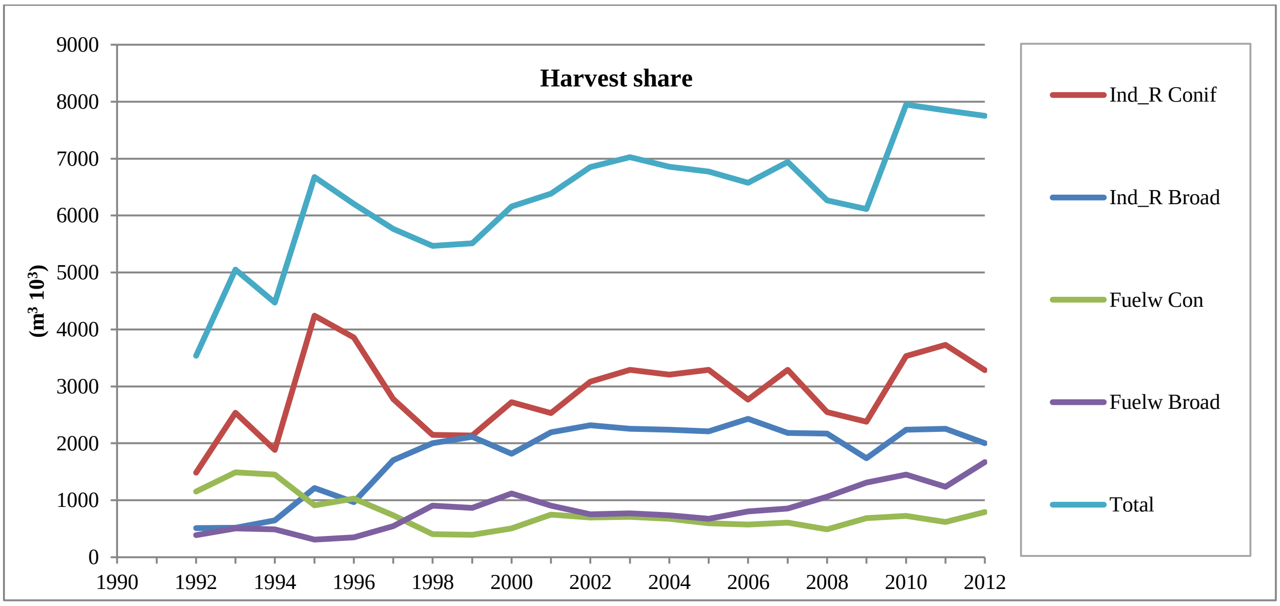

Figure 104: share of harvest applied by CBM for the historical period (until 2012), distinguished between IRW and FW and between conifers (C) and broadleaves (B).

The fraction of domestic production estimated in our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is in Figure 105.

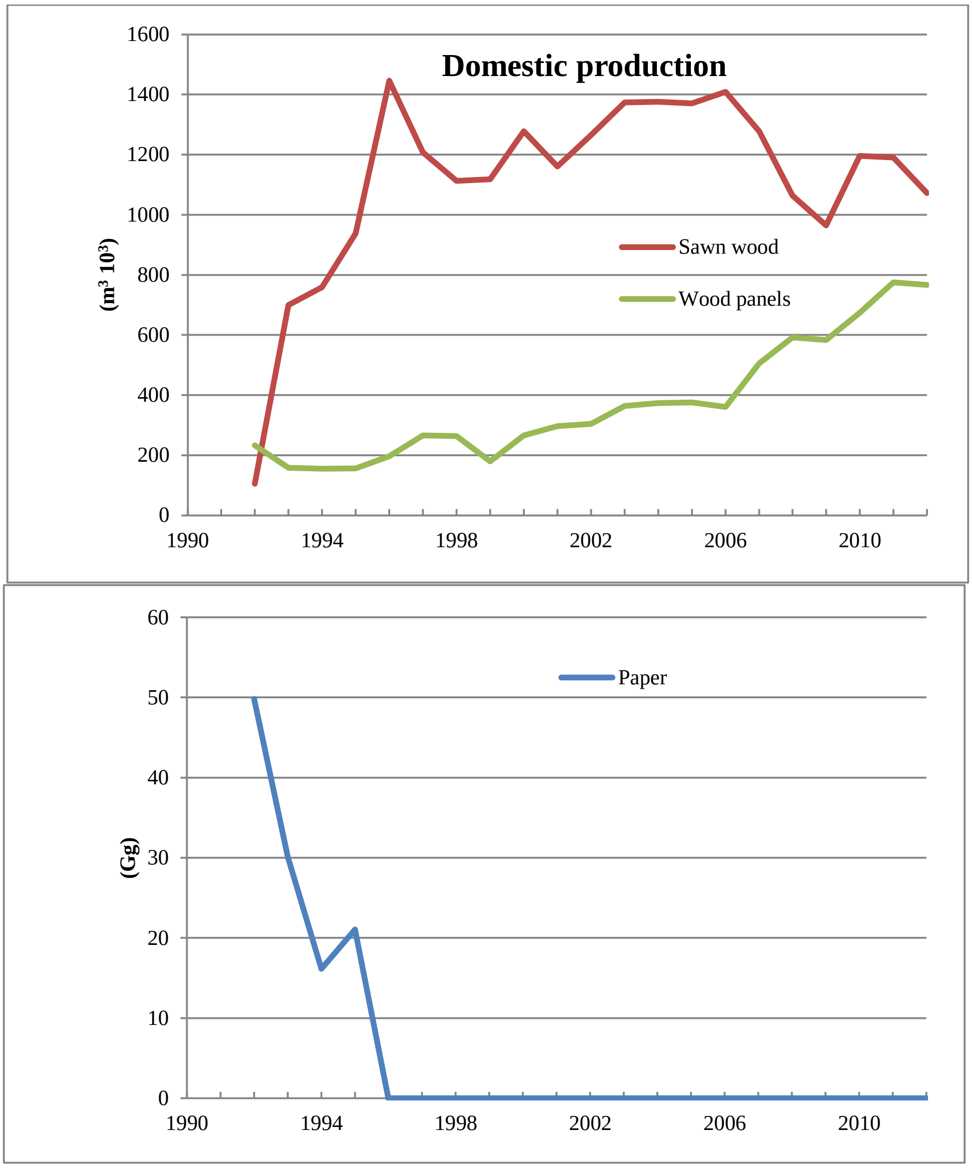

Figure 105: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Luxembourg

NFI data and model assumptions

The analysis was based on the 1998-2000 Forest Inventory of Luxemburg[106]. Since the original data were referred to 1999, they were not scaled back of 10 years. The total forest area was distributed between 1 administrative region and 2 Climatic units, as reported by Figure 32 for Belgium[107]. The total forest area reported by the original NFI data, equal to about 72 kha, was scaled to the FM area reported in the Submission on forest management reference level of Luxembourg, equal to 89 kha and it was further decreased to account for the amount of deforestation occurred between 1990 and 1999 (equal to 380 ha yr^{-1}).

The main species reported by the NFI were grouped in 5 forest types, reported in Tab. 73. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the minimal age for final felling applied for Belgium.

Tab. 73: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	**Acronym**	**Min. rotation length (yrs)**
Other broadleaves	**OB**	**80**
Other conifers	**OC**	**50**
Picea abies	**PA**	**50**
Pseudotsuga menziesii	**DF**	**50**
QuercuS spp.	**QR**	**120**

The harvest criteria applied by CBM for Luxembourg are reported on Tab. 74.

Tab. 74: main parameters defining the harvest criteria applied by CBM for Estonia, including the age classes affected by each silvicultural treatment and the relative share of harvest provided by each treatment (average for the historical period).

Silvicultural treatment	**Criteria**	**Harvest share**
15% Commercial Thinnings	>10 yrs	<1%
20% Commercial Thinnings	> 30 yrs	1%
Clearcut (95% commercial thinning)	Depending by species	98%

[106] Available at: http://www.environnement.public.lu/forets/publications/gdl_bref/gdl_bref.pdf

[107] Both the age class distribution (i.e., the Inventory table used by CBM) and the yield tables used as input by CBM were considerably revised, compared with the previous model runs.

Luxembourg

Since no specific data on biomass stock was available at national level, the same equations selected for Italy and Germany were applied to Luxembourg, according to the assumptions reported in Tab. 75.

Tab. 75: association between the forest types and the default species provided by the original CBM database, based on the selection applied to Luxembourg.

FT	Species selected by default CBM database	Germany (DE) or Italy (IT)	Correspondence with the German or Italian FTs
OB	Eastern white pine (P. strobus)	IT	OB
OC	Red pine (Pinus resinosa)	IT	OC
PA	Norway Spruce	DE	PA
DF	Red pine (P. resinosa)	DE	DF
QR	Ironwood (Ostria virginiana)	DE	QR

Species-specific historical YTs were selected using the average volume reported by NFI. Since no increment data was available, the same current YTs selected for the Wallonia region were applied to Luxemburg (see Tab. 76).

Luxembourg

Tab. 76: Yield tables applied by CBM model for Luxembourg. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	OB	9.2	7.8	6.6	5.6	4.7	4.0	3.4	2.8	2.4	2.0	1.7	1.4	1.2	1.0
Current	OC	21.8	20.6	19.0	17.3	15.7	14.3	12.9	11.7	10.5	9.5	8.6	7.7	6.9	6.2
Current	PA	21.8	20.6	19.0	17.3	15.7	14.3	12.9	11.7	10.5	9.5	8.6	7.7	6.9	6.2
Current	QR	1.5	1.6	1.7	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0
Current	DF	23.0	24.4	24.2	23.2	22.0	20.6	19.2	17.8	16.4	15.1	13.9	12.7	11.6	10.6
Historic	OB	2.1	20.0	57.9	106.1	154.2	196.0	229.6	255.4	274.4	288.2	298.0	304.9	309.8	313.2
Historic	OC	4.6	19.9	44.8	77.4	115.5	157.4	201.5	246.6	291.8	336.2	379.3	420.7	460.1	497.4
Historic	PA	2.6	15.2	39.9	75.5	119.9	170.4	224.8	280.9	337.1	392.2	445.2	495.5	542.6	586.5
Historic	QR	4.3	13.7	26.3	41.2	57.7	75.3	93.6	112.4	131.3	150.2	168.9	187.4	205.4	223.1
Historic	DF	1.6	14.5	45.6	93.2	151.6	214.4	276.7	335.1	387.7	433.8	473.2	506.4	534.0	556.8

Luxembourg

The effects of Storm disturbance events were considered according to the following assumptions:

1. Based on the information reported by the FORESTORMS[108] database 90,000 m^3 of merchantable biomass were damaged in Luxembourg in 2010 (no further information is reported on natural disturbance events).
2. We assumed that about 60% of the volume damaged by this event was removed as salvage logging (i.e., about 54,000 m^3). This amount was distributed proportionally to the forest area occupied by each FT.
3. The storm was simulated as a widespread disturbance event (i.e., not stand replacing), assuming that 50% of the living biomass was damaged and, on this amount, about 60% of the damaged merchantable biomass (i.e., 30% of the total) was moved to the products pool (i.e., harvested after the disturbance event) and the other living biomass components were moved to the dead wood and litter pools.

Harvest and HWP analysis

The historical FAO statistics provide data only from 2000. The amount of harvest reported by FAOSTAT is on average 12% lower than the values reported by the country's submission for FMRL but it also has a higher inter-annual variability (Figure 106). Since the values reported in the FRA 2010 Country Report[109], are referred to the volume over bark and they are consistent with FAOSTAT, no further correction was applied. No data is reported by the last NIR (2014). After 2010, the Submission for FMRL reports a constant harvest demand, with a final amount of harvest equal to 0.31 million m^3 for 2020.

[108] http://www.efiatlantic.efi.int/portal/databases/forestorms/
[109] FRA 2010 – Country Report, Luxembourg (pag. 29), reporting the volume over bark.

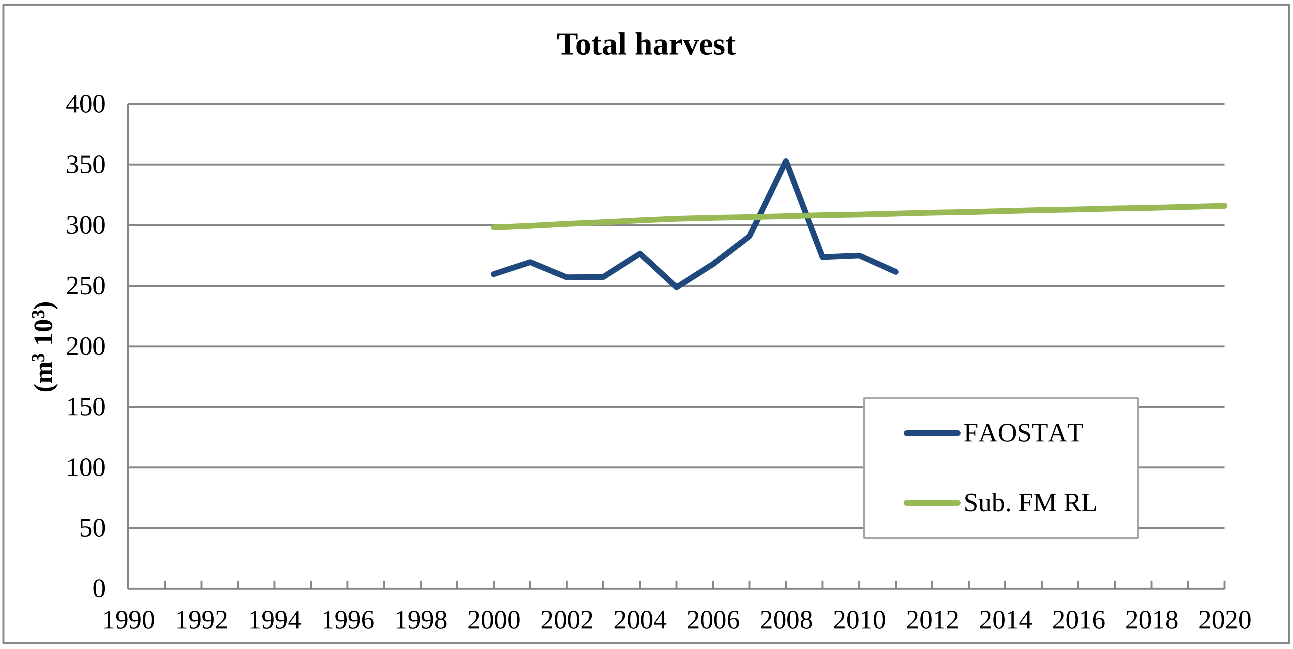

Figure 106: the figure shows the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (over bark) and National Submission for FM Reference Level (Sub. FMRL). The future harvest demand (i.e., from 2013) is reported according to the National Submission for FM Reference Level.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is shown in Figure 107. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

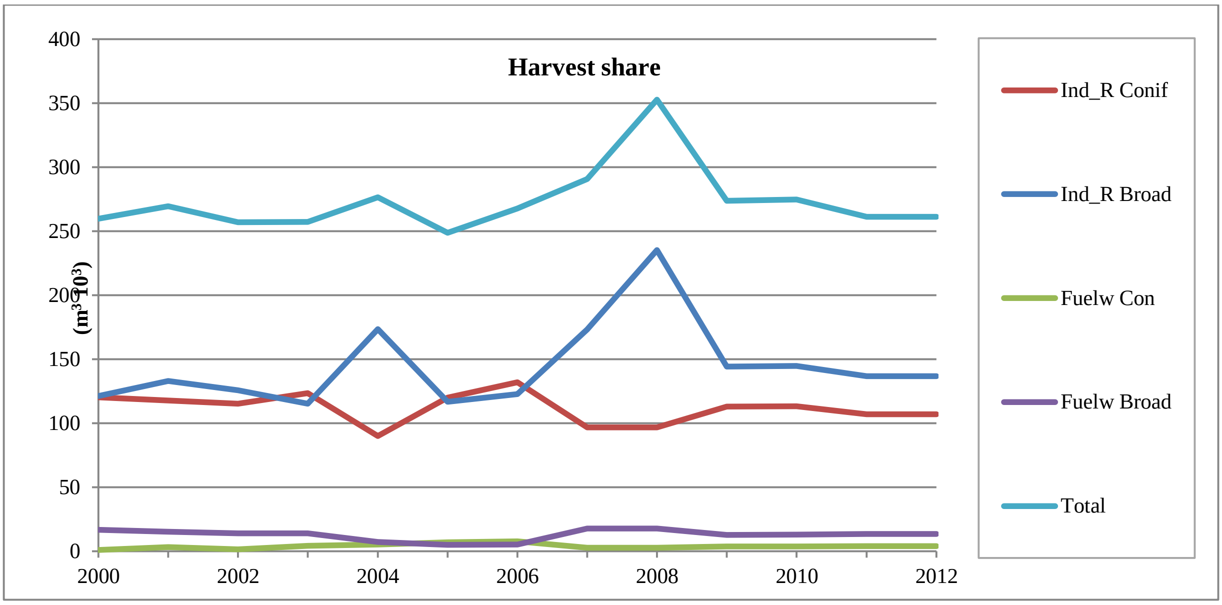

Figure 107: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest until 2012 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 108.

Luxembourg

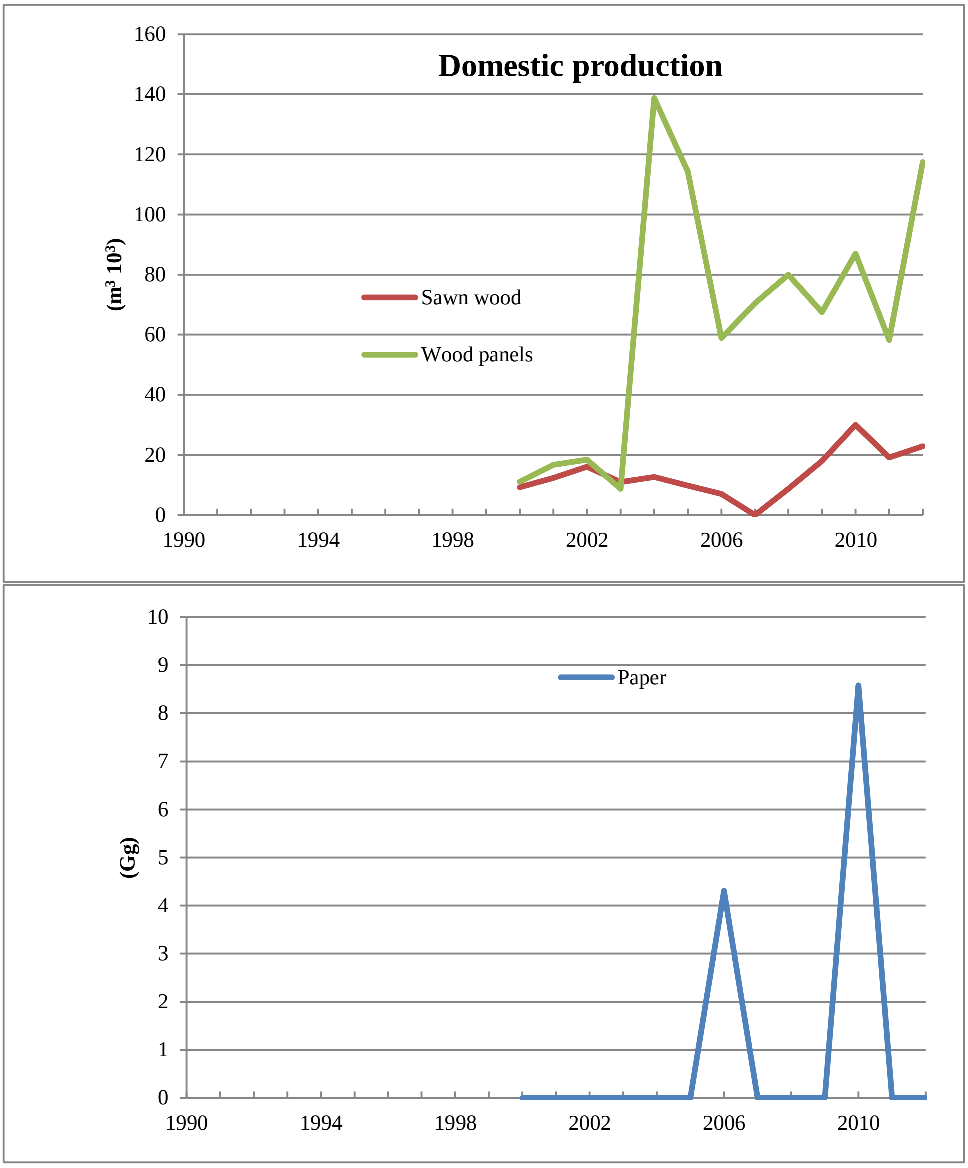

Figure 108: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

The Netherlands

NFI data and model assumptions

The analysis was based on data reported by the EFI database, referred to the period 1995 – 1999, integrated with additional data provided by the country for the increment. Since the original data were referred to 1997, they were not scaled back of 10 years. Due to the lack of detailed information on the age class distribution, the total forest area was aggregated at national level and included only the CLU 35 (see Figure 32). The total forest area reported by NFI data, equal to 306 kha, was scaled to 348 kha, i.e. the FM area reported for 1997 by the Submission of information on forest management reference level of Netherlands[110].

The main species reported by the NFI were grouped in 10 forest types, reported in Tab. 77. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the minimal age for final felling applied to Belgium.

Tab. 77: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	Acronym	Min. rotation length (yrs)
Betula sp.	**BT**	**50**
Pseudotsuga menziesii	**DF**	**50**
Fagus sylvatica	**FS**	**120**
Larix sp.	**LD**	**50**
Other broadleaves	**OB**	**50**
Other conifers	**OC**	**50**
Picea abies	**PA**	**50**
Pinus sylvestris	**PS**	**70**
Populus sp.	**PT**	**30**
Quercus sp.	**QR**	**90**

The main parameters defining the harvest criteria applied by CBM for the Netherlands are reported on Tab. 78.

[110] This means that no further correction to account for the deforestation is needed.

The Netherlands

Tab. 78: main parameters defining the harvest criteria applied by CBM for the Netherland, including the age classes affected by each silvicultural treatment and the total amount of harvest provided by each treatment.

Silvicultural treatment	Criteria	Harvest share
15% Commercial Thinnings	20 – 60 yrs	1%
20% Commercial Thinnings	> 10 yrs.	28%
30% Commercial Thinnings	20 – 50 yrs	7%
Clearcut (95% commercial thinning)	Depending by species	64%

Since no specific data on biomass stock was available at national level, the same equations selected for Germany, Italy and Latvia were applied to the Netherlands, according to the assumptions reported in Tab. 79.

Tab. 79: association between the forest types used for the Netherlands and the default species provided by the original CBM database, based on the selection applied to Germany, Italy and Latvia.

FT	Species selected by default CBM database	Germany (DE), Italy (IT) or Latvia (LV)	Correspondence with the German, Italian or Latvian FTs
BT	Red pine (P. resinosa)	LV	Birch (LV)
DF	Red pine (P. resinosa)	DE	DF
FS	Sugar Maple	DE	FS
OB	Eastern white pine (P. strobus)	IT	OB
OC	Red pine (Pinus resinosa)	IT	OC
PA	Norway Spruce	DE	PA
LD	Tamarack (Larix laricina)	DE	LD
PS	Eastern white-cedar	DE	PS
PT	White spruce (P. glauca)	LV	Aspen (LV)
QR	Ironwood (Ostria virginiana)	DE	QR

Species-specific YTs were selected using the average volume reported by the EFI database and the specific increment data reported by the Submission of information on forest management reference level of the Netherlands. A correction factor equal to 1.05 was applied to the original NFI data to account for the trees under a minimum Dbh threshold equal to 5 cm. The current library and the historical library applied by CBM model are reported in Tab. 80.

The Netherlands

Tab. 80: Yield tables applied by CBM model for the Netherlands. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	BT	5.3	6.6	7.2	7.4	7.4	7.3	7.1	6.9	6.6	6.3	6.0	5.6	5.3	5.0
Current	DF	9.6	14.2	16.2	16.5	15.8	14.6	13.2	11.7	10.2	8.8	7.5	6.3	5.3	4.5
Current	FS	11.4	14.1	15.0	14.9	14.4	13.6	12.7	11.7	10.7	9.7	8.8	7.9	7.1	6.3
Current	LD	18.7	16.9	15.1	13.5	12.0	10.6	9.4	8.3	7.4	6.5	5.8	5.1	4.5	4.0
Current	OB	9.4	10.6	10.9	10.7	10.3	9.7	9.1	8.4	7.8	7.2	6.6	6.0	5.5	5.0
Current	OC	20.6	17.8	15.4	13.3	11.5	10.0	8.6	7.4	6.4	5.6	4.8	4.2	3.6	3.1
Current	PA	26.0	22.8	19.2	16.0	13.2	10.9	8.9	7.3	6.0	4.8	4.0	3.2	2.6	2.1
Current	PS	17.4	15.1	13.1	11.4	9.9	8.6	7.4	6.4	5.6	4.9	4.2	3.7	3.2	2.8
Current	PT	8.9	15.2	17.0	16.1	13.9	11.3	8.9	6.7	5.0	3.6	2.6	1.8	1.3	0.9
Current	QR	7.5	9.9	10.8	10.9	10.6	10.1	9.4	8.6	7.8	7.1	6.3	5.6	5.0	4.4
Historic	BT	2.1	21.7	65.3	121.8	178.3	227.4	266.6	296.3	318.0	333.6	344.6	352.3	357.6	361.3
Historic	DF	30.5	106.5	199.7	292.6	376.5	448.2	507.4	555.3	593.3	623.2	646.5	664.5	678.5	689.2
Historic	FS	21.8	65.1	116.4	169.2	219.9	266.7	308.9	346.3	379.0	407.4	431.8	452.6	470.4	485.5
Historic	LD	11.5	53.8	116.5	185.6	251.9	310.6	360.2	400.6	433.0	458.4	478.1	493.4	505.1	514.0
Historic	OB	11.8	55.0	125.7	214.7	313.6	415.8	516.5	612.4	701.6	783.1	856.6	922.0	979.8	1030.6
Historic	OC	19.6	107.7	236.0	364.2	471.9	554.5	614.5	656.6	685.6	705.3	718.5	727.4	733.3	737.2

The Netherlands

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Historic	PA	2.0	34.0	122.5	246.3	371.3	477.2	558.1	616.4	656.7	684.0	702.2	714.1	722.0	727.1
Historic	PS	2.1	21.7	65.3	121.8	178.3	227.4	266.6	296.3	318.0	333.6	344.6	352.3	357.6	361.3
Historic	PT	14.0	82.6	198.9	336.1	472.2	594.6	698.4	782.9	850.0	902.1	942.2	972.7	995.7	1013.0
Historic	QR	1.7	13.8	42.2	86.4	142.3	205.2	270.8	335.4	396.8	453.6	504.8	550.3	590.2	624.9

Based on the information reported by the FORESTORMS[111] database, the effect of a storm occurred in 2007 was considered. About 0.25 million m^3 were damaged; we assumed that: (i) this amount was distributed between the main FTs, according to their proportion in the total forest area; (ii) 15% of the living biomass was damaged by this disturbance (i.e., this was a widespread disturbance event); (iii) all the merchantable biomass damaged by this event was removed as salvage logging; (iv) there was a direct salvage of logging residues, moving 10% of the merchantable biomass to the product sector (i.e., 5% of the living biomass moved to the DOM pools).

Harvest and HWP analysis

The historical FAO statistics provide complete data since 1961. The amount of harvest reported by FAOSTAT shows the same trend reported by the country's submission for FMRL but it is on average 13% lower than this one (Figure 109). According to the FRA 2010 Country Report[112], the bark's fraction is equal to 1.18 for conifers and 1.15 for broadleaves; therefore we assumed an average correction factor equal to 1.165. No data is reported in the last NIR (2013). After 2010, the Submission for FMRL reports a constant harvest demand, with a final amount of harvest equal to 1.2 million m^3 for 2020.

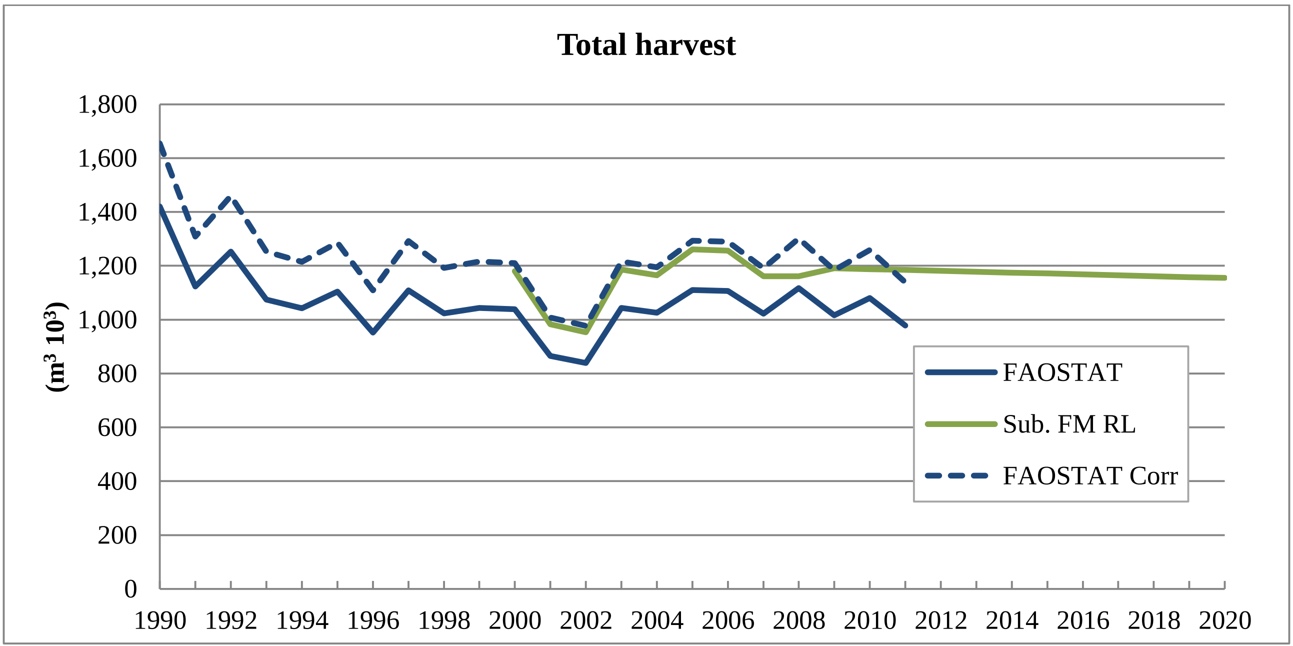

Figure 109: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (over bark) and National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a general correction factor equal to 1.116. The future harvest demand (i.e., from 2013) is reported according to the National Submission for FM Reference Level.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 110. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

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[111] http://www.efiatlantic.efi.int/portal/databases/forestorms/
[112] FRA 2010 – Country Report, The Netherlands (pag. 40), reporting the volume over bark.

The Netherlands

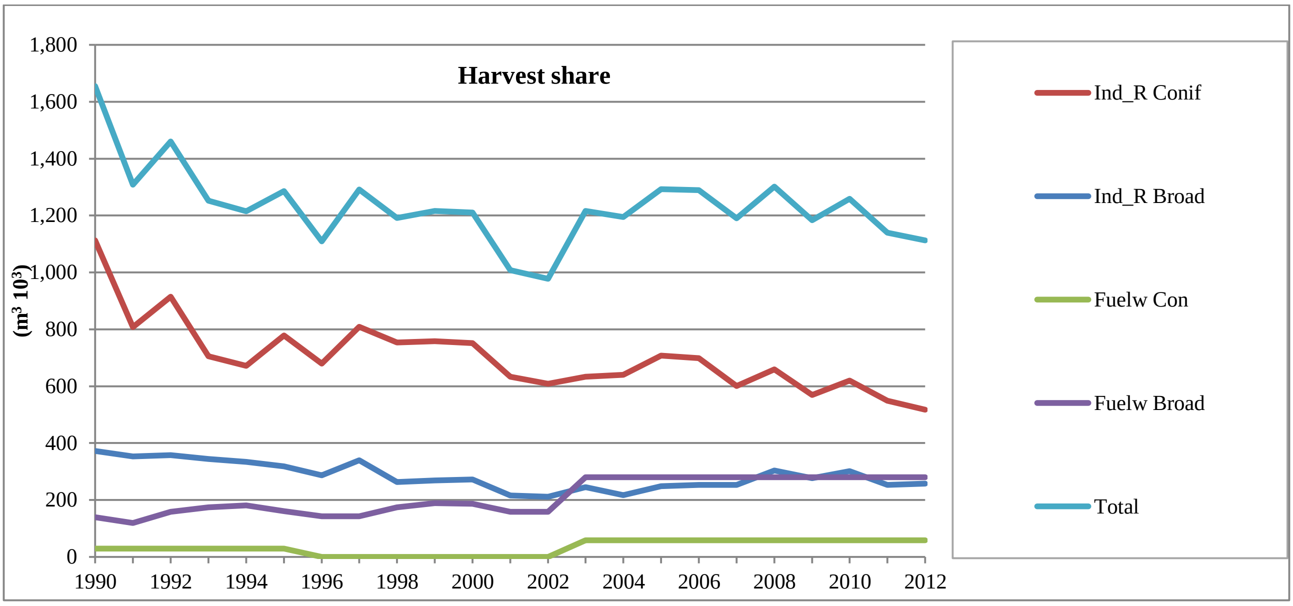

Figure 110: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2012 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 111.

The Netherlands

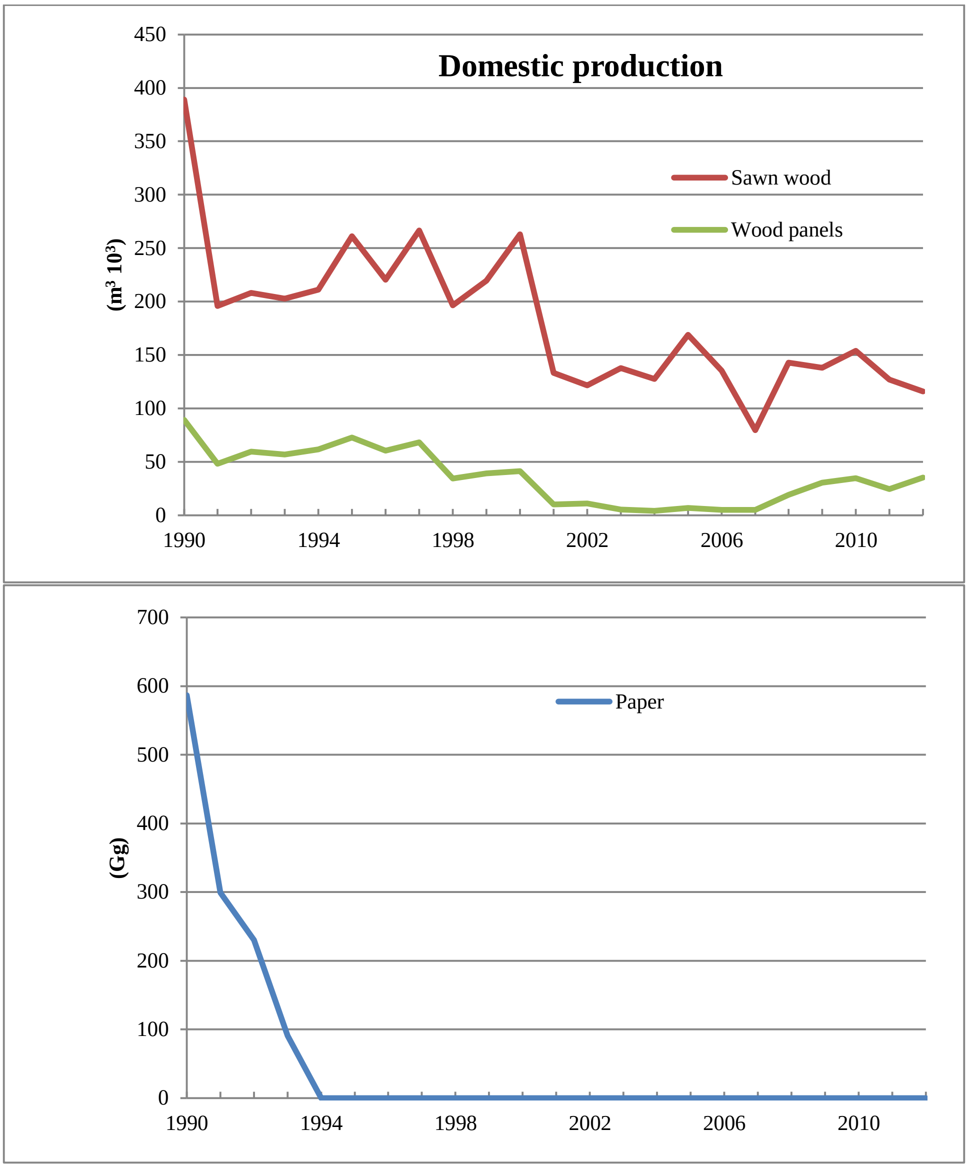

Figure 111: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Poland[113]

NFI data and model assumptions

The analysis was based on data collected by the available NFI data collected in 1993 (therefore original data were not scaled back). The total forest area equal to 8,873 kha[114] was distributed between 9 CLUs (Figure 112) and further decreased in order to account for the total amount of deforestation occurred until 1993 (i.e., about 540 ha yr^{-1}). For the final analysis, all input data were grouped at national level.

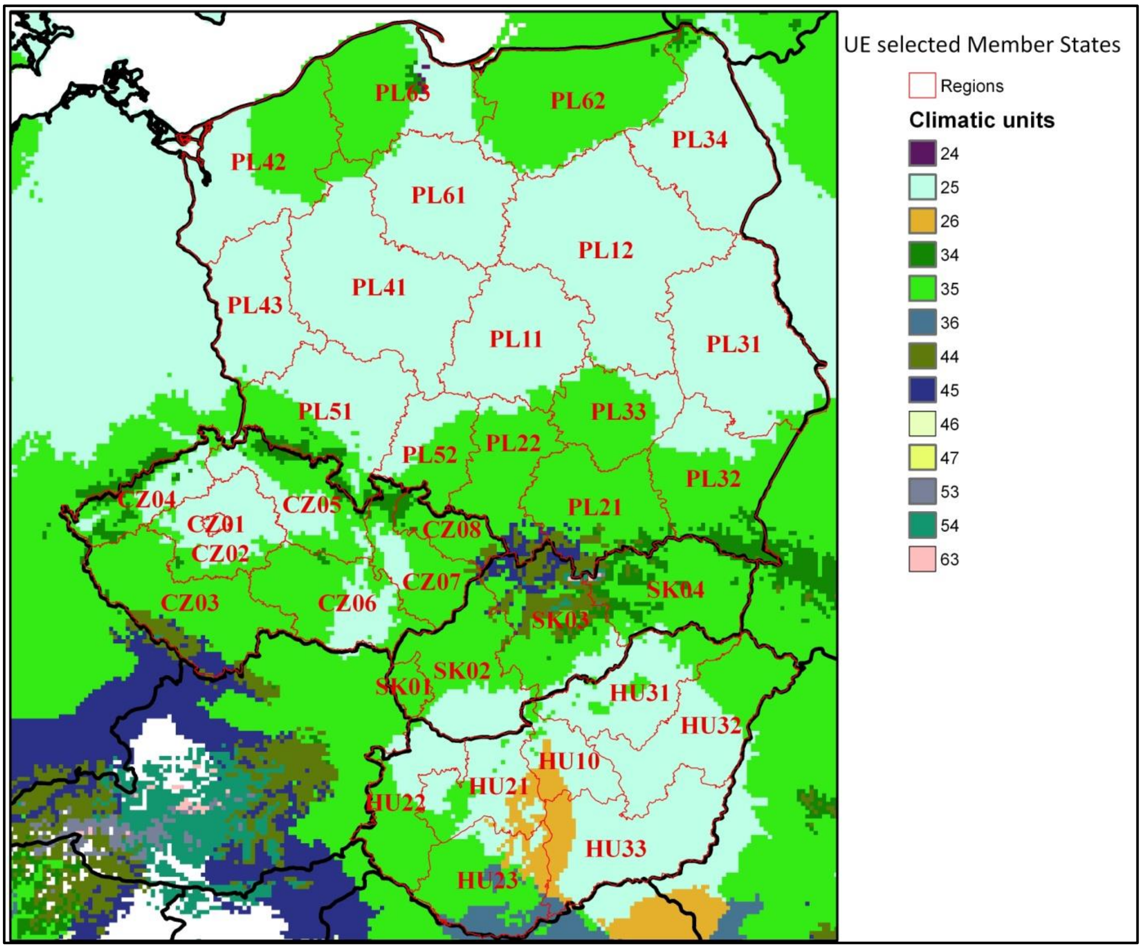

Figure 112: Administrative regions defined at NUTS2 level and CLUs applied to Poland, Czech Republic, Slovakia and Hungary.

The main species reported by the NFI were grouped in 9 forest types, reported in Tab. 81. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the information reported by the Submission of information on forest management reference level of Poland[115].

[113] Further information on this case study are reported by Pilli et al., 2016.
[114] The original NFI forest area, equal to 8,813 kha was scaled to the FM area reported for 2009 by the Submission for the forest management reference level of Poland.
[115] Available at: http://unfccc.int/documentation/documents/advanced_search/items/6911.php?priref=600006460#beg

Poland

Tab. 81: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	Acronym	Min. rotation length (yrs)
Abies alba	AA	**120**
Alnus sp. (we assumed that Black Alder was the main species)	AG	**80**
Betula sp.	BT	**70**
Fagus sylvatica	FS	**100**
Other broadleaves	OB	**80**
Picea abies	PA	**80**
Pinus sp.	PS	**80**
Populus sp.	PT	**40**
Quercus sp. (we assumed that Quercus robur was the main species)	QR	**130**

The main parameters defining the harvest criteria applied by CBM for Poland are reported on Tab. 82

Tab. 82: main parameters defining the harvest criteria applied by CBM for Poland, including the age classes affected by each silvicultural treatment and the relative amount of harvest provided by each treatment (estimated as the average amount of harvest provided between 1993 and 2012).

Silvicultural treatment	Criteria	Harvest share
20% Commercial Thinnings	> 10 yrs.	33%
30% Commercial Thinnings	> 10 yrs.	24%
Clearcut (95% commercial thinning)	Depending by species	41%
Salvage logging after Nat. Disturbances	Depending by years	≈ 1%

Since no specific data on biomass stock was available at national level, the equations selected for Germany and Latvia were applied to Poland, according to the assumptions reported in Tab. 83.

Tab. 83: association between the Polish forest types and the default species provided by the original CBM database, based on the selection applied to the Latvian case study.

FT	Species selected by default CBM database	Germany (DE) or Latvia (LV)	Correspondence with the German or Latvian FTs
AA	Jack Pine (Pinus banksiana)	DE	AA
AG	Eastern white pine (P. strobus)	LV	Black alder (LV)
BT	Red pine (P. resinosa)	LV	Birch (LV)
FS	Sugar Maple (Acer saccharum)	DE	FS
OB	Willow (Salix sp.)	DE	OB_L
PA	Norway Spruce (Picea abies)	DE	PA
PS	Eastern white-cedar (Thuia occidentalis)	DE	PS
PT	White spruce (P. glauca)	LV	Aspen (LV)
QR	Ironwood (Ostria virginiana)	DE	QR

Species-specific YTs were selected using the average volume and increment reported at national level. Since the NFI reports the gross annual increment (including the volume of dead trees) by species and age classes, original NFI data were corrected to account for natural mortality. The historical library (based on the average volume reported by NFI for each species) and the current library are reported in Tab. 84.

Poland

Tab. 84: Yield tables applied by CBM model for Poland. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16	Age17
Current	**AA**	0.1	1.6	3.8	6.1	7.9	8.9	9.3	9.1	8.5	7.7	6.8	5.9	4.9	4.1	3.4	2.7	2.2
Current	**AG**	0.8	1.7	2.4	3.0	3.5	3.9	4.2	4.4	4.6	4.8	4.9	5.0	5.1	5.1	5.2	5.2	5.1
Current	**BT**	0.4	1.6	2.6	3.4	4.0	4.4	4.7	4.8	4.8	4.7	4.6	4.4	4.1	3.9	3.6	3.4	3.1
Current	**FS**	0.1	1.2	3.0	5.0	6.6	7.7	8.2	8.3	8.0	7.4	6.7	5.9	5.1	4.4	3.7	3.1	2.5
Current	**OB**	0.5	1.6	2.5	3.2	3.8	4.2	4.5	4.7	4.9	4.9	4.9	4.8	4.7	4.6	4.4	4.3	4.1
Current	**PA**	0.1	1.6	5.2	9.3	12.3	13.7	13.7	12.6	10.8	8.9	7.1	5.4	4.1	3.0	2.2	1.5	1.1
Current	**PS**	0.2	1.7	3.8	5.6	6.9	7.4	7.5	7.1	6.5	5.7	4.9	4.1	3.4	2.8	2.3	1.8	1.4
Current	**PT**	0.6	3.1	5.1	6.1	6.1	5.6	4.8	3.9	3.1	2.4	1.8	1.3	1.0	0.7	0.5	0.4	0.3
Current	**QR**	0.1	1.2	2.8	4.5	5.9	6.8	7.3	7.3	7.1	6.7	6.1	5.5	4.8	4.2	3.6	3.0	2.5
Historic	**AA**	1.5	11.8	34.3	67.3	107.1	149.9	192.5	233.1	270.1	303.2	332.1	356.9	378.0	395.8	410.7	423.1	433.3
Historic	**AG**	1.0	7.3	21.4	43.4	72.3	106.7	144.7	184.9	225.9	266.6	306.1	344.0	379.7	413.0	443.8	472.0	497.8
Historic	**BT**	4.8	20.2	43.1	70.1	98.5	126.5	152.9	177.1	198.7	217.9	234.6	249.0	261.4	272.0	281.0	288.6	295.0
Historic	**FS**	1.5	11.8	34.3	67.3	107.1	149.9	192.5	233.1	270.1	303.2	332.1	356.9	378.0	395.8	410.7	423.1	433.3
Historic	**OB**	1.8	8.3	19.6	35.6	55.9	80.1	107.7	138.5	171.8	207.4	244.8	283.8	324.0	365.1	406.9	449.1	491.5
Historic	**PA**	13.4	48.3	94.2	143.4	191.2	235.2	274.2	308.1	336.9	361.2	381.4	398.1	411.9	423.2	432.4	439.9	446.0
Historic	**PS**	10.4	34.9	66.2	99.9	133.4	165.0	194.0	220.1	243.1	263.2	280.7	295.7	308.5	319.4	328.7	336.6	343.2

Poland

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16	Age17
Historic	**PT**	2.1	20.0	57.9	106.1	154.2	196.0	229.6	255.4	274.4	288.2	298.0	304.9	309.8	313.2	315.5	317.2	318.3
Historic	**QR**	3.9	23.5	57.7	99.1	140.9	179.3	212.5	239.9	262.1	279.5	293.2	303.7	311.7	317.8	322.5	326.0	328.6

Poland

The effects of Storm disturbance events were considered according to the following assumptions:

1. Based on the information reported by the FORESTORMS[116] database, the following storms affected Poland's forests during the last years (Tab. 112).

Tab. 85: amount of merchantable volume (in million m^3) damaged by storms in Poland, as reported by the FORESTORMS database.

Year	Primary damage (Mm3)
	B
1999	2.0
2007	3.0

2. The volume damaged by each storm was distributed between each FT according to its proportion in the total forest area and converted to tons of C using the wood density.
3. The disturbance event was simulated as a widespread–storm (i.e., not stand replacing), affecting 15% of the living biomass, with a direct salvage of logging residues. This one was simulated moving 10% of the merchantable biomass to the product pool and the remaining 5% to DOM.

Harvest and HWP analysis

The historical FAO statistics provide complete data since 1961. The amount of harvest reported by FAOSTAT is consistent with the data reported by the country's submission for FMRL but it is lower than the values reported in the FRA 2010 Country Report[117] (Figure 113). According to this report, the national statistics report the volume under bark and a correction fraction equal to 1.2 is generally applied at the country level. No data is reported by the last NIR (2013). After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 42.5 million m^3 for 2020.

[116] http://www.efiatlantic.efi.int/portal/databases/forestorms/

[117] FRA 2010 – Country Report, Poland (pag. 43), reporting the volume over bark.

Poland

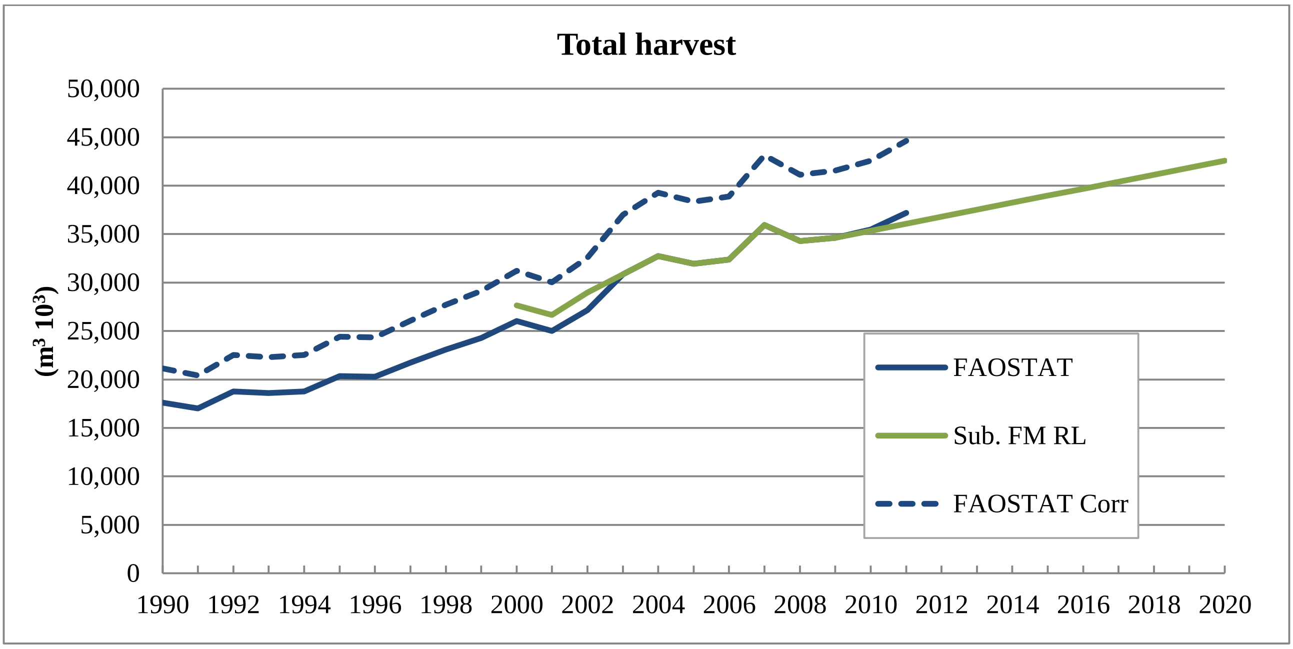

Figure 113: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (over bark) and the National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a general correction factor equal to 1.2. The future harvest demand (i.e., 2013 onward) is reported according to the National Submission for FM Reference Level.

The historical share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 114. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

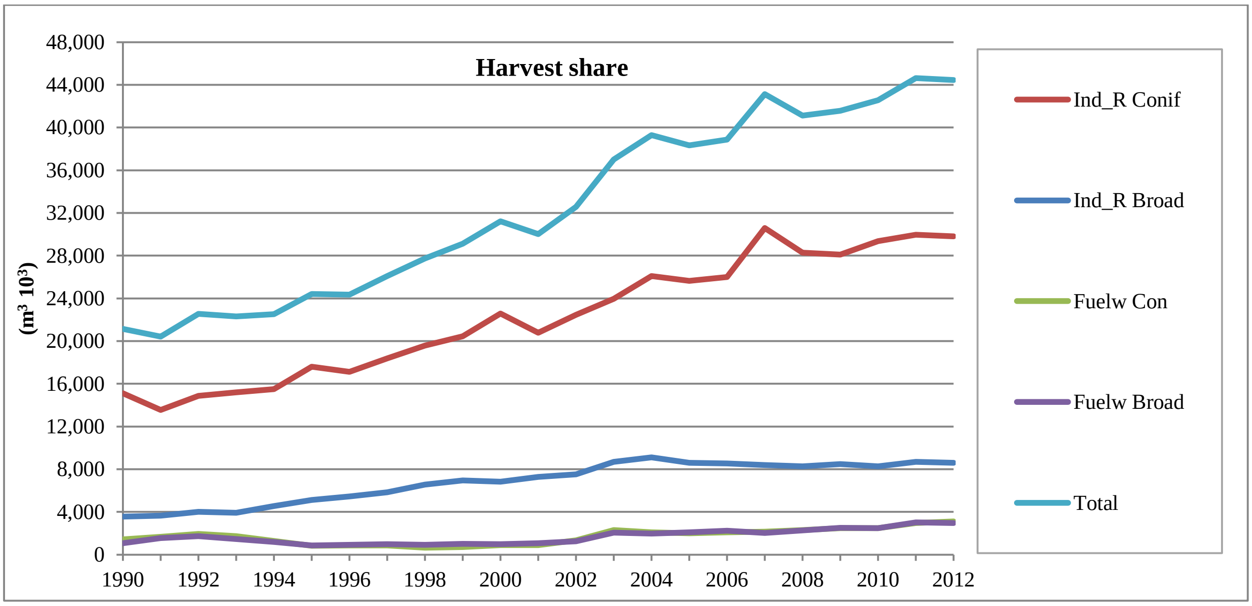

Figure 114: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2012 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 115.

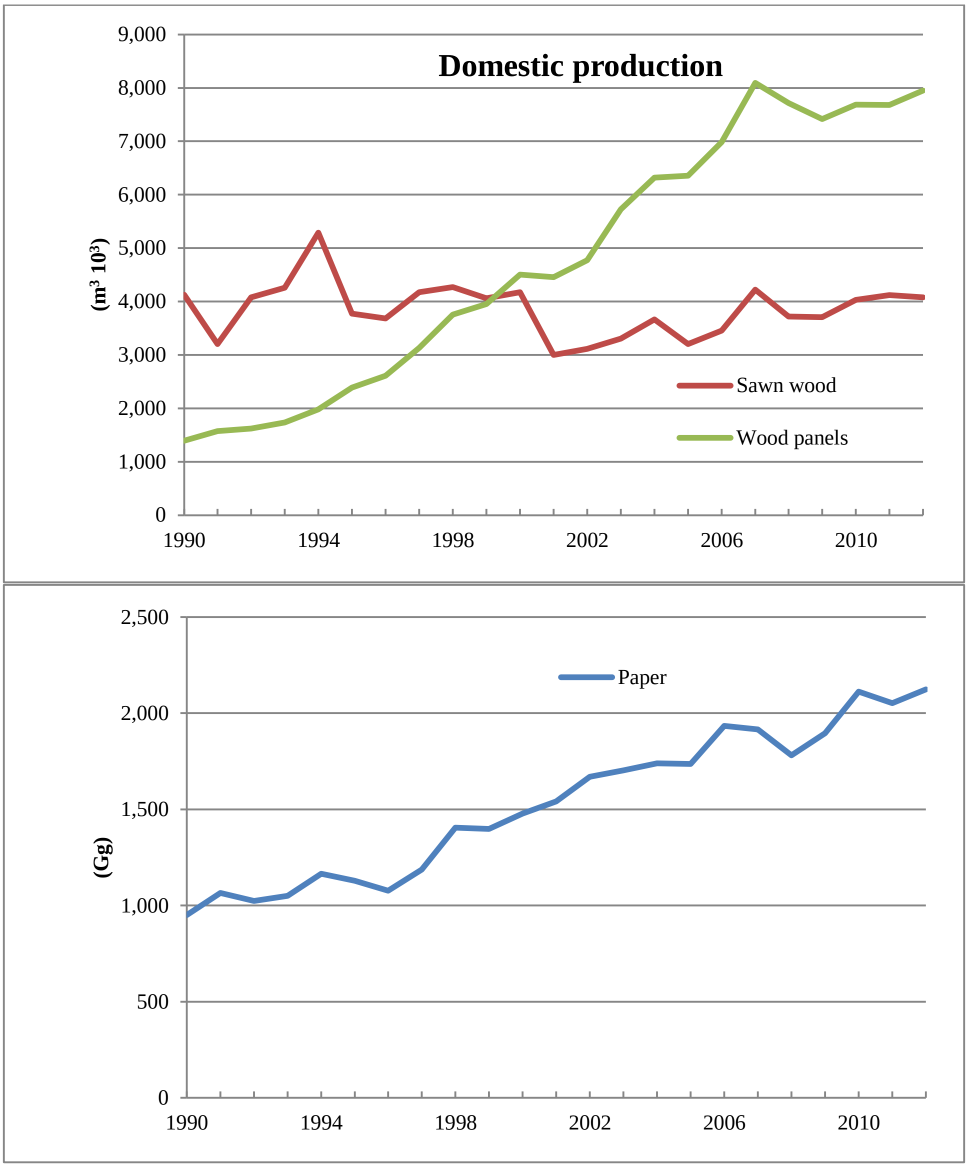

Figure 115: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Portugal[118]

NFI data and model assumptions

The analysis was based on data reported in the 2005 NFI, reporting a total forest area equal to 3,169 kha. The original age class distribution was scaled back to 1995 and to a forest area equal to 3,614 kha (i.e., the FM area referred to 1990 equal to 3,700 kha, minus 5 times the annual rate of deforestation reported by Portugal, equal to 14.2 kha yr^{-1}). The area was finally distributed between 5 administrative regions[119] and 12 Climatic units, reported by Figure 116.

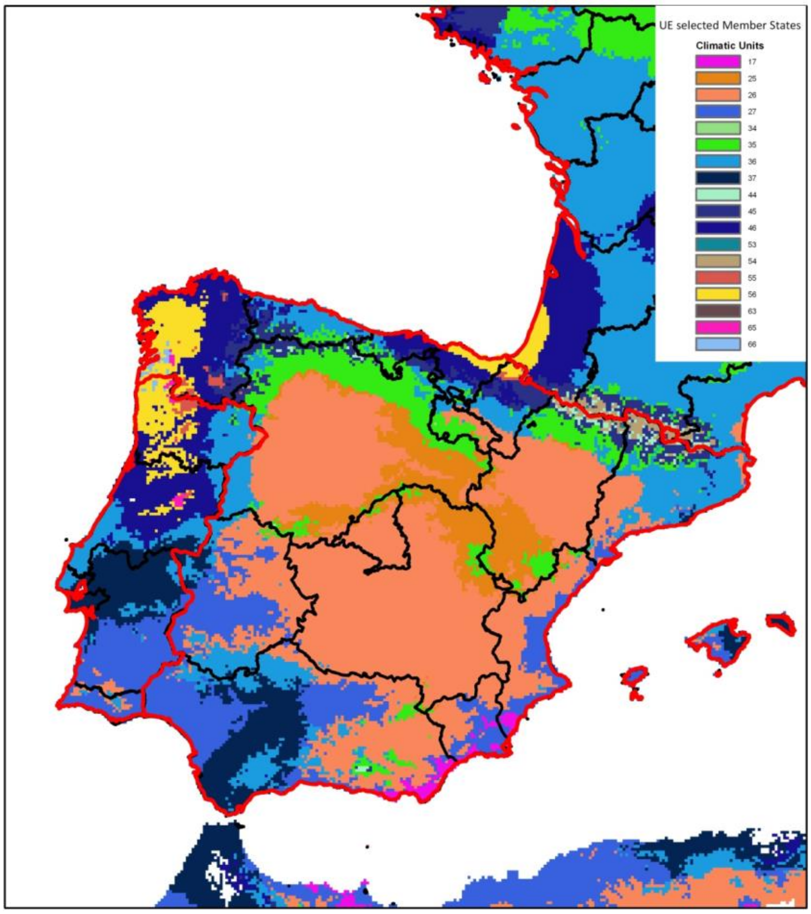

Figure 116: Administrative regions defined at NUTS2 level and CLUs applied to Portugal and Spain.

The total forest area reported by NFI was further scaled by age classes and species according to the additional information reported by the submission for forest management reference level of Portugal (2011).The main species reported by NFI were grouped in 8 forest types (Tab. 88). All species, except *Eucaliptus sp.*, were managed as high forests[120]. We assumed that the area reported as "irregular forests" was managed as uneven-aged.

Specific equations were selected using volume and the aboveground biomass by species, estimated by country-specific equations provided by literature (Portuguese National Forest Authority, 2010). The average aboveground total biomass by species was compared with the

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[118] A specific validation of CBM on the Lithuania's case study is reported by Pilli et al., 2016.
[119] Due to the high variability of the volume and increment data reported by NFI, used to derive the YTs library, the analysis was performed at regional (i.e., NUTS 2 level).
[120] For the even-aged FTs, the area originally reported by NFI as age class 70, was distributed from age classes 70 to 120.

values provided by the original set of equations reported by Boudewin et al (2007) for Quebec. The equations selected for Portugal are reported Tab. 86.

Tab. 86: association between the forest types and the default species provided by the original CBM database.

FT	Species selected by default CBM database
PM	Red pine (P. resinosa)
PP	Jack Pine (Pinus banksiana)
OC	Red pine (P. resinosa)
EG	Red pine (P. resinosa)
OB	White elm (Ulmus americana)
QH	White elm (Ulmus americana)
QR	White elm (Ulmus americana)
QS	Green ash (Fraxinus pennsylvanica var. subintegerrima)

Tab. 98 reports the percentage difference between the average aboveground total biomass estimated by the selected equations and the country-specific values of biomass.

Tab. 87: the table reports the mean percentage difference and the standard deviation between the average aboveground total biomass estimated by the selected CBM equations and the country-specific biomass values (the mean and the standard deviations were estimated considering the values reported by FT and age class)

FT	Mean Δ	St dev.
EG	24.96	12.43
PM	45.27	10.97
PP	21.67	27.22
QH	-5.87	5.34
QR	20.80	3.68
QS	13.90	26.74

Portugal

Specific rotation lengths were applied for each even-aged FT, according to the values reported by literature. After 2011 a reduction factor equal to 0.9 of the default minimum rotation length was applied during the model run.

Tab. 88: main species grouped by forest types and minimum rotation length applied by CBM model to the even-aged forests. The table also reports the management type (H, for high forests and C for coppices) and the management strategy (E, for even-aged forests and U for uneven-aged forests) applied to each FT.

Forest type (main species)	Acronym	MT / MS	Min. rotation length applied to even-aged (yrs)
Pinus pinaster	PM	**H E /U**	**35**
Pinus pinea	PP	**H E/U**	**95**
Other conifers	OC	**H E/U**	**65**
Eucaliptus spp.	EG	**C E /U**	**8-20**
Other broadleaves	OB	**H E/U**	**65**
Quercus rotundifolia	QH	**H E/U**	**105**
Quercus spp.	QR	**H E/U**	**65**
Quercus suber	QS	**H E/U**	**105**

Portugal

The main parameters defining the harvest criteria applied by CBM for Portugal are reported on Tab. 89.

Tab. 89: main parameters defining the harvest criteria applied by CBM for Portugal, including the age classes affected by each silvicultural treatment (or the minimum cutting cycle for uneven aged forests) and the Management strategy (MS) where each treatment was applied (HE=evenaged high forests, HU=unevenaged high forests, C=coppices) the relative share of harvest provided by each treatment (average for the historical period).

Silvicultural treatment	Harvest criteria	Harvest share[1]
20% Commercial Thinnings	**HE**: > 20 yrs.	<1%
25% Commercial Thinnings	**HE**: > 15 yrs. **HU**: minimum every 7 years	14%
30% Commercial Thinnings	**C**: > 10 yrs. **HU**: minimum every 12 years	9%
35% Commercial Thinnings	**HU**: minimum every 6 years	5%
Clearcut - 95% commercial thinning	**HE/C**: Depending on species	56% [1]
Salvage logging on burned area (Min 15% of merchantable biomass)		15% [1]
1: depending by year, according to the amount of harvest provided by burned area		

Species-specific YTs were selected using the average volume and increment reported by NFI at regional level. Species-specific correction factors (reported by Tab. 90) were applied to these last parameters, according to the values of increment reported by the Submission of information on forest management reference levels by Portugal (2011), estimated by additional information on the total volume and increment, directly provided by the country. Further correction factors were also applied to the original data of volume (referred to "pure stands") to account for the presence of other dominated tree species in each stands. These Mixed Correction Factors (Mix_CF) were estimated as the ratio between the average volume of the dominant species and the total volume reported by the NFI for each FT (see Table 7-12, NIR 2014).

Tab. 90: the correction factor (CF) applied to the increment values reported (region by region and species by species) by the original NFI data (reported in the first column) was estimated as the ratio between the NFI data and data provided by the country submission.

	Increment (m^3 ha^{-1} yr^{-1})		Increment CF	Mix CF (volume)
FT	**NFI**	**Submission**		
EG	3.8	9.5	**2.49**	**1.14**
PM	2.4	5.6	**2.31**	**1.11**
PP	3.6	5.6	**1.57**	**1.44**
OC	2.1	5	**2.42**	**1.07**
QS	1.1	0.5	**0.45**	**1.17**
QH	0.5	0.5	**1.08**	**1.25**
QR	1.4	2.9	**2.01**	**1.66**
OB	4.9	2.9	**0.59**	**1.88**

An example (for one region) of the current library and the historical library applied by CBM model is reported in Tab. 91.

Tab. 91: The table report an example (for the region PT11) of the yield tables applied by CBM model for Portugal for the even aged (i.e. MS='E') and the uneven aged forests (i.e. MS='U'). The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied by time step 0 to 36 (i.e., during the model run); the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.). Since Portuguese forests are generally younger than 80 yrs., only age classes < 70 yrs. are reported.

Library	FT	MS	Age1	Age2	Age3	Age4	Age5	Age6	Age7
Current	EG	E	8.7	10.4	0.0	0.0	0.0	0.0	0.0
Current	OB	E	1.8	3.2	3.3	3.0	2.5	2.0	1.6
Current	OC	E	0.6	2.5	4.3	5.5	6.2	6.4	6.4
Current	PM	E	0.6	2.5	4.4	5.9	6.7	7.0	6.9
Current	QH	E	0.3	0.9	1.3	1.5	1.6	1.6	1.5
Current	QR	E	0.3	1.5	2.7	3.7	4.4	4.8	4.9
Current	QS	E	0.3	0.9	1.3	1.5	1.6	1.6	1.5
Curr./Hist	EG	U	-	-	-	8.0	9.7	10.9	11.6
Curr./Hist	OB	U	-	-	-	8.8	11.1	12.9	14.1
Curr./Hist	OC	U	-	-	-	5.1	6.2	7.0	7.4
Curr./Hist	PM	U	-	--	-	11.7	15.2	18.1	20.3
Curr./Hist	QH	U	-	-	-	0.8	0.8	0.8	0.8
Curr./Hist	QR	U	-	-	-	5.3	6.4	7.2	7.7
Curr./Hist	QS	U	-	-	-	0.4	0.4	0.4	0.3
Historic	EG	E	57.2	134.0	186.0	216.0	216.0	216.0	216.0
Historic	OB	E	4.7	23.3	51.6	82.6	112.1	137.7	159.0
Historic	OC	E	4.4	16.8	33.8	52.7	71.7	89.7	106.1
Historic	PM	E	15.2	38.6	65.3	93.7	122.7	151.9	180.8
Historic	QR	E	3.4	15.9	35.1	57.7	80.9	103.0	123.0
Historic	QS	E	3.0	11.9	24.9	39.9	55.8	71.6	86.6
Historic	QH	E	3.0	11.9	24.9	39.9	55.8	71.6	86.6

Portugal

Due to the major importance of forest fires in Portugal, these were taken into consideration as the main natural disturbance in the country. Figure 117 shows the historical area affected by fires (based on data reported by 2014 CRF tables) included in the model simulation.

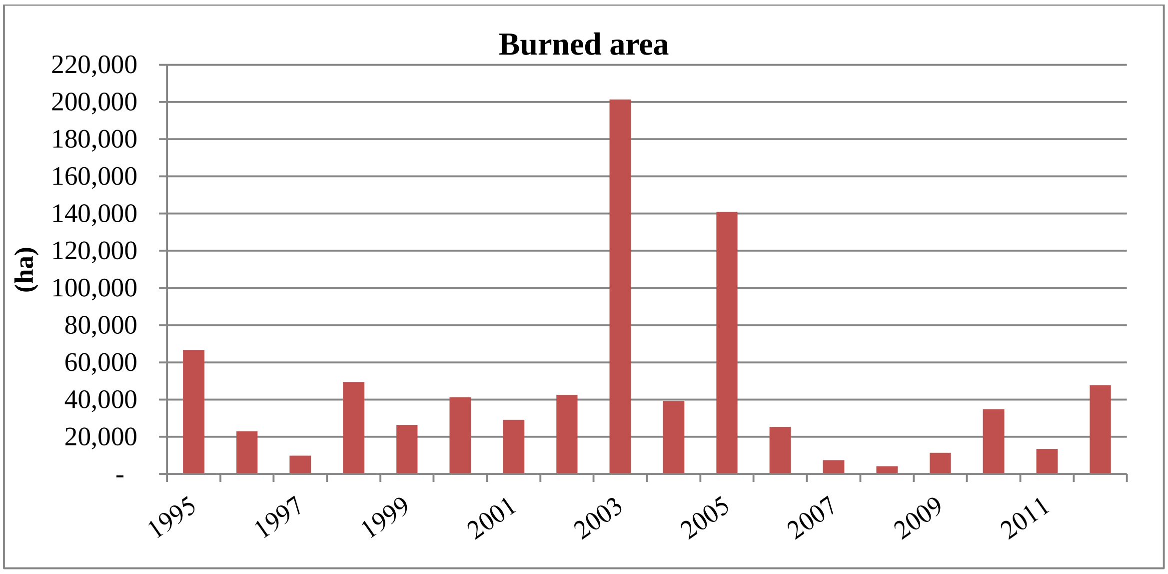

Figure 117: amount of area burned between 1995 and 2012.

The total forest area affected by fires was first distributed between the main species (see Tab. 92), based on additional information reported by the Submission for FMRL (2011[121]) on the total amount of burned area (by species) referred to 2012.

Tab. 92: the first column reports, for each FT, the relative proportion of the total burned area affected (each year) by fire disturbances. The second column reports the proportion of burned area affected by Stand replacing disturbance event (p_{SR}).

Forest types	Fire distribution applied to the total burned area	Proportion of burned area affected by Stand replacing disturbance event (p_{SR})
PM	0.32	0.25
QS	0.07	0.2
EG	0.40	0.5
QH	0.03	0
QR	0.12	0
OB	0.04	0.1
PP	0.02	0.4
OC	0.01	0

[121] See Table 14 reported by the submission FMRL.

According to the information reported by the country a fraction of the total harvest demand comes from the amount of merchantable wood removed by area affected by fires (i.e., salvage of logging residues). We defined two possible fire disturbances:

1. *Fire Stand Replacing*: assuming that on the area affected by fire, a complete salvage of logging residues (i.e., on 100% of the merchantable biomass) was provided and the stand moves to the age class 0 after the disturbance event. In this case all the living biomass components not moved to the product pool will move to the DOM pool.
2. *Fire Not-Stand Replacing*: assuming that the forest area was only partially affected by fire (i.e., the stand maintains the current age class after the disturbance event and about 25% of the living biomass was burned). In this case, based on the mortality rates reported by NIR (2014[122]) we defined the average mortality rate of broadleaves (26%) and conifers (63%). We assumed that half of the dead merchantable biomass (i.e., 13% for broadleaves and 31.5% for conifers) was harvested (i.e., moved to the products pool through salvage of logging residues) while the remaining merchantable biomass (such as 26% and 63% of the other living biomass components) moves to the DOM pool.

In order to define the amount of burned area affected by these disturbance events, we first considered the total amount of forest area reported by the original NFI distribution into the first age class (i.e., with age < 10yrs, therefore potentially affected by a stand replacing disturbance event during the previous 10 yrs.). We defined for each FT a constant proportion of the total burned area potentially affected by Stand-Replacing disturbance event (p_{SR}). The remaining area (i.e., 1-p_{SR}) will be affected by a Not-Stand-Replacing disturbance event. The area affected by Not-Stand Replacing disturbances was therefore estimated as the difference between the total area affected by fire for each species and year and the Fire Stand Replacing area. Figure 118 reports the final amount of area affected by these disturbances. After 2013, all the burned forest area was assigned to the Not-Stand-Replacing disturbance event and a constant amount of burned area, equal to the average amount 2000 – 2012 was applied.

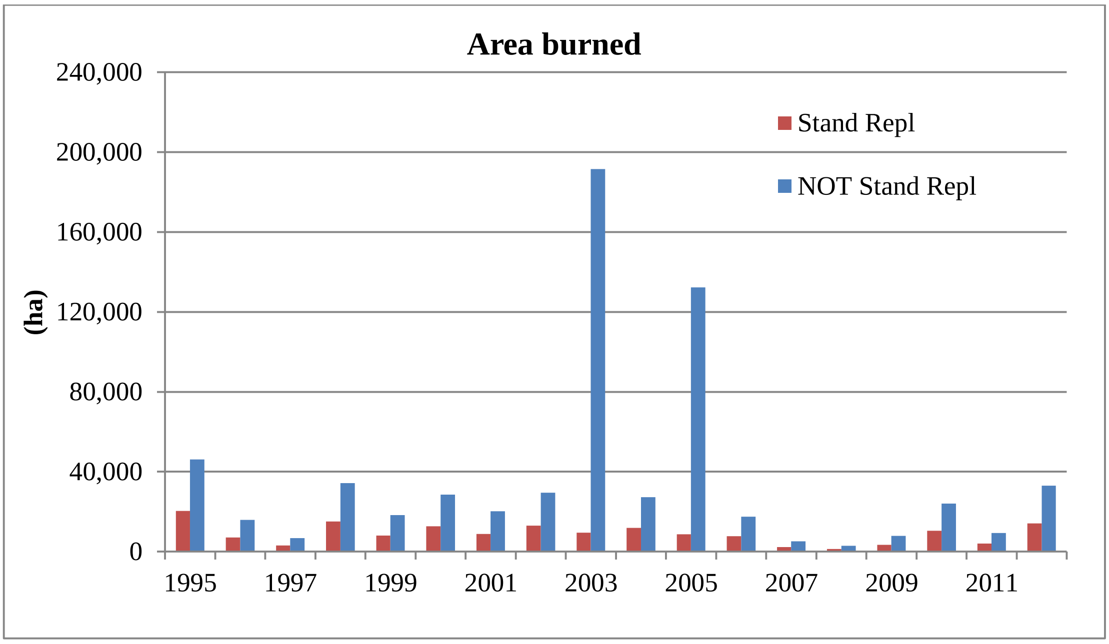

Figure 118: amount of burned area affected by Stand Replacing and Not-Stand-replacing fire disturbances, according to our model assumptions.

[122] See Table 7-27, NIR 2014

Harvest and HWP analysis

The historical FAO statistics provide complete data starting from 1961. The amount of harvest reported by FAOSTAT is consistent with the data reported by the country's submission for FMRL but it is lower than the values reported in the FRA 2010 Country Report[123] (Figure 119). According to this report, the national statistics report the volume under bark and a correction fraction equal to 1.25 and 1.18, for conifers and broadleaves, respectively, is generally applied at the country level. No numerical data is reported by the last NIR (2013).

After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 11.3 million m^3 for 2020.

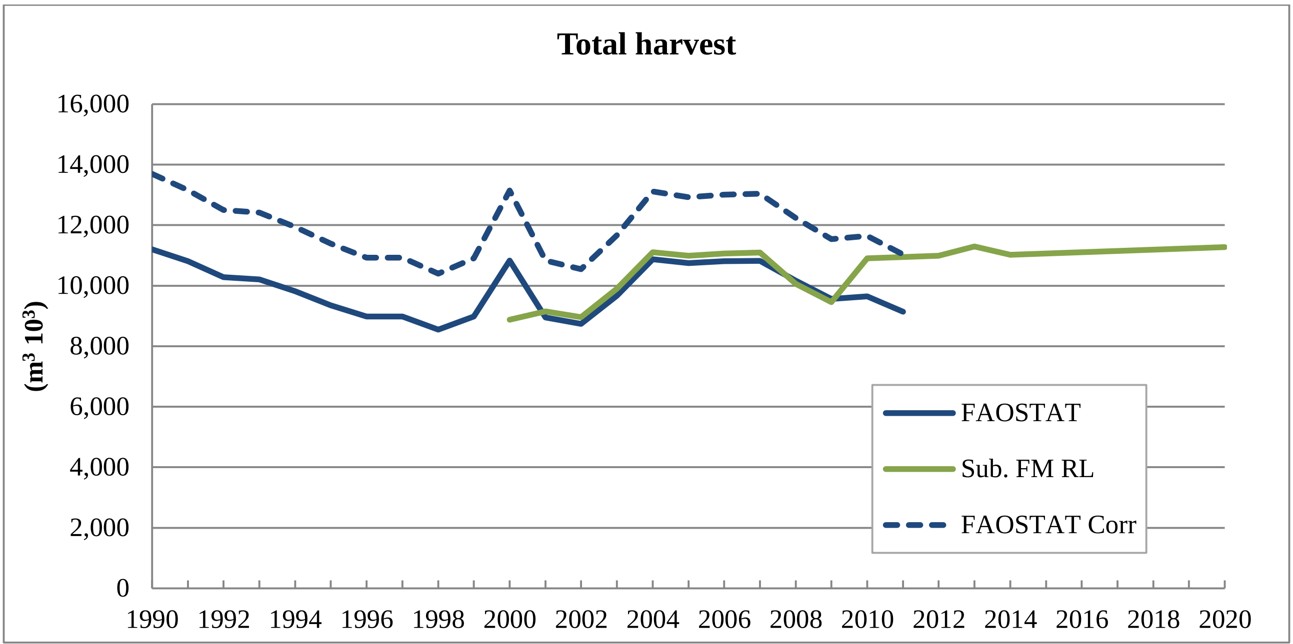

Figure 119: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (under bark) and National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on country specific correction factors equal to 1.25 and 1.18, for conifers and broadleaves, respectively. The figure also reports the future harvest demand (i.e., 2013 onward) according to the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 120. These data, corrected to account for the OWCs (see materials and methods) can be used as input by CBM.

[123] FRA 2010 – Country Report, Portugal (pag. 42).

Portugal

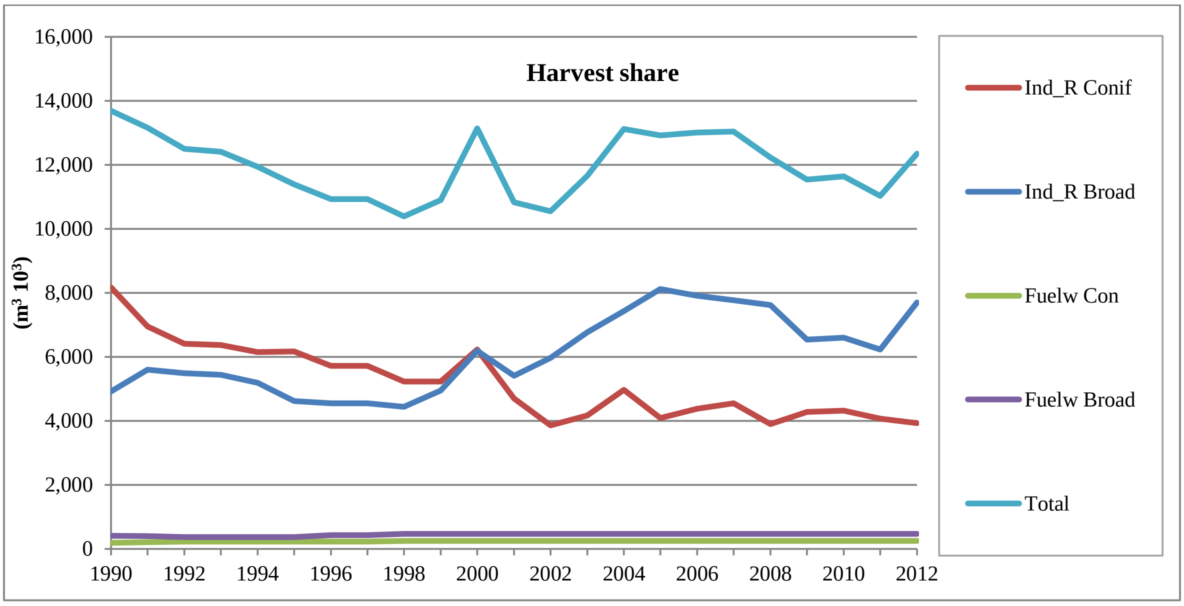

Figure 120: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

According to the information reported by the NIR (2014), Eucalyptus plantations are harvested in a period of 12 years (i.e., according to KP, before the 20 yrs. conversion period from AR to FM is completed)[124]. Therefore, for Portugal, we assumed that a fraction of the IRW broadleaves demand (IRW_B reported by Figure 120) is directly provided by AR (IRW_{AR}) activities on Eucalyptus plantations managed through clearcut with a minimum rotation period equal to 12 yrs. The amount of IRW broadleaves provided by FM was therefore estimated as the difference between the total IRW_B and IRW_{AR}. The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 121.

[124] NIR 2014, pag. 7-35

Portugal

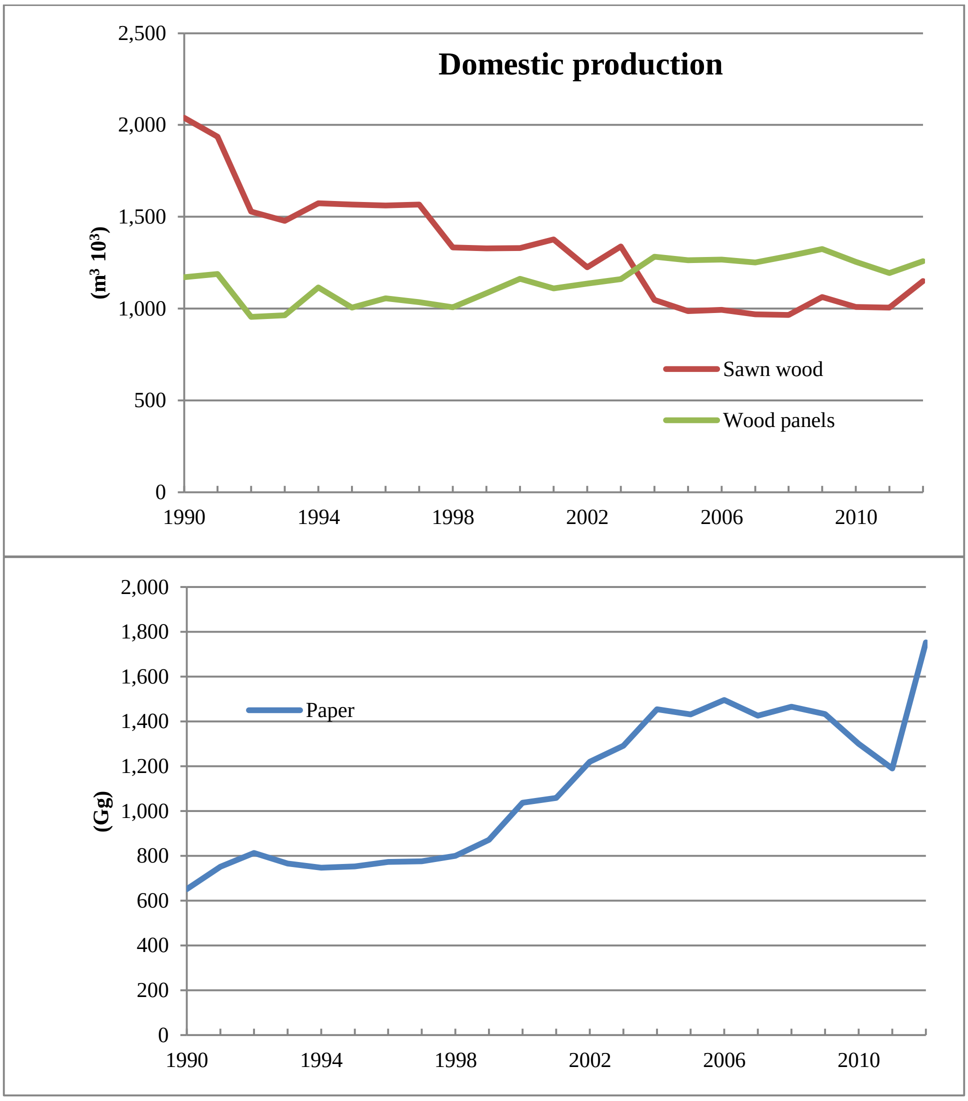

Figure 121: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Romania[125]

NFI data and model assumptions

The analysis was based on the data provided by the 1st cycle of the Statistic Sampling for the National Forest Inventory (2008-2012, with 2010 assumed as reference year)[126]. The total forest area subject to wood removal reported by NFI was 6,072 kha, which is considered as FM area ("Forest area subject to wood harvesting"). This area excludes about 792 kha, not subject to wood removals, and excluded from the current simulation. The original age class distribution was roll back of 20 years (i.e., to 1990), in order to ensure a larger comparability with the first NFI cycle available for Romania (referred to 1985). The total forest area was distributed between 8 climatic units (see Figure 36, for Bulgaria and Romania) and 7 regional units corresponding to regional development units (RO31 and RO32 were merged in RO31).

Tab. 93 reports the main species considered for Romania, grouped between 10 forest types and the cut cycles applied to each forest type (FT). All the FTs are managed as even-aged high forests, except RP (*Robinia* sp.), managed as coppice.

Tab. 93: forest types and minimum rotation length applied for each FT. The table also reports the wood density applied for each FT to convert volume to biomass.

Main species included by each FT	FT acronyms	Min. rotation length (yrs)	Wood density
Spruce	PA	110	0.40
Other broadleaved	OB	70	0.60
Beech	FS	100	0.64
Oaks	QR	120	0.645
Fir	AA	110	0.40
ConBroad (40%PA, 40%FS, 10%AA, 10%OB)	ConBroad	130	0.5225
PredCon (60%PA, 10%AA, 20%FS, 10%OB)	PredCon	120	0.5225
PredBroad (20%PA, 60%FS, 10%AA, 10%OB)	PredBroad	120	0.5225
Other resinous	OC	70	0.40
Robinia sp. (managed as coppice)	RP	30	0.645

[125] The analysis was developed in collaboration with Viorel Blujdea who provided specific information for this country.
[126] available at: http://roifn.ro/site/rezultate-ifn-1/.

Romania

Species-specific equations were selected [from CBM archive] based on the total aboveground volume reported by NFI1, on each of 7 regional development units. Since original values of volume include the total volume of trees (including all branches), the merchantable volume was derived from available volume diminished to account for bark contribution (by 5-32% on species) and branches (4-32% on species) (these factors were derived from national data – Giurgiu et al., 1972). Annual current increment on species was decreased with the same shares. Tab. 94 reports the original species from which were derived the equations selected for each forest type. The volume was finally converted to biomass applying country-specific values of wood density (reported in Tab. 93).

Tab. 94: are reported the original species from which were derived the allometric equations selected for each forest type, according to the methodological assumptions previously defined. The acronym applied to each FT was also reported.

Acronym	Forest type (FT)	Species selected by default CBM database
AA	Fir	Eastern white-cedar (*Thuja occid.)*
FS	Beech	Largetooth aspen (*Populus grandidentata*)
OB	Other Broadleaved	Balsam poplar
OC	Other conifers	Eastern white-cedar (*Thuja occid*.)
RP	Robinia sp.	Eastern white-cedar (*Thuja occid*.)
PA	Spruce	Eastern white-cedar (*Thuja occid*.)
QR	Oaks	Balsam poplar
ConBroad	Mixed forests (30-70%)	No data available → assigned as PA
PredBroad	Predominantly broadleaved (> 70%)	No data available → assigned as FS
PredCon	Predominantly coniferous (> 70%)	No data available → assigned as PA

Romania

The harvest criteria applied by CBM for Romania are reported on Tab. 103.

Tab. 95: main parameters defining the harvest criteria applied by CBM for Romania, including the minimum age classes affected by each silvicultural treatment and the relative share of harvest provided by each treatment (average for the historical period 1990 - 2012).

Silvicultural treatment	Criteria	Harvest share
20% Commercial Thinnings	> 5 - 15 yrs.	31%
30% Commercial Thinnings	> 50 – 65 yrs.	38%
50% Commercial Thinn. (pre final cut)	> 100 – 120 yrs.	6%
Clearcut (95% commercial thinning)	Depending by species	26%

Species-specific YTs were selected using the average volume and increment reported by the NFI. Taking in consideration the information available at species and regional level, the historical YTs (applied during the stand-initialization procedure) were defined at regional level, while the current YTs (applied during the model run) were defined at national level (Tab. 96).

The effect of the storms occurred between 2000 and 2010 were not yet considered in the current analysis.

Romania

Tab. 96: Yield tables applied by CBM model for Romania. The historical library (defined at regional level), reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure; the current library (defined at country level), reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Region	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
Historical	AA	RO11	22.6	61.8	105.8	149.4	190.1	226.4	257.4	283.1	303.5	318.8	329.5	336.0	338.7	338.2	334.8
Historical	AA	RO12	16.9	61.6	121.2	185.3	246.6	300.6	345.0	378.9	402.2	415.8	420.6	418.0	409.3	395.6	378.3
Historical	AA	RO21	37.7	94.9	156.3	216.5	272.8	323.6	368.3	406.7	438.9	465.0	485.4	500.6	510.9	517.0	519.2
Historical	AA	RO22	164.7	238.1	293.0	337.5	374.9	407.1	435.2	459.8	481.6	500.9	518.1	533.3	546.9	559.0	569.7
Historical	AA	RO31	80.3	143.2	199.7	252.0	300.9	347.1	390.8	432.3	471.8	509.6	545.7	580.2	613.2	644.8	675.1
Historical	AA	RO41	1.3	16.5	61.6	137.0	229.6	321.9	398.7	451.3	476.6	476.7	456.2	421.1	376.9	328.7	280.3
Historical	AA	RO42	61.1	109.1	153.1	194.7	234.6	273.2	310.8	347.5	383.5	418.8	453.5	487.7	521.4	554.7	587.7
Historical	ConBroad	RO11	7.7	38.0	87.1	146.0	206.2	261.2	306.9	341.4	364.1	375.7	377.5	370.9	357.8	339.7	318.2
Historical	ConBroad	RO12	15.1	53.6	105.0	161.8	218.2	270.8	317.1	356.0	386.9	409.9	425.5	434.2	436.8	434.1	426.9
Historical	ConBroad	RO21	22.8	75.4	141.9	211.8	278.6	338.1	388.4	428.4	458.1	478.2	489.3	492.6	489.2	480.2	466.7
Historical	ConBroad	RO22	28.0	65.0	105.9	149.2	194.0	239.8	286.4	333.4	380.6	428.0	475.2	522.3	569.2	615.7	661.9
Historical	ConBroad	RO31	27.9	61.6	97.8	135.9	175.3	215.9	257.4	299.8	343.0	386.8	431.3	476.4	522.0	568.1	614.6
Historical	ConBroad	RO41	4.1	25.5	67.8	127.4	197.7	271.8	343.9	409.2	464.9	509.0	541.0	561.0	569.9	568.8	559.2
Historical	ConBroad	RO42	9.1	45.6	107.0	183.7	266.2	346.2	418.0	478.0	524.4	556.7	575.5	582.1	578.1	565.1	545.1
Historical	FS	RO11	21.2	63.1	113.2	165.0	214.7	259.9	299.6	332.9	359.9	380.6	395.4	404.9	409.5	409.9	406.7
Historical	FS	RO12	42.9	96.5	150.8	202.9	251.5	295.9	336.0	371.5	402.8	429.8	452.8	472.0	487.7	500.1	509.6
Historical	FS	RO21	5.7	32.2	80.1	142.5	211.0	278.4	339.0	389.3	427.5	453.1	466.8	469.7	463.3	449.4	429.6
Historical	FS	RO22	120.8	171.2	210.0	242.7	271.5	297.6	321.6	343.9	364.9	384.8	403.7	421.7	439.0	455.7	471.8
Historical	FS	RO31	62.6	114.0	159.8	201.1	238.7	273.0	304.3	332.8	358.8	382.6	404.1	423.7	441.4	457.3	471.7
Historical	FS	RO41	58.5	124.1	186.6	243.7	294.6	339.2	377.6	410.0	436.9	458.7	475.9	488.8	497.8	503.5	506.1
Historical	FS	RO42	42.8	96.2	151.1	205.0	256.6	305.3	350.6	392.5	430.8	465.6	497.0	525.0	549.8	571.5	590.3
Historical	OB	RO11	21.4	55.2	91.7	127.1	159.7	188.4	212.8	232.9	248.9	260.9	269.3	274.4	276.7	276.5	274.1

Romania

Library	FT	Region	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
Historical	OB	RO12	23.3	58.3	95.9	132.9	167.7	199.4	227.6	252.2	273.1	290.5	304.5	315.3	323.2	328.5	331.4
Historical	OB	RO21	12.6	45.3	88.7	135.2	179.7	219.1	251.7	276.7	294.3	304.8	309.1	307.9	302.3	293.1	281.0
Historical	OB	RO22	41.2	71.3	98.2	123.2	147.0	169.8	191.7	213.1	233.8	254.1	274.0	293.5	312.6	331.5	350.0
Historical	OB	RO31	14.9	46.2	84.2	123.3	160.3	193.2	221.0	243.3	260.2	271.9	279.0	281.8	281.0	277.2	270.8
Historical	OB	RO32	6.4	31.0	70.5	117.4	164.9	207.9	243.3	269.7	286.8	295.1	295.7	289.9	279.0	264.3	247.0
Historical	OB	RO41	38.1	76.3	112.0	144.7	174.4	201.1	224.9	245.9	264.4	280.5	294.3	306.1	315.9	323.9	330.4
Historical	OB	RO42	16.7	53.9	100.0	147.9	193.4	233.8	267.8	294.9	314.9	328.5	336.1	338.4	336.2	330.2	321.2
Historical	OC	RO11	1.5	13.3	39.8	77.2	118.2	155.5	184.6	203.0	210.7	208.9	199.6	185.0	167.1	147.7	128.1
Historical	OC	RO12	15.9	46.0	80.8	115.9	148.7	177.8	202.6	222.7	238.3	249.5	256.8	260.5	261.2	259.1	254.8
Historical	OC	RO21	5.3	26.7	61.9	104.5	148.1	188.2	221.6	246.9	263.7	272.3	273.7	269.1	259.6	246.4	230.8
Historical	OC	RO22	3.1	22.2	60.7	111.6	165.5	214.2	252.3	277.4	289.3	289.5	280.1	263.6	242.4	218.5	193.6
Historical	OC	RO31	1.6	7.1	16.9	31.4	50.8	75.3	104.9	139.9	180.3	226.2	277.7	334.9	397.9	466.8	541.5
Historical	OC	RO41	0.0	1.3	9.9	35.1	80.7	141.2	204.6	258.4	293.8	307.5	301.0	278.7	246.3	209.3	171.8
Historical	OC	RO42	6.2	28.8	64.1	105.5	147.0	184.5	215.4	238.5	253.7	261.3	262.4	257.8	248.9	236.7	222.1
Historical	PA	RO11	22.6	61.8	105.8	149.4	190.1	226.4	257.4	283.1	303.5	318.8	329.5	336.0	338.7	338.2	334.8
Historical	PA	RO12	16.9	61.6	121.2	185.3	246.6	300.6	345.0	378.9	402.2	415.8	420.6	418.0	409.3	395.6	378.3
Historical	PA	RO21	37.7	94.9	156.3	216.5	272.8	323.6	368.3	406.7	438.9	465.0	485.4	500.6	510.9	517.0	519.2
Historical	PA	RO22	164.7	238.1	293.0	337.5	374.9	407.1	435.2	459.8	481.6	500.9	518.1	533.3	546.9	559.0	569.7
Historical	PA	RO31	80.3	143.2	199.7	252.0	300.9	347.1	390.8	432.3	471.8	509.6	545.7	580.2	613.2	644.8	675.1
Historical	PA	RO41	1.3	16.5	61.6	137.0	229.6	321.9	398.7	451.3	476.6	476.7	456.2	421.1	376.9	328.7	280.3
Historical	PA	RO42	61.1	109.1	153.1	194.7	234.6	273.2	310.8	347.5	383.5	418.8	453.5	487.7	521.4	554.7	587.7
Historical	PredBroad	RO11	17.4	60.7	117.7	179.6	240.3	295.7	343.6	382.8	413.1	434.5	447.8	453.8	453.4	447.5	437.1
Historical	PredBroad	RO12	30.6	69.1	111.3	156.2	203.1	251.7	301.7	353.1	405.5	459.0	513.5	568.9	625.0	682.0	739.6
Historical	PredBroad	RO21	19.4	70.3	138.5	212.8	285.4	351.0	406.9	451.6	484.8	507.0	519.0	522.2	517.6	506.8	490.8
Historical	PredBroad	RO22	50.5	100.7	150.7	200.6	250.3	299.9	349.3	398.5	447.6	496.6	545.4	594.0	642.6	690.9	739.1

Romania

Library	FT	Region	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
Historical	PredBroad	RO31	53.9	98.8	140.7	180.8	219.7	257.6	294.6	331.1	366.9	402.2	437.1	471.6	505.7	539.4	572.9
Historical	PredBroad	RO41	34.5	86.7	143.8	200.8	255.3	305.9	351.8	392.7	428.4	459.0	484.7	505.7	522.2	534.7	543.4
Historical	PredBroad	RO42	36.2	92.2	154.4	217.8	279.6	338.1	392.4	441.9	486.4	525.7	560.0	589.2	613.8	633.8	649.6
Historical	PredCon	RO11	30.6	85.8	147.8	208.7	264.3	312.3	351.8	382.8	405.6	420.7	429.1	431.6	428.9	422.1	411.7
Historical	PredCon	RO12	31.1	94.0	168.3	243.4	313.1	373.8	424.1	463.5	492.2	511.0	521.0	523.1	518.7	508.8	494.5
Historical	PredCon	RO21	27.6	92.7	176.1	264.6	349.5	425.8	490.4	542.1	580.7	606.9	621.8	626.6	622.7	611.6	594.6
Historical	PredCon	RO22	34.8	93.4	160.5	230.1	298.4	363.4	423.7	478.6	527.5	570.4	607.2	638.2	663.6	683.7	698.9
Historical	PredCon	RO31	76.6	135.3	188.8	239.0	287.0	333.4	378.3	422.1	465.0	506.9	548.2	588.7	628.7	668.1	707.0
Historical	PredCon	RO41	19.7	68.5	131.1	196.8	258.4	311.8	354.9	387.2	408.8	420.7	424.0	420.1	410.2	395.7	377.6
Historical	PredCon	RO42	66.8	123.2	176.3	227.4	276.9	325.4	372.8	419.6	465.6	511.0	555.9	600.4	644.4	688.0	731.3
Historical	QR	RO11	14.3	50.2	94.9	139.4	178.3	208.9	230.4	243.2	248.1	246.5	239.7	228.9	215.4	200.1	183.9
Historical	QR	RO12	44.3	101.8	151.3	188.2	212.2	225.0	228.5	225.0	216.3	204.0	189.6	174.0	157.9	142.1	126.9
Historical	QR	RO21	68.5	97.9	120.1	138.3	153.8	167.4	179.5	190.3	200.1	209.0	217.2	224.6	231.5	237.8	243.6
Historical	QR	RO22	11.2	35.0	60.2	81.2	95.8	104.0	106.4	104.3	99.0	91.6	83.0	74.0	64.9	56.3	48.3
Historical	QR	RO31	26.7	55.2	82.0	106.6	128.8	148.4	165.7	180.6	193.4	204.1	213.0	220.1	225.7	229.9	232.8
Historical	QR	RO32	6.5	33.2	76.4	127.0	176.7	219.6	252.4	274.2	285.1	286.4	279.9	267.3	250.4	230.8	209.7
Historical	QR	RO41	28.7	57.9	84.5	107.9	128.1	145.2	159.5	171.2	180.5	187.6	192.8	196.3	198.4	199.1	198.6
Historical	QR	RO42	8.6	32.8	66.8	105.5	144.8	182.0	215.1	243.2	265.8	282.7	294.2	300.7	302.8	300.9	295.8
Historical	RP	RO11	5.3	43.1	99.3	136.3	140.7	121.4	92.5	64.3	41.8	25.7	15.1	8.6	4.7	2.5	1.3
Historical	RP	RO12	0.3	16.5	73.7	123.5	120.9	84.1	46.3	21.4	8.7	3.2	1.1	0.3	0.1	0.0	0.0
Historical	RP	RO21	10.2	40.1	73.1	97.2	108.6	108.8	101.0	88.7	74.7	60.8	48.2	37.4	28.4	21.3	15.7
Historical	RP	RO22	6.6	38.7	85.0	124.8	146.9	150.3	139.6	120.9	99.1	77.9	59.2	43.7	31.5	22.2	15.4
Historical	RP	RO31	17.2	48.8	82.0	111.1	133.9	149.9	159.3	163.1	162.2	157.8	150.7	141.7	131.6	120.9	110.1
Historical	RP	RO32	5.7	48.0	125.0	200.7	247.2	257.6	239.0	203.8	162.9	123.7	90.2	63.5	43.5	29.0	19.0
Historical	RP	RO41	0.8	23.2	79.9	113.2	98.5	62.9	32.5	14.4	5.6	2.0	0.7	0.2	0.1	0.0	0.0

Romania

Library	FT	Region	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
Historical	RP	RO42	11.6	44.1	79.5	105.7	118.8	120.1	112.8	100.5	85.9	71.2	57.4	45.3	35.1	26.8	20.2
Current	AA	RO00	1.17	5.38	10.81	15.43	18.28	19.23	18.66	17.05	14.88	12.54	10.26	8.19	6.41	4.93	3.74
Current	ConBroad	RO01	1.45	3.14	4.66	5.91	6.89	7.62	8.10	8.39	8.51	8.49	8.35	8.13	7.84	7.51	7.14
Current	FS	RO02	2.91	4.85	6.22	7.18	7.81	8.19	8.38	8.40	8.31	8.13	7.88	7.58	7.25	6.89	6.53
Current	OB	RO03	1.49	3.03	4.28	5.23	5.90	6.33	6.55	6.60	6.53	6.36	6.12	5.82	5.49	5.15	4.79
Current	OC	RO04	1.80	2.82	3.53	4.02	4.34	4.55	4.65	4.69	4.66	4.59	4.49	4.35	4.20	4.04	3.86
Current	PA	RO05	1.77	3.93	5.79	7.21	8.20	8.81	9.08	9.10	8.91	8.58	8.14	7.63	7.09	6.53	5.97
Current	PredBroad	RO06	2.23	4.25	5.89	7.15	8.08	8.73	9.14	9.36	9.41	9.33	9.16	8.90	8.59	8.23	7.84
Current	PredCon	RO07	2.09	4.33	6.24	7.76	8.90	9.71	10.22	10.48	10.54	10.44	10.20	9.88	9.47	9.02	8.53
Current	QR	RO08	1.77	3.08	3.99	4.59	4.94	5.11	5.12	5.03	4.87	4.65	4.39	4.12	3.83	3.54	3.26
Current	RP	RO09	1.32	2.98	4.08	4.54	4.51	4.17	3.68	3.12	2.58	2.09	1.66	1.30	1.01	0.77	0.59

Harvest and HWP analysis

The historical FAO statistics provide complete data starting from 1961. The NFI estimates a total amount of felling (i.e., removals + residues) equal to 32 mil m^3 for the mid-year 2010 which is 83% higher than the total average amount of harvest reported by the National Institute of Statistics for the corresponding period of time (2008-2012). The amount of harvest reported by FAOSTAT is on average 23% lower (between 1994 and 2010) than the amount of harvest reported by National Institute of Statistics (2016) and 14% lower than the country's submission for FMRL (Figure 122). The values reported by the FRA 2010 Country Report[127] are consistent with FAOSTAT and referred to the volume over bark. The final amount of harvest applied by CBM for the historical period was derived by the time series provided by the National Institute of Statistics, corrected according to the amount of removals (i.e., excluding harvest residues, equal to about 19% of the total felling) reported by the NFI for 2010. After 2010, the Submission for FMRL reports a constant harvest demand, with a final amount of harvest equal to 16.6 million m^3 for 2020.

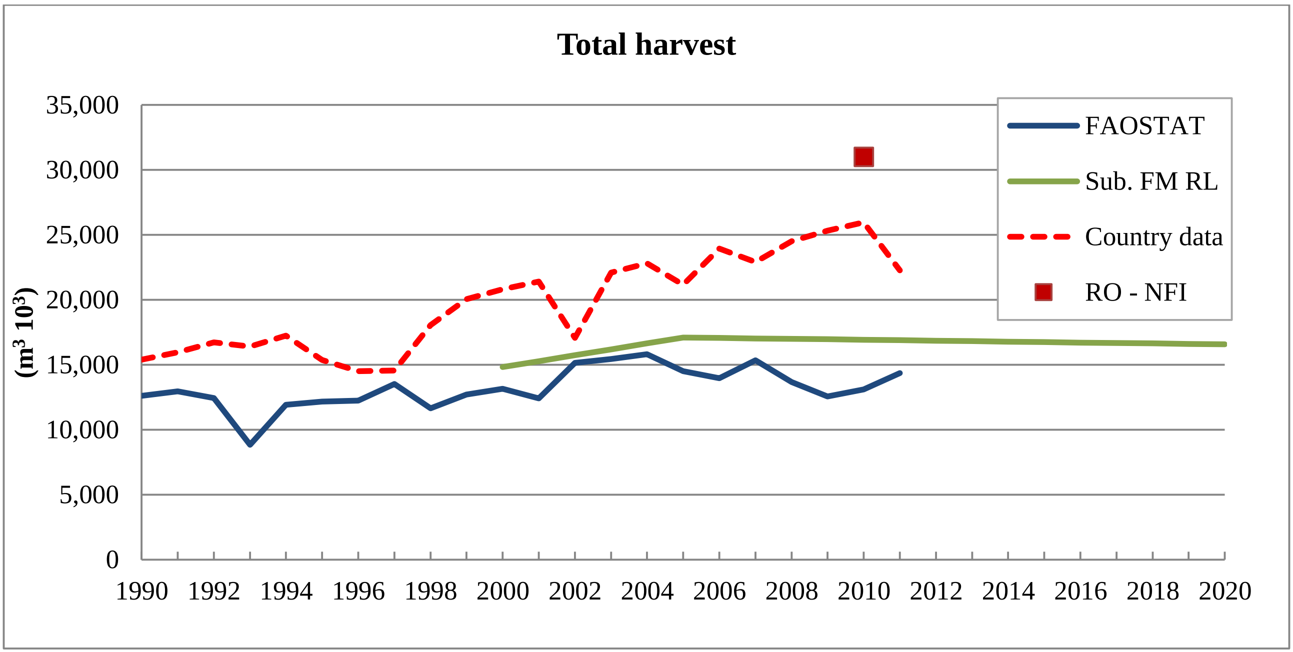

Figure 122: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (over bark), the last NFI (amount of felling referred to 2010), the corrected amount of harvest (i.e., country data), derived by the values reported by the National Institute for Statistics, corrected to account for the information reported by NFI and applied by CBM as historical harvest rate. The future harvest demand (i.e., 2013 onward) is reported according to the National Submission for FM Reference Level (Sub. FMRL).

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 123. Additionally, since total annual harvest was adjusted, it was assumed that the difference is FW. These data, corrected to account for the OWCs (see materials and methods) can be used as input by CBM.

[127] FRA 2010 – Country Report, Romania (pag. 39).

Romania

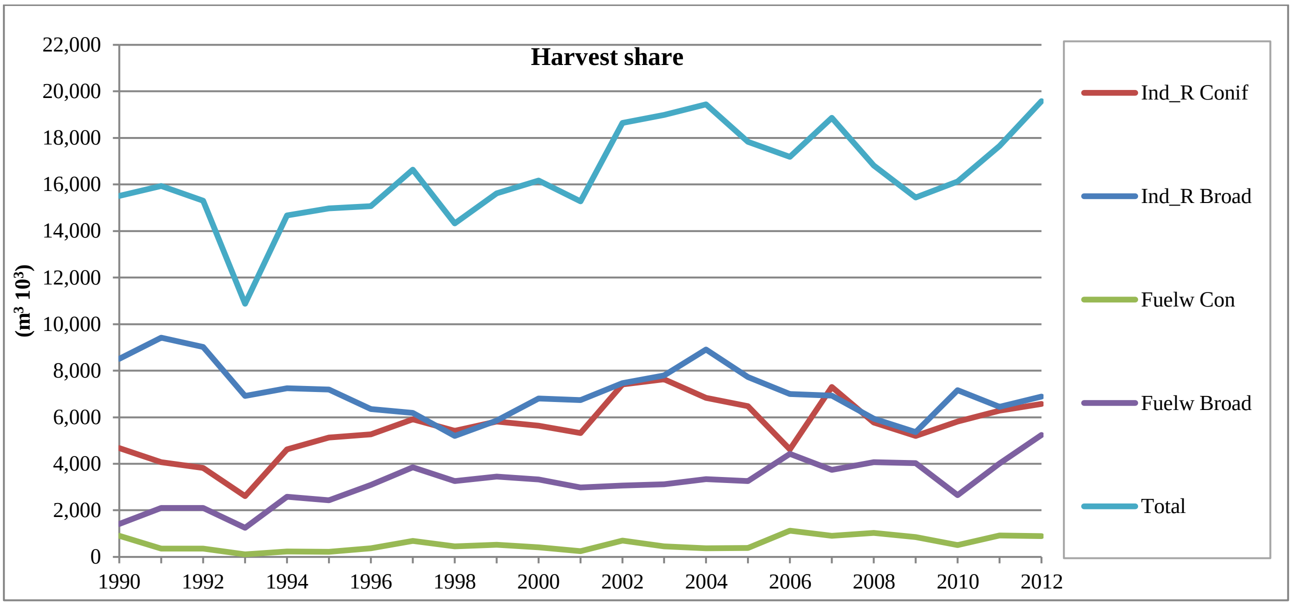

Figure 123: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 124.

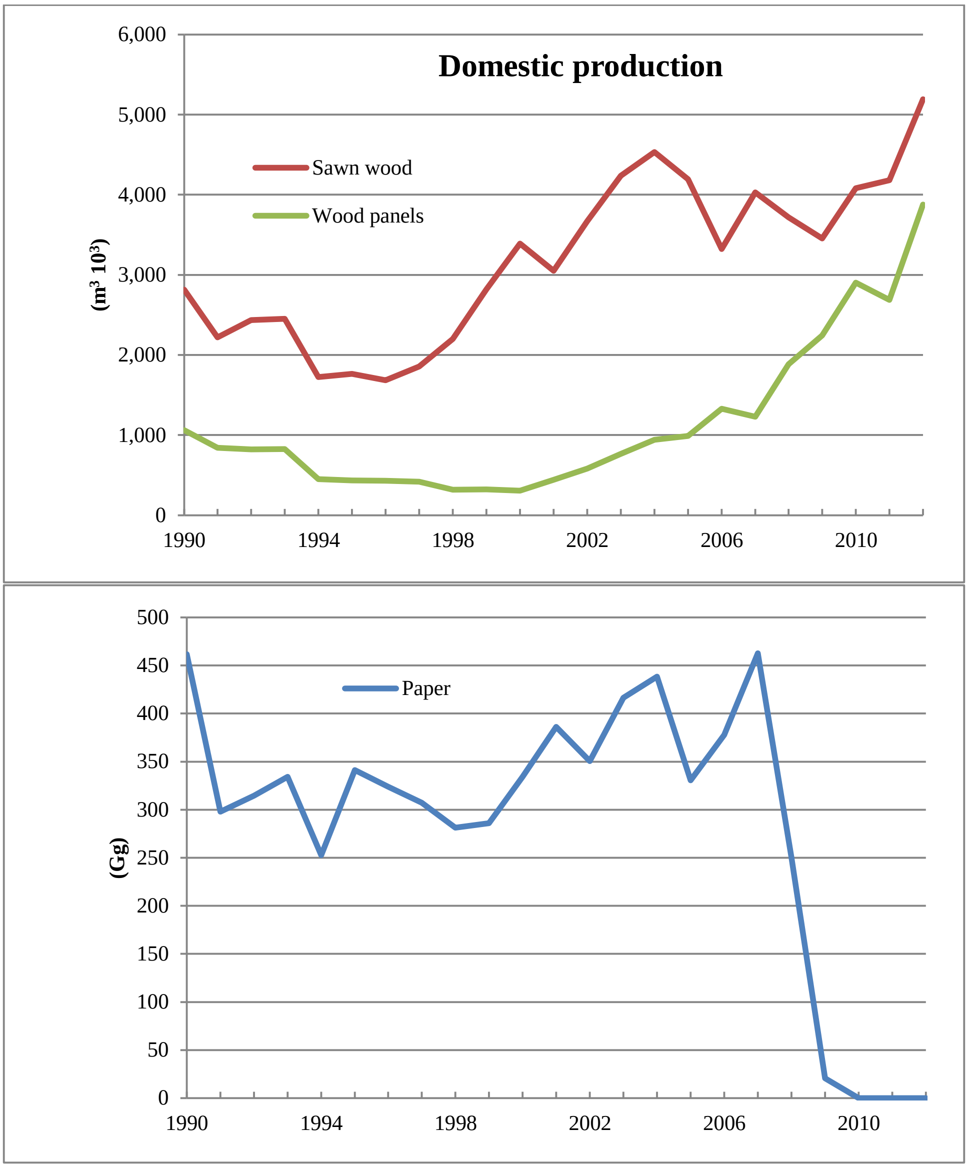

Figure 124: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Slovakia[128]

NFI data and model assumptions

The analysis was based on data reported by the EFI database. We assumed that the original data were referred to 2000 as reported for the Czech Republic (no specific information was reported by the EFI database). Due to the lack of specific information, the total forest area was aggregated at national level (i.e., without any regional distribution) and it was distributed between 6 Climatic units (CLUs 25, 34, 35, 44, 45, 53, 54, 63), reported by Figure 46 for the Czech republic. We maintained the 2000 as reference year and we scaled the original NFI area, equal to about 1,909 kha, to the FM area reported by the Submission on forest management reference level of Slovakia, equal to 1,918 kha for 2000. This amount was further decreased to 1,913 kha, in order to account for the total amount of deforestation occurred until 2000 (i.e., about 370 ha yr^{-1}).

The main species reported by the NFI were grouped in 7 forest types, reported in Tab. 97. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the minimal age for final felling reported by the Report of the technical assessment of the forest management reference level submitted by Slovakia in 2011.

Tab. 97: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	Acronym	Min. rotation length (yrs)
Abies alba	**AA**	**100**
Fagus sylvatica	**FS**	**90**
Other broadleaves	**OB**	**80**
Other conifers	**OC**	**80**
Picea abies	**PA**	**80**
Pinus sylvestris	**PS**	**110**
Quercus sp.	**QR**	**100**

According to the last NIR (2014), incineration of harvesting residues after clearcut is still quite common in Slovakia and the harvesting residues are burned on about 50% of the forest clearing area (for coniferous about 10% and for broadleaves about 25% of the aboveground tree biomass is generally burned). Taking into account these information, we assumed that about 50% of the area affected by clearcut each year was also affected by incineration of harvest residues, with different rates of incinerations (10% and 25% for coniferous and broadleaves, respectively). The main parameters defining the harvest criteria applied by CBM for Slovakia are reported in Tab. 98.

[128] The analysis was developed in collaboration with Tibor Priwitzer who provided specific information for this country.

Slovakia

Tab. 98: main parameters defining the harvest criteria applied by CBM for Lithuania, including the age classes affected by each silvicultural treatment and the relative amount of harvest provided by each treatment (estimated as the average amount of harvest provided between 2000 and 2012).

Silvicultural treatment	Criteria	Harvest share
15% Commercial Thinnings	> 15 yrs.	< 2%
20% Commercial Thinnings	> 35 yrs.	25%
Clearcut (95% commercial thinning)	Depending by species	64%
Salvage logging after Nat. Disturbances	Depending by years	≈9%

Since no specific data on biomass stock was available at national level, the same equations selected for Czech Republic and Austria were applied to Slovakia, according to the assumptions reported in Tab. 99.

Tab. 99: association between the Slovakian forest types and the default species provided by the original CBM database, based on the selection applied to Czech Republic and Austria.

FT	Species selected by default CBM database	Austrian (AT) or country specific selection (CZ)	Correspondence with the Austrian FTs
AA	Eastern white pine (P. strobus)	AT	Fir (AT)
FS	Sugar Maple (Acer saccharum)	CZ	FS_CZ
OB	Basswood (Tilia americana)	AT	OB_AT
OC	Red spruce (Picea rubens)	CZ	OC_CZ
PA	Red spruce (Picea rubens)	CZ	PA_CZ
PS	White spruce (Picea glauca)	CZ	PS_CZ
QR	Black cherry (Prunus serotina)	AT	Oak (AT)

Species-specific YTs were selected using the average volume and increment reported at national level. The historical library (based on the average volume reported by NFI for each species) and the current library are reported in Tab. 100.

Slovakia

Tab. 100: Yield tables applied by CBM model for Slovakia. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age1 0	Age1 1	Age1 2	Age1 3	Age1 4
Current	AA	1.4	4.3	7.1	9.1	10.2	10.5	10.2	9.4	8.5	7.4	6.4	5.4	4.5	3.7
Current	FS	1.6	3.9	5.7	6.9	7.6	7.8	7.7	7.3	6.7	6.1	5.4	4.8	4.1	3.6
Current	LD	1.1	2.5	3.8	4.7	5.2	5.5	5.5	5.3	5.0	4.6	4.2	3.8	3.4	3.0
Current	OB	1.2	4.1	6.6	7.7	7.4	6.5	5.2	4.0	2.9	2.1	1.4	0.9	0.6	0.4
Current	OC	6.1	9.6	11.2	11.7	11.5	10.8	9.8	8.8	7.7	6.7	5.8	4.9	4.2	3.5
Current	PA	1.4	4.3	7.1	9.1	10.2	10.5	10.2	9.4	8.5	7.4	6.4	5.4	4.5	3.7
Historic	PS	11.1	40.3	81.0	128.2	178.4	229.0	278.4	325.3	369.3	409.8	446.9	480.6	510.8	538.0
Historic	QR	2.0	13.1	35.8	68.1	106.7	148.5	190.7	231.5	269.7	304.5	335.7	363.3	387.4	408.2
Historic	AA	1.2	6.6	16.9	32.1	51.5	74.5	100.2	127.9	157.0	186.9	217.1	247.2	276.8	305.8
Historic	FS	1.7	7.2	16.1	27.7	41.7	57.4	74.4	92.4	111.0	129.9	149.0	167.9	186.7	205.0
Historic	LD	24.6	75.6	132.5	185.8	232.0	270.3	301.1	325.4	344.5	359.2	370.5	379.1	385.7	390.7
Historic	OB	7.0	27.8	57.0	89.7	122.6	153.5	181.6	206.3	227.7	246.0	261.3	274.2	284.9	293.7

Slovakia

The effect of three different natural disturbances was considered:

1. Wind Storms: based on the information reported by the FORESTORMS database and by country specific data[129], various storms and ice sleets damaged Slovakian forests between 2000 -2010 (Tab. 101).

Tab. 101: the table reports the total amount of merchantable volume damaged by natural disturbances in Slovakia between 2000 and 2012, the amount of salvage of logging residues related to each disturbance event, the type of disturbance (i.e., wind storm or ice sleet) and the specific model assumptions on the type of disturbance event (i.e., assumed as stand replacing or widespread disturbance) and the main species affected by each disturbance (all data and information were provided by literature).

Year	Vol affected (m^3)	Salvage Logging (m^3)	Disturbance event	CBM assumptions and additional information provided by literature
2000	0	**-**		
2001	487,000	**466,000**	Ice sleet	Widespread event: 280,000 m3 on beech and 90,000 m3 on oak
2002	1,500,000	**1,500,000**	Wind storm	Stand replacing event: mainly on spruce
2003	0	**-**		
2004	5,400,000	**-0**	Wind storm	Stand replacing event: mainly on spruce
2005		**5,400,000**		
2006	260,000	**260,000**	Ice sleet	Widespread event mainly on spruce and pine
2007	1,400,000	**700,000**	Wind storm	Stand replacing event: mainly on spruce
2008		**700,000**	storm	
2009		**-**		
2010	465,000	**465,000**	Wind storm	Stand replacing event: mainly on broadleaves
2011		**-**		
2012		**-**		

The wind storm damages were simulated through a stand-replacing disturbance event (see last column in Tab. 101). Based on a preliminary run we estimated the amount of area affected by each disturbance event in order to provide the expected volume damaged by storm. This amount was distributed between different FTs according to their proportion in the total forest area and to the additional information provided by literature. We assumed that 80% of the living biomass was damaged by storm and moved to DOM pools, without any direct salvage of logging residues. This one was

[129] http://www.efiatlantic.efi.int/portal/databases/forestorms/
http://www.lesmedium.sk/clanok.php?id=167988

http://www.forestportal.sk/SitePages/lesne_hospodarstvo/los/kalamity/kalamity.aspx applied the year after each storm disturbance, through a specific event, applied on the same forest area affected by storm[130].

2. Ice sleets (see Tab. 101): they were simulated as a widespread disturbance event (i.e., not stand replacing). Based on a preliminary run we estimated the amount of area affected by this event in order to provide the expected volume damaged by storm. This amount was distributed between different FTs according to their proportion in the total forest area and to the additional information provided by literature. We assumed that 20% of the living biomass was damaged and the merchantable biomass fraction was directly moved to the product pool (i.e., there was a direct salvage of logging residues), while the other wood components moved to DOM pools.
3. Fires: data on the amount of burned area were taken from the JRC Technical Report on Forest Fires in Europe (2013) for 2000–2012 (Figure 125). A constant amount of burned area, equal to the average amount 2000 – 2012 was applied from 2013 to 2030.

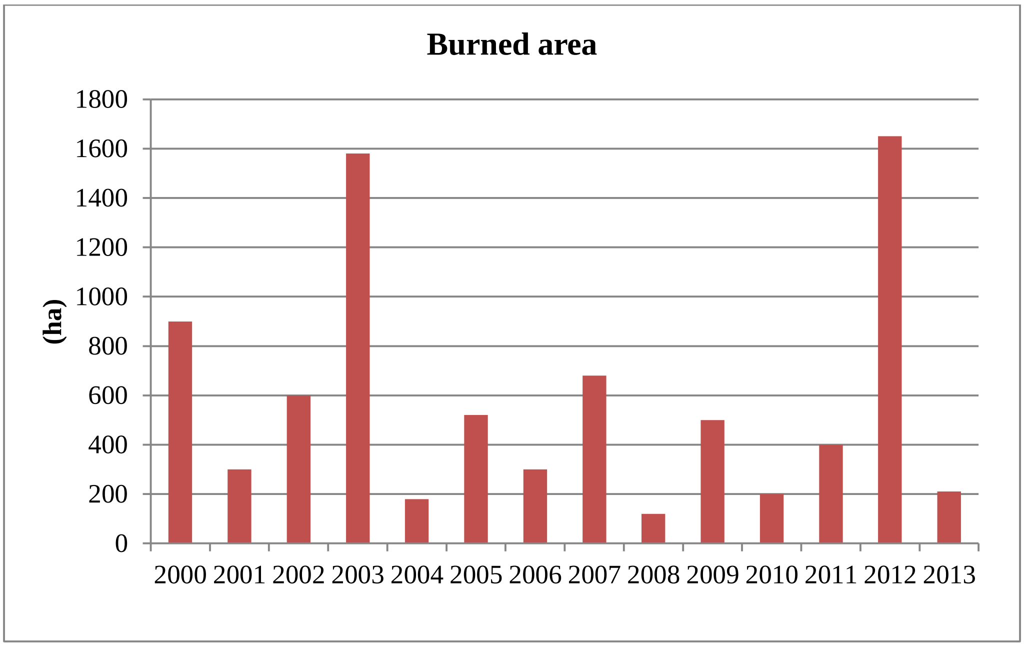

Figure 125: amount of area burned between 2000 and 2012.

Fire disturbances were simulated assuming that fires affect 50% of the living biomass, with salvage of 15% of logging residues.

Harvest and HWP analysis

The historical FAO statistics provide complete data starting from 1993. FAOSTAT reports the same amount of harvest reported by the country's submission for FMRL and they are consistent with the data reported in the last NIR (2013), referred to the volume under bark (Figure 126). The FRA 2010 Country Report[131] reports the following correction factors to account for the bark's fraction: 1.10 for coniferous and 1.12 for non-coniferous species. After

[130] As suggested by the CBM's User Guide, the Sort type of this disturbance event was modified (to Sort type 7) in the project database file, in order to give priority to stands having the highest stem snag carbon pool.
[131] FRA 2010 – Country Report, Slovakia (pag. 44).

2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 9.7 million m^3 for 2020.

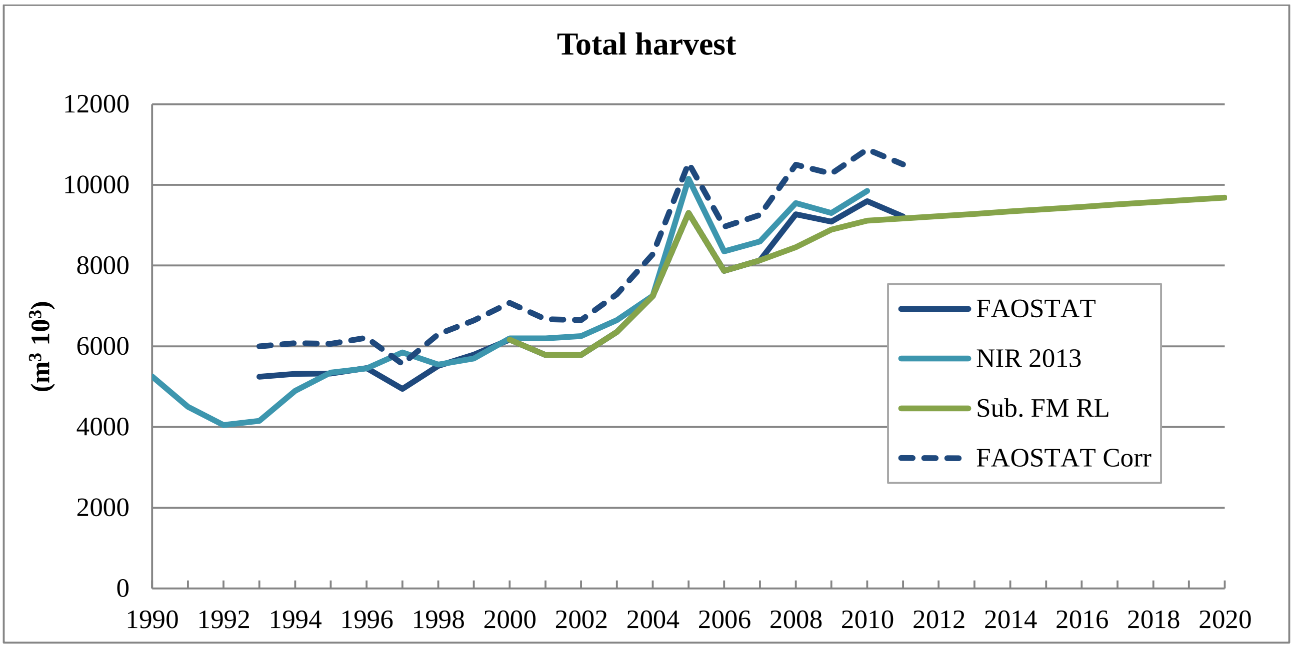

Figure 126: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (under bark) and the National Submission for FM Reference Level (Sub. FMRL), the last NIR (2013). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a bark correction factors equal to 1.10 for conifers and 1.12 for broadleaves. The future harvest demand (i.e., since 2013) is reported according to the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 127. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

Slovakia

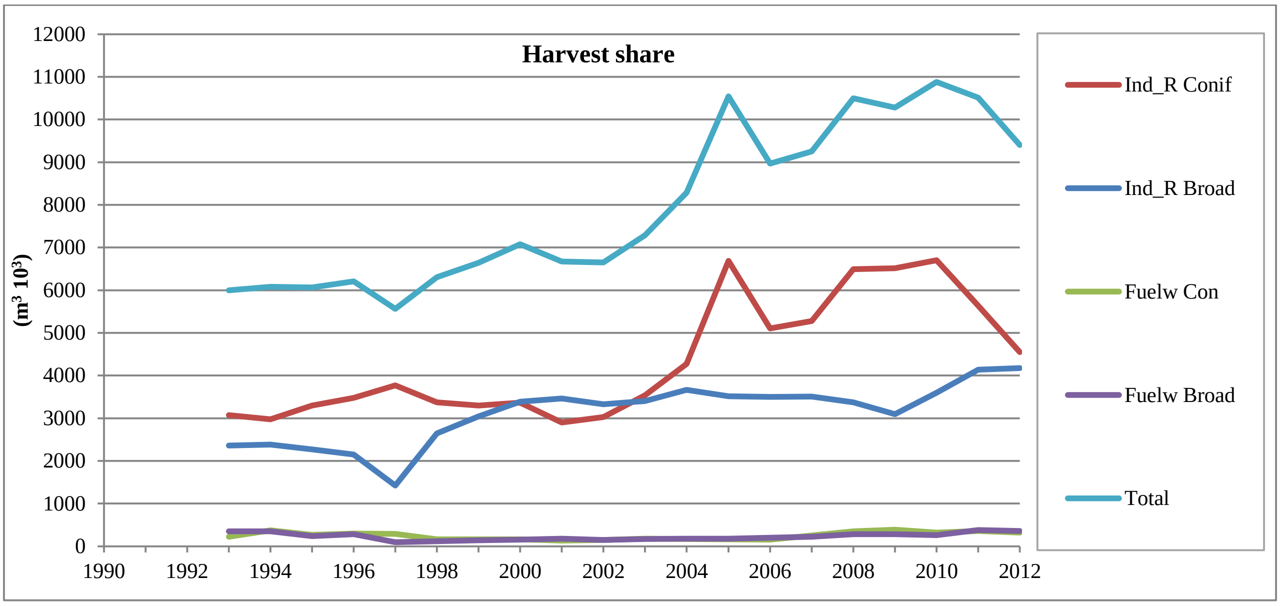

Figure 127: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 128.

Slovakia

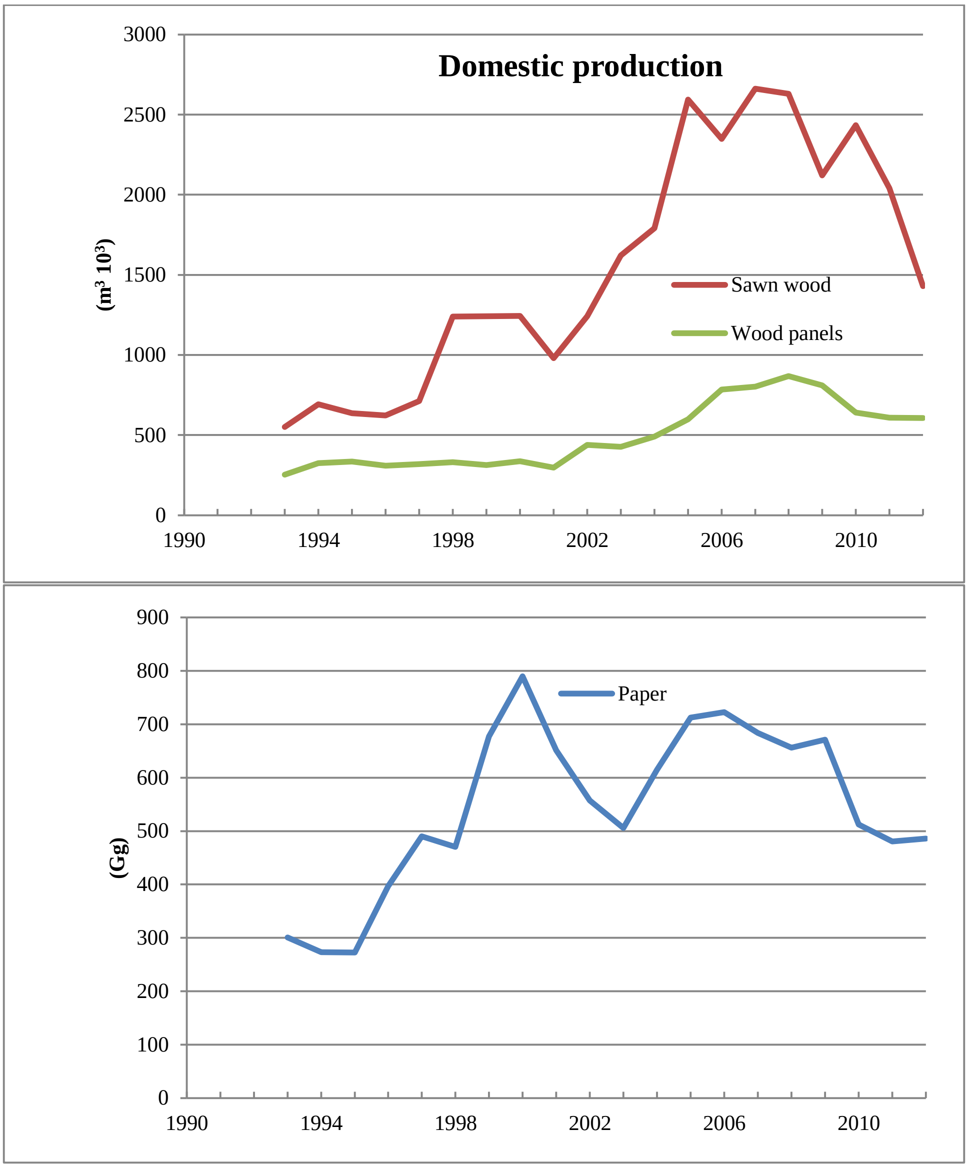

Figure 128: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Slovenia

NFI data and model assumptions

The analysis was based on the NFI data reported by the EFI database, referred to 2000. Due to the lack of specific information, the total forest, area equal to 1,134 kha, was aggregated at national level, it was corrected to account for the total amount of deforestation occurred until 2000 (i.e., about 240 ha yr^{-1}) and distributed between 7 CLUs (Figure 129).

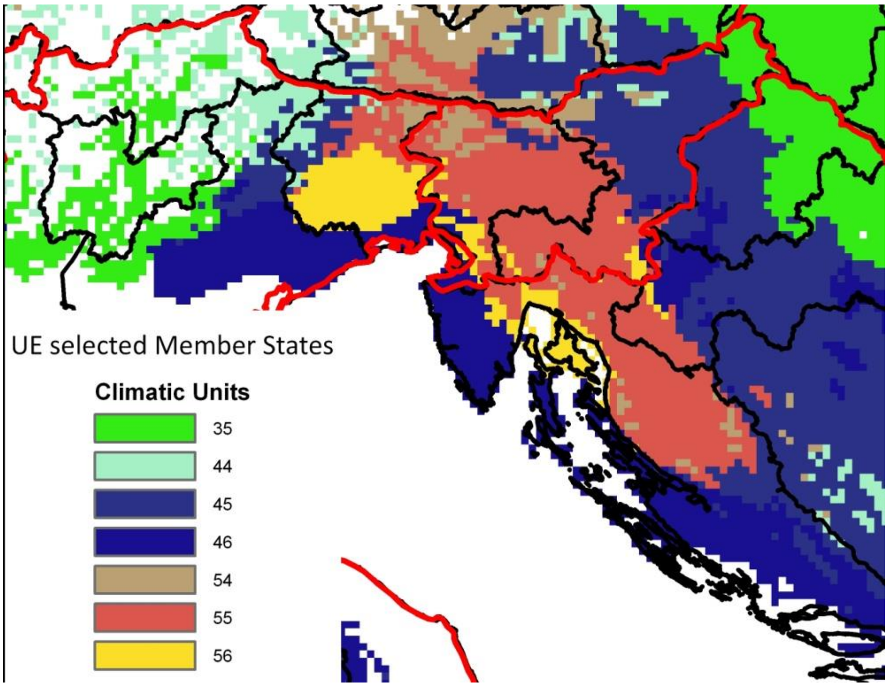

Figure 129: CLUs applied to Slovenia.

The three species reported by original data (conifers, broadleaves and mixed) were grouped between conifers (OC) and broadleaves (OB) pure forest types, distributing the mixed group between OC and OB (Tab. 102), taking into account the proportion of growing stock composition reported by the NIR[132] (2014). We assumed that both these FTs were managed as high forests. The same rotation lengths were applied for each FT, according to the minimal age for final felling reported by the Report of the technical assessment of the forest management reference level submitted by Slovenia in 2011. After 2010 a reduction factor equal to 0.9 of the default minimum rotation length was applied during the model run.

Tab. 102: main species grouped by forest types, total forest area and minimum rotation length applied by CBM.

Forest type (main species)	Acronym	Area (kha)	Min. rotation length (yrs)
Broadleaves	**OB**	**533**	**120**
Conifers	**OC**	**599**	**120**

[132] Tab. 7.3.4, NIR 2014.

Slovenia

The harvest criteria applied by CBM for Slovenia are reported on Tab. 103.

Tab. 103: main parameters defining the harvest criteria applied by CBM for Slovenia, including the age classes affected by each silvicultural treatment and the total amount of harvest provided by each treatment.

Silvicultural treatment	Criteria	Harvest share
15% Commercial Thinnings	15 – 35 yrs	<1%
20% Commercial Thinnings	> 40 yrs.	39%
Clearcut (90-95% commercial thinning)	110 – 120 yrs.	60%

Since no specific data on biomass stock was available at national level, the same equations selected for Italy were applied to Slovenia, assuming that the most common species were spruce and beech (as also highlighted by NIR, 2014), for the conifer and broadleaves groups, respectively (Tab. 104). The same wood density suggested by the Slovenian NIR was applied.

Tab. 104: association between the Slovenian forest types and the default species provided by the original CBM database, based on the selection applied to Italy and wood density applied to each FT, based on the values suggested by NIR (2014).

FT	Species selected by default CBM database	Correspondence with the Italian FTs	Wood density ($t\ m^{-3}$)
OB	Gray birch (*Betula populifera*)	FS_IT	0.58
OC	Red pine (*Pinus resinosa*)	PA_IT	0.39

Species-specific YTs were selected using the average volume and increment reported at national level, further distinguished between three groups of different fertility classes for each species, as reported by the original values provided by NFI. A correction factor equal to 1.05 was applied to the original volume figures, to account for a minimum Dbh equal to 10 cm. Both the historical and the current library, were directly derived by the average volume (for the historical YTs) increment (for the current YTs) values reported by NFI for each species and age classes, using a combined exponential and power function. This approach ensured a larger consistency between the NFI's original values and the figures applied by CBM. The historical library (based on the average volume reported by NFI for each species) and the current library applied by model are reported in Tab. 105.

Slovenia

Tab. 105: Yield tables applied by CBM model for Slovenia, distinguished between OB and OC and between three different fertility classes (I, II, III). The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Class	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	OB	I	2.87	4.11	4.93	5.50	5.89	6.15	6.32	6.40	6.43	6.40	6.34	6.24	6.12	5.98
Current	OB	II	2.30	3.02	3.54	3.97	4.33	4.66	4.95	5.22	5.47	5.70	5.92	6.12	6.32	6.51
Current	OB	III	0.34	1.51	3.14	4.80	6.20	7.19	7.76	7.93	7.77	7.38	6.82	6.18	5.49	4.80
Current	OC	I	6.23	6.54	6.73	6.87	6.97	7.06	7.14	7.21	7.27	7.32	7.37	7.42	7.46	7.50
Current	OC	II	3.00	4.32	5.24	5.91	6.42	6.80	7.07	7.27	7.41	7.48	7.52	7.51	7.48	7.42
Current	OC	III	2.91	4.87	6.32	7.39	8.15	8.68	9.01	9.18	9.23	9.18	9.04	8.84	8.60	8.31
Historic	OB	I	40.4	78.2	115.0	151.3	187.1	222.5	257.7	292.6	327.4	361.9	396.3	430.5	464.6	498.6
Historic	OB	II	17.5	50.4	90.2	132.7	175.2	216.3	254.7	289.9	321.3	349.0	372.7	392.6	408.7	421.4
Historic	OB	III	4.6	26.3	65.2	115.3	169.3	221.1	266.2	302.0	327.4	342.6	348.2	345.6	336.2	321.5
Historic	OC	I	18.5	55.8	101.9	151.5	201.1	248.8	293.0	332.9	367.9	397.9	422.9	443.0	458.5	469.6
Historic	OC	II	102.6	144.9	177.3	204.6	228.6	250.3	270.3	288.9	306.3	322.8	338.5	353.5	367.8	381.6
Historic	OC	III	71.6	125.4	174.1	219.7	263.1	304.8	345.3	384.6	423.0	460.6	497.5	533.8	569.5	604.6

Slovenia

The effect of two different natural disturbances was considered:

1. Fires: data on the amount of burned area were directly taken from the NIR (2014) for 2000-2012 (Figure 130). Fire disturbances were simulated assuming that fire affect 50% of the living biomass, with salvage of 15% of logging residues. A constant amount of burned area, equal to the average amount 2000 – 2012 was applied from 2013 to 2030.

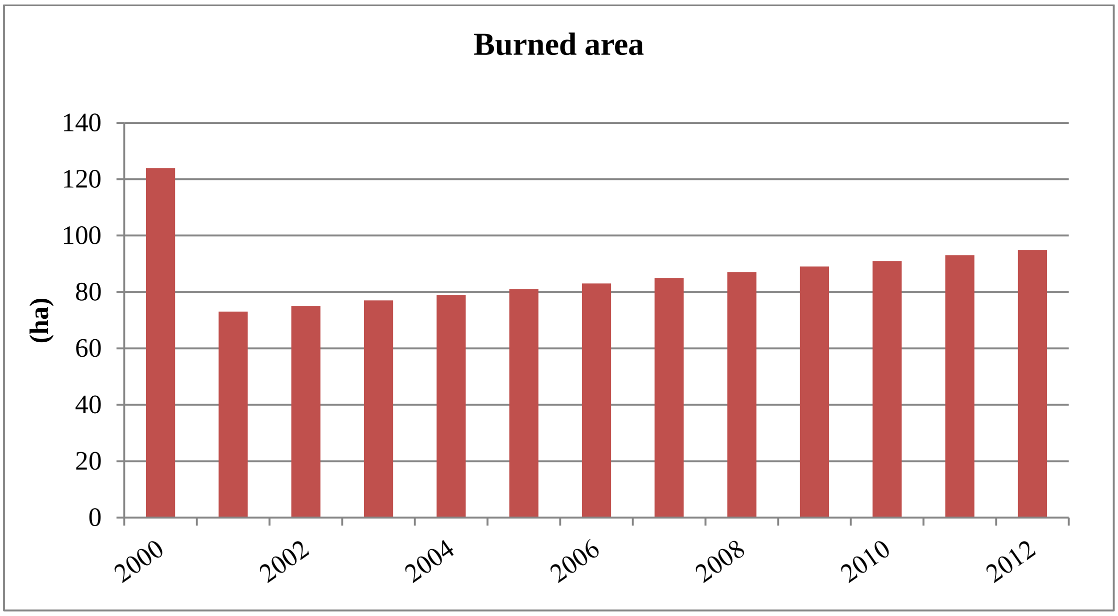

Figure 130: amount of area burned between 2000 and 2012 (based on data reported by NIR, 2014).

2. Ice sleet: according to the information reported by Slovenia to the European Union Solidarity Found (EUSF), relevant ice sleet damages affected Slovenian forests in January – February 2014. Based on a preliminary evaluation, about 480,000 ha of forests were damaged (about 31% on coniferous and 69% on broadleaves)133. Due to this event, forest authorities expect to harvest about 7 million m3 of wood during the following years.
   Taking into account these preliminary data, this event was modelled assuming that 5% of the living biomass was directly damaged and moved to snag pools in 2014 (i.e., based on the current model's assumption, during the "future" harvest scenarios), on a total forest area equal to about 331,000 ha and 148,000 ha of broadleaves and conifers, respectively. Salvage of logging residues after the disturbance, was simulated through a specific event, moving the biomass from the stem snags pool to the product pools in 2014 (on 50% of the total area affected by ice sleet), 2015 (on 30% of the total area affected by ice sleet) and 2016 (on 20% of the total area affected by ice sleet).

Harvest and HWP analysis

The historical FAO statistics provide complete from 1993 onward. The amount of harvest reported by FAOSTAT is on average 16% lower than the country's submission for FMRL (Figure 131). The FRA 2010 Country Report[134] reports the following correction factors to account for the bark's fraction: 1.17 for coniferous and 1.13 for non-coniferous species. The original FAO

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[133] Terrestrial Assessment Damage Report Ice Sleet in Slovenia, Harterbrodt and Quadt, 2014. We thank P. Vogt for the information and support to analyze the documents provided to the European Union Solidarity Found.
[134] FRA 2010 – Country Report, Slovenia (pag. 44).

statistics corrected for bark are consistent with the other data sources. No data is reported by the last NIR (2013). After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 5.2 million m^3 for 2020.

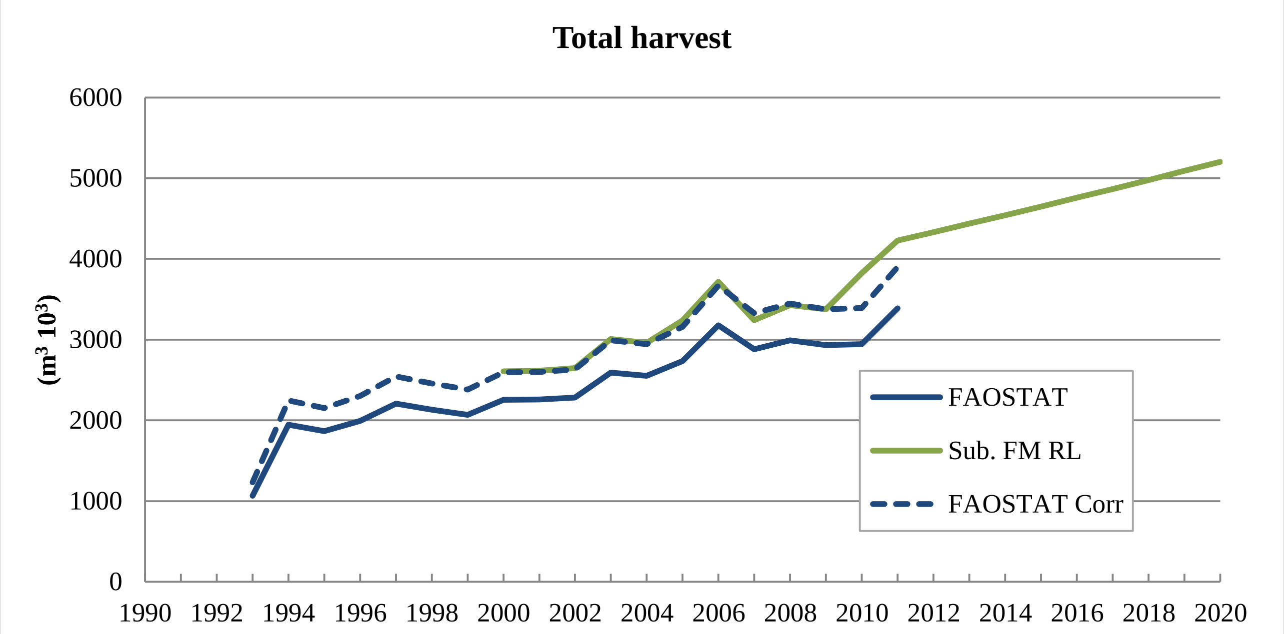


Figure 131: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (over bark) and the National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a bark correction factors equal to 1.17 for conifers and 1.13 for broadleaves. The figure also reports the future harvest demand (i.e., since 2013) according to the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 132. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

Slovenia

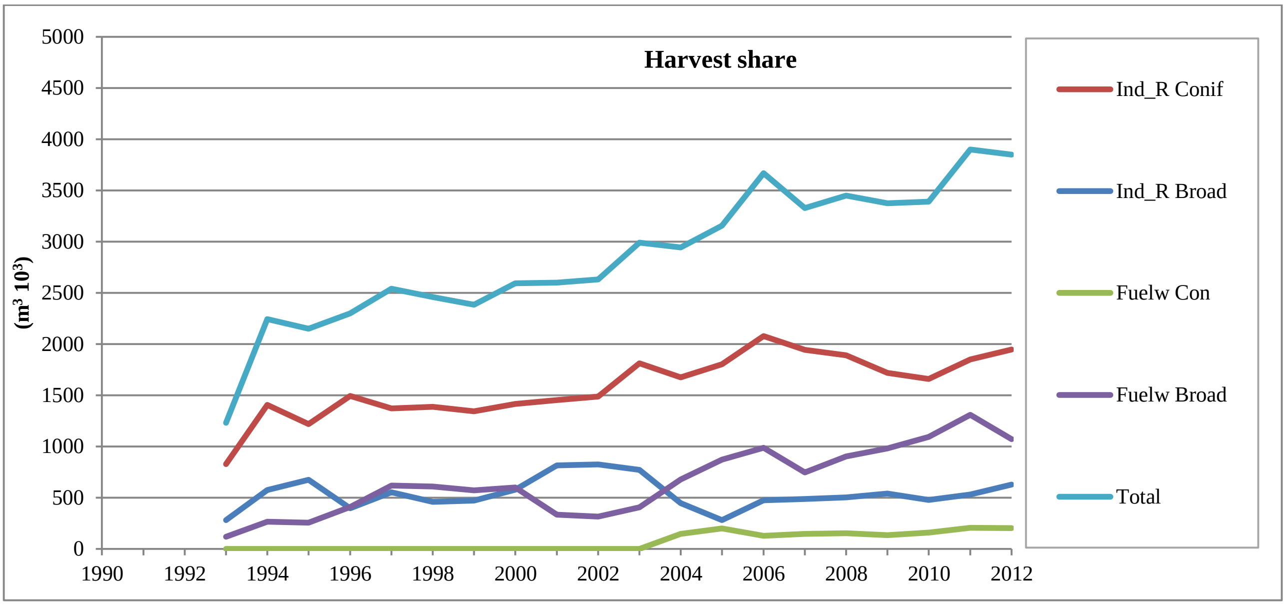
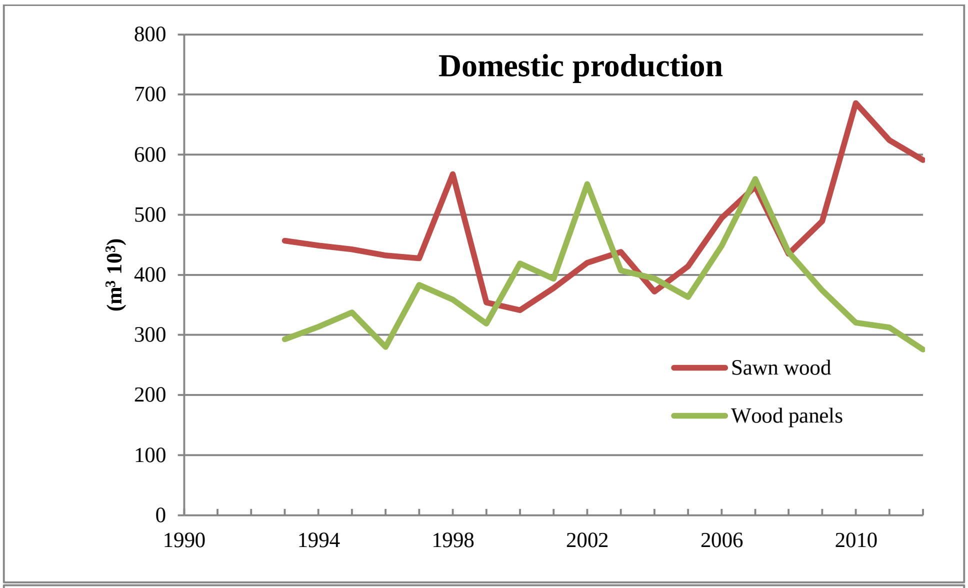


Figure 132: share of harvest applied by CBM for the historical period (until 2012) and the constant harvest scenario (from 2013), distinguished between IRW and FW and between conifers (C) and broadleaves (B).

The fraction of domestic production estimated in our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 133.

Slovenia



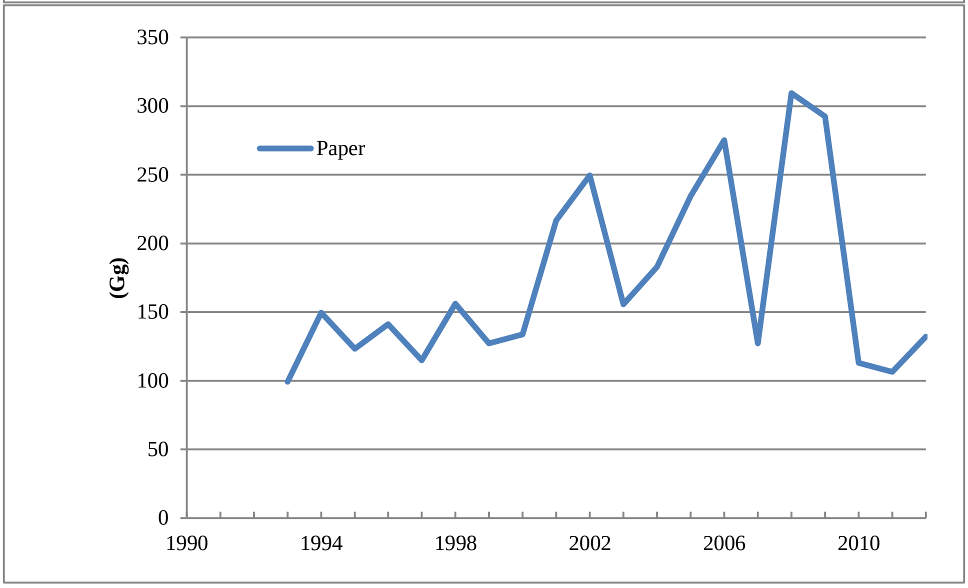


Figure 133: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Spain

NFI data and model assumptions

The analysis was based on data reported by the country in the NFI, referred to 2002. The original forest area (18,556 kha) was scaled back to 1992, with a total value equal to 12,581 kha. The total forest area was further decreased to 12,572 kha, in order to account for the total amount of deforestation occurred until 1992 (i.e., about 4,710 ha yr^{-1}) and it was distributed between 17 administrative regions and 18 Climatic units, reported by Figure 116 for Portugal.

Exclusively data regarding two groups of species were reported by the NFI and thus only two main types were used: conifers and broadleaves. Nevertheless, given the great differences between the Mediterranean and Atlantic areas of Spain regarding the forest production and the main species, these groups were also split into these two bio-geographical areas (i.e. Mediterranean and Atlantic).

No age class distribution was provided by the NFI data, however, considering that one of the main characteristics of the Spanish forests is that most of them are uneven aged forests[135], the entire forest area was considered as an uneven-aged high forest.

All forests were therefore managed through a single tree selection method, simulated by a 30-35% commercial thinning. The same cutting cycle was applied to each uneven-aged FT (Tab. 106). After 2011 a reduction factor equal to 0.9 of the default minimum cutting cycle was applied during the model run.

Tab. 106: main forest types and minimum period between cuts applied by CBM model to the uneven-aged forests for Spain.

Forest type (most representative species)	Acronym	Min. rotation period between cuts (yrs)
Atlantic conifers *(Pinus radiate and Pinus pinaster)*	CA	**10**
Mediterranean conifers (Pinus sylvestris)	CM	**10**
Atlantic broadleaves *(Eucaliptus globulus)*	BA	**10**
Mediterranean broadleaves (*Quercus ilex*)	BM	**10**

135 Submission for forest management reference level of Spain (2011), page 10.

Since no specific data on biomass stock was available at national level, the same equations selected for Italy and Portugal were applied to Spain (Tab. 107), according to the most representative species reported on Tab. 107 for each FT.

Tab. 107: association between the Spanish forest types and the default species provided by the original CBM database, based on the selection applied to Italy and Portugal.

FT	Species selected by default CBM database	Italian (IT) or Portugal selection (PT)	Correspondence with the original FTs
BA	Eastern white pine (P. strobus)	PT	EG_PT
CA	Red pine (P. resinosa)	PT	PP_PT
BM	White elm (Ulmus americana)	IT	QI_IT
CM	Red pine (Pinus resinosa)	IT	PS_IT

Species-specific YTs were provided for each FT and region, based on the average volume and increment reported by NFI. A correction factor equal to 1.07 was applied to the original volume data, in order to account for the minimum Dbh equal to 7.5 cm. Figure 134 reports an example of the YTs applied by model for each forest type.

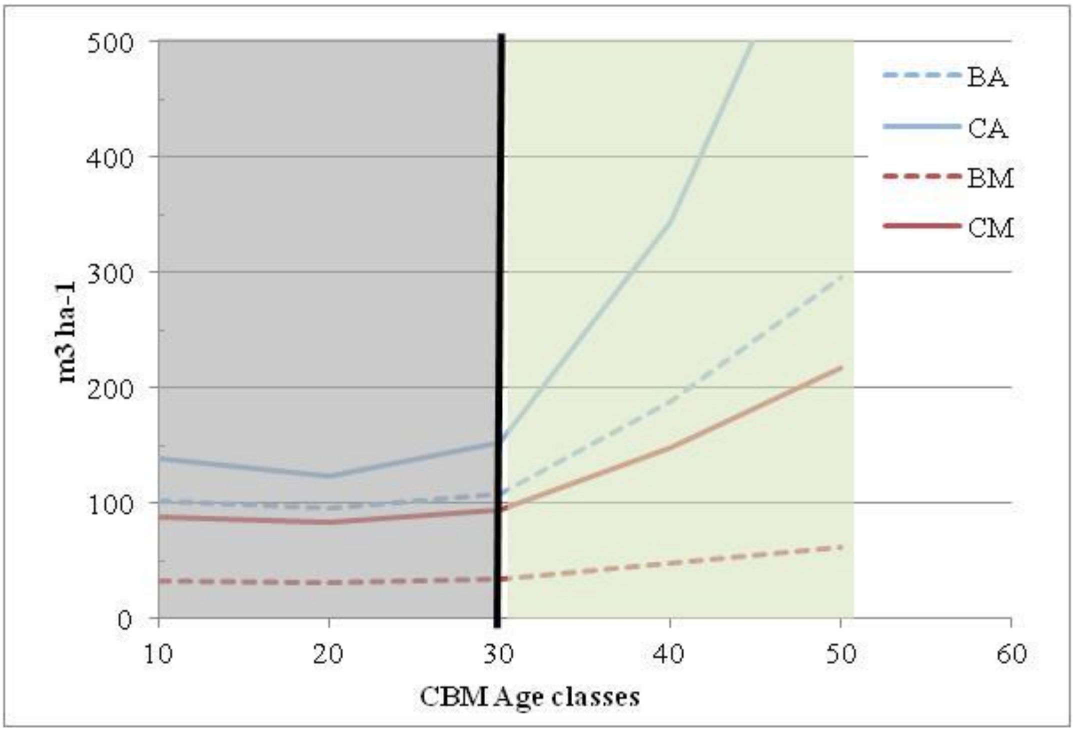


Figure 134: example of the YTs applied by CBM model for the broadleaves Atlantic (BA), conifers Atlantic (CA), broadleaves Mediterranean (BM) and conifers Mediterranean (BM) forest types, based on the YTs selected for the regions ES12 and ES41, for the Atlantic and Mediterranean zone, respectively. Note that, due to the specific model assumptions applied to the uneven-aged forests, all the forest area was initially assigned to the age class 30 (highlighted by the black line). During the model run, each stand growths by

this reference age class. After each disturbance event, the stand will return to the initial reference age class.

Due to the major importance of forest fires in Spain, these were taken into consideration as the main natural disturbance in the country. Figure 135 shows the historical area affected by fires included in the model simulation. A constant amount of burned area, equal to the average amount 2000 – 2012 was applied from 2013 to 2030.

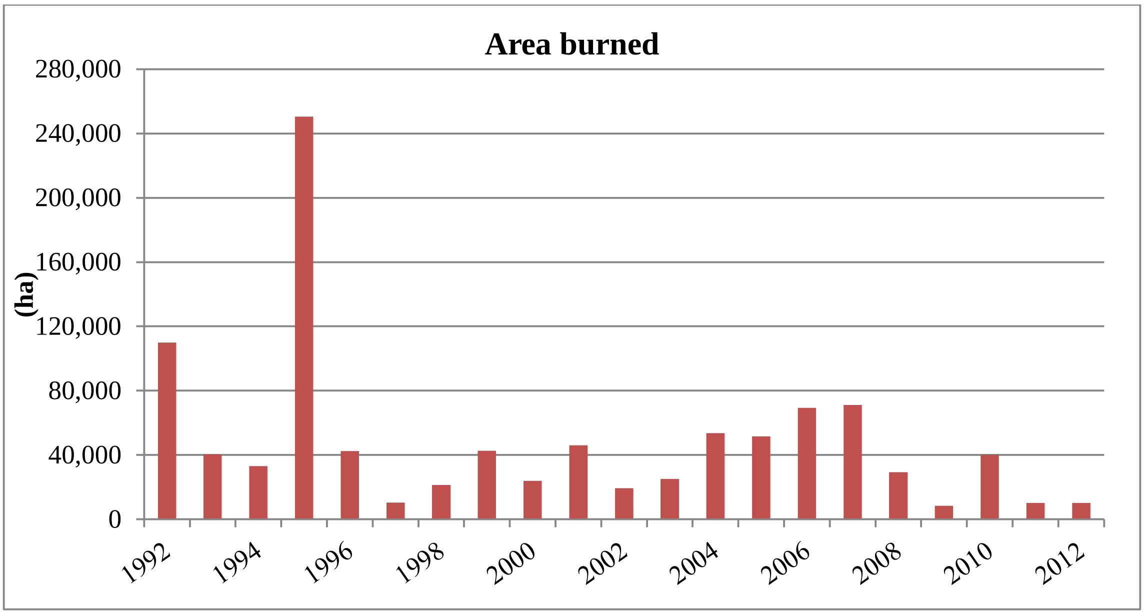


Figure 135: amount of area burned between 1992 and 2012.

Fire disturbances were simulated assuming that fire affected 50% of the living biomass, with salvage of 8% of logging residues (i.e., 42% of the living biomass was moved to DOM pools). Fires were distributed proportionally to the forest area of each FT and region.

Since for Spain we assumed that the FM area was covered by uneven-aged forests and no yield table applicable to the even-aged forests system was available, we applied to afforestation the current yield tables selected from Portugal and Italy, as reported in Tab. 108

Tab. 108: yield tables applied for AR in Spain, based on yield tables selected for Portugal and Italy.

Spain FT	Main species	YT provided by (country, region)	Original FT of the YT
CA	*P. radiata and P. pinaster*	Portugal – PT11	*Pinus pinaster*
CM	*P. sylvestris*	Italy – ITE1	*Pinus sylvestris*
BA	E. globulos	Portugal – PT11	*Eucaliptus spp*
BM	Q. ilex	Portugal – PT16	*Quercus spp.*

Harvest and HWP analysis

The historical FAO statistics provide completed data since 1961. The amount of harvest reported by FAOSTAT is on average 13% lower than the country's submission for FMRL (Figure

136). Since these last values are consistent with the FRA 2010 Country Report[136], reporting the volume over bark, we assumed that FAOSTAT reports the volume under bark and we applied a bark's correction factor equal to 1.10. The original FAOSTAT data corrected for bark are consistent with the other data sources. No data is reported by the last NIR (2013). After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 19.2 million m^3 for 2020.

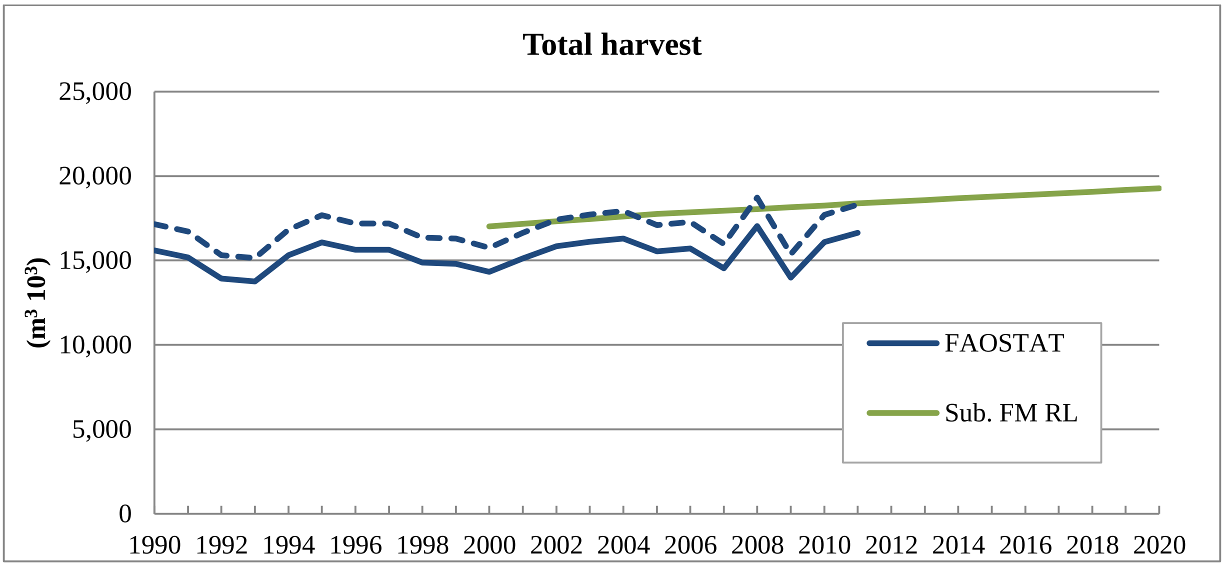


Figure 136: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (over bark) and the National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a bark correction factors equal to 1.10. The future harvest demand (i.e., since 2013) is reported according to the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 137. These data, corrected to account for the OWCs (see materials and methods) can be used as input in CBM.

[136] FRA 2010 – Country Report, Spain (pag. 48).

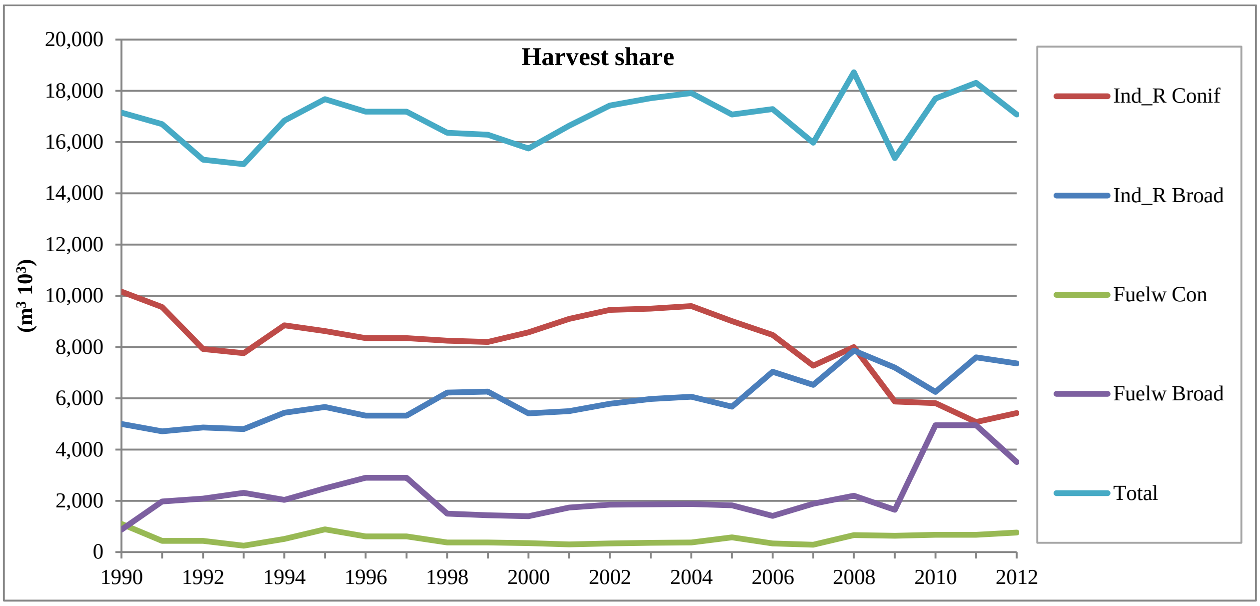


Figure 137 share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest until 2012 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 138.

Spain

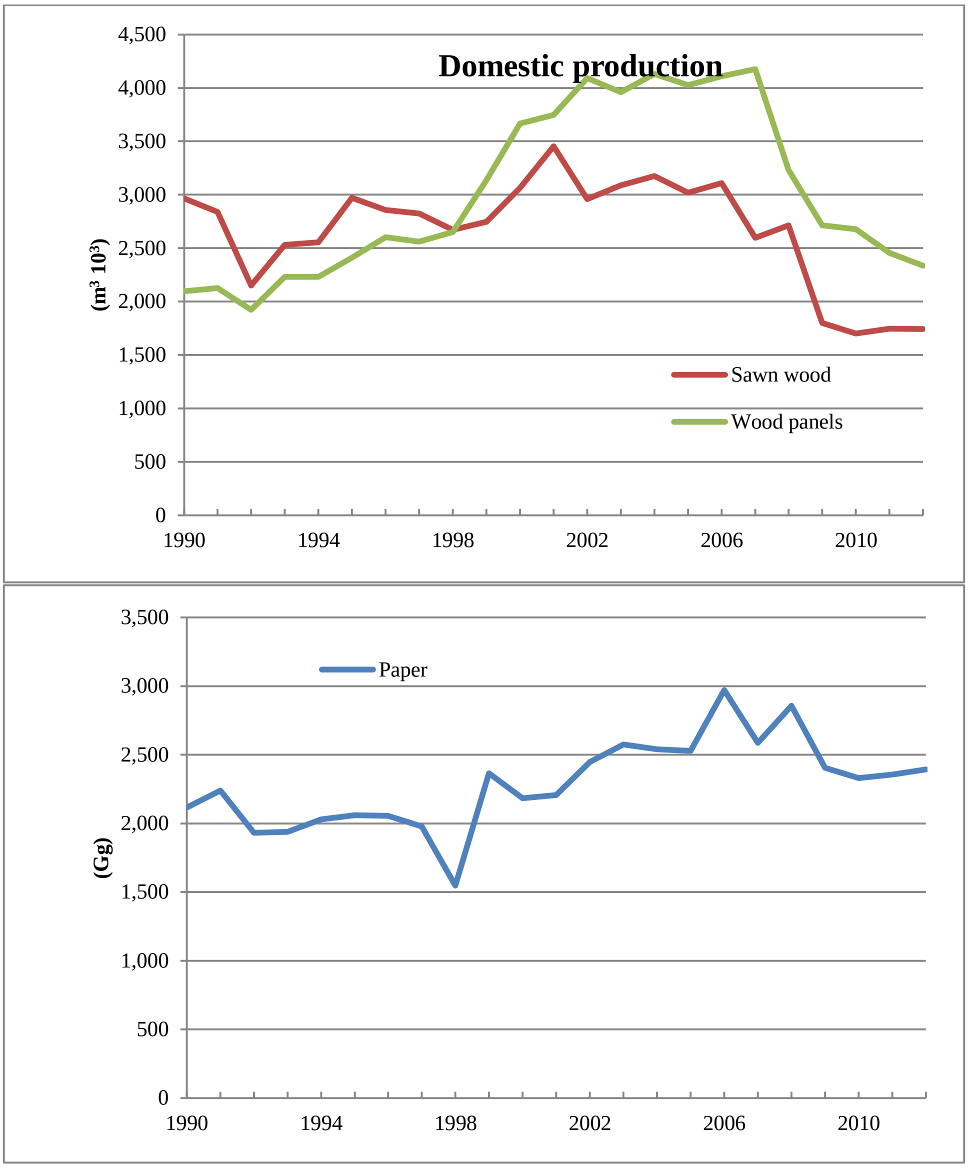


Figure 138: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

Sweden

NFI data and model assumptions

The analysis was based on data provided by the NFI 2004-2008[137]. All data were referred to 2006 and integrated with further information provided by the Official Statistics of Sweden (Forestry statistics, 2010) and specific data provided at country level. The total forest area reported by these data was equal to 22,650 kha. This area was about 3% lower than the total productive forest area reported by the national Submission of information on forest management reference level (2011), equal to 23,400 kha. According to this document, a fixed annual value of net removals in biomass carbon pools equal to 2 Gt CO_2 yr^{-1} has been added to account for protective forests (i.e., about 3,000 kha). Since we assumed the 2006 as NFI reference year, all data were brought back to 1996. The total forest area was corrected to account for the total amount of deforestation occurred until 1996 (i.e., about 11,130 ha yr^{-1}, with a final forest area equal to 22,583 kha for 1996. The original forest area reported by the NFI was distributed between 12 Climatic units (Figure 139) and grouped at national level to simplify the model run:

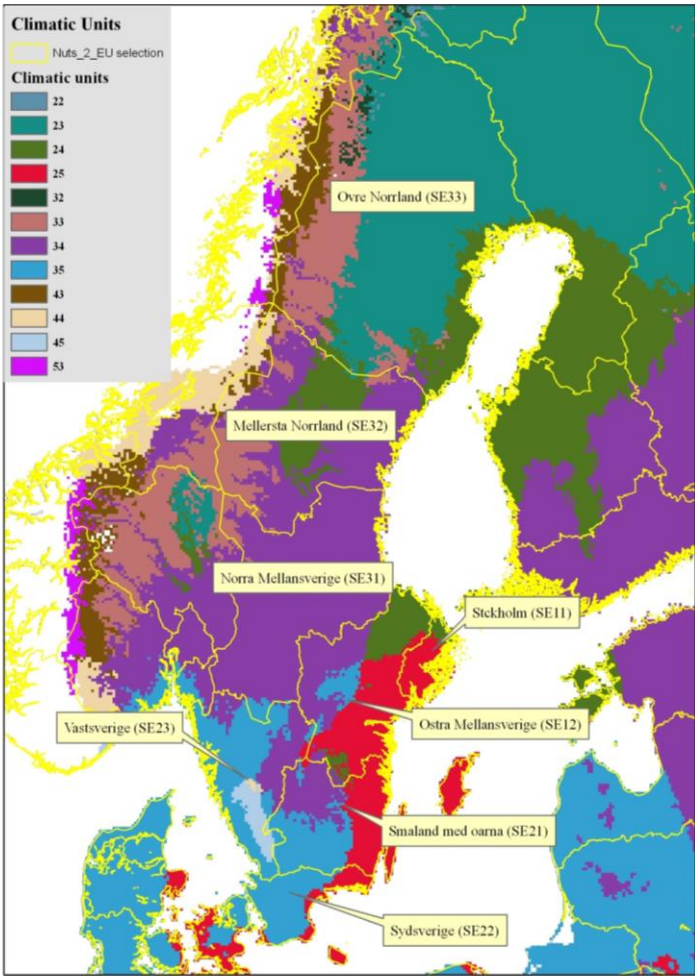


Figure 139: regional borders defined at NUTS 2 level and climatic borders assumed by CBM model. For the final analysis, all input data were regrouped at national level.

In Tab. 109 are reported the forest types and cutting cycles applied for Sweden.

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[137] available at: http://www.slu.se/en/webbtjanster-miljoanalys/forest-statistics/

Sweden

Tab. 109: main species grouped by forest types, minimum rotation length and wood density applied by model.

Main species	FT acronyms	Cutting cycle	Wood density (tons m^3)
Spruce (P. abies)	**PA**	**90 yrs.**	**0.40**
Pine (P. sylvestris)	**PS**	**80 yrs.**	**0.42**
Birch (Betula sp)	**BT**	**60 yrs.**	**0.51**
Other broadl. (Oaks, Ash)	**OB**	**70 yrs.**	**0.50**

The harvest criteria applied by CBM for Sweden are reported on Tab. 114.

Tab. 110: main parameters defining the harvest criteria applied by CBM for Sweden, including the age classes affected by each silvicultural treatment and the relative amount of harvest provided by each treatment (estimated as the average amount of harvest provided between 1996 and 2012).

Silvicultural treatment	Criteria	Harvest share
30% Commercial Thinnings on Conifers	> 30 yrs.	33%
Clearcut (95% commercial thinning)	Depending by species	60%
Salvage logging after Nat. Disturbances	Depending by years	≈7%

The same set of equations selected for Latvia was applied to Sweden. Species-specific YTs were selected using the average volume and increment reported at national level for each FT. The historical library (i.e., the YTs applied during the stand-initialization procedure) and the current library (i.e., the YTs applied during the model run) are reported in Tab. 111.

Sweden

Tab. 111: Yield tables applied by CBM model for Sweden. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age10	Age20	Age30	Age40	Age50	Age60	Age70	Age80	Age90	Age100	Age110	Age120	Age130	Age140	Age150
Historical	BT	1.15	6.11	14.99	26.91	40.79	55.69	70.83	85.64	99.74	112.90	124.98	135.93	145.76	154.52	162.26
Historical	OB	1.15	6.11	14.99	26.91	40.79	55.69	70.83	85.64	99.74	112.90	124.98	135.93	145.76	154.52	162.26
Historical	PA	3.02	11.94	24.85	39.95	55.84	71.61	86.64	100.59	113.27	124.65	134.73	143.59	151.32	158.03	163.82
Historical	PS	1.74	7.22	16.06	27.72	41.65	57.37	74.41	92.40	111.00	129.94	148.99	167.95	186.66	205.01	222.89
Current	BT	0.12	1.24	3.56	6.24	8.52	10.06	10.80	10.87	10.45	9.70	8.77	7.78	6.79	5.85	5.00
Current	OB	0.12	1.24	3.56	6.24	8.52	10.06	10.80	10.87	10.45	9.70	8.77	7.78	6.79	5.85	5.00
Current	PA	4.21	8.98	9.76	8.77	7.21	5.66	4.31	3.22	2.38	1.74	1.27	0.92	0.66	0.48	0.35
Current	PS	4.21	8.98	9.76	8.77	7.21	5.66	4.31	3.22	2.38	1.74	1.27	0.92	0.66	0.48	0.35

Sweden

The effects of Storm disturbance events were considered according to the following assumptions:

1. Based on the information reported by the FORESTORMS[138] database and by the country, the following storms affected Sweden since 1996 (Tab. 112).

Tab. 112: area (in ha) affected by the main storms in Sweden and amount of merchantable volume (in million m^3) damaged by each event.

Year	Affected Area (ha)	Primary damage (Mm3)
	A	B
1997	N.R.	0.1
1999	N.R.	5.0
2001	N.R.	2.1
2002	N.R.	2.0
2003	N.R.	1.3
2005	280,000	63.0
2007	66,000	12.0

2. The volume damaged by each storm (col B, Tab. 112) was distributed between each FT according to its proportion in the total forest area and converted to tons of C using the specific wood density reported in Tab. 109.
3. We assumed that the disturbance event was a stand-replacing disturbance affecting 95% of the living biomass, with a direct salvage of logging residues. This one was simulated moving 90% of the merchantable biomass to the product pool and the remaining 5% to DOM.

Harvest and HWP analysis

The historical FAO statistics provide complete starting from 1961. The amount of harvest reported by FAOSTAT is on average 24% lower than the country's submission for FMRL (Figure 140). The values reported by the FRA 2010 Country Report[139] (referred to the volume over bark) are higher than FAOSTAT but lower than the country's submission for FMRL. Therefore, we assumed that: (i) FAOSTAT reports the volume under bark and a country specific correction factor equal to 1.14 (FRA 2010 Country Report) can be applied; the higher values reported by the country's submission for FMRL include both the bark's fraction and forest residues. No data is reported by the last NIR (2013). After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 92.4 million m^3 for 2020.

[138] http://www.efiatlantic.efi.int/portal/databases/forestorms/
[139] FRA 2010 – Country Report, Sweden (pag. 39).

Sweden

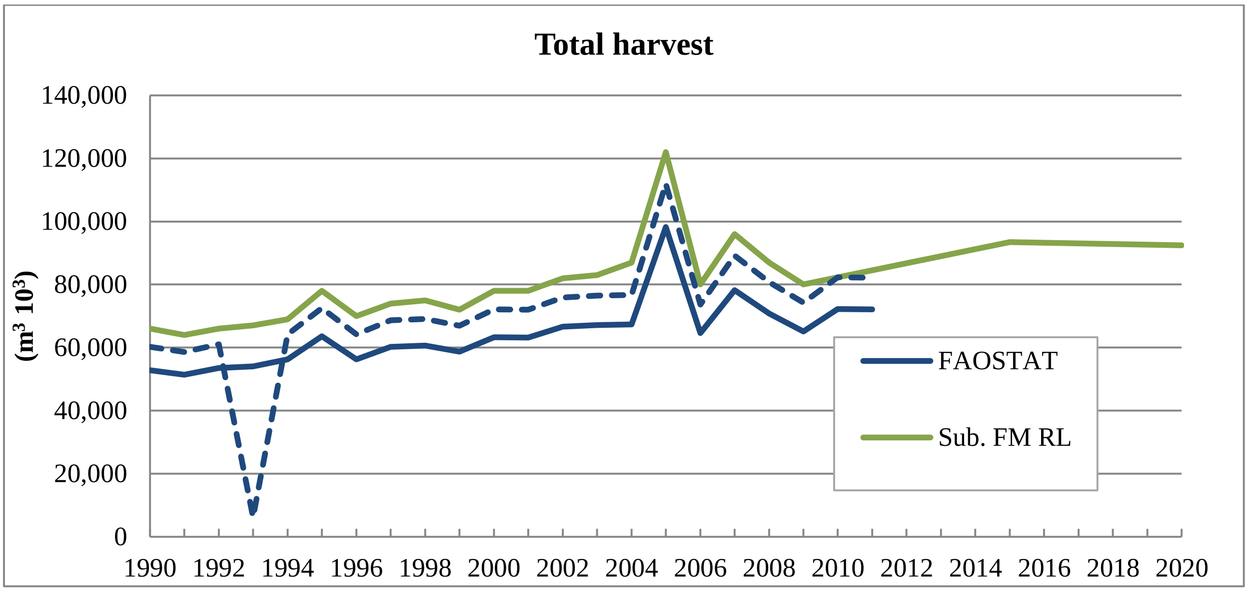

Figure 140: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2011 (historical data): FAOSTAT (over bark) and the National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on a bark correction factors equal to 1.14. The future harvest demand (i.e., since 2013) is reported according to the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 141. These data, corrected to account for the OWCs (see materials and methods) can be used by CBM as input.

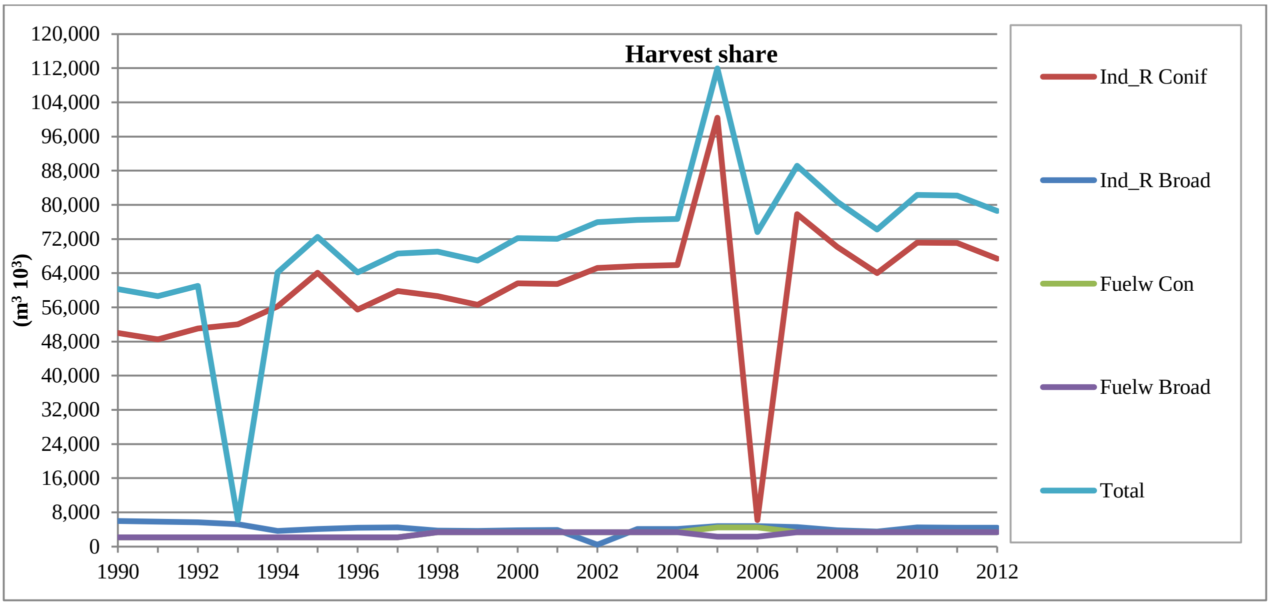

Figure 141: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2012 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated in our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC is reported in Figure 142.

Sweden

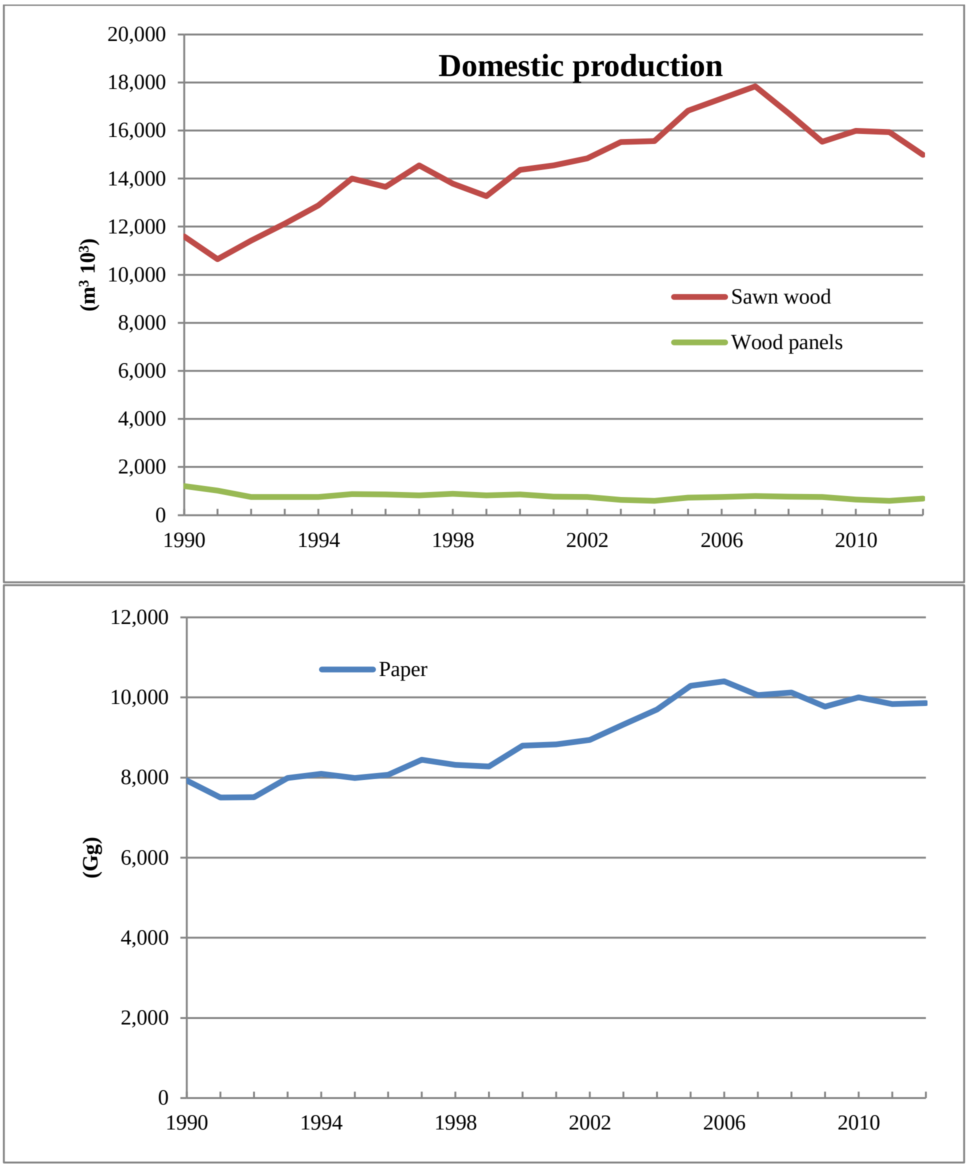

Figure 142: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

The United Kingdom of Great Britain and Northern Ireland

NFI data and model assumptions

The analysis was based on the data reported by the EFI database, for the 1994-2000 NFI (assuming 1997 as the reference year). The total forest area reported by this database, equal to 2,202 kha, also included the amount of area reported as afforestation, equal to about 283 kha established between 1990 and 2008. Due to the lack of detailed information on the age class distribution, all data were aggregated at national level, scaled to a total forest area equal to 2,546 kh (referred to 1997) and distributed between 13 Climatic units, reported by Figure 85 for Ireland and UK.

The main species reported by the NFI were grouped in 7 forest types, reported in Tab. 113. All species were managed as high forests. Specific rotation lengths were applied for each FT, according to the minimal age for final felling reported by the literature.

Tab. 113: main species grouped by forest types and minimum rotation length applied by CBM model.

Forest type (main species)	**Acronym**	**Min. rotation length (yrs)**
Betula, Acer and Fraxinus spp.	**BT**	**60**
Fagus sylvatica	**FS**	**90**
Other broadleaves	**OB**	**60**
Other conifers	**OC**	**30**
Picea spp.	**PA**	**60**
Pinus spp.	**PS**	**55**
Quercus sp.	**QR**	**100**

The main parameters defining the harvest criteria applied by CBM for the UK are reported on Tab. 114.

Tab. 114: main parameters defining the harvest criteria applied by CBM for the UK, including the age classes affected by each silvicultural treatment and the relative amount of harvest provided by each treatment (estimated as the average amount of harvest provided between 1997 and 2012).

Silvicultural treatment	**Criteria**	**Harvest share**
15% Commercial Thinnings	> 15 yrs	1%
20% Commercial Thinnings	> 25 yrs.	16%
Clearcut (95% commercial thinning)	Depending by species	83%

Since no specific data on biomass stock was available at national level, the same equations selected for Germany and Latvia were applied to Ireland, according to the assumptions reported in Tab. 115.

Tab. 115: association between the British forest types and the default species provided by the original CBM database, based on the selection applied to Germany and Latvia.

FT	Species selected by default CBM database	Germany (DE), Italy (IT) or Latvia (LV)	Correspondence with the German, Italian or Latvian FTs
BT	Red pine (P. resinosa)	LV	Birch (LV)
FS	Sugar Maple	DE	FS
OB	Red pine (P. resinosa)	LV	OB_LV
OC	White spruce (P. glauca)	LV	Spruce (LV)
PA	White spruce (P. glauca)	LV	Spruce (LV)
PS	Red pine (P. resinosa)	LV	Scots pine (LV)
QR	Ironwood (Ostria virginiana)	DE	QR

Species-specific YTs were selected using the average volume and increment reported at national level. Since the original NFI data report the gross annual increment of all trees with a Dbh>4 cm, we applied a correction factor equal to 1.05 to the original data on volume. The current library and the historical library applied by CBM model are reported in Tab. 116. Because the final analysis was performed at national level, for each FT we calculated the average volume by age class, using as weighting factor the area occupied by each FT at regional level.

UK

Tab. 116: Yield tables applied by CBM model for the UK. The current library, reporting the current annual increment (all values in mc ha^{-1} yr^{-1}) was applied during the model run; the historical library, reporting the volume (all values in mc ha^{-1}) was applied during the stand-initialization procedure. Age classes with a 10 years span were assumed (i.e., Age1 -> age class 1 to 10 years; Age2 → age class 11 to 20 years, etc.).

Library	FT	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
Current	BT	2.42	6.63	9.87	11.42	11.45	10.55	9.16	7.59	6.08	4.74	3.63	2.72	2.01	1.47
Current	FS	0.54	2.6	5.28	7.66	9.19	9.7	9.46	8.66	7.58	6.39	5.26	4.21	3.31	2.56
Current	OB	2.11	5.52	8.09	9.36	9.49	8.87	7.84	6.62	5.43	4.35	3.41	2.63	2	1.5
Current	OC	0.65	5.01	11.32	15.34	15.74	13.52	10.25	7.13	4.59	2.83	1.64	0.93	0.52	0.28
Current	PA	1.6	8.03	14.62	17.52	16.75	13.86	10.41	7.28	4.83	3.08	1.89	1.13	0.67	0.38
Current	PS	0.52	4.4	10.45	14.65	15.35	13.32	10.21	7.1	4.59	2.81	1.65	0.92	0.51	0.26
Current	QR	0.66	3.17	6.11	8.16	8.92	8.54	7.51	6.2	4.89	3.68	2.72	1.94	1.36	0.96
Historic	BT	4.2	22.2	54.6	95.7	141.8	188.1	232	272.3	308.1	339.6	367	389.9	408.5	425.3
Historic	FS	16.9	48.3	86.1	125.1	162.9	197.8	229.2	257.4	281	302.5	320.8	336.8	350.8	362.7
Historic	OB	14.5	36.8	62.9	91.2	119.2	146.1	171.9	194.6	214.9	233.5	249.2	263.9	275.6	286.6
Historic	OC	7.2	33	74.8	127.1	185.8	247.2	308.1	368.1	425.7	479.6	530.4	576.5	619.8	659.4
Historic	PA	8	40.2	94.5	162.8	238.6	315.1	387.5	452.6	511.1	561.2	605.1	641.2	671	696.3
Historic	PS	1.5	14	48	102.4	173.1	252.1	332.7	410.3	482.7	547.7	604.8	653.8	695.2	730.3
Historic	QR	6.7	26.4	54.4	86.4	119.4	149.7	177.3	201.3	222.1	240.1	255.2	268.1	278.5	287.7

The effect of the following natural disturbances was considered:

1. Storms: based on the information reported by the FORESTORMS[140] database, the main storm affecting UK during the last years occurred in 2005 when about 0.5 million m^3 were damaged. This event was simulated through a widespread-disturbance, assuming that only 50% of the existing living biomass is disturbed and about 45% of the biomass damaged by this event was removed as salvage logging (i.e., about 23% of the total aboveground biomass moves to the HWP pool and about 27% moves to DOM pools). The effect of this disturbance event was concentrated on PA (i.e., the main FT, covering about 40% of the total forest area).
2. Fires: data on the amount of burned area for the period 1997–2012 were derived by the NIR (2014); for the implementation of the model after 2012, the constant average amount of burned area can be assumed, in this case equal to 3,563 ha yr^{-1} (Figure 143). Fire disturbances were simulated assuming that fire affect 50% of the living biomass, with salvage of 15% of logging residues. Fires were distributed both on the FM and on the not-FM area, proportionally to the forest area of each FT. A constant amount of burned area, equal to the average amount 2000 – 2012 was applied from 2013 to 2030.

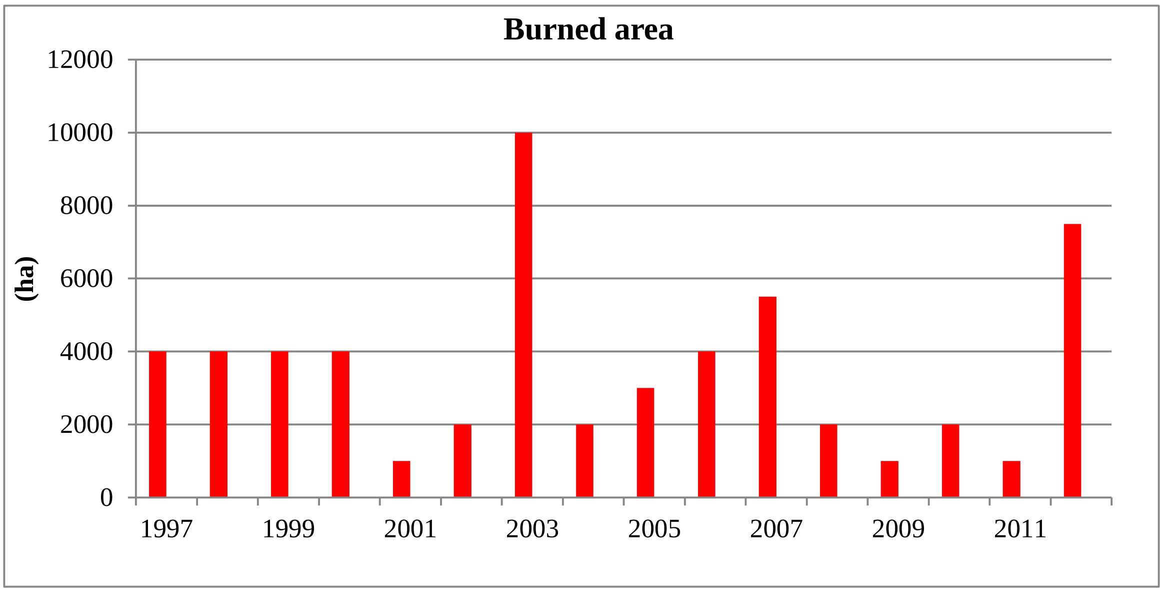

Figure 143: amount of area burned between 1997 and 2012 (based on data reported by NIR, 2014).

Harvest and HWP analysis

The historical FAO statistics provide complete data starting from 1961. The amount of harvest reported by FAOSTAT is on average 20% lower than the country's submission for FMRL (Figure 144). According to the FRA 2010 Country Report[141], these values are referred to the volume under bark and country specific correction factors, equal to 1.14 and 1.12 for hardwood species (assumed as broadleaves) and softwood species (assumed as conifers) can be applied. No data are reported by the last NIR (2014).

After 2010, the Submission for FMRL reports an increasing harvest demand, with a final amount of harvest equal to 18.3 million m^3 for 2020.

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[140] http://www.efiatlantic.efi.int/portal/databases/forestorms/

[141] FRA 2010 – Country Report, United Kingdom (pag. 50).

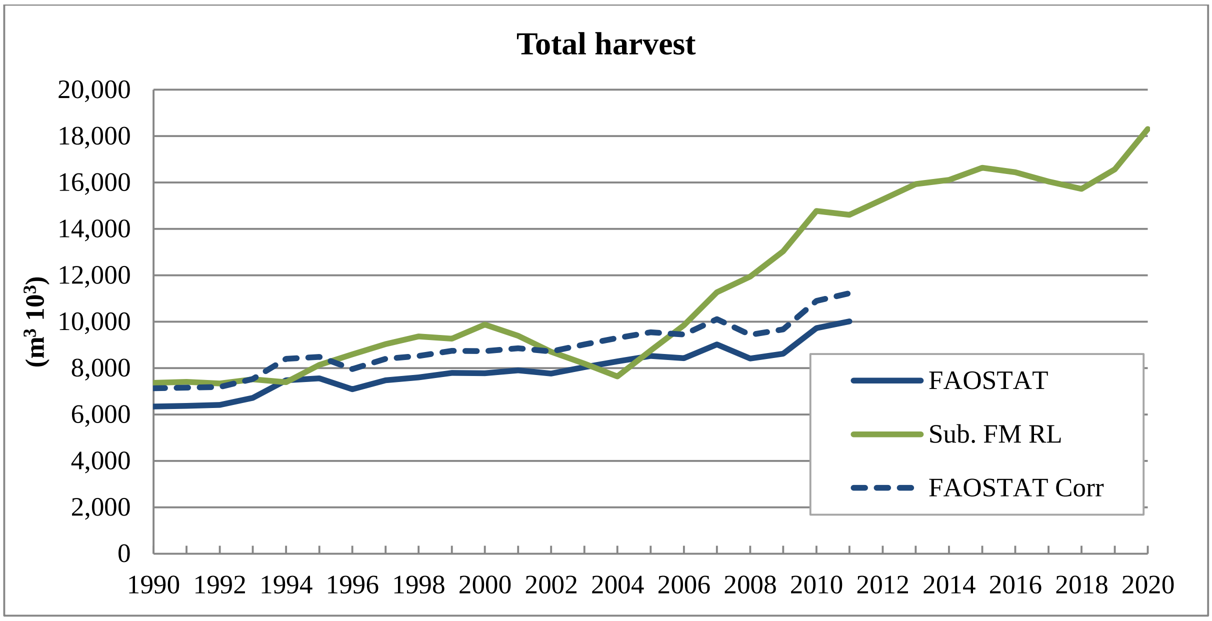

Figure 144: the figure reports the total amount of harvest provided from different data sources for the period 1990 – 2012 (historical data): FAOSTAT (over bark) and the National Submission for FM Reference Level (Sub. FMRL). We also reported the FAOSTAT corrected estimates (FAOSTAT Corr), based on the country's specific bark correction factors. The figure also reports the future harvest demand (i.e., since 2013) according to the National Submission for FM Reference Level.

The share of harvest between IRW and FW production and between conifers and broadleaves is reported in Figure 145. These data, corrected to account for the OWCs (see materials and methods) can be used as input by CBM.

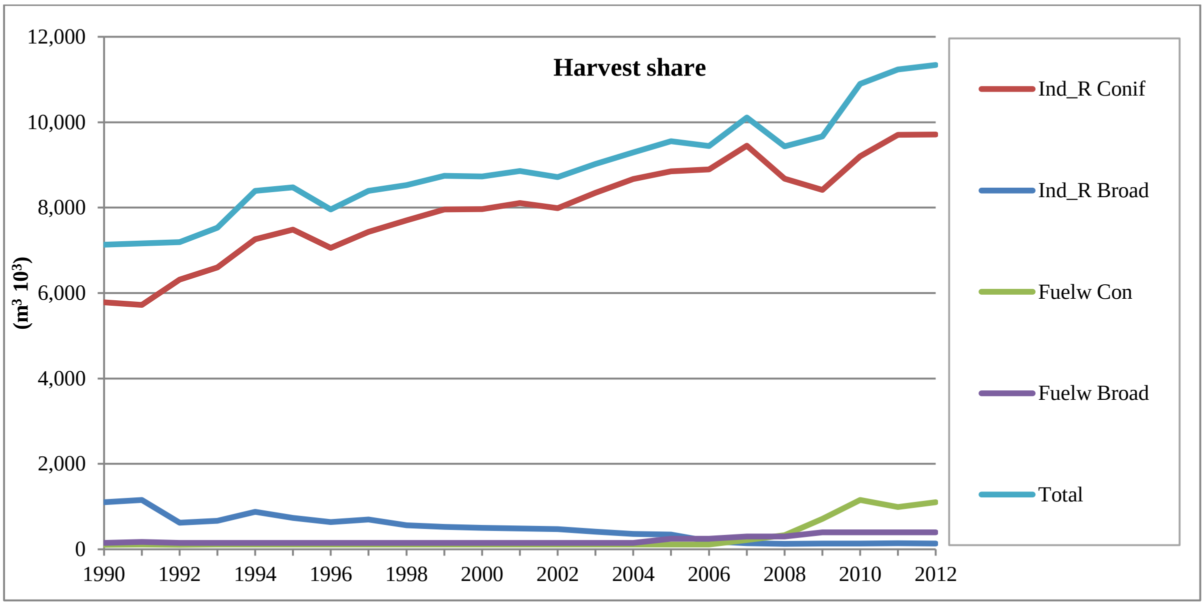

Figure 145: share of harvest between IRW and FW, further distinguished between conifers and broadleaves. The total amount of harvest before 2013 is equal to the FAOSTAT estimates, corrected for bark.

The fraction of domestic production estimated by our analysis for the three main HWP categories, using the Tier 2 method proposed by IPCC, is reported in Figure 146.

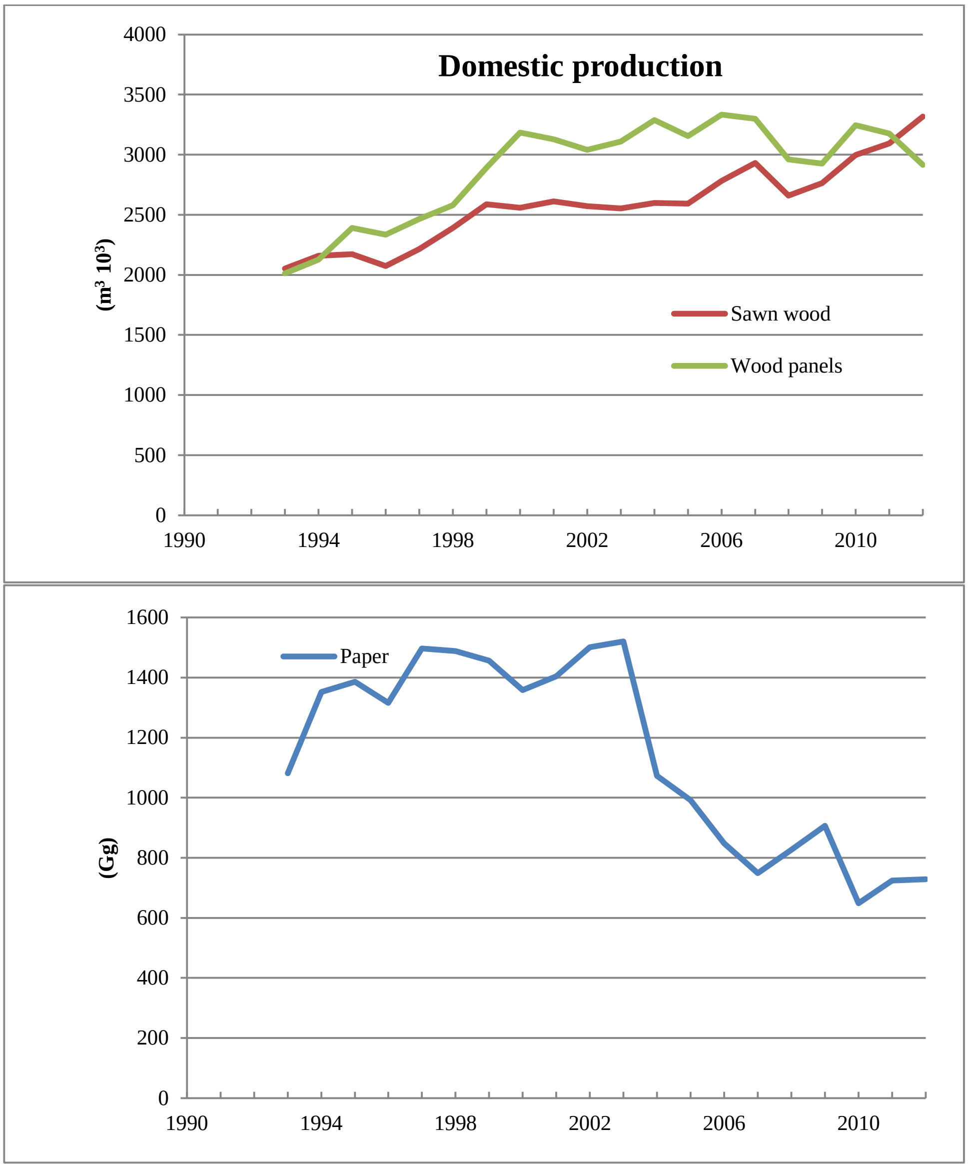

Figure 146: the figure reports the country's domestic production distinguished between sawn wood products, wood based panels (upper panel, in m^3 10^3) and paper and paper board (lower panel, in Gg). No value is reported from the country's submission for FMRL.

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List of abbreviations and definitions

ARD →Afforestation and reforestation

CBM → Carbon Budget Model

D →deforestation

FM →Forest management

FRA →Forest resources assessment

FW → fuel wood

HWP →Harvested wood products

IRW →Industrial roundwood

KP →Kyoto protocol

LULUCF →Land use, land use change and forestry

NFI → National Forest Inventory

NIR →National inventory report

PP →Paper and paperboards

RL →Reference level

SW →Sawnwood

WP →Wood based panel

YTs → Yield tables

ANNEX 2B
CBM RESULTS: COUNTRY REPORTS

Contract n° 33920-2015 NFP

Administrative agreement

340202/2015/705777/CLIMA.A.2

Roberto Pilli, Giulia Fiorese, Giacomo Grassi
Coordination by Giacomo Grassi

2016

Table of contents

Introduction

The general aim of the subtasks a ("Projections of FM") and b ("Projections of AR") of the AA is providing projections consistent with the IPCC methods, for each MS, from 2000 to 2030, including:

- Forest Management (FM) and natural disturbances.
- Harvested Wood products (HWP).
- Forest land use change, i.e., Afforestation/Reforestation (AR) and deforestation (D).
- A sensitivity analysis on harvest rate and on land use change.

To this aim, the Carbon Budget Model (CBM) developed by the Canadian Forest Service (Kurz et al., 2009) was used, as part of a broader effort for a comprehensive modelling framework for the forest sector. During the last years, the CBM was successfully adapted to specific forest management conditions in Europe (e.g. uneven-aged forests, Pilli et al., 2013), validated at regional and country level (Pilli et al., 2014a; Pilli et al., 2016a) and successfully applied to 26 MSs to estimate the C balance for FM (Pilli et al., 2016a) and AR (Pilli et al., 2014b and Pilli et al., 2016b).

In Annex 2b we include all the country-specific results of the analyses of the forest C sink and of the HWP mitigation potential.

Austria

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		3,192	3,158	3,147	3,143	3,826[FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	9.7	14.6	7.2	9.0	2.3	7.2
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		2.5	1.7	0.6	0.4	1.7

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM,

only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

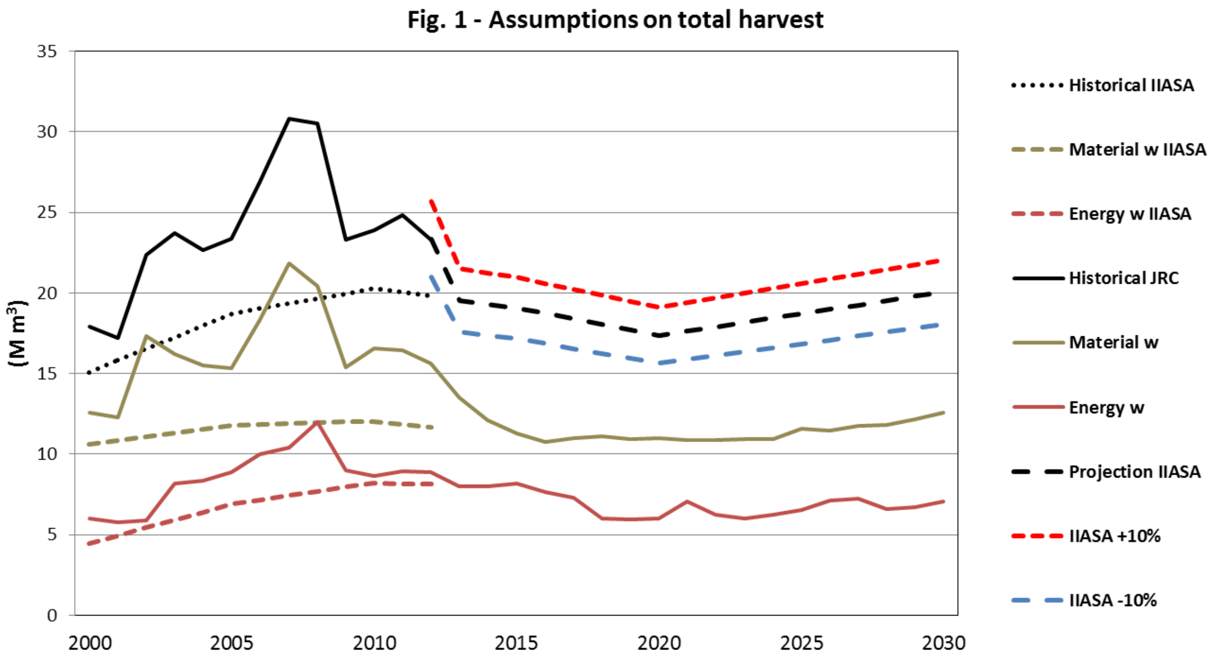
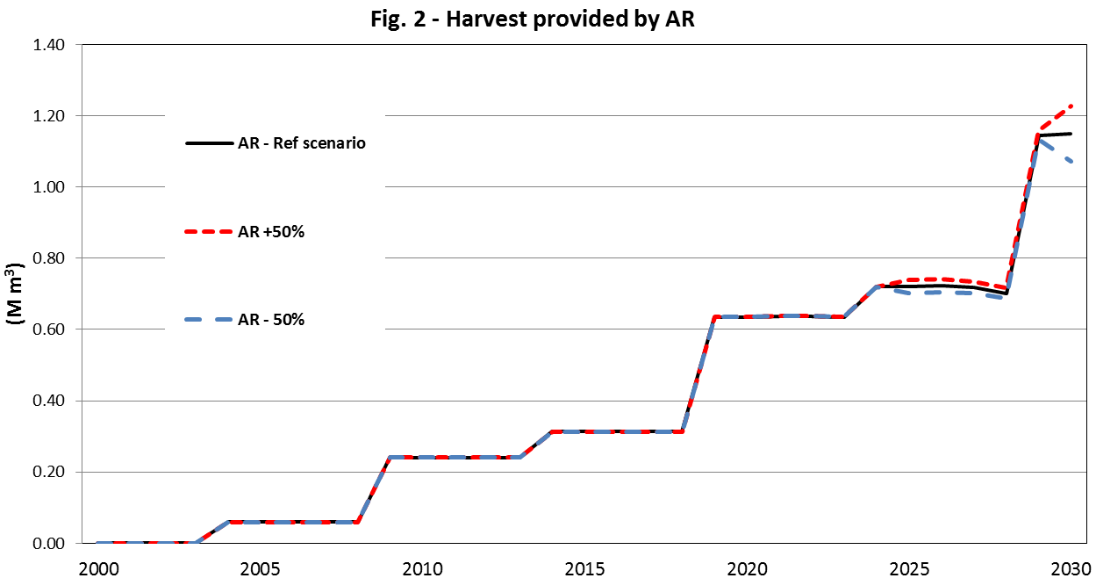


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

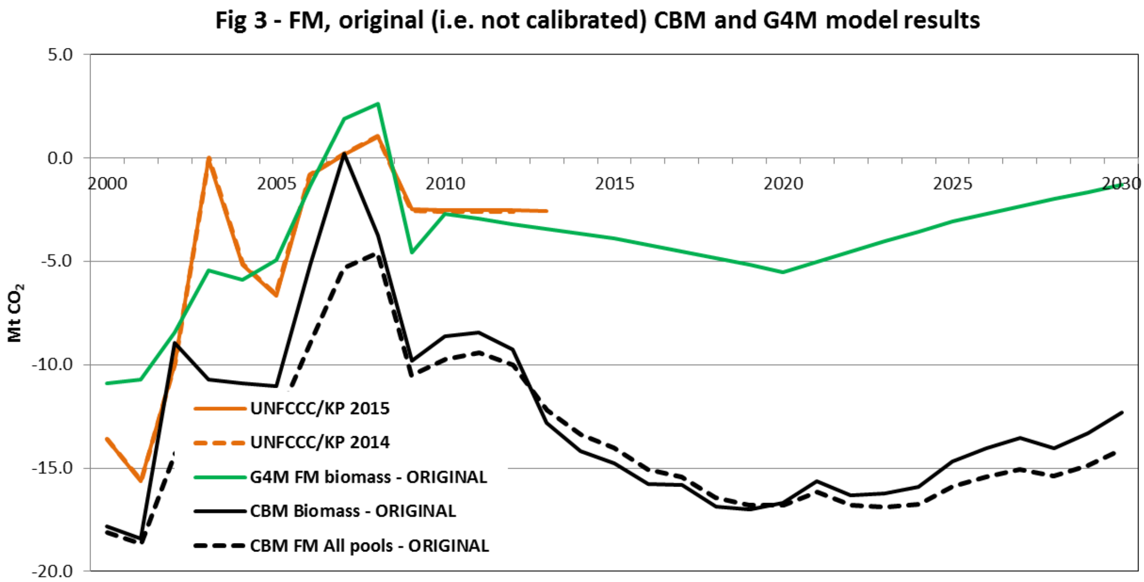
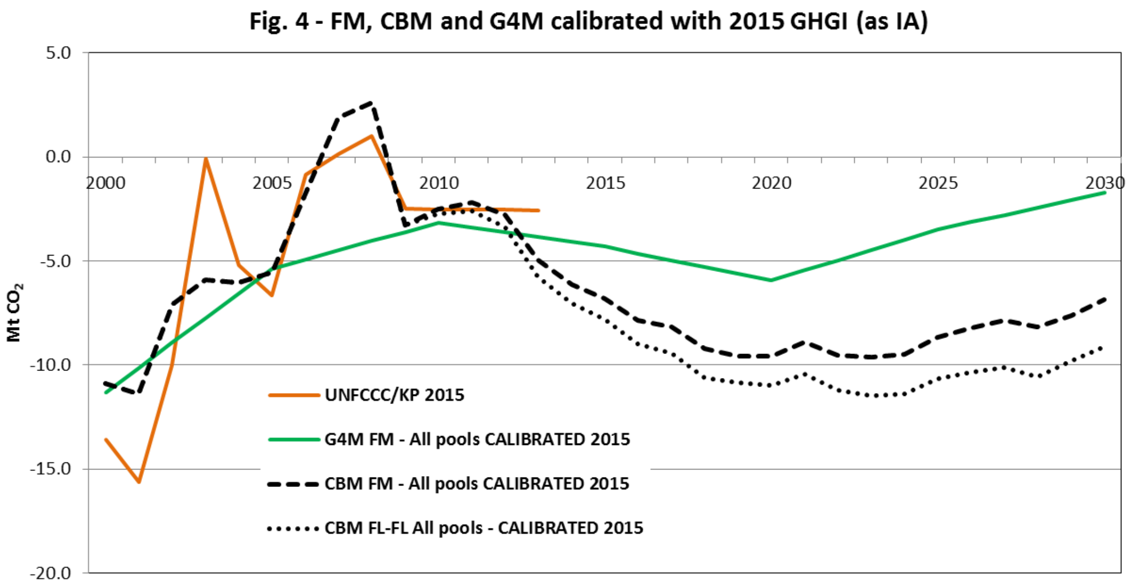


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[142] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



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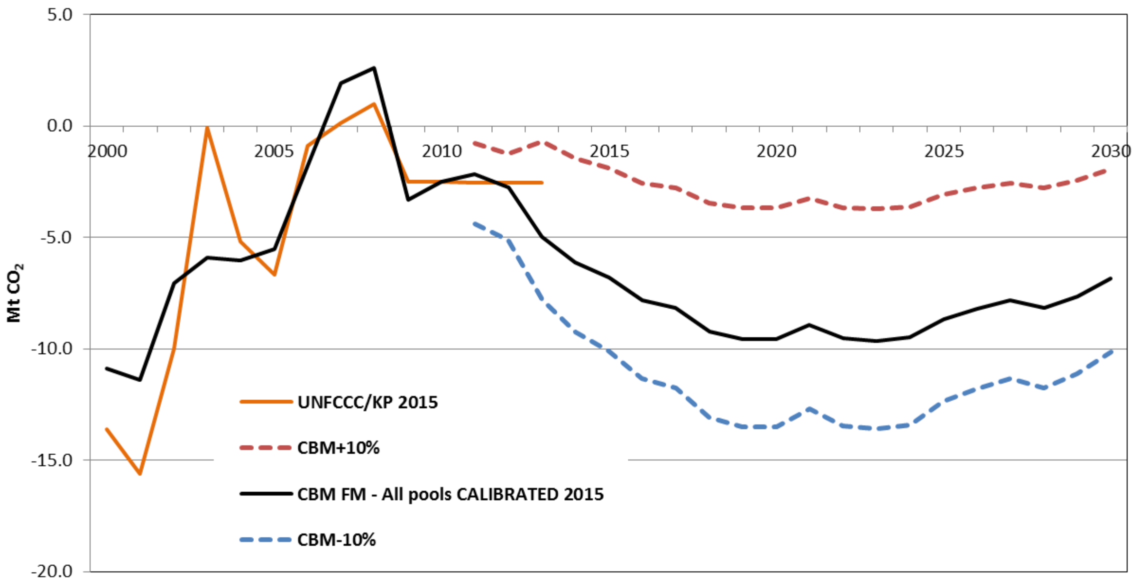
[142] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the <u>preliminary results</u> on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.

Fig. 5 FM, CBM (calibrated GHGI 2015) + / - 10% harvest



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

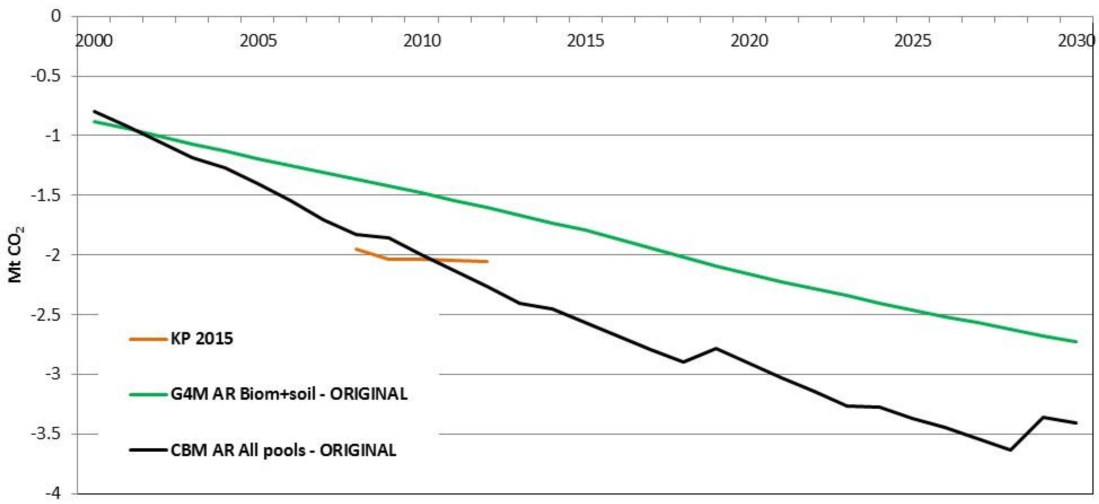
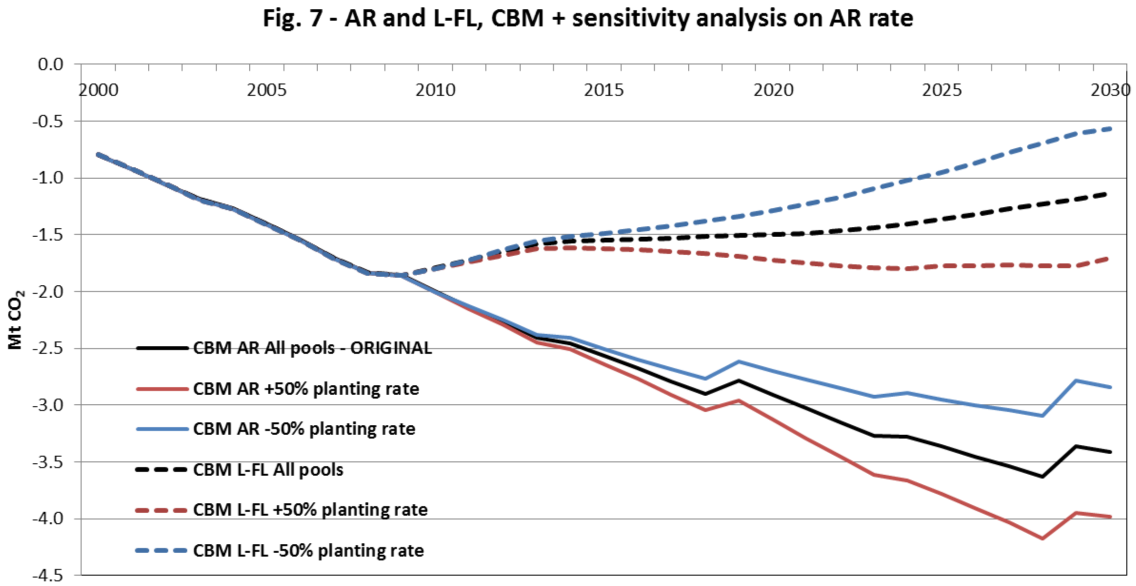


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

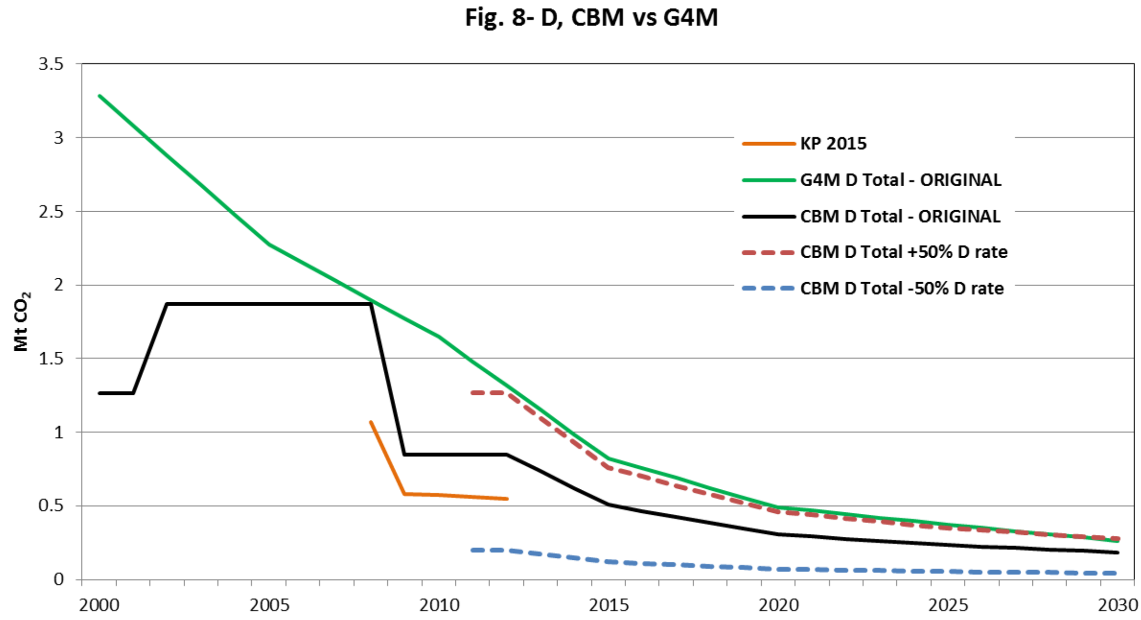
(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.



Deforestation

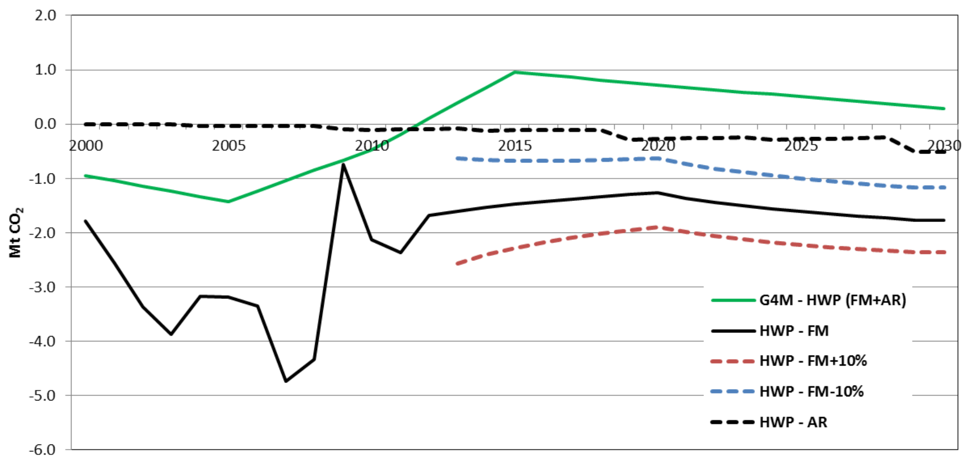
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[143]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

Fig. 9-HWP, CBM vs G4M

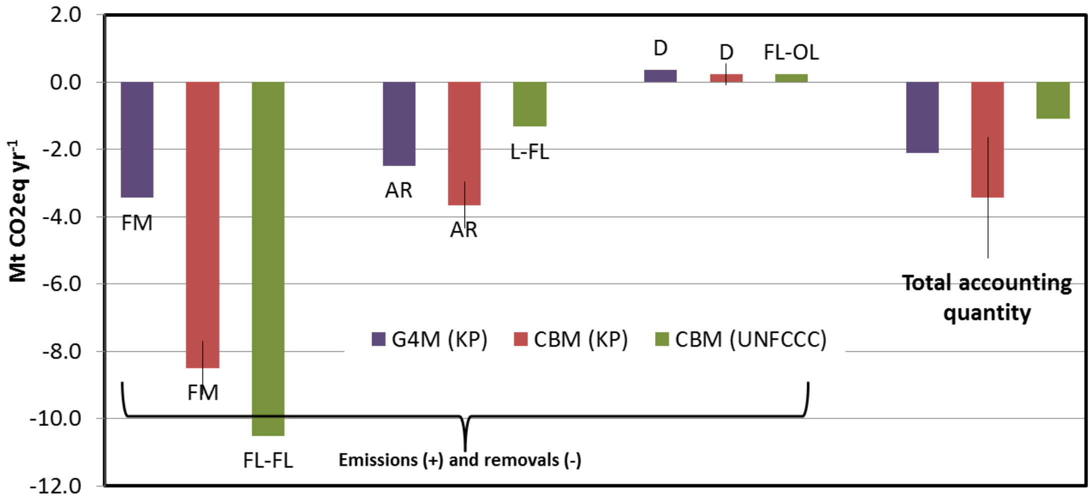


Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[144]; +/- 50% planting rate for AR; D/-50% D rate).

[143] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[144] Based on preliminary results.

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical harvest rate considered by G4M is considerably lower than the harvest rate applied by CBM. On the contrary, the FM area considered by CBM is 14% lower than the area considered by G4M.
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA.

Belgium

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		697	685	676	673	691[FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	1.1	1.2	2.0	1.2	1.6	1.1
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		1.0	1.8	0.4	0.2	0.9

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

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if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

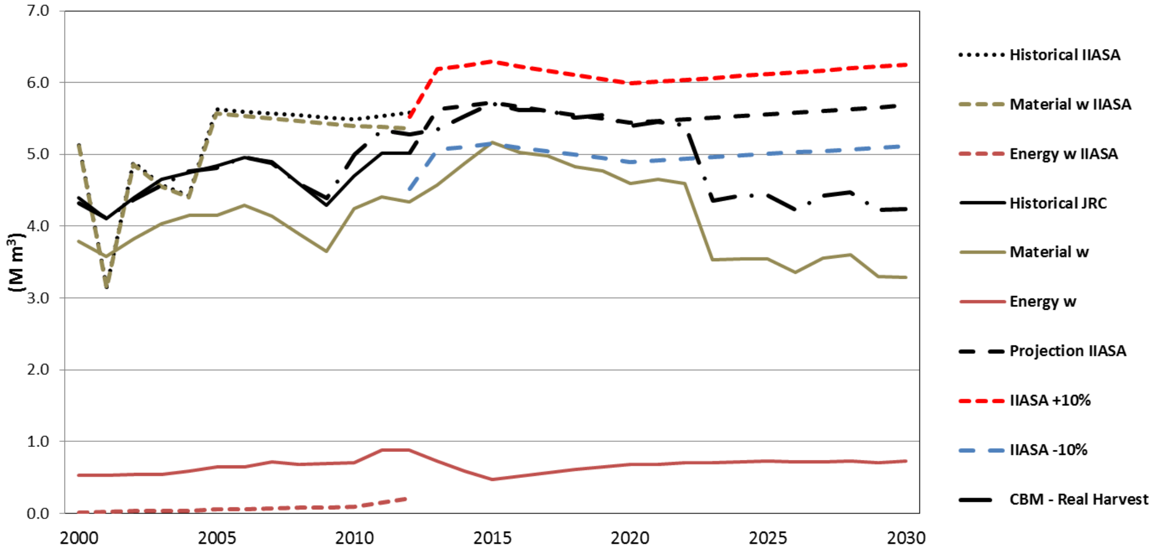
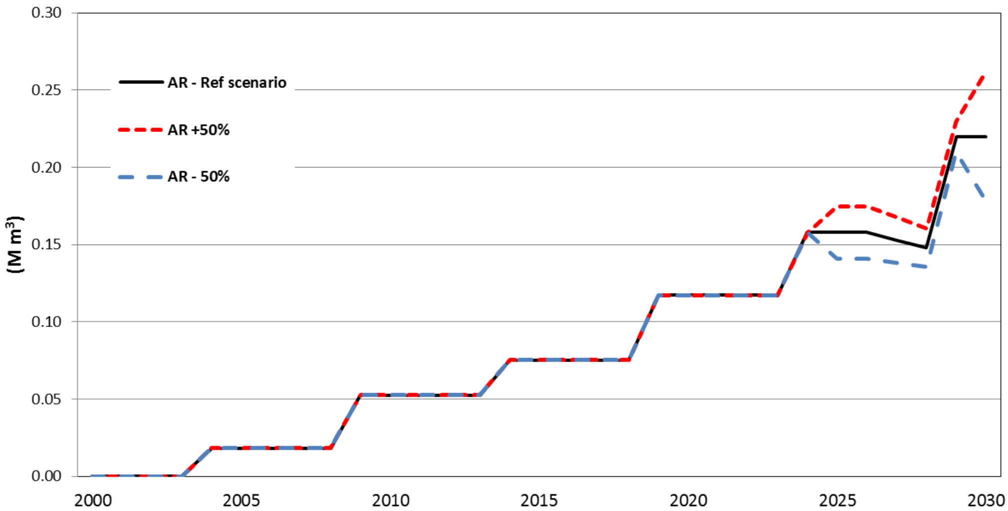


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

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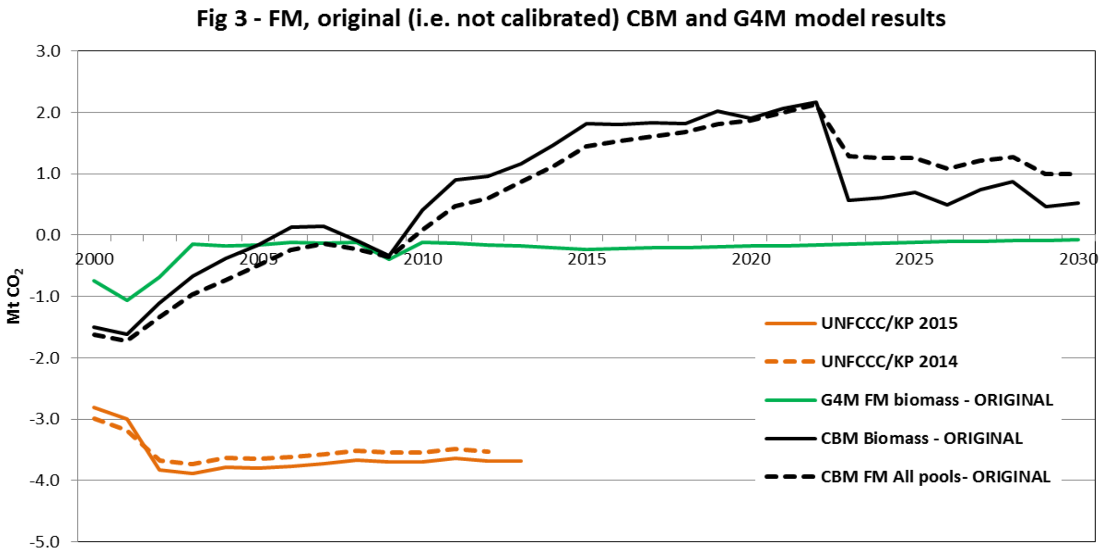

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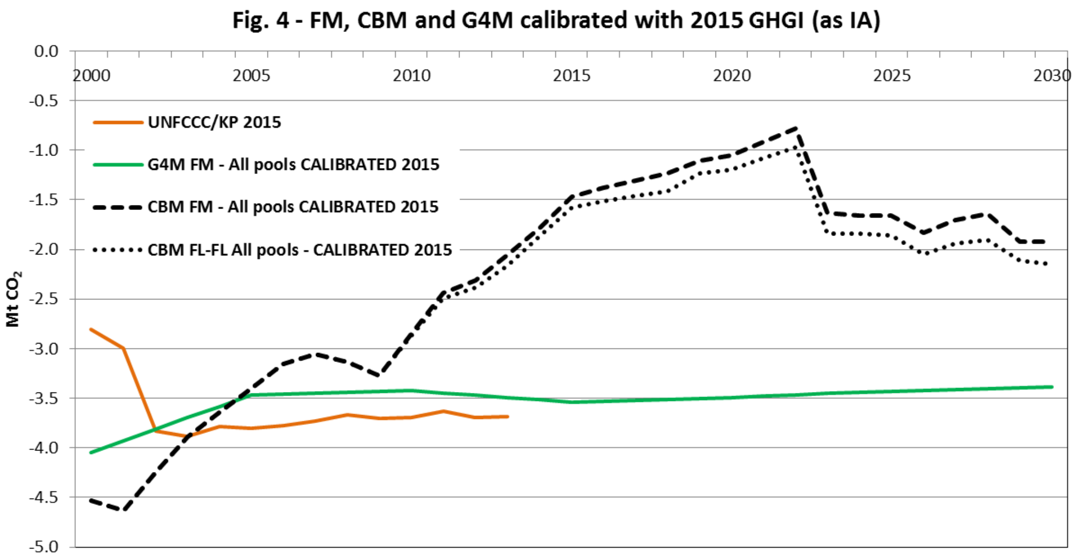

145 Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

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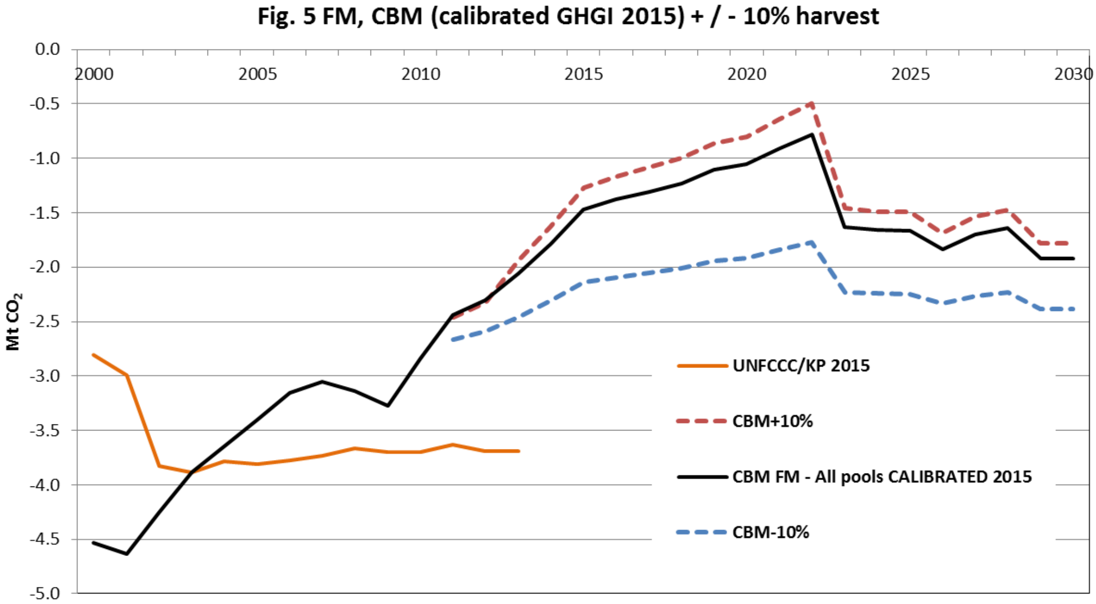

Afforestation/Reforestation

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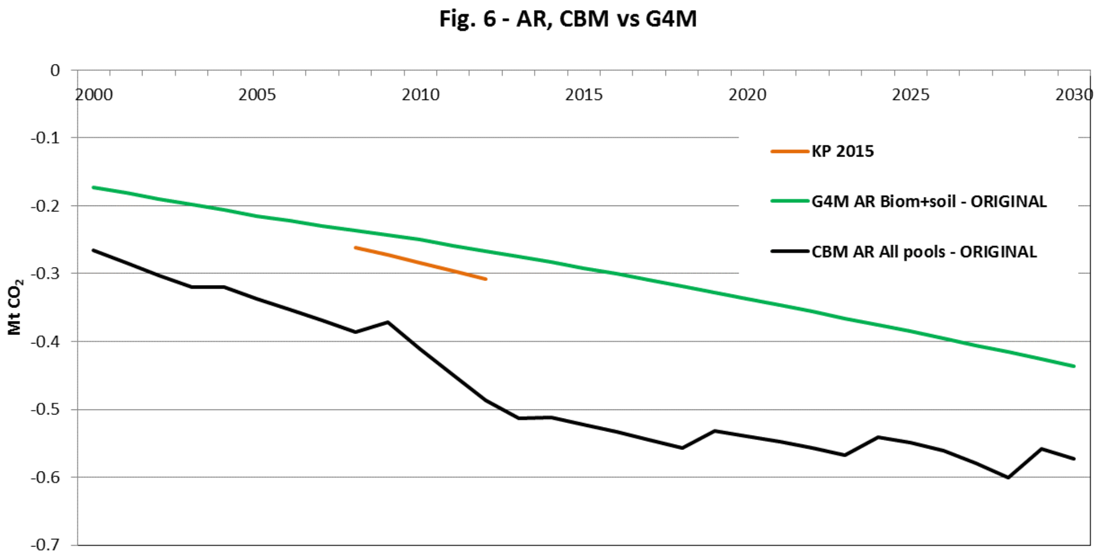

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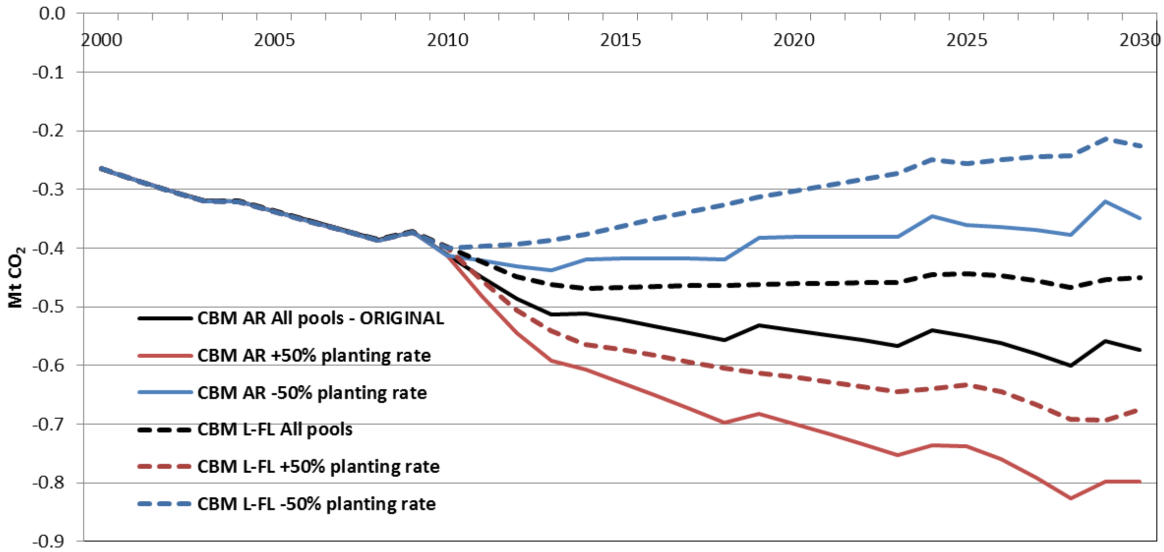
(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

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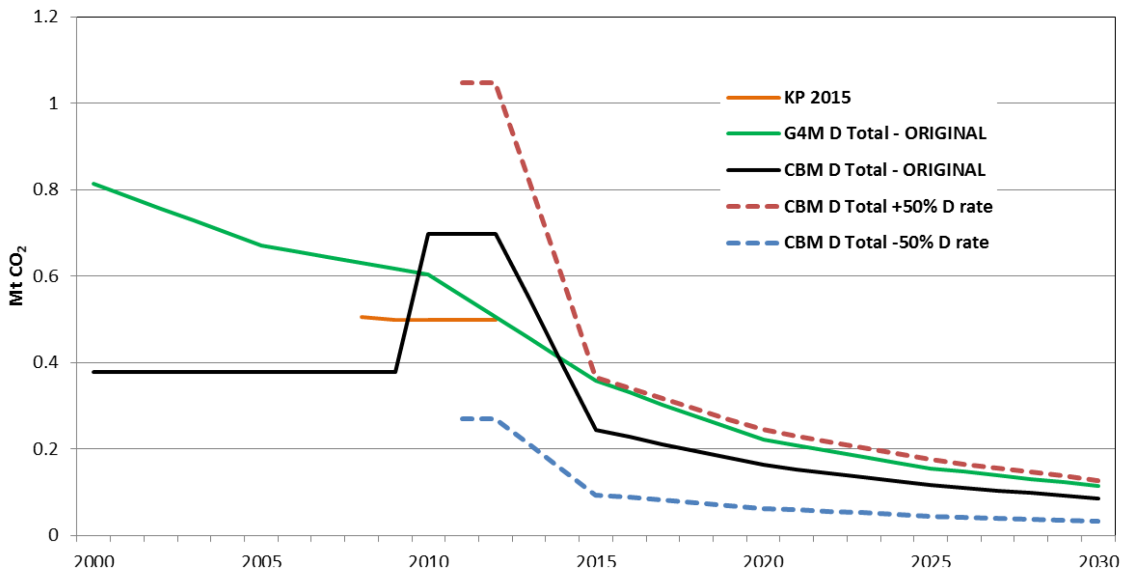
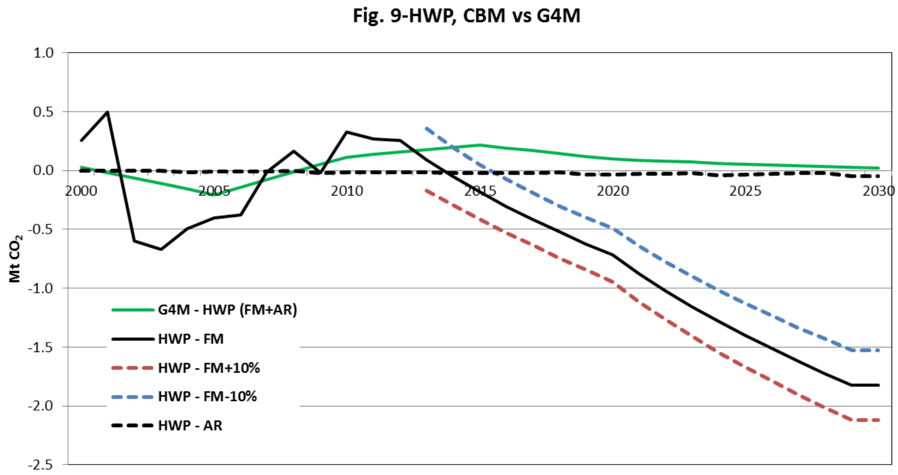


Harvested Wood Products (HWP)

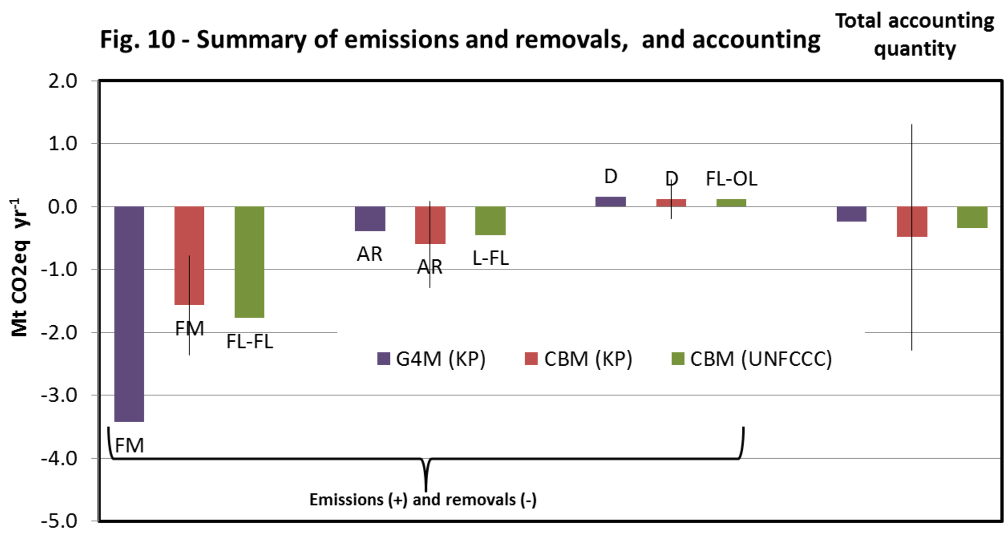
Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[146]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.



Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[147]; +/- 50% planting rate for AR; D/-50% D rate).

[146] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[147] Based on preliminary results.



Comments on CBM run and model assumptions:

- According to CBM, the future harvest demand expected by IIAS cannot be satisfied after 2023.
- From 2023 on, the harvest provided by CBM decreases because of the overexploitation during the previous period. In 2030 the final harvest provided by CBM is 2% lower than 2005. The harvest expected by IIASA in 2030 is +40%, compared to 2005. The amount of removals per ha expected by IIASA (on average equal to 8.8 m^3 ha^{-1} yr^{-1} from 2012 to 2030), seems considerably higher (and not sustainable in the medium term) than the historical Net Annual Increment reported by Belgium, equal on average to 6.9 m^3 ha^{-1} yr^{-1} from 2000 to 2010[148].
- The total C stock change estimated by CBM shows a step in 2024 due to the effect of the decreasing harvest rate applied by model.
- The historical C stock change estimated for HWP is based on the data reported by FAOSTAT and it may deviate from the data considered by IIASA. Moreover, the increasing HWP C sink estimated after 2012, is based on the assumption of an increasing material wood amount that, according to CBM, cannot be supplied after 2023.
- Because the harvest demand cannot be satisfied (even assuming a -10% harvest scenario) the results provided by the sensitivity analysis are not significant.

[148] State of Europe's Forest, 2015.

Bulgaria

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		3,632	3,630	3,628	3,627	3,631[FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	7.1	11.3	12.5	13.1	10.6	12.5
Deforest. (D)	Area of forest conversion to other land since 1990			0.1	0.3	0.2	0.1	0.3

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

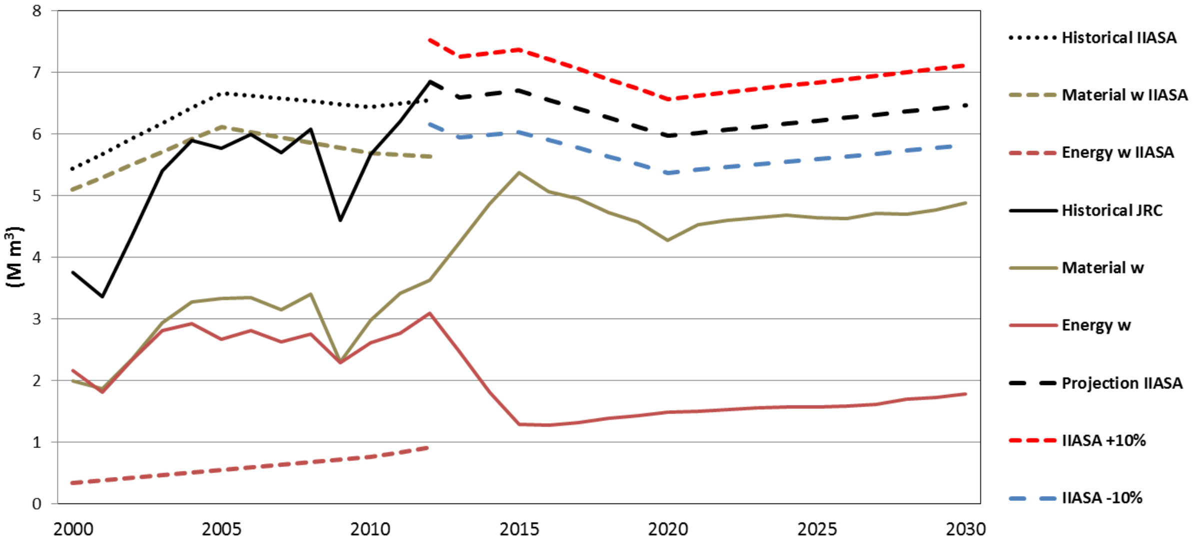
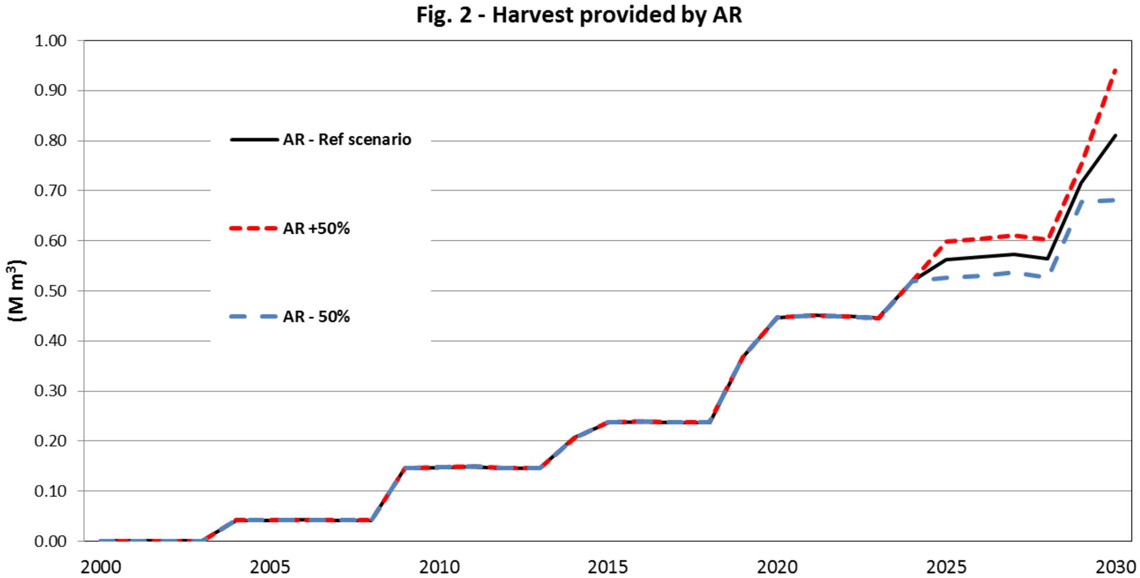


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

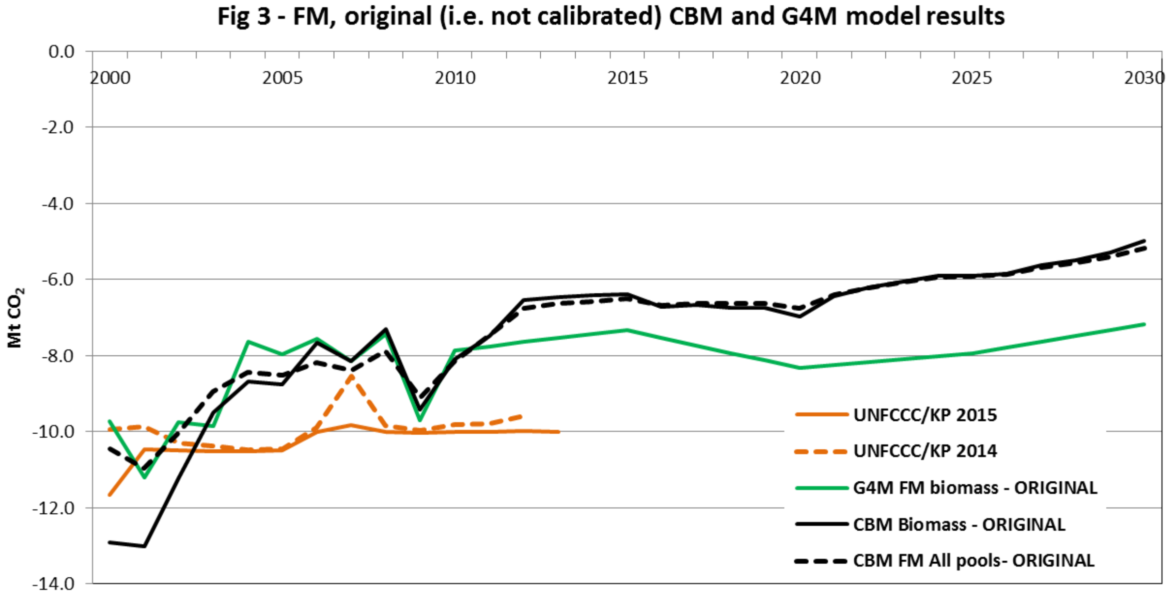


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[149] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

[149] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

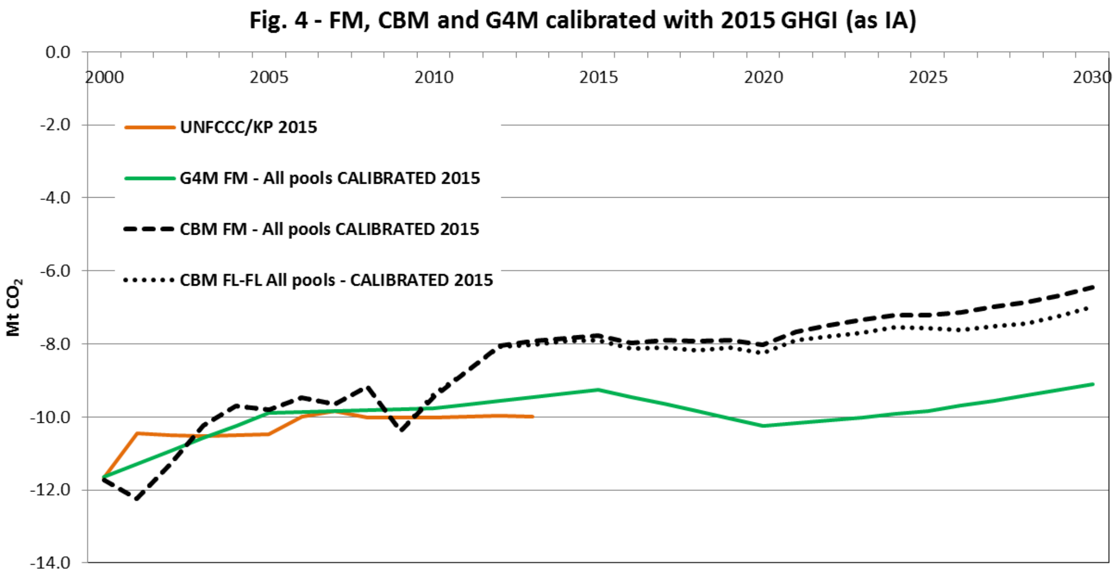
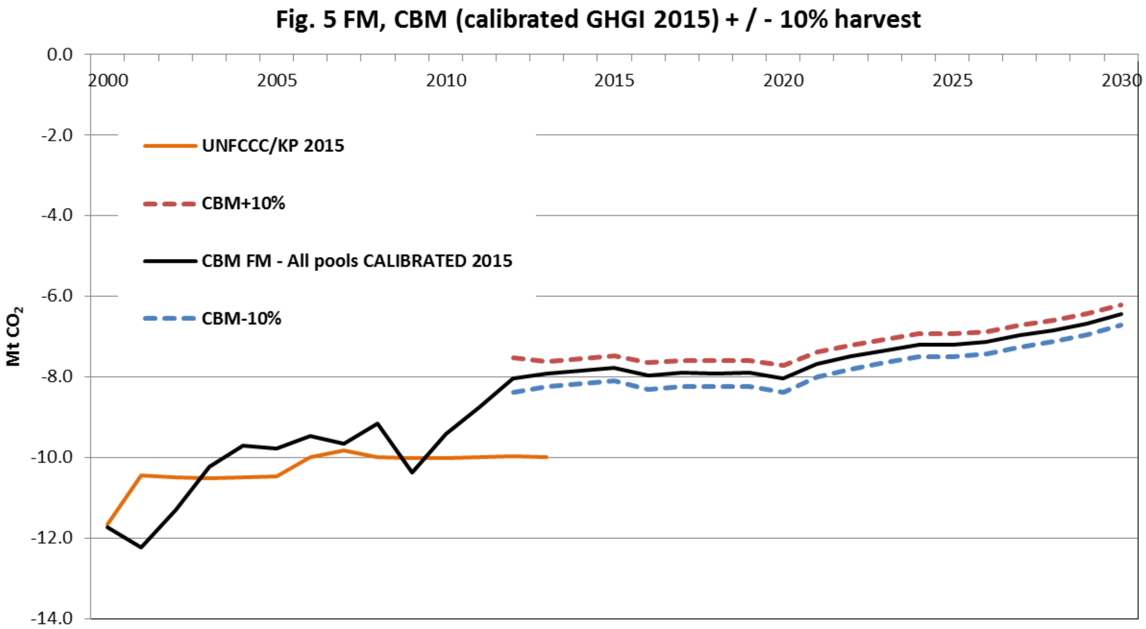


Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

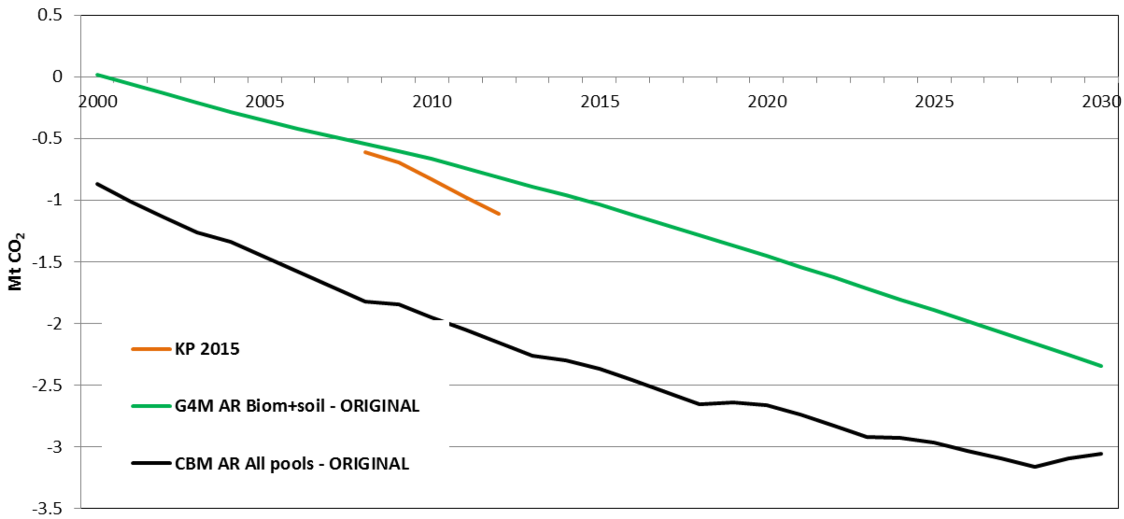
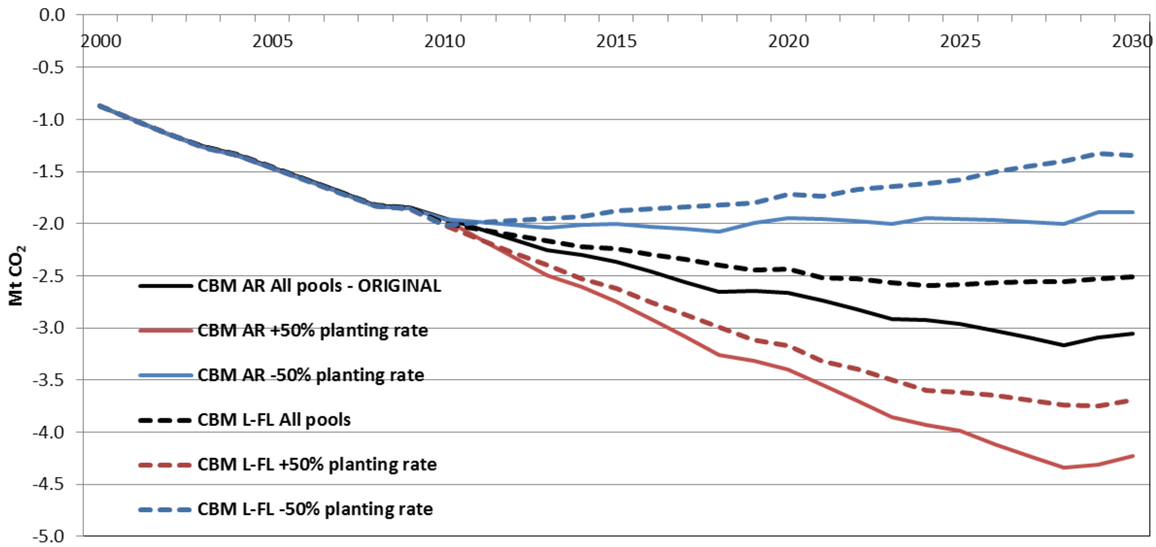


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

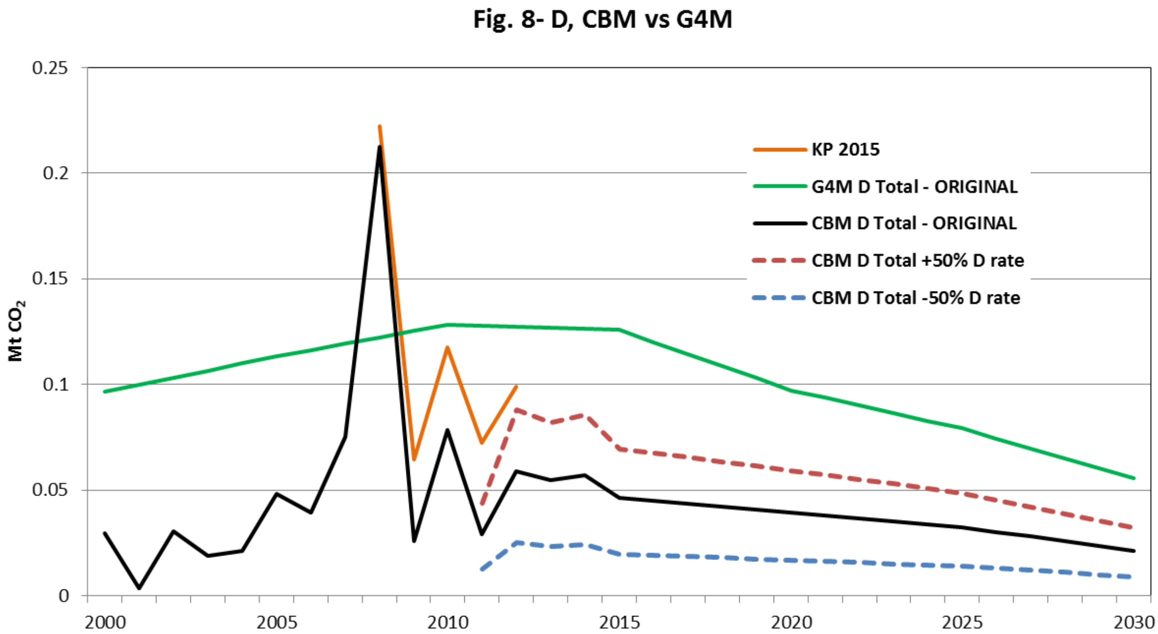
(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



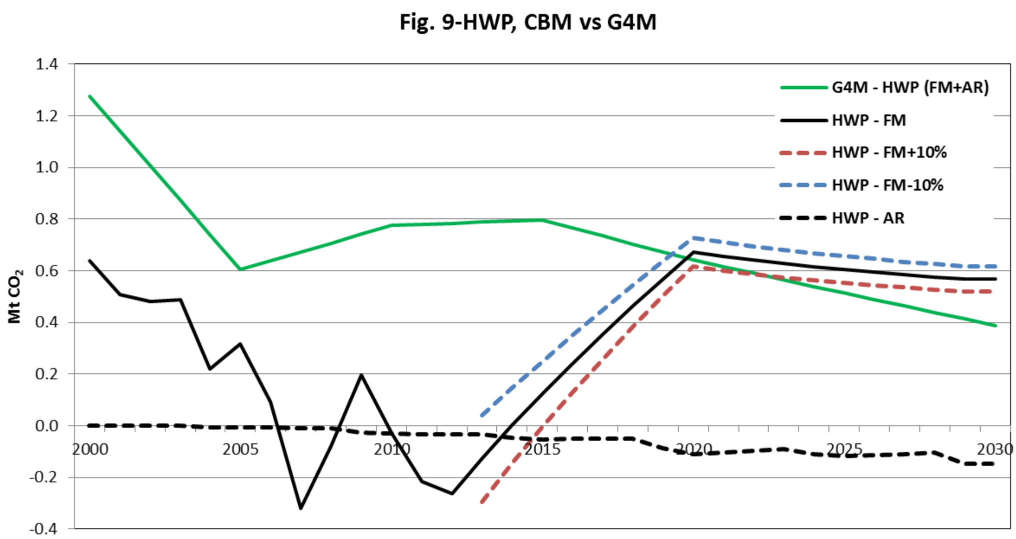
Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[150]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

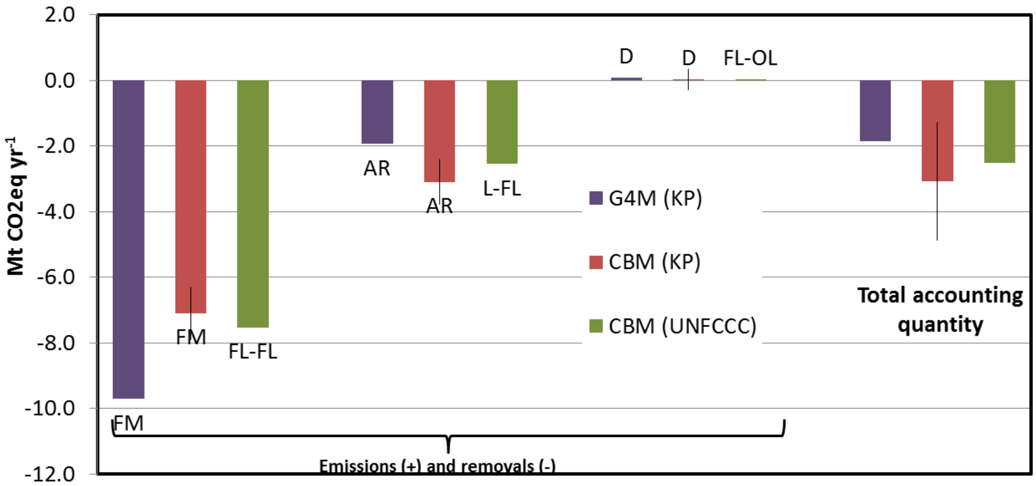


[150] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[151]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical harvest rate considered by G4M is considerably different (both in the trend and in the level) from the harvest rate applied by CBM and this may explain the different C sink estimated by the two models, above all from 2000 to 2005 (see Fig. 3).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT. Because these are quite different from the data considered by IIASA, the HWP C sink estimated by the two models has a different trend, above all before 2020.

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[151] Based on preliminary results.

Czech Republic

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		2,565	2,559	2,555	2,554	2,562[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	1.3	2.7	2.7	2.5	2.4	2.7
Deforest. (D)	Area of forest conversion to other land since 1990			0.7	0.6	0.3	0.1	0.6

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA).**
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**).**
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported

if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

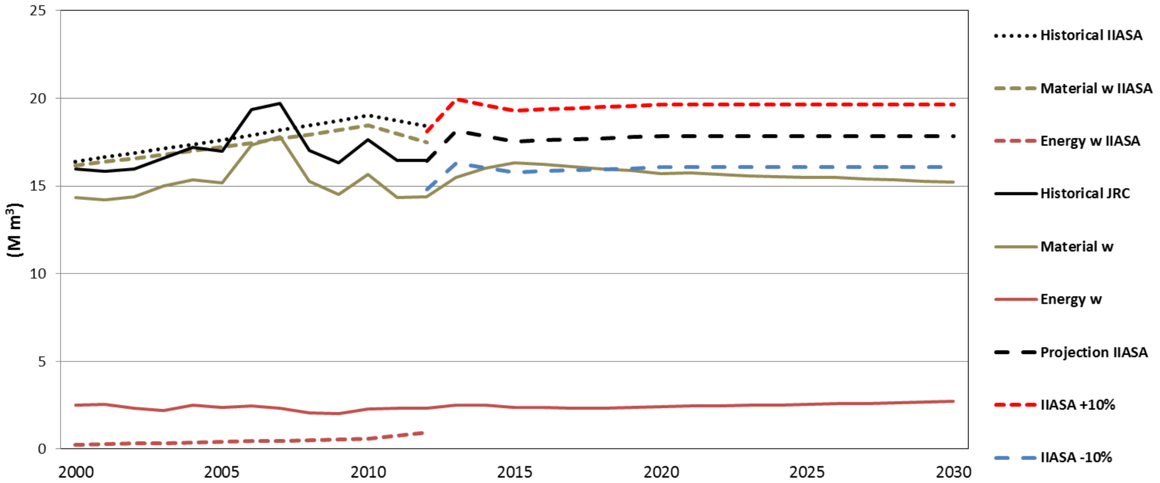
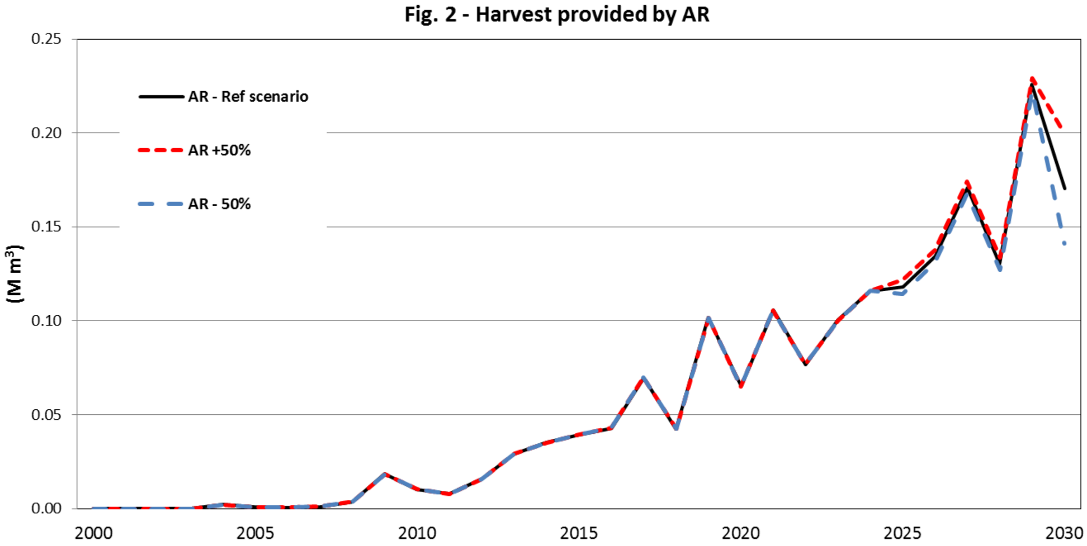


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

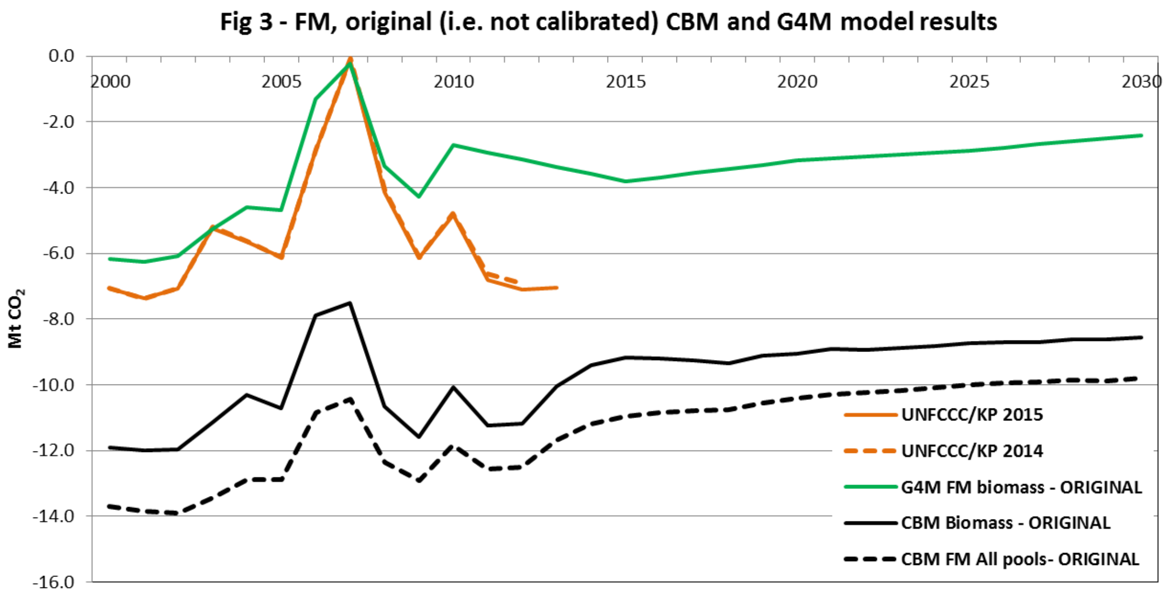
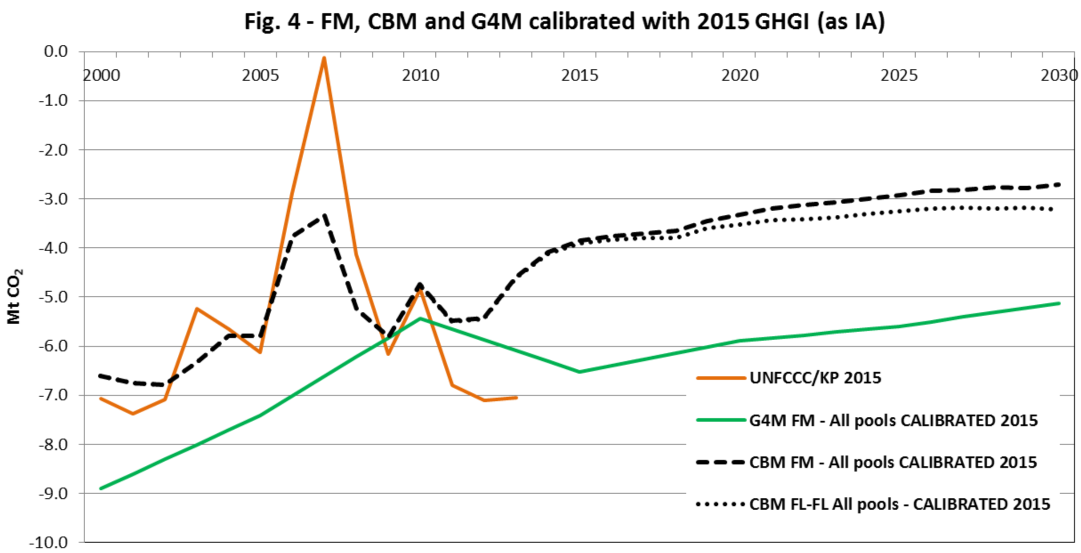
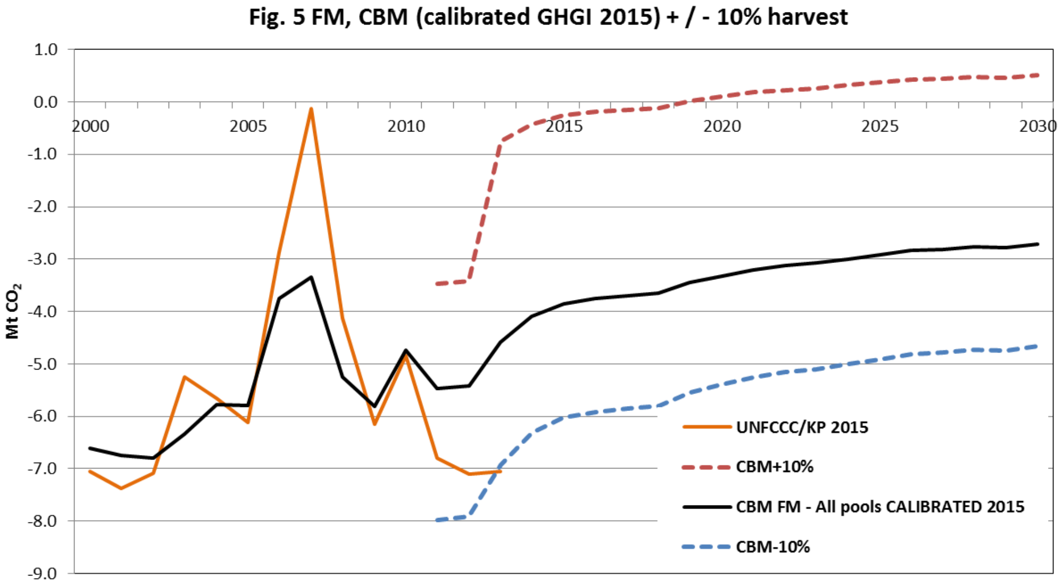


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[152] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



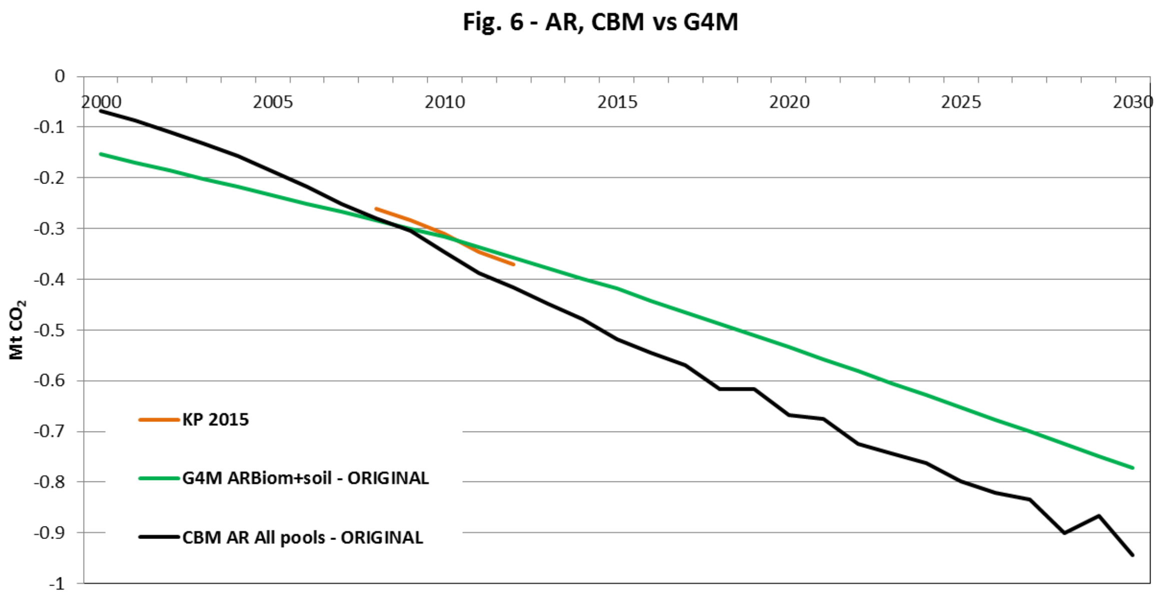
[152] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.



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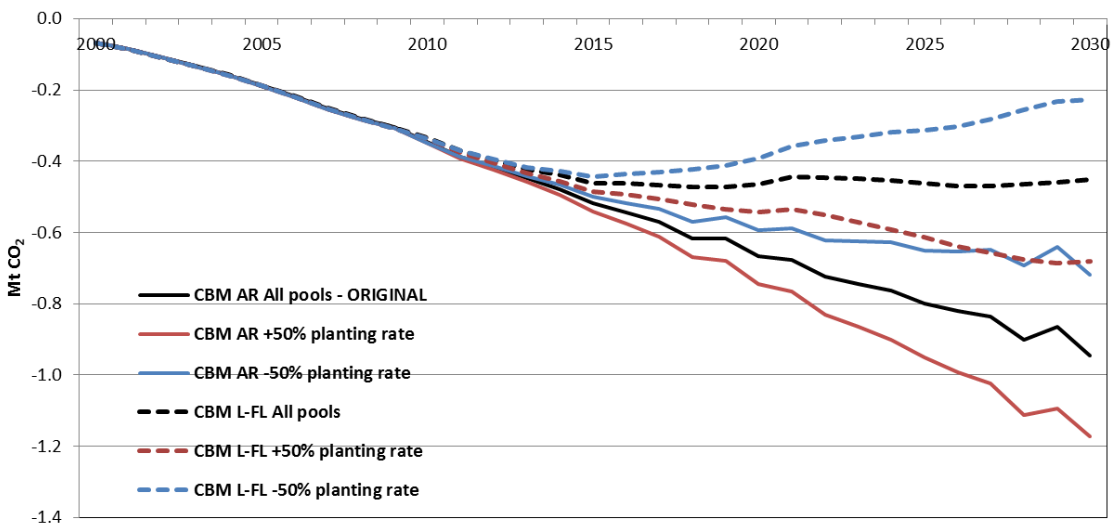
(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

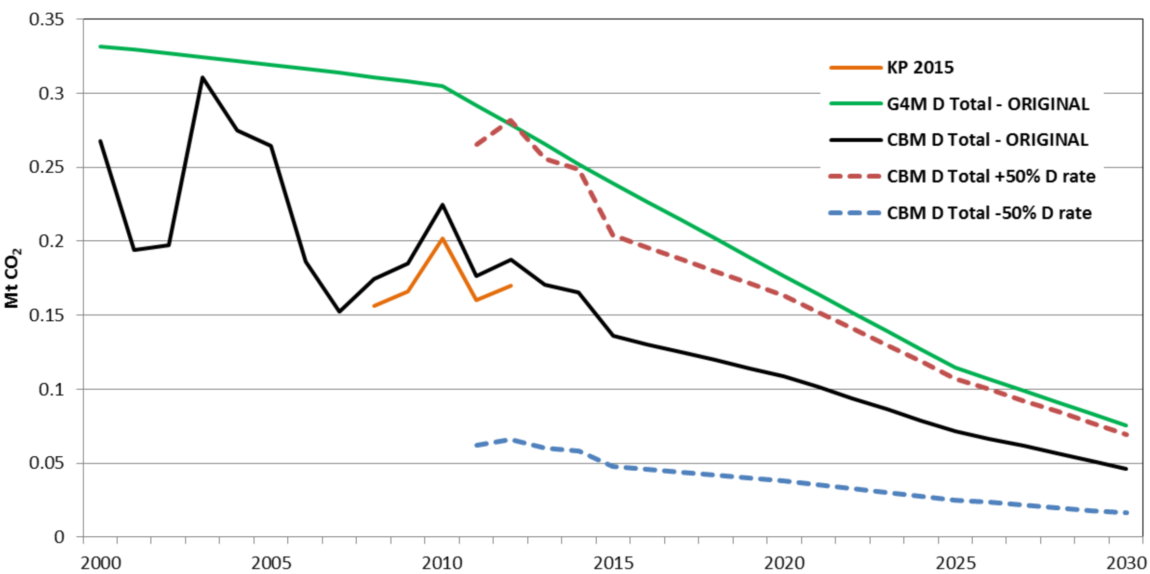
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

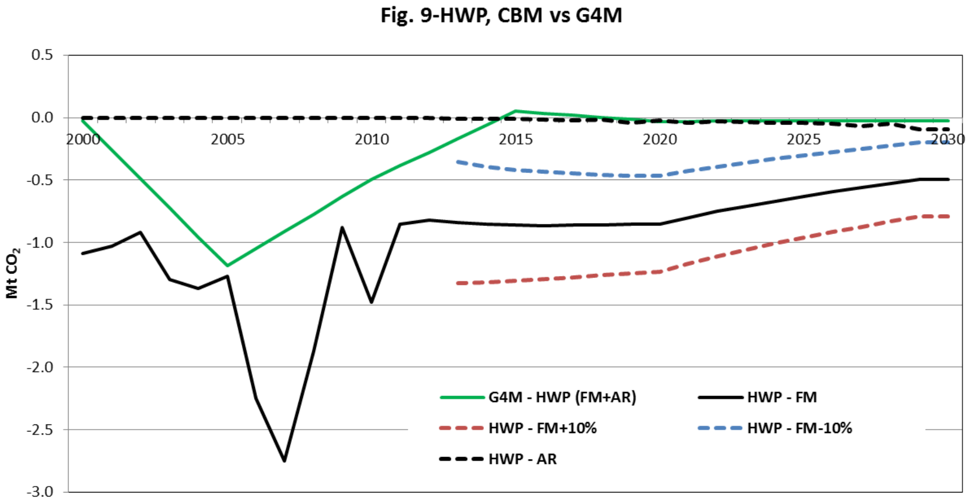
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[153]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.



Summary of emissions/removals and accounting

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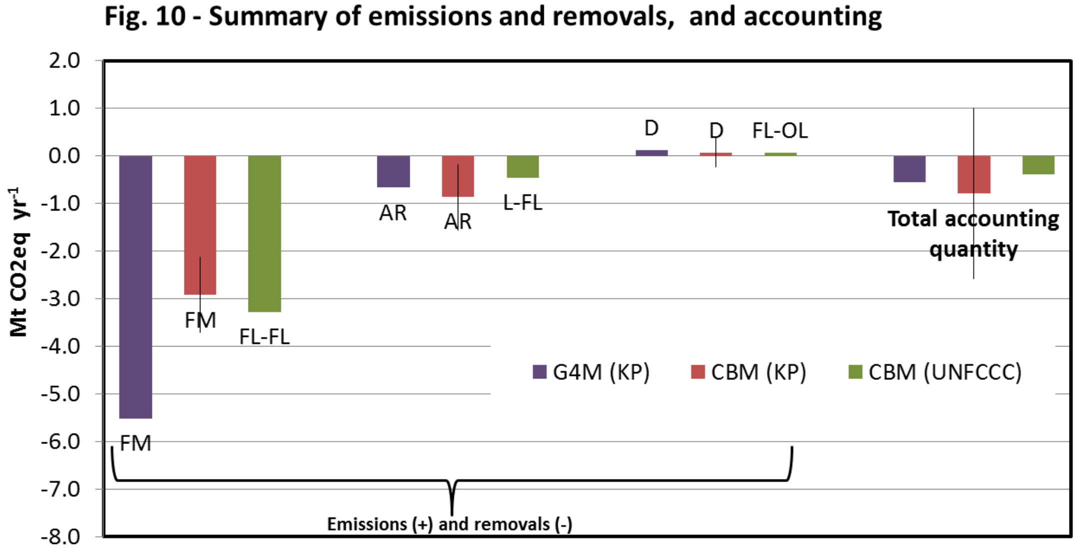
[153] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[154] Based on preliminary results.



Comments on CBM run and model assumptions:

- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA.

Germany

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		10,754	10,630	10,570	10,547	10,780[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	22.0	22.0	10.5	17.4	15.2	14.1
Deforest. (D)	Area of forest conversion to other land since 1990			11.4	9.4	3.5	1.5	11.0

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

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HARVEST - Assumptions

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- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

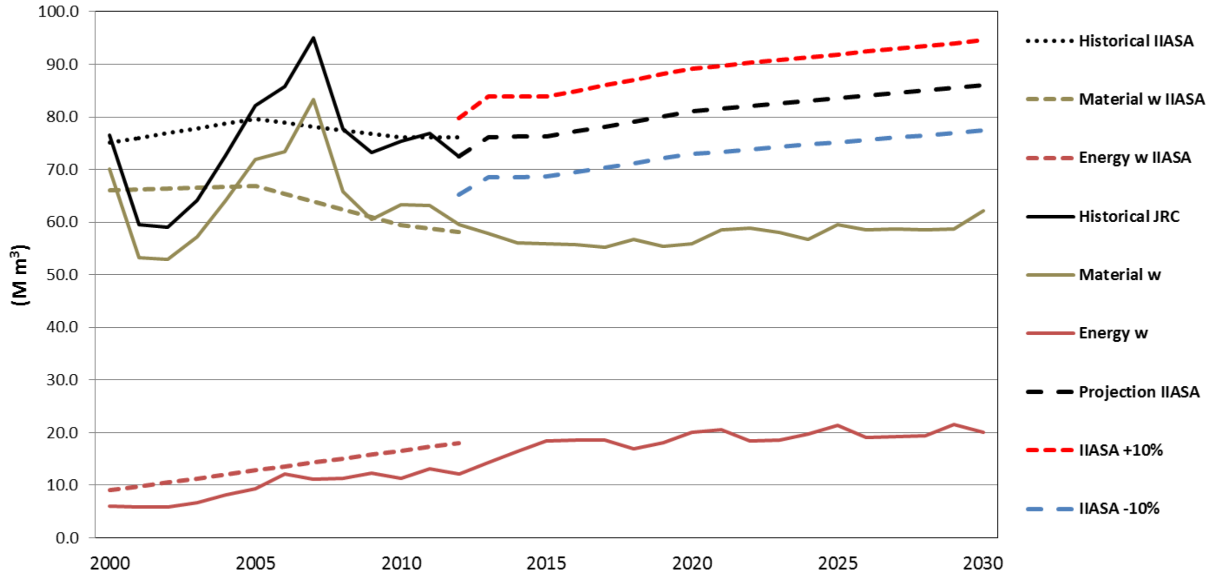
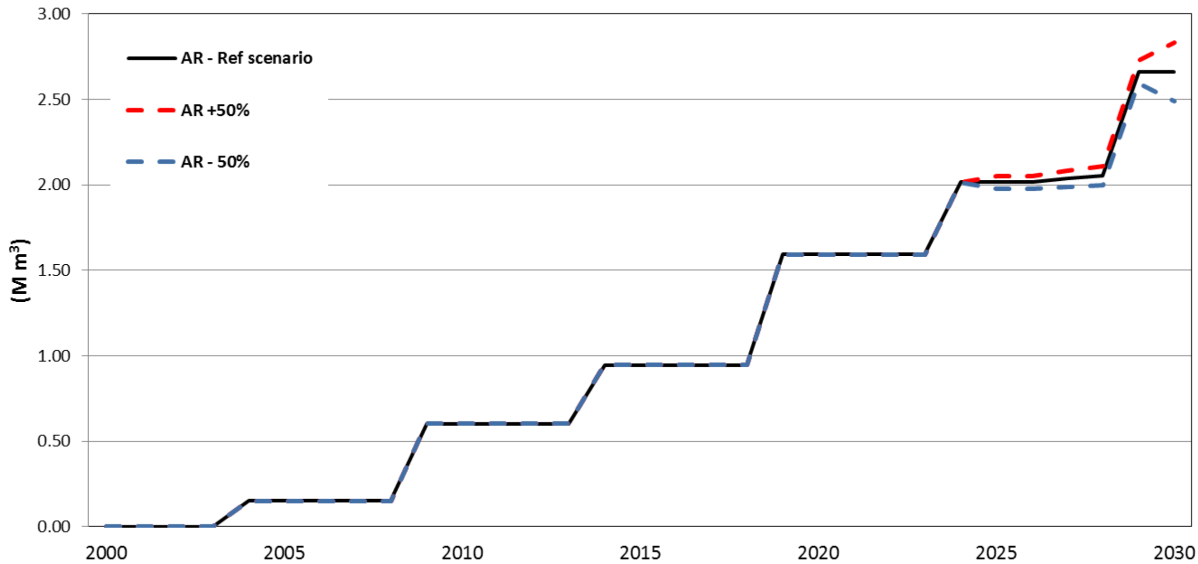


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

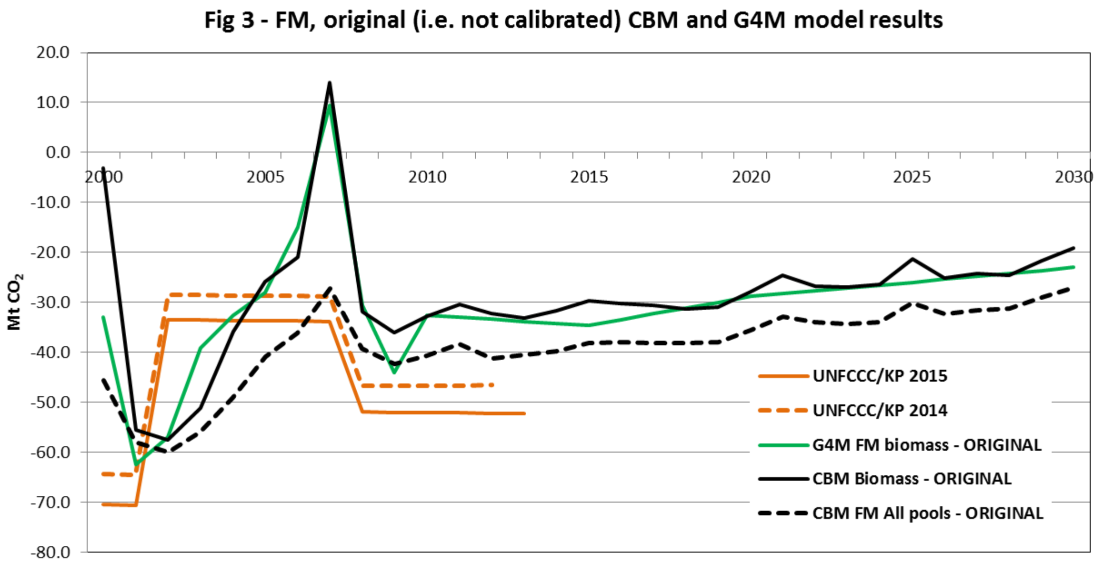
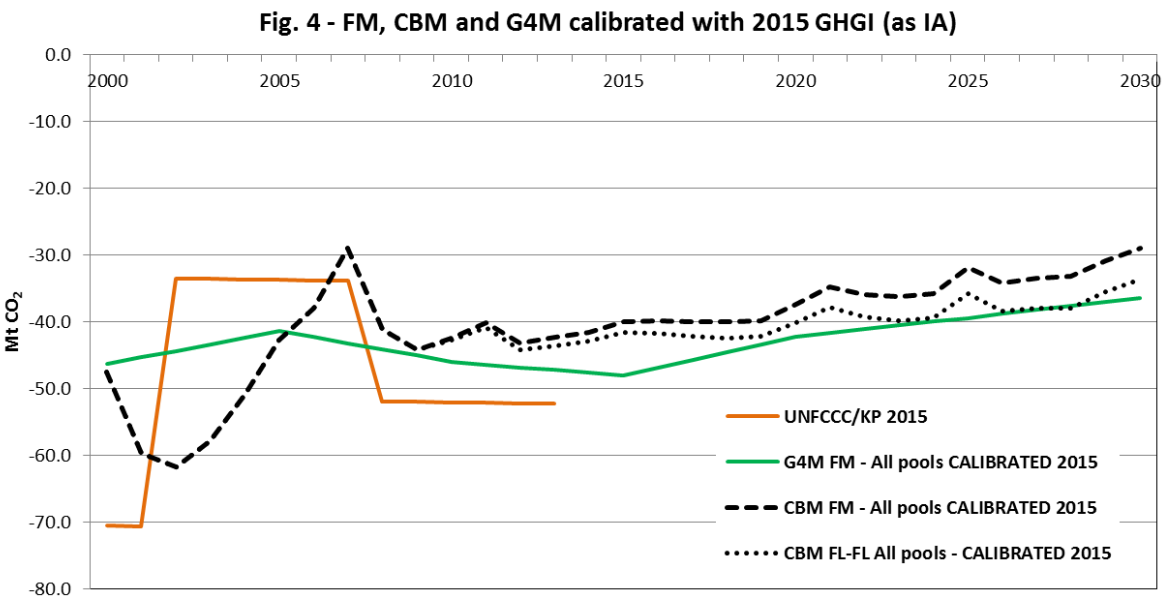
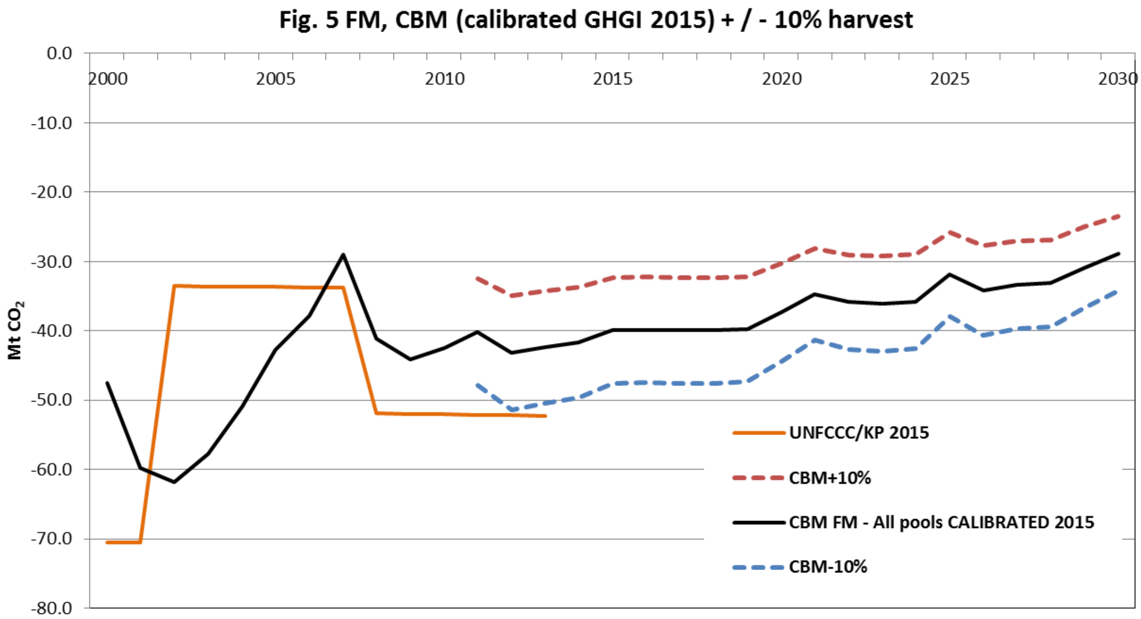


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[155] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



155 Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

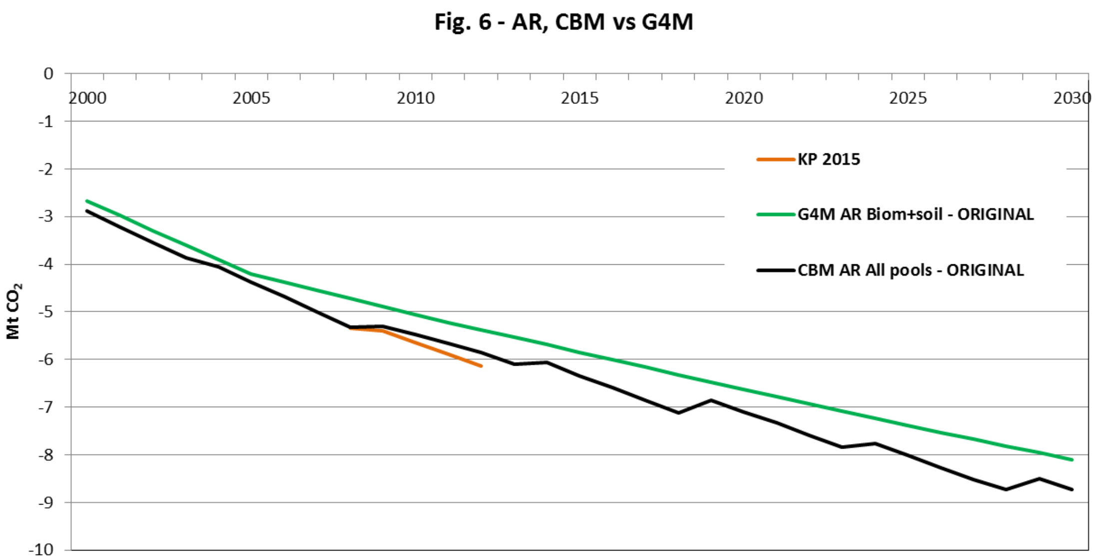
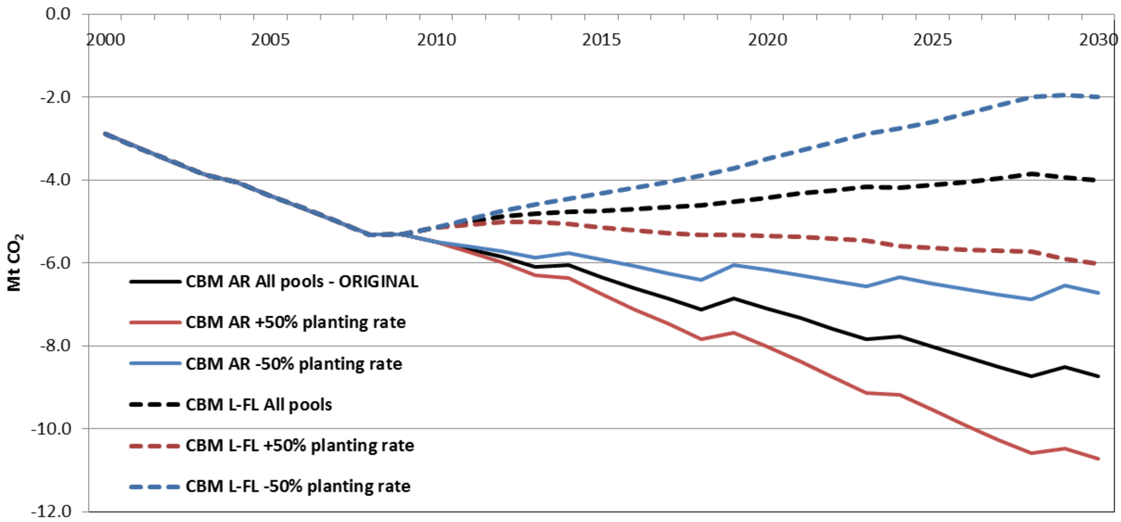


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

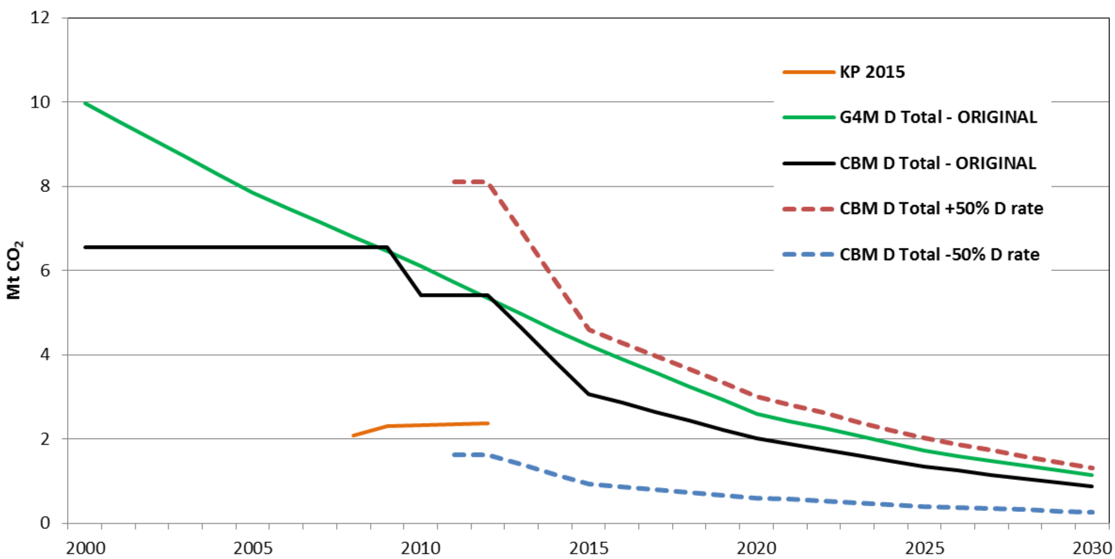
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

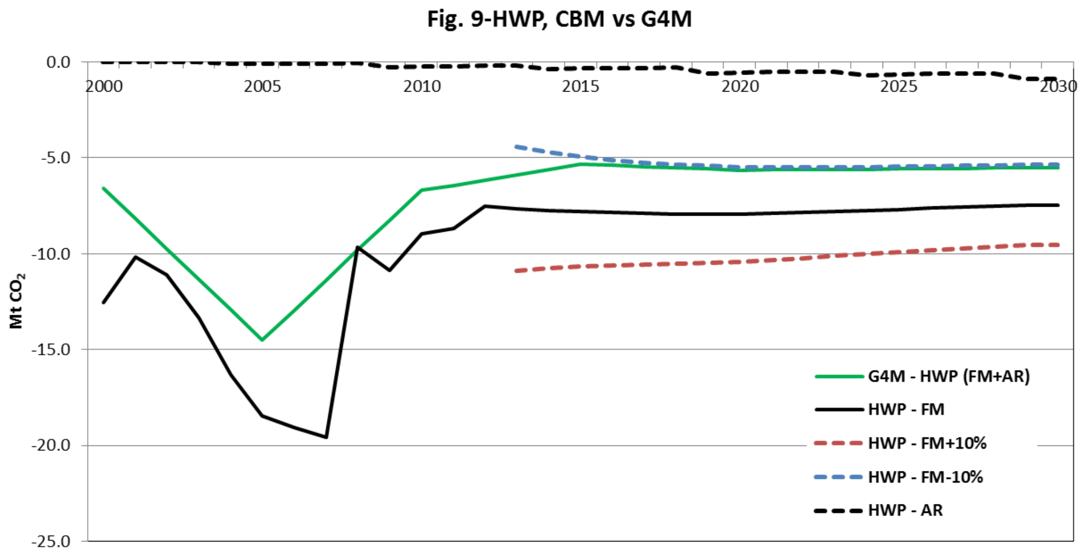
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[156]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

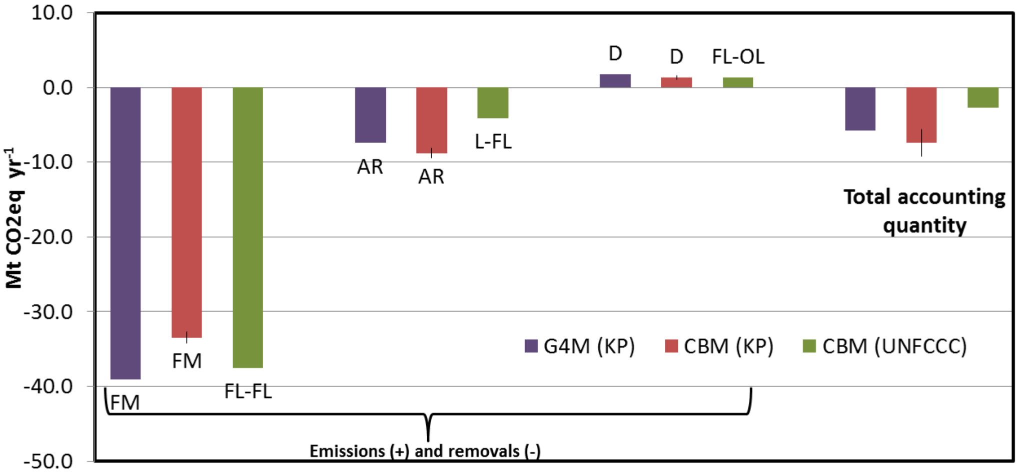


[156] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[157]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[157] Based on preliminary results.

Denmark

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		539	535	532	528	539[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	4.2	4.1	4.3	6.1	5.4	4.2
Deforest. (D)	Area of forest conversion to other land since 1990			0.1	0.5	0.3	0.3	0.5

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.
[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

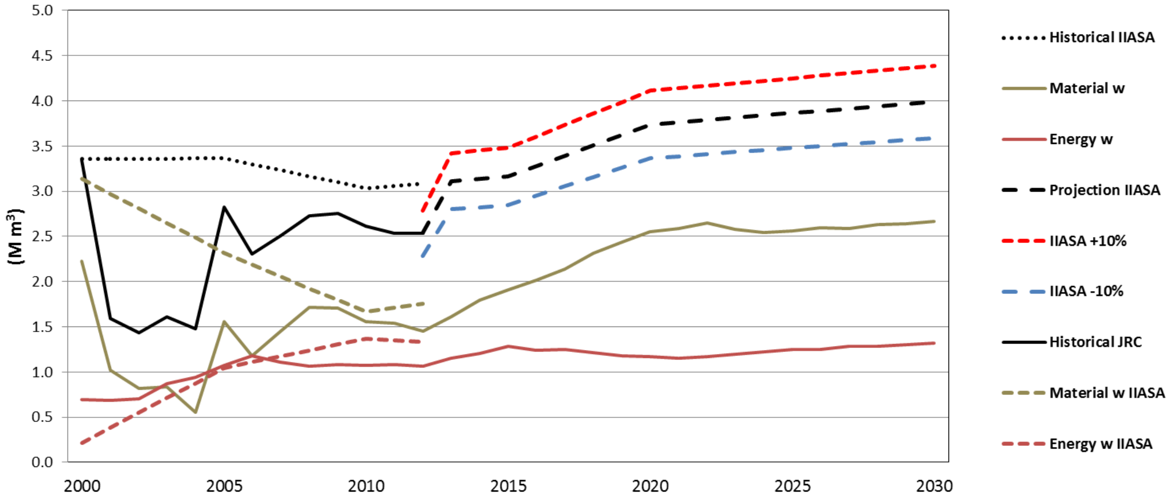
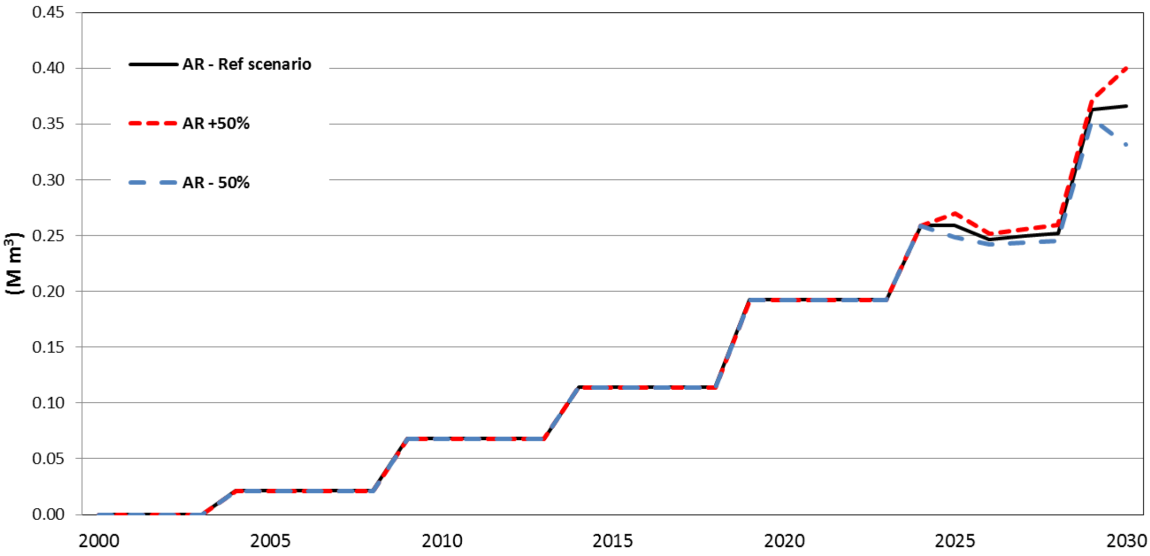


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

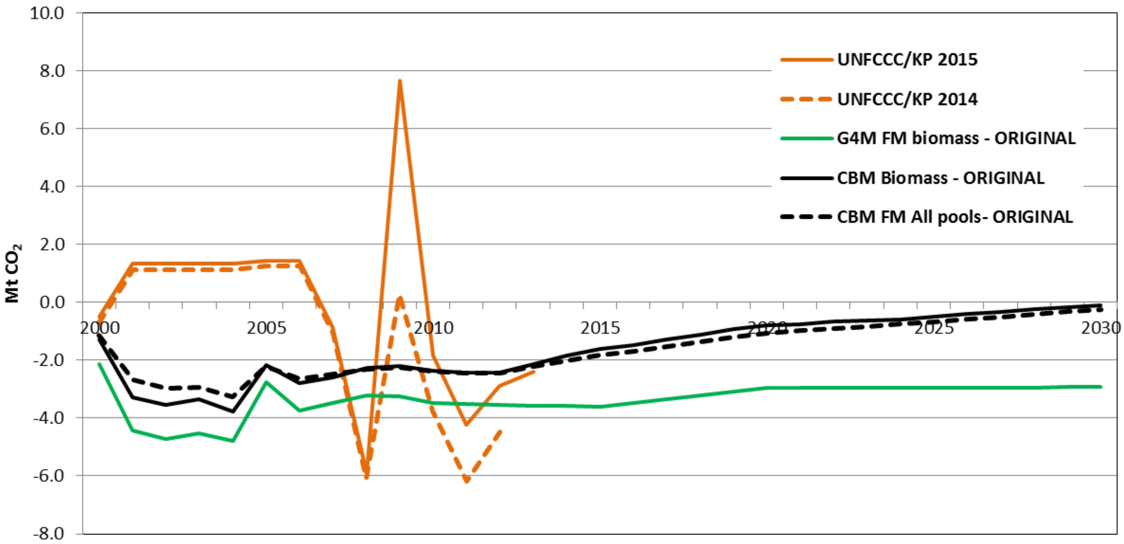
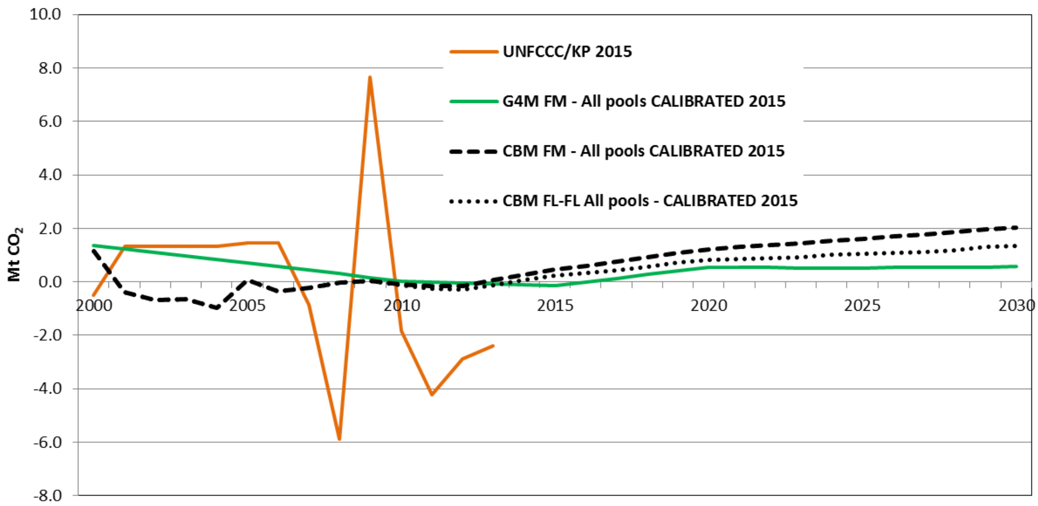


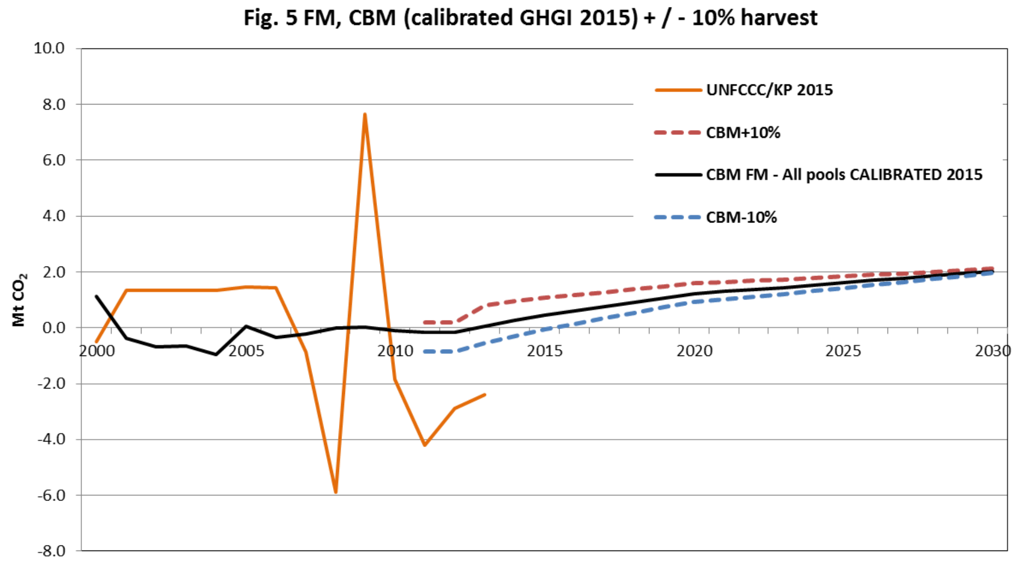
Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[158] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)



[158] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

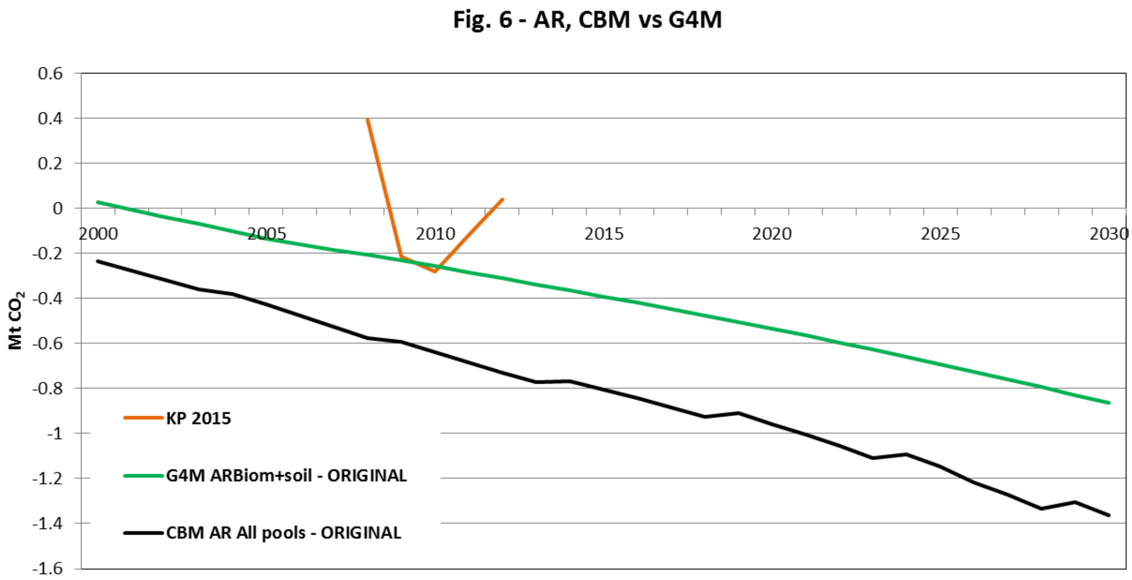
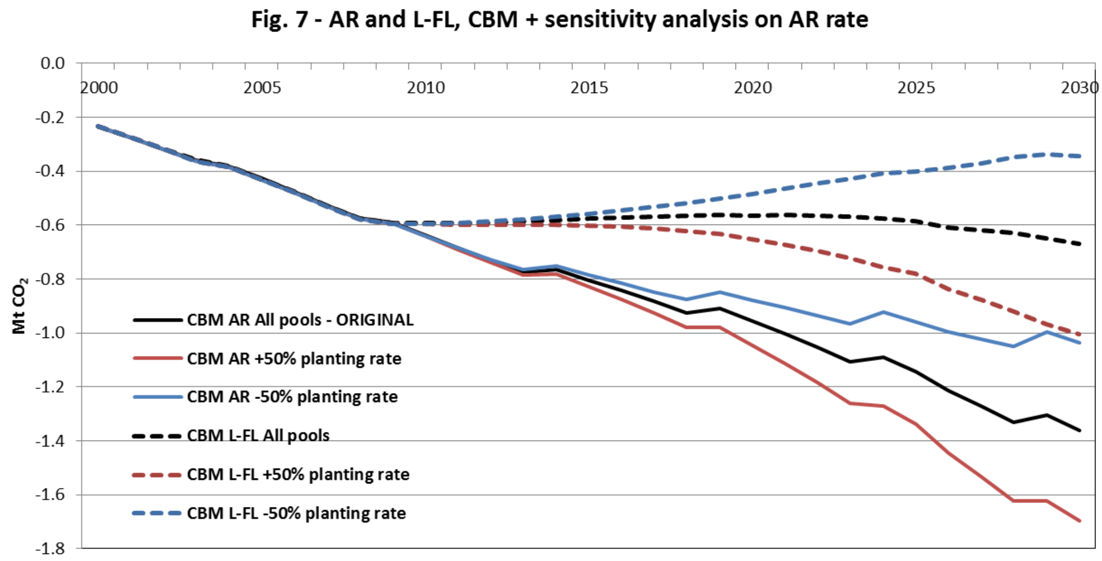


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

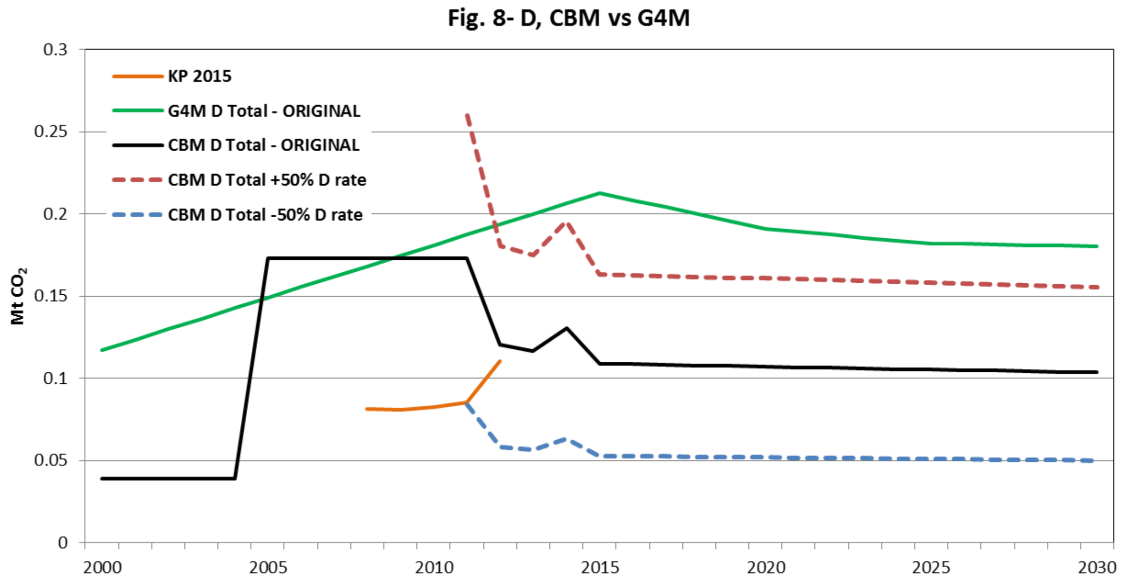
(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**” (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.



Deforestation

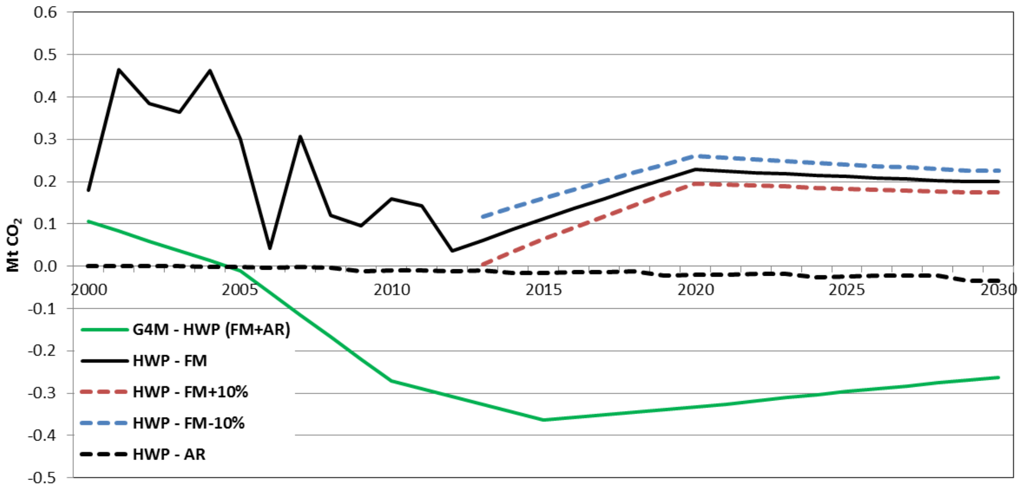
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. “forest converted to other land use”, FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[159]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

Fig. 9-HWP, CBM vs G4M

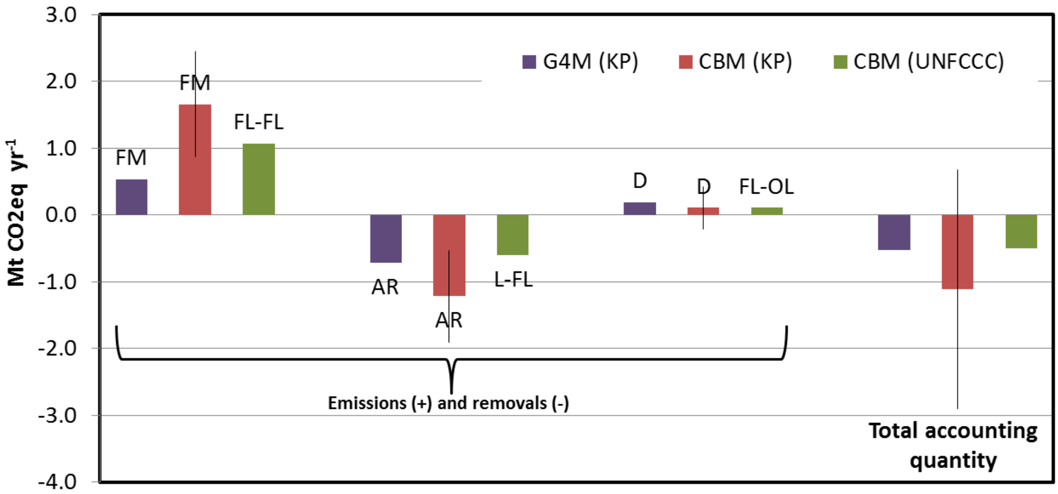


Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[160]; +/- 50% planting rate for AR; D/-50% D rate).

[159] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[160] Based on preliminary results.

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical harvest rate considered by G4M is considerably higher (excepted 2000 when exceptional disturbances affected the Danish forests) than the harvest rate applied by CBM (this may also explain the different HWP C sink estimated by the two models).
- Despite the different harvest rate, the historical C sink estimated by the two models on FM is similar (see Fig. 3) and, in both cases, it is quite different from the GHGI. Indeed, both CBM and G4M estimated a C sink on the period 2000 – 2012, while the country reports a source for the same period. As expected, the calibration on the GHGI data, considerably changes the forecasts provided by both the models (see Fig. 4).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA.

Estonia

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		2,073	2,058	2,049	2,044	2,212[FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	4.1	1.8	1.3	2.0	2.1	0.4
Deforest. (D)	Area of forest conversion to other land since 1990			0.3	1.4	0.7	0.3	1.4

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.
[FM] Forest Management Area, if elected, otherwise [FL]
[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

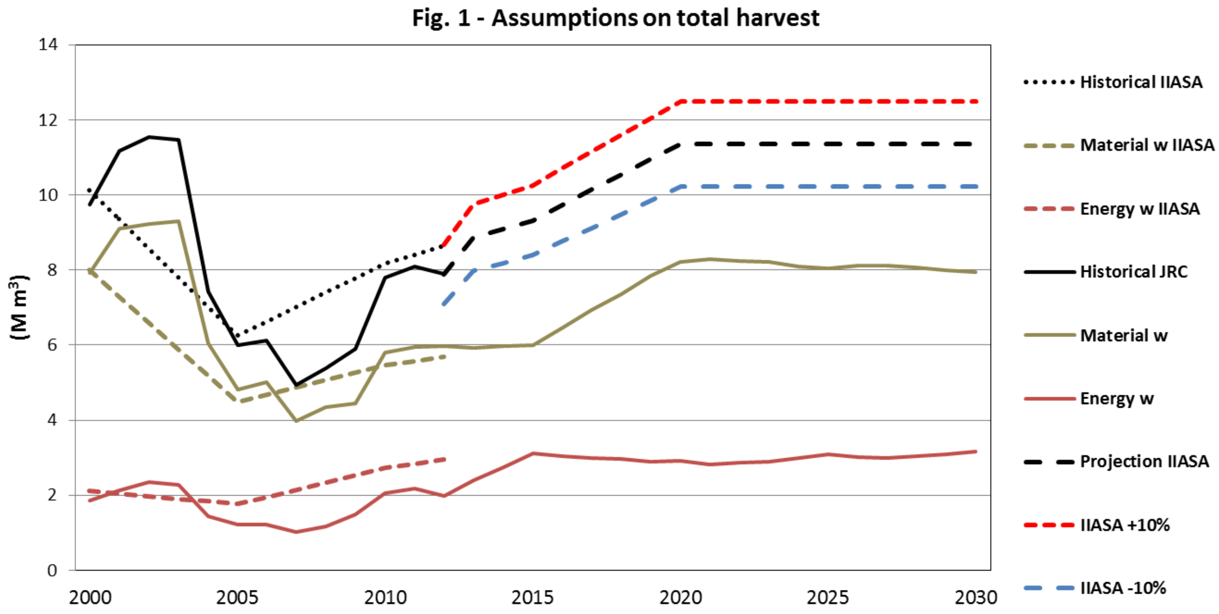
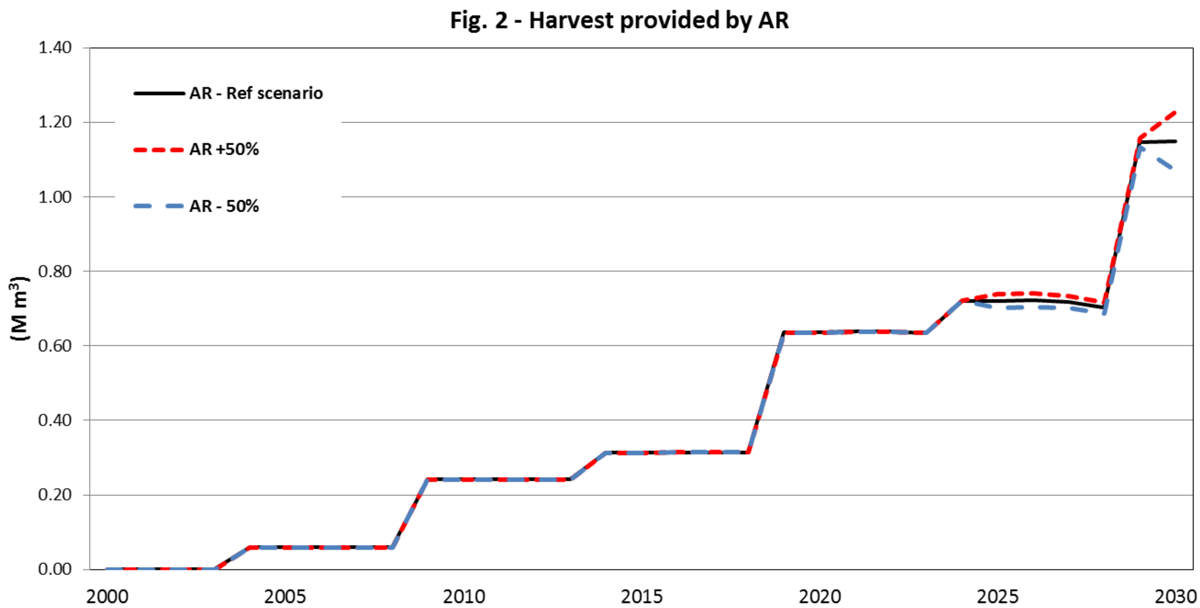


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

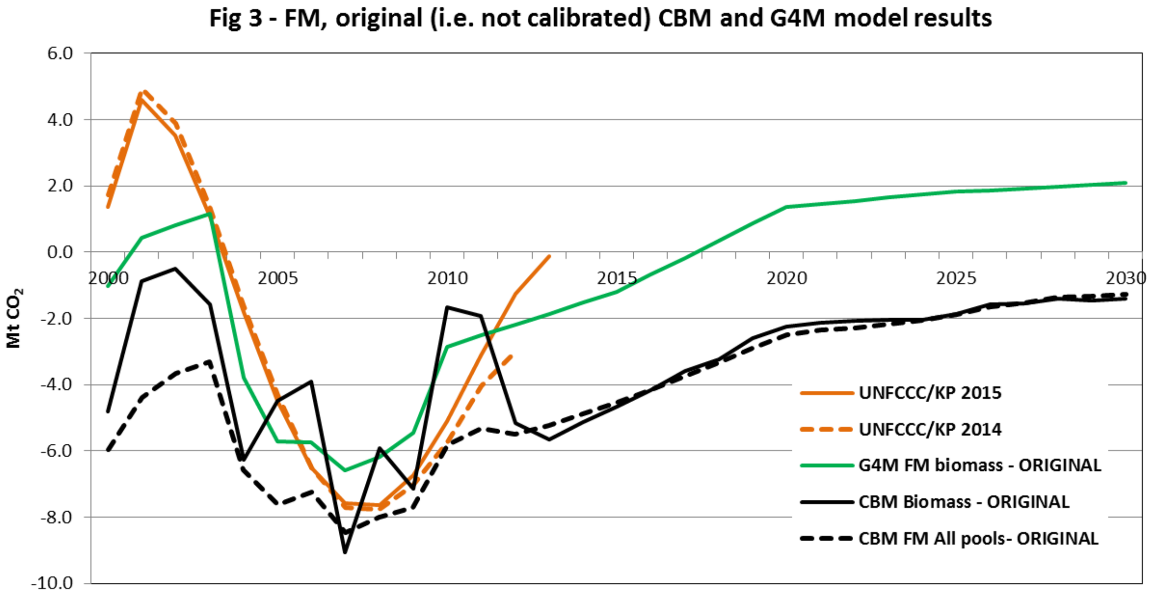
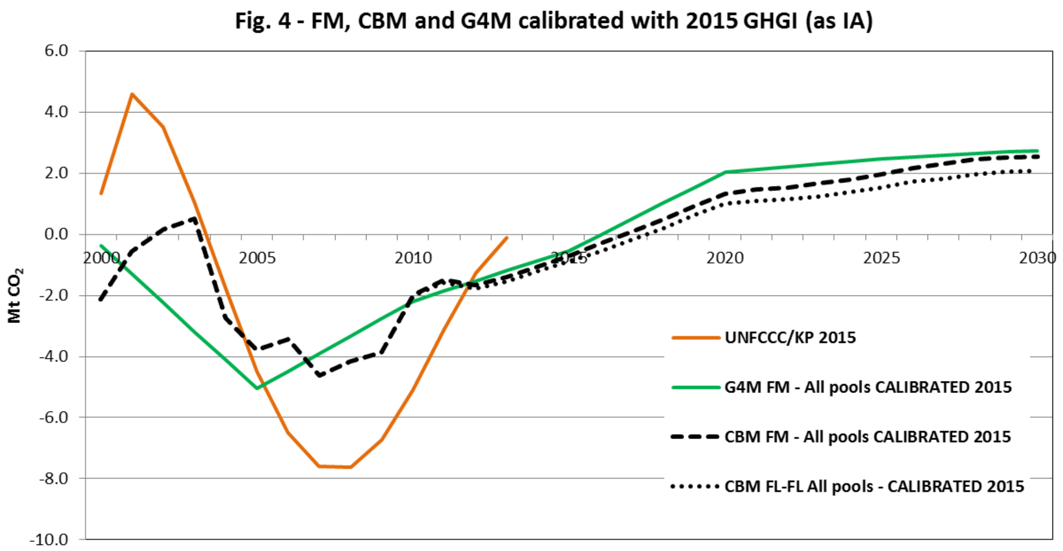


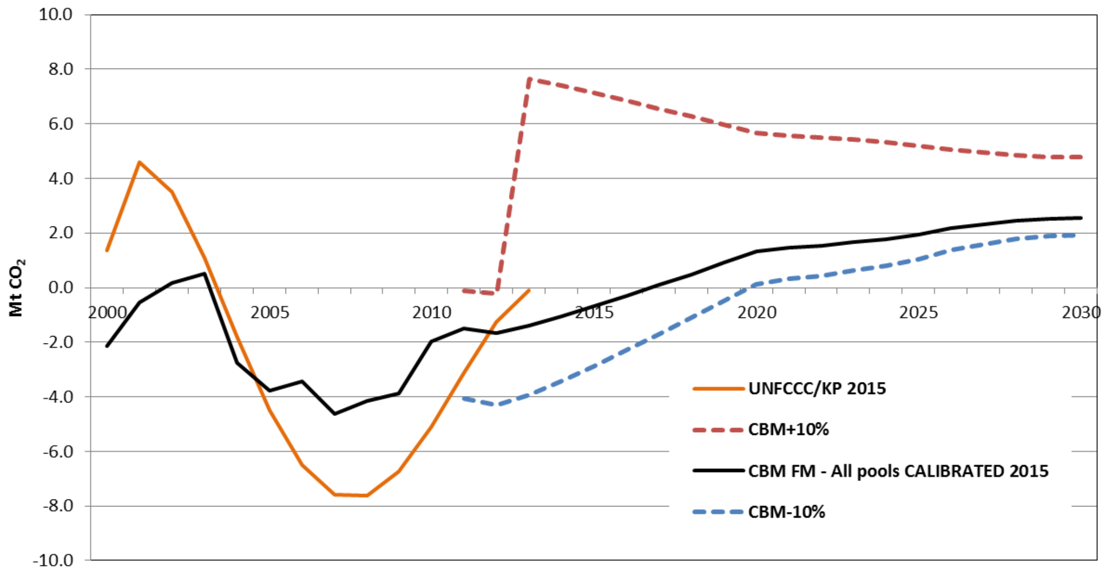
Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[161] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



[161] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.

Fig. 5 FM, CBM (calibrated GHGI 2015) + / - 10% harvest



Afforestation/Reforestation

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Fig. 6 - AR, CBM vs G4M

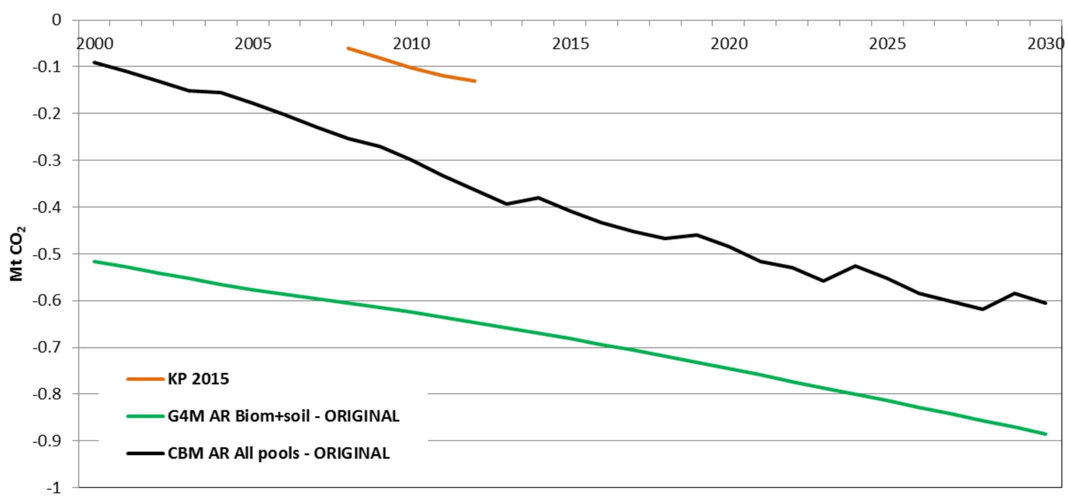
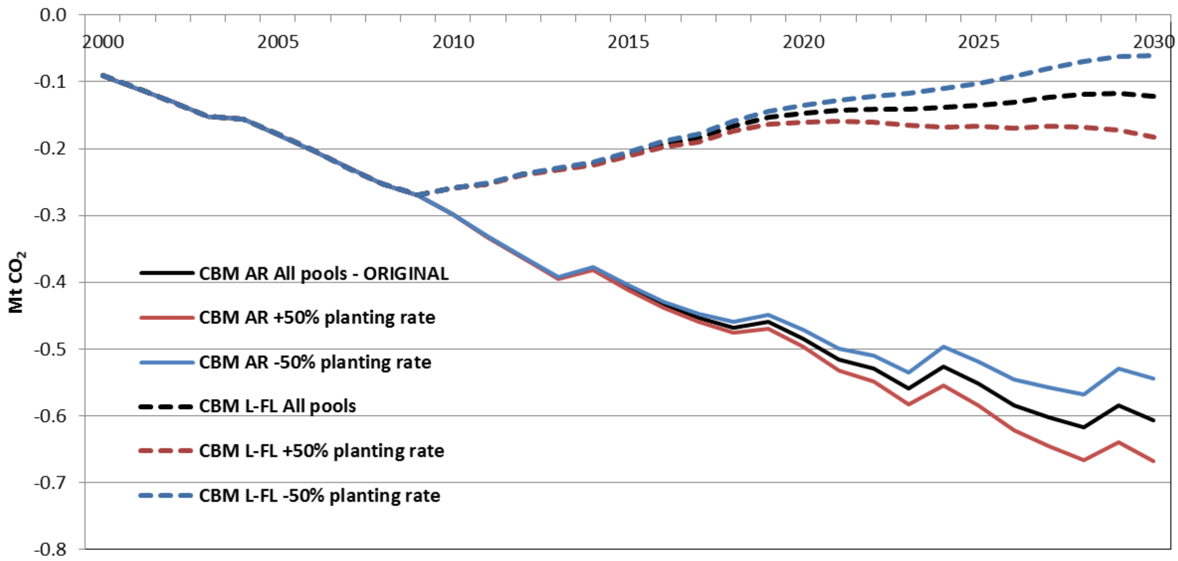


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

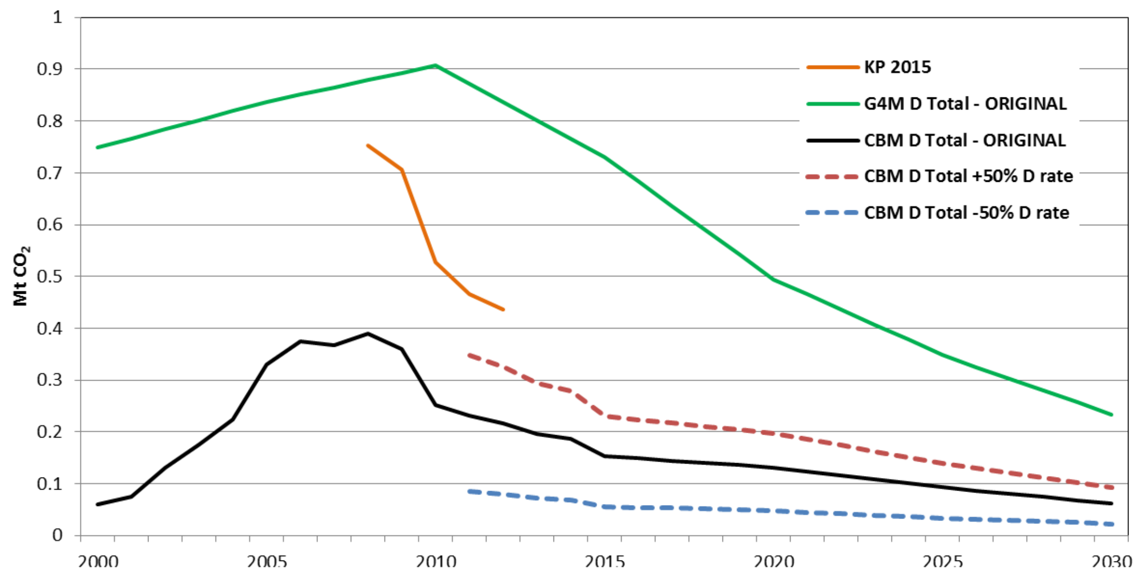
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

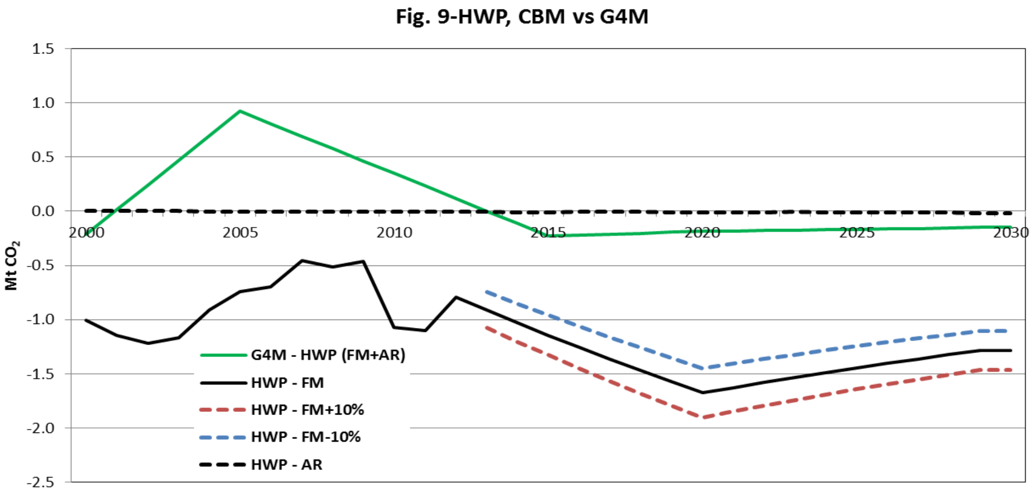
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[162]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

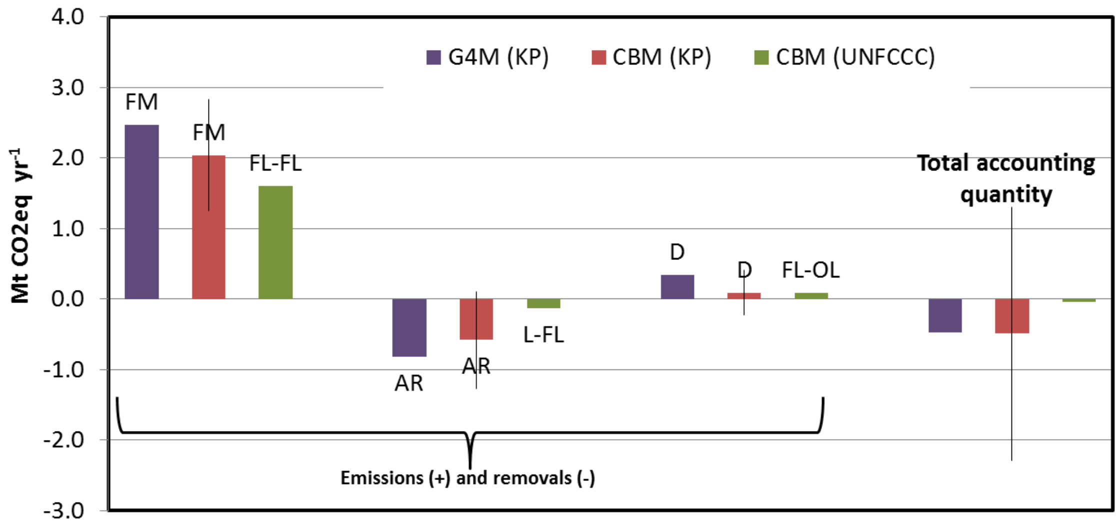


Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[163]; +/- 50% planting rate for AR; D/-50% D rate).

[162] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[163] Based on preliminary results.

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA. This may explain the differences highlighted on Fig. 9.

Spain

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030), comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		14,362	14,178	14,087	14,021	14,453[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	74.1	27.4	14.0	26.9	17.4	14.0
Deforest. (D)	Area of forest conversion to other land since 1990			17.9	15.9	4.9	8.0	3.7

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

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- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
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- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

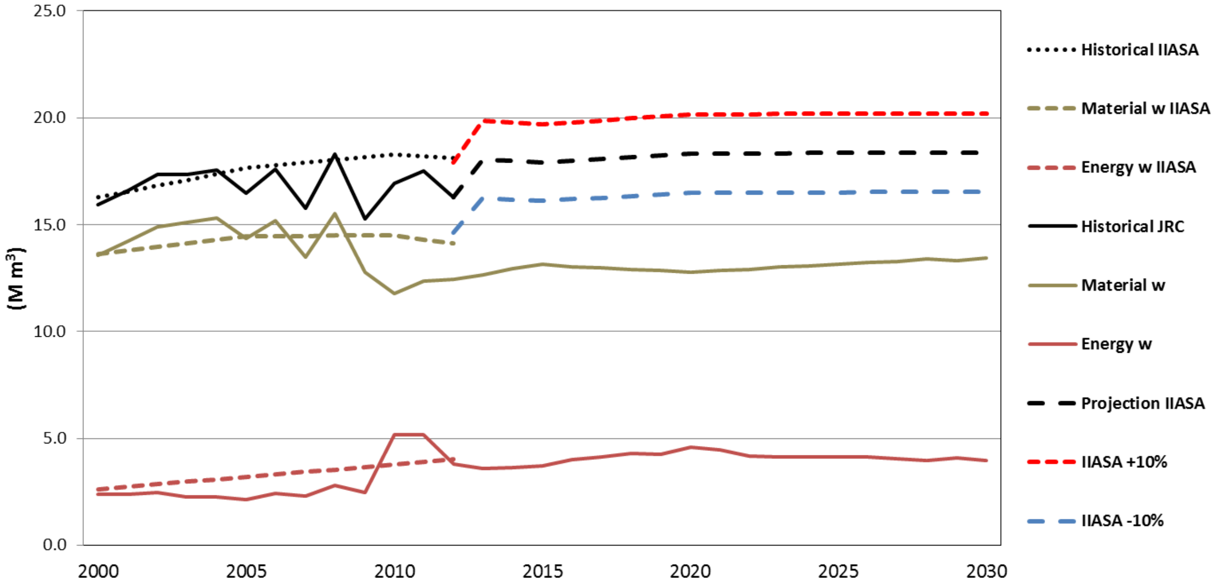
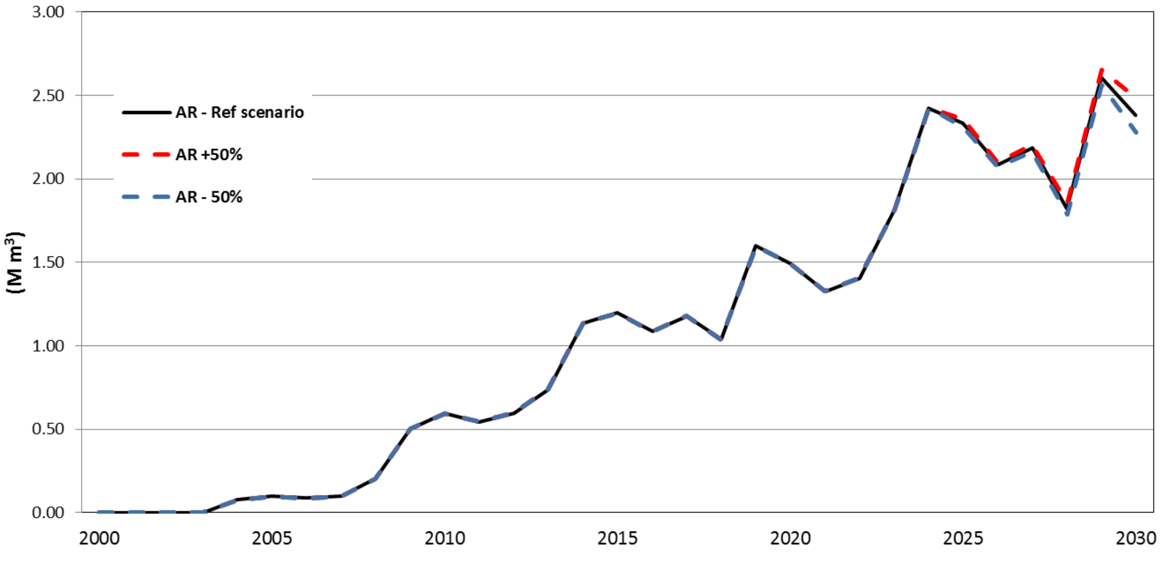


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

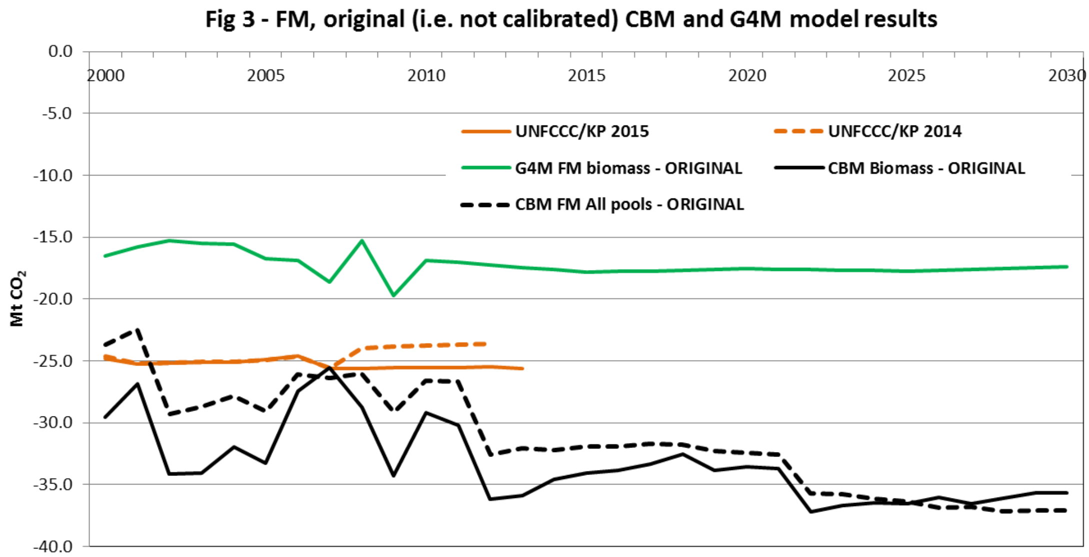


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[164] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

[164] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

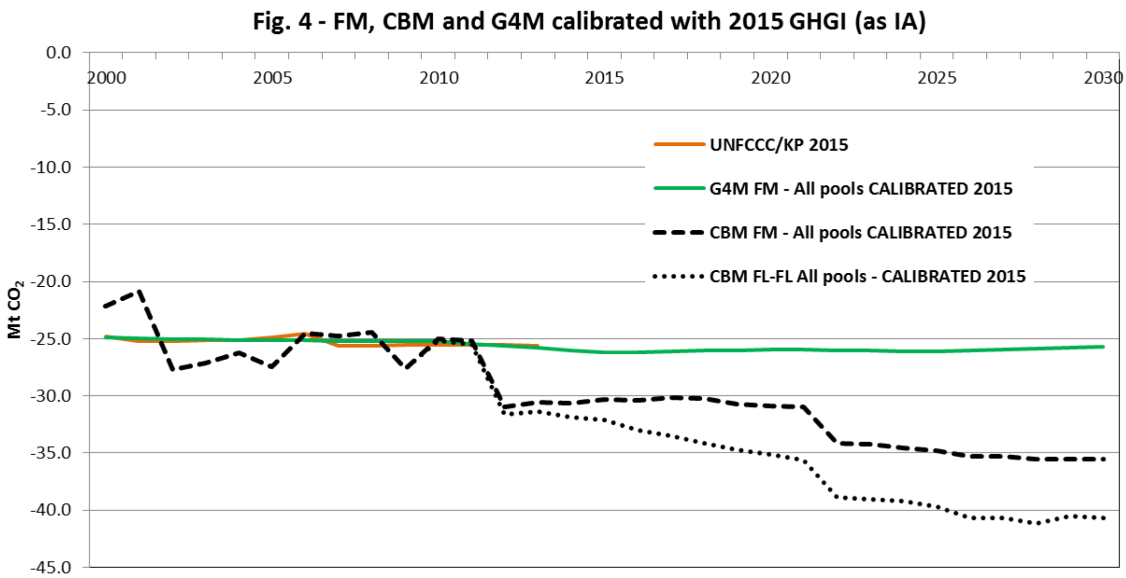
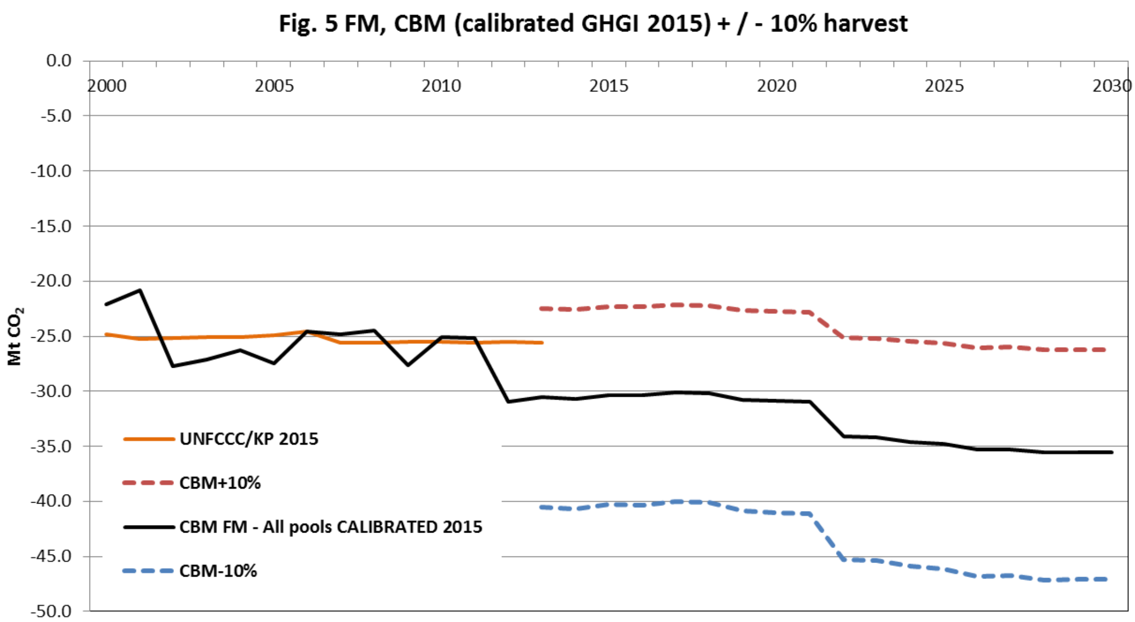


Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

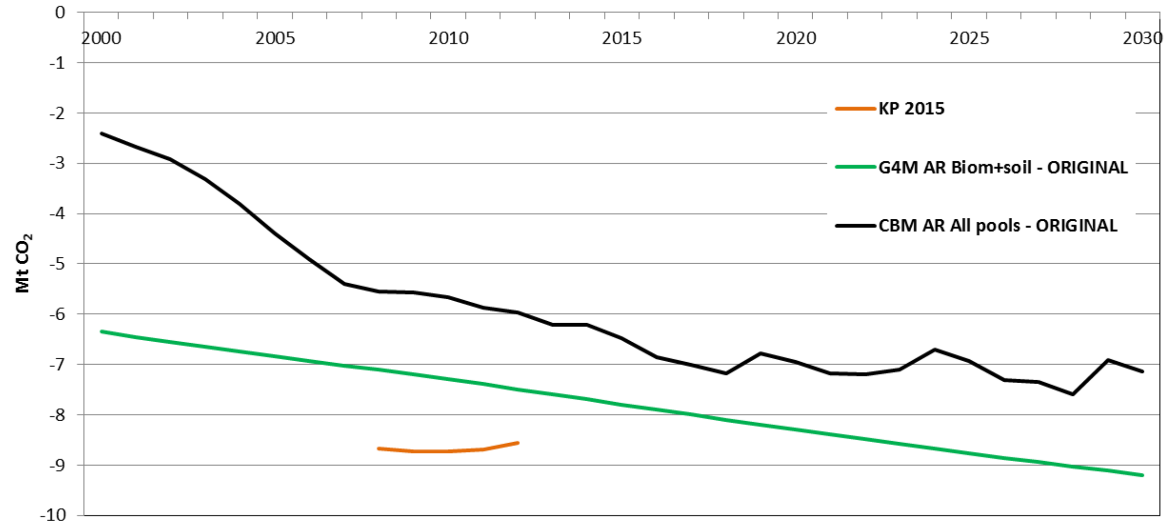
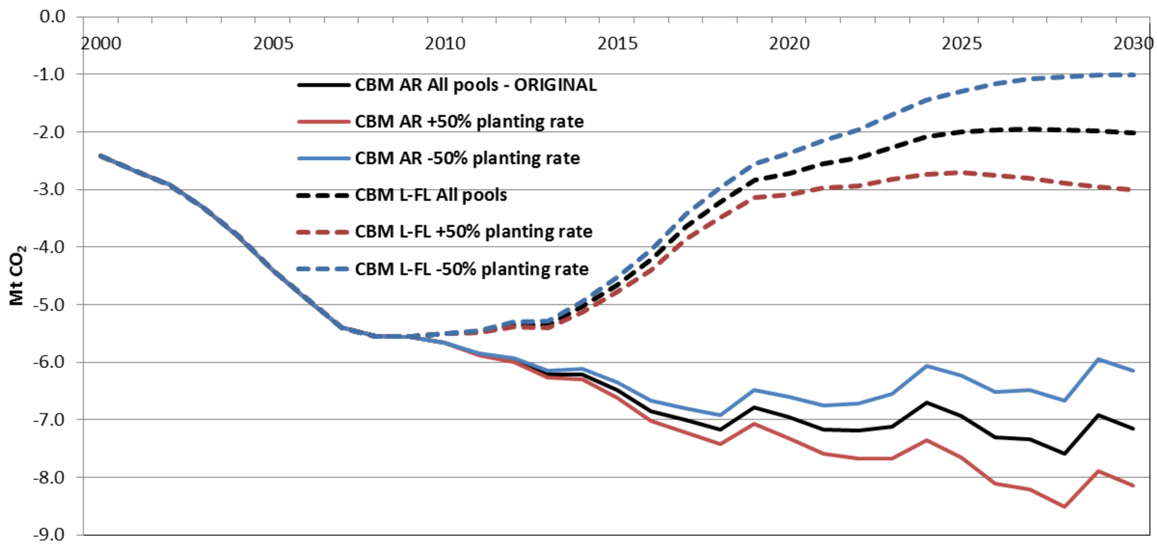


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

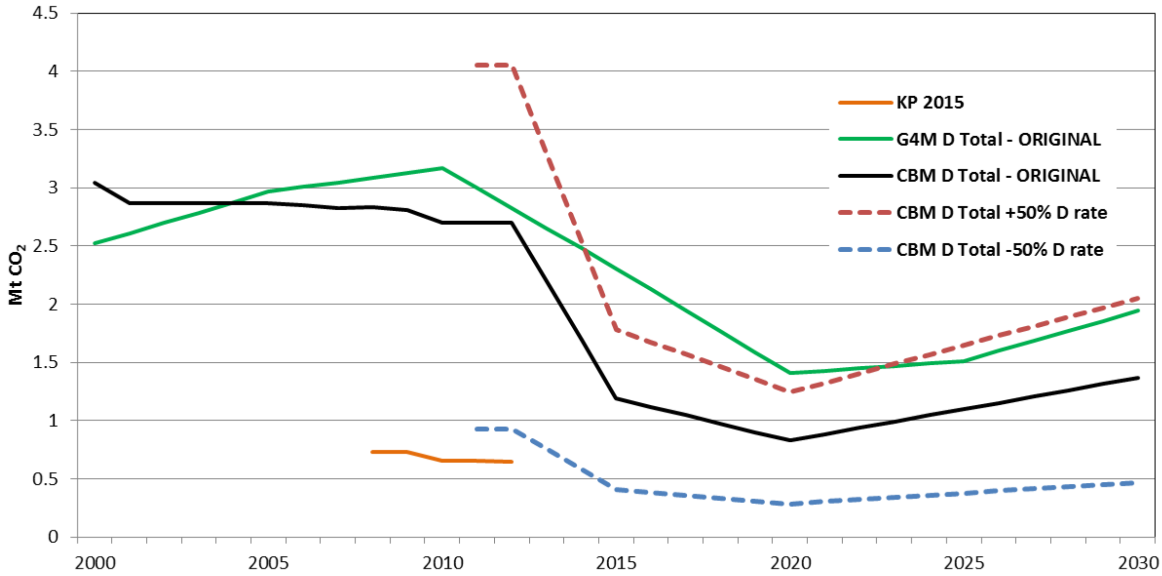
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M

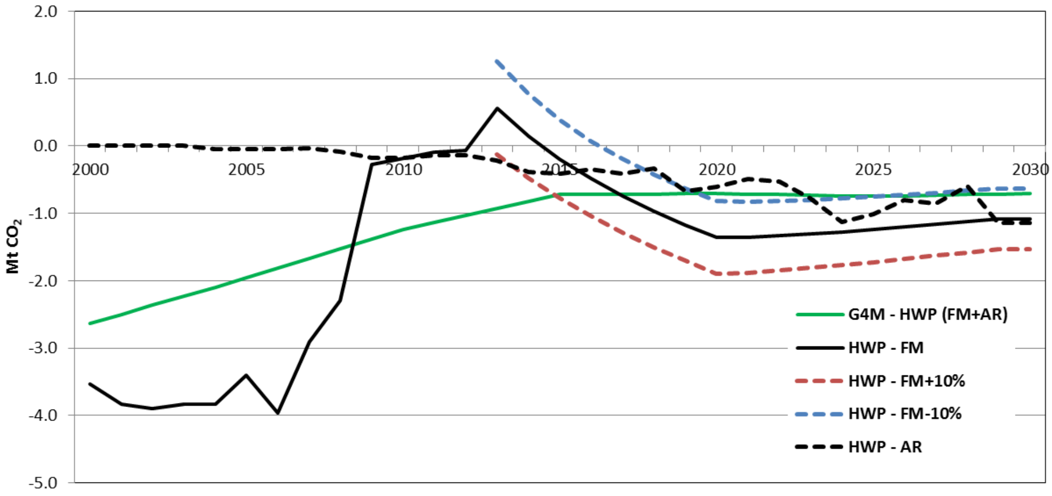


Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[165]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

[165] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

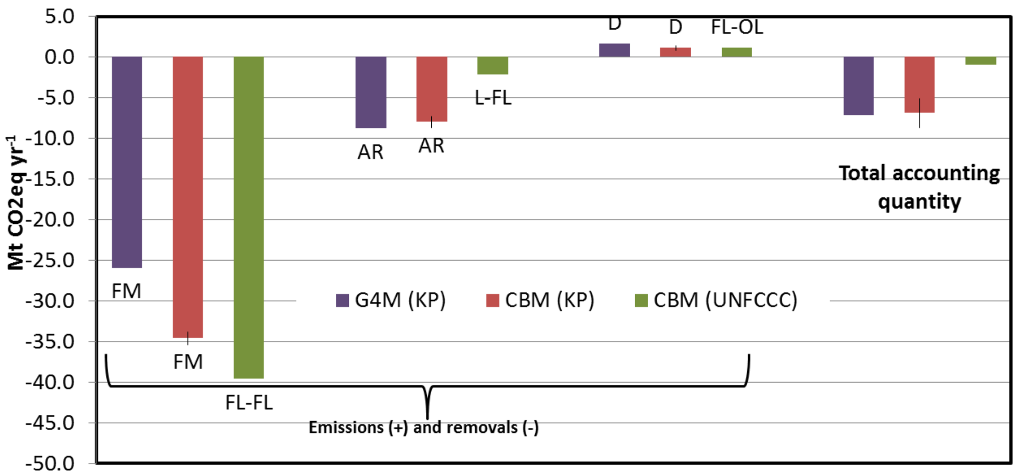
Fig. 9-HWP, CBM vs G4M



Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[166]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM is similar to the estimate provided by the 2015 GHGI (i.e., has the same trend and level, see Fig. 3), even if with larger inter-annual variations due to the effect of fires). G4M estimates a lower C sink (-85%, compared with CBM), despite the larger FM area considered by IIASA

[166] Based on preliminary results.

compared with JRC (+12% in 2000).

- The future harvest demand expected by IIASA, assuming a constant harvest rate, is satisfied. Calibrating the original model results on the GHGI data (see Fig. 4), CBM estimates an increasing C sink in 2030 (-35 Mt CO_2 yr^{-1}), while G4M estimates a constant C sink (-26 Mt CO_2 yr^{-1}).
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

Finland

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		21,841	21,627	21,532	21,491	21,844^FM
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	12.3	2.7	2.7	3.8	5.4	2.2
Deforest. (D)	Area of forest conversion to other land since 1990			16.3	14.7	6.6	2.6	10.8

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

FM Forest Management Area, if elected, otherwise FL

FL Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

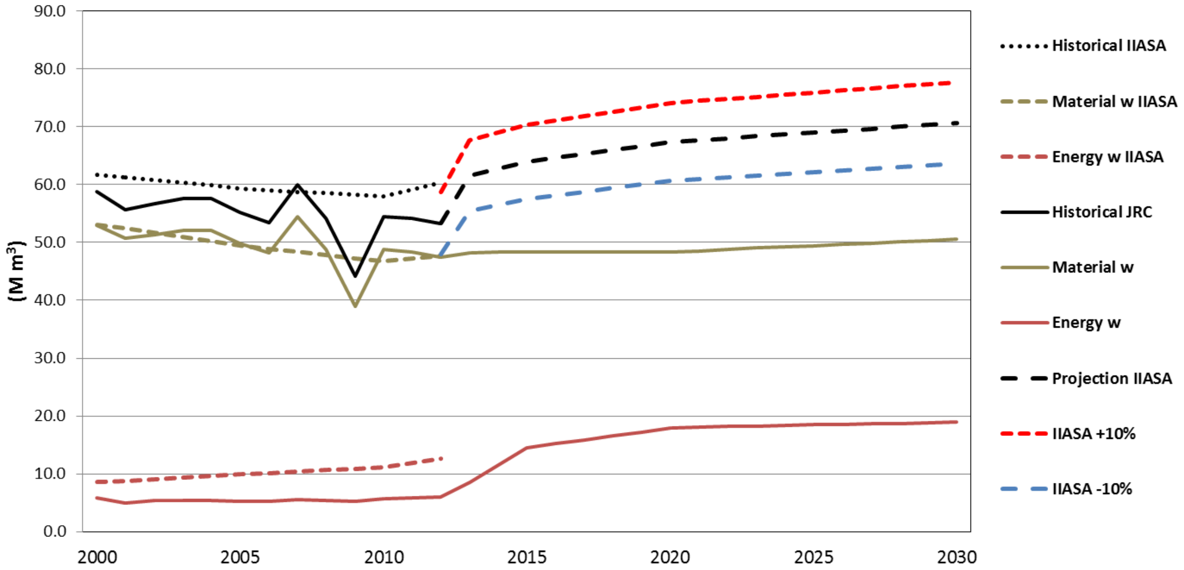
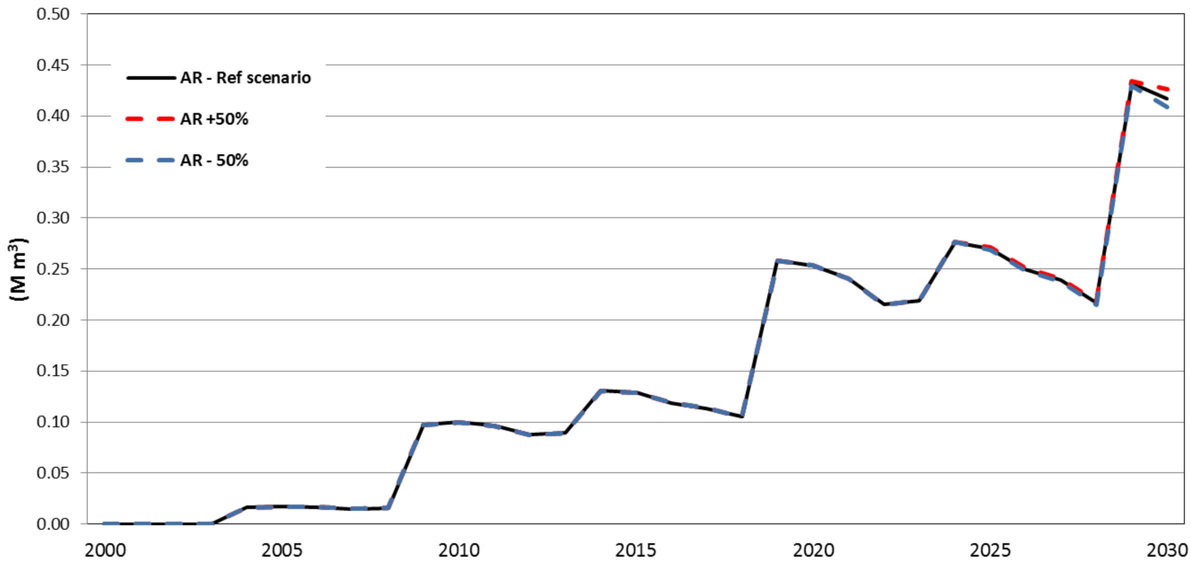


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

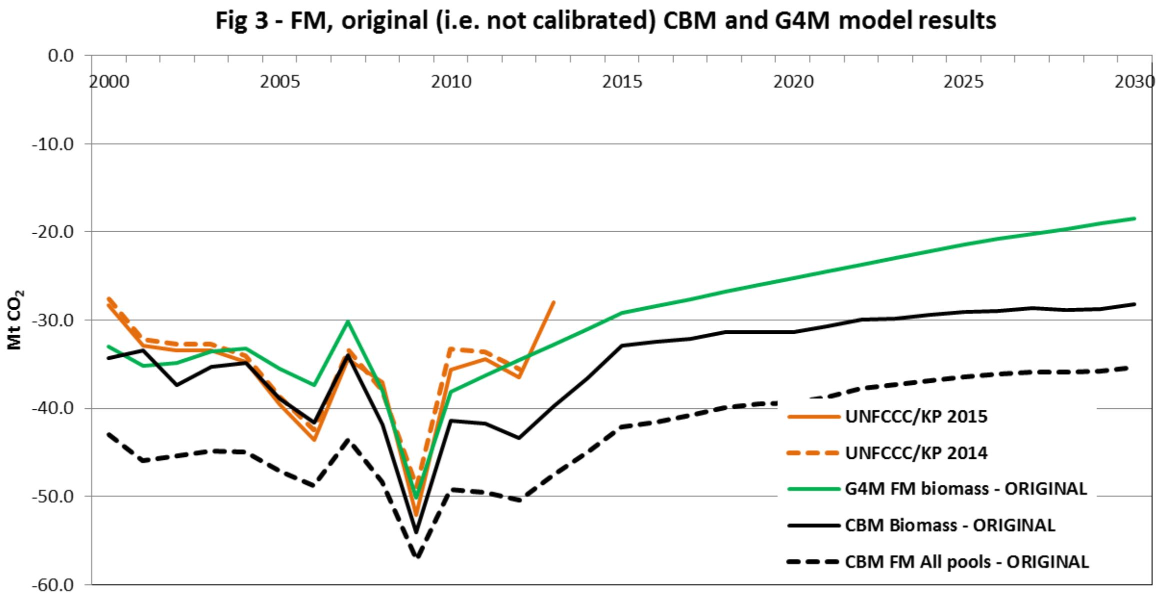


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[167] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

[167] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

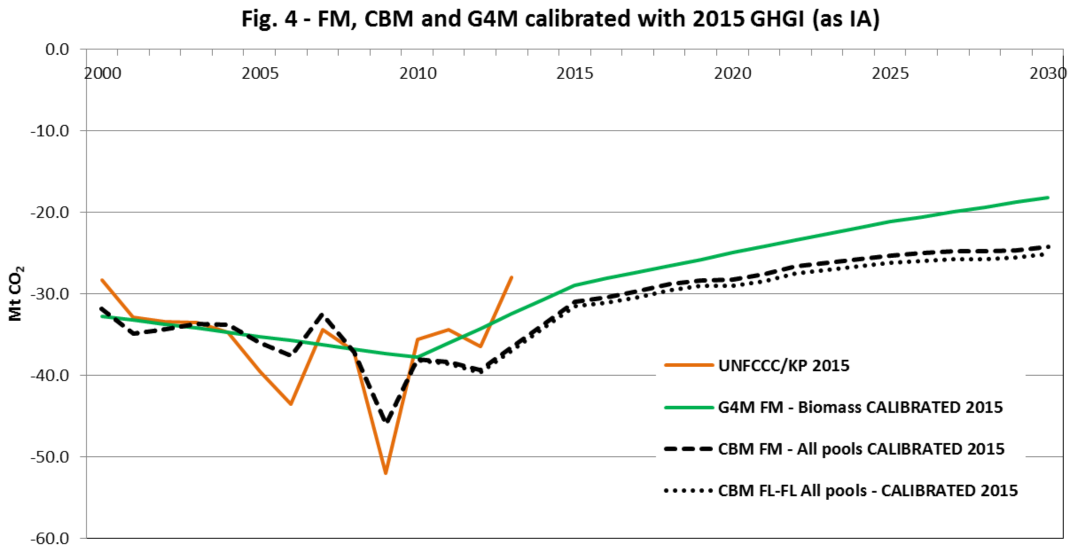
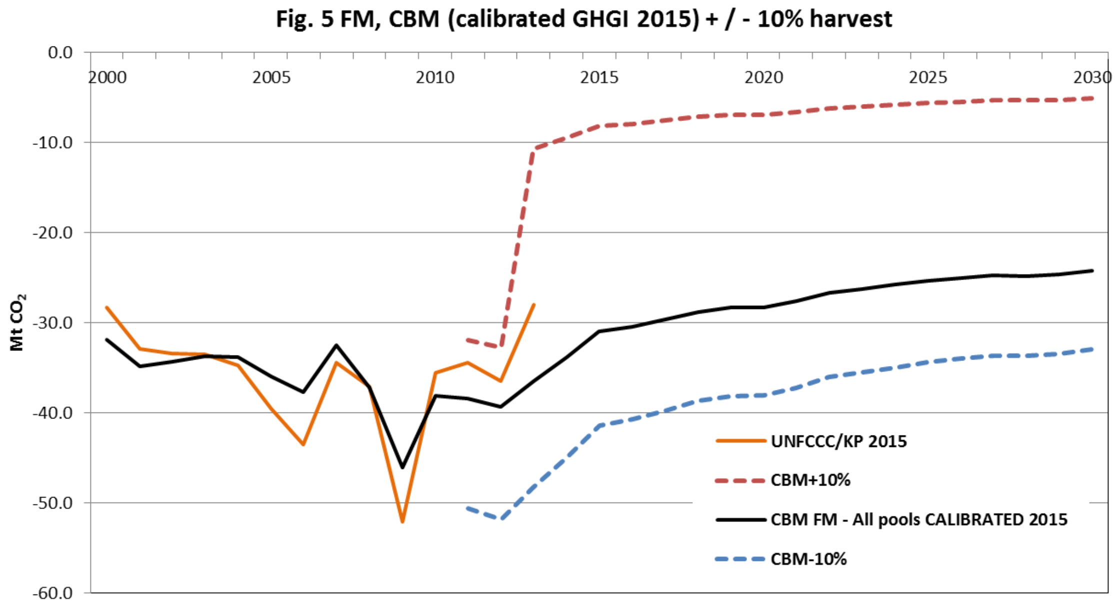


Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

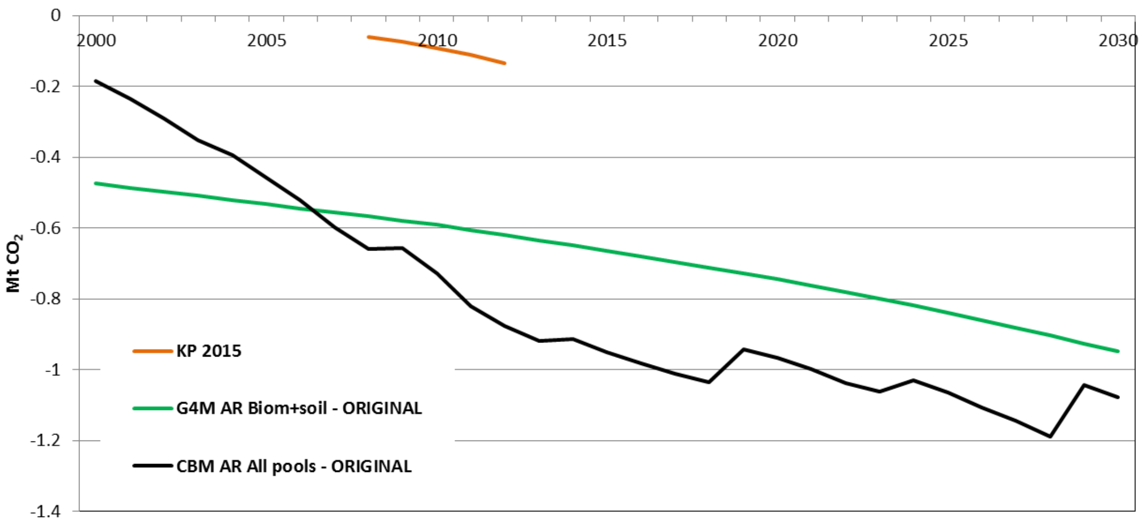
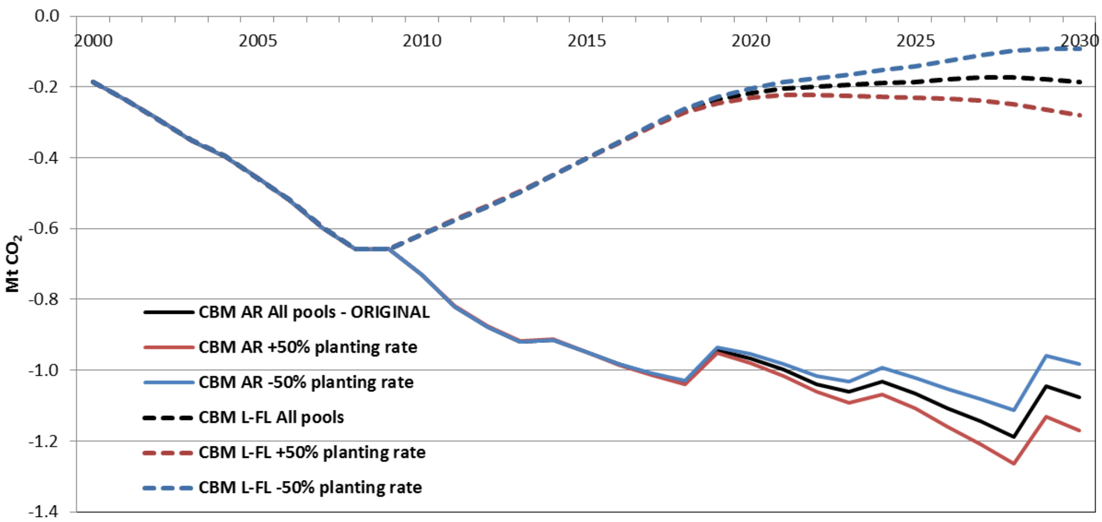


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

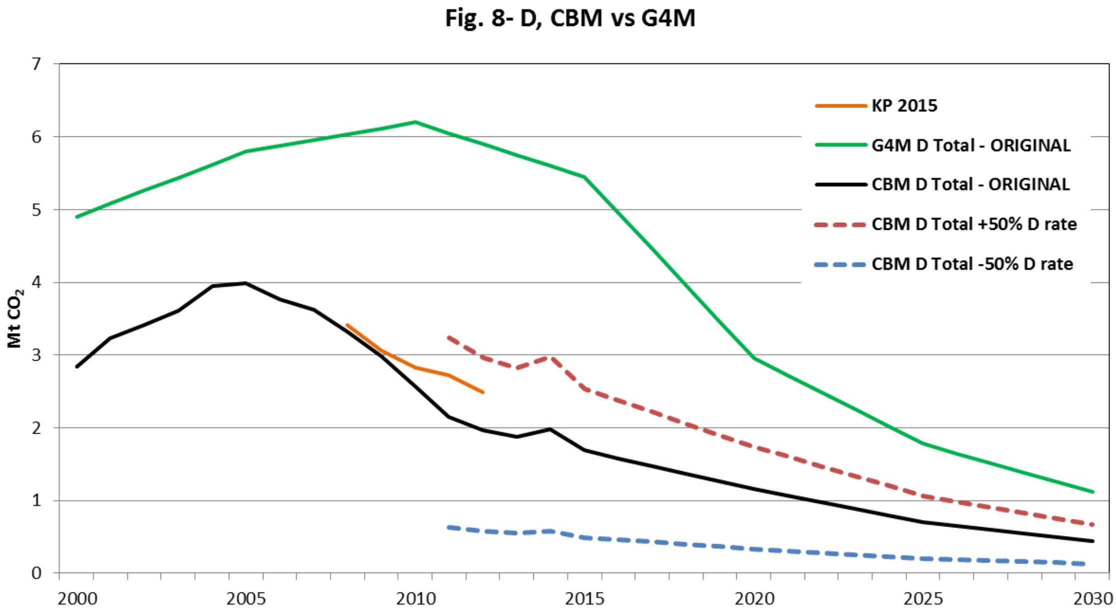
(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

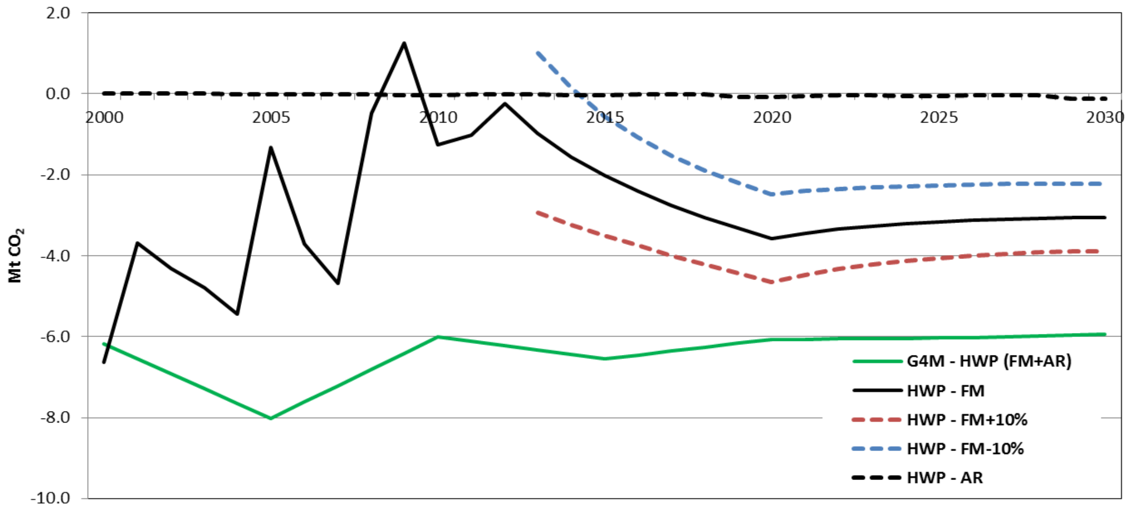


Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[168]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

[168] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

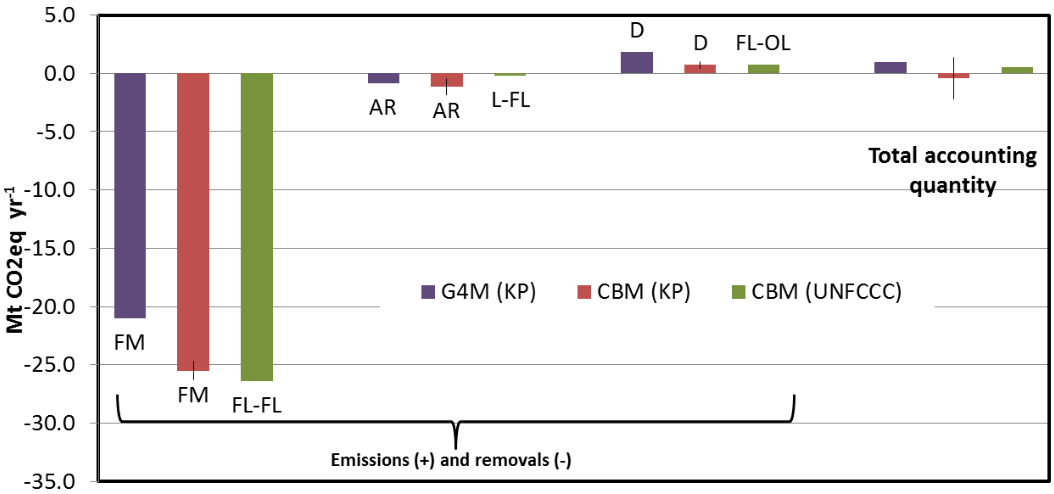
Fig. 9-HWP, CBM vs G4M



Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[169]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical harvest rate applied by CBM is slightly lower than the amount of harvest applied by G4M, and it shows a higher inter-annual variability due to the effect of natural disturbances.
- The future harvest demand expected by IIASA is satisfied.

169 Based on preliminary results.

- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA. This may explain the differences highlighted on Fig. 9.

France

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		13,524	13,045	12,741	12,566	13,111 FM
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	64.6	89.8	25.1	41.8	48.5	32.7
Deforest. (D)	Area of forest conversion to other land since 1990			43.8	41.5	21.2	14.4	44.6

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

FM Forest Management Area, if elected, otherwise FL

FL Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

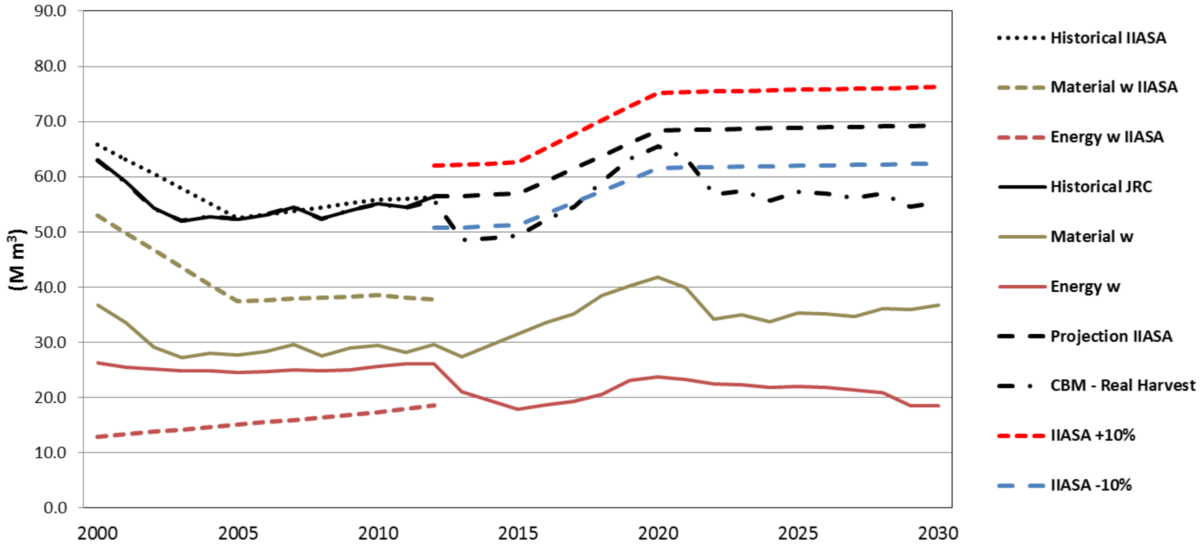
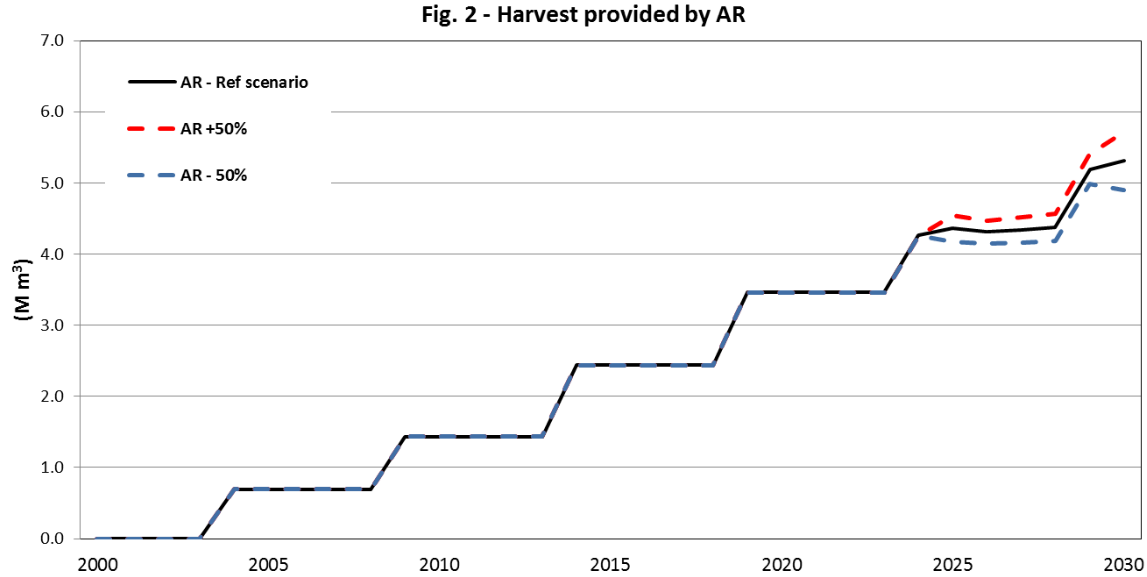


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

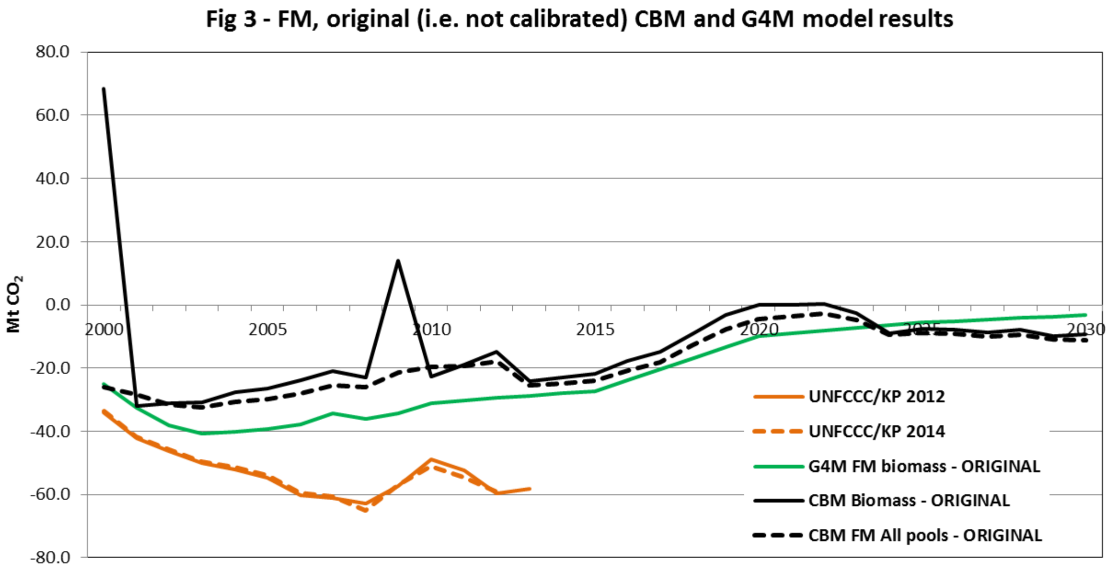
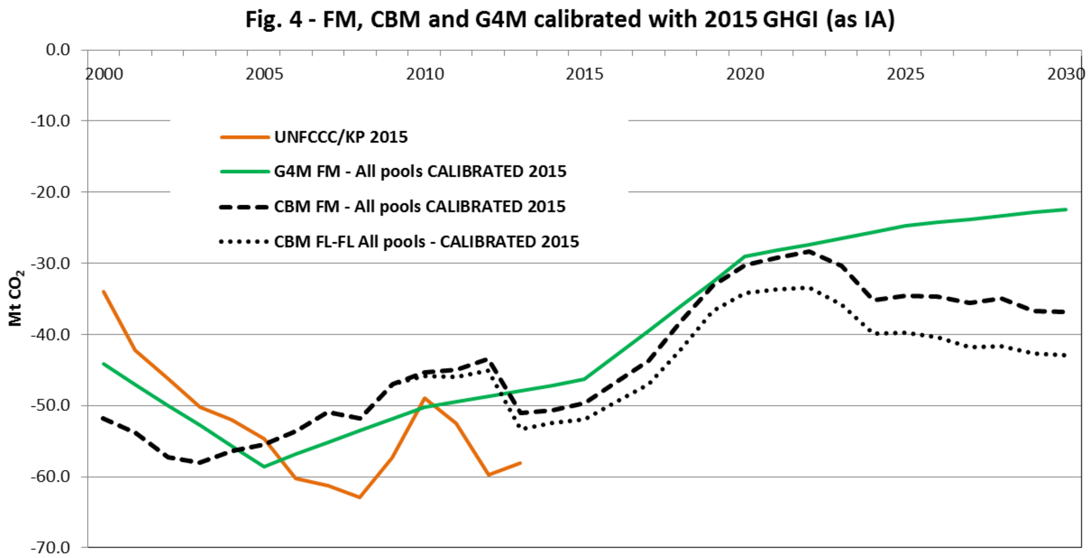


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[170] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

[170] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.



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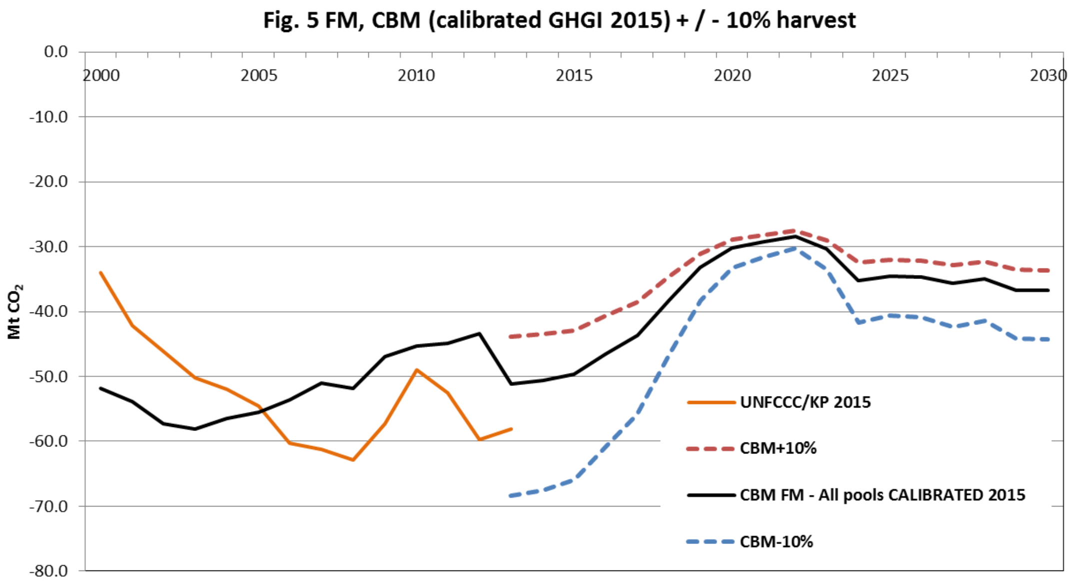


Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

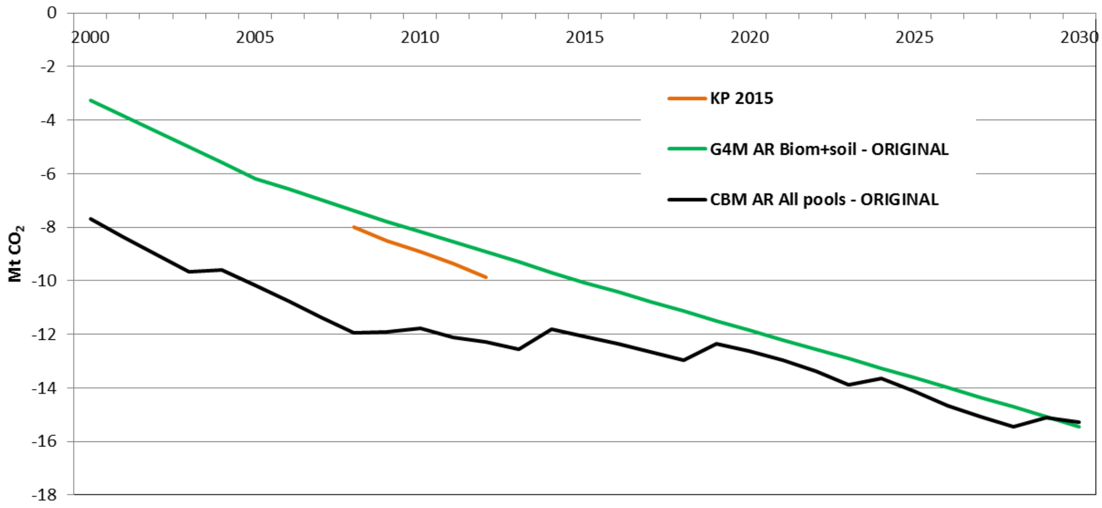
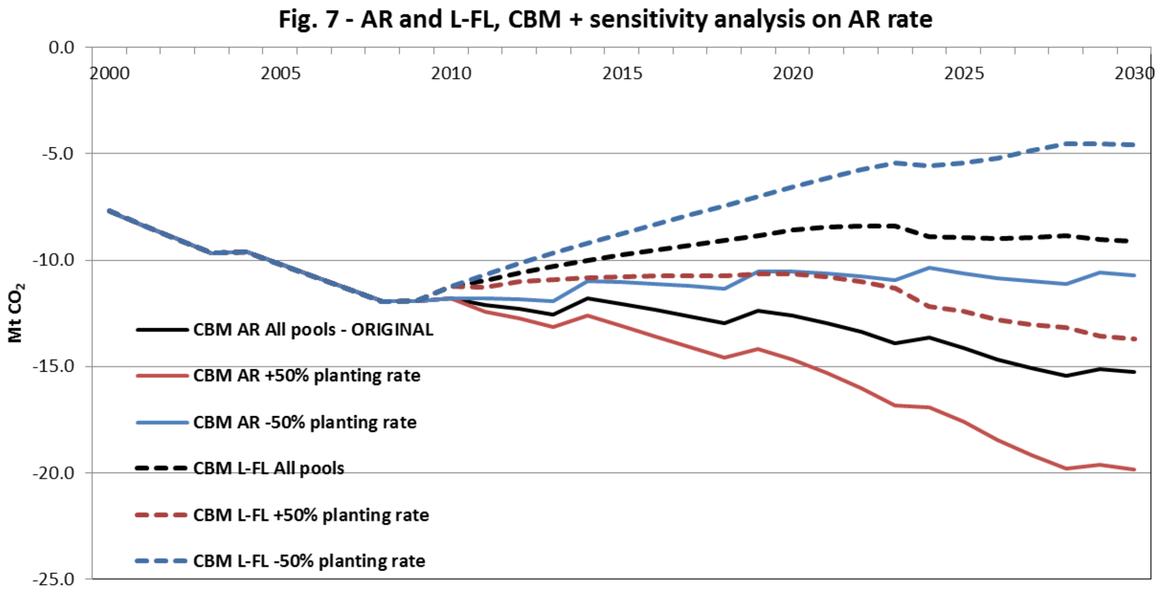


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

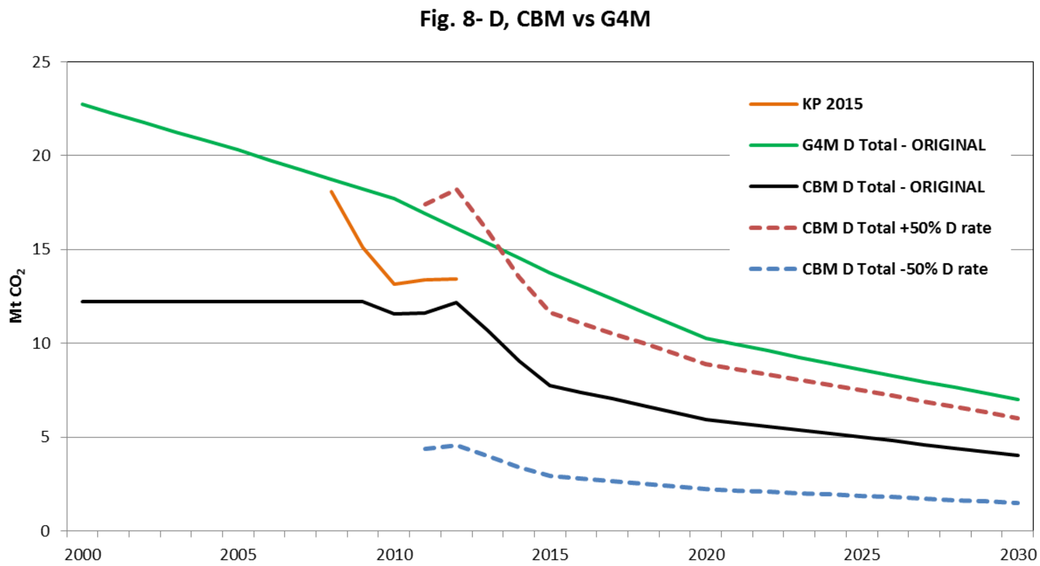
(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.



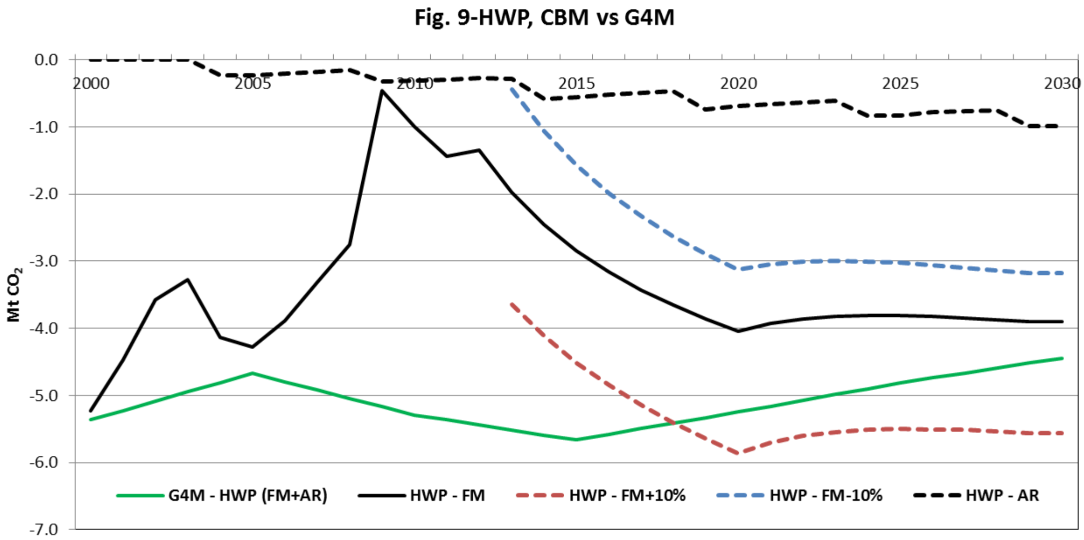
Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.



Harvested Wood Products (HWP)

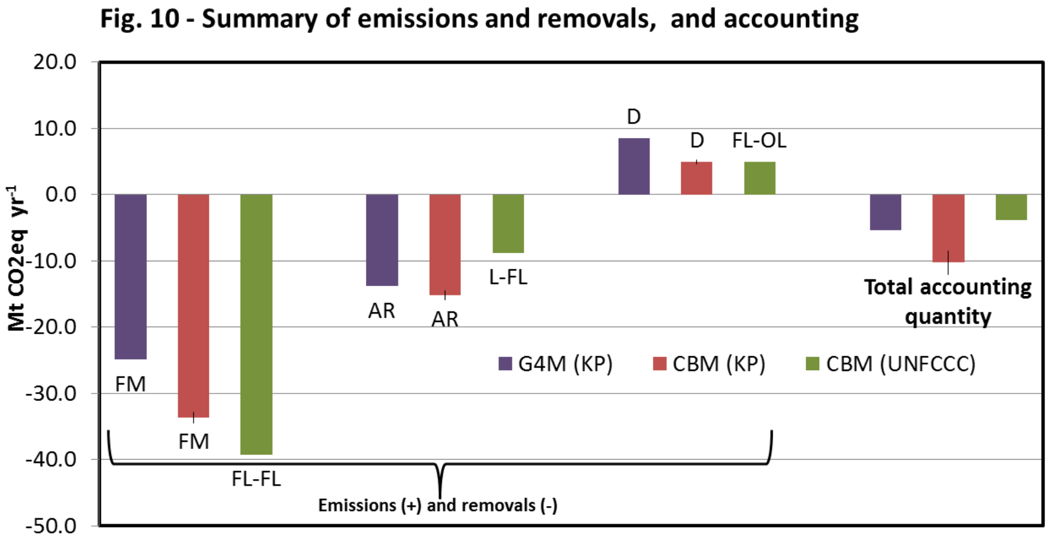
Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[171]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.



[171] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[172]; +/- 50% planting rate for AR; D/-50% D rate).



Comments on CBM run and model assumptions:

- The future harvest demand expected by IIASA cannot be fully satisfied after 2023 (see Fig 1).
- As a consequence, the CBM estimates an increasing C sink on FM after 2023, due to the decreasing amount of harvest applied by model (see Fig. 3). This is due to the fact that, according to CBM, the harvest requested after 2023 is not sustainable.
- During the historical period 2000 -2012, the average C sink estimated by CBM is about 60% lower than the sink estimated by G4M. If compared with the GHGI data, both the models estimate a considerably lower C sink. Despite the differences on the historical period, the future C sink on FM estimated by both the models is similar until 2023 (see Fig. 3 and 4).
- Because the harvest demand cannot be satisfied, the results provided by the sensitivity analysis do not represent the expected harvest demand (i.e., +-10% variation on the harvest).
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[172] Based on preliminary results.

Greece

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		1,211	1,209	1,206	1,205	1,229[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	2.0	1.0	0.0	0.2	0.2	0.0
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		0.2	0.0	0.2	0.2	0.0

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

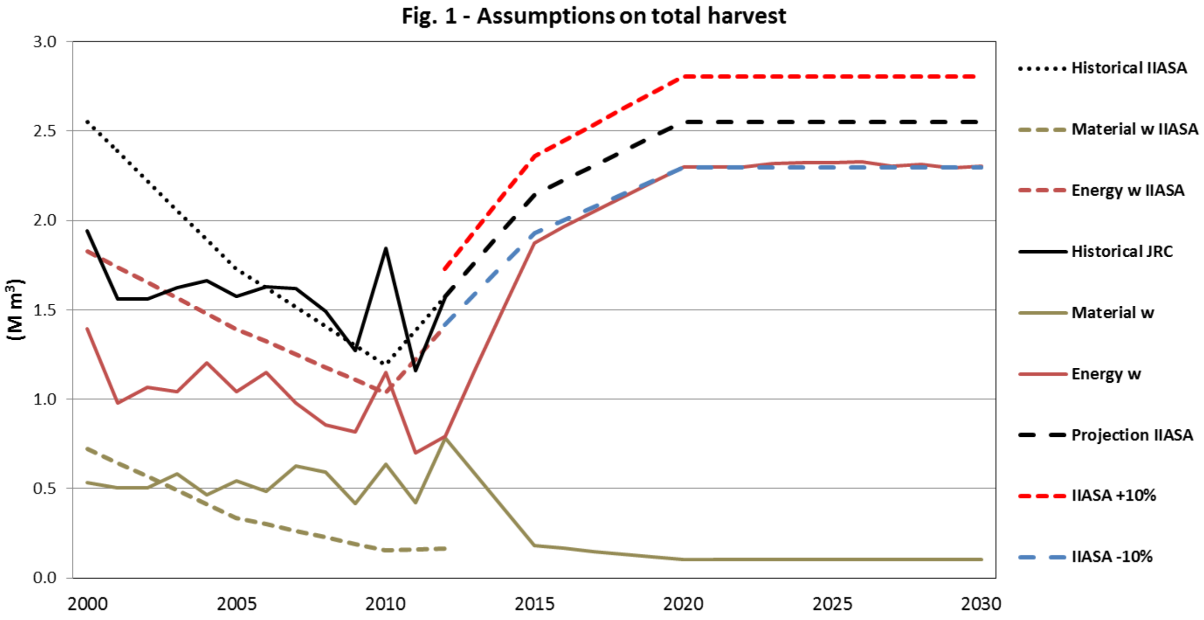
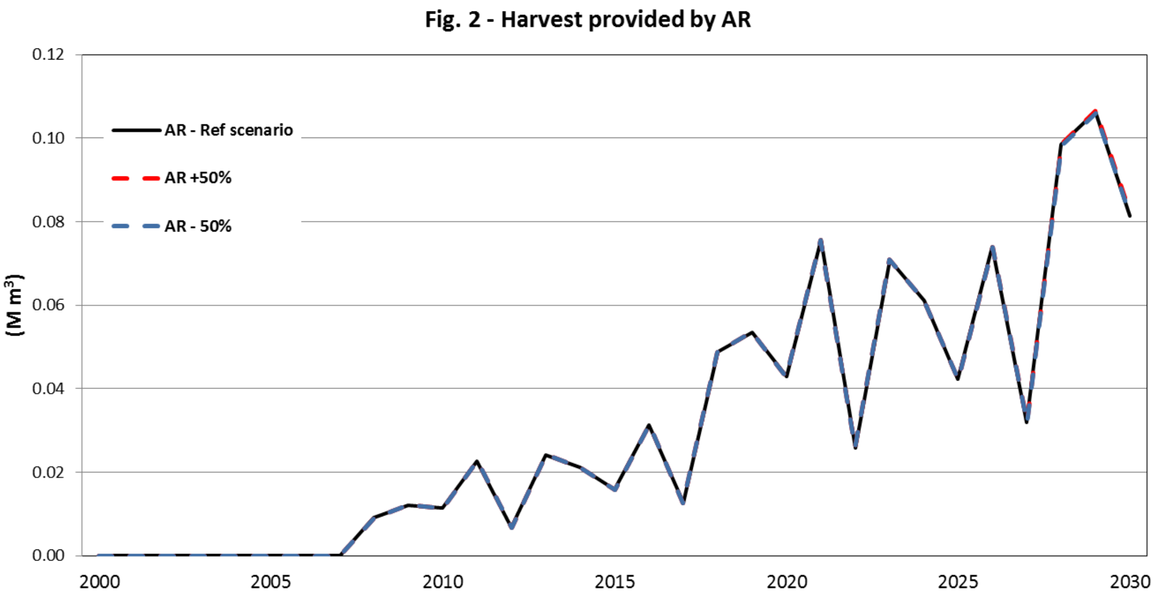


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

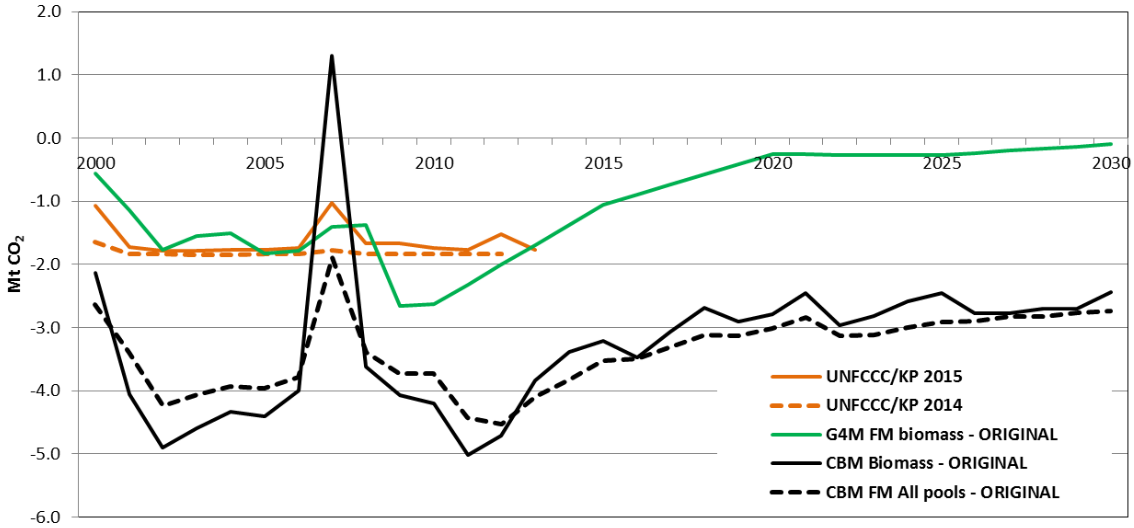


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[173] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

[173] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

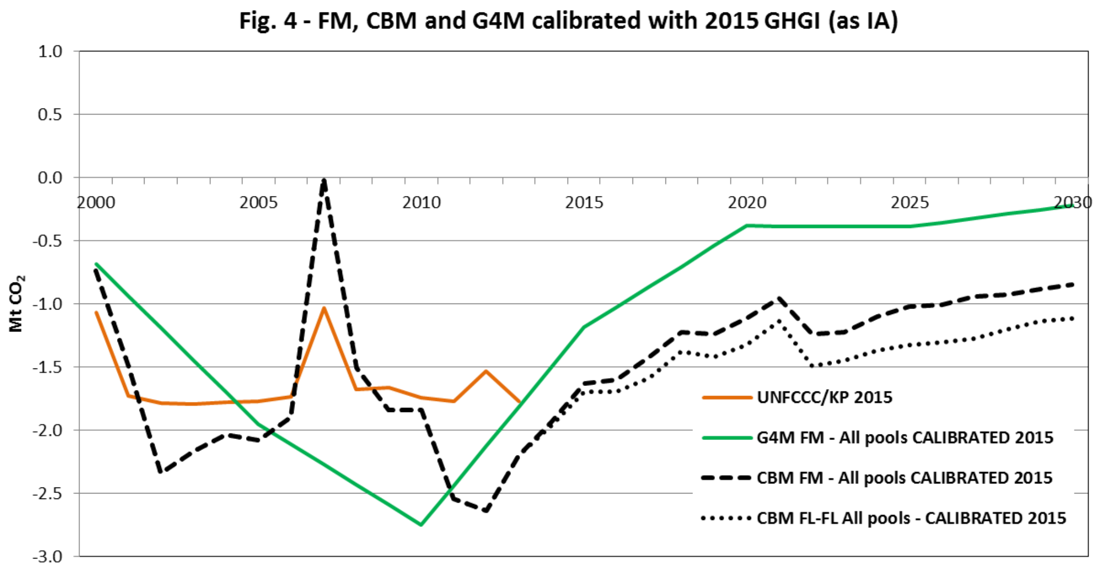
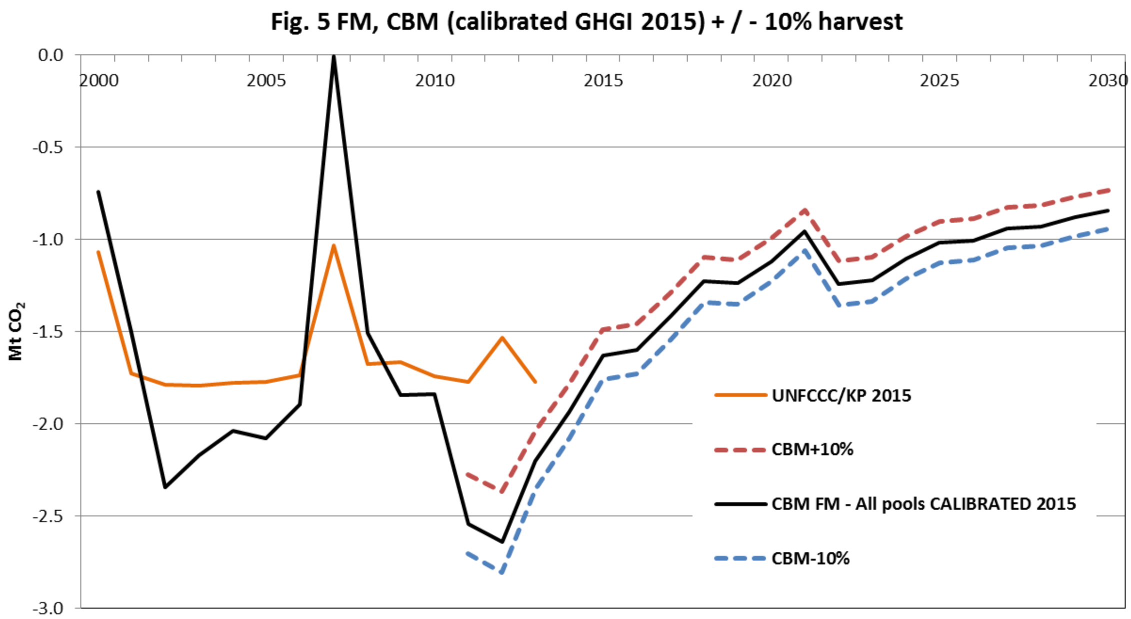


Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/-10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

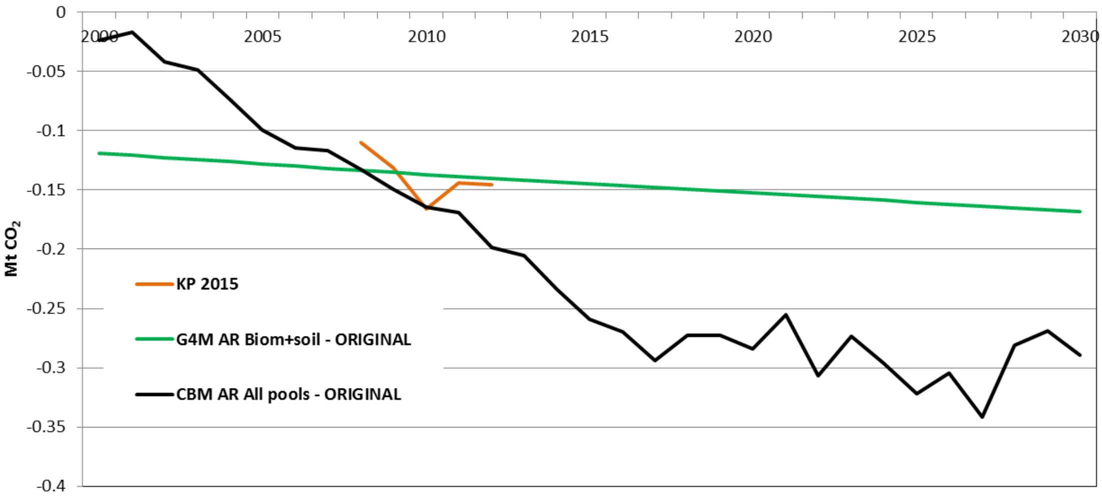
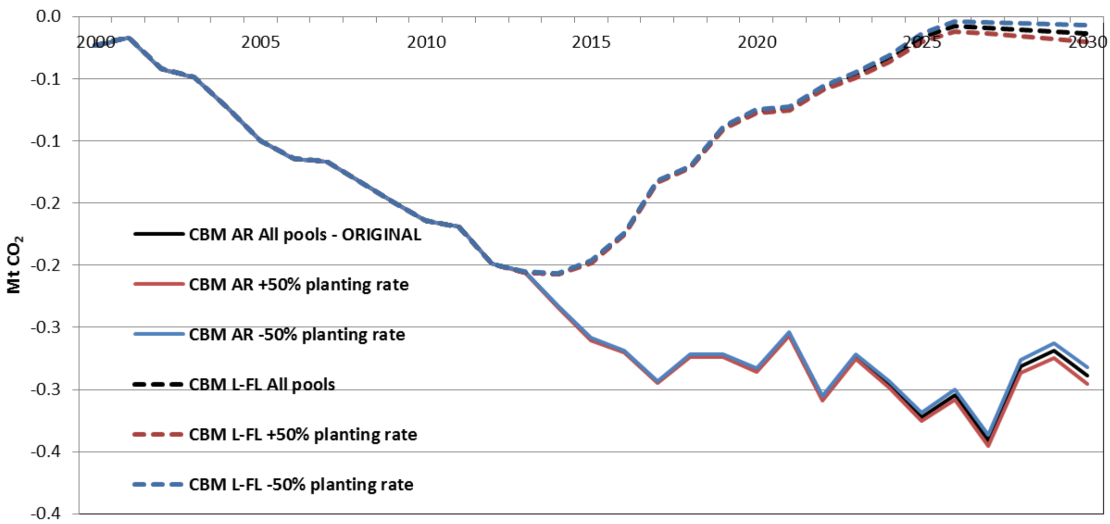


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

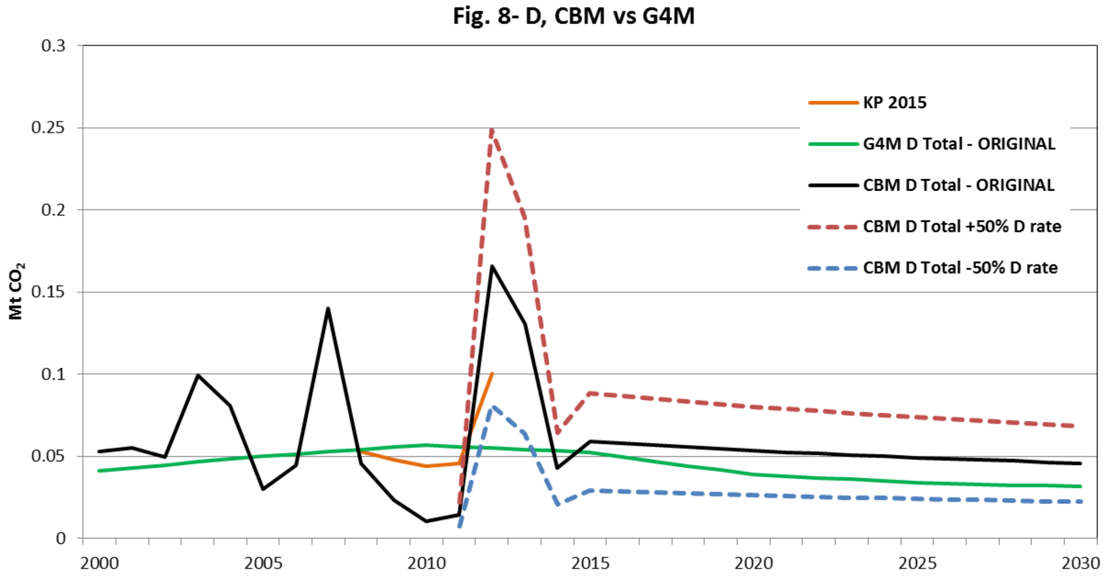
(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



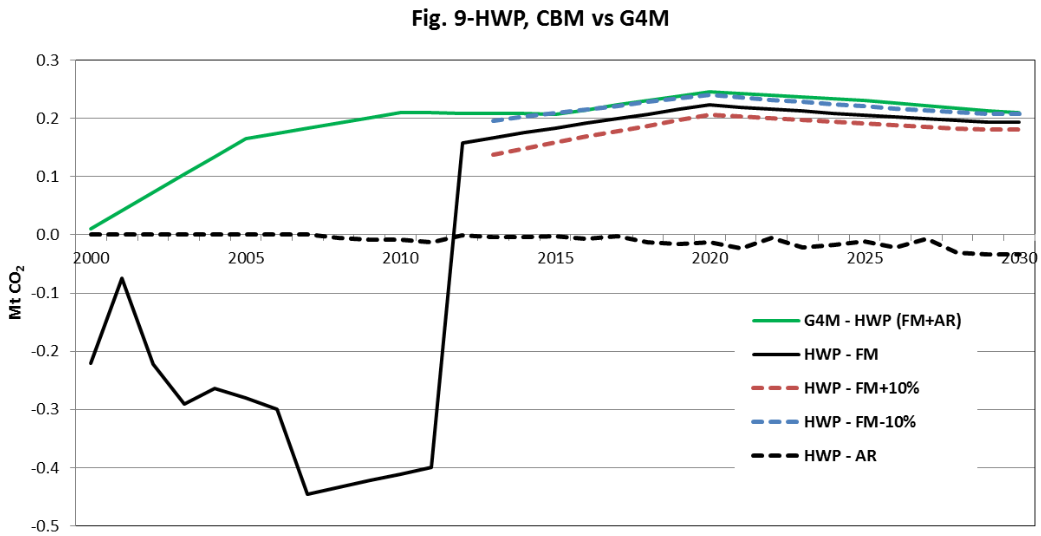
Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.



Harvested Wood Products (HWP)

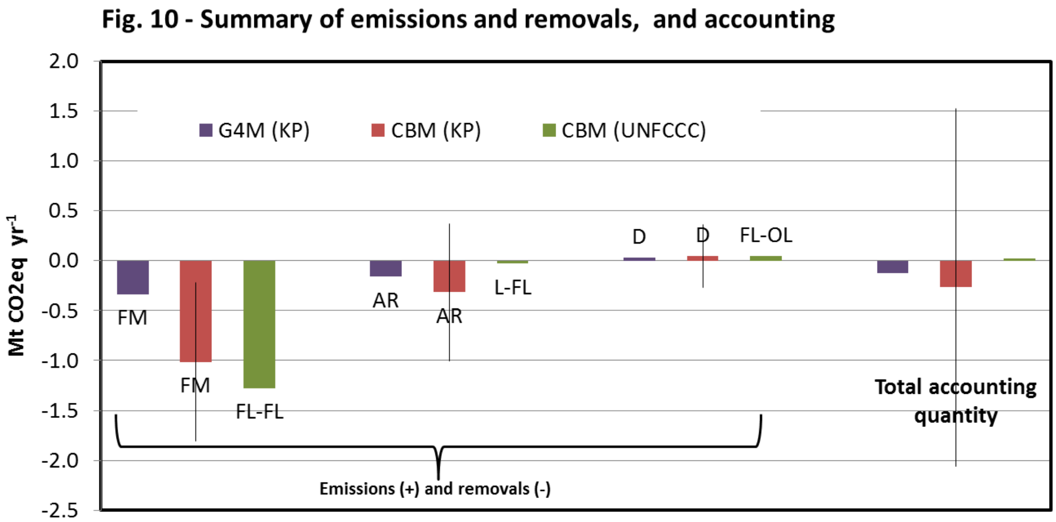
Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[174]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.



[174] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[175]; +/- 50% planting rate for AR; D/-50% D rate).



Comments on CBM run and model assumptions:

- The FM considered by G4M is considerably higher (+80% in 2000) than the FM area considered by CBM.
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[175] Based on preliminary results.

Croatia

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		2,015	2,011	2,010	2,009	2,299[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	0.2	3.8	4.8	1.5	1.1	4.8
Deforest. (D)	Area of forest conversion to other land since 1990			0.2	0.3	0.1	0.0	0.3

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.
[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

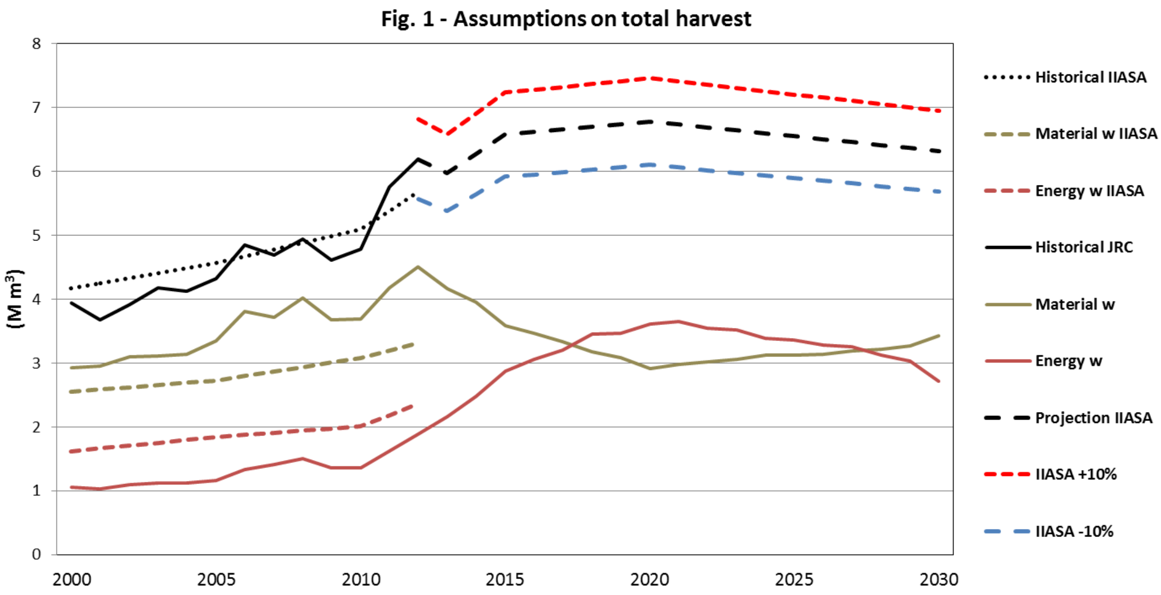
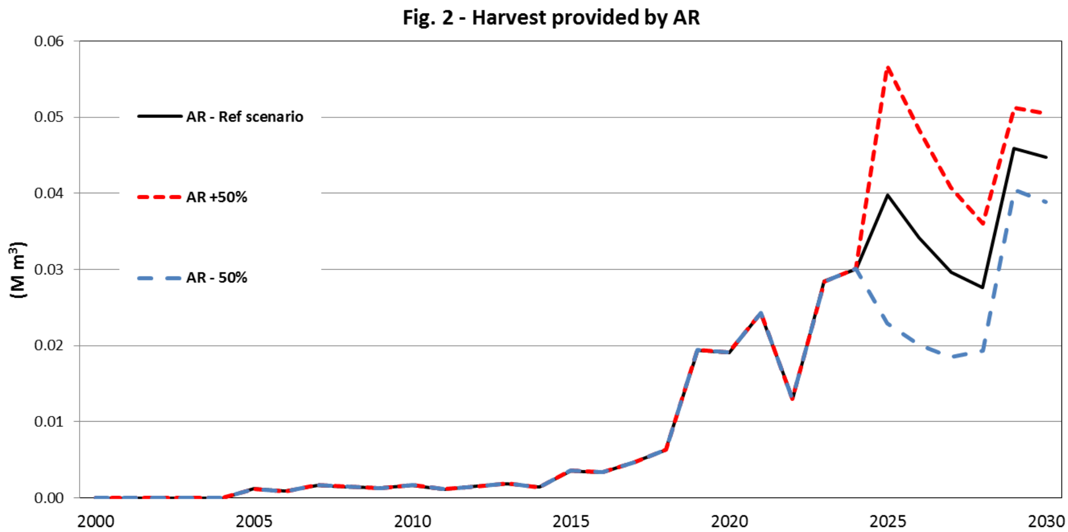


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

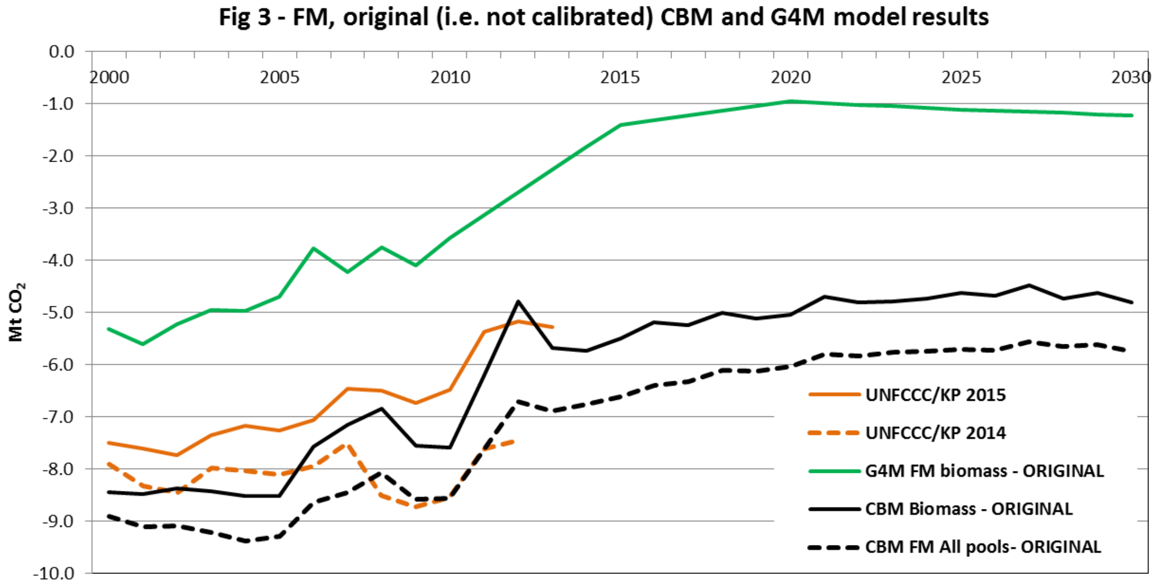
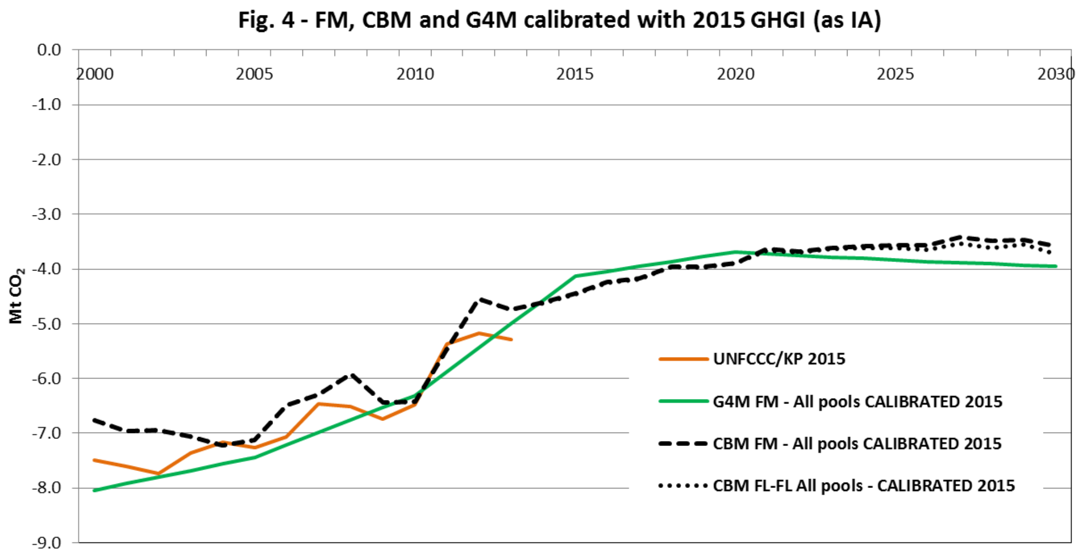


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[176] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



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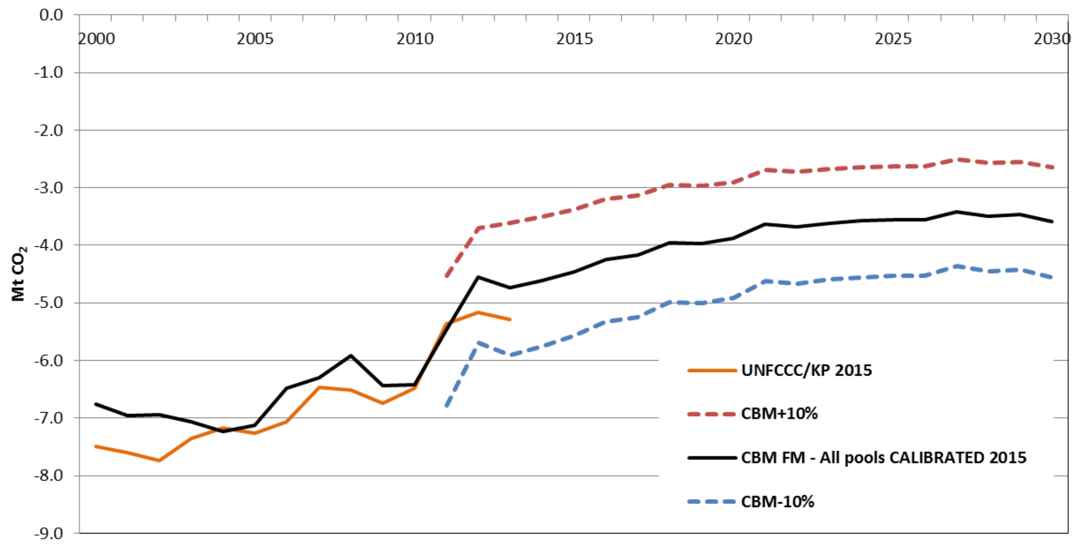
[176] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.

Fig. 5 FM, CBM (calibrated GHGI 2015) + / - 10% harvest



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

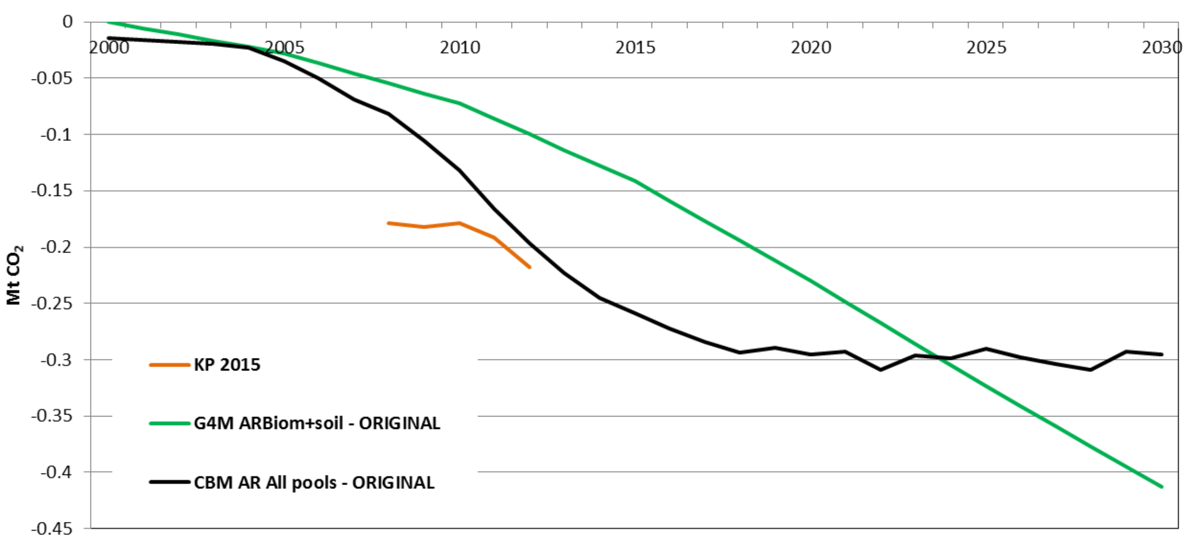
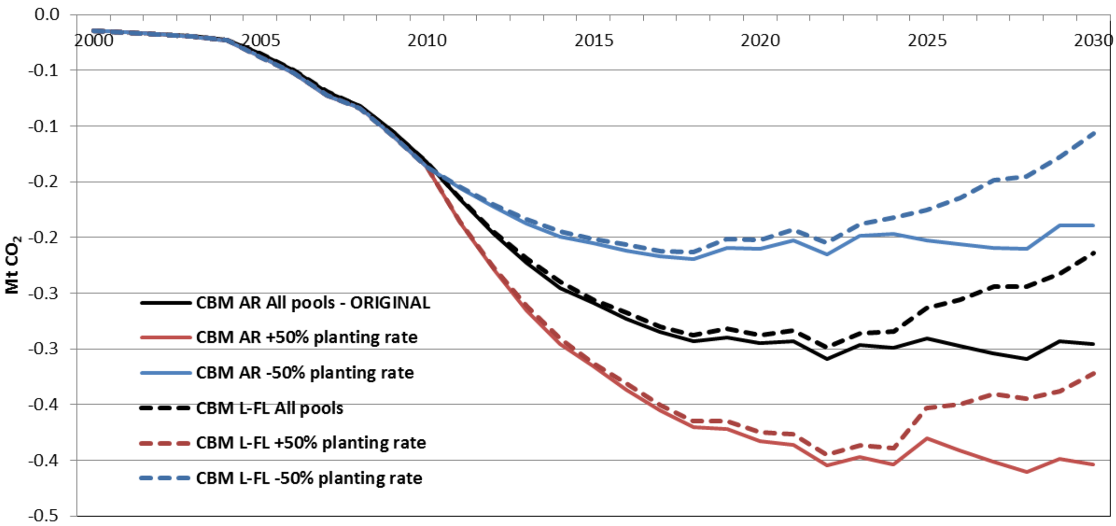


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

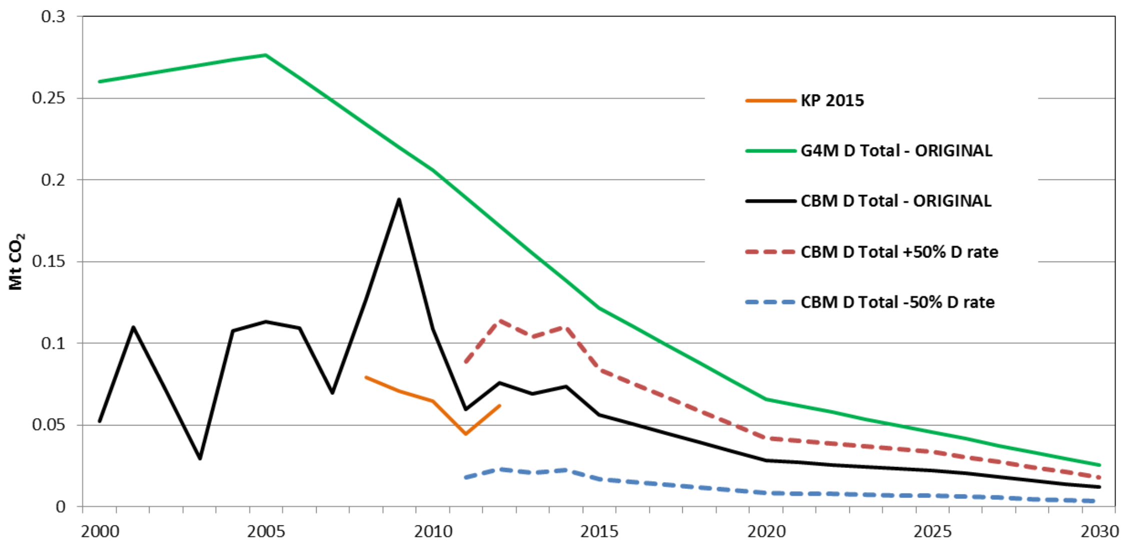
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

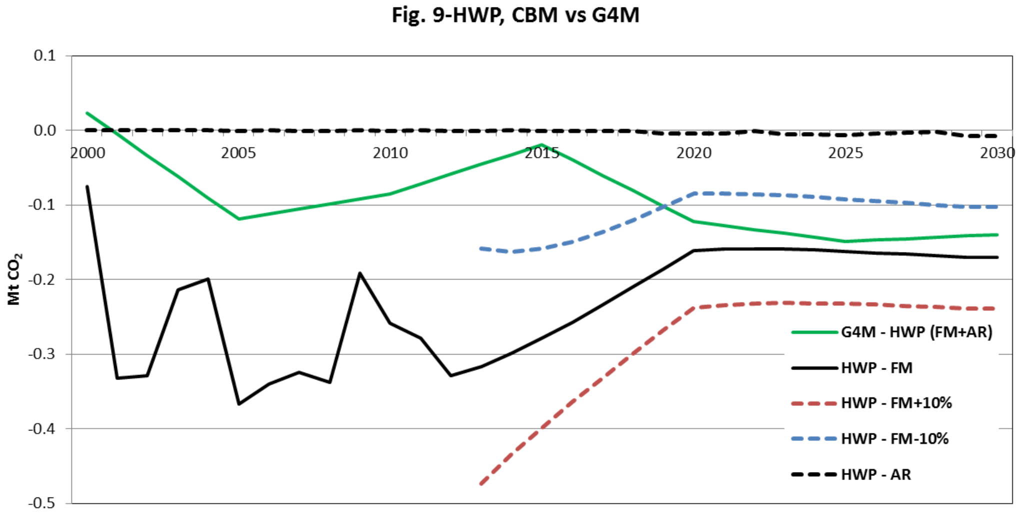
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

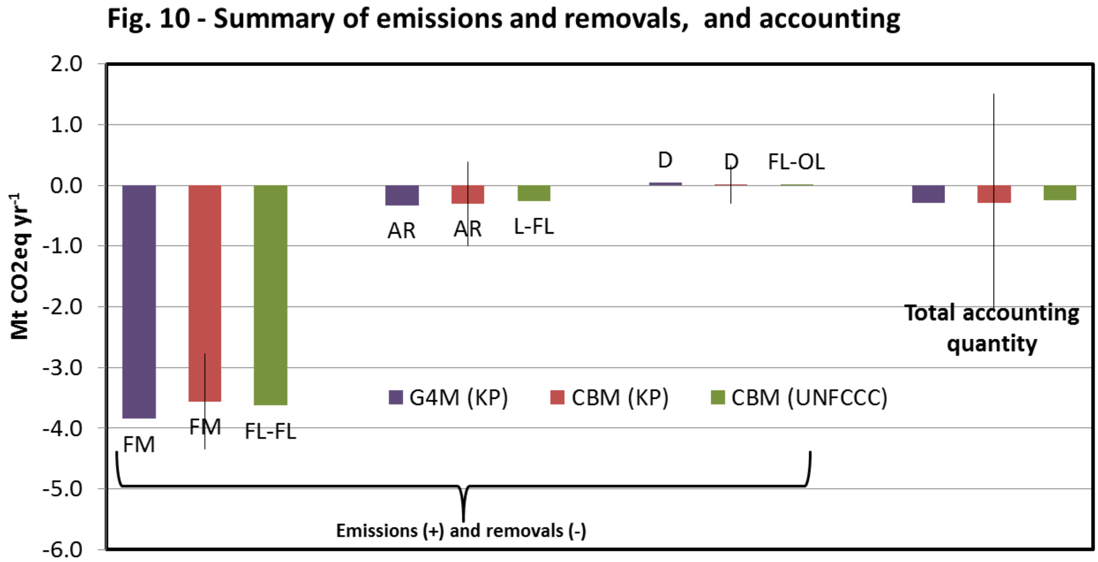
Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[177]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.



Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[178]; +/- 50% planting rate for AR; D/-50% D rate).

[177] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[178] Based on preliminary results.



Comments on CBM run and model assumptions:

- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA.

Hungary

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		1,658	1,642	1,635	1,633	1,656[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	11.4	12.4	9.4	9.5	7.8	6.3
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		1.2	2.4	0.2	0.2	0.2

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

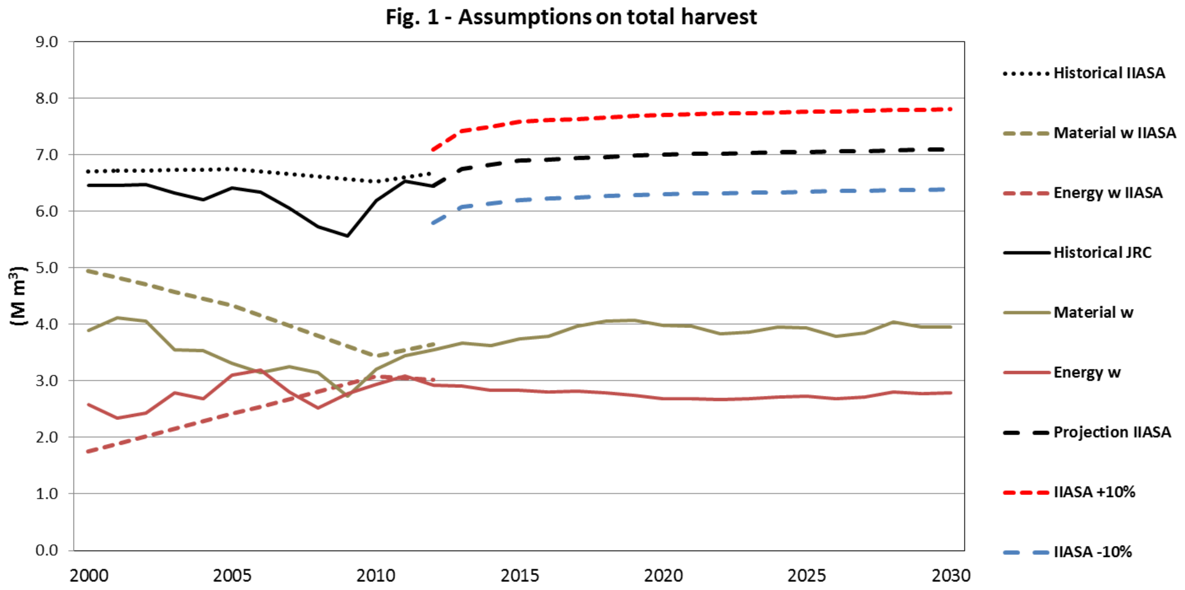
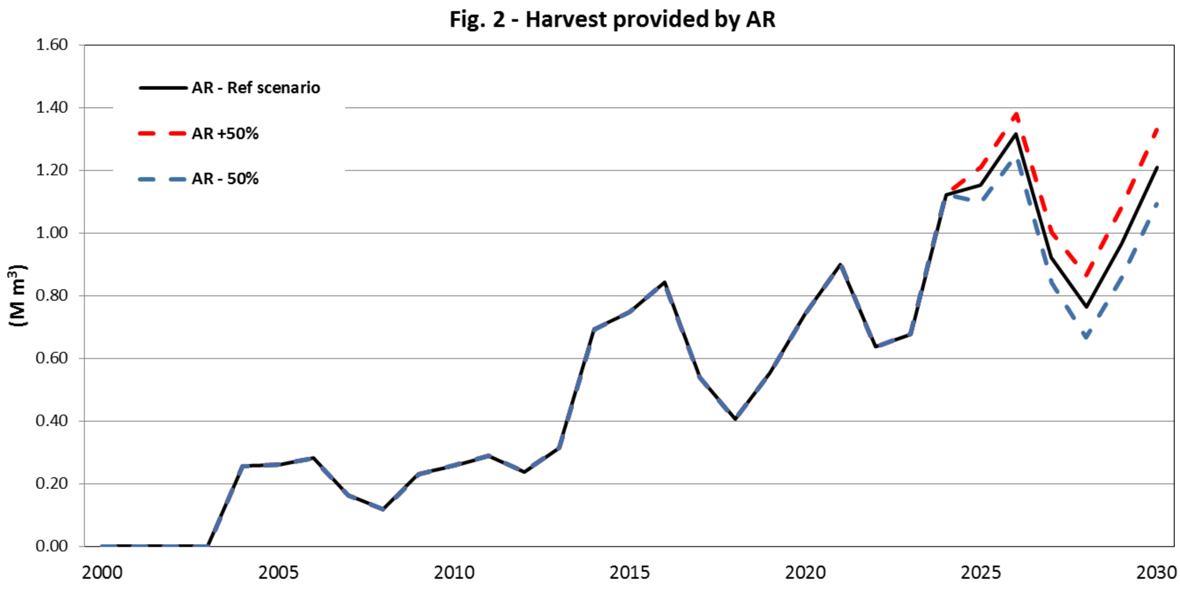


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

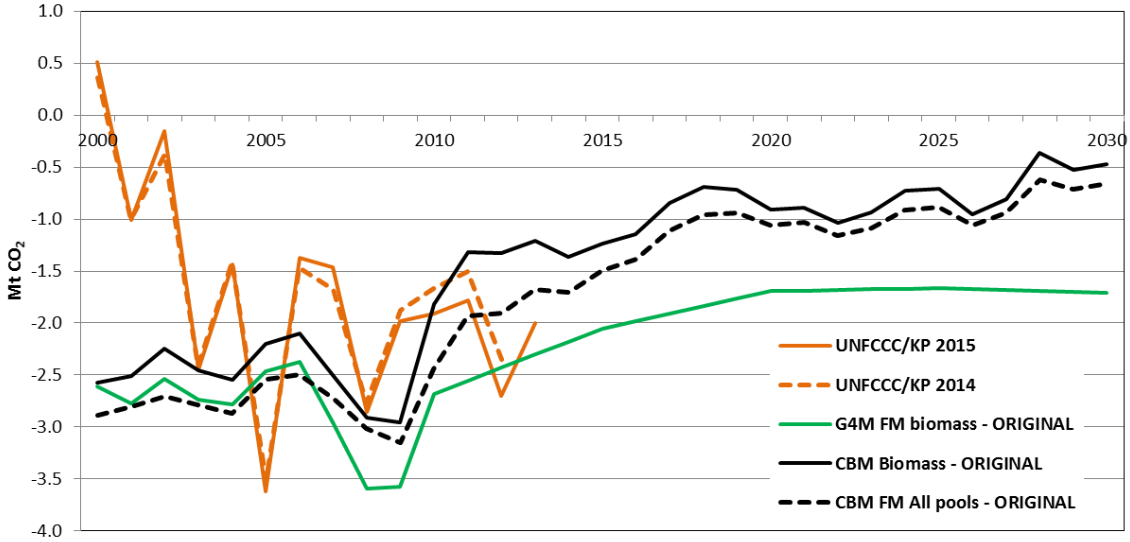


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[179] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)

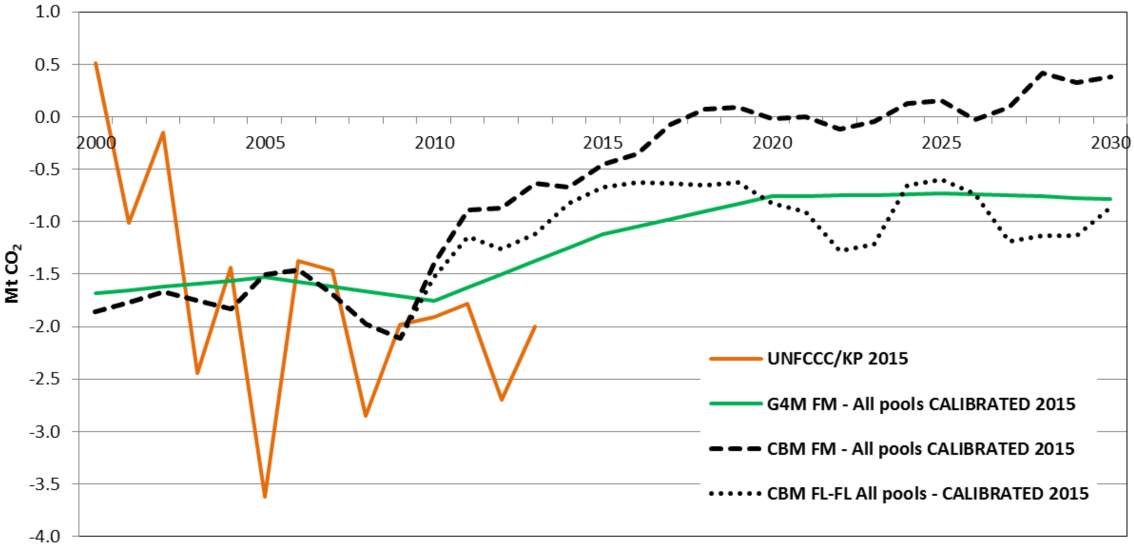
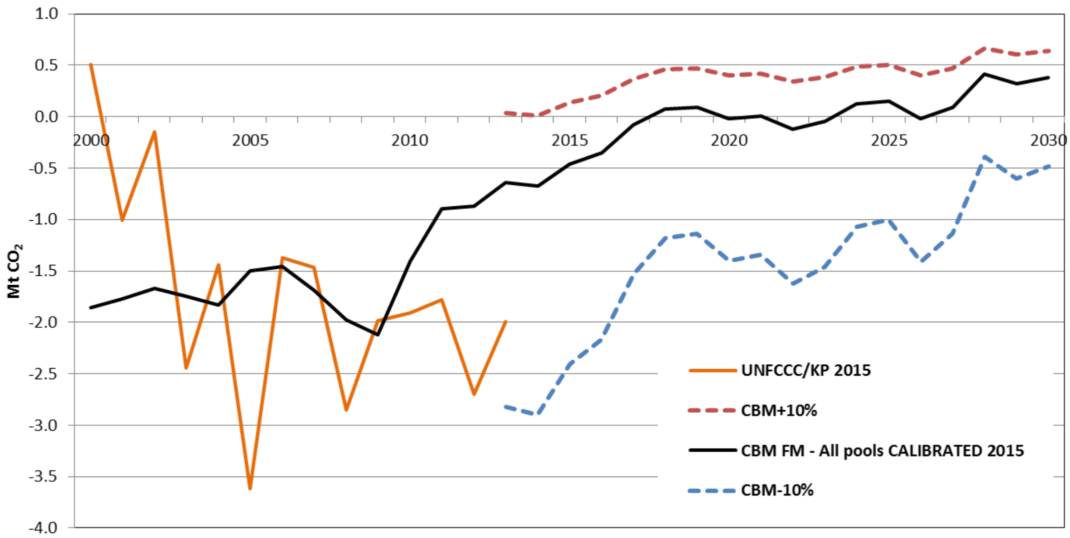


Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.

Fig. 5 FM, CBM (calibrated GHGI 2015) + / - 10% harvest



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[179] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

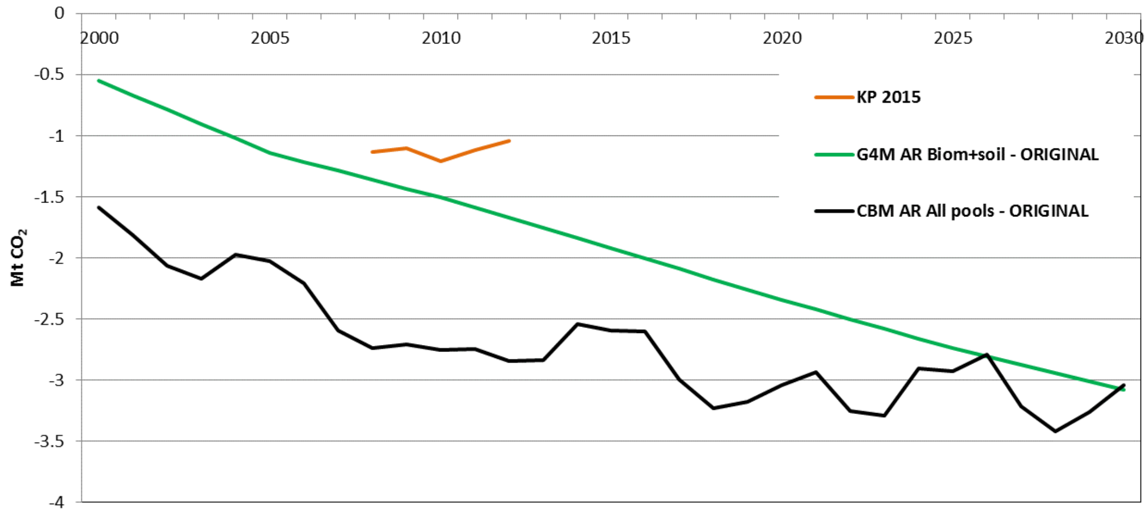
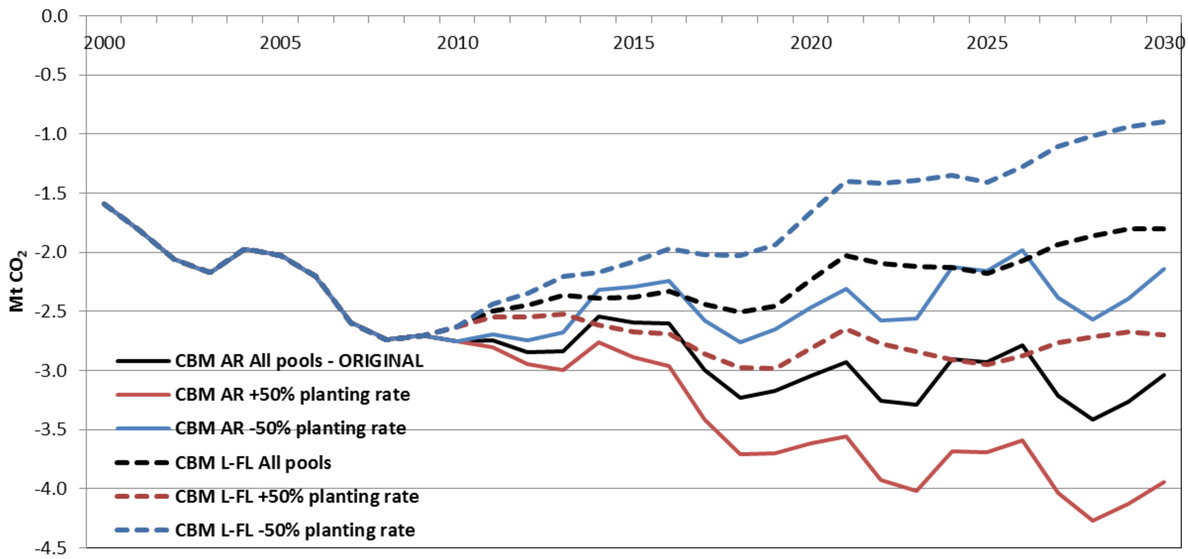


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

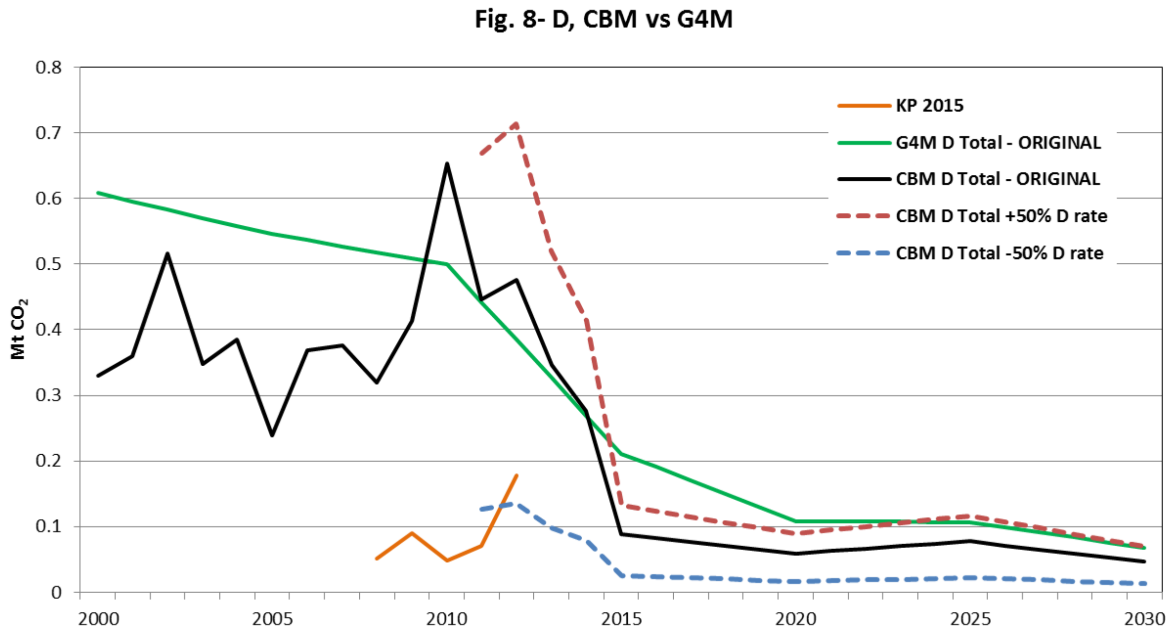
(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



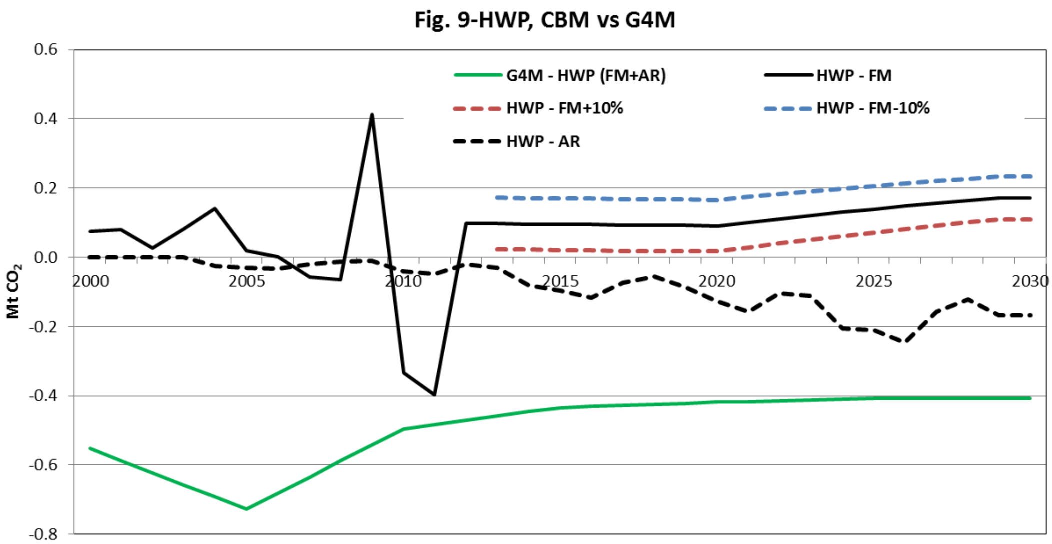
Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[180]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

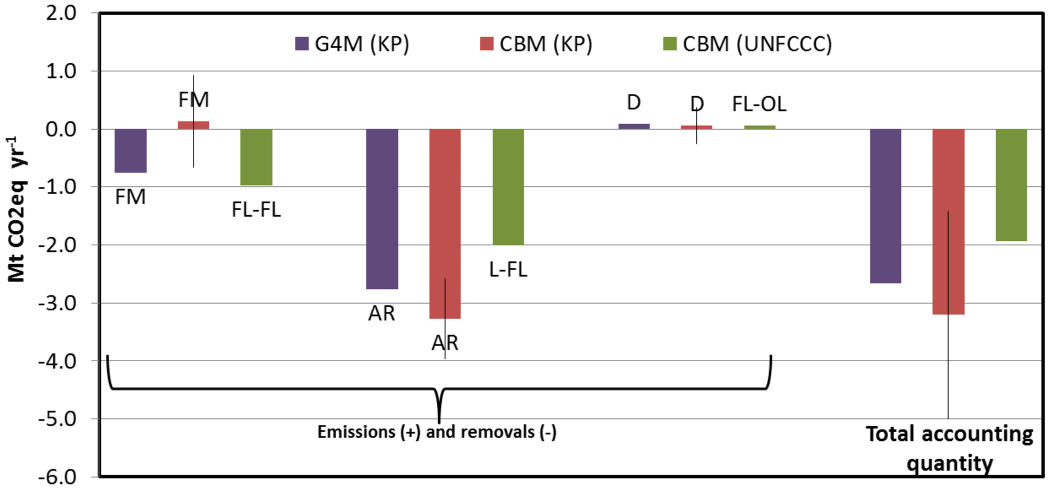


[180] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[181]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The FM C sink estimated by the models for the historical period is similar, but it is not consistent with the trend reported by the GHGI, above all before 2005 (see Fig. 3). Between 2009 and 2012, however, CBM estimates a stronger reduction of the FM C, compared with G4M, due to different assumptions on the historical amount of harvest (see Fig. 1). This also affect the future C sink estimated by the two models.
- The future harvest demand expected by IIASA is satisfied, but CBM estimates a C source in 2030, while G4M estimates
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

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[181] Based on preliminary results.

Ireland

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		449	437	430	425	451[FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	16.9	4.6	8.3	13.5	14.6	8.3
Deforest. (D)	Area of forest conversion to other land since 1990			0.9	0.8	0.5	0.4	0.8

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). For Ireland, this amount includes the harvest provided by FM and AR, reported in Fig. 2).

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

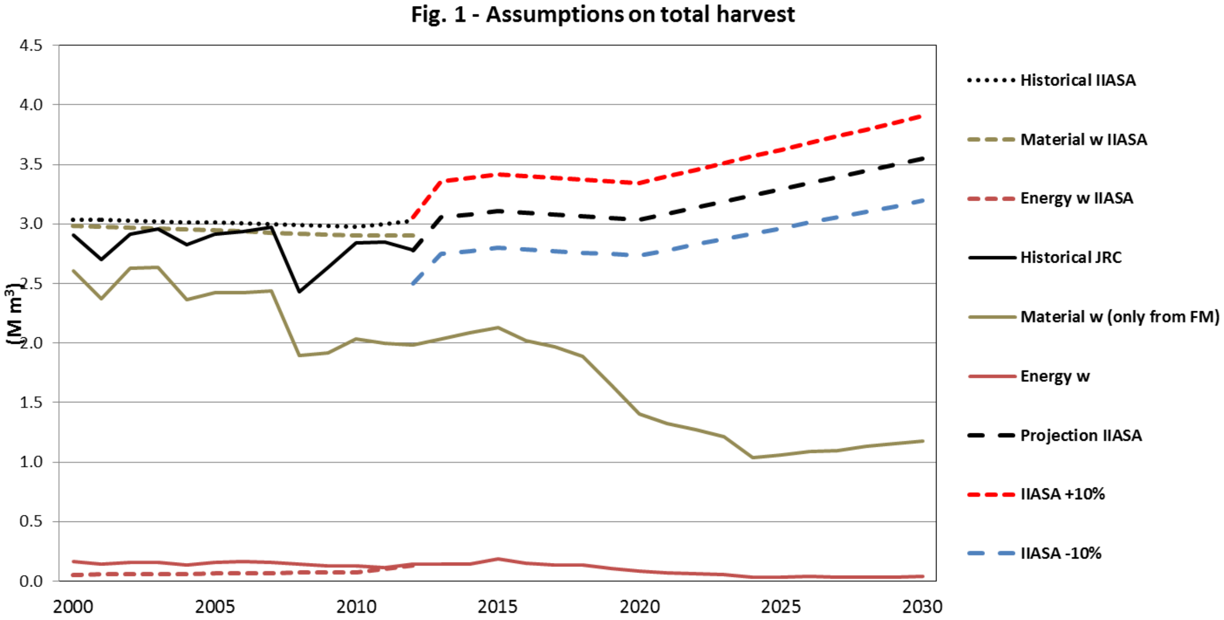
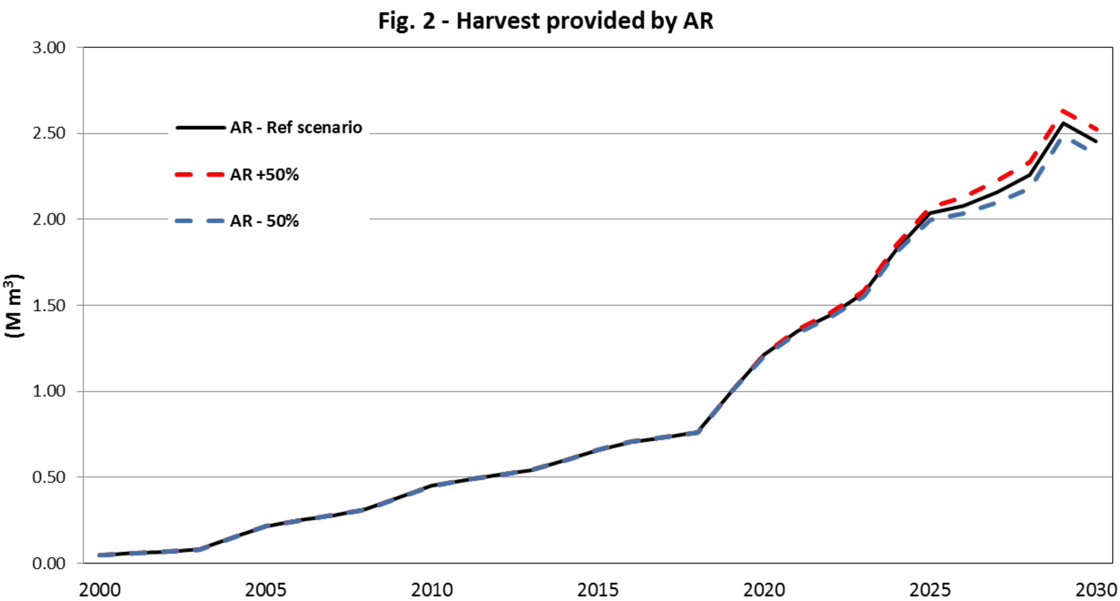


Fig. 2 reports the amount of total harvest potentially provided by AR. For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

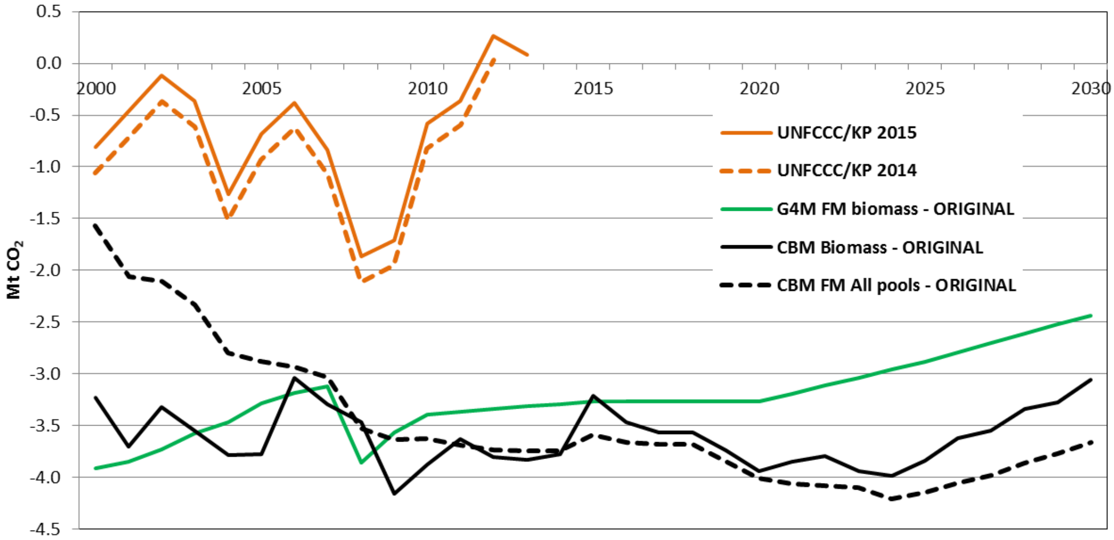


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[182] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

[182] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)

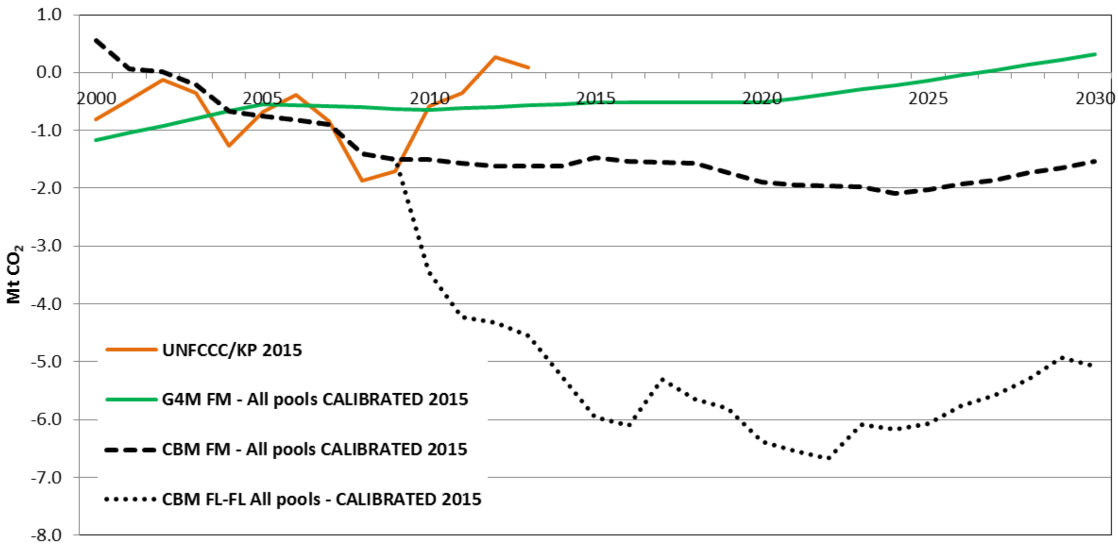
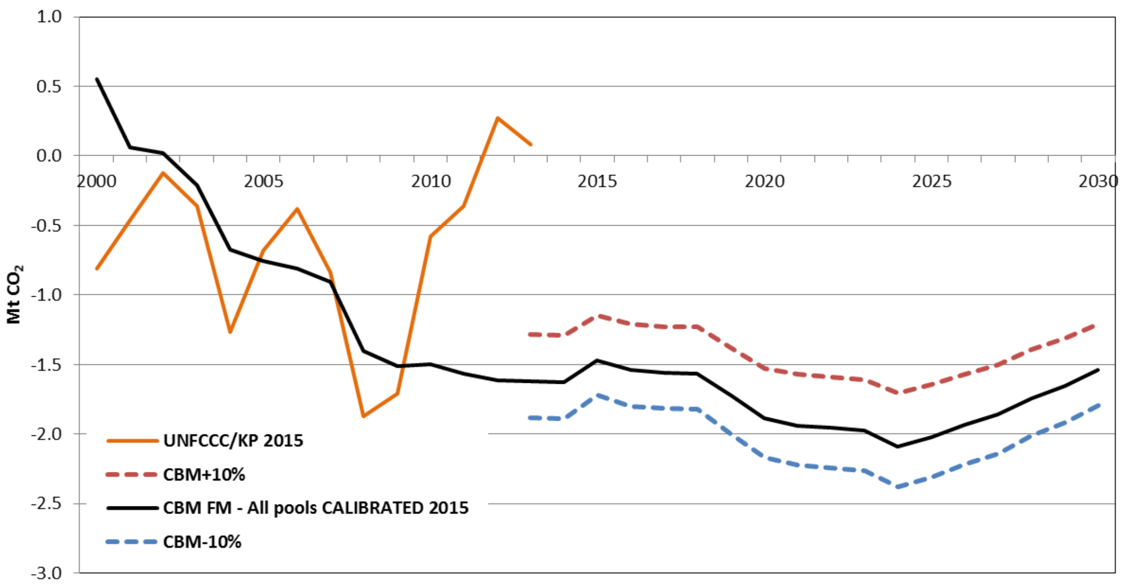


Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.

Fig. 5 FM, CBM (calibrated GHGI 2015) + / - 10% harvest



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

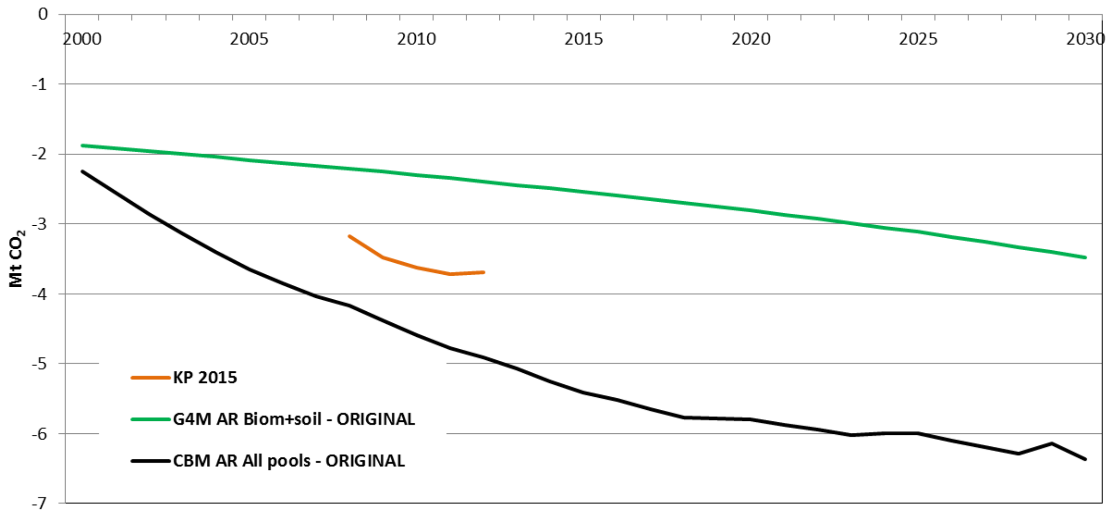
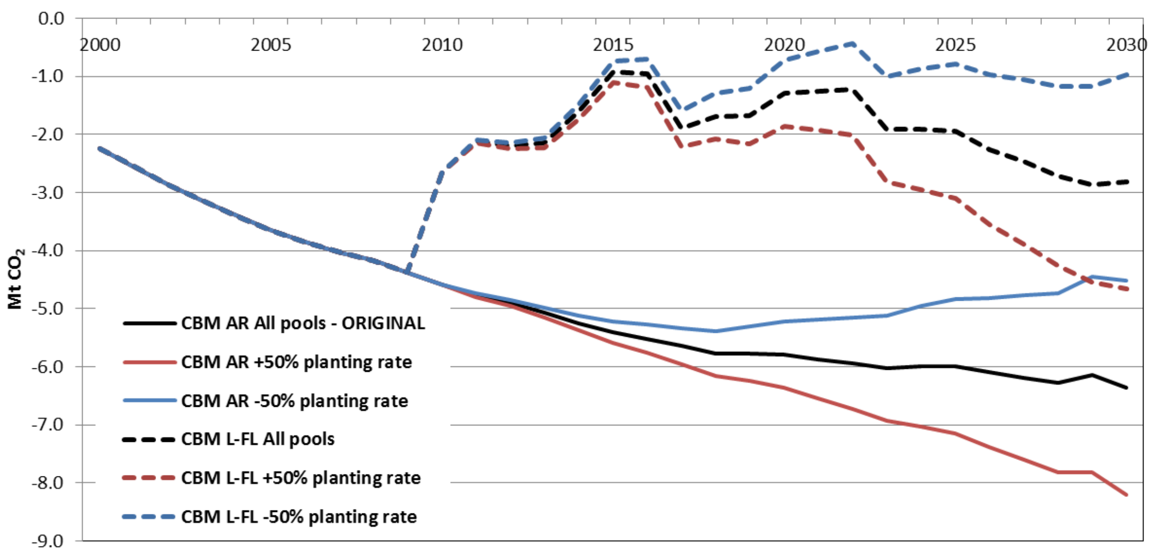


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

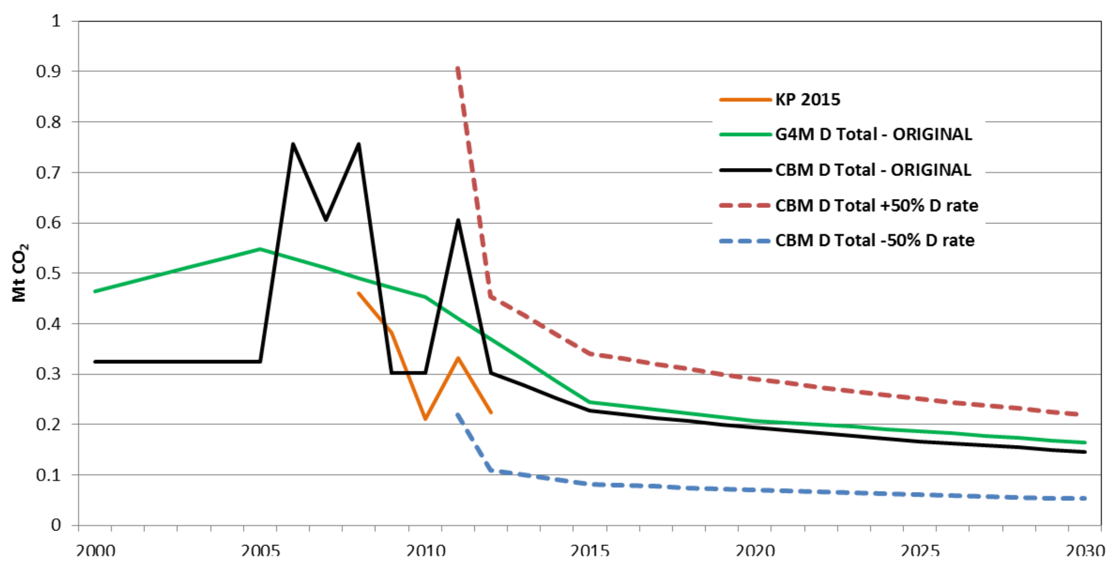
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

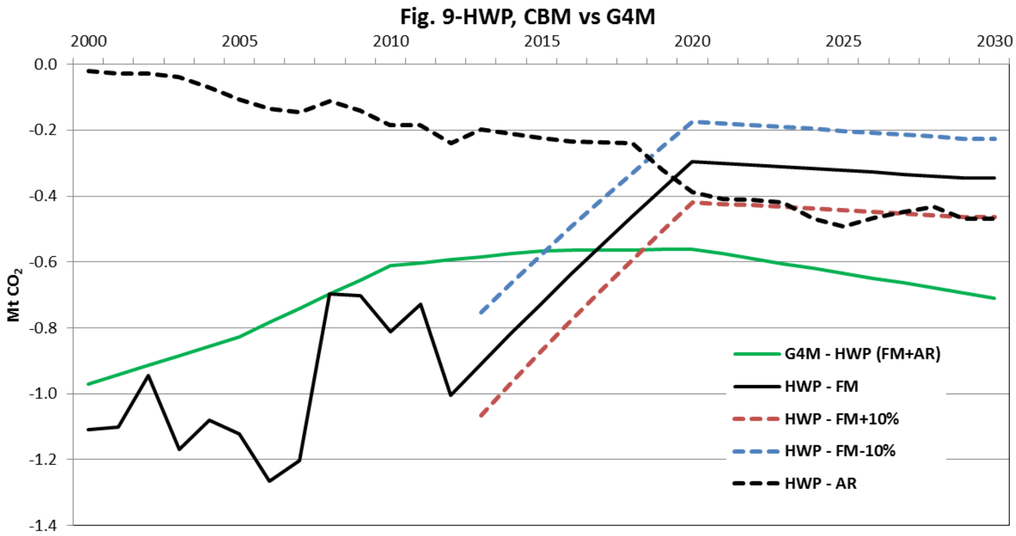
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[183]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

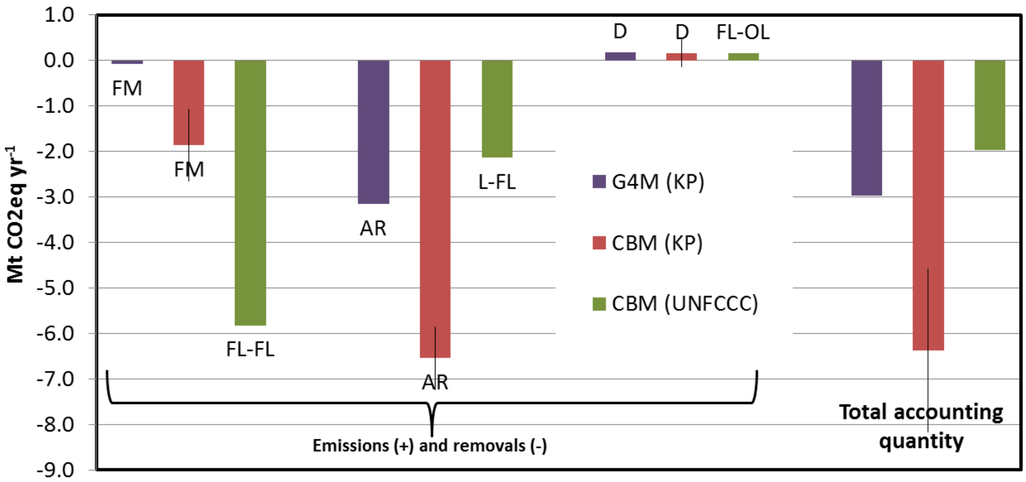


Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[184]; +/- 50% planting rate for AR; D/-50% D rate).

[183] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[184] Based on preliminary results.

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- For IE, considering the information provided by the country, we even considered the harvest potential provided by AR (i.e., the harvest expected by FM is the difference between the future total harvest expected by IIASA minus the harvest provided by AR, as reported in Fig. 2).
- The future harvest demand expected by IIASA is satisfied, but the future harvest provided by FM was reduced, in order to not exceed the harvest expected by IIASA. Of course, this affect the future C sink estimated by CBM both for FM and for FL-FL (see Fig. 3 and Fig. 4).
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW).

Italy

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		7,565	7,525	7,503	7,500	7,479[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	74.8	103.2	54.4	33.5	22.4	58.3
Deforest. (D)	Area of forest conversion to other land since 1990			2.7	8.1	0.3	0.4	3.7

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.
[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

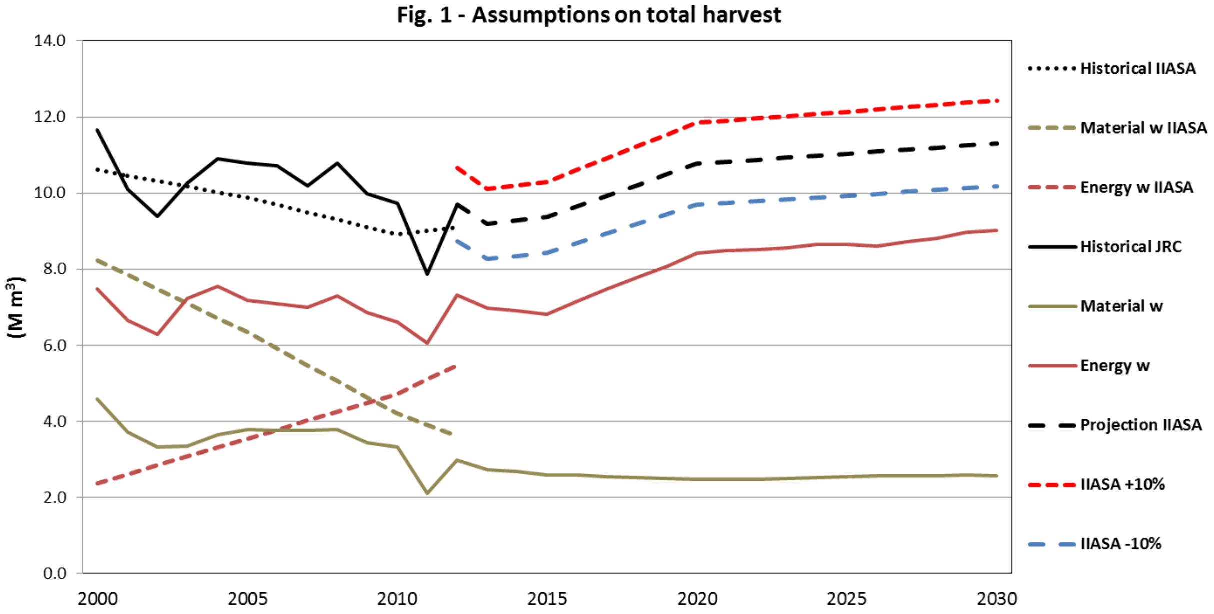
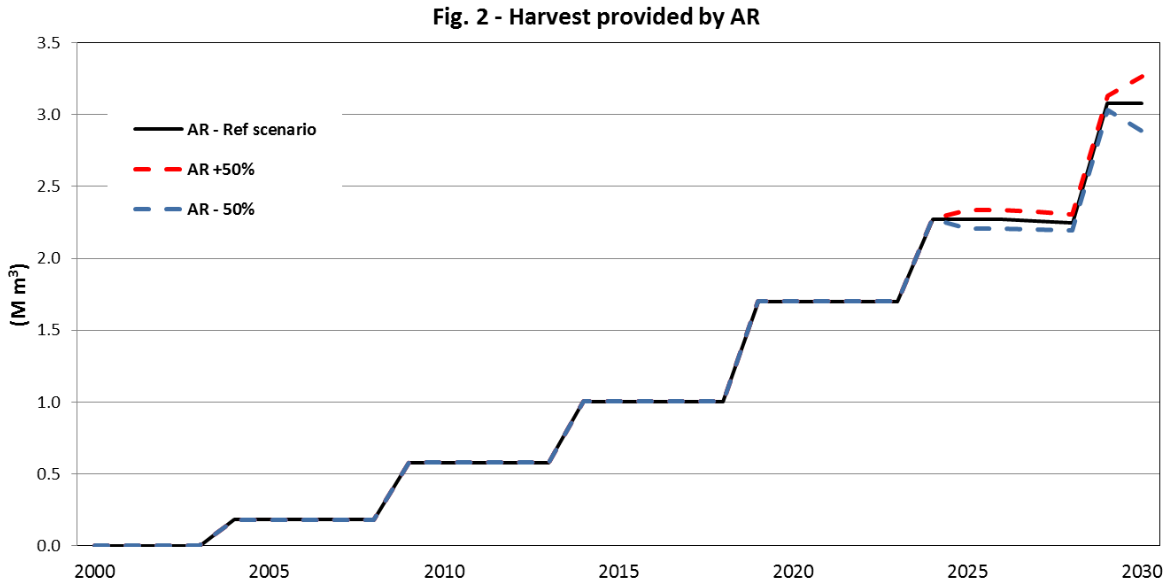


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

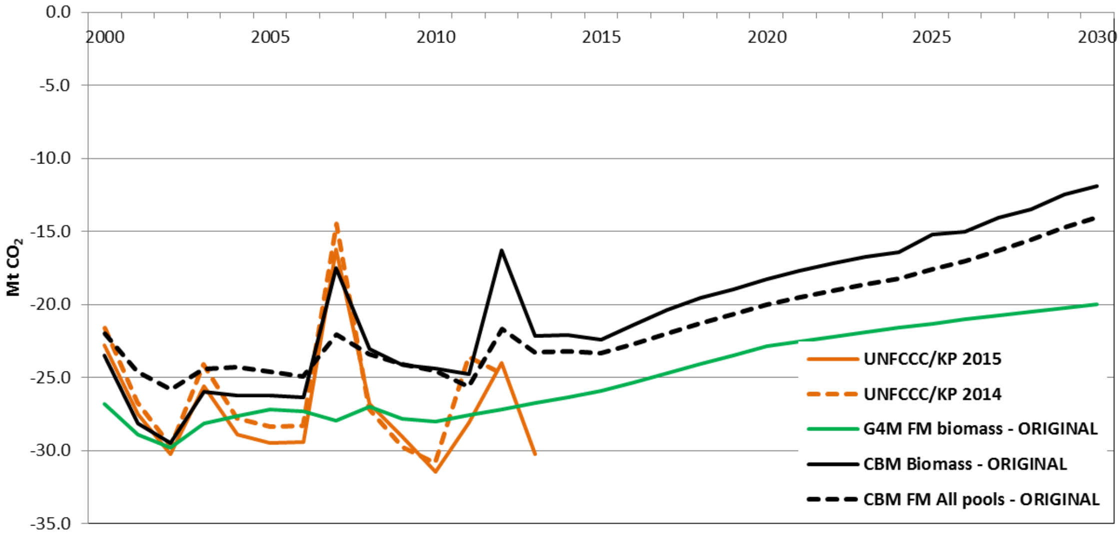
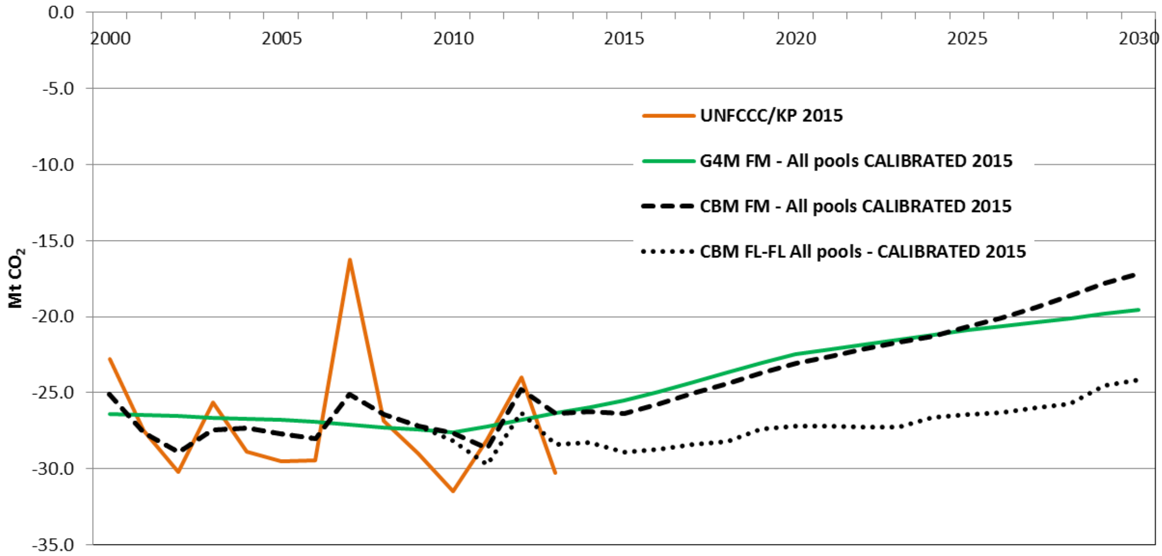


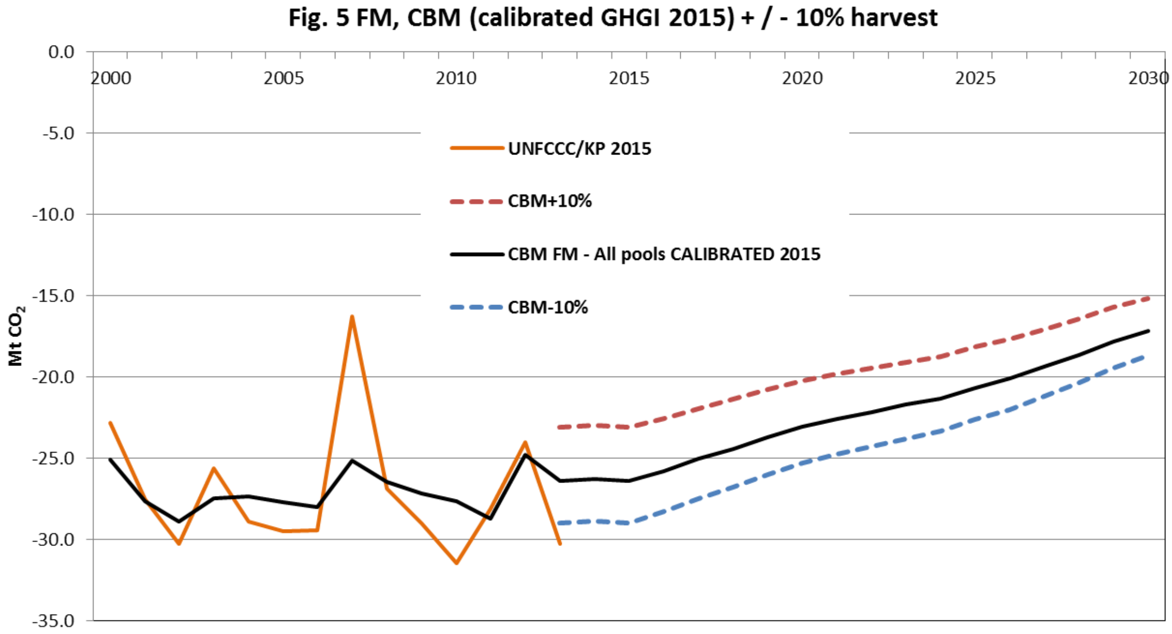
Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[185] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)



[185] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the <u>preliminary results</u> on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

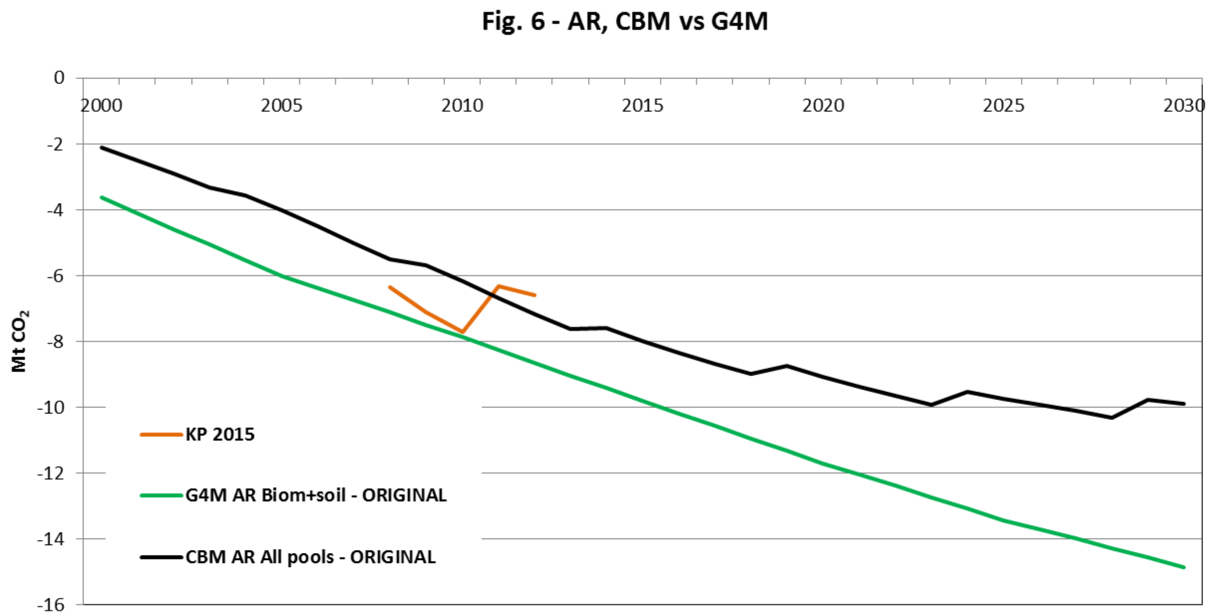
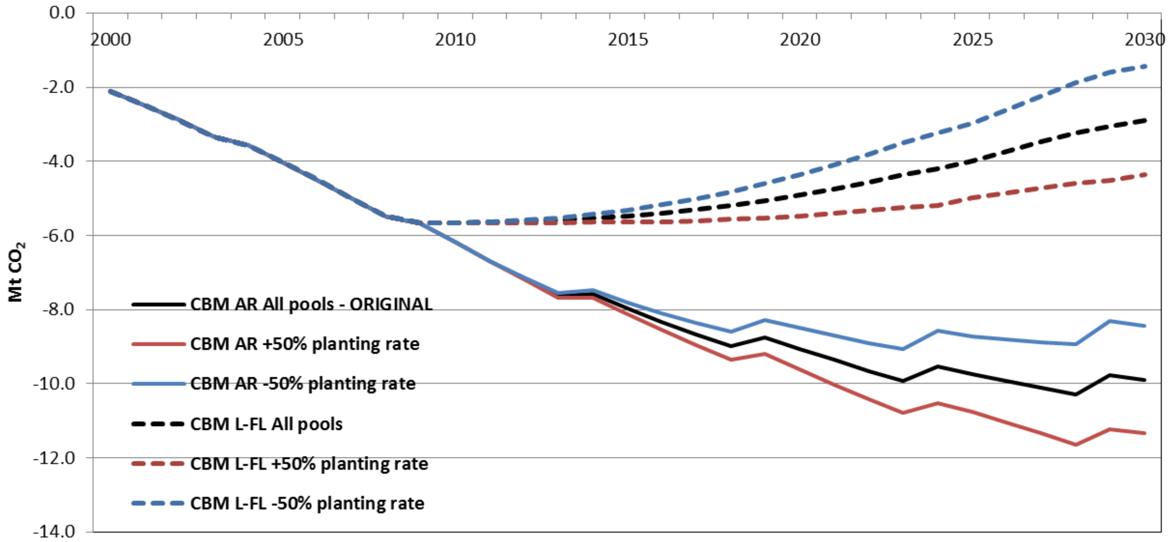


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

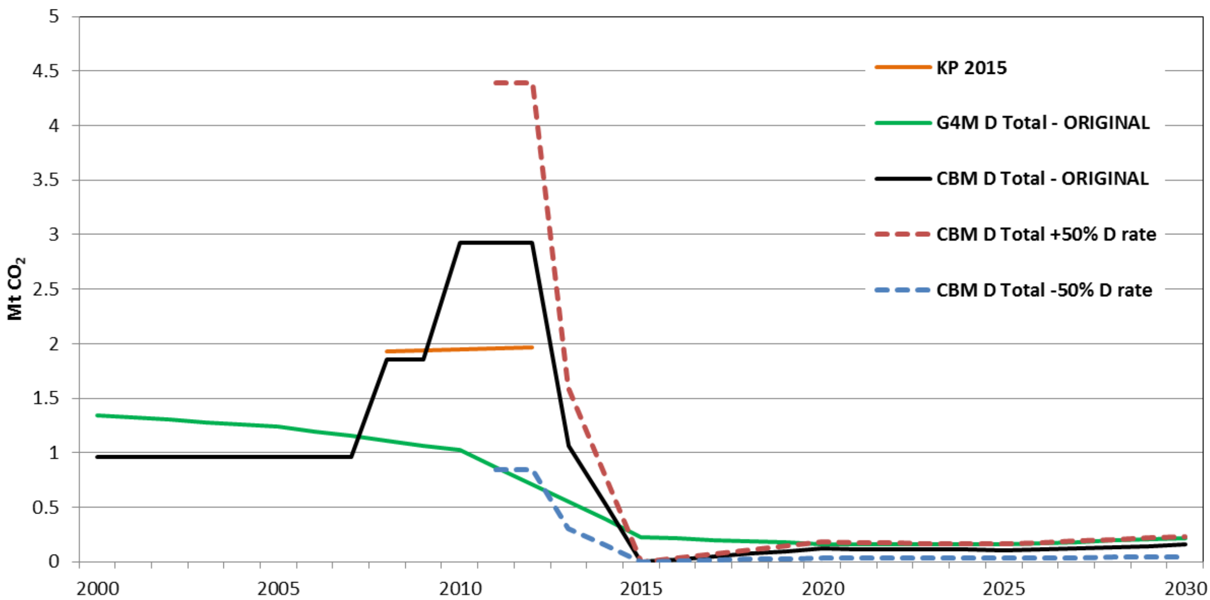
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

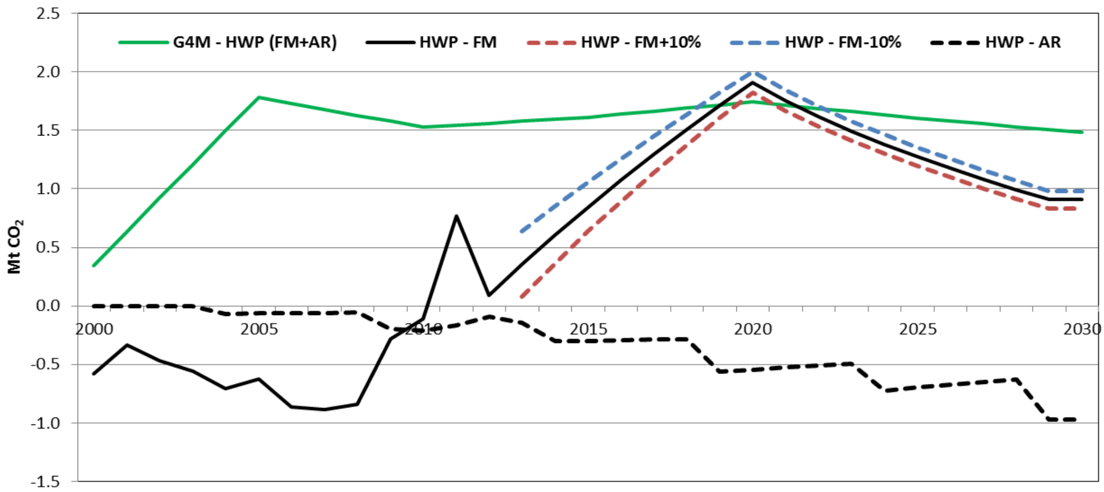
Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[186]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

Fig. 9-HWP, CBM vs G4M



Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[187]; +/- 50% planting rate for AR; D/-50% D rate).

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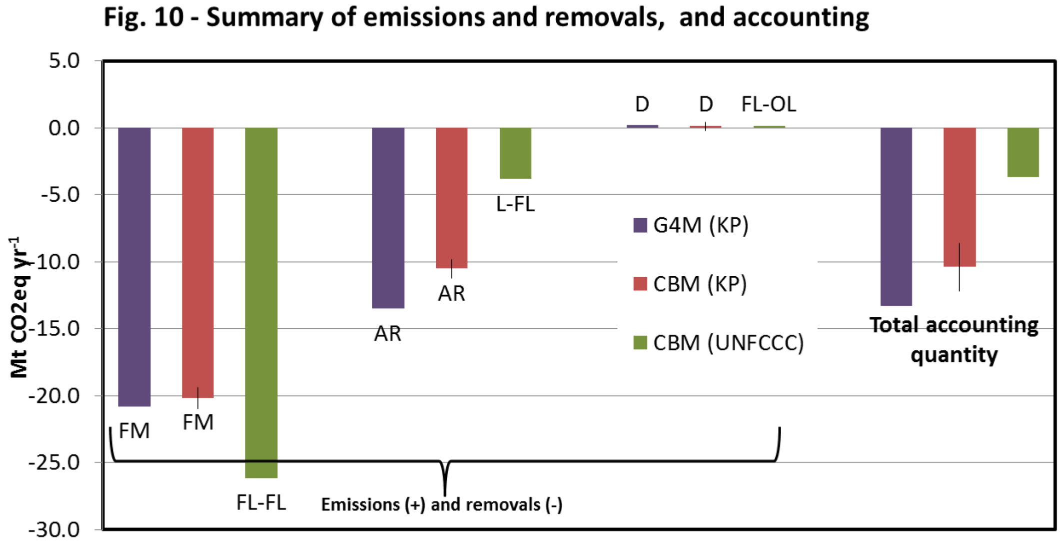
[186] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[187] Based on preliminary results.



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by the models is similar and is consistent with the GHGI data (see Fig. 3).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

Lithuania

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		1,999	1,997	1,996	1,995	2,141[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	4.7	6.0	6.4	7.2	7.5	4.7
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		0.0	0.0	0.1	0.0	0.1

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

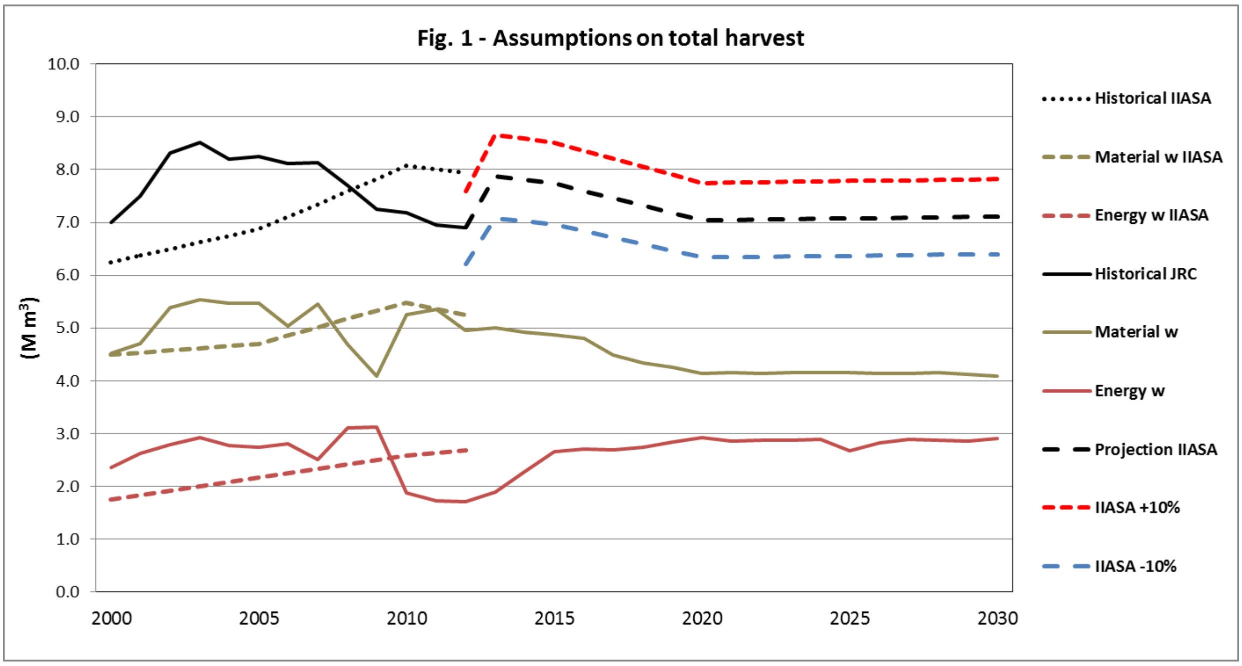
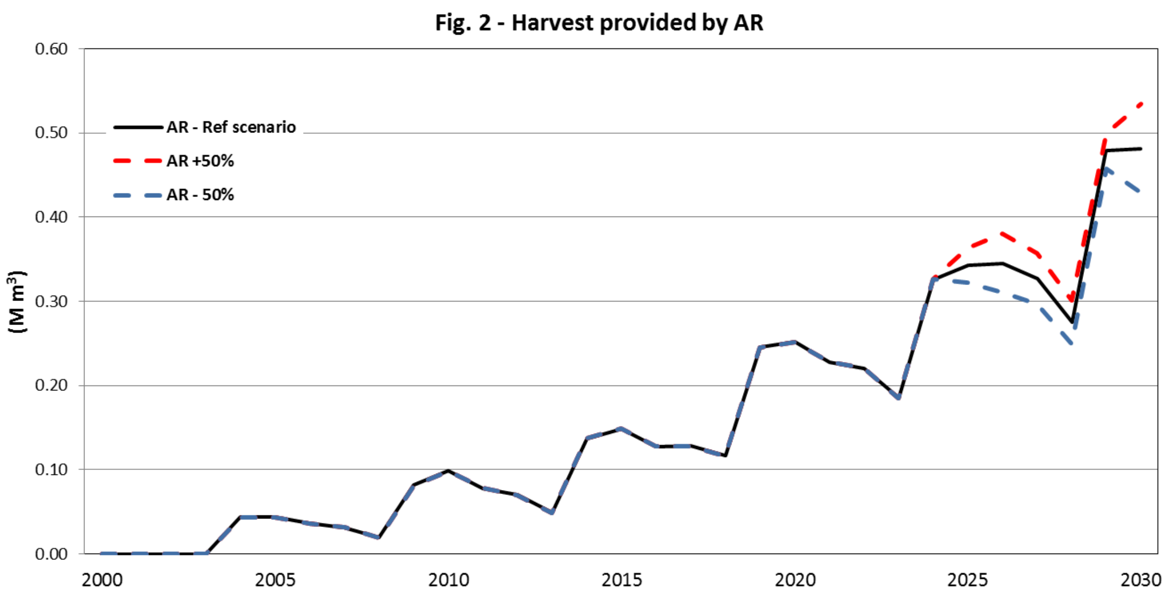


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

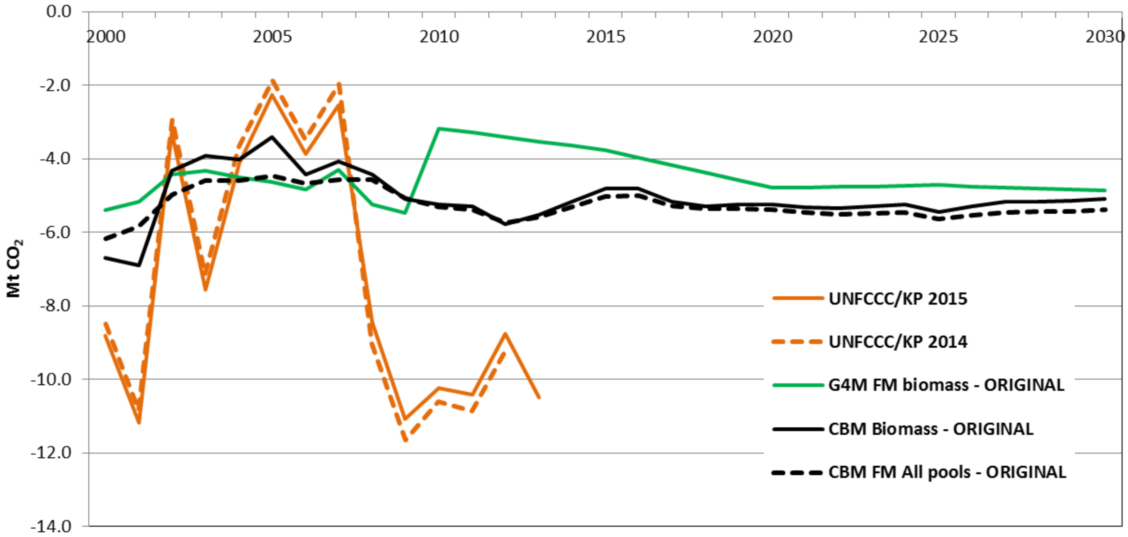
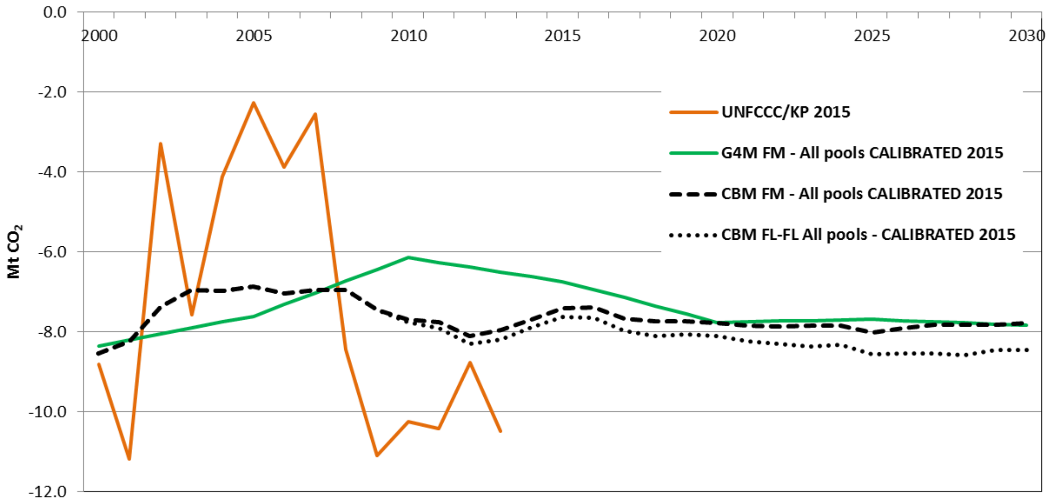


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[188] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)



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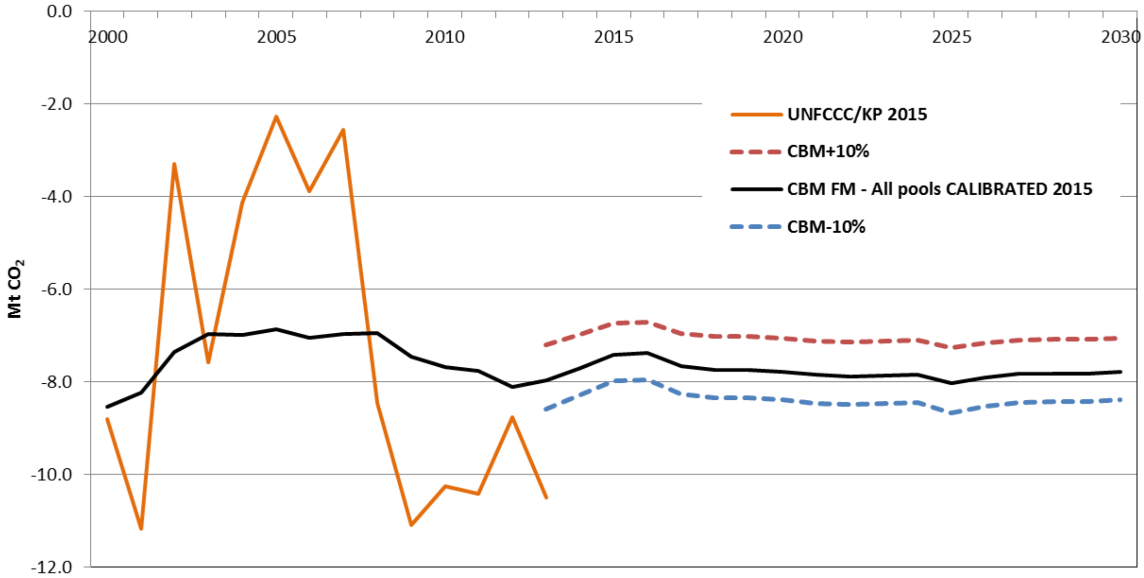
188 Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.

Fig. 5 FM, CBM (calibrated GHGI 2015) + / - 10% harvest



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

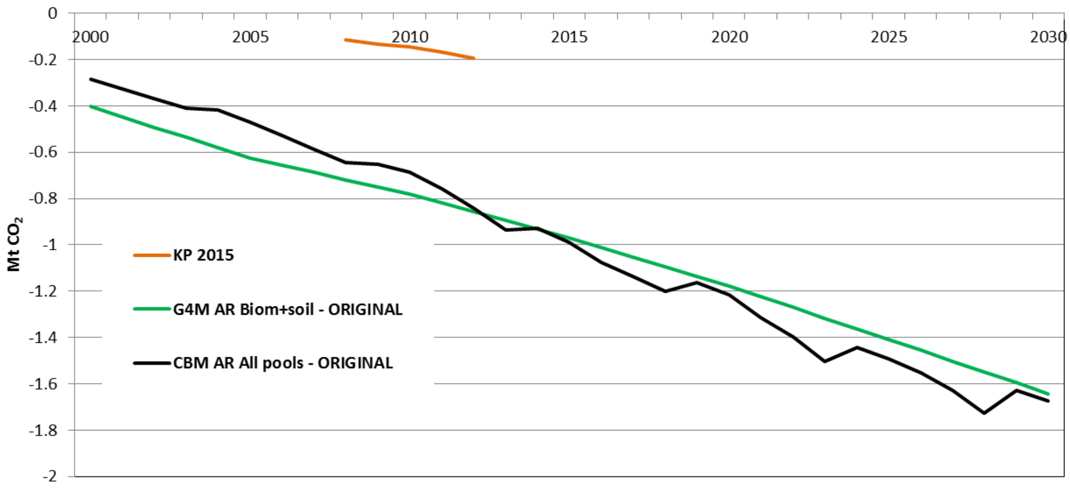
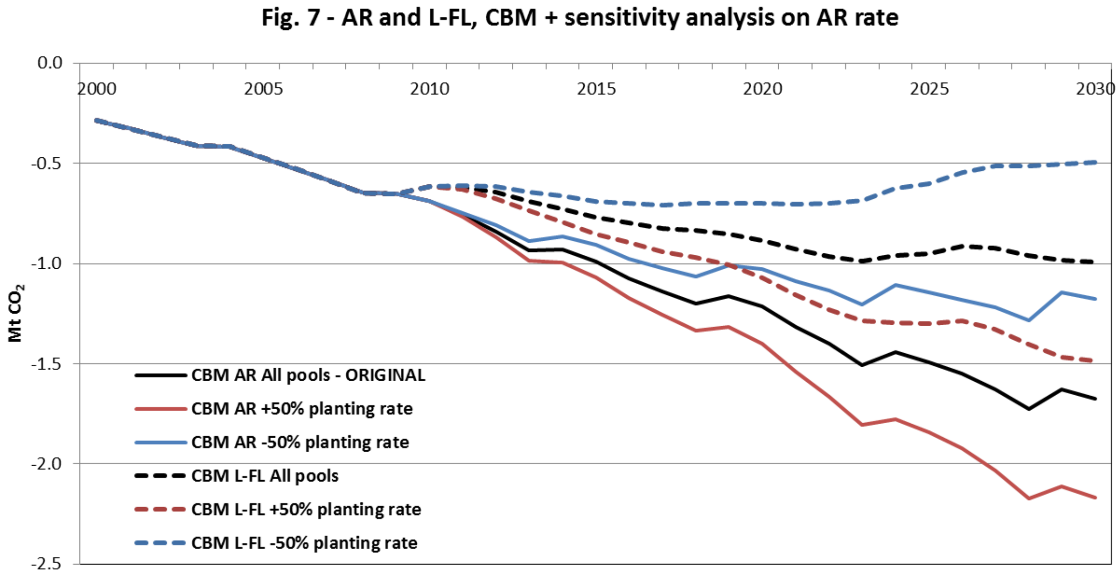


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

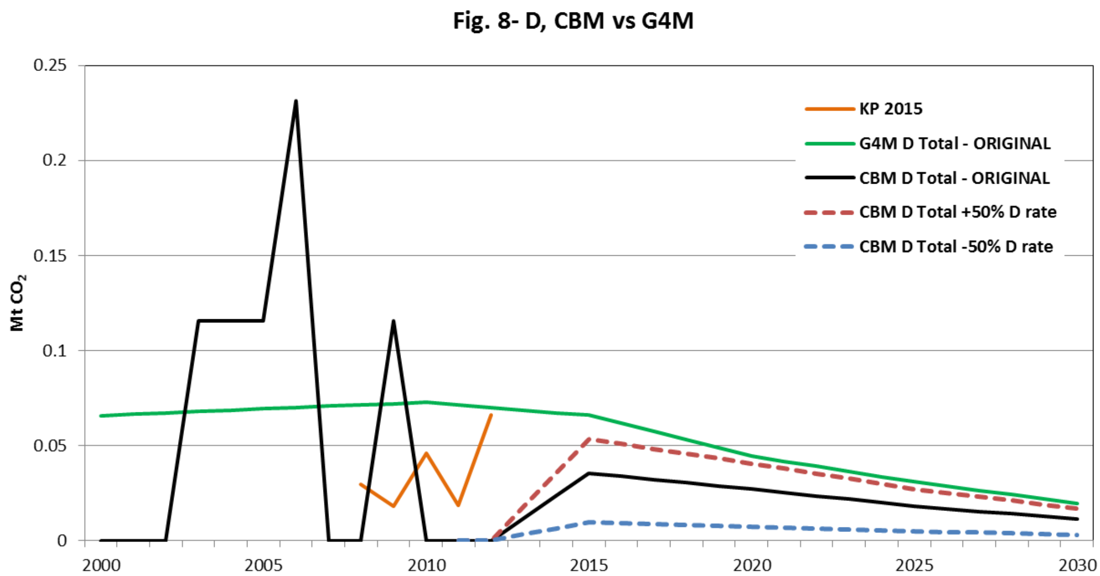
(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.



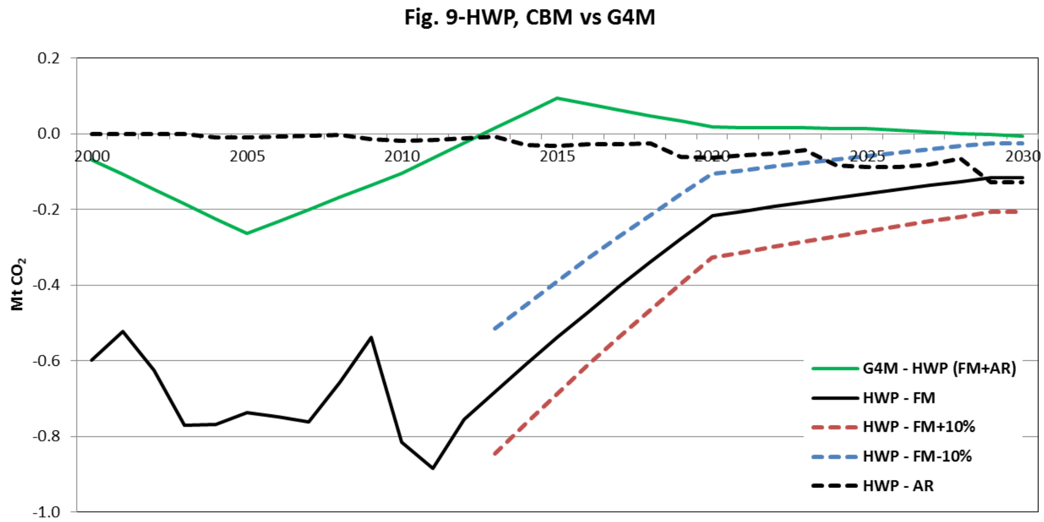
Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.



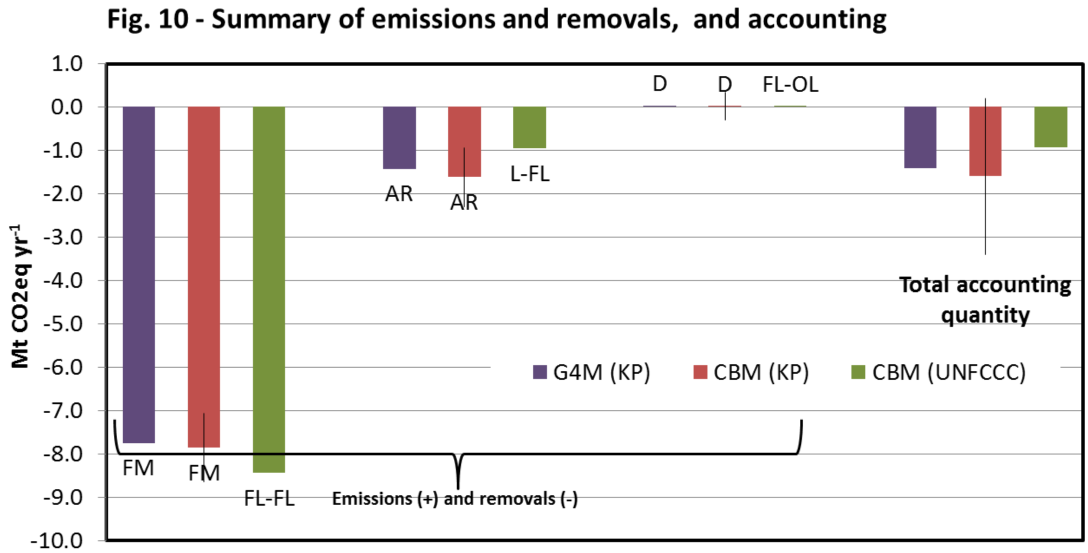
Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[189]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.



Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[190]; +/- 50% planting rate for AR; D/-50% D rate).



[189] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[190] Based on preliminary results.

Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM is similar to the estimate provided by G4M (i.e., has the same trend and level). Compared with the 2015 GHGI, both the models estimate a lower inter-annual variability, probably due to the effect of some natural disturbance event, not considered by the models (see Fig. 3).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

Luxemburg

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		89	85	81	79	86[FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	0.4	0.3	0.4	0.3	0.3	0.1
Deforest. (D)	Area of forest conversion to other land since 1990			0.3	0.3	0.4	0.2	0.0

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA)**, further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**).**
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

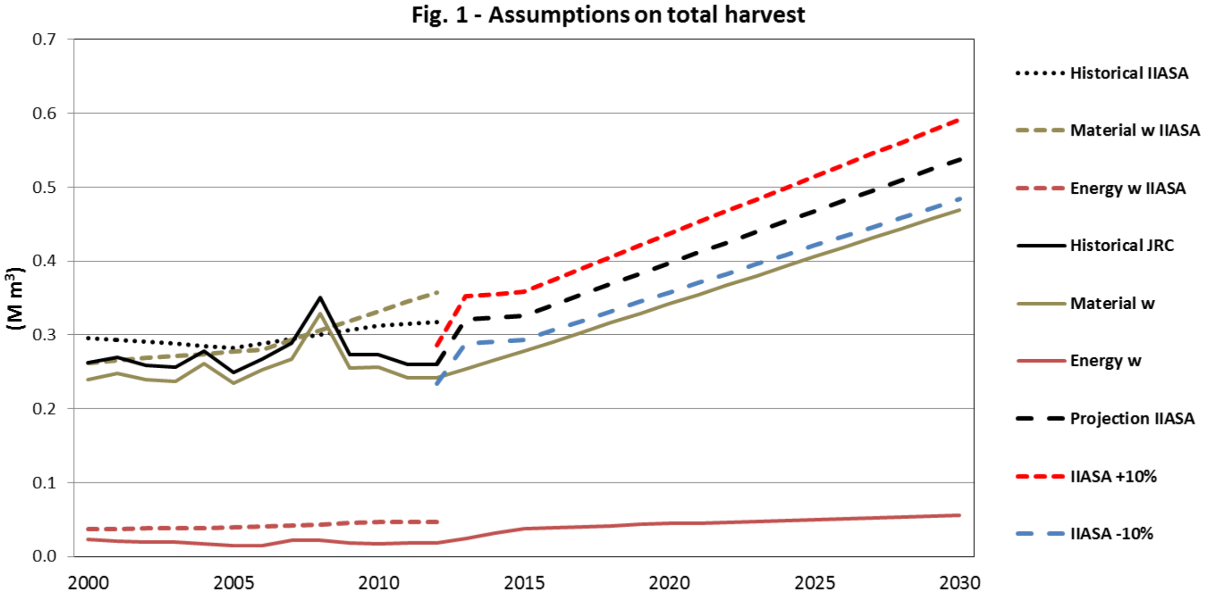
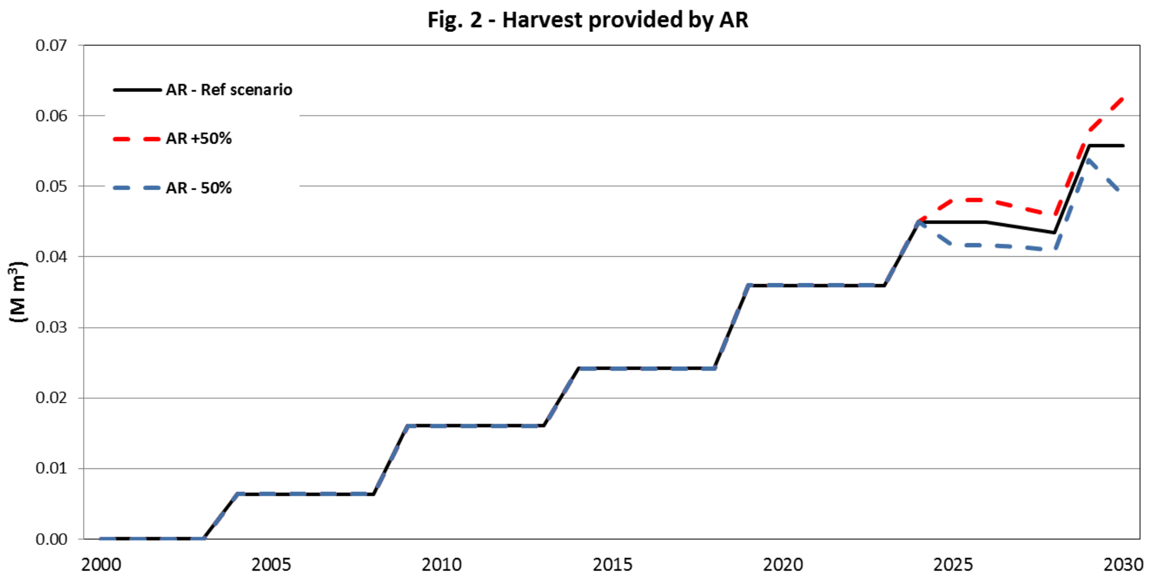


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

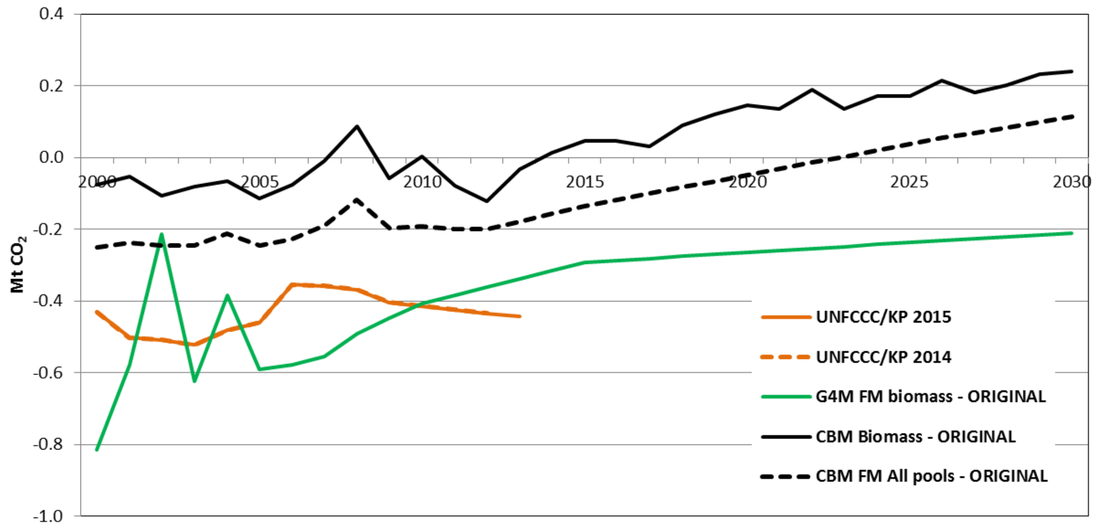
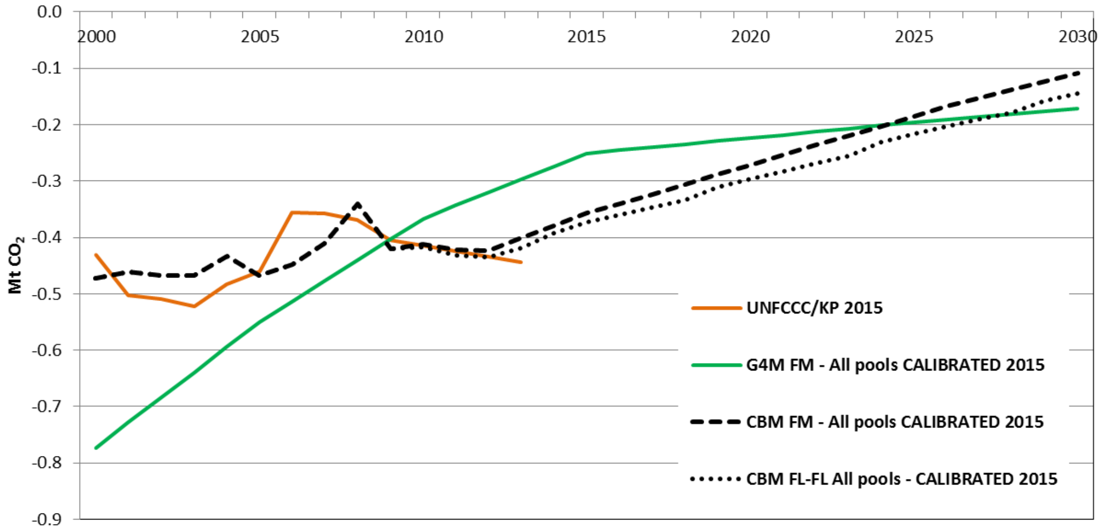


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[191] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

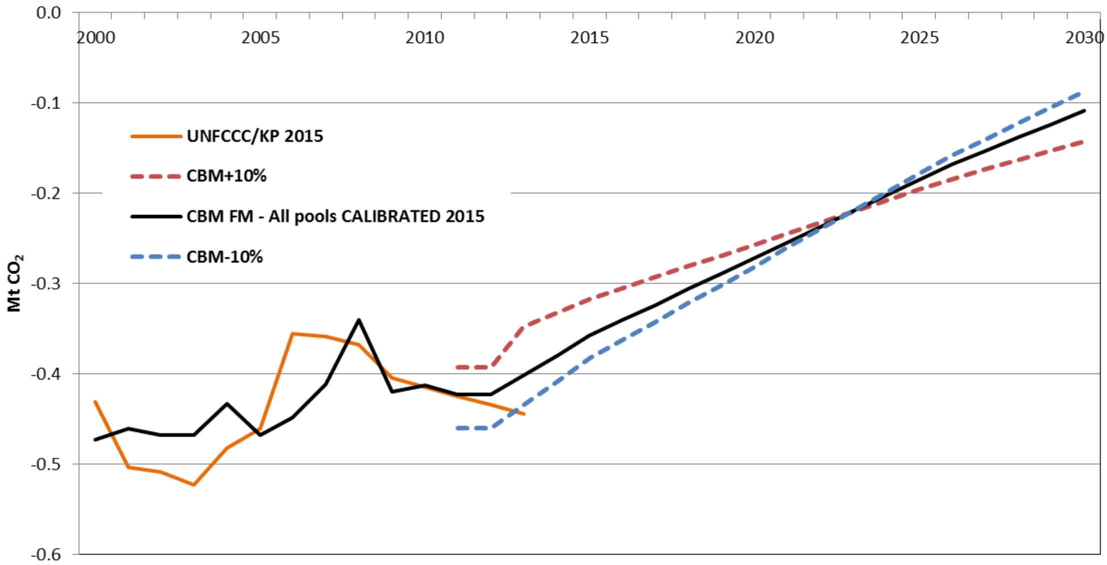
Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)



[191] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.

Fig. 5 FM, CBM (calibrated GHGI 2015) + / - 10% harvest



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

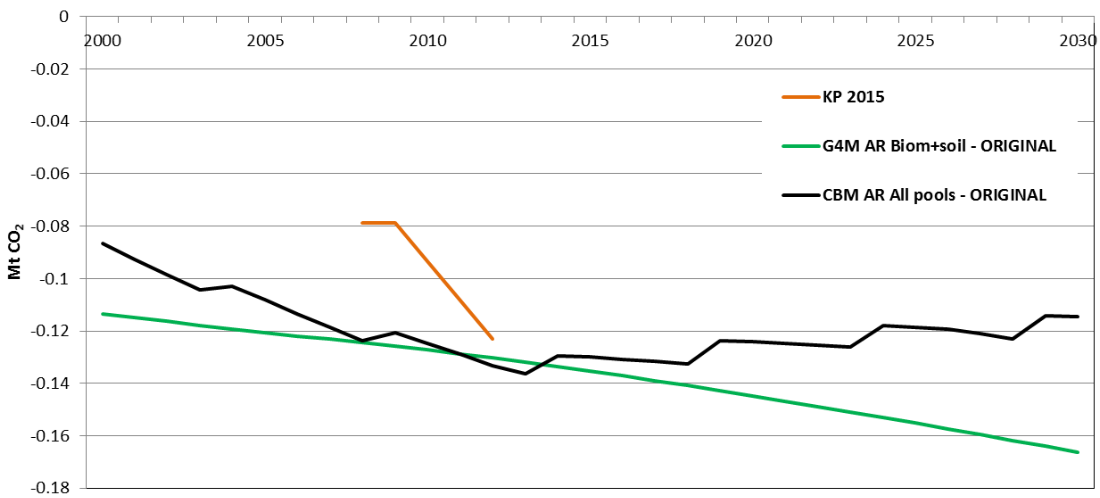
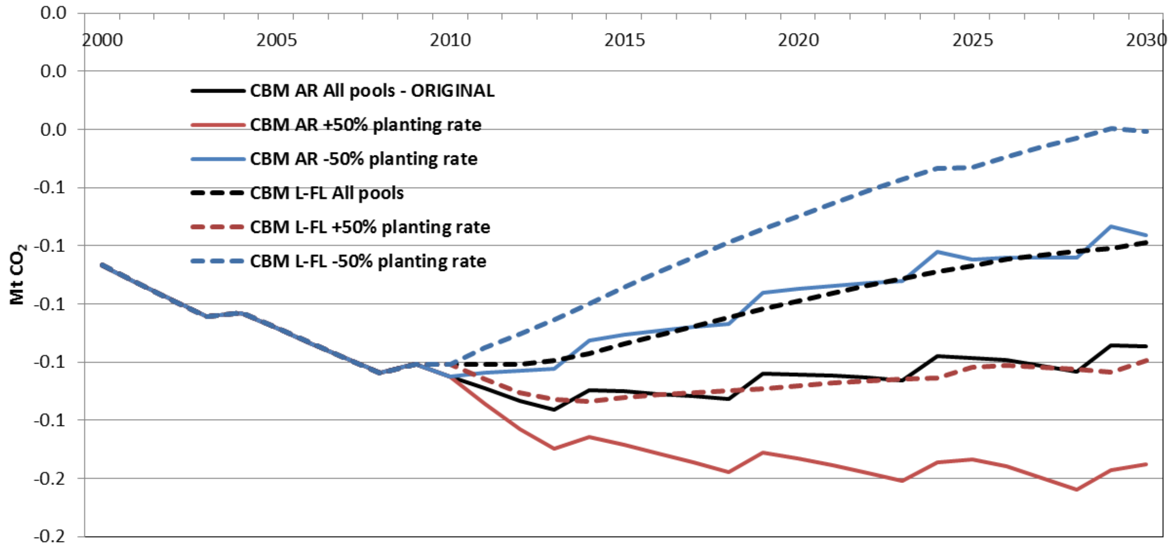


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

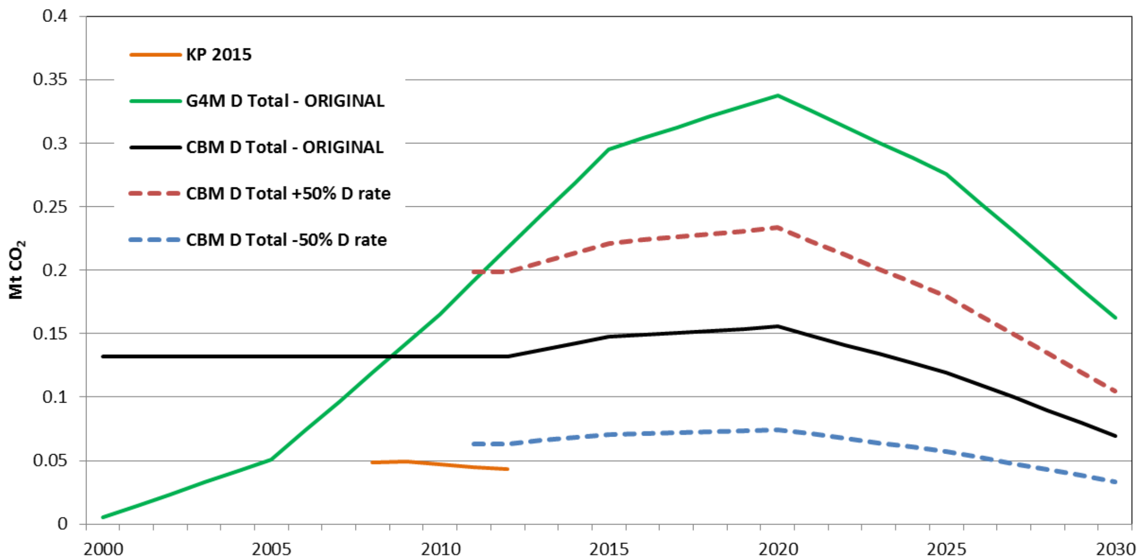
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

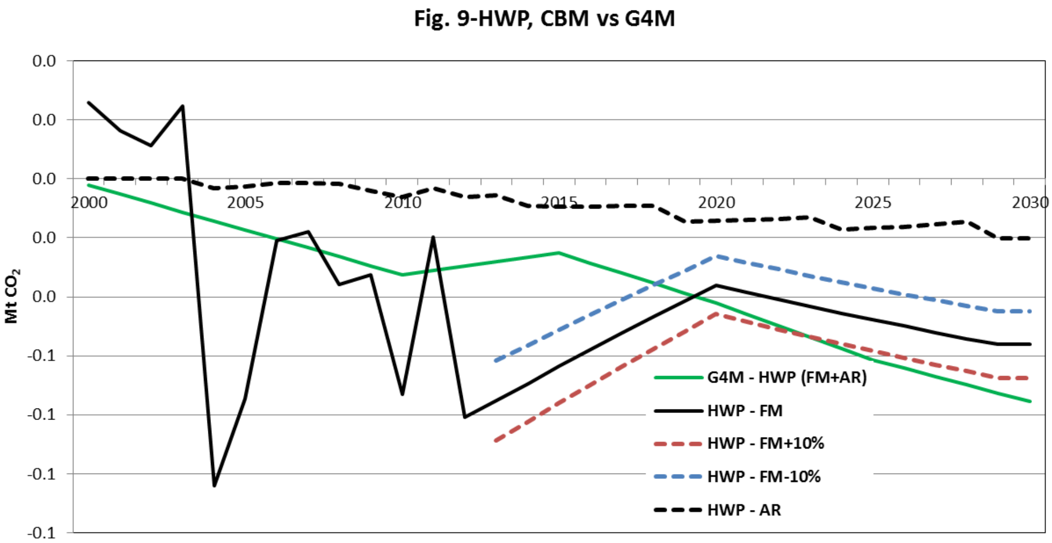
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[192]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

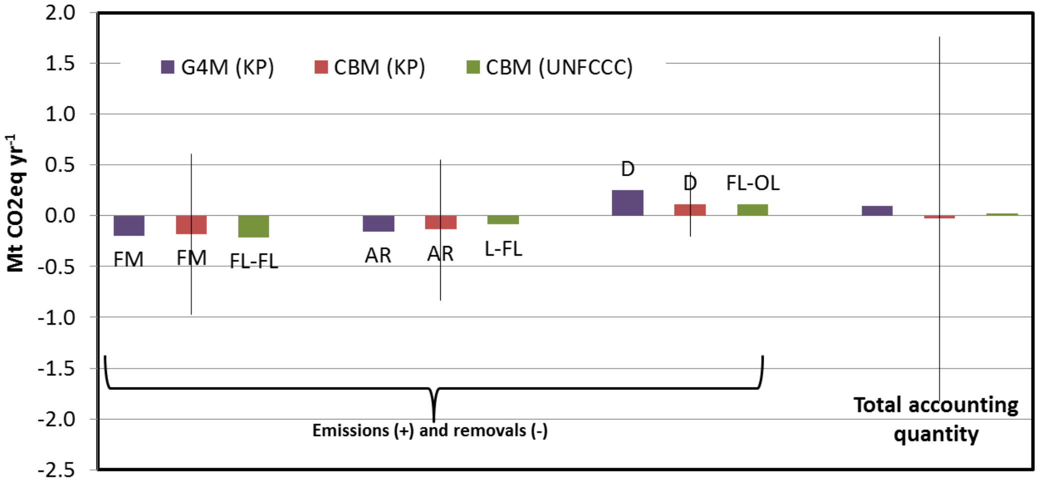


Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[193]; +/- 50% planting rate for AR; D/-50% D rate).

[192] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[193] Based on preliminary results.

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM is about 90% lower than the estimates provided by G4M and by the 2015 GHGI data (see Fig. 3). This also affects the future C sink estimated by CBM for 2030, but due to the calibration on the GHGI data, the final C sink estimated by CBM is similar to the value reported by G4M (see Fig. 4).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

Latvia

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		3,202	3,184	3,144	3,114	3,330[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	9.3	7.4	0.0	8.6	8.9	0.0
Deforest. (D)	Area of forest conversion to other land since 1990			1.3	2.1	10.3	0.8	1.2

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

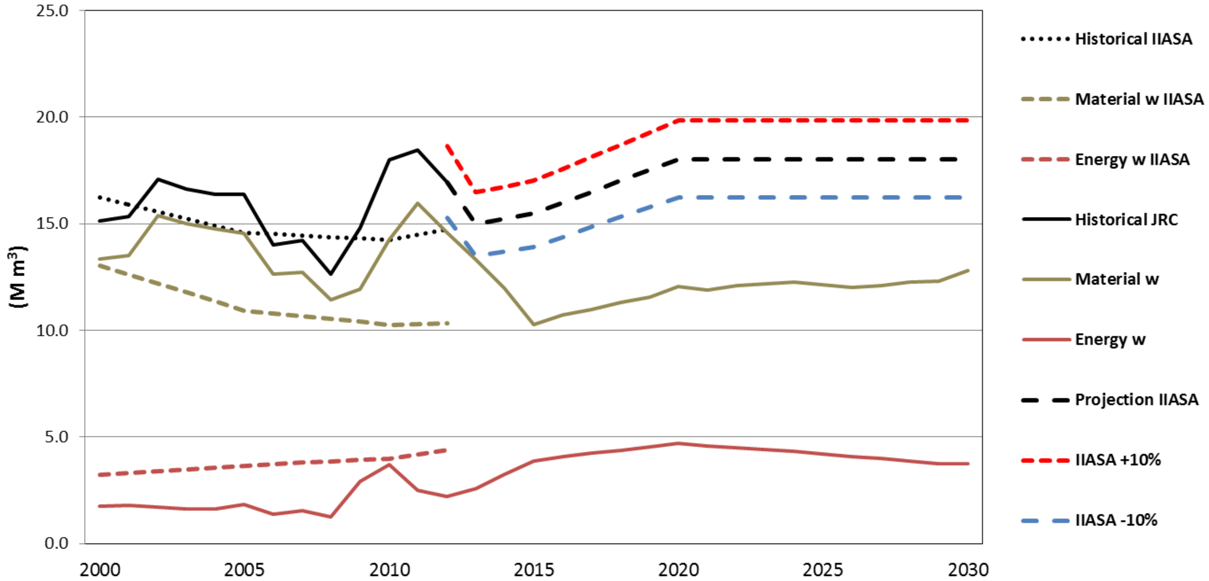
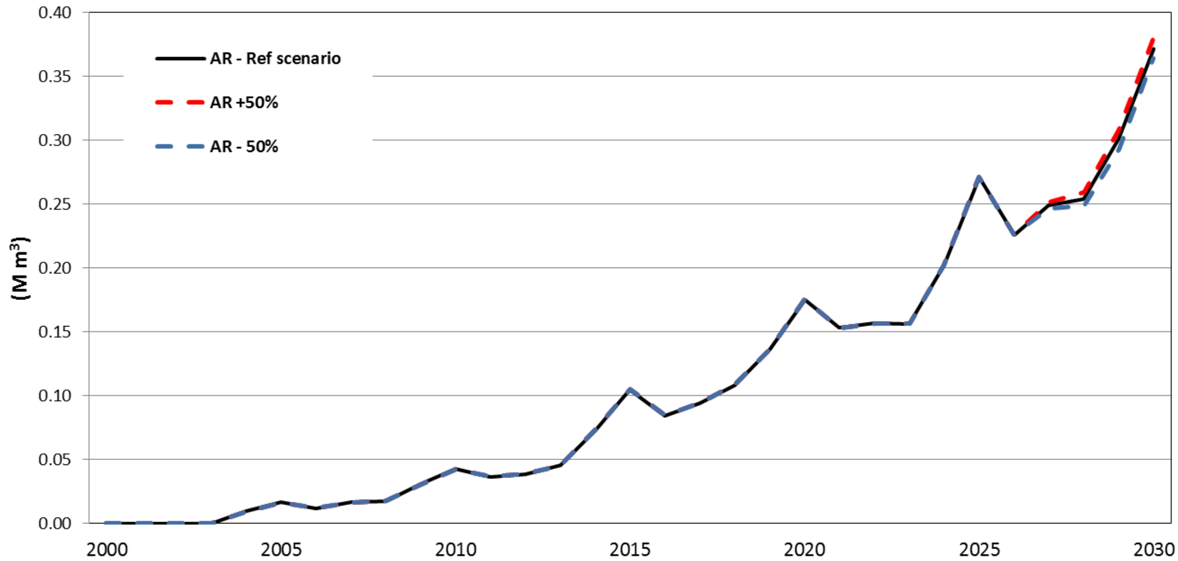


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

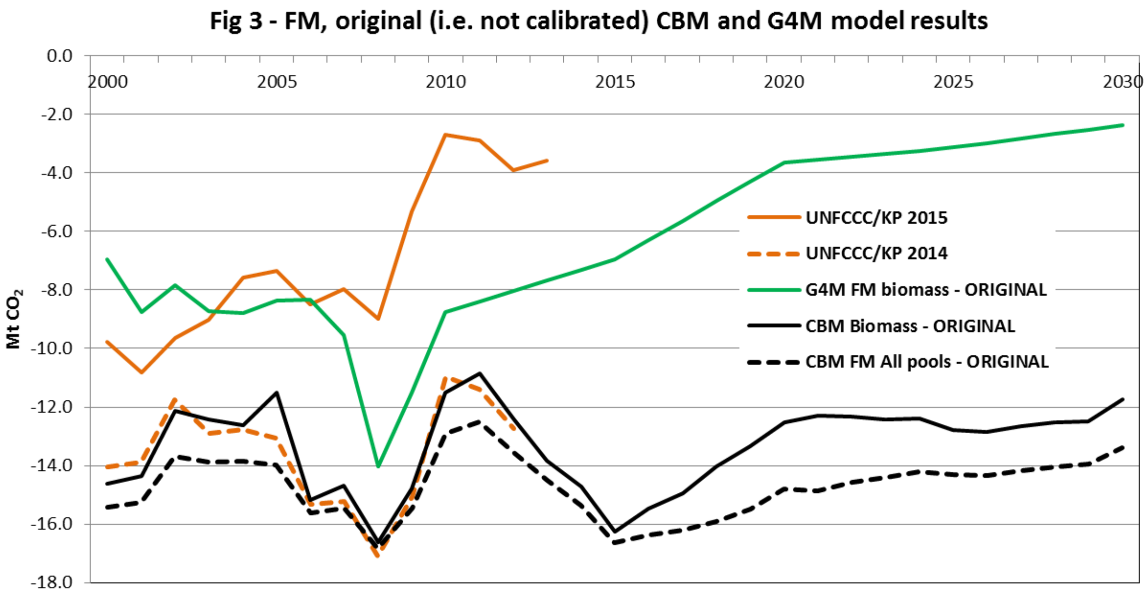


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[194] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

[194] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

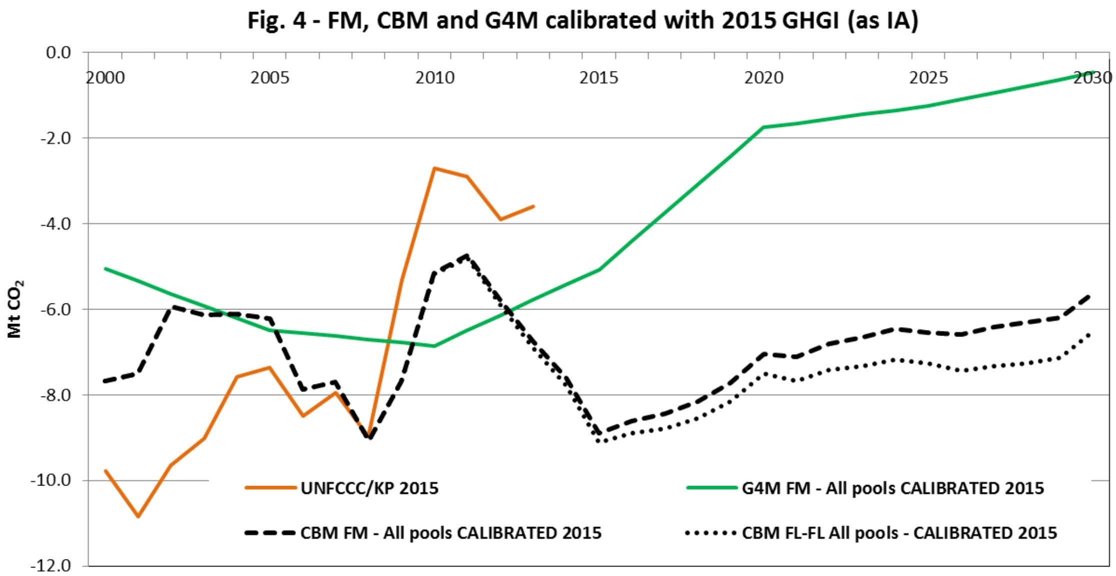
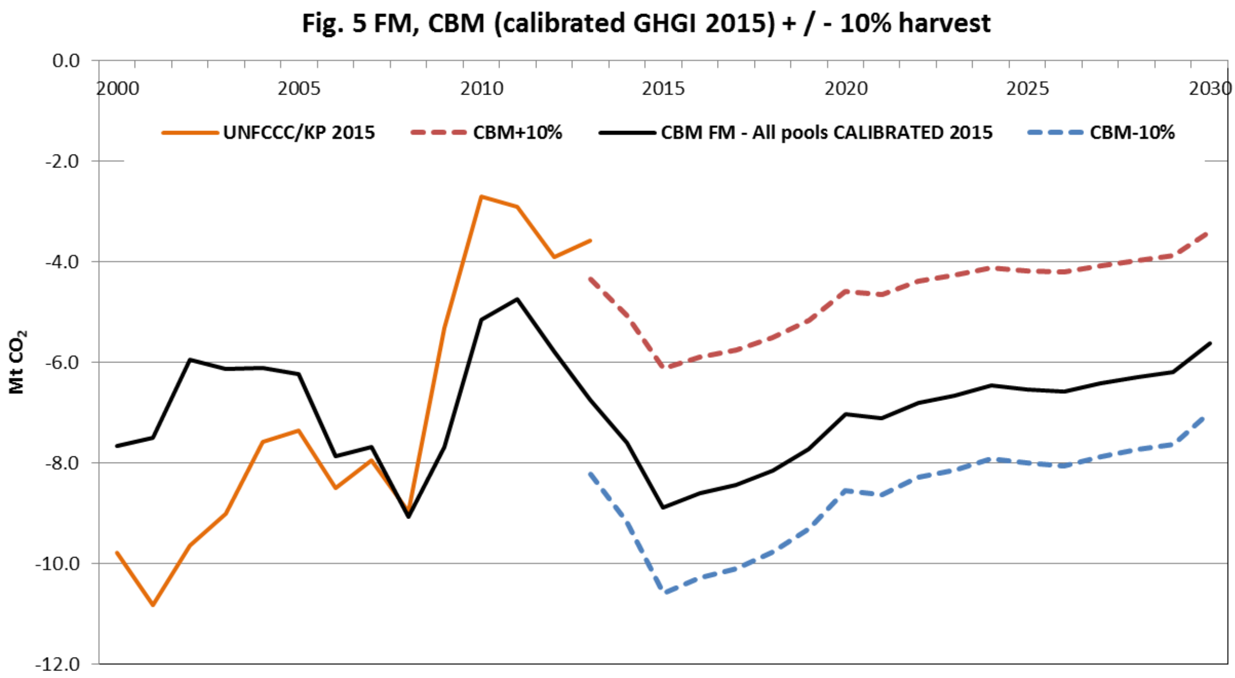


Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

Fig. 6 - AR, CBM vs G4M

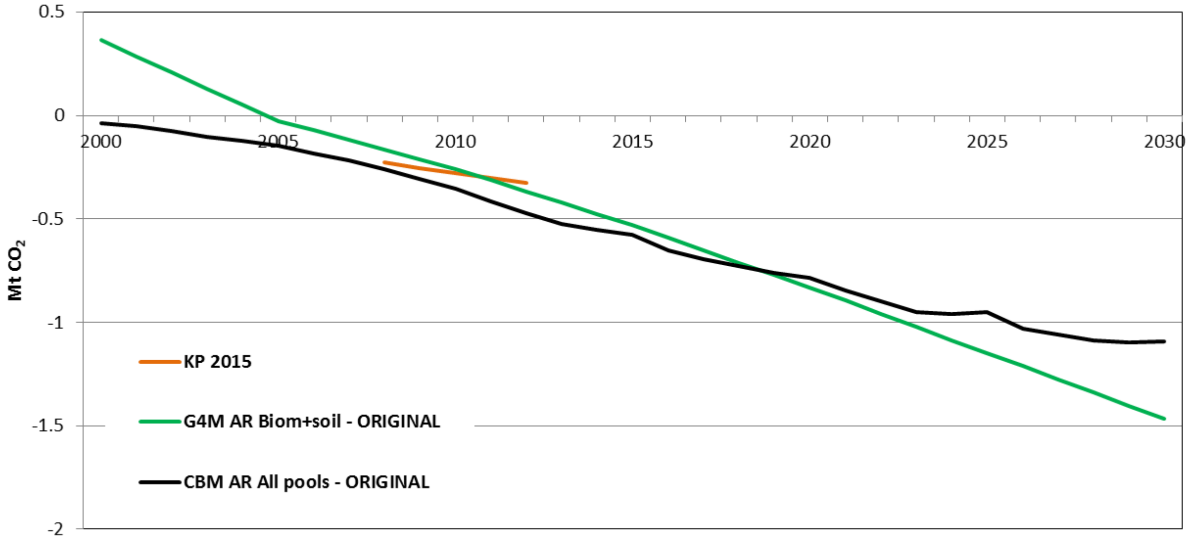
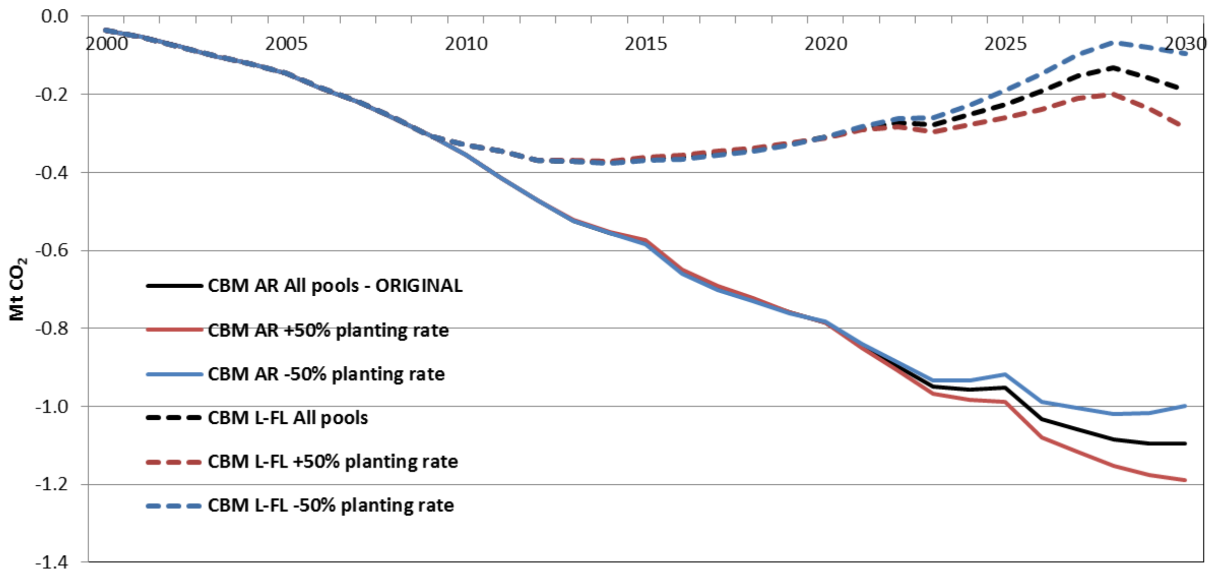


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

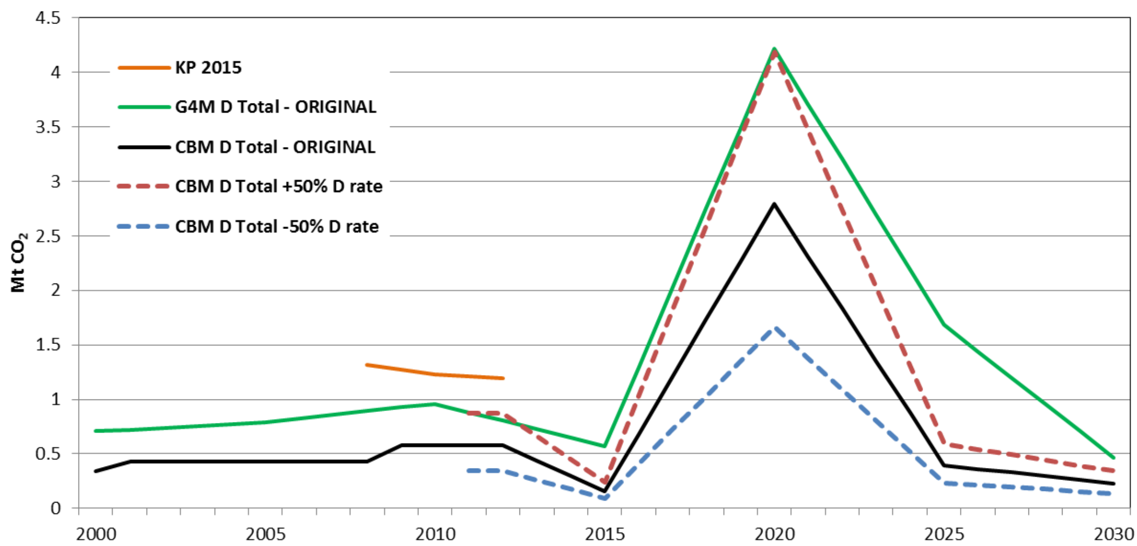
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

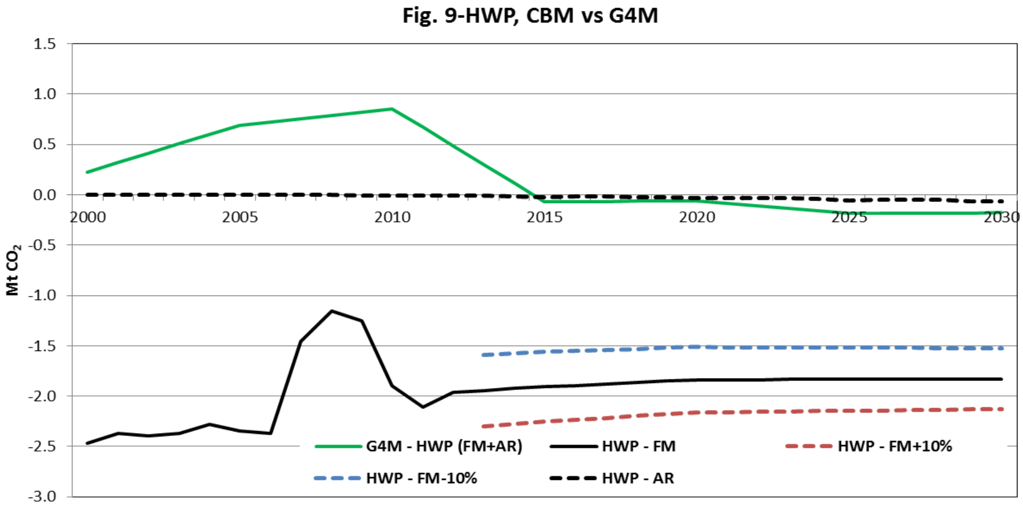
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[195]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

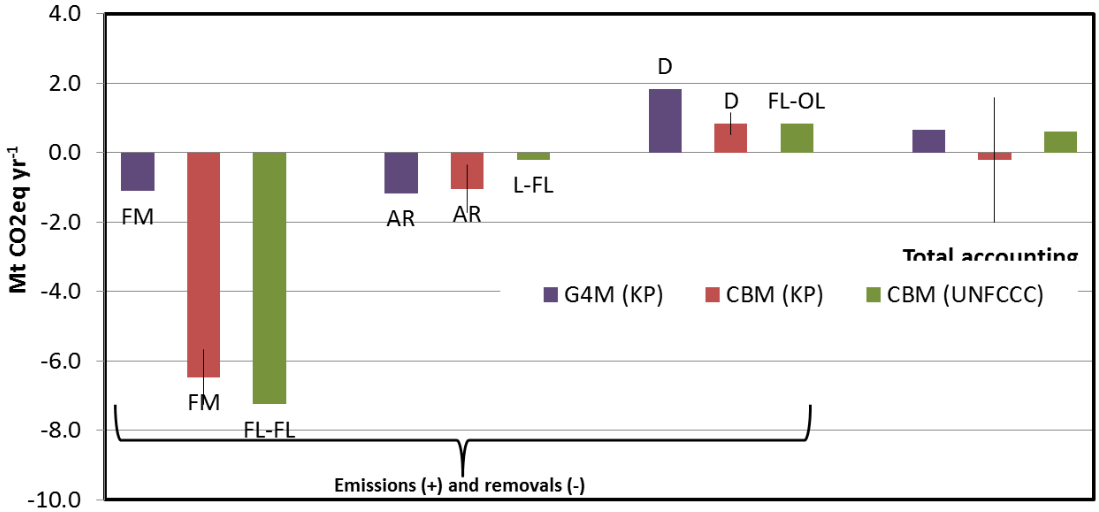


[195] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[196]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM (fully consistent with the 2014 GHGI) is about 50% higher than the value reported by G4M, and also by the 2015 GHGI (see Fig. 3). Indeed, due to some recent recalculations on the country's data, the estimates provided by CBM are not consistent with the last GHGI. This also affect the estimates on the future C sink (see Fig. 4).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[196] Based on preliminary results.

The Netherlands

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		339	315	303	298	337[FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	2.8	3.4	3.0	2.1	0.0	2.9
Deforest. (D)	Area of forest conversion to other land since 1990			2.1	2.5	0.5	0.3	3.2

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

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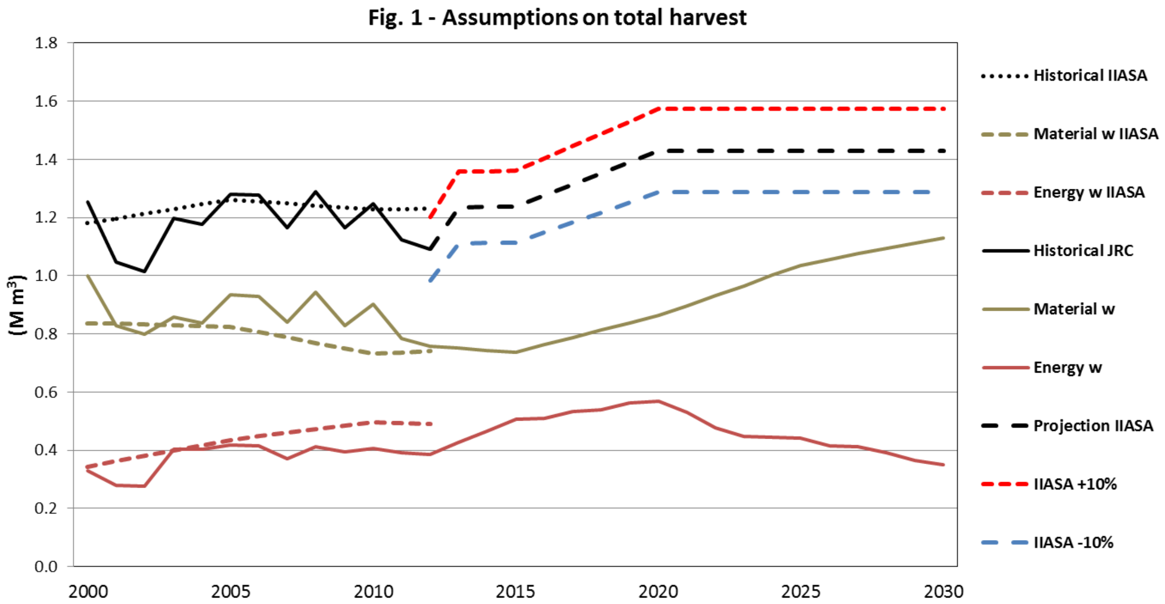
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).



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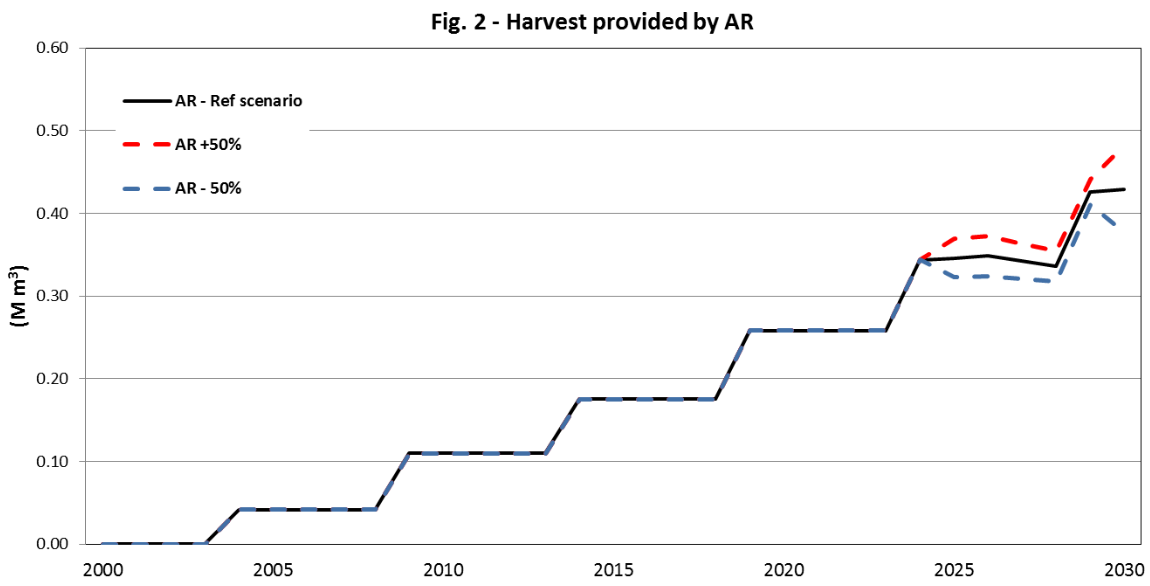

MODEL OUTPUTS

Forest Management

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Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

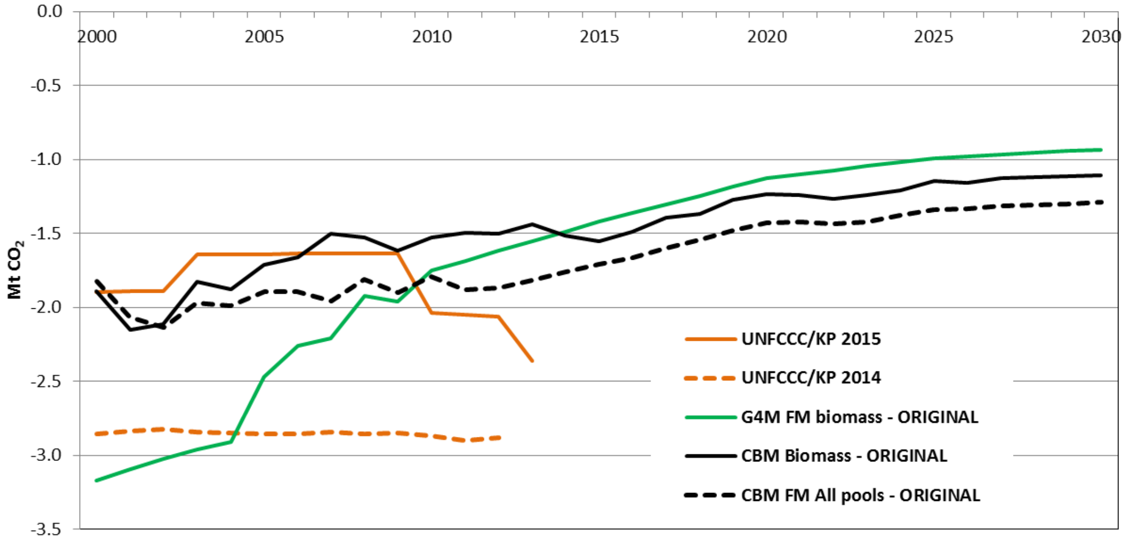
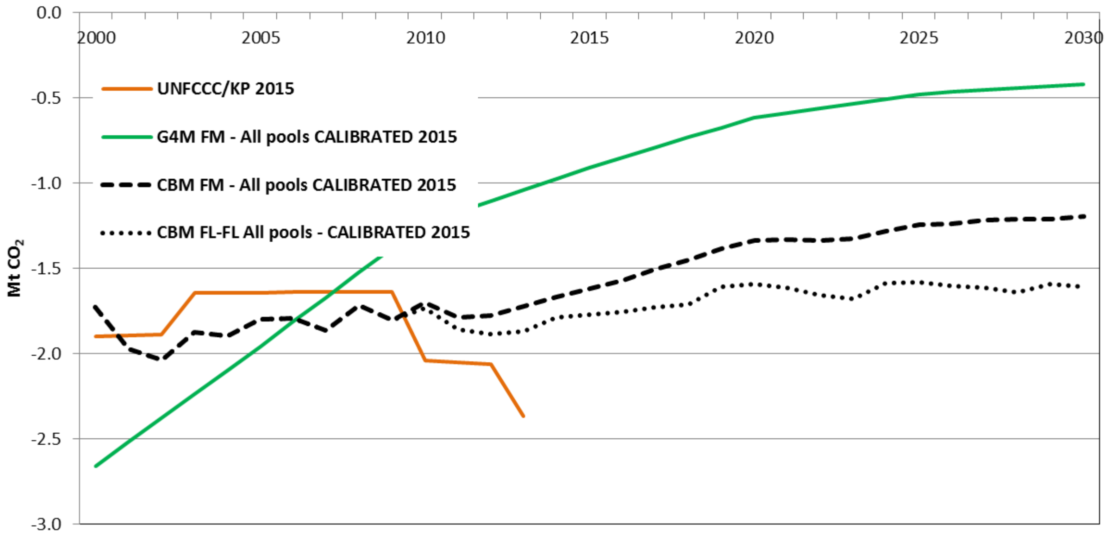


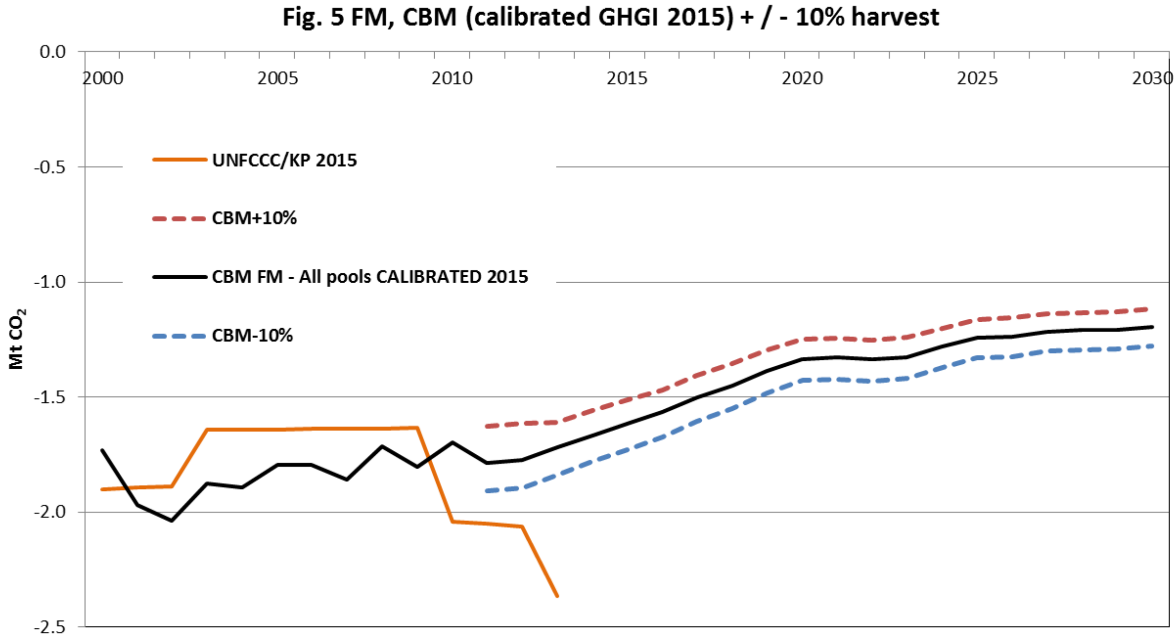
Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[197] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)



[197] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

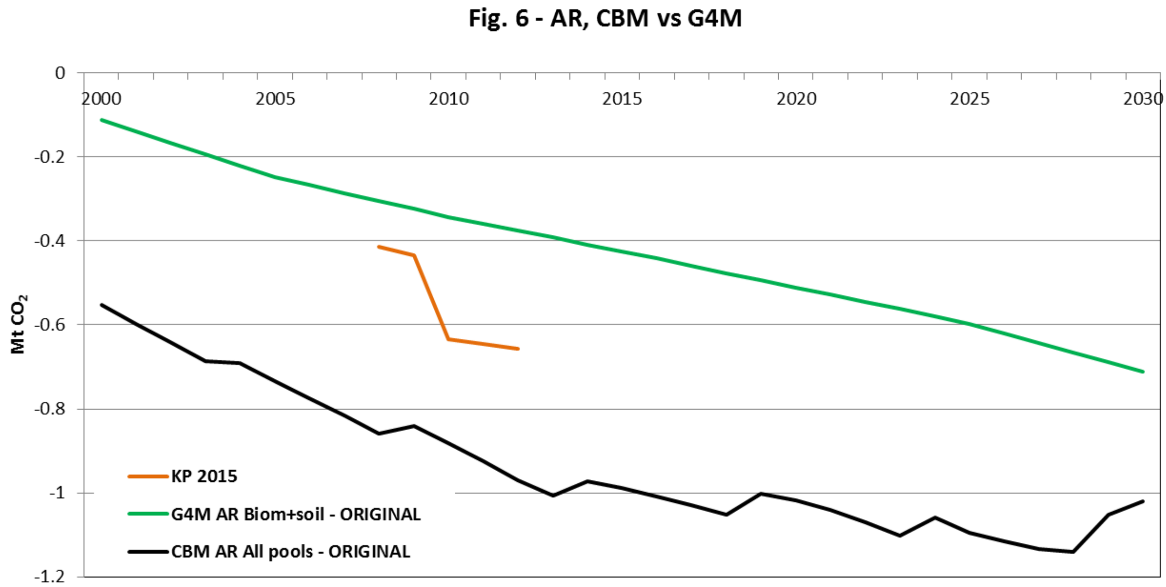
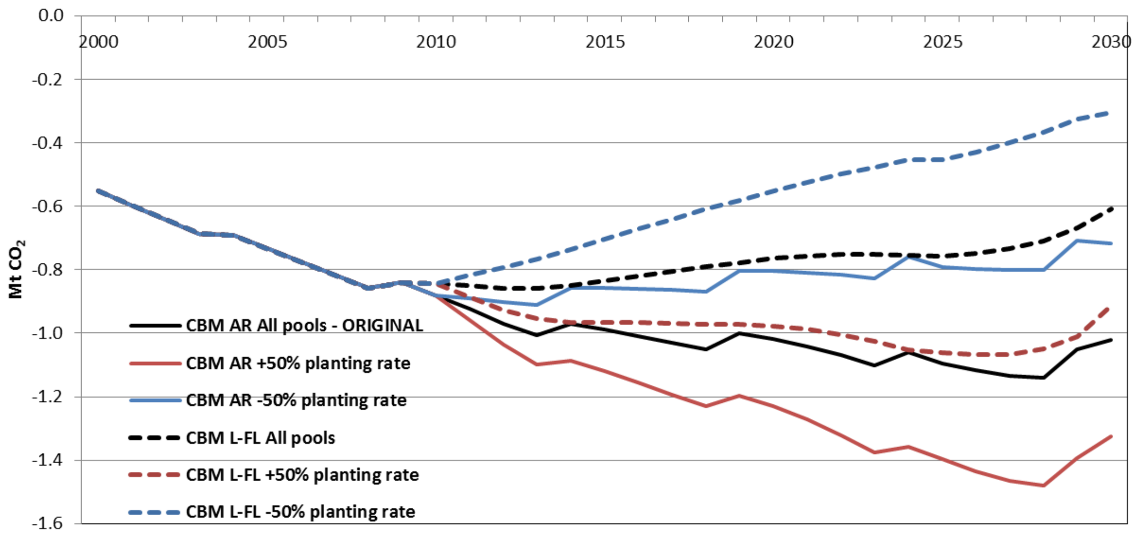


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

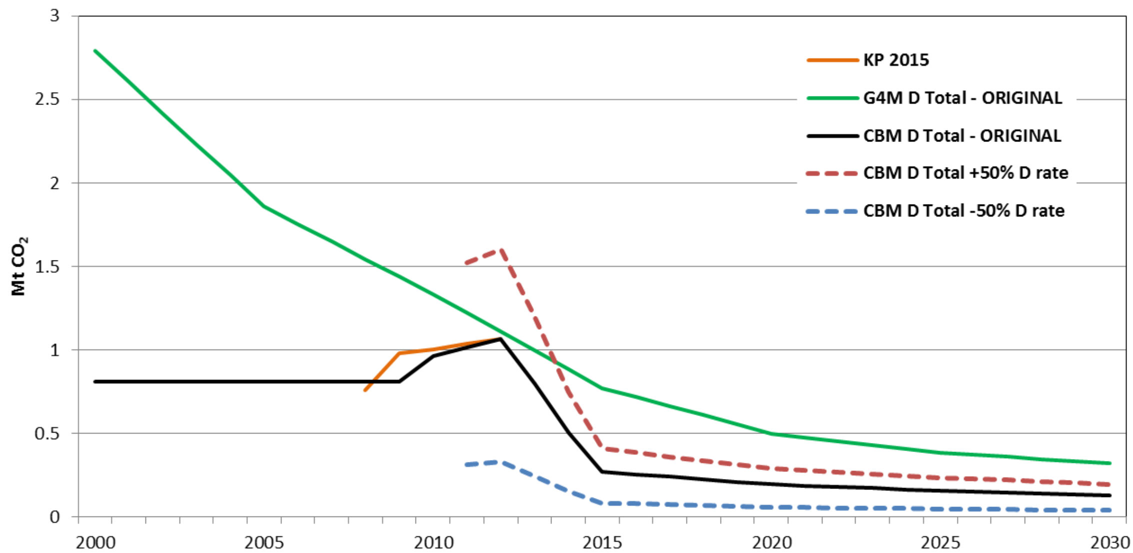
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

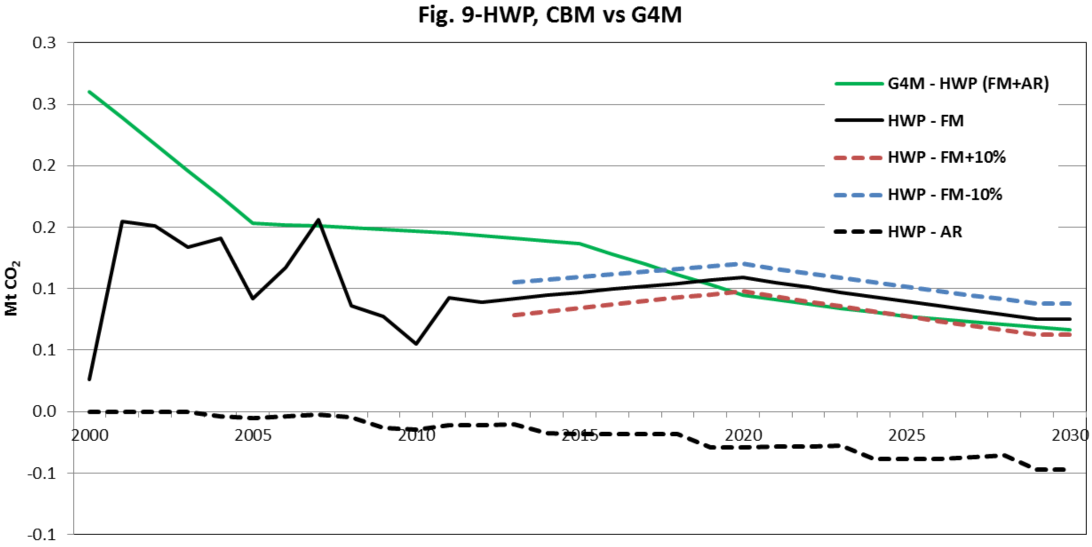
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

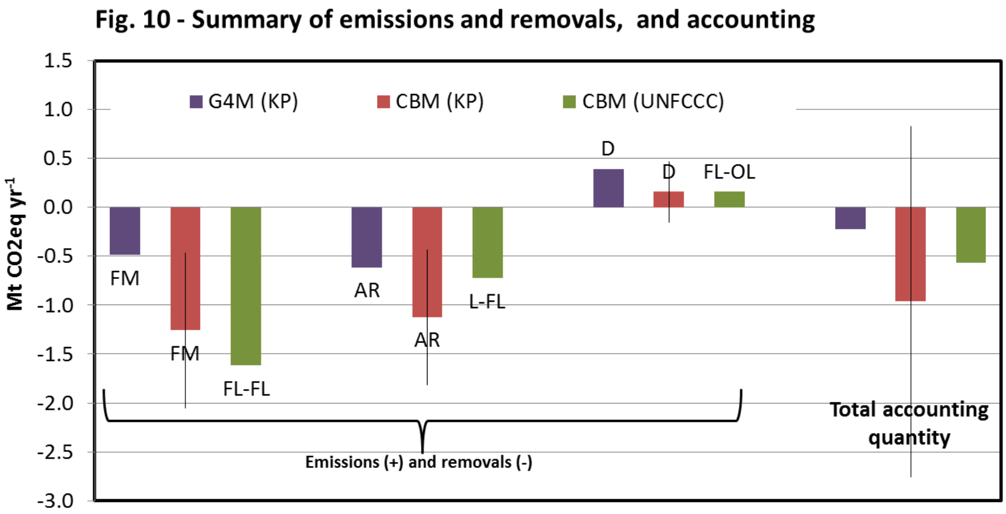
Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[198]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.



Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[199]; +/- 50% planting rate for AR; D/-50% D rate).

[198] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[199] Based on preliminary results.



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM is consistent with the 2015 GHGI until 2009 (see Fig. 3). From 2010 to 2013, the C sink reported by the GHGI increases by 50%, while the CBM C sink is quite stable, due to the constant harvest rate applied during the same period. From 2000 to 2010, G4M estimates a decreasing C sink, considerably lower than the value estimated by CBM in 2000 (-52%, compared with CBM) and equal to the estimate provided by CBM for 2012.
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

Poland

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		8,873	8,867	8,863	8,861	8,668[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	20.7	50.5	29.6	26.0	14.5	29.5
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		0.4	0.6	0.3	0.1	0.6

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

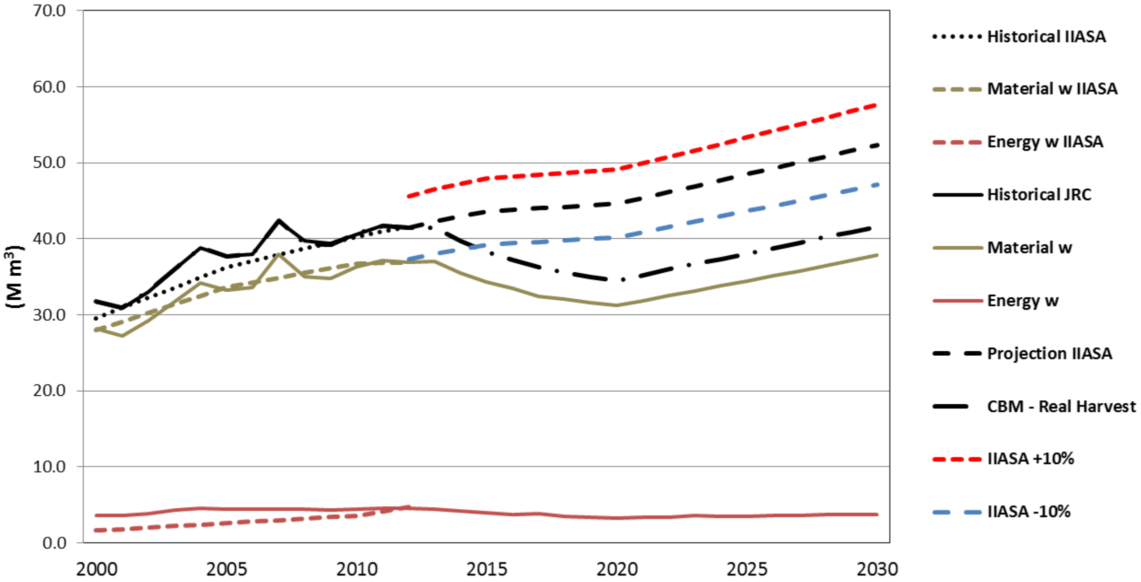
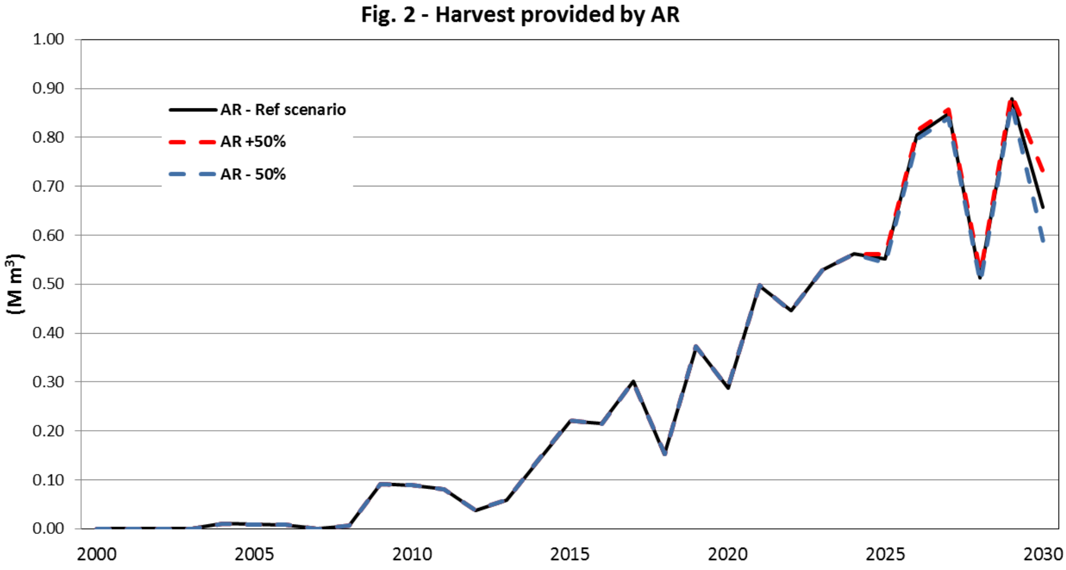


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

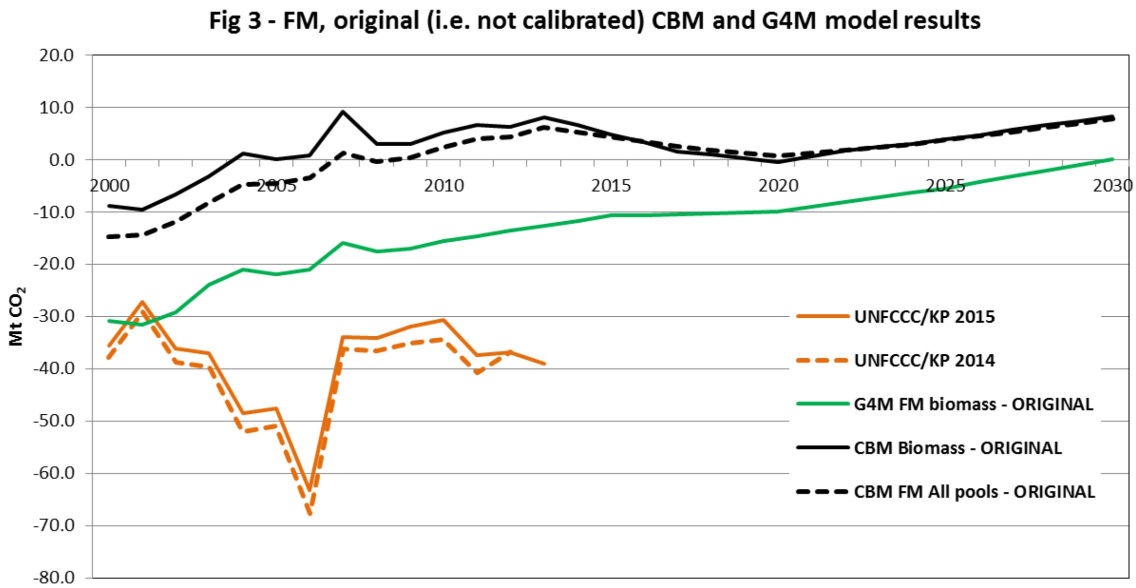
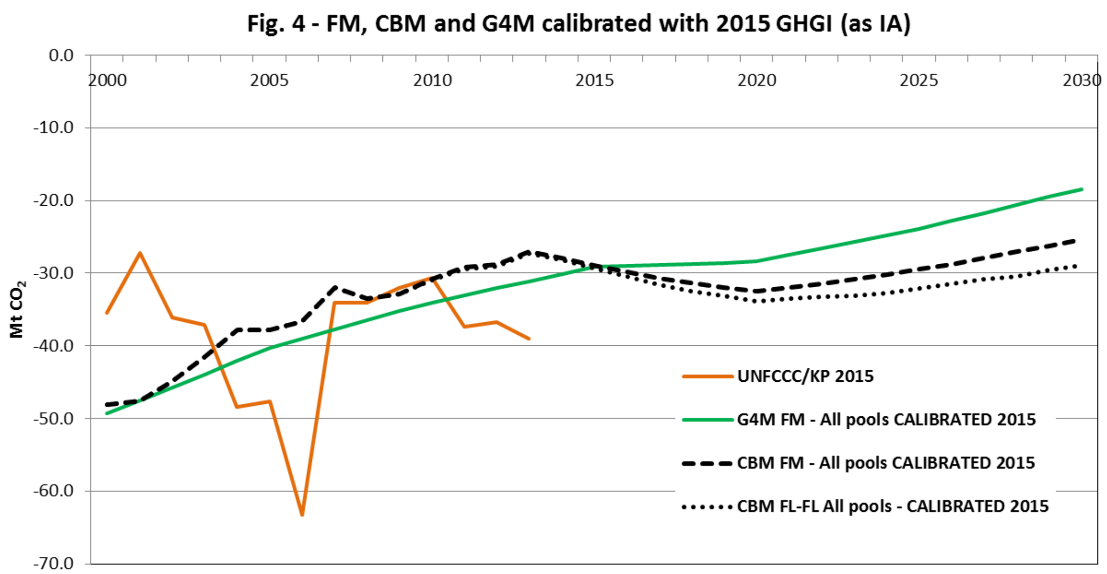
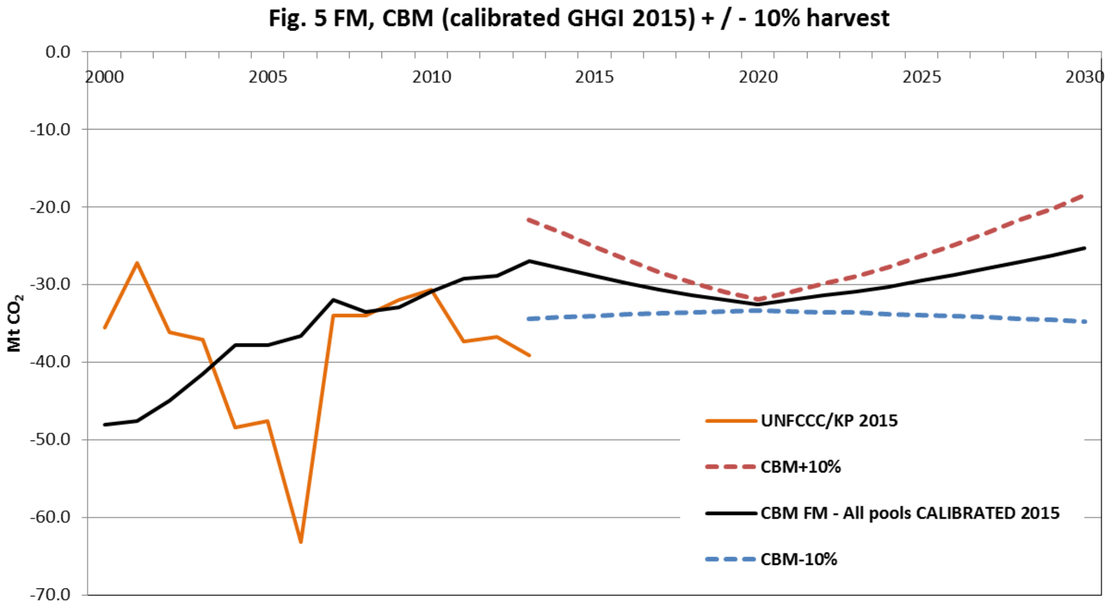


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[200] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



[200] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

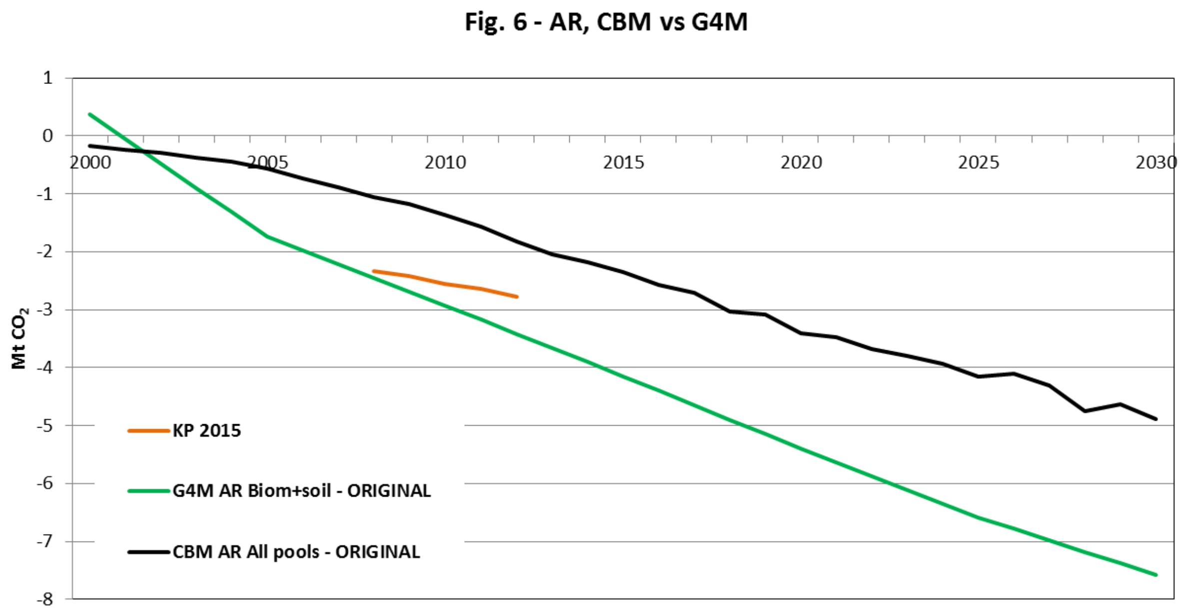
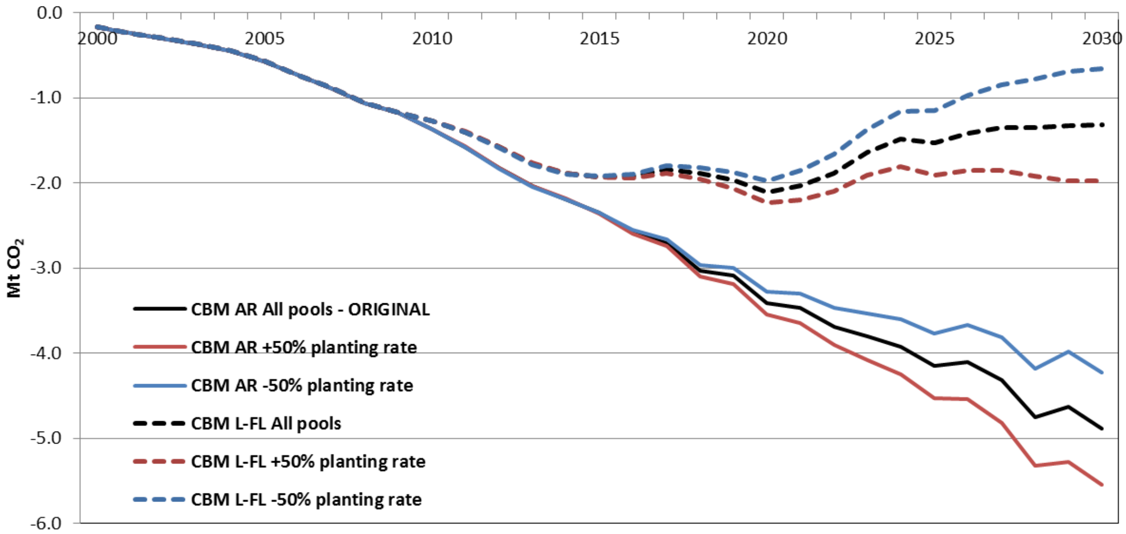


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

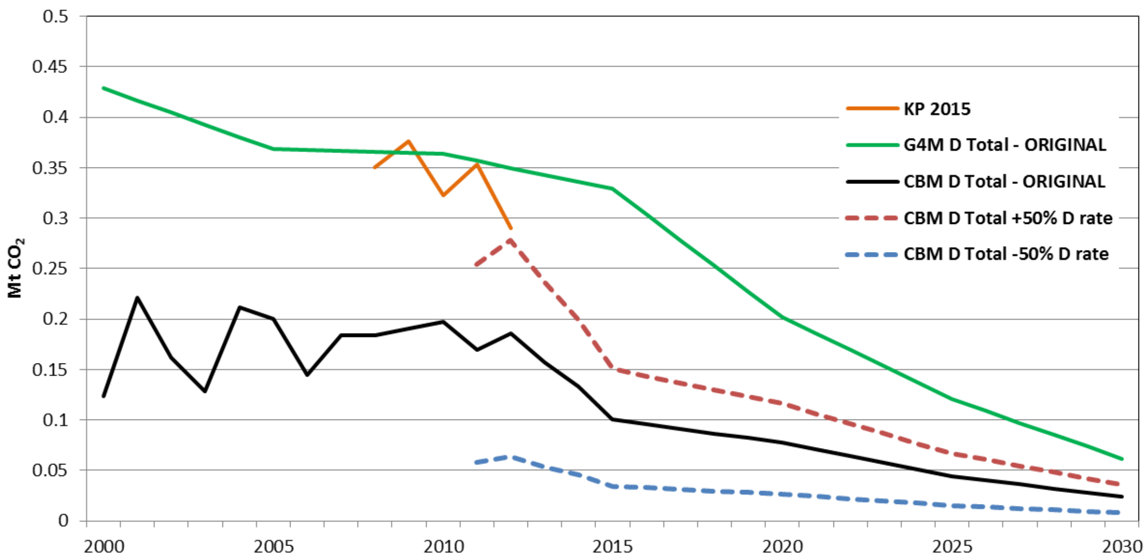
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

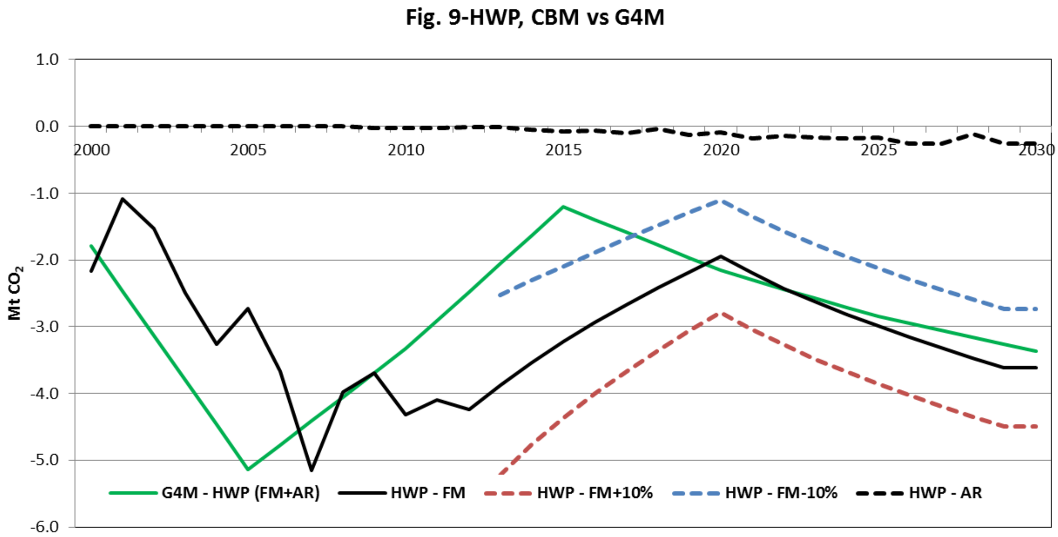
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[201]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

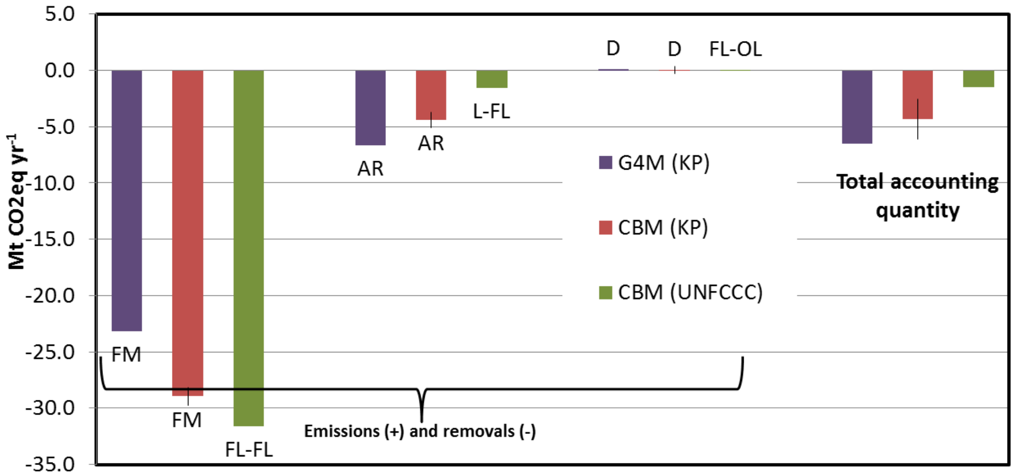


Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[202]; +/- 50% planting rate for AR; D/-50% D rate).

[201] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[202] Based on preliminary results.

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM is about 100% lower (on average from 2000 to 2012) than the estimate provided by G4M and this last one is about 50% lower than the C sink reported by the 2015 GHGI (see Fig. 3). However, while both the models report a decreasing C sink (i.e., the same trend, consistent with the increasing harvest rate applied from 2000 to 2012, see Fig. 1), the GHGI reports an opposite trend from 2000 to 2006.
- The 2030 C sink estimated by CBM, after the calibration on the 2015 GHGI data, is about 37% higher than the C sink reported by G4M. This result however, is mainly due to the calibration and to the lower amount of harvest applied by CBM since 2013 (see Fig 1). Indeed, the future harvest demand expected by IIASA, cannot be satisfied by CBM and the final harvest applied to 2030 is equal to the harvest rate applied in 2012. This is probably due to the lower increment expected by CBM compared with G4M.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

Portugal

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		3,543	3,436	3,389	3,362	3,763[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	33.8	16.6	6.4	13.7	9.3	7.3
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		11.8	6.2	3.3	2.4	6.2

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). For Portugal, this amount includes the harvest provided by FM and AR, reported in Fig. 2).

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

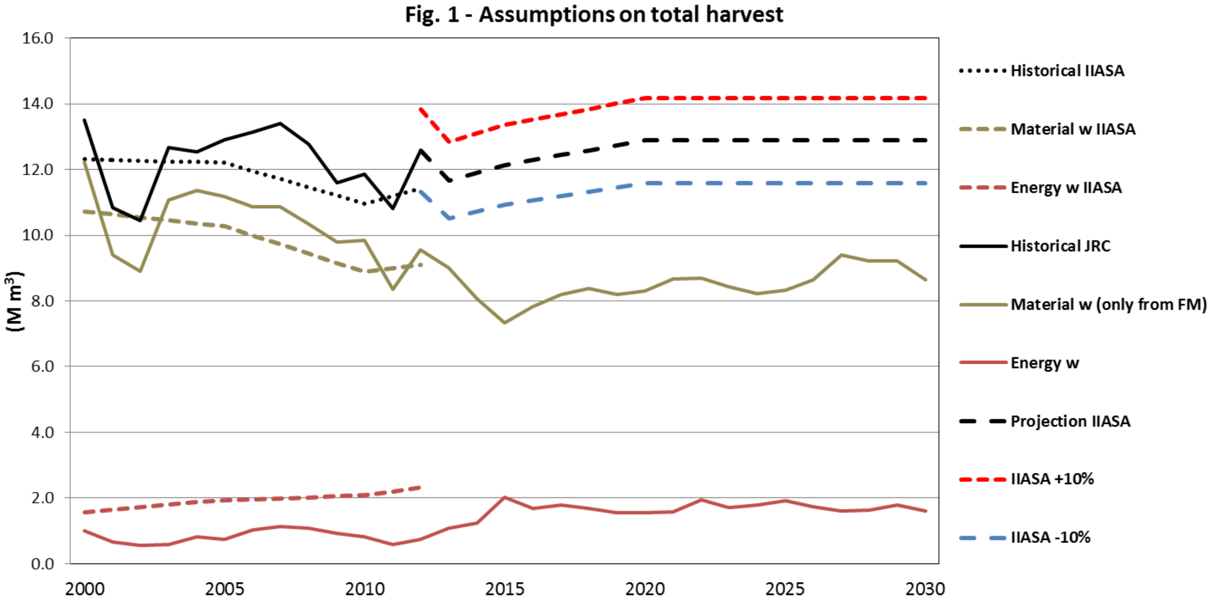
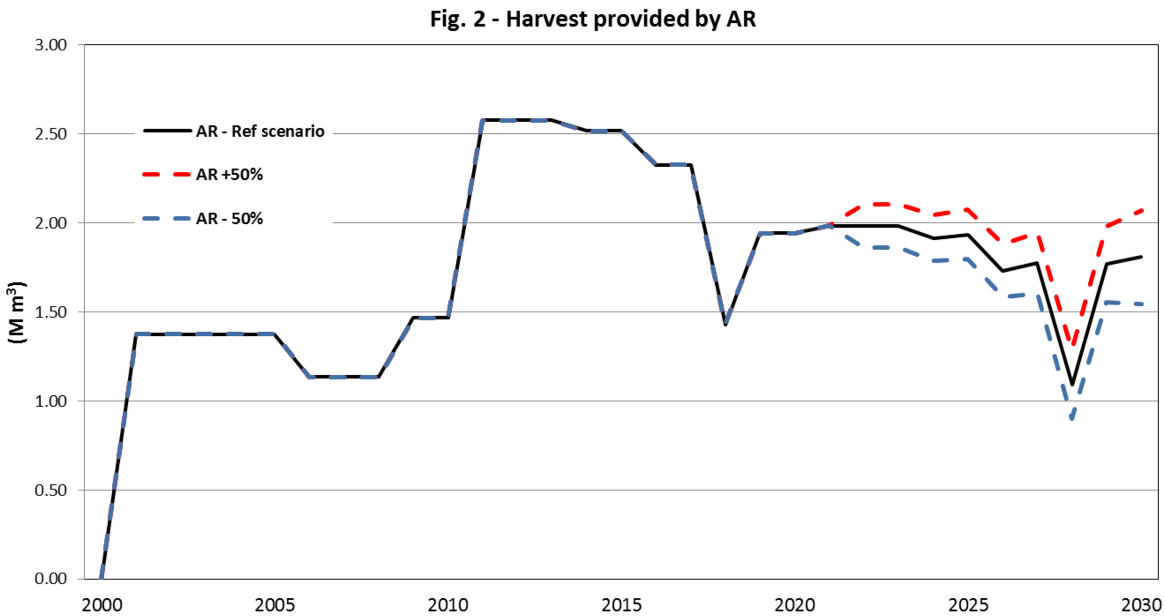


Fig. 2 reports the amount of total harvest potentially provided by AR. For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

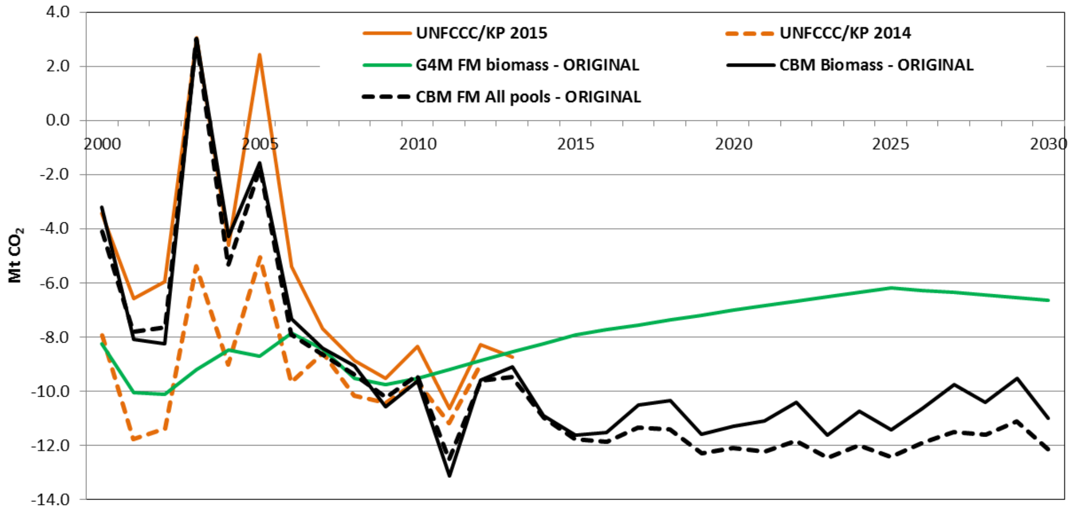
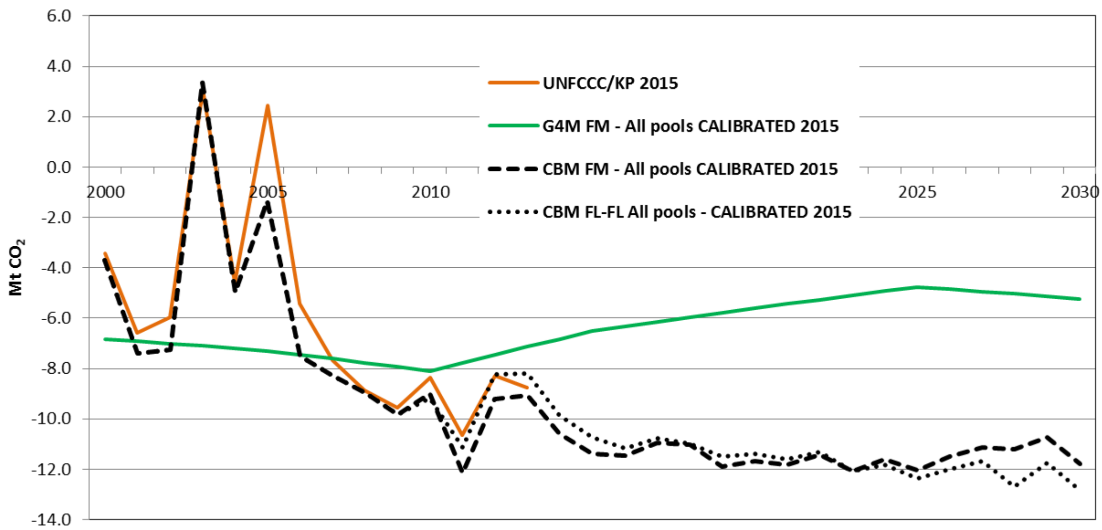


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[203] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)



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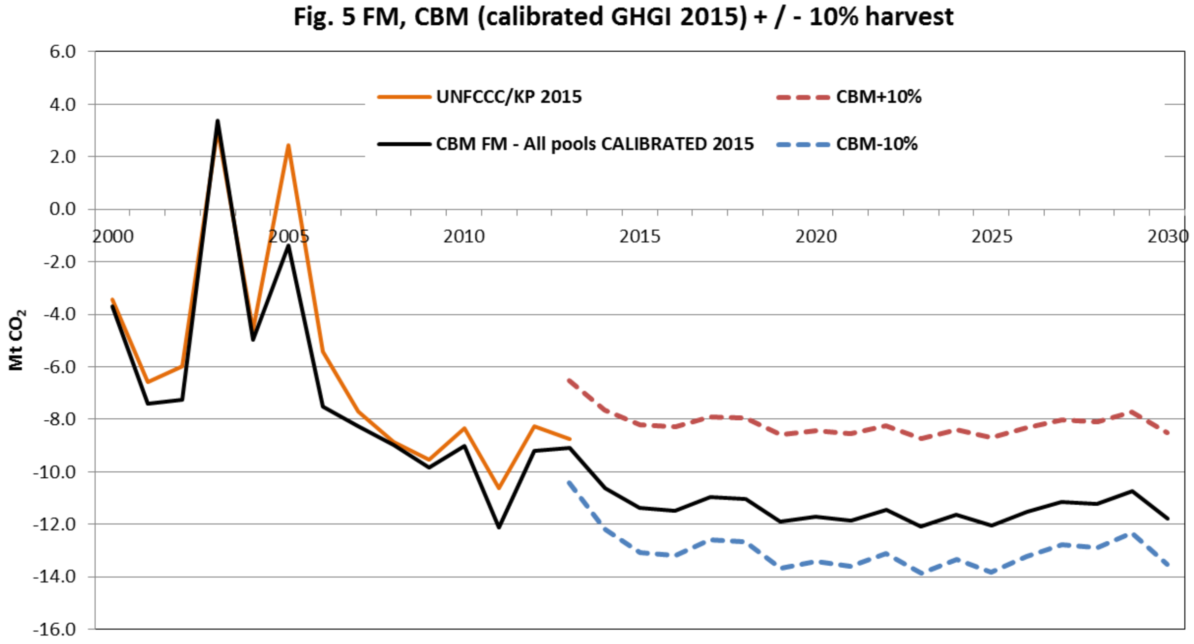
[203] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

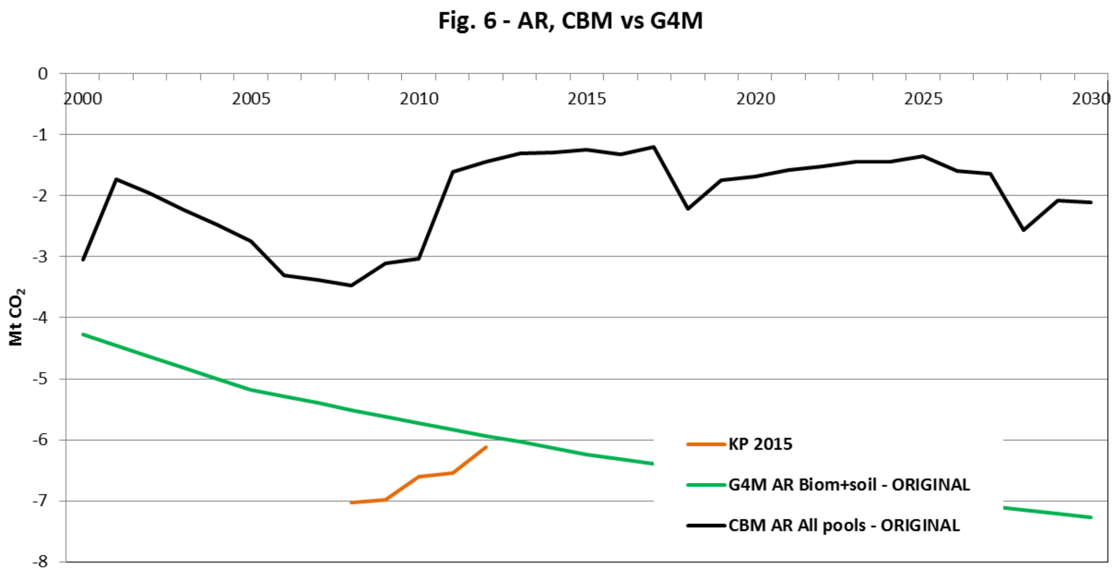
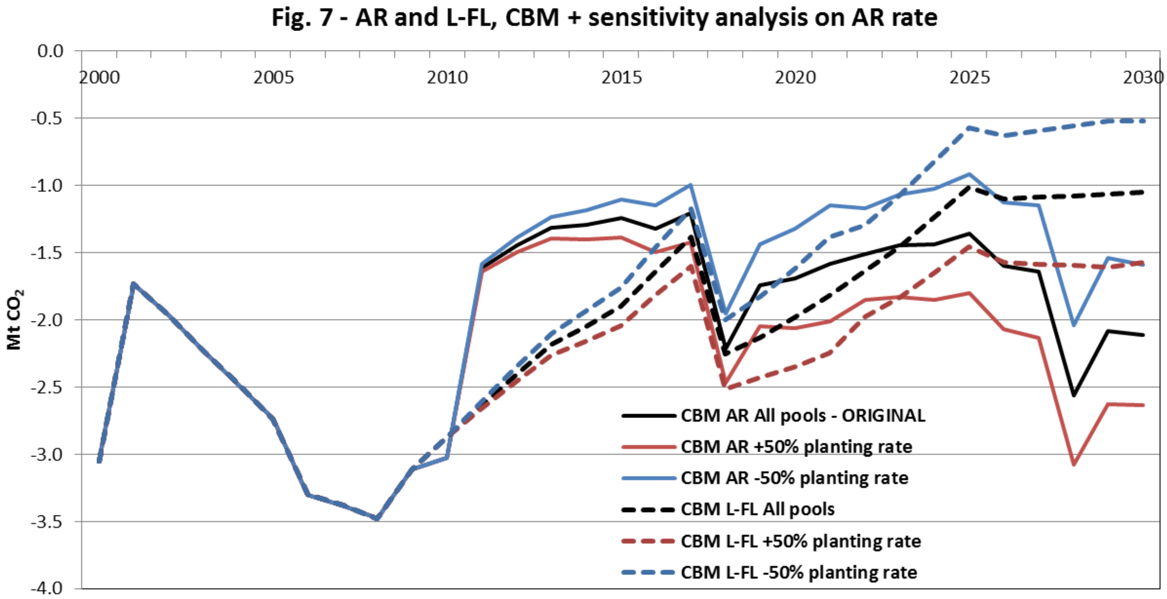


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

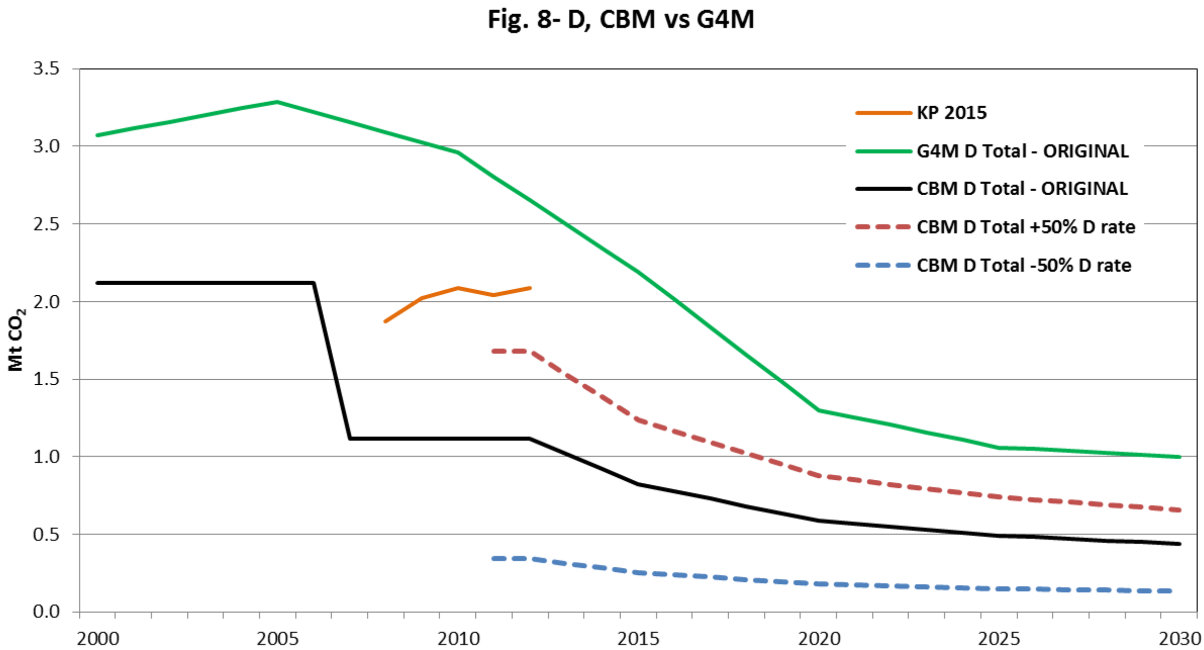
(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.



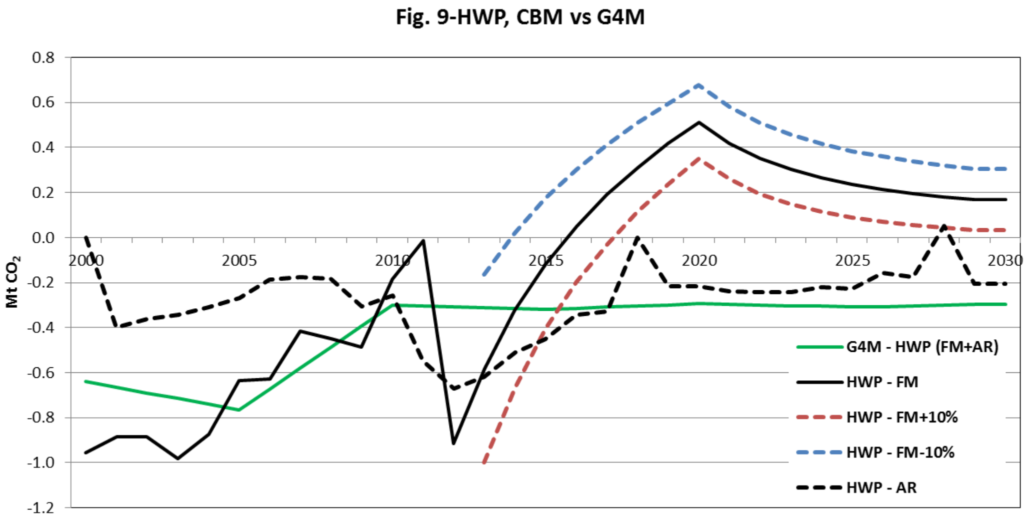
Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[204]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

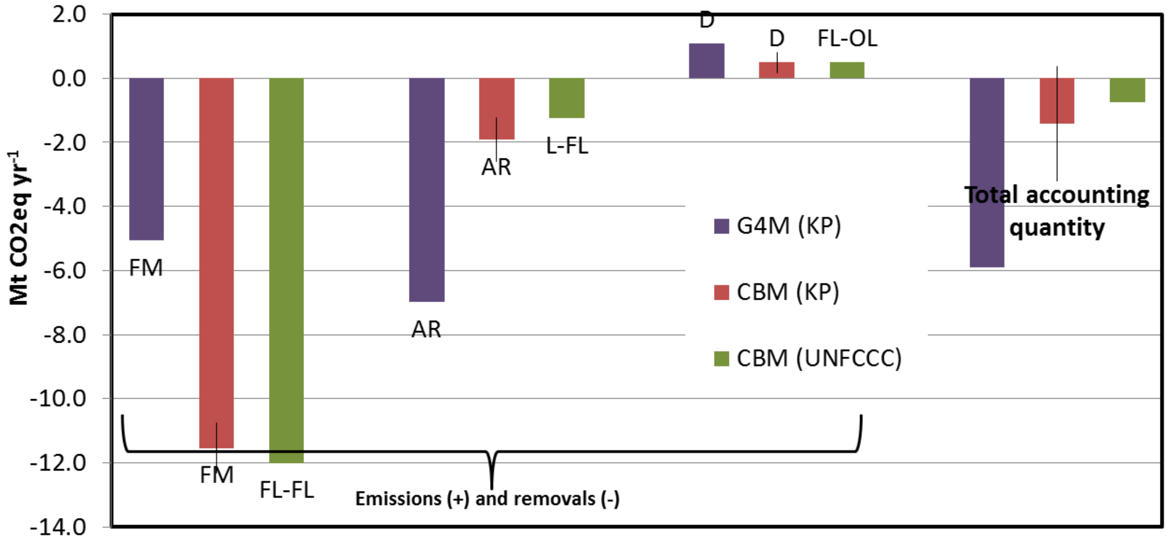


[204] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[205]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM is similar (i.e., it has the same trend and level) to the estimate provided by the 2015 GHGI (see Fig. 3). The average historical C sink estimated by G4M is, on average and for the same period, 24% higher Compared with the 2015 GHGI, both the models estimate a lower inter-annual variability, probably due to the effect of some natural disturbance event, not considered by the models (see Fig. 3).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by G4M (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[205] Based on preliminary results.

Romania

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030), comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		6,163	6,065	6,028	6,023	6,327[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	18.5	30.9	18.5	3.2	0.6	0.5
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		8.9	8.9	1.6	0.2	0.1

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**) and by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

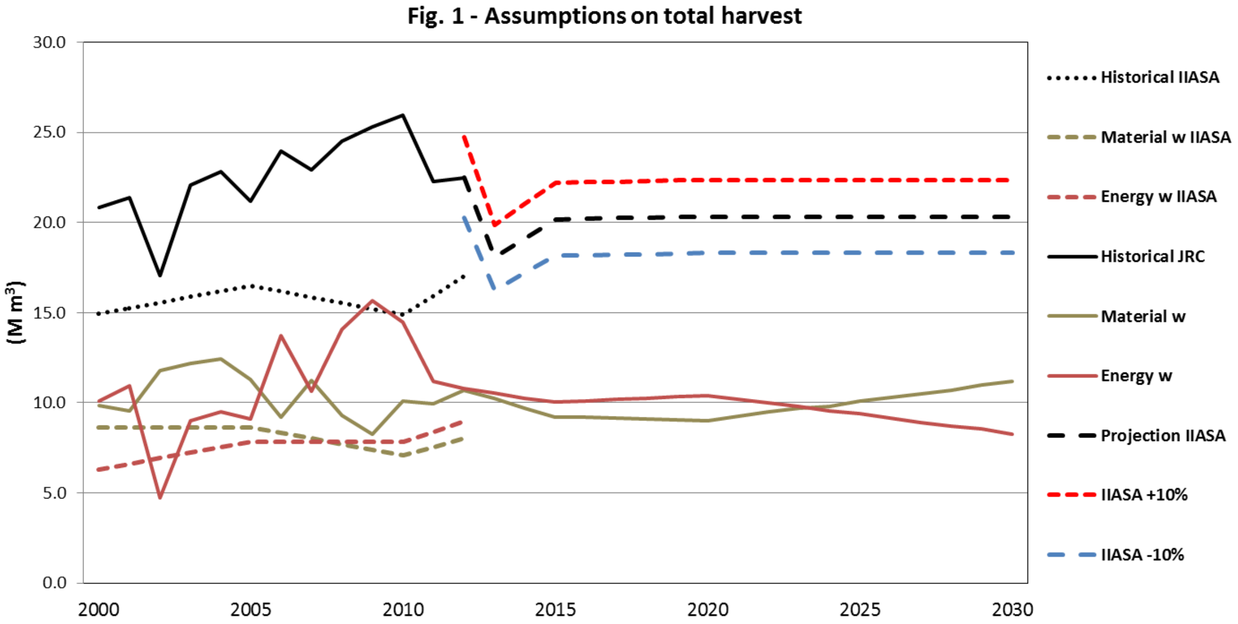
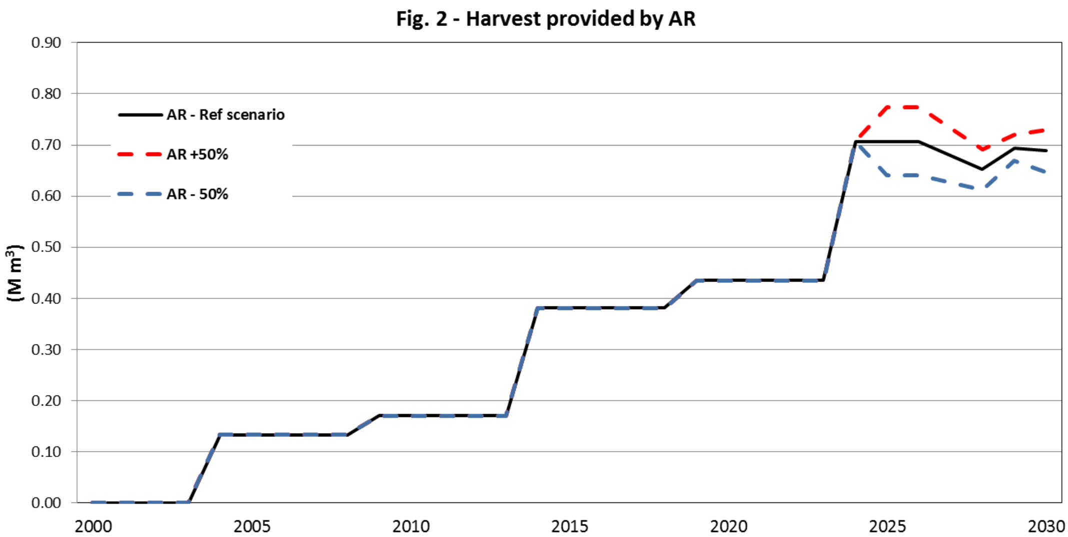


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

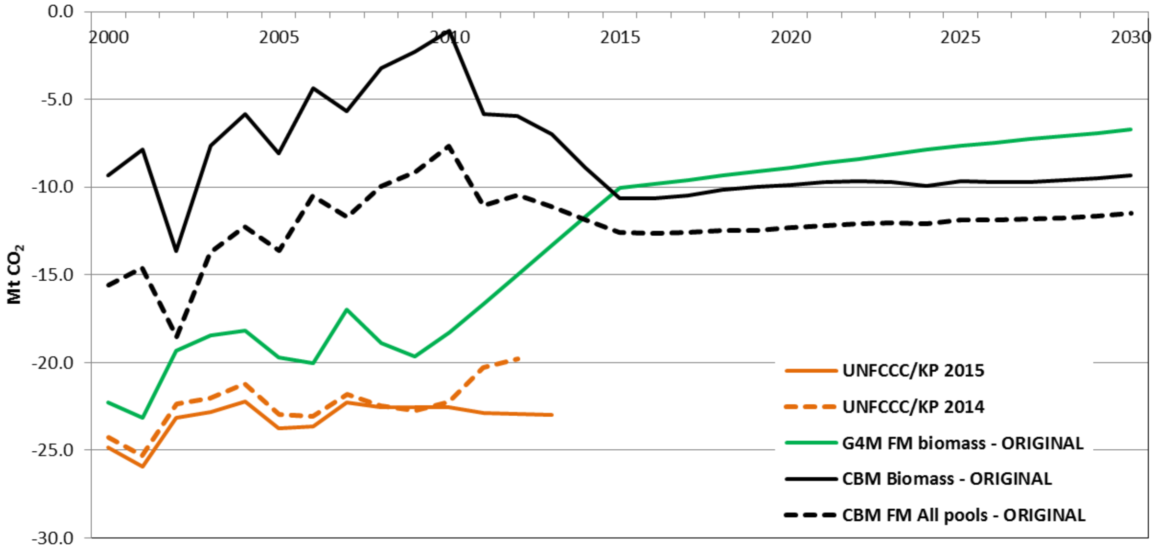
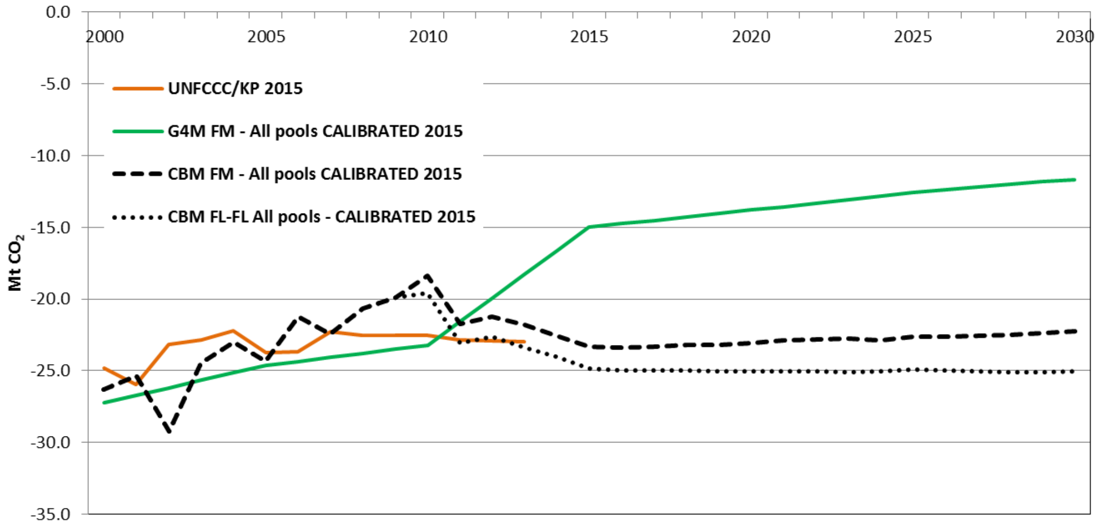


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[206] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)



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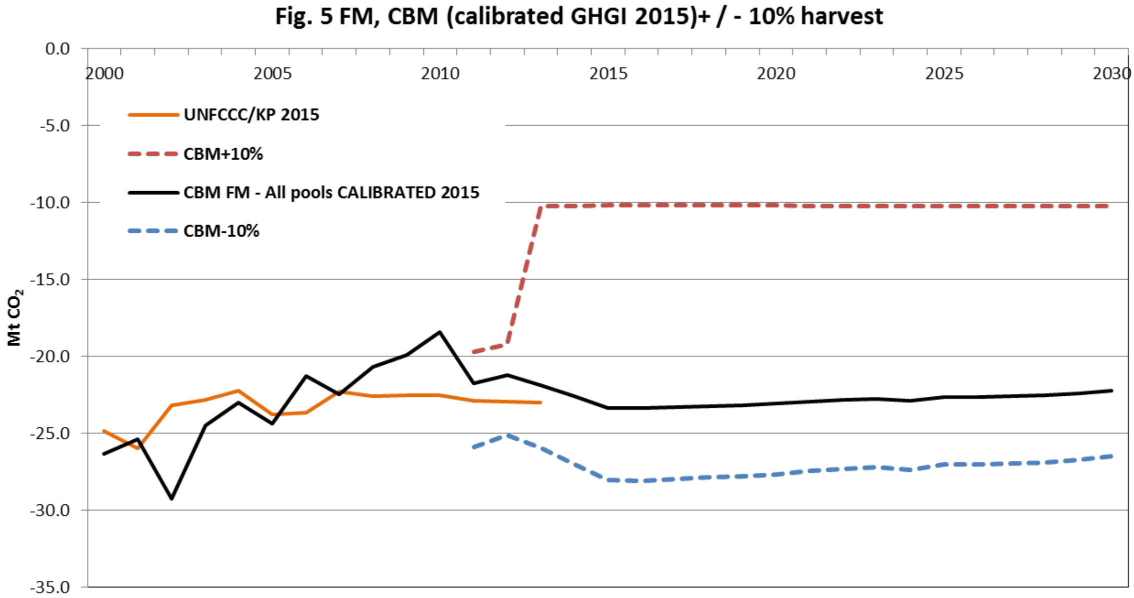
[206] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

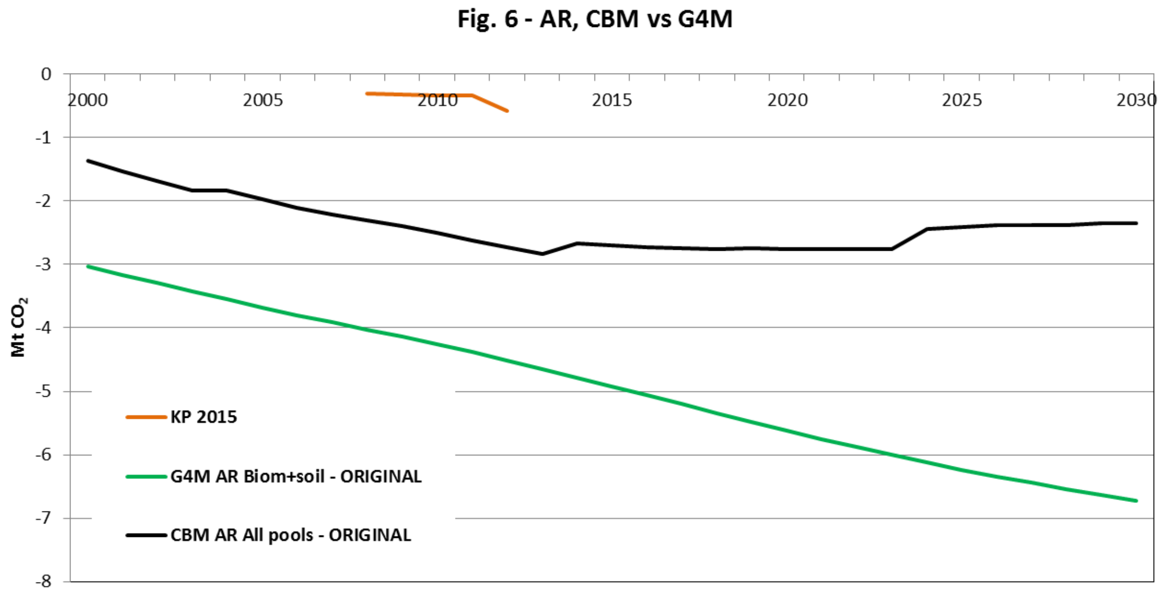
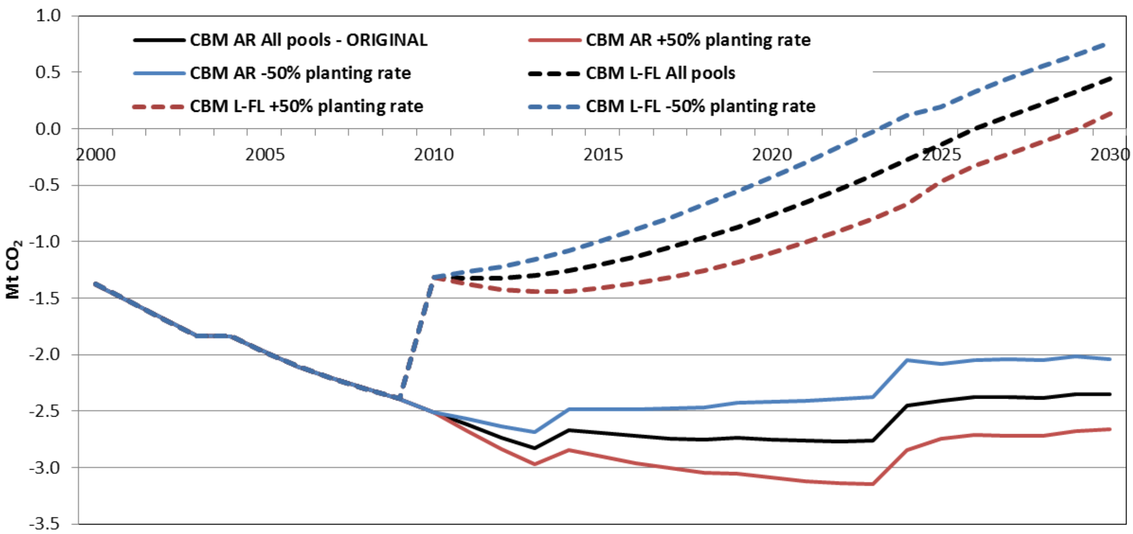


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

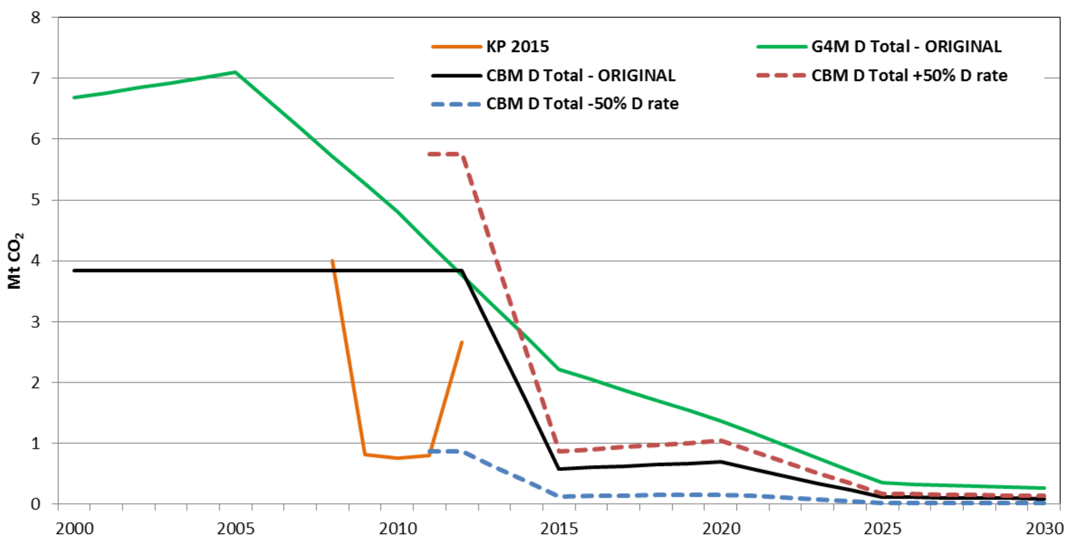
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

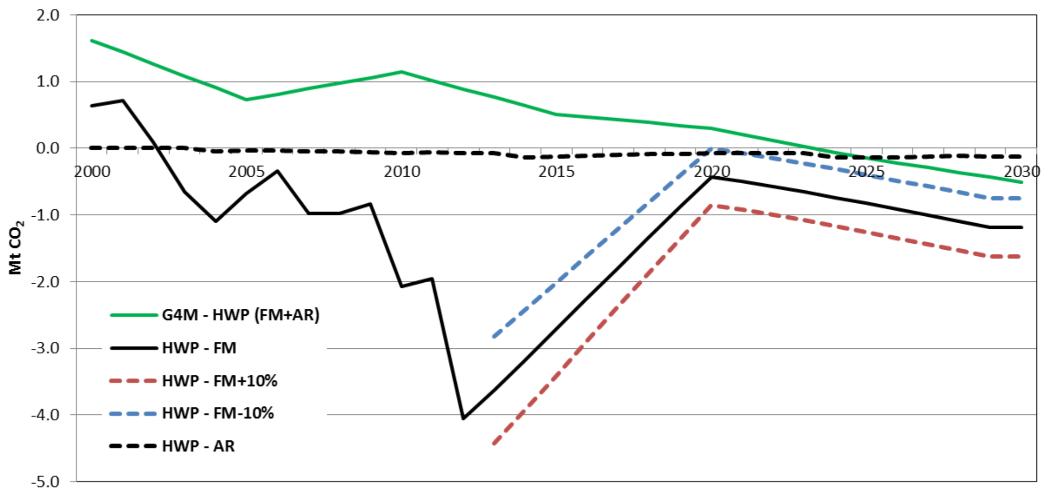
Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[207]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

Fig. 9-HWP, CBM vs G4M



Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[208]; +/- 50% planting rate for AR; D/-50% D rate).

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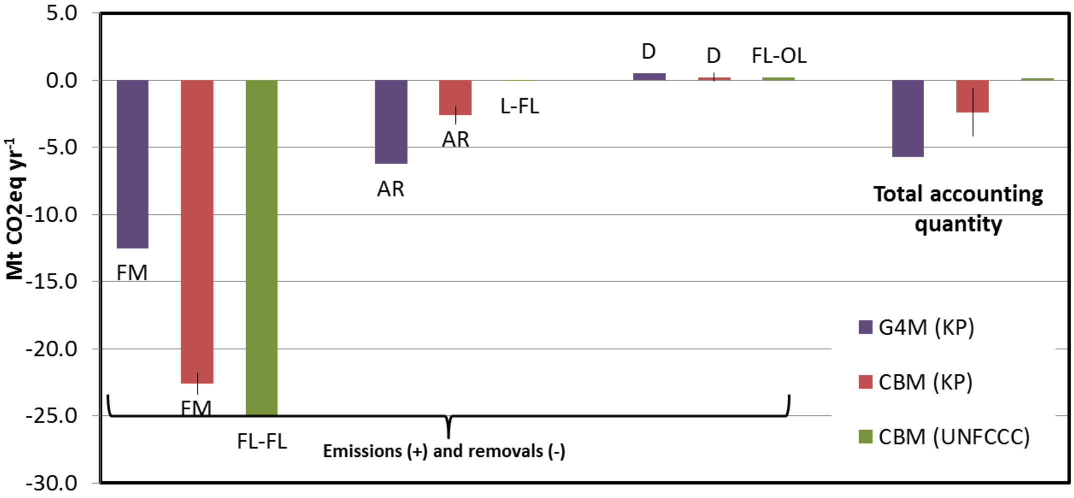
[207] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[208] Based on preliminary results.

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM is 73% lower than the average C sink reported by the 2015 GHGI and 67% lower than the values reported by G4M (see Fig. 3)[209]. However, calibrating the models on the GHGI data, the final C sink reported by CBM results 46% higher than the value reported by G4M (this appears as an "artifact" due to the effect of calibration").
- The future harvest demand expected by IIASA is satisfied.
- HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[209] This is probably due to the higher harvest rate applied by CBM for the historical period (see Fig. 1), based on new data provided by Romania.

Sweden

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030), comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		22,503	22,359	22,334	22,312	28,156[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	14.0	31.5	0.0	6.6	2.6	7.8
Deforest. (D)	Area of forest conversion to other land since 1990			14.2	0.0	2.9	1.5	0.6

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**) and by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

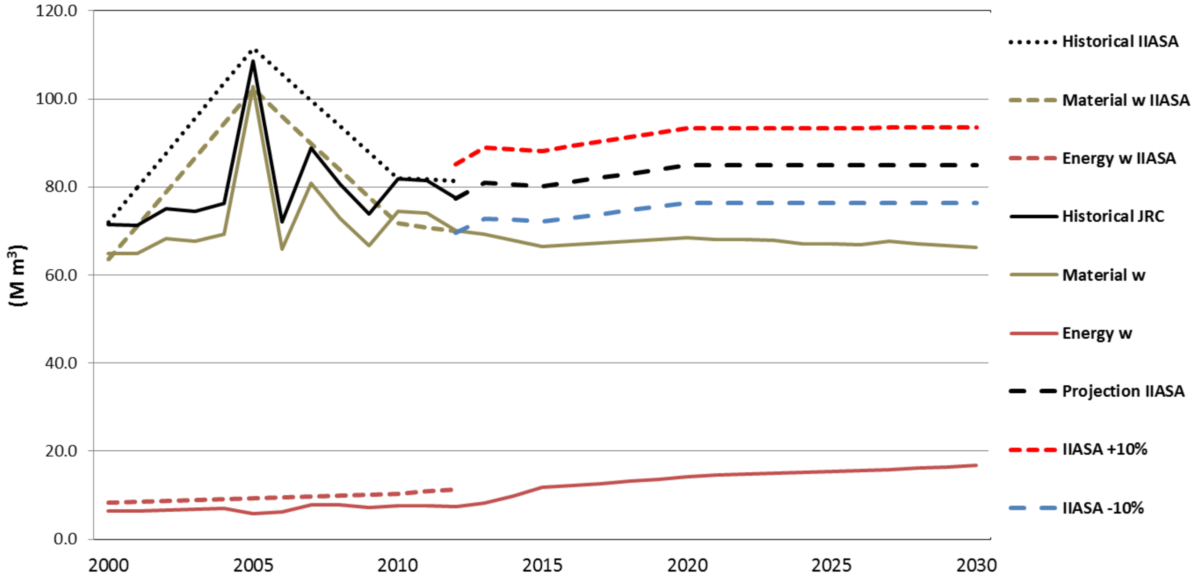
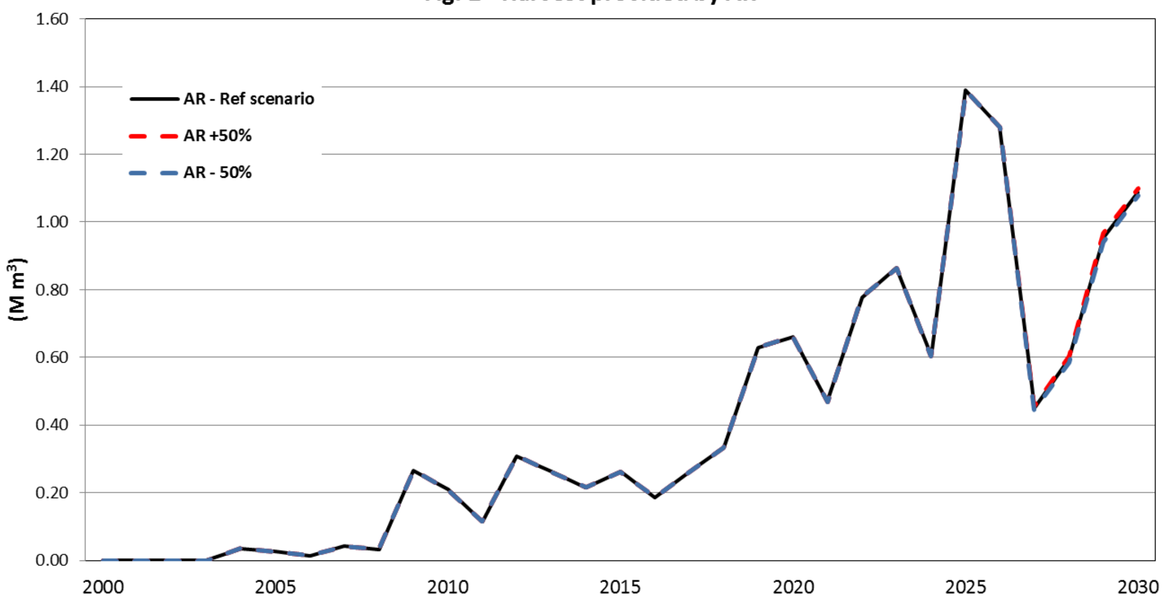


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

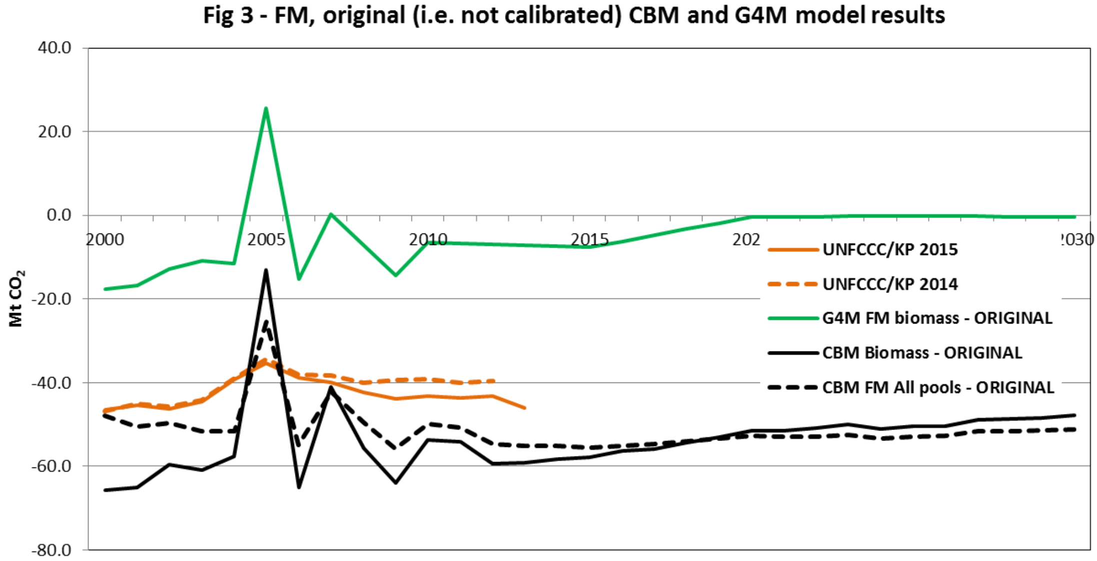
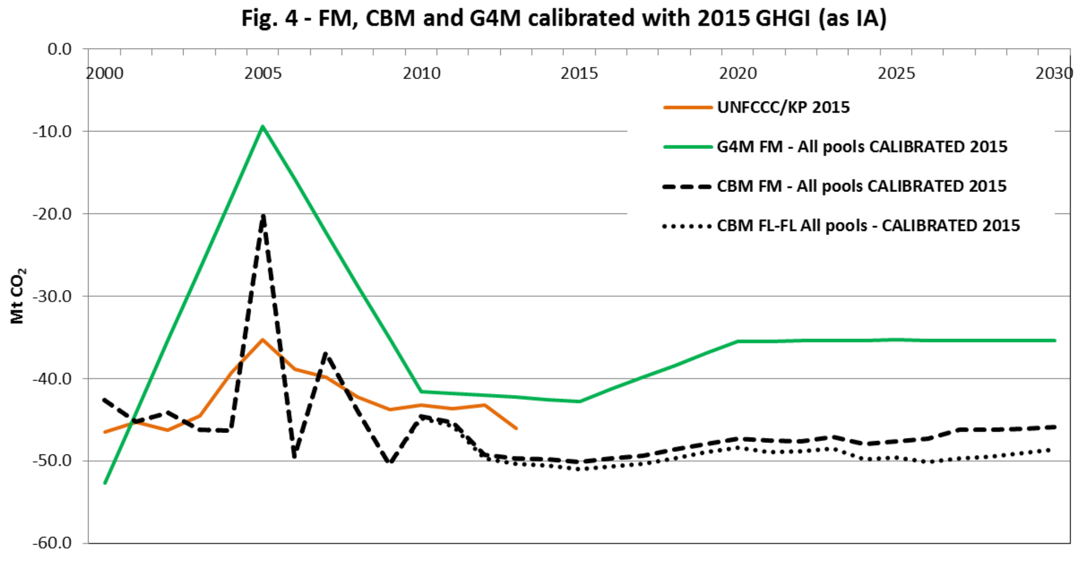
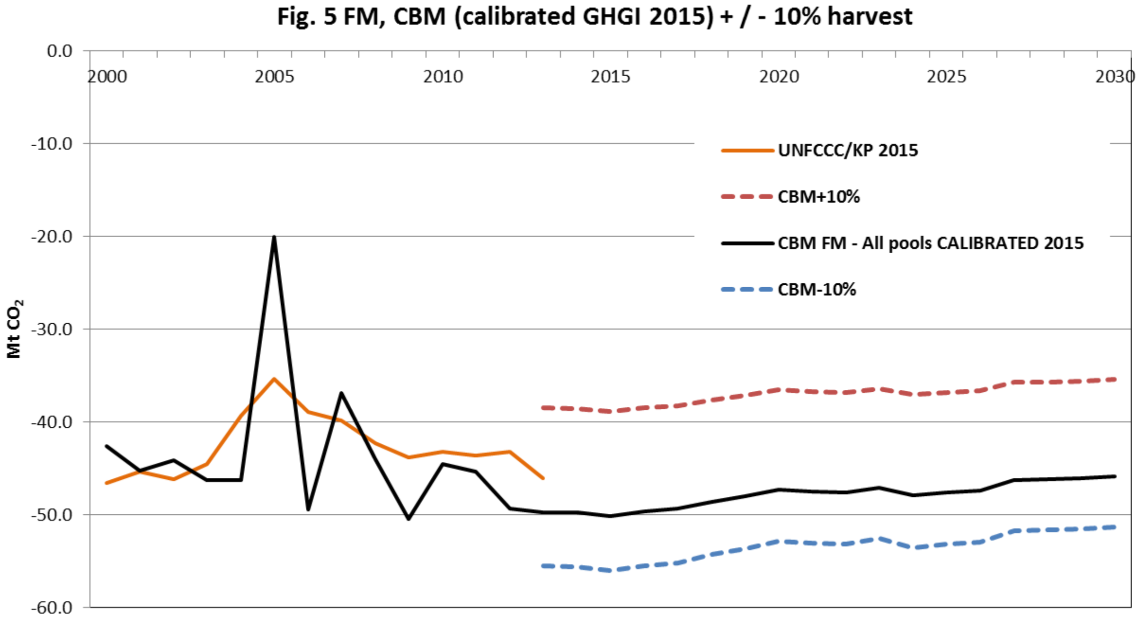


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[210] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



[210] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/-10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

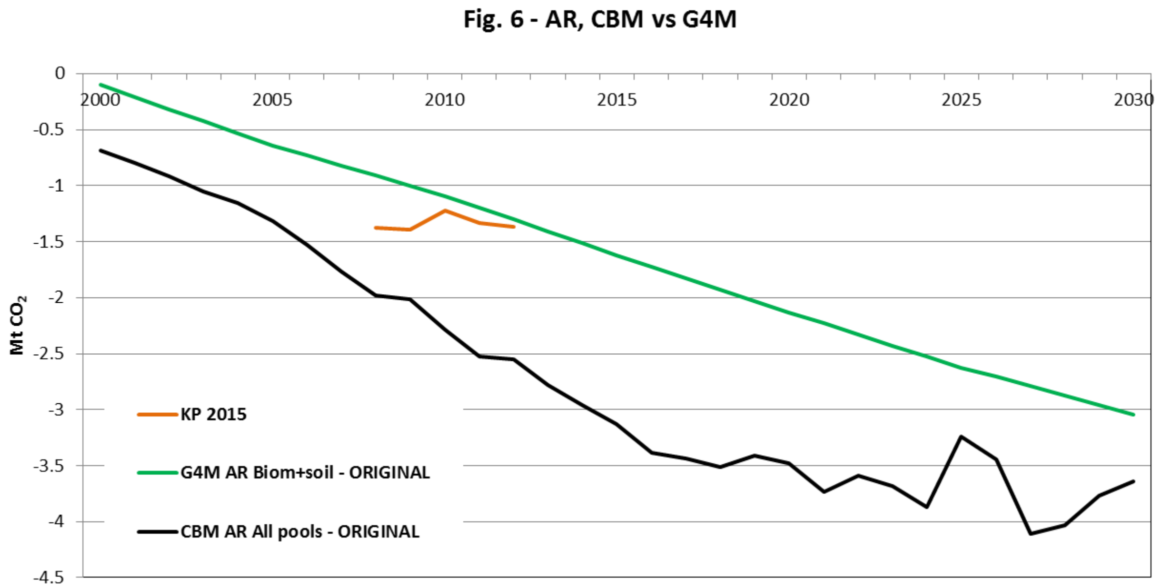
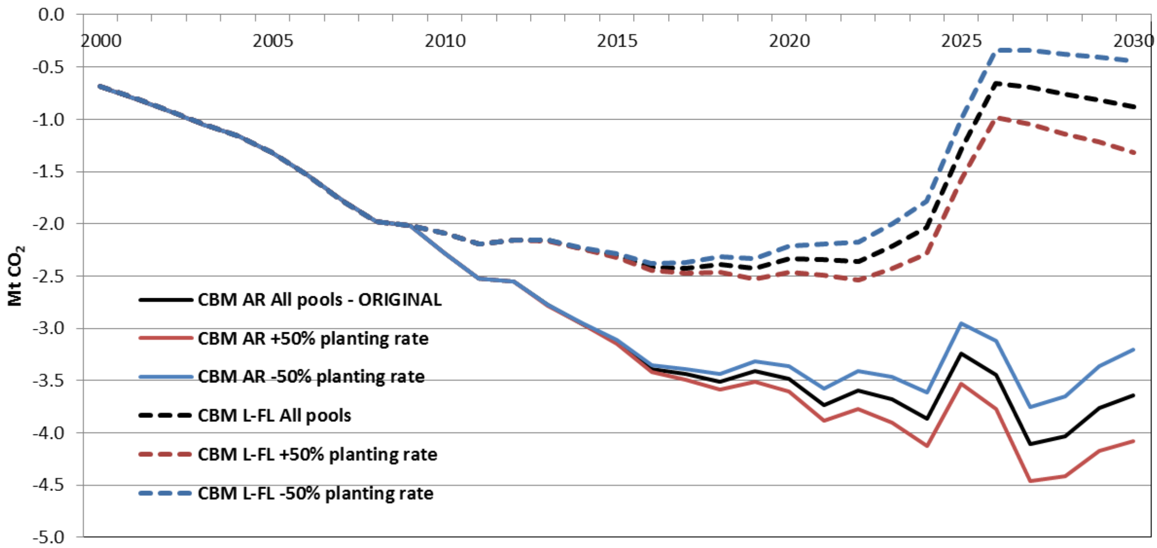


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

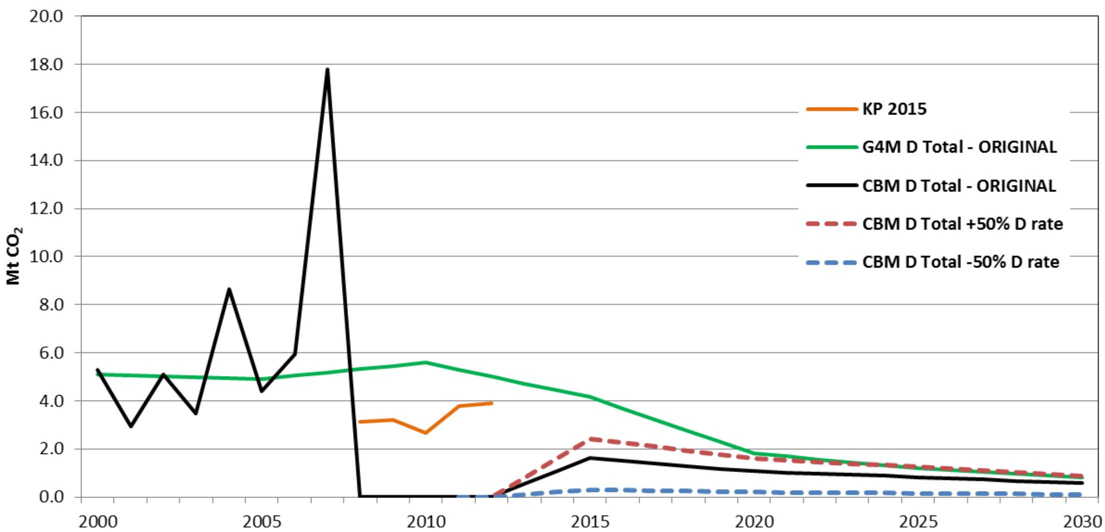
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

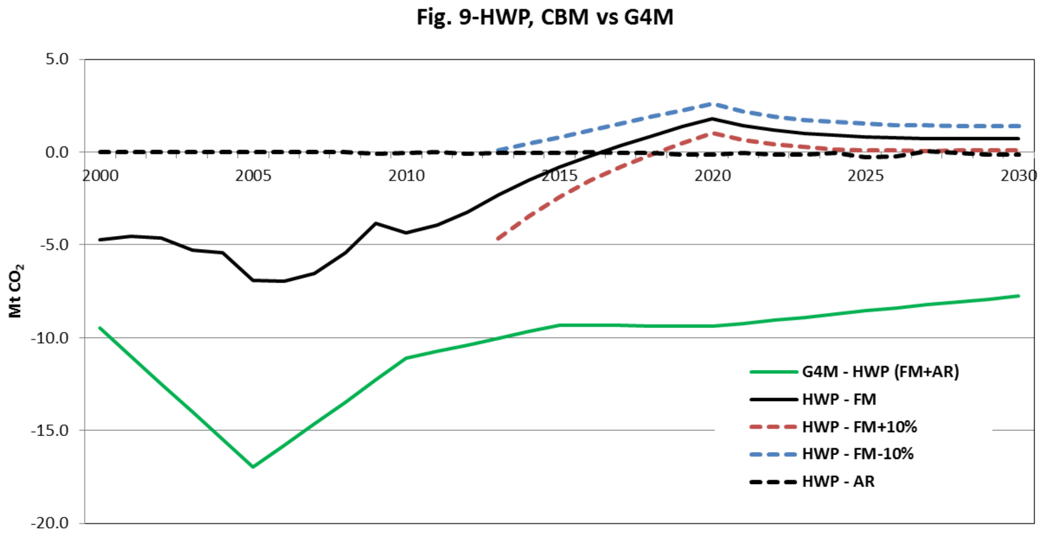
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[211]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

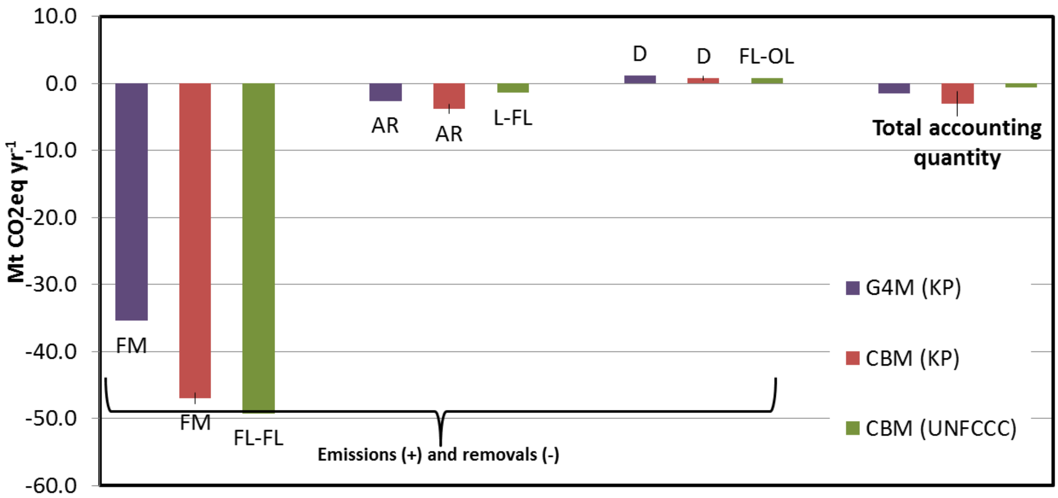


[211] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[212]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The FM area applied by G4M is 21% higher (for 2010) than the area considered by CBM. This is mainly due to the protective forest area, equal to about 3,000 kha, not considered by CBM.
- The historical FM C sink estimated by CBM has the same trend reported by the 2015 GHGI, but it is about 29% higher. On the opposite, the FM C sink estimated by G4M is considerably lower (-450%, despite the wider forest area, compared with CBM) than the value reported by the GHGI (see Fig 3). Both the models estimates a future constant C sink to 2030 (see Fig. 4).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[212] Based on preliminary results.

Slovakia

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030), comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		1,913	1,910	1,908	1,907	1,981[FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	1.9	1.3	2.7	1.4	1.5	2.7
Deforest. (D)	Area of forest conversion to other land since 1990	Annual rate (kha/yr)		0.1	0.3	0.1	0.1	0.3

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**) and by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

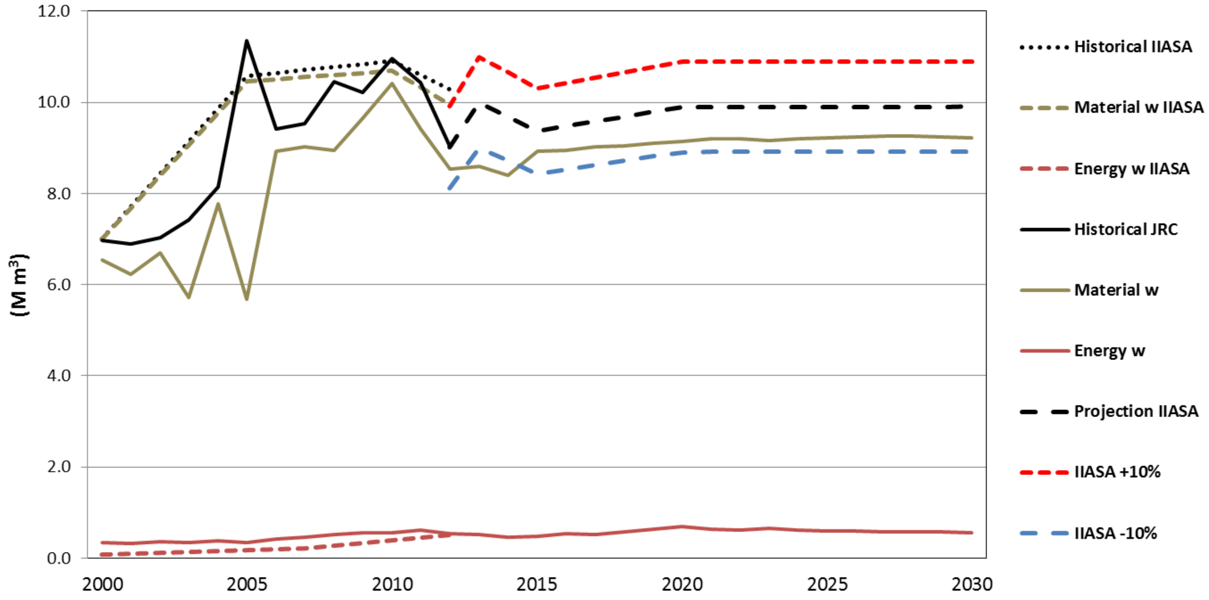
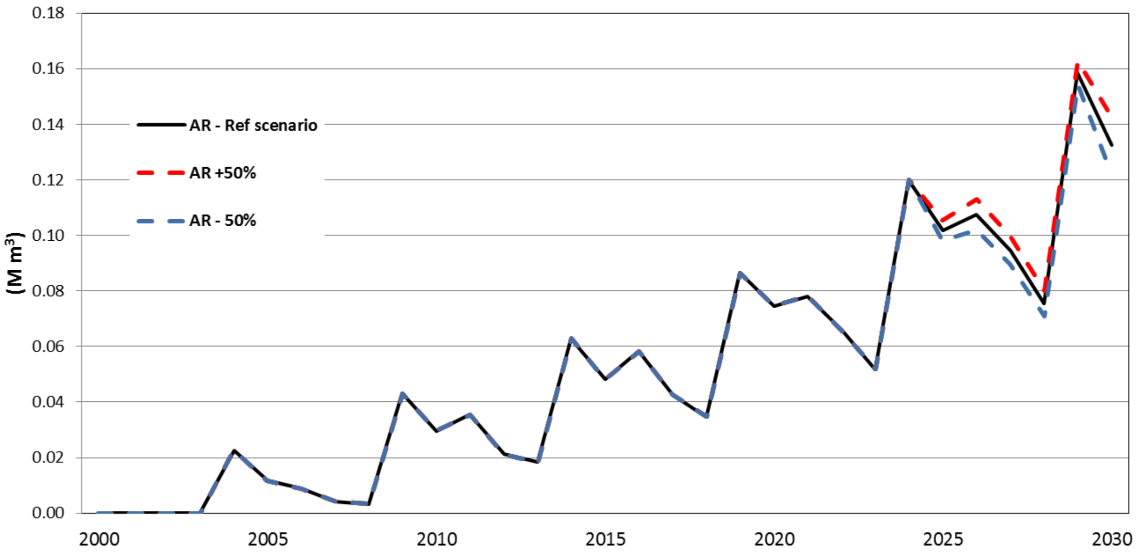


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

Fig 3 - FM, original (i.e. not calibrated) CBM and G4M model results

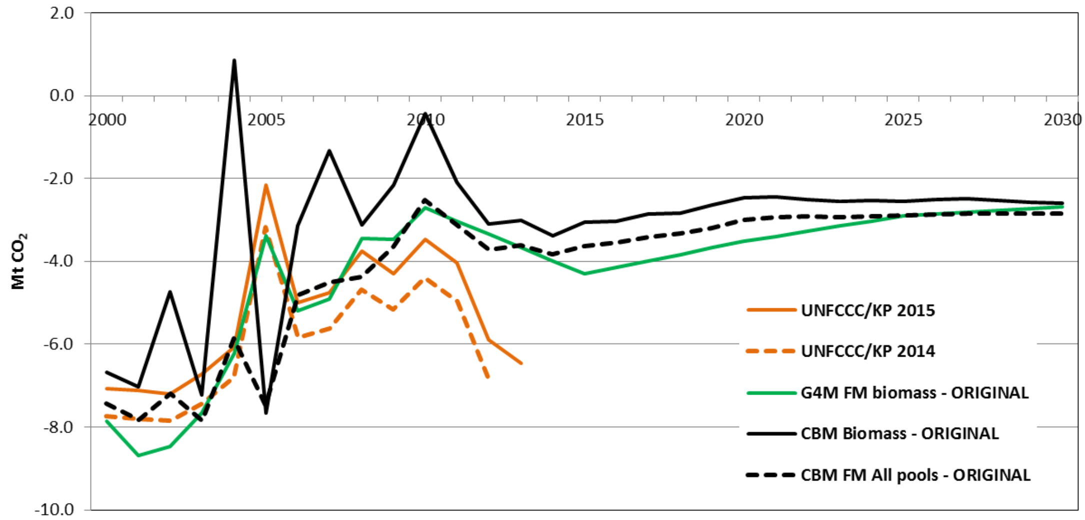
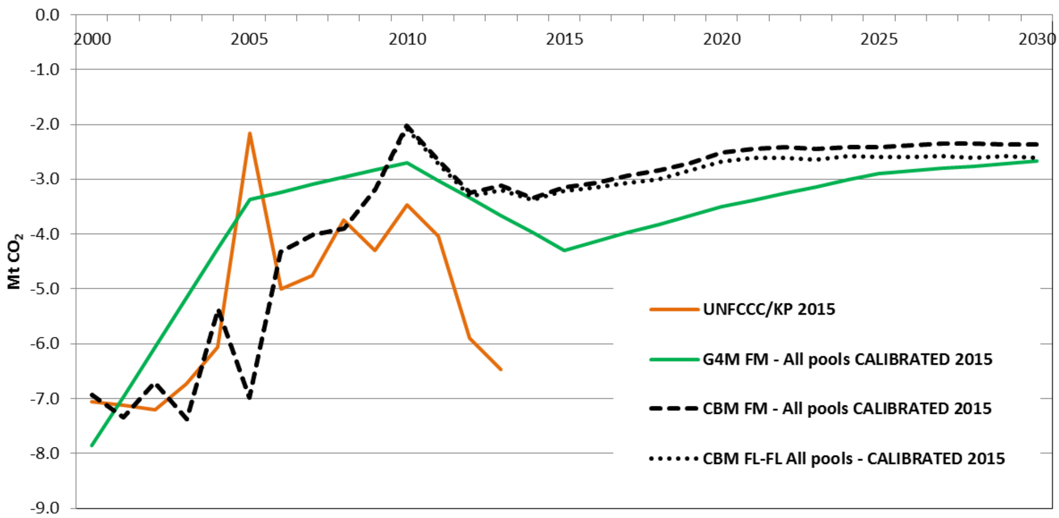


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[213] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).

Fig. 4 - FM, CBM and G4M calibrated with 2015 GHGI (as IA)



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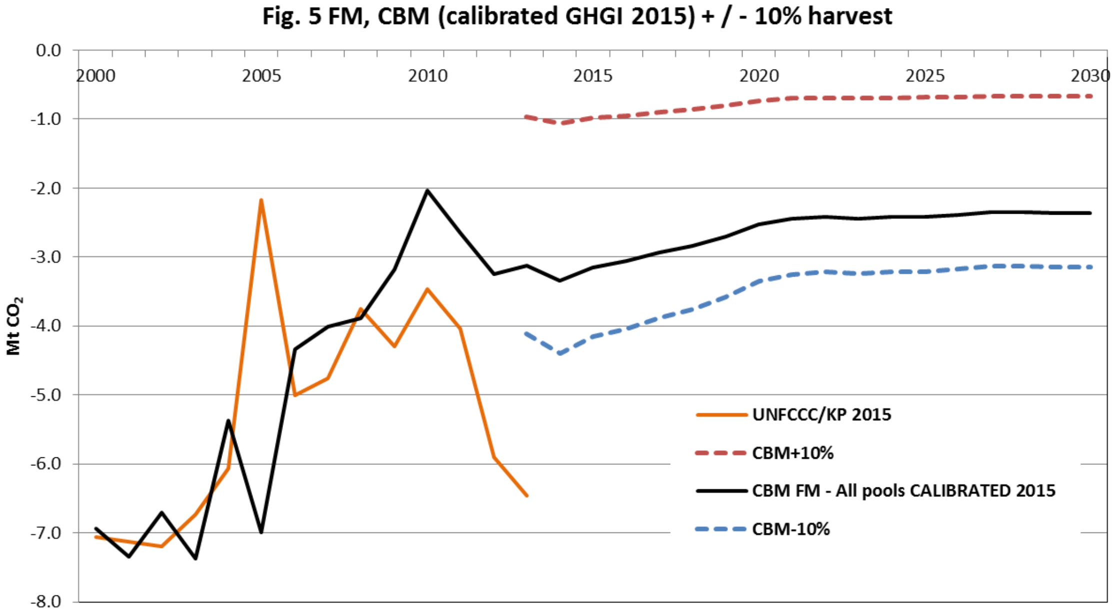
[213] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/-10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

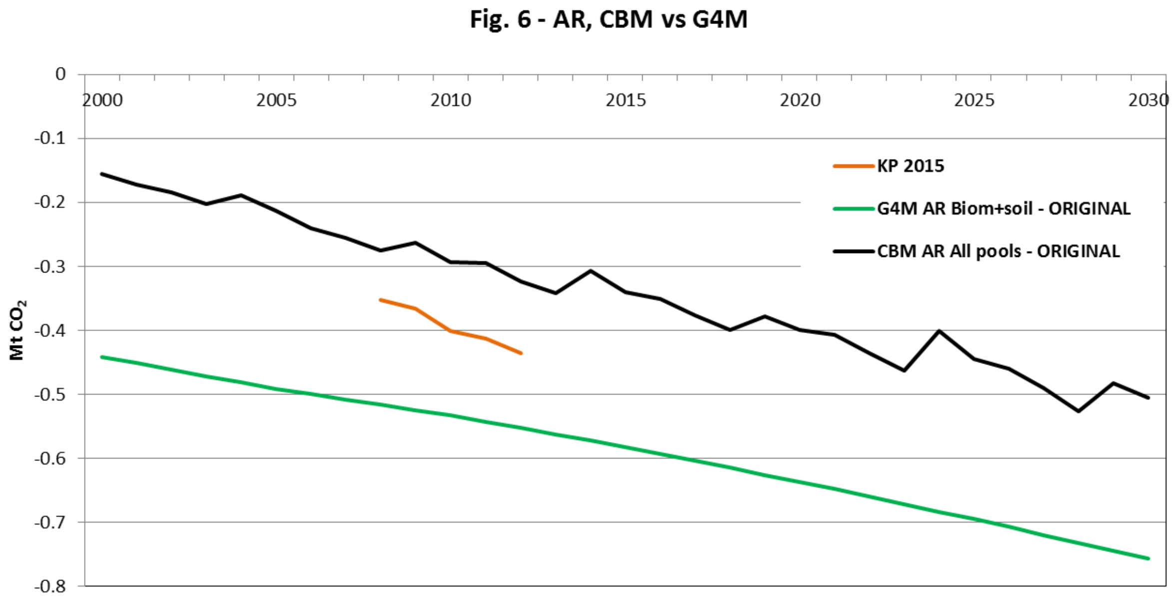
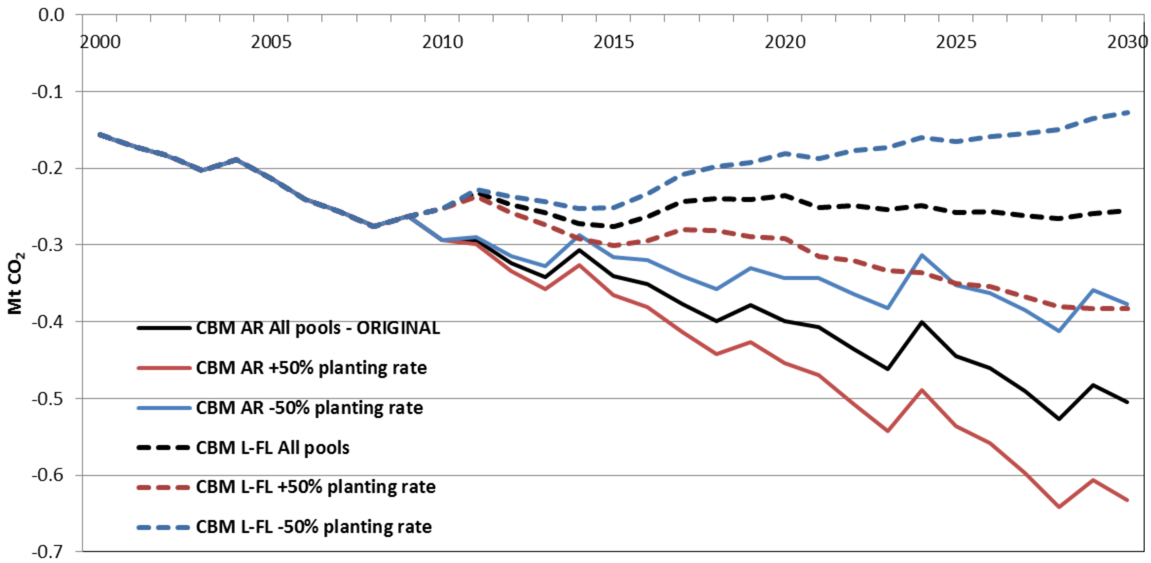


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

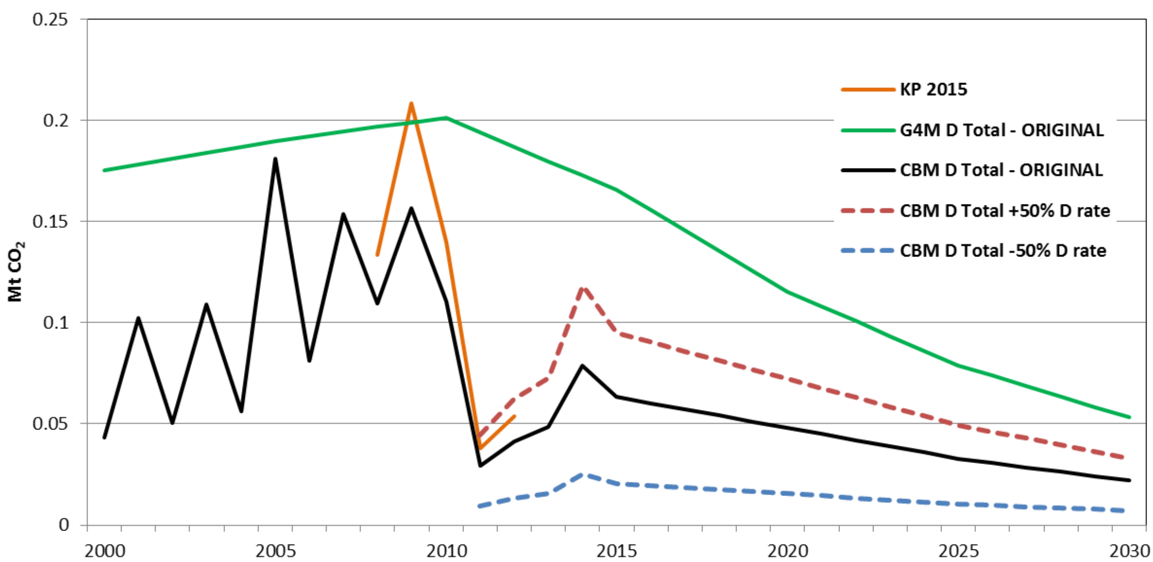
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

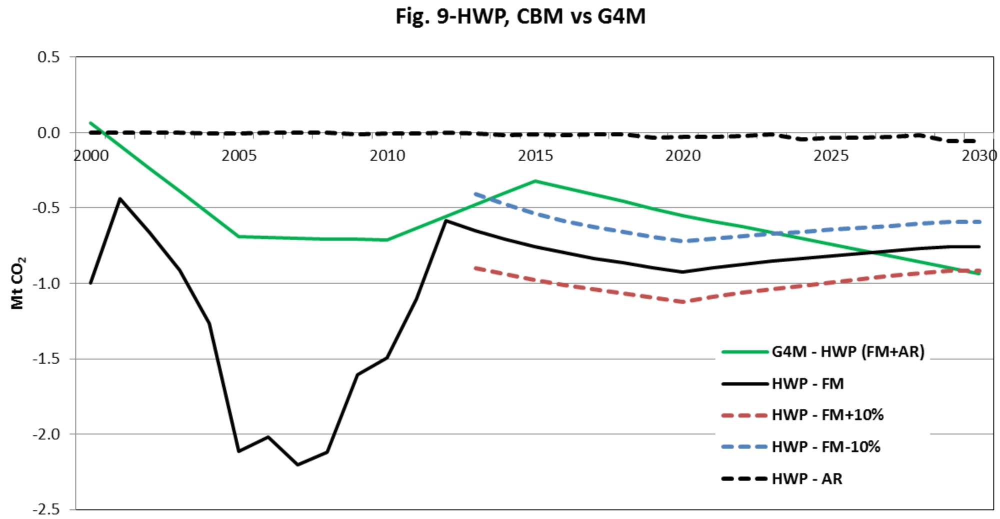
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[214]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

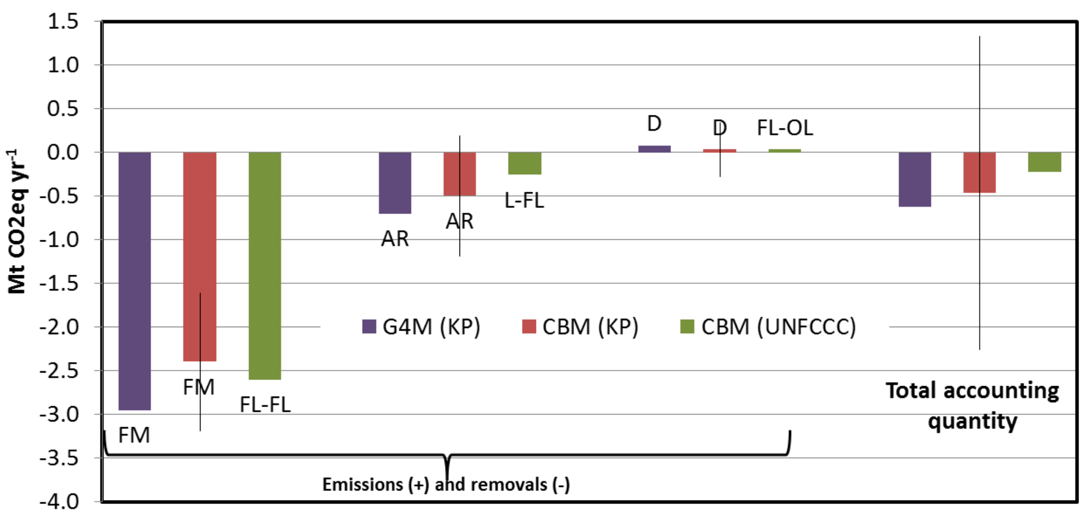


[214] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[215]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM is consistent with the estimate provided by G4M and by the 2015 GHGI (see Fig. 3).
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[215] Based on preliminary results.

Slovenia

CBM Estimates based on LULUCF Reference Scenario Input data – 2016

(updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030), comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		1,128	1,085	1,066	1,063	1,185[FM]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	4.6	3.1	4.6	1.0	0.3	0.0
Deforest. (D)	Area of forest conversion to other land since 1990			3.9	3.9	0.5	0.2	0.7

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**) and by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**) and the real amount of harvest provided by CBM, only reported if different from the expected one ("**CBM – Real harvest**"). This amount is referred to FM, excluding the harvest provided by AR.

- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

Fig. 1 - Assumptions on total harvest

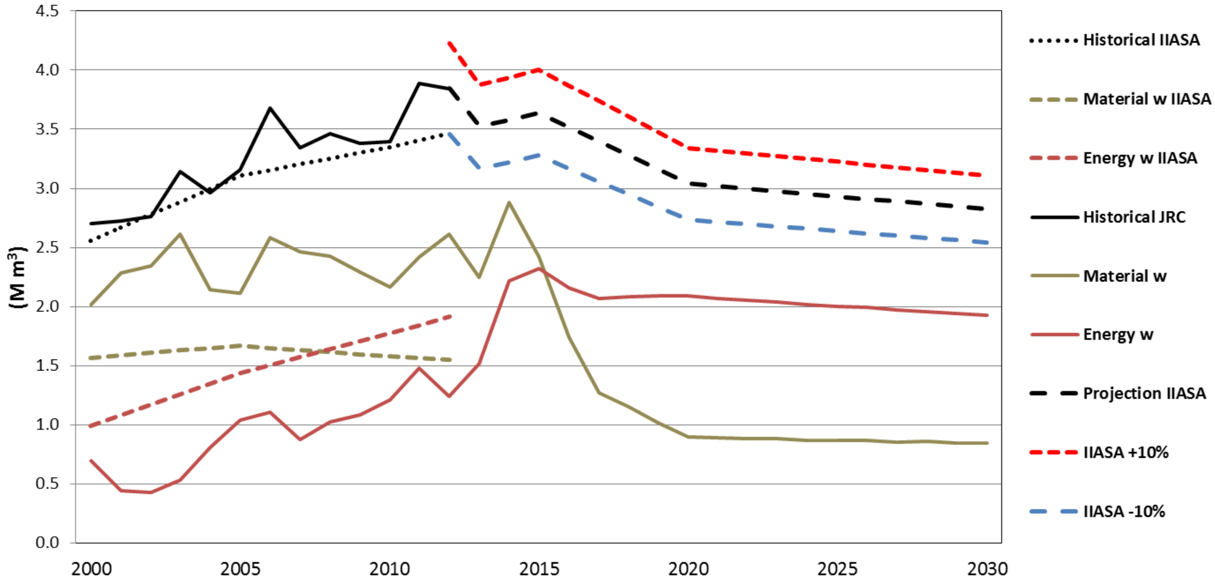
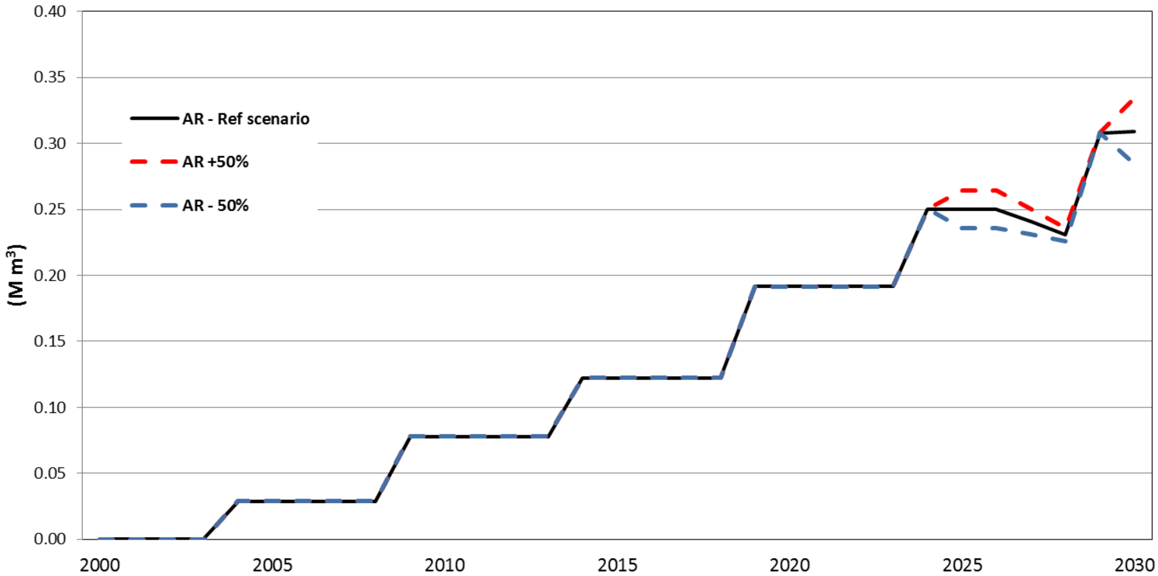


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.

Fig. 2 - Harvest provided by AR



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2014 and 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

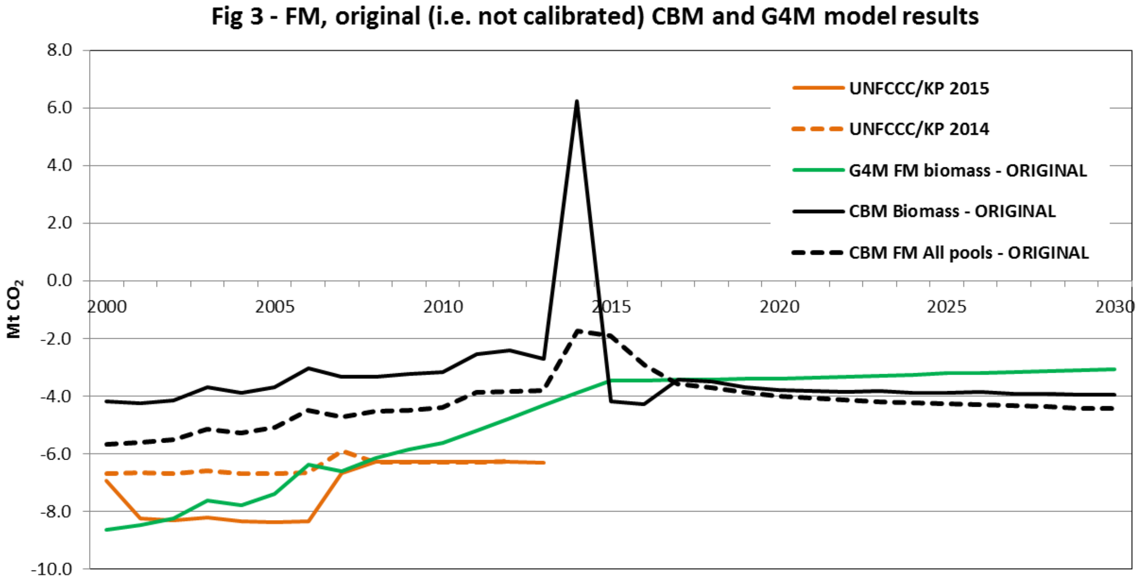
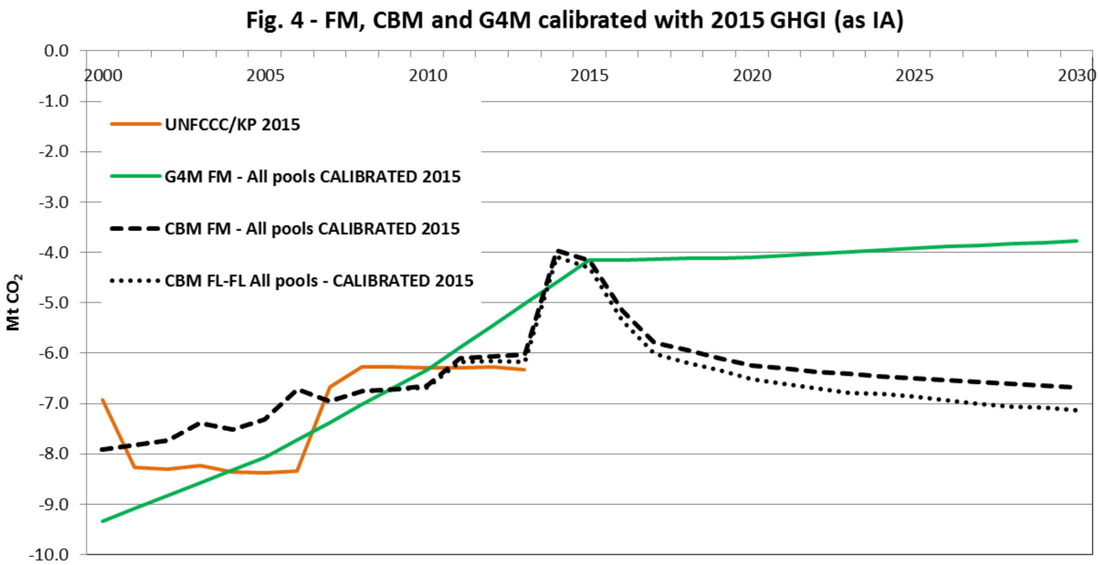
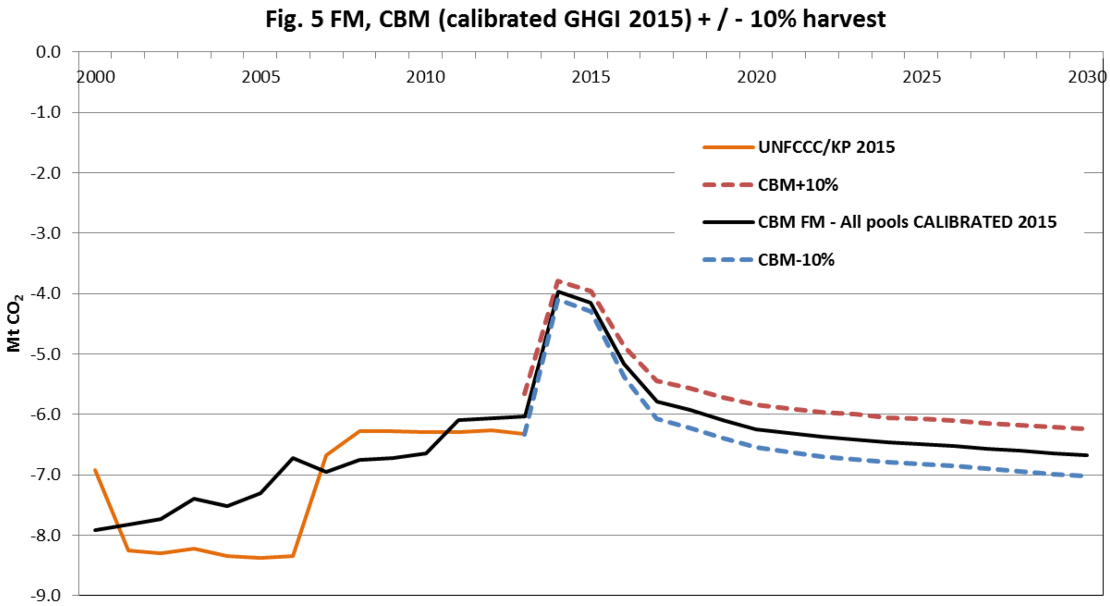


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[216] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



[216] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

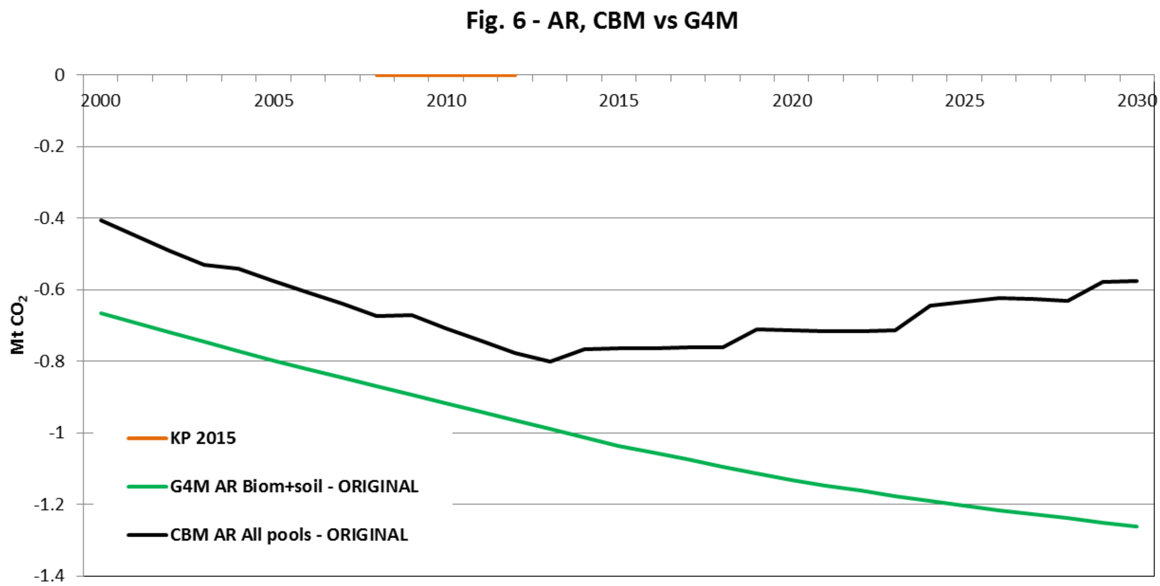
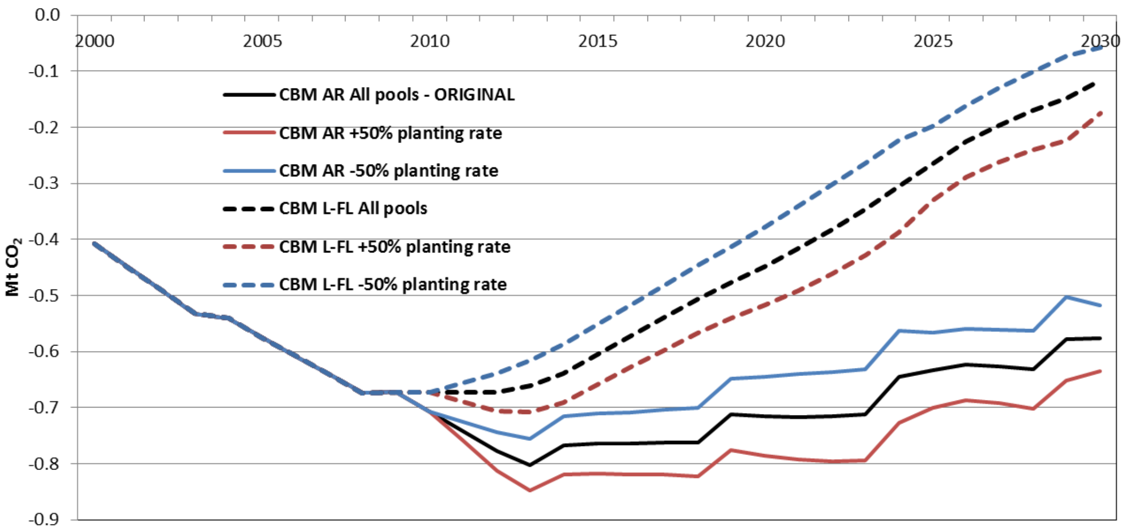


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

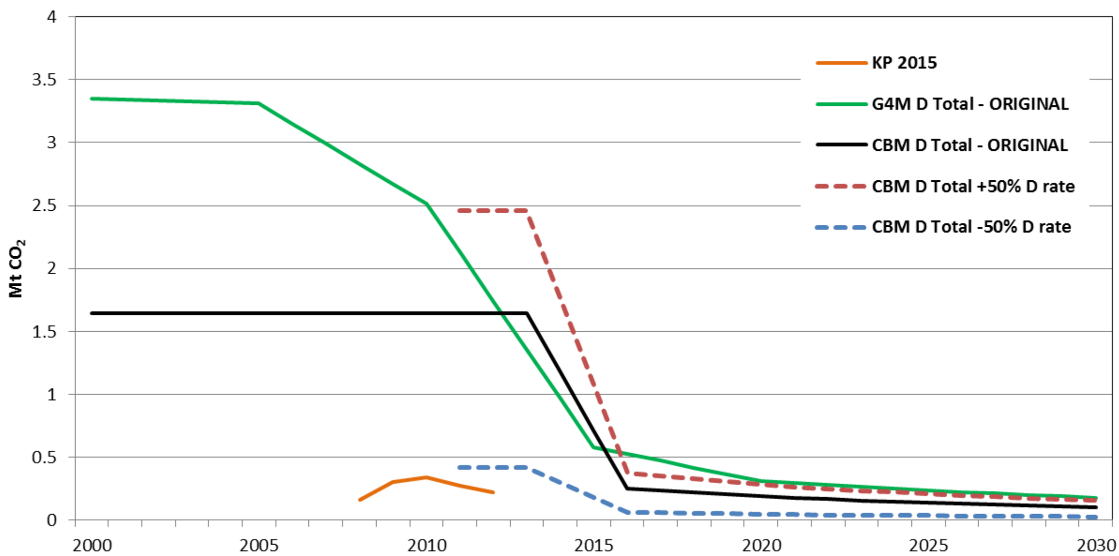
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

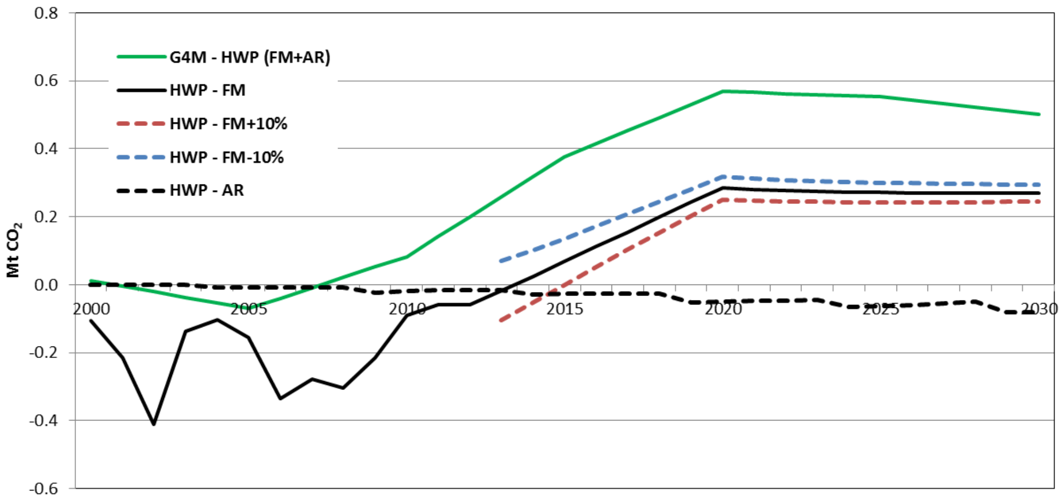
Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[217]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

Fig. 9-HWP, CBM vs G4M

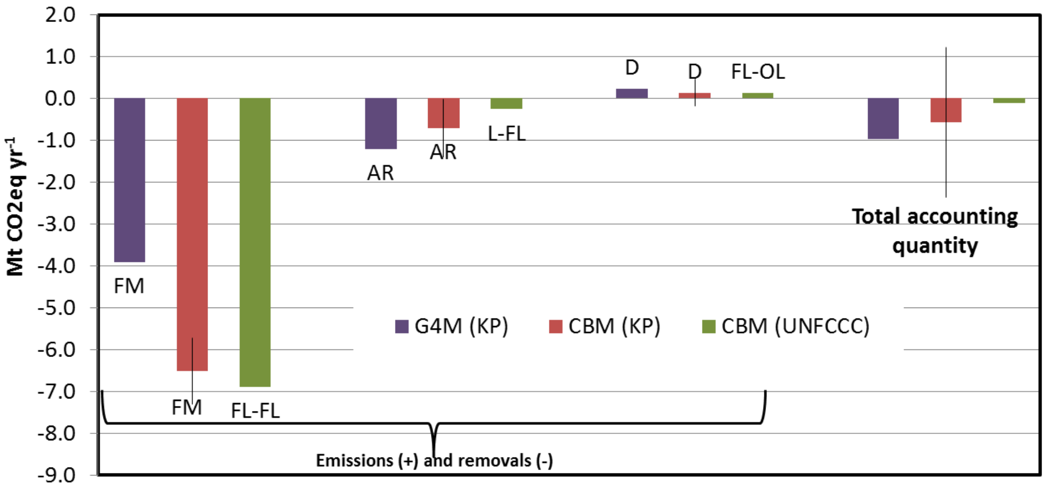


[217] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.

Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[218]; +/- 50% planting rate for AR; D/-50% D rate).

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- The historical FM C sink estimated by CBM has the same trend reported by G4M and by the 2015 GHGI but the average biomass C sink estimated by CBM is about 50% lower (see Fig. 3). Despite these differences, the future C sink estimated by the models based on the original data (as reported on Fig. 3) is similar. However, due to the calibration on the GHGI data, the "calibrated" future C sink reported by CBM is about 78% higher than the value reported by G4M (see Fig. 4). This is also due to the effect of the natural disturbances considered by CBM for 2014, probably not considered by G4M.
- The future harvest demand expected by IIASA is satisfied.
- The C stock change estimated for HWP is based on the data reported by FAOSTAT and may deviate from the historical data considered by IIASA (see on Fig.1 the share IRW/FW). This may explain the differences highlighted on Fig. 9.

[218] Based on preliminary results.

EU

CBM Estimates based on LULUCF Reference Scenario Input data – 2016 (updated April 2016)

MODEL INPUTS

AREA - Basic assumptions used by CBM for FM, AR and D (= to assumptions in the Reference Scenario 2016 as modelled by IIASA from 2015 to 2030) and comparison with the data reported by the country for 2010 (see last column).

Activity	Definition	Unit	1990	2000	2010	2020	2030	Country data 2010
Forest Manag. (FM)	Forest area in 1990 minus any subsequent D	Total (kha)		138,069	136,436	135,597	135,144	145,070[FM, FL]
Aff/Ref.(AR)	Area of forest expansion after 1990	Annual rate (kha/yr)	435	476	236	260	202	232
Deforest. (D)	Area of forest conversion to other land since 1990			145	127	62	37	97

* A sensitivity analysis with a +/-50% planting (or "forest expansion") rate on AR, and a +/-50% rate for D, was done for the period 2011-2030.

[FM] Forest Management Area, if elected, otherwise [FL]

[FL] Total Forest Land 1990 – Cumulated Deforestation (1990-2010)

Results include estimates for "**Forest Land Remaining Forest Land** (**FL-FL**, i.e. forest remained forest in the last 20 yrs)" and "**Land converted to Forest Land**" (**L-FL**, i.e. land converted to forests in the last 20-yrs.). Forest converted to other land (FL-OL) is not considered because emissions are assumed to be equal to deforestation.

HARVEST - Assumptions

The following **Fig 1** reports:

- The Historical total Harvest applied by G4M (**Historical IIASA**), further distinguished between Material wood **(Material w IIASA)** and Energy wood **(Energy w IIASA)**.
- The Historical total Harvest applied by CBM in this study (**Historical JRC**), further distinguished between Material wood **(Material w**, reported both for the historical period and to 2030**)** and Energy wood **(Energy w**, reported both for the historical period and to 2030**)**.
- The Future total Harvest demand applied by IIASA and used as input in this study (**Projection IIASA**), and the real amount of harvest provided by CBM ("**CBM – Real harvest**", excluding the harvest provided by AR).
- The sensitivity analysis, assuming a ± 10% of the harvest expected by IIASA from 2013 to 2030 (**IIASA +10% and IIASA -10%**).

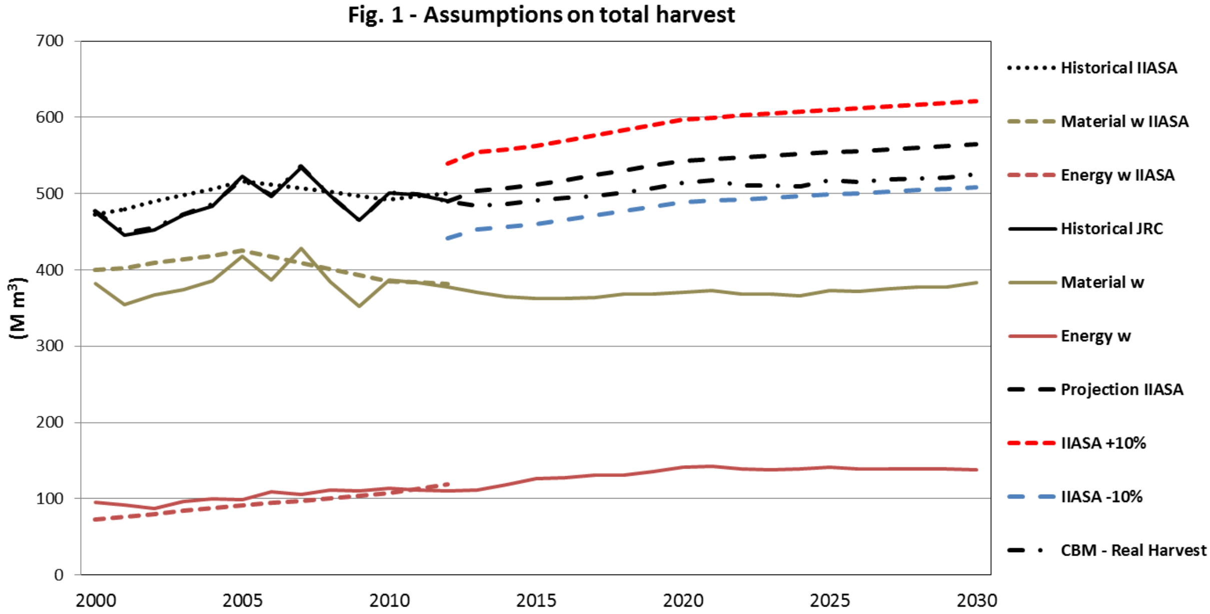
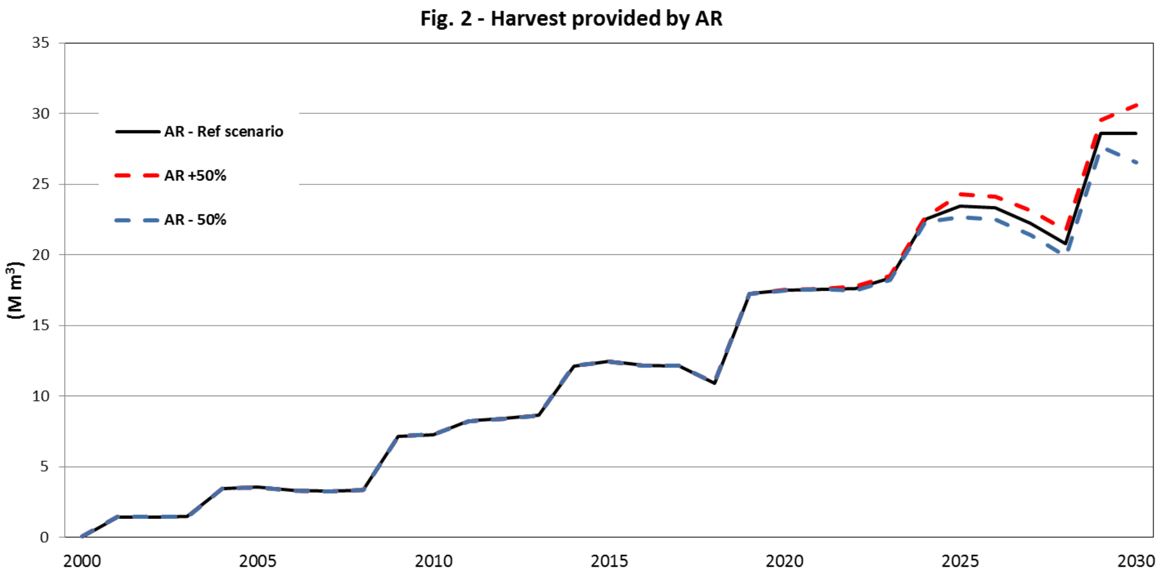


Fig. 2 reports the amount of total harvest potentially provided by AR (if not explicitly considered by the country, we assumed that the future harvest demand is totally provided by FM). For the future, this harvest is modulated according to the two scenarios of AR rates.



MODEL OUTPUTS

Forest Management

Fig. 3 compares the UNFCCC/KP countries' data (i.e. FM when available, otherwise FL-FL) from 2015 GHGI inventories (all available C pools: living biomass + soil + DOM) with (i) the ORIGINAL estimates provided by G4M (IIASA) for the living biomass and (ii) the original estimates provided by CBM for the living biomass and for all C pools.

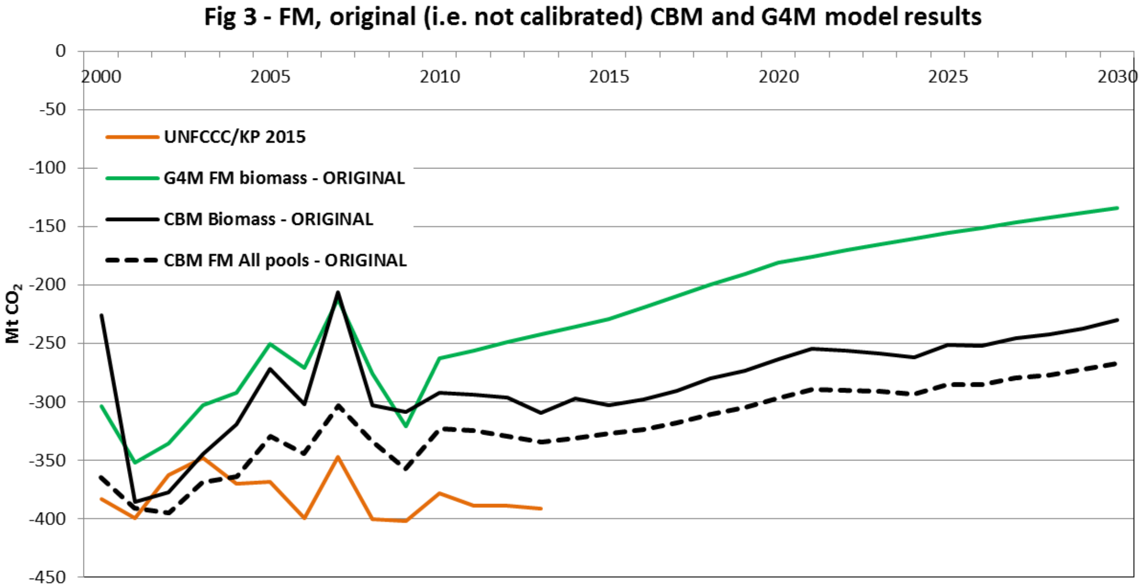
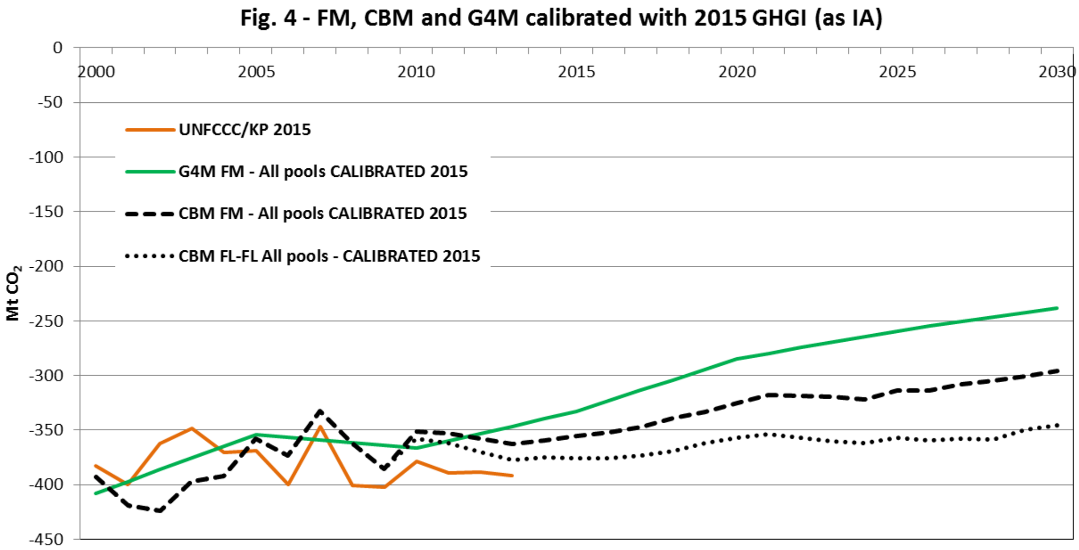
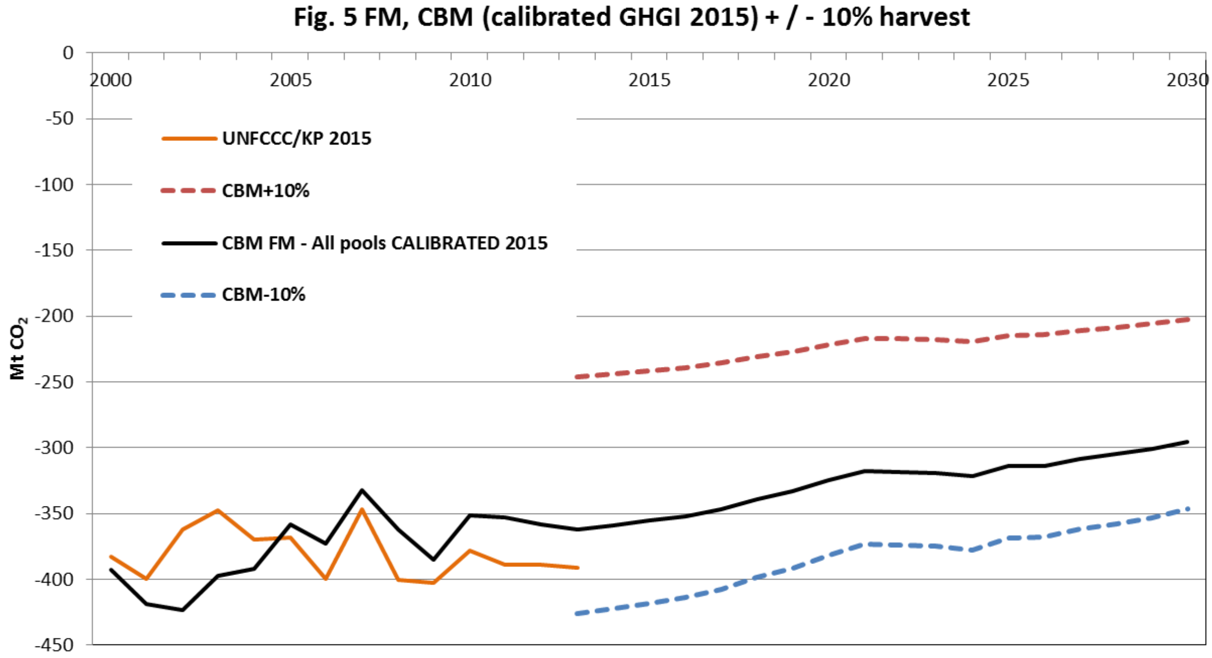


Fig. 4 compares the UNFCCC/KP 2015 GHGI data (all C pools) with the estimates provided: (i) by G4M for all C pools calibrated on the 2015 GHGI data (G4M FM All pools CALIBRATED[219] 2015); (ii) by CBM for all C pools calibrated on the 2015 GHGI data (CBM FM All pools CALIBRATED 2015), and (iv) by CBM for "forest land remaining forest land" (CBM FL-FL All pools calibrated 2015).



[219] Calibrated means 'adjusted' for the historical period 2000 – 2012 to force matching with the GHG inventory 2015.

Fig. 5 shows the preliminary results on the sensitivity analysis performed by CBM (+/- 10% harvest demand as compared to Ref scenario), calibrated with 2015 GHGI.



Afforestation/Reforestation

Fig. 6 compares the KP 2014 data on AR referred to the total C pools (i.e, living biomass + soil + DOM) with (i) the G4M data on AR including biomass and soil, and (ii) the CBM data on AR including all the C pools. Please note that CBM is accounting AR since 1990 while G4M is computing AR since 2000.

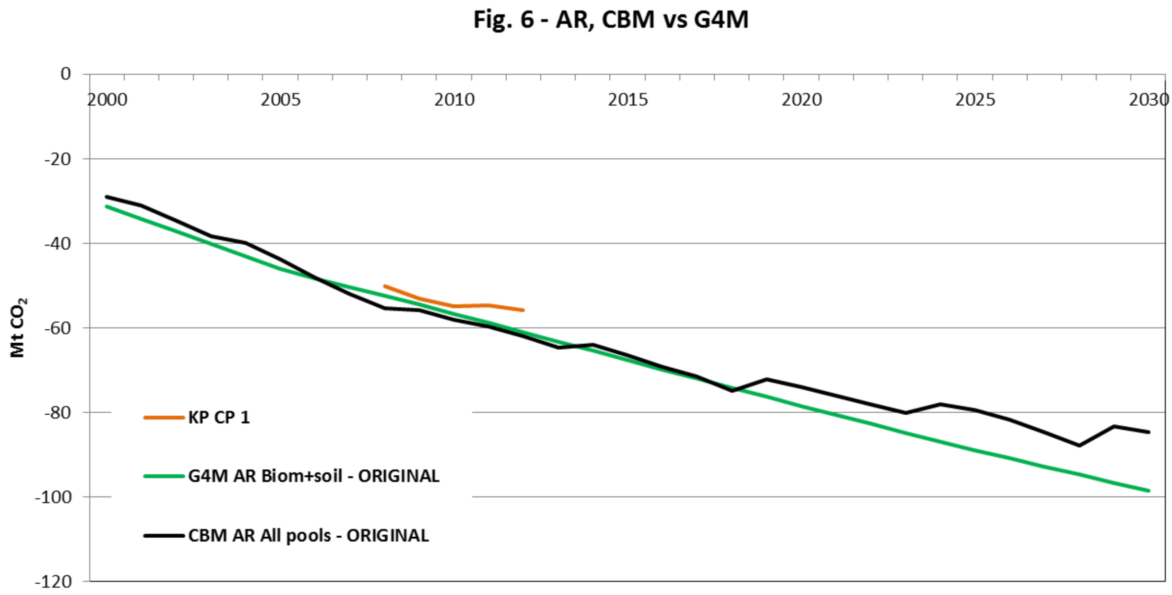
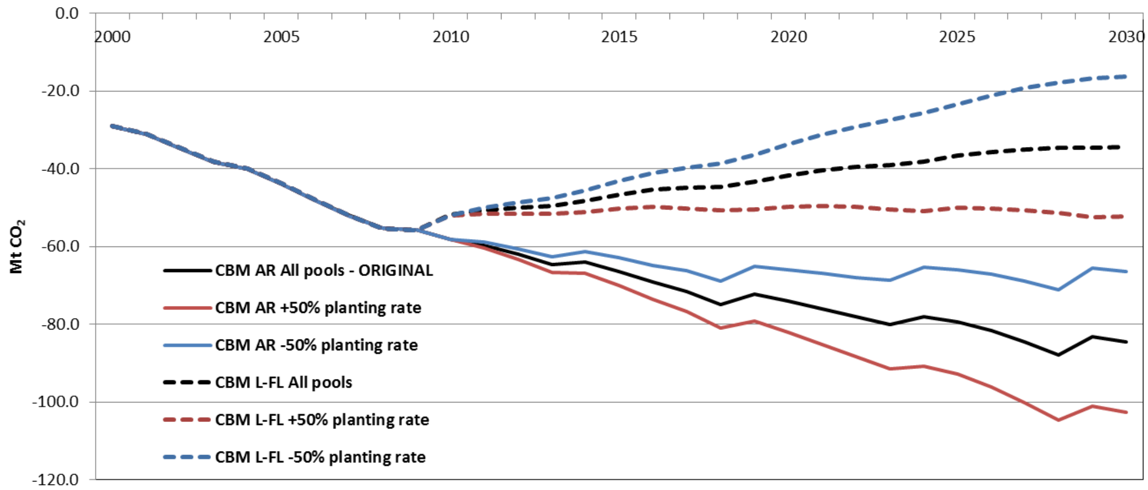


Fig. 7 compares the estimates provided by CBM on new forest area (including all C pools) based on different accounting options and model assumptions:

(A) considering the **total AR occurred since 1990** (i.e., as under KP) and assuming 3 different planting rates after 2010 (ref scenario +/-50%);

(B) considering the **Land converted to Forest Land**" (**L-FL**, i.e. using the 20-yrs transition period used under UNFCCC reporting) and the 3 different planting rates after 2010.

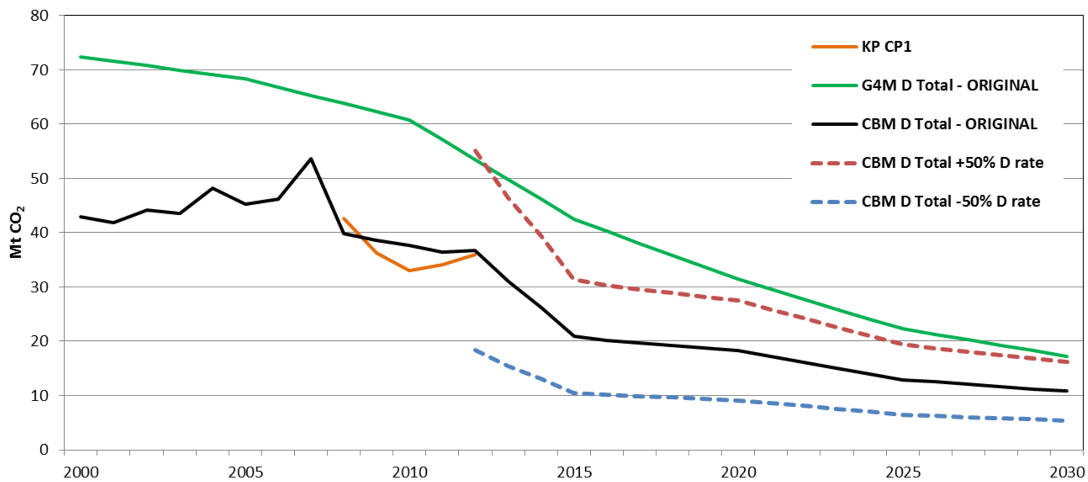
Fig. 7 - AR and L-FL, CBM + sensitivity analysis on AR rate



Deforestation

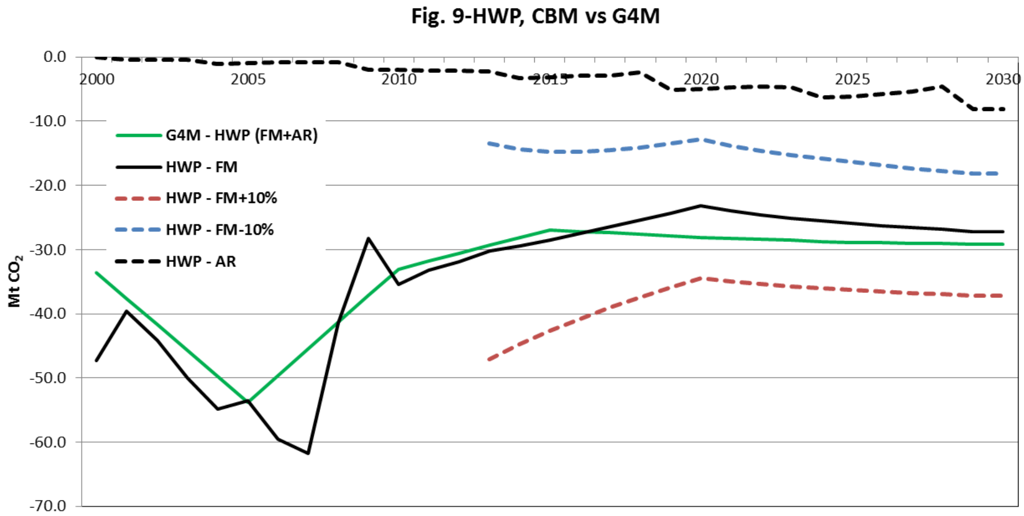
Fig. 8 reports the total emissions related to deforestation post-1990 as reported by the KP 2014 data and estimated by G4M and CBM. The impact of considering the 20-yrs transition (i.e. "forest converted to other land use", FL-OL as in the UNFCCC) is not shown here because the difference is considered to be negligible (i.e. the results would be = to D). The sensitivity analysis by CBM is also shown.

Fig. 8- D, CBM vs G4M



Harvested Wood Products (HWP)

Fig. 9 shows the HWP estimated by G4M (FM+AR together) and by CBM (separately for FM, including sensitivity analysis, and AR[220]). The CBM estimates are based on the IPCC 2014 approach (2013 IPCC KP Supplement) applied to the 2012 FAOSTAT data and they include the C inflow to HWP before 2000.

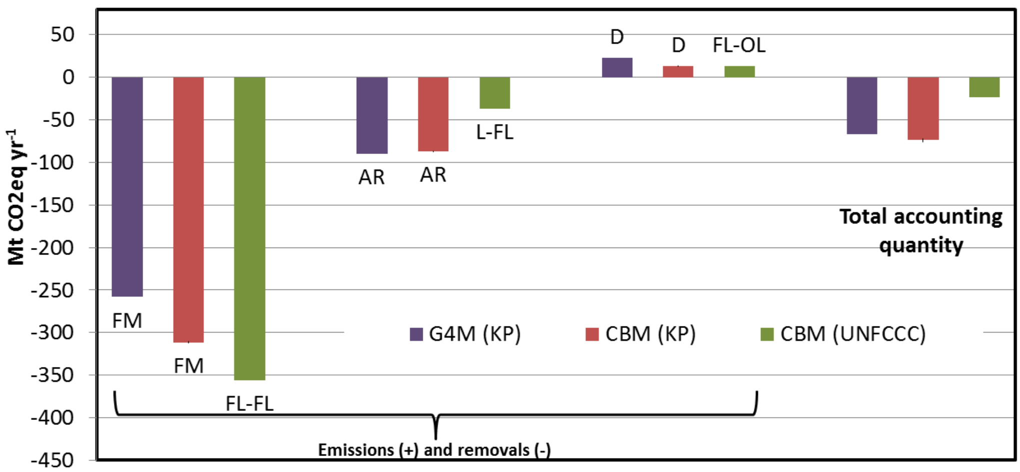


Summary of emissions/removals and accounting

Fig 10 shows the emissions (+) and removals (-) estimated for the period 2021-2030 by G4M and CBM for the KP activities (FM, AR, D) and by CBM for the UNFCCC forest categories (FL-FL, L-FL, FL-OL). The "Total accounting quantity" (note: same sign as emissions and removals) has been estimated assuming 0 for FM/ FL-FL (i.e., it is assumed that the projected emissions/removals will represent the BAU FMRL) and gross-net accounting for AR / FL and D / FL-OL. The bars (for KP activities estimated by CBM) indicate the results of the sensitivity analysis (+/-10% harvest for FM[221]; +/- 50% planting rate for AR; D/-50% D rate).

[220] This is a potential amount of harvest provided by AR, generally not included in the computation of the total harvest expected to 2030, if not explicitly suggested by country.
[221] Based on preliminary results.

Fig. 10 - Summary of emissions and removals, and accounting



Comments on CBM run and model assumptions:

- Overall, at EU level, the historical amount of harvest (2000-2012) considered by CBM is similar to the harvest considered by G4M (see Fig 1, Historical IIASA and Historical JRC). The future harvest demand expected by IIASA could not be fully satisfy by CBM (see Fig. 1 "CBM – Real harvest", and the specific county's reports for details). The amount of harvest applied by CBM on the FM area is 7% lower (in 2030) than the amount expected by IIASA, but adding the potential amount of harvest provided by AR, this is only 3% lower than the expected amount of harvest. These differences are mainly due to some countries where the total amount of harvest provided by CBM on the FM area, is lower than the amount expected by IIASA for 2030 (-25%, -13% and -21% for Belgium, France and Poland, respectively).
- The original (non-calibrated) biomass C sink estimated by CBM for 2030 is considerably higher (+71%) than the estimates provided by G4M, even if for the historical period 2000 – 2012, the sink provided by CBM is only 23% higher (on average) than the sink reported by G4M (see Fig. 3). Both the models report a lower C sink, compared with the GHG inventory data.
- Calibrating both the models on the 2015 GHGI data, the total C sink estimated by CBM for FM is about 24% higher, in 2030, than the estimates reported by G4M (see Fig. 4). This is mainly due to the lower "real" harvest implemented by CBM compared to G4M. In addition, other factors that may explain the difference between the two models are different assumptions on the increment, the age structure and the silvicultural treatments (e.g., the amount of harvest residues). In particular, CBM estimated a higher C sink (on the period 2025-2030) for FM for Austria (+200%), Greece (+210%), Latvia (+629%), the Netherlands (+172%), Romania (+86%), Slovenia (+71%), Spain (+36%) and Sweden (+32%). Despite possible differences on input data used by models (i.e., in case of Romania, CBM used new input data based on the last NFI), in many cases, the differences on the final results were "amplified" by the calibration on the GHGI data. This is the case of the Netherlands, Romania and Slovenia, where the original estimates provided by both the models (i.e., not calibrated) are fully consistent on the future C sink, but they differ on the historical period (i.e., 2000 – 2012). In one case, i.e., Belgium, the sink estimated by CBM is considerably lower (-48%) than the value reported by G4M. For 17 out of 26 countries, the C sink provided by CBM is similar, both in the trend and in the level (for Croatia, Denmark, Estonia, Finland, France, Italy, Lithuania, Luxemburg and Slovakia) or slightly higher (for Ireland and Portugal) or lower (for Bulgaria, Czech Republic, Germany, Hungary and UK) than the estimates provided by G4M. Where the future harvest demand could not be satisfied (I.e., for

Belgium, France and Poland), CBM estimated an increasing C sink, due to the lower harvest rate applied by model, compared to the expected amount of harvest.

- The results reported for the sensitivity analysis performed on FM (Fig. 5), assuming a ±10% variation on the future harvest demand, are very preliminary.
- The estimates on the AR provided by both the models are quite similar and fully consistent with the KP data (see Fig. 6). The emissions on D estimated by CBM are consistent with the KP data but generally lower (on the historical period), than the emissions reported by G4M (Fig. 7).
- The HWP C sink estimated by both the models is similar, with a final C sink equal to about -30 Mt CO_2 yr^{-1} in 2030.
- The removals estimated by CBM for the period 2021-2030 (reported on Fig. 10) are, on average, +20% (for FM), +15% (for AR) higher the estimates provided by G4M. On the contrary, the emissions estimated by CBM for D are 41% lower than G4M. For the UNFCCC forest categories the removals estimated by CBM are equal to -56 Mt CO_{2eq} yr^{-1}, and -36 Mt CO_{2eq} yr^{-1}, for FL-FL and L-FL, respectively.

List of abbreviations and definitions

ARD →Afforestation and reforestation

CBM → Carbon Budget Model

D →deforestation

FM →Forest management

FRA →Forest resources assessment

FW → fuel wood

HWP →Harvested wood products

IRW →Industrial roundwood

KP →Kyoto protocol

LULUCF →Land use, land use change and forestry

NFI → National Forest Inventory

NIR →National inventory report

PP →Paper and paperboards

RL →Reference level

SW →Sawnwood

WP →Wood based panel

YTs → Yield tables

ANNEX 3 OF AA LULUCF 2030 MODEL INTEGRATION OF LUISA AND CBM TO SIMULATE AR/D

Contract n° 33920-2015 NFP

Administrative agreement

340202/2015/705777/CLIMA.A.2

Roberto Pilli, Giulia Fiorese, Claudia Baranzelli, Carlo Lavalle, Giacomo Grassi

Coordination by Giacomo Grassi

2016

Table of contents

1 Introduction

Within the broader perspective of integrated modeling, in order to account for spatially explicit land use changes, in this AA we have addressed the integration of the LUISA platform (i) with CBM, for forest expansion and growth, and (ii) with IPCC tier 1 and a biophysical model for cropland/grazing management. These exercises aim at simulating the impacts of the Reference scenario 2030 on land use changes and at assessing the LULUCF emissions that derive from such a scenario.

The line of work for integrating CBM and LUISA is part of a long collaboration that started with the AA AFOCC (Fiorese et al., 2015) and that is continuing in both the IES institutional work-programme "LUISA" and the BIOMASS Project (previously known as JRC Overarching study on Biomass). Similarly, the IPCC Tier 1 has been applied to land uses as simulated by LUISA in several studies. The work performed within this AA is thus a key step to meet the ambitious goal of developing a JRC framework capable of modelling the main land-based production sectors (forest and agriculture), in particular relation to bioenergy and wood products.

The specific objective of this AA is to model within LUISA the evolution of forest land under the reference scenario, distinguishing afforestation (AR) and deforestation (D). In section 3 we briefly describe the modelling assumptions and we present the results at EU level. Results specific for Member States are reported in Annex 3. As for IPCC Tier 1, the aim is to develop and apply a method for estimating changes soil C-stocks resulting from modeled changes in land use as provided by LUISA. The methodology is briefly described in the following, while details are reported in Annex 4.

2 LUISA: a short description of the platform

The 'Land-Use-based Integrated Sustainability Assessment' modelling platform (LUISA) is a platform of inter-linked data, processes and models for the analysis of the evolution of European territories (macro-regions, countries, regions or urban areas) triggered by EU investments and policies. LUISA is equipped to measure the impact over time of national, regional and urban economic performance (e.g. GDP, sector production, employment, convergence, etc.) and allows for the mapping of access to services (e.g. to public structures, recreational and cultural sites, etc.) and infrastructures for housing, transport, energy, etc. Moreover, the LUISA platform permits the monitoring of the status of ecosystem services and their regional endowment.

LUISA is primarily used for the ex-ante evaluation of EC policies that have a direct or indirect territorial impact. Beyond a traditional land use model, LUISA adopts a new approach towards activity-based modelling based upon the endogenous dynamic allocation of population, services and activities.

LUISA can be configured to project a baseline (or reference) scenario, assuming official socio-economic trends (from ECFIN and EUROSTAT), and the effect of established European policies with direct and/or indirect territorial impacts. Variations to that reference scenario may be used to estimate impacts of specific policies, or of alternative macro-assumptions and sectorial investments.

LUISA is based upon the notion of land function – a new concept for cross-sector integration and for representing complex system dynamics. LUISA aims to contribute to the understanding, modelling and assessment of the impacts of land functions dynamics as they interact from local to global scales in the context of multiple and changing drivers. A land function can, for example, be societal (e.g. provision of housing, leisure and recreation), economic (e.g. provision of production factors - employment, investments, energy – or provision of manufacturing products and services – food, fuels, consumer goods, etc.) or environmental (e.g. provision of ecosystem services). Land functions are temporally and spatially dynamic, and are constrained and driven by natural, socio-economic, and techno-economic processes. The ultimate product of LUISA is a set of spatially explicit indicators that can be combined according to the 'function' of interest and/or to the sector under assessment.

This is notably a wider notion of just "land use modelling" and of what so far has been referred to in literature.

Contributions have already been provided in the Impact Assessments (formal and informal) related to Common Agricultural Policy, Integrated Coastal Zone Management, Regional Policy (Sixth report on economic, social and territorial cohesion), Energy (shale gas and energy package), EU Water Blueprint, and Resource Efficiency Roadmap and the Modelling of ecosystems and ecosystem services (MAES). Current applications are related to the review of the Energy Performance of Buildings Directive, the review if the Renewal Energy Directive, the assessment of the status and trends of European Cities (as contribution to the EU Urban Agenda and the HABITAT II initiative) and the preparation of the post-2020 Multiannual Financial Framework.

One of the major milestones in the LUISA development plan is the implementation of a shared EC baseline (or reference) scenario. The shared baseline scenario includes the full scope of relevant policies assuring coherence among them. Because of its benchmark function, the correct definition and implementation of such a baseline scenario is essential to correctly evaluate EC proposals. LUISA is configured to implement the Reference Scenario with annual up-dates, following major policies revisions and the setting of new socio-demographic projects.

2.1 Model Input, Parameterization and output

LUISA links specialized models and data within a coherent workflow. The resource-demand module uses outputs from demographic (EUROPOP 2008, 2010, 2013 and updates) and economic projections (from ECFIN and/or from models e.g.: CAPRI, GEM-E3, RHOMOLO, E3ME and others) to drive the allocation of activities and services. In particular, the reference scenario configuration used in this exercise, is based on the latest available Market Outlook of the CAPRI model.

The allocation module uses a number of spatially explicit parameters at different resolutions (1 x 1 km, 100 x 100 m) in order to define an overall suitability for every modelled land use/cover type. LUISA integrates factors related to accessibility (e.g. computed using the TRANSTOOLS network), soil characteristics, topography and availability of infrastructures. In addition, the neighborhood interactions between land types are taken into account dynamically, as the land use patterns evolve and change through time. The definition of policy options requires the development of a range of parameters which take into account both location specific policies (e.g. demand for each land use class, zoning maps, region-specific support measures, etc.) and the characteristics of land-use dynamics (e.g.: transition rules, conversion costs, neighborhood effects, attractiveness etc.). The actual conversion from the land-use state in t_n to a land use state in t_{n+1} for each location, is based on the most suitable land use type for that specific location at that specific time. The land use state in t_0 is given by a refined version of the CORINE Land Cover map of 2006 and will be soon up-dated with the refined CLC2012.

LUISA is prepared to make simulations for all EU28 Member States – currently and gradually being extended to a full European coverage. Other neighbouring countries of interest can be included if CORINE Land Cover 2006 (or comparable map) is available. LUISA can be set to run individual NUTS1/NUTS2 or individual countries alone. In addition, the model can run all EU28 by batching all countries-runs.

The land allocation module of LUISA requires a calibration which is based on the observed/historical land use/cover changes, as reported by the CORINE Land Cover set of maps (1990, 2000, and 2006). Verification is performed with detailed historical datasets on demographic census, transport networks and regional/urban digital maps.

In the current (2014) reference scenario, the allocation module runs from 2006, producing yearly results up to 2050. However, the runs can be extended 10 or 20 more years, as long as demand is provided for the land use/cover types of interest.

The main direct outputs of LUISA are: 1) a simulated map of the land use/cover for a given year in the future; 2) projected population density maps at high geographical resolution; 3) detailed accessibility maps. The combination of direct outputs with other data layers and with thematic models allows the computation of a wide range of indicators, representing the simulated land functions.

2.2 Forest area

The aim of linking LUISA and CBM is to assess how much forest biomass is available given the area available for harvest and given the management of forests, currently and in future projections. LUISA simulates the spatial allocation of different land uses/covers over time. Specifically, the evolution of forest areas over time (expressed in ha/yr) is of interest in this context. The linkage between LUISA and CBM is based on the exchange of two variables: forest area available for wood supply (FAWS[222], from LUISA to CBM) and harvest from forest land (from CBM to LUISA).

Regarding the first linkage based on forest areas, extensive work has been dedicated to harmonize the forest area used in the two models. Forest areas in the LUISA platform and in the CBM model are, in their original configurations, based on very different data sources, created for accomplishing rather different aims.

In LUISA, the starting state of the simulation is a refined version of Corine Land Cover 2006 (CLC06ref, Batista et al., 2013). Corine maps are developed from satellite images, with a spatial resolution of 100m and focusing on the detection of homogeneous landscapes. On the other hand, the CBM model is based on the most recent national statistics (i.e., National Forest Inventories) which mainly record forest available for wood supply (FAWS), i.e. forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood. This implies that forest land in LUISA is derived from land cover-related data sources at high (100m) spatial resolution and for the year 2006, whereas CBM is primarily based on land use-related data, available at regional or national level. As a consequence, forest area estimates derived from CLC06ref and the national statistics may significantly diverge. For many MSs, the forest area mapped in CLC06ref does not provide a satisfactory representation of the officially reported forest area available for harvest. In order to achieve a better representation of forest areas in LUISA and make them converge to the statistics reported by the single MSs in 2010, the following steps have been implemented:

- The demand module of the platform has been modified, in order to be able to specify forest land requirements at country level instead of regional (NUTS2) level. This configuration, based on larger geographical units, allows for a greater

[222] This is defined as a forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood. Note that we are always referring to data at national level. We are not capable of identify FAWS areas on a map.

flexibility of the allocation procedure, which is implemented with the aid of ancillary spatial data (see point 3 below).

- Yearly forest land requirements have been aligned to the official figures reported by Member States (UNFCCC and Kyoto Protocol reporting) on afforestation and deforestation rates, for the period until the year 2012, available at the time of writing.
- The allocation of forest land, previously essentially based on calibrated parameters, is now enriched with high resolution (30m) ancillary data, namely the suite of forest layers recently made available by the University of Maryland (Hansen et al., 2013); the dataset is imagery-based and it covers the period spanning from the year 2000 to 2012. For being included in the LUISA platform, the layers of forest cover and forest gain have been merged together, in order to obtain the forest cover in the year 2012. The resolution of the resulting layer has been subsequently degraded from the original 30m to 100m: each pixel represents the crown cover over the 1ha area, as percentage[223].

As a result of the modifications implemented, the allocation mechanism of forest land in LUISA has been updated so that the probability of conversion to forest land increases as the crown cover mapped by the layer produced at step 3 becomes higher. The use of this layer, based on data whose level of spatial detail is greater than the one of Corine, allows for improving the accuracy of the spatial patterns simulated in LUISA. At the same time, the use of robust historical time-series in the definition of the forest land requirements, ensures the convergence, at country level, to official statistics.

3 Projections of AR/D at EU level

LUISA simulates future land use allocation: the demand module provides an input for the land allocation module, specifying the required amount of land for different economic sectors, corresponding to the simulated land-use/cover classes. External models provide the inputs to derive land claims for different land use/cover classes; e.g. agricultural classes are derived from the CAPRI model. With regards to forest land and the forestry sector, LUISA has the possibility to incorporate the afforestation rates projected by the PRIMES/G4M/GLOBIOM models, as set in the EUCLIMIT platform (EU Reference Scenario).

With the aim of building a modelling platform based on JRC models, we want to substitute future afforestation rates from the reference scenario with figures derived from JRC-based models.

Table 5: data on national area, forest area and historical average afforestation (1990-2010) as from the UNFCCC 2015 submission. Cyprus and Malta are excluded.

	Policy objectives
DK	An increase in forest landscapes to 2025% within 80-100 years
EE	In order to preserve good condition of threatened species and endemic species of Estonia at least 10% of the forest land will be placed under strict protection. In order to preserve good condition of threatened species and endemic species of Estonia at least 10% of the forest land will be placed under strict protection. Secure forest functions as habitat and natural environment. To preserve forest genetic resources the area of gene reserve forests will be increased up to 2876 ha. Share of genetically improved forest reproductive material will be increased. Area of regeneration 34500 ha annually.

223 It is worth noting that the validation of the original product, conducted by Hansen (2013), has proved it robust at the 120m pixel scale.

	Policy objectives
FI	Due to the high forest coverage (73% of the total land area) it has not been considered necessary to set specific targets related to land use and forest area. Preventing the increase of the percentage of endangered forest species of the estimated number of forest species from the level established in the assessment of threatened species in 2000 (564 species). Increasing the volume of deadwood in forest and scrub land areas by 5% to 3.4 m3/ha in southern Finland and 8.0 m3/ha in northern Finland. More quantified targets included in the Forest Biodiversity Programme for Southern Finland METSO
DE	The forest area in Germany is to be maintained and, if possible, enlarged. The stability, productivity, diversity and naturalness of forests are to be further improved through the proven integrative approach of sustainable, multi-functional forest management. The planting of site-specific, mainly indigenous species of trees is an important contributory factor here.
HU	To increase permanently the forest land area by first afforestation, of which long term goal is to achieve a forest cover of 25-27%. According to this objective, first afforestation ranged btw 3,000-19,000 ha/y in the period of 2006-2015. Introduction of agro-forestry systems on 3000 hectares. Reduce the area of unmanaged forest land.
IE	To achieve 18% forest cover by 2046. The previous policy objective was to reach 17% forest cover by 2030 but this objective is unlikely to be achieved at current planting rates. The new policy, which was recommended in the report of the Forest Policy Review Group in July 2014, aims to achieve increased forest cover at a slower rate, reflecting the reduction in new forest planting in recent years. To increase the forest area, in accordance with SFM principles, in order to support a long term sustainable roundwood supply of 7 to 8 million cubic metres per annum.
LV	To prevent reduction of forest cover by setting limits on the transformation of forest lands
LU	Maintain the global forest area for Luxembourg.
PL	Increasing forest cover of the country to 30% in 2020 and to 33% after 2050. Increasing the size of the capture and storage of carbon dioxide by 10% by 2020 and 20% in the second half of the twenty-first century, it is respectively 4.5 and 9 million tonnes. Increase the capacity of annual timber harvest from forests of all ownership forms of the then level of 21 million m3 to 24 million m3 after 2010.
RO	The overall objective is to ensure sustainable management of the forest sector in order to increase quality of life and to ensure the present and future needs of society in the European context. The expected impact of NFS is social (creating new jobs), institutional (strengthening control capacity), on policy (reducing political interference by competitive management criteria), legislative (less bureaucratic rules governing the system), environmental (increase by 10 000 ha/year of forest area), fiscal (increasing the value of sales in the sector in terms of reduction of black wood market share) and economic (increased access to forest by 6500
SK	Creation of healthy, ecologically stable and biologically diversified forests as a basic condition of sustainable management and forest land use, under the conditions of synergic effects of injurious agents and expected climate change - To maintain biological sources of forests, their genetic and ecosystems diversity, to use them in a sustainable way - Assuring maximal functional efficiency of forests with prevailing protection functions (ecological and social) by maintaining and enhancing their vitality and stability - Elaborating a programme of afforestation of marginal agricultural lands
SL	Forest cover in Slovenia has reached 60 percent of the land area and should in general not increase further. Large complexes of forests should not be fragmented. In erosionn sensitive areas forest cover should increase, in some other landscapes, where forests do not play so important environmental functions, they could be partly cleared for agriculture and other uses, if so decided in land use plans. The NFP of 2007 clearly stipulates that allowable cut on the national level should attain 75 percent of the increment and that actual harvest rate should approach this figure as much as possible.
UK	Increase the many diverse benefits that forests provide. Promote both productive and native woodland, bring undermanaged woodlands back into production, encourage integration between farming and forestry. England - policy aspiration to increase woodland area from 10% to 12% by 2060. Scotland - increase woodland area from 17% to 25% by mid-21 century. Wales - create 100,000ha of new forest by 2030. Northern Ireland - double the forest area from 6% to 12% by 2056

In addition to the reference scenario, two other scenarios have been tested for a subset of countries: Finland, France, Germany, Italy and Ireland. Under the first option, the Market Outlook projections from CAPRI are replaced with the EU Reference 2013 simulation (as implemented in Baranzelli et al., 2014). This option reflects a more energy-oriented scenario, characterized by, on average, higher demand for dedicated lignocellulosic energy crops. Under the second option, afforestation ranges have been widened, setting the minimum to zero and thus making the afforestation dynamics more dependent by the evolution of other sectors and less tied to specific afforestation policies.

3.1 Afforestation

There are many possible factors that drive afforestation; we may assume that the most important ones are related to policy support to foster climate change mitigation, land abandonment and subsequent forest natural expansion. Our aim is modelling future afforestation rates starting from JRC data collected for the UNFCCC or the KP reporting. We look for a relationship that can be extrapolated from historic data on afforestation and that can be used for the future.

To analyse past data of afforestation across EU-MS, we processed the data in order to have some comparability across EU. First, we normalized forest areas over the national areas. To have deal with comparable quantities, we also normalized, for each country, the average AR rate (1990-2010) with respect to the forest area (data are reported in Table 6). The rationale behind this assumption is that, if a country has a high coverage of forests and a high AR rate, future AR will be lower than a country with lower forest areas and lower AR rates. Results are shown in Figure 147 where each plotted dot represents a MS. It is in fact possible to identify a relationship between the average AR rate and forest area: the larger the forest area, the smaller afforestation is.

Table 6: data on national area, forest area and historical average afforestation (1990-2010) as from the UNFCCC 2015 submission. Cyprus and Malta are excluded.

	NATIONAL AREA	**TOTAL FOREST LAND**		**Forest Area normalized**	**AVERAGE AR**	**Average AR normalized**
	Area (kha)	**1990 (kha)**	**2010 (kha)**	**(%)**	**1990-2010 (kha/yr)**	
AT	8,386	3,891	4002	48	8.66	0.22
BE	3,053	712	714	23	1.12	0.16
BG	11,099	3,634	3825	34	9.59	0.25
HR	5,659	2,314	2335	41	1.19	0.05
CZ	7,887	2,577	2604	33	2.00	0.08
DK	4,308	548	628	15	4.20	0.67
EE	4,523	2,245	2289	51	3.14	0.14
FI	33,842	22,110	21950	65	8.14	0.04
FR	64,068	14,950	15422	24	62.72	0.41
DE	35,702	11,155	11356	32	21.41	0.19
GR	13,199	3,370	3399	26	1.58	0.05
HU	9,303	1,814	2046	22	12.77	0.62
IE	7,027	481	732	10	13.35	1.83
IT	30,134	7,590	9032	30	73.79	0.82
LV	6,459	3,169	3332	52	9.73	0.29
LT	6,520	2,061	2166	33	5.50	0.25
LU	259	93	96	37	0.43	0.45
NL	4,154	383	396	10	2.84	0.72
PL	31,269	8,694	9305	30	30.53	0.33
PT	9,239	3,729	3841	42	27.52	0.72
RO	23,839	7,028	7219	30	18.47	0.26

SK	4,904	1,989	2011	41	1.58	0.08
SL	2,027	1,192	1208	60	4.60	0.38
ES	50,403	14,560	15389	31	57.27	0.37
SE	44,996	28,139	28358	63	20.28	0.07
UK	24,361	2,384	2635	11	14.96	0.57

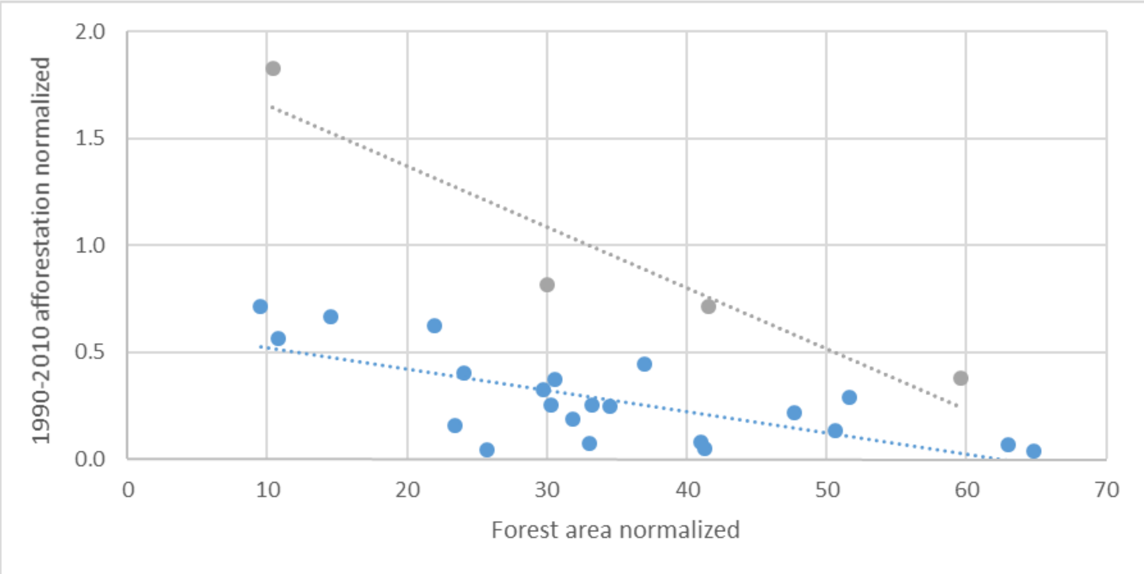


Figure 147: the normalized forest area is plotted vs. the normalized average afforestation rate for each MS (excluding CY and MT).

From the observation of all MS data (excluding CY and MT), we may define two linear relationships that describe the relation between AR rates and forest area. With the first relationship we may relate one to another 22 over 26 MS. There are four countries that cannot be represented in this relation. These MS cannot be grouped together with the others because they represent specific situations where afforestation is particularly high with respect to the forest area. Specifically, these four countries are:

- IE where there is strong policy support to increase forest area (SoEF 2015).
- IT and SL where land abandonment has been driving natural reforestation.
- PT where forest extensions and dynamics are more difficult to capture then in other countries, because of the widespread presence of eucalyptus plantations.

We calculated the linear regression for the two groups of countries and identified the parameters in Table 7. We also estimated the parameters to identify lower and upper ranges of uncertainty defined by the 95 percentiles (see Table 7). These ranges are then used in LUISA to define the minimum and the maximum potential variations of AR.

Table 7: parameters for the linear regression of the two groups of countries (elaborated with SAS). HIGH_AFF groups together IT, IE, SL and PT. The other 22 countries are in the EUROPE groups. MT and CY are excluded.

		Intercept	Slope	_RSQ_
EUROPE		0.62098	-0.0098647	0.49006
	L95B	0.44794	-0.0145583	
	U95B	0.79401	-0.0051711	
HIGH_AFF		1.92674	-0.0283304	0.88138
	L95B	0.72578	-0.0599516	

	U95B	3.1277	0.0032909	

We then used these linear relations to project the afforestation in each MS, up to 2030. For each country, we are able to provide a set of values that define the possible range of variation of future afforestation. This set of values is an input to the LUISA platform. Ranges for 2030 are listed in Table 8.

Table 8: 2030 range of variations for afforestation and for deforestation rates for EU-26 MS.

	AR 2030		**D 2030**	
	MIN	**MAX**	**MIN**	**MAX**
AT	8.9	20.9	0	3.88
BE	1.1	4.7	0	1.82
BG	9.1	22.8	0	0.83
HR	0.8	13.0	0	1.32
CZ	1.9	15.7	0	1.37
DK	4.2	4.4	0	0.52
EE	3.4	11.6	0	2.13
FI	9.0	94.4	0	22.86
FR	64.6	100.8	0	45.60
DE	22.0	69.3	0	11.41
GR	1.8	21.9	0	1.08
HU	13.1	13.6	0	2.35
IE	14.4	23.3	0	2.00
IT	74.8	296.9	0	4.44
LV	10.6	16.7	0	2.50
LT	5.5	13.0	0	0.80
LU	0.4	0.6	0	0.34
NL	2.8	2.9	0	3.27
PL	31.0	57.8	0	3.71
PT	31.0	128.7	0	32.73
RO	18.5	44.7	0	13.81
SK	1.6	11.2	0	0.99
SI	4.6	41.7	0	3.89
ES	64.0	95.0	0	17.86
SE	21.6	124.8	0	47.62
UK	16.4	19.2	0	4.10

We may compare our results with other future afforestation rates and specifically we may compare them with (i) the extrapolation of the historical UNFCCC data into the future for each MS and (ii) future rates from the 2016 reference scenario estimated by G4M and GLOBIOM models. Results for each MS are showed in the specific graphs in Annex 3, while the graph in Figure 18 shows results at EU level.

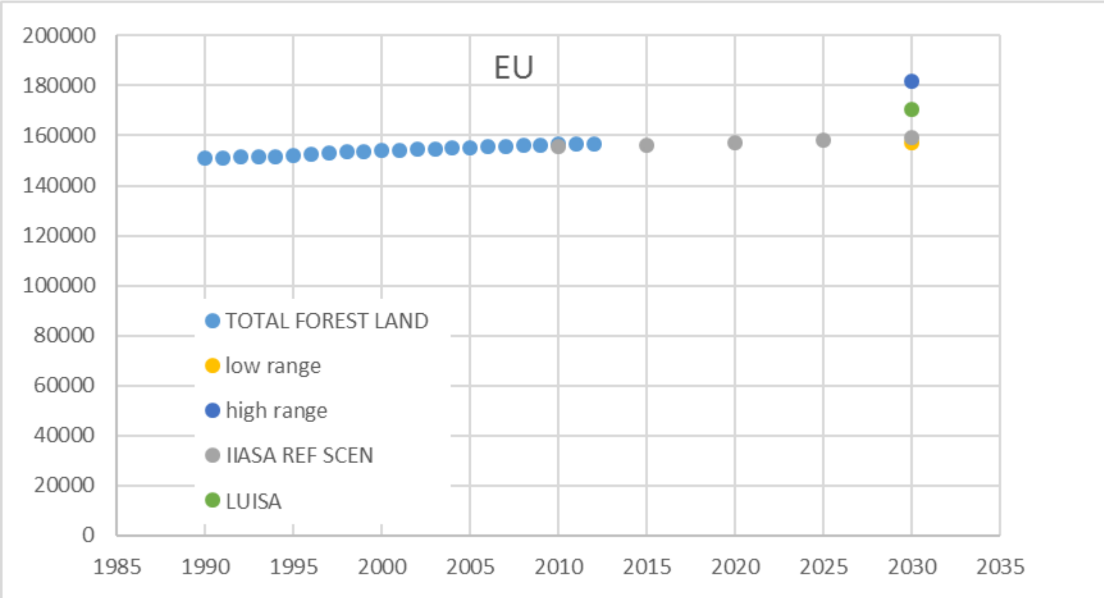


Figure 148: Historic evolution of EU forest land (in blue) compared with projected trends from the 2013 Reference Scenario (in grey) and with 2030 projections as elaborated with LUISA (in green). The graph also shows the range of variation that was allowed to LUISA for 2030 (yellow and dark blue).

In LUISA, afforestation can take place on land previously used for agriculture (arable land for food and feed production, grazed land –pastures, and dedicated energy crops) or land originally occupied by natural coverage, such as shrubby vegetation.

Afforestation is not allowed on built-up land used for residential or industry/commerce/services. In the case of abandonment of industrial sites (no longer productive) or residential neighborhoods (no longer inhabited), a mechanism of natural re-vegetation may take place in the long term. Eventually, the parcel would be converted to forest, unless the land is claimed back to a productive state.

3.2 Deforestation

While intensive deforestation has occurred in Europe at different times in its history, today it is marginal and restricted to only a few regions.

To model deforestation in LUISA we have to provide the model with a range of future deforestation. As for the lowest value of the range, we assume zero deforestation for all EU countries, since this is the target set for 2020 (Communication on deforestation, 2008). As for the higher value of the range, we assume that it is equal to the maximum annual rate of deforestation occurred for each country since 1990. The resulting ranges for all EU-MS are listed in Table 8.

In LUISA deforestation takes place in case demand for other sectors increases (e.g. increasing agricultural production, expansion of residential areas, etc.) and availability of less costly options, such as unused land, is limited.

The presence of natural protected sites is taken into account, so that deforestation in these areas is in general less likely to happen, depending on the specific level of protection that is enforced.

4 Results

The configuration of the LUISA platform has been updated so to simulate separately deforestation and afforestation. The dynamics of the two phenomena have been modelled independently, in order to allow for (1) explicit control on the annual afforestation and deforestation rates and (2) detailed representation of land-use change dynamics, possibly implementing specific policies targeting afforestation. The results of the LUISA simulation for the period 2010 – 2030 are reported in Table 9.

According to this simulation, overall in EU-28 total forest land is projected to increase by slightly more than 9% (net afforestation) from 2010 to 2030. In particular, afforestation is going to be almost 9.5%, whereas deforestation is approximately 0.3%.

Table 9: Total forest land in EU-28.

	Total forest land [10^3ha]	
Country	**2010**	**2030**
AT	4,001	4,165
BE and LU	714	714
BG	3,825	4,280
CY	173	171
CZ	2,604	2,915
DE	11,241	11,940
DK	617	691
EE	2,269	2,501
ES	13,674	14,637
FI	22,032	23,892
FR	15,424	17,403
GR	3,388	3,625
HR	2,320	2,578
HU	2,046	2,303
IE	731	736
IT	8,900	10,383
LT	2,166	2,386
LV	3,348	3,682
MT	1	1
NL	402	403
PL	9,303	10,265
PT	3,252	3,857
RO	6,758	7,650
SE	28,309	29,633
SI	1,208	1,347
SK	2,011	2,235
UK	2,626	2,927
Tot	**153,343**	**167,320**

According to our results, afforestation takes place mainly on arable land (44% of total AR), followed by other nature land (37%), pastures (18%) and permanent crops (1%), as shown in Figure 149. As for deforestation (Figure 150), forest land in mainly converted to arable land (44%) and urban land (30%), while the remaining 26% is distributed among pastures, dedicated energy crops, industry and other land. Figure 151 shows a zoom-in of land uses in 2010 and 2030 in a small area of Italy. Maps for all countries, together with detailed results, are reported in the final part of the Annex.

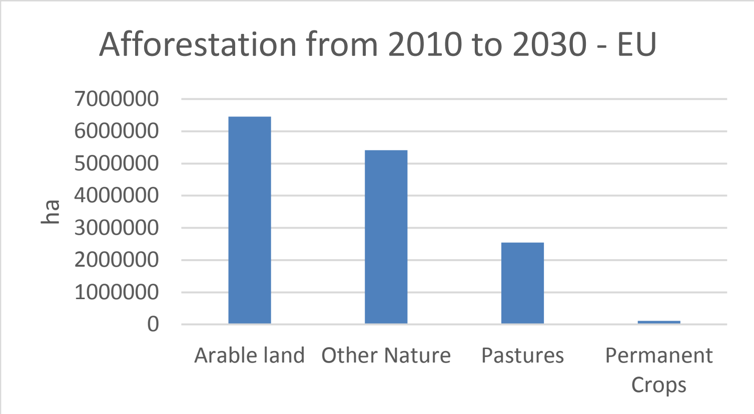


Figure 149: Conversion of land to forest land, 2010 to 2030.

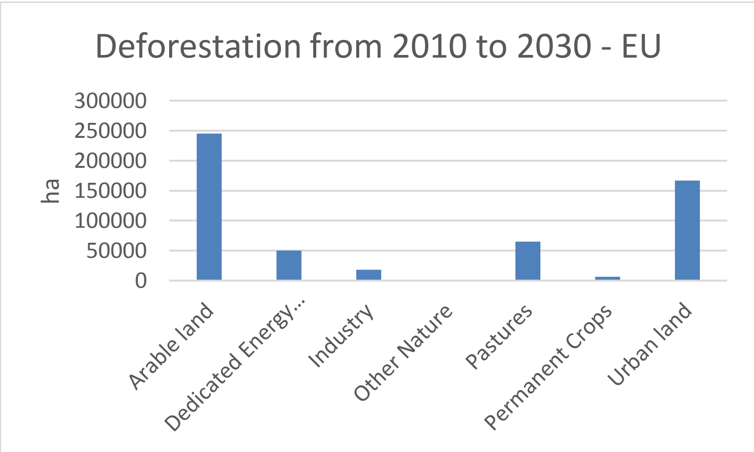


Figure 150: Conversion of forest land to other land, 2010 to 2030.

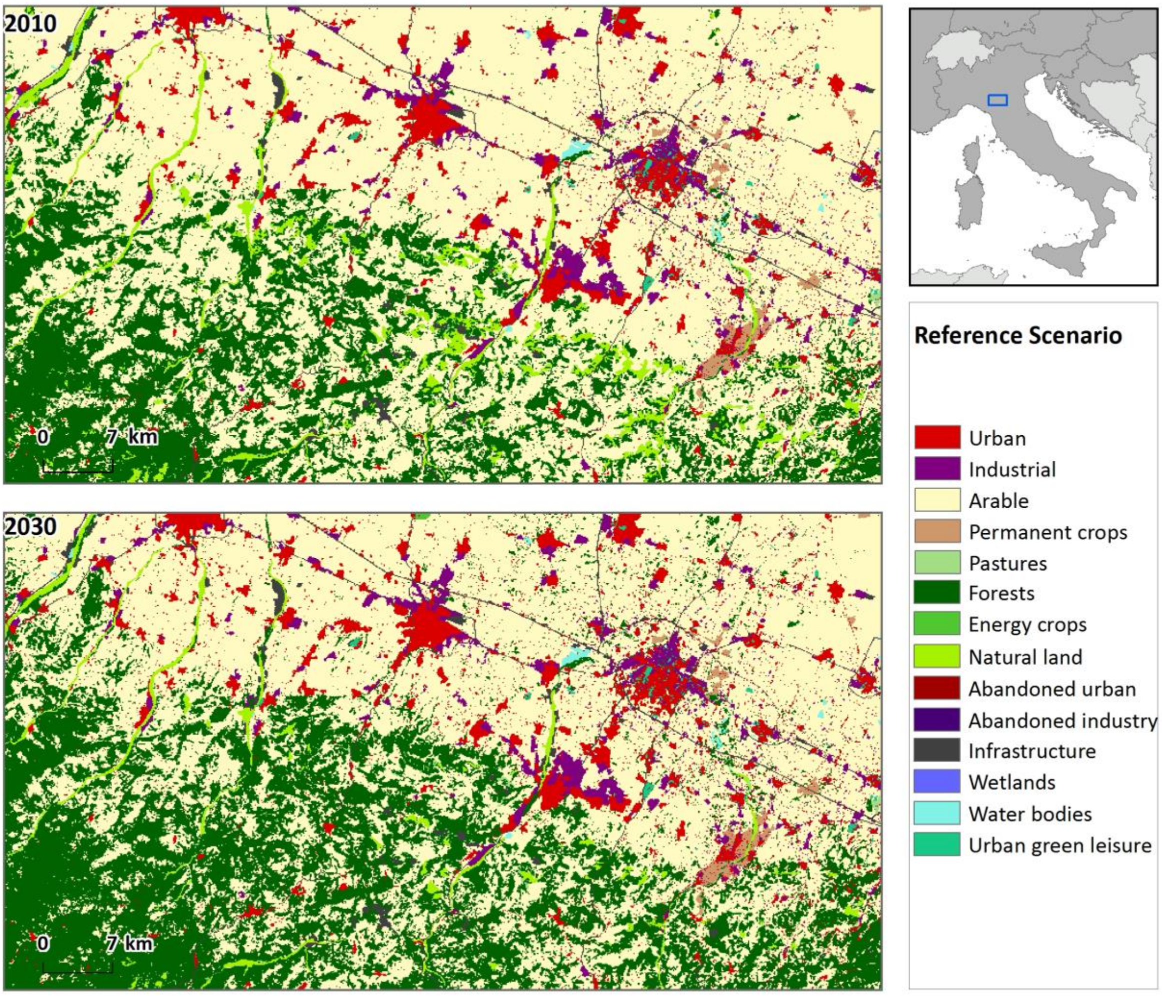


Figure 151: Zoom on land use changes in Italy, 2010 and 2030.

If we look at the results country by country, we may see that in many cases (14 over 26) the 2030 value determined by LUISA falls close to the higher value of the allowed range of variation. This also results in future AR/D rates that are higher than, for example, projections from the Reference Scenario. In order to try to understand the mechanism that gives such high future afforestation rates, we implemented in LUISA two different scenarios for five MS (DE, FI, FR, IE and IT). Under the first option, the Market Outlook projections from CAPRI are replaced with the EU Reference 2013 simulation, this is characterized by a high demand for energy crops. Under the second option, afforestation ranges have been widened, setting the minimum to zero and thus making the afforestation dynamics more dependent by the evolution of other sectors and less tied to specific afforestation policies. Results, shown in Figure 152, show that changing from the reference scenario (Market Outlook) to the EU Reference 2013 (orange bar) does not imply significant changes in total forest land. Whereas, when we implement a scenario where AR can vary within a wider range, future total forest land changes: in FI and FR we may expect higher afforestation; in IE and IT, lower afforestation while in DE it remains similar to the reference scenario. While, in many cases, the method used is able to provide results that are consistent with the countries reported values, specific figures are to be considered the first preliminary results of a much complex modeling effort. Further work is necessary in order to be able, as a JRC modelling team, to provide a robust assessment of future afforestation and deforestation in EU.

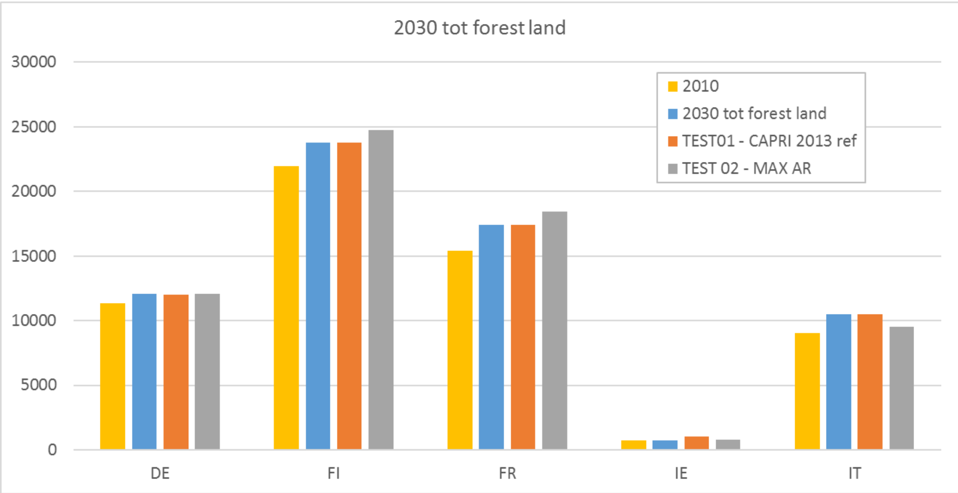
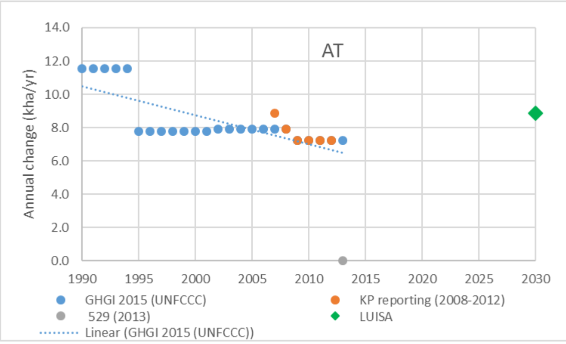


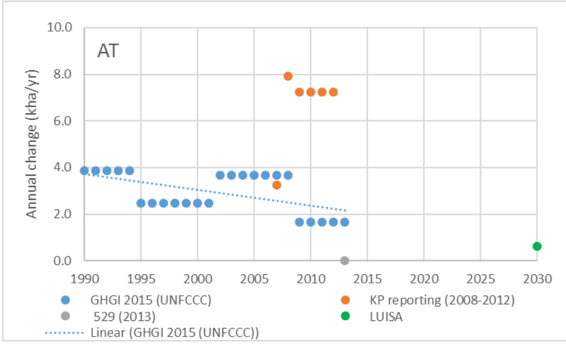
Figure 152: total forest land in 2030 as resulting from LUISA under different scenarios.

Austria

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).

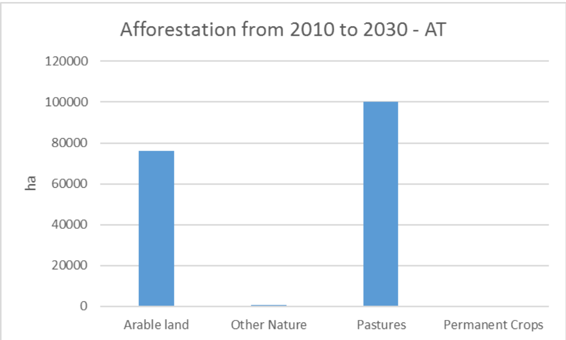


The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



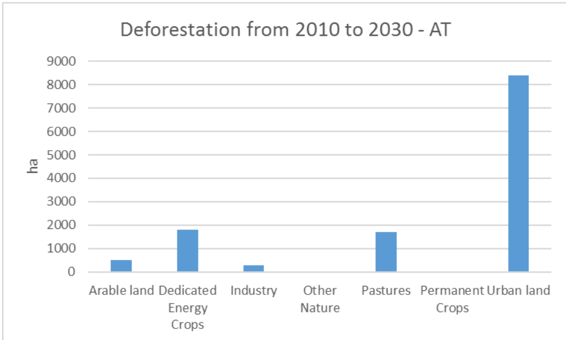
Afforestation

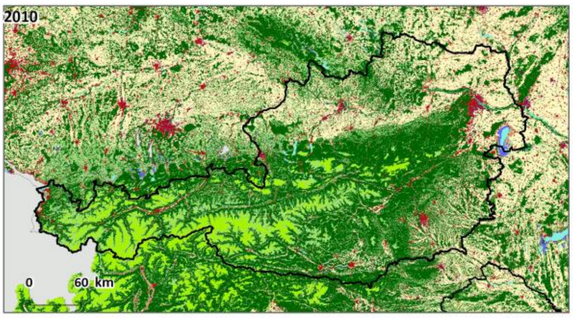
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



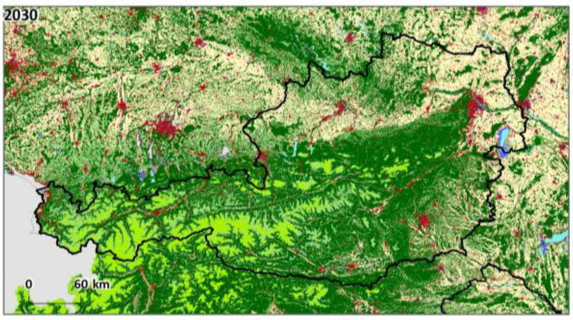
Deforestation

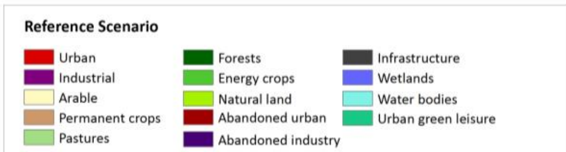
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).

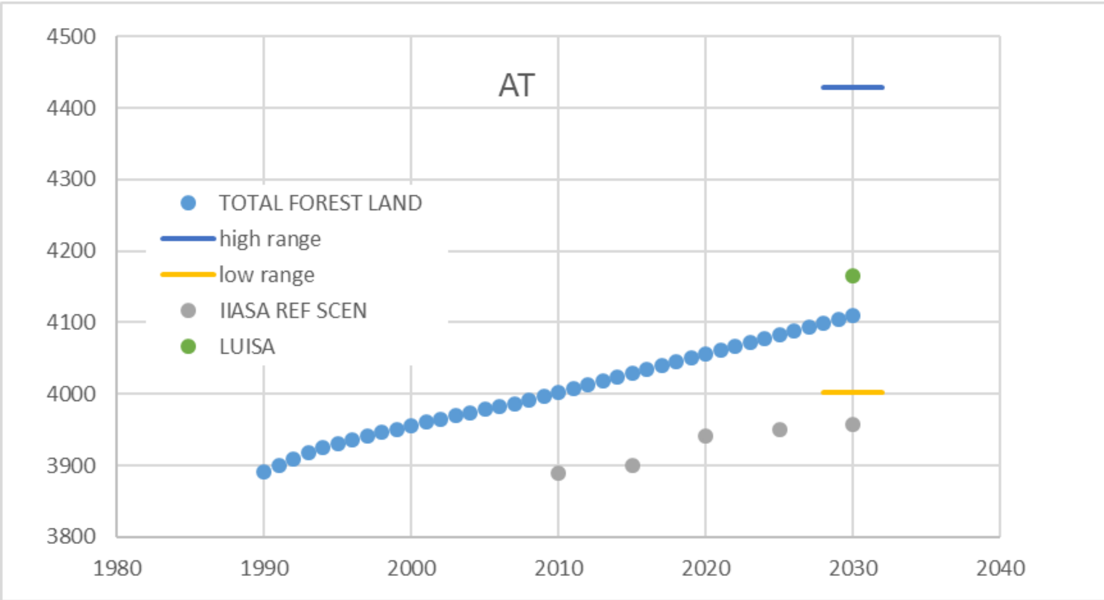




The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).







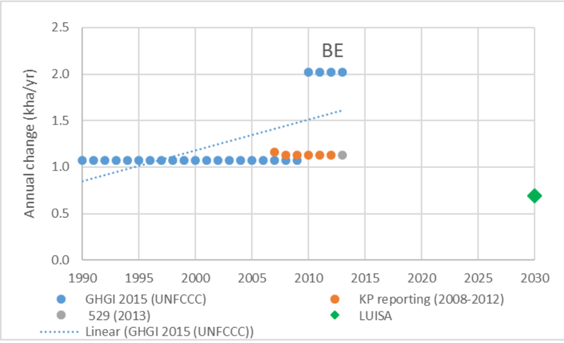
<u>Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)</u>

There are no “in-house” elaboration for future AR/D. Data presented in the report come from EUCLIMIT.

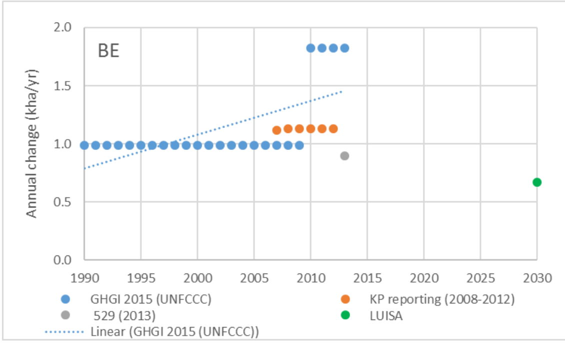
No change of historical rate of AR. The Austrian Rural Development Programme resulted in the conversion of 788 ha of agricultural land into forest land in the period 2007-2013. AR is limited to some regions, in 2007-2009, 161 ha have been afforested, mainly to protect lands from erosion, but also to improve biodiversity and to mitigate climate change.

Belgium

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).

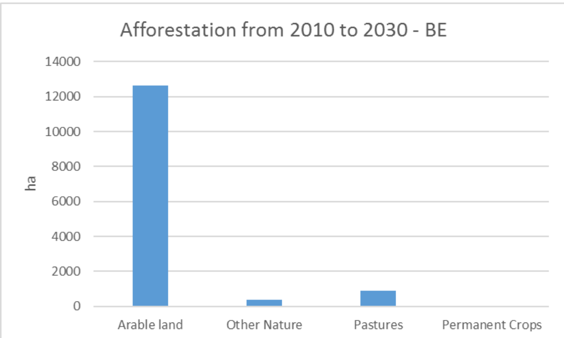


The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



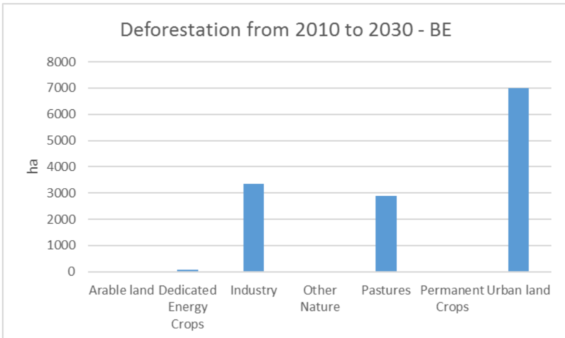
Afforestation

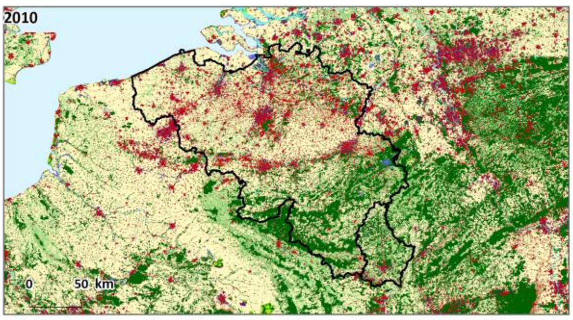
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).

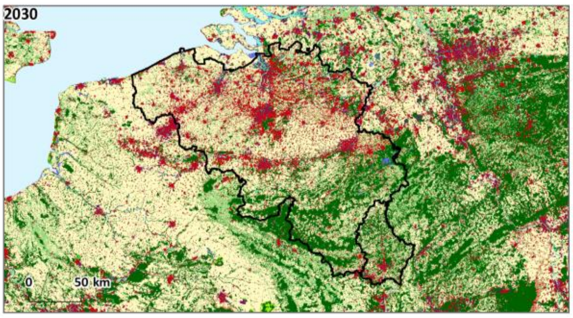


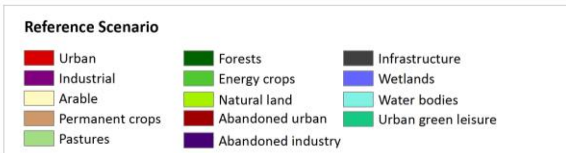
Deforestation

Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).

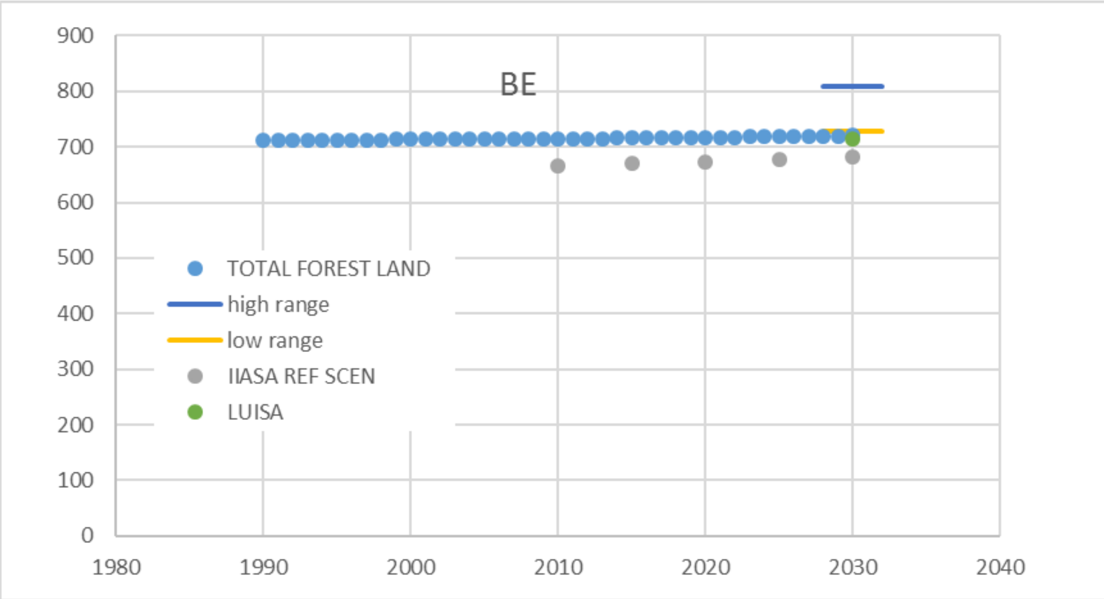








The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).



Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

There are no "in-house" elaboration for future AR/D. Data presented in the report come from EUCLIMIT.

Since the reform of the agricultural policy in 2014, 30% of the direct payments is linked to the compliance with 3 practices contributing to a better management of natural resources and to improved climate action. This is referred to as the Green Direct Payment.

Measures related to forest activities are different in the three regions.

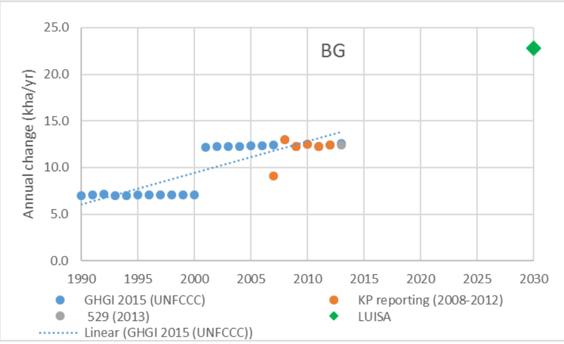
Rural Development Plan III: Afforestation (Flanders). This measure includes a plant subsidy, a maintenance subsidy and a compensation for income losses. The RDP III aims at an area of 860 ha and 4 million euros will be provided for current and future contracts.

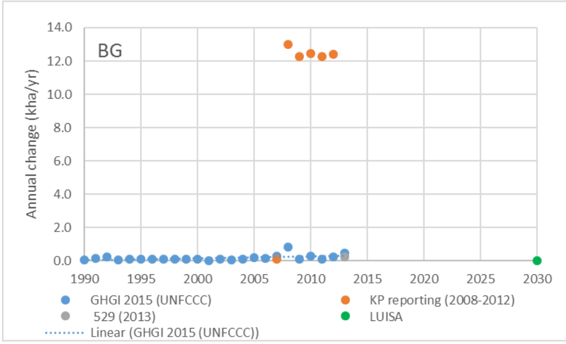
RDP III: Reforestation (Flanders). Subsidies are granted to reforestation projects of at least 0,5 ha. A target area of 1.150 ha has been defined and a budget of about 3 million euros will be allocated to support these projects.

Preventing deforestation: In Wallonia, Article 38 of the Forest Code limits the logging to 5 ha in coniferous stands and to 3 ha in deciduous stands.

Bulgaria

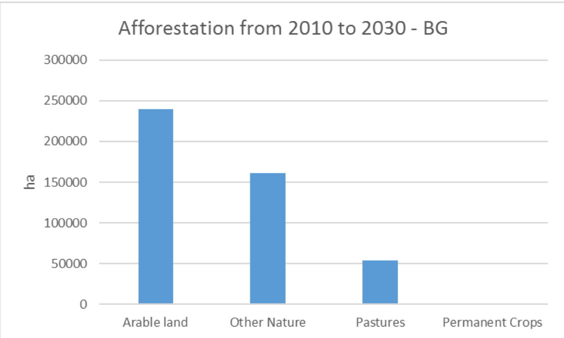
The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).	The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).





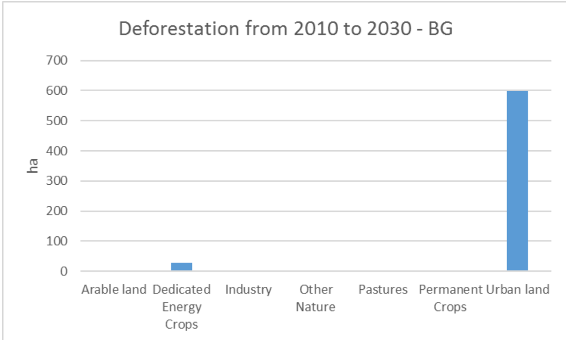
Afforestation

Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).

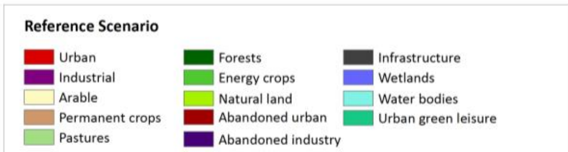


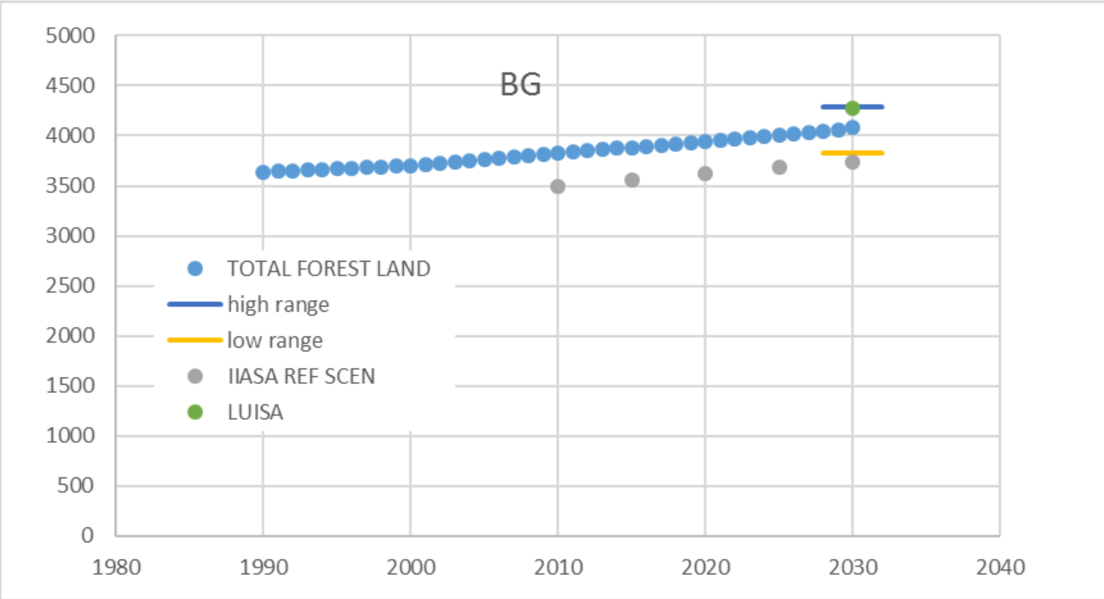
Deforestation

Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).



The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).





<u>Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)</u>

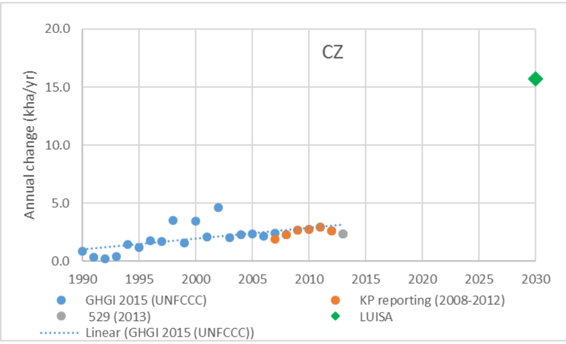
One of the main strategic documents containing measures for the LULUCF sector is the Third National Action Plan on Climate Change[224] (NAPCC) for the period 2013-2020. Sixteen measures are developed and included, grouped into four priority axes, comprising several popular approaches to managing the carbon flows. The first priority axis combines measures to increase the sequestration of greenhouse gases. The necessary measures are associated with increase of the areas of land use categories - sinks of greenhouse gases - forests, pastures and meadows, and with their sustainable maintenance in order to increase the amount of biomass.

Part of the measures are aimed at afforestation in both existing forests and parks as well as in newly abandoned agricultural or eroded lands. The total value of these measures is estimated at 10.45mln. BGN. The effect is reduction of emissions by 51 000 tonnes at a cost of 205 BGN per tonne.

[224] Published on the Ministry of Environment and Water’s website: http://www.moew.government.bg/?show=top&cid=570

Czech Republic

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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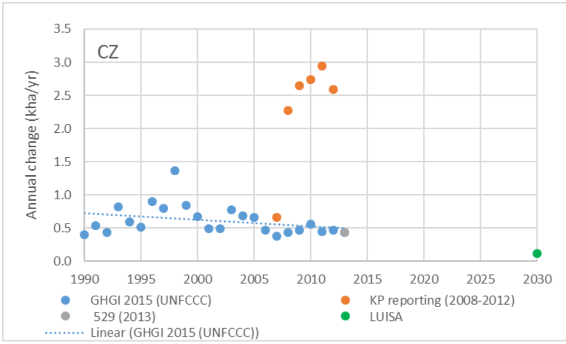
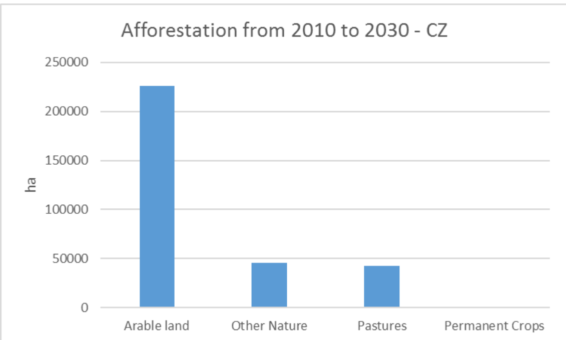


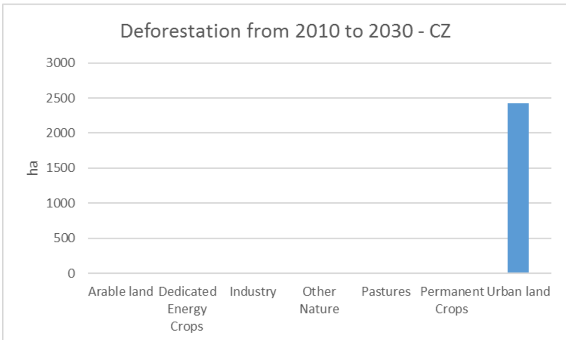
Afforestation

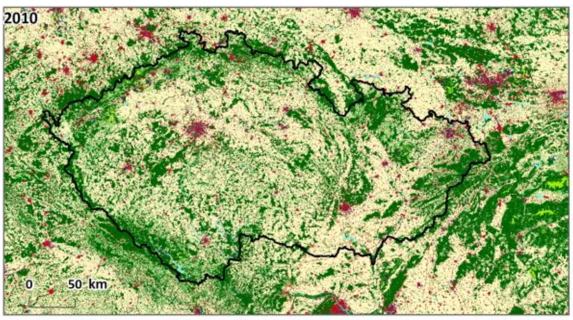
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



Deforestation

Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





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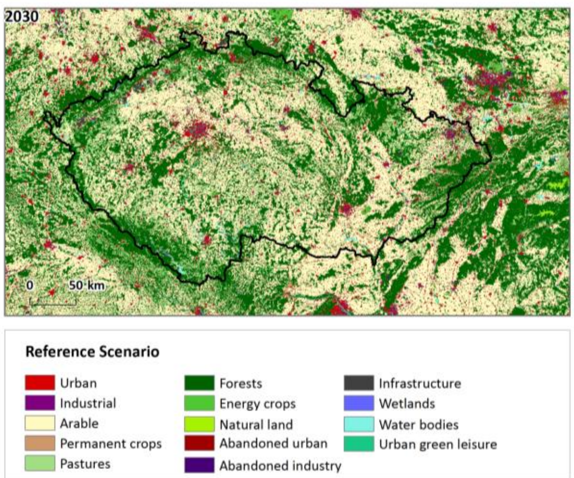
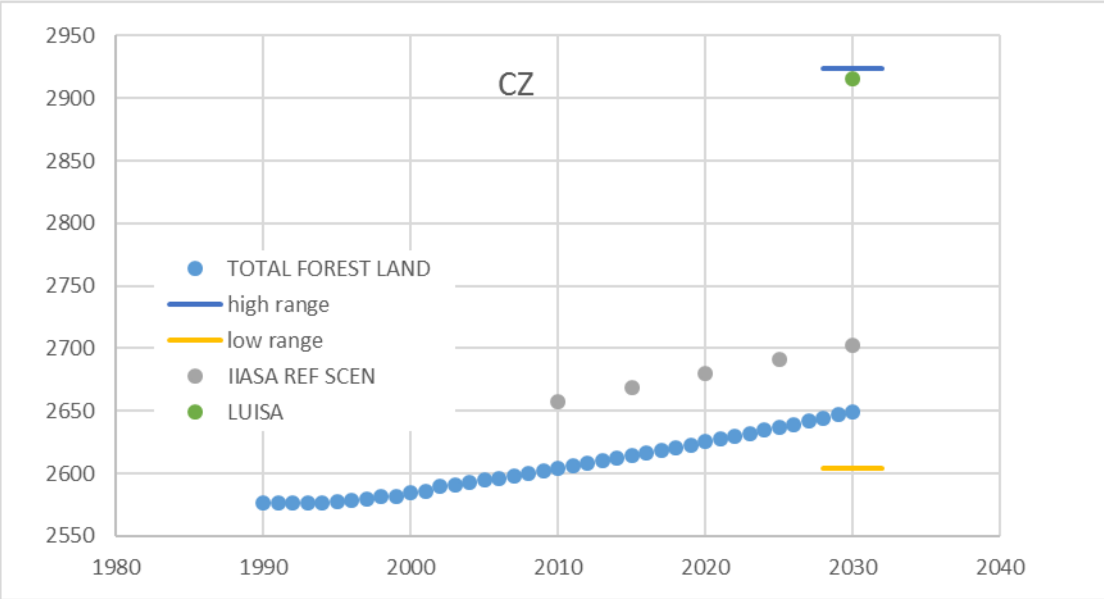




Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

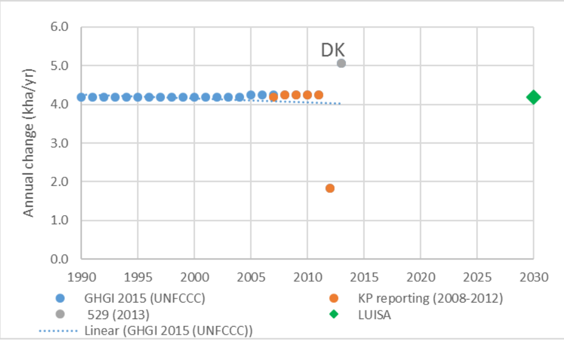
The area of forests has been growing because of a long-term afforestation of infertile cropland (in recent years the annual gain has been approximately 2,000 ha). There is also a specific financial state support focused on ensuring the necessary ratio of ameliorative and reinforcing woody species during forest restoration.

The GHG emission projections are based on the observed trends and anticipation of gradually less intensive land use changes until 2030. Forest, grassland and wetland land use categories are slightly increasing, while the area of cropland has been decreasing. Forest land is expected to change from 2,662 kha in 2012 (last reported figure) to 2,669 in 2020 and 2,671 in 2030.

The potential for mitigation in relation to forestry activities is mainly connected to: afforestation of agricultural land with low productivity; replacing fossil energy with bioenergy, including from harvesting residues; replacing greenhouse gas intensive materials with harvested wood products.

Denmark

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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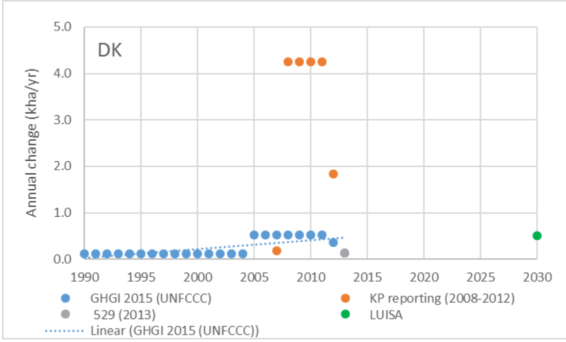
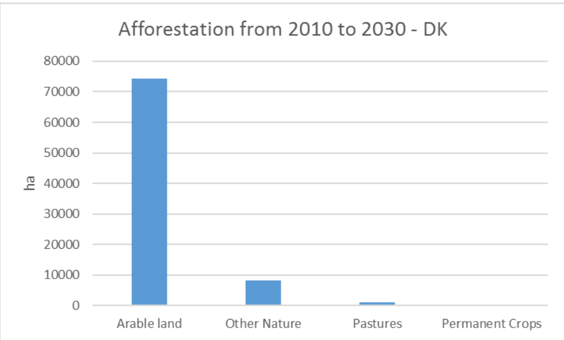


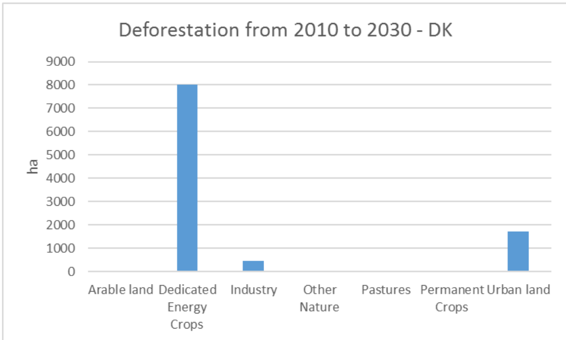
Afforestation

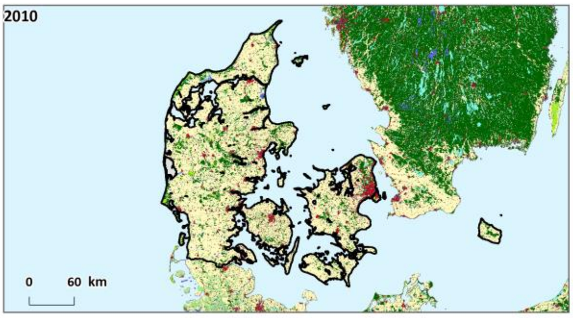
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



Deforestation

Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





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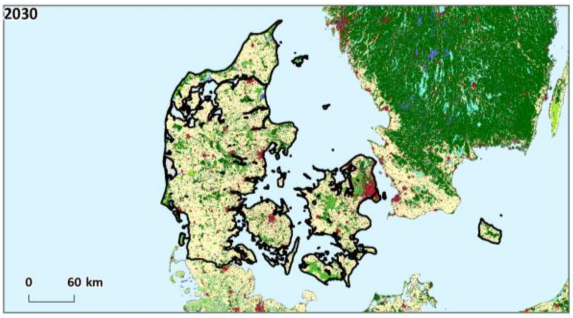
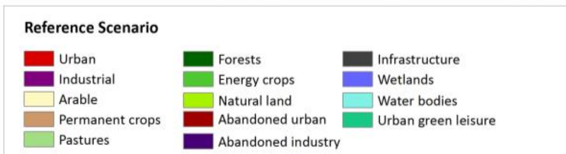
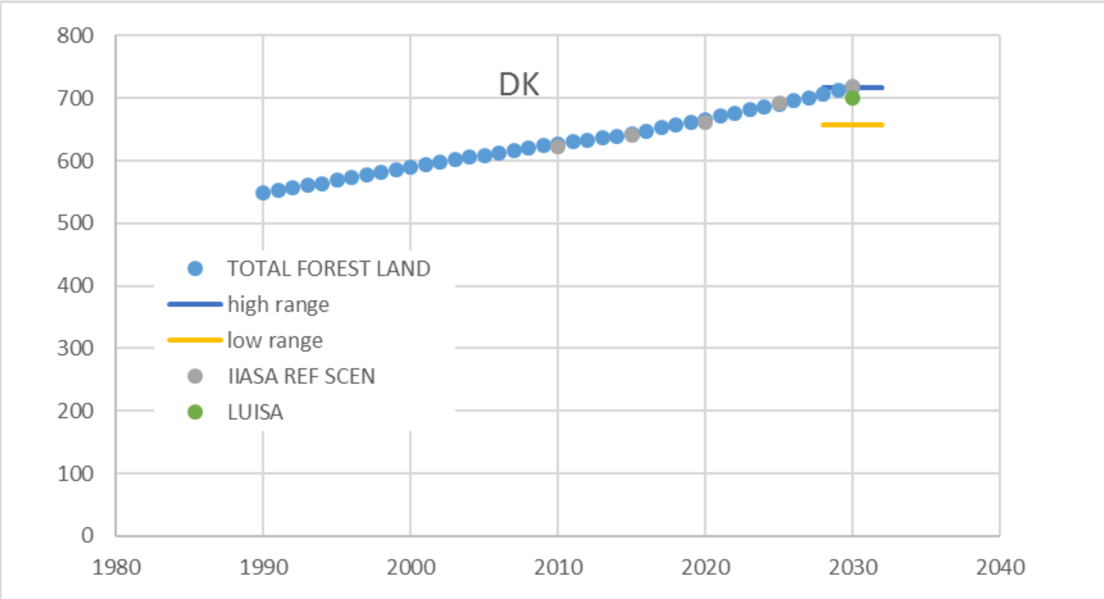






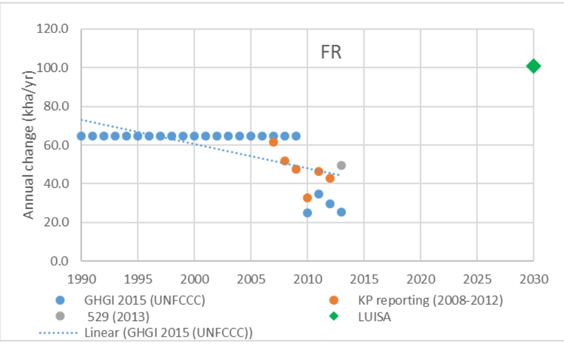
<u>Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)</u>

There are no "in-house" elaboration for future AR/D. Data presented in the report come from EUCLIMIT.

Subsidies for afforestation are part of Denmark's forest policy.

France

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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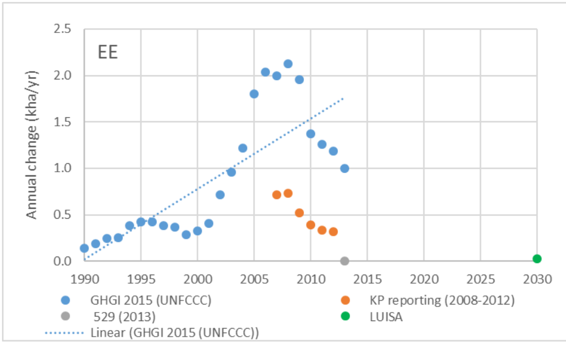
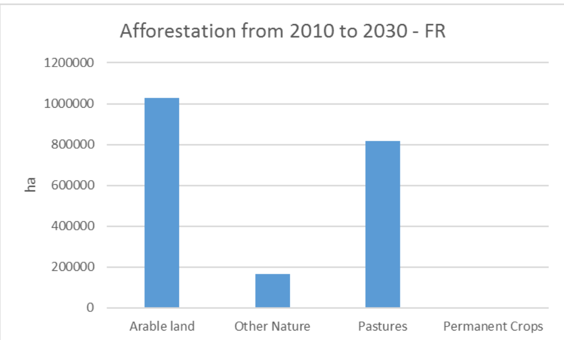


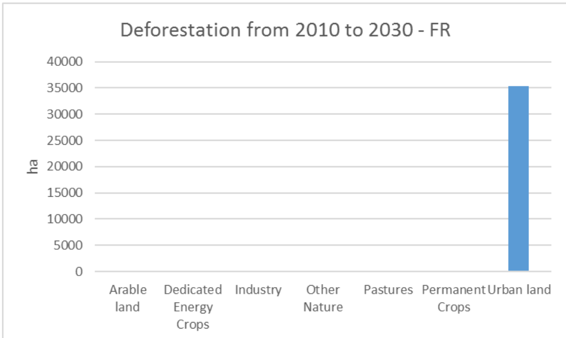
Afforestation

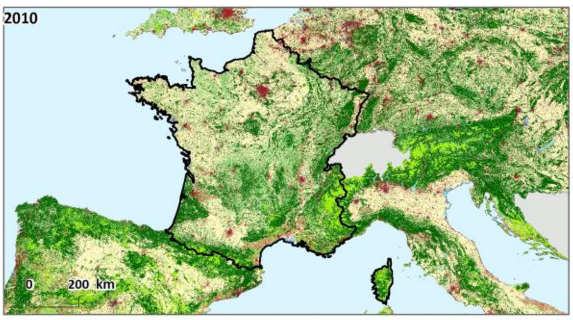
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



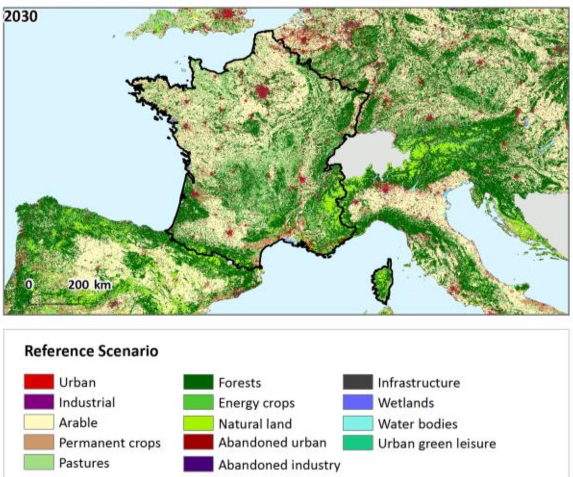
Deforestation

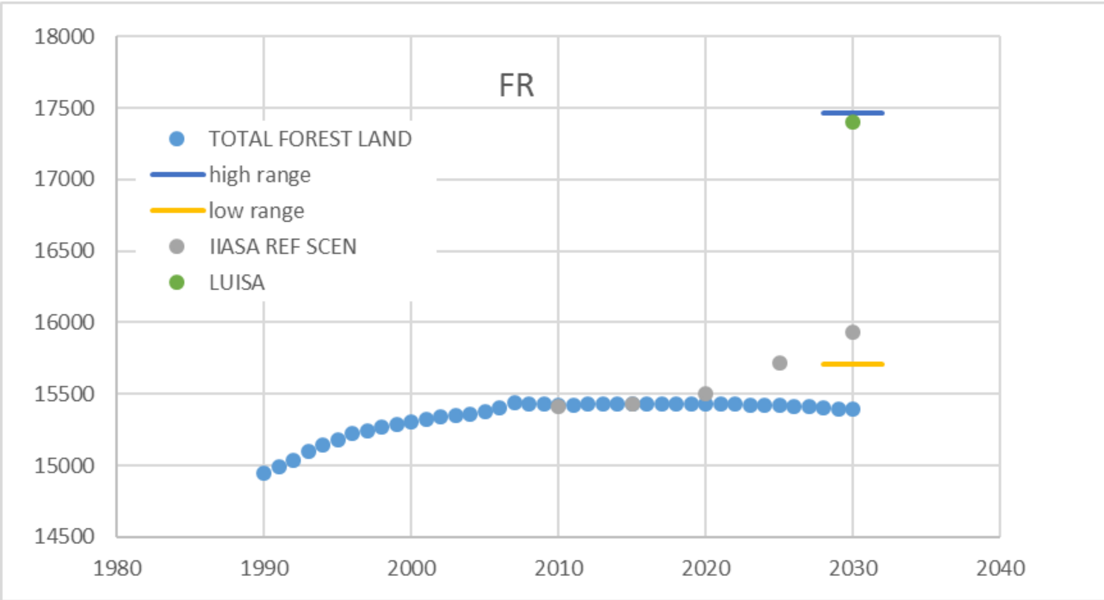
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).

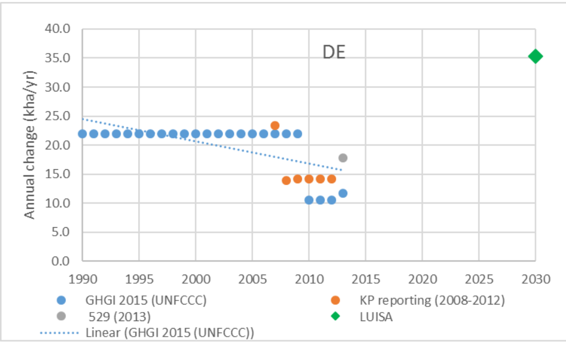




Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)
Forest area is expected to continue to evolve following the same trend as in 2005-2012, i.e. a net increase of about 100 kha/year.

Germany

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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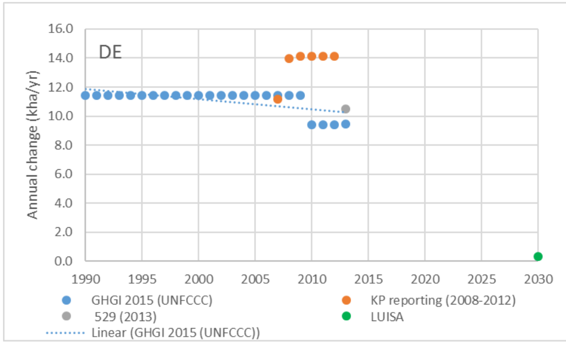
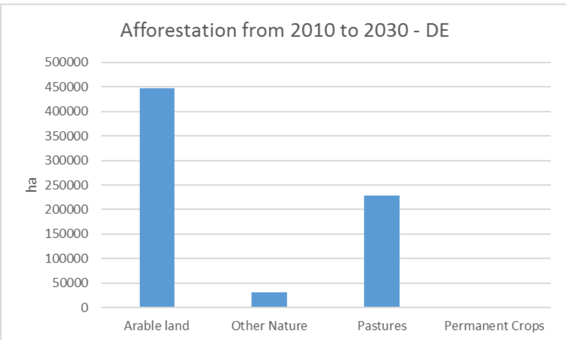


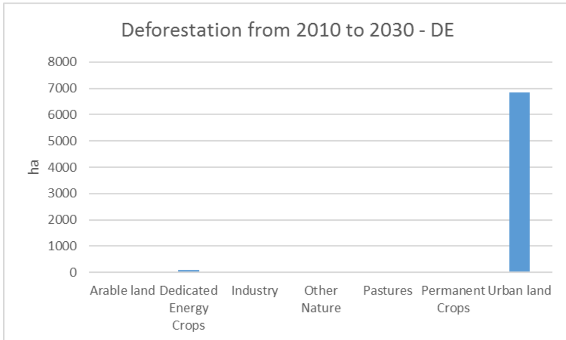
Afforestation

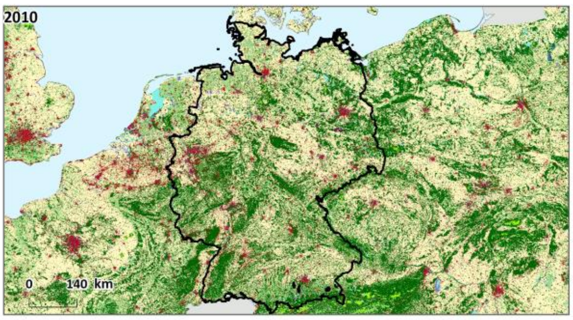
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



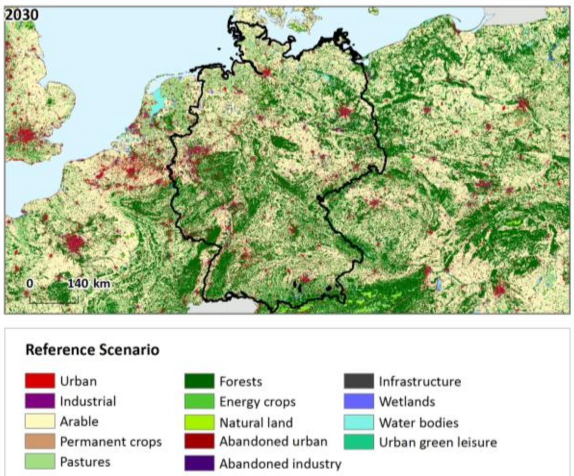
Deforestation

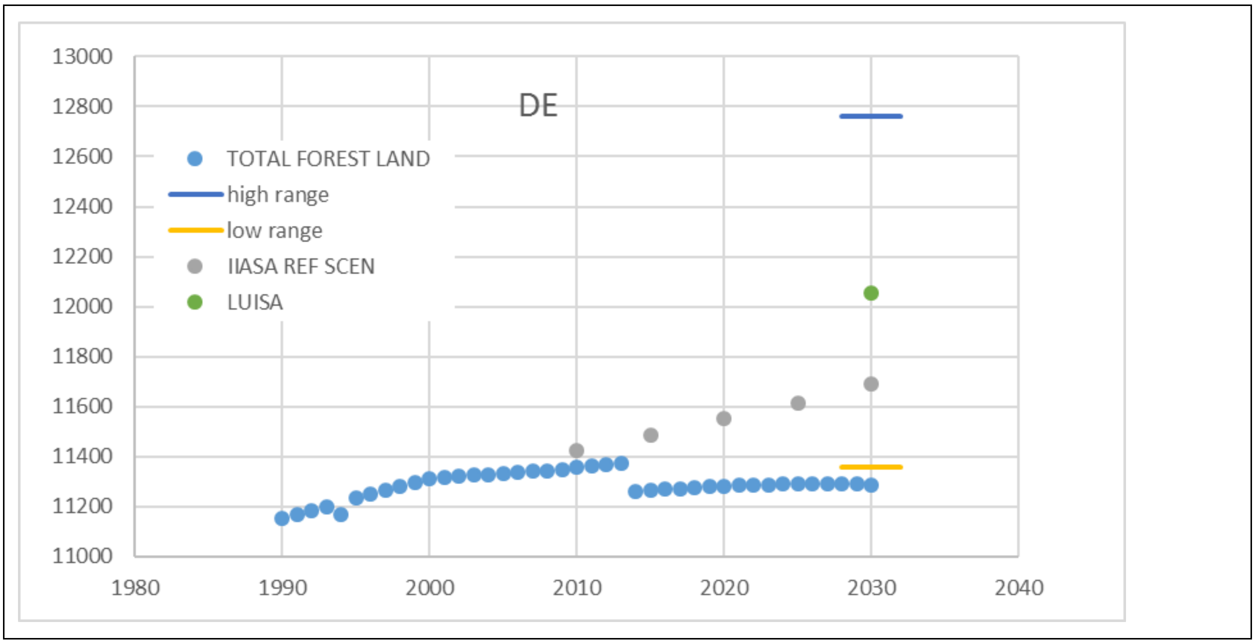
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).

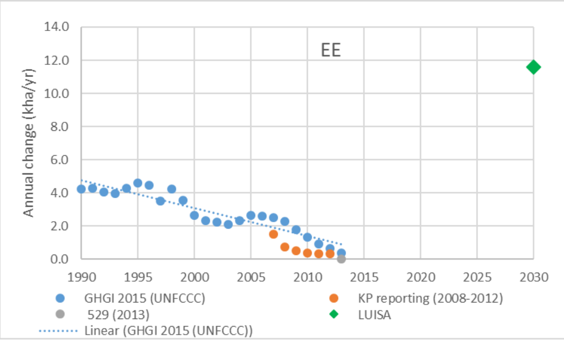


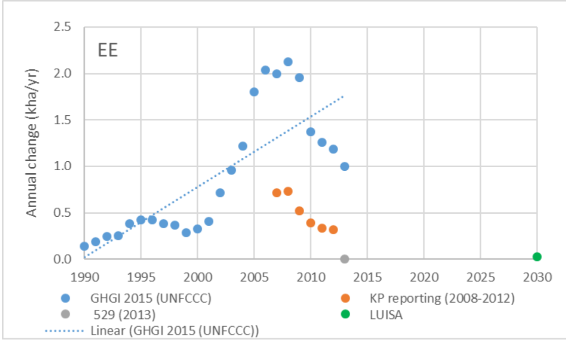


DE
TOTAL FOREST LAND
high range
low range
IIASA REF SCEN
LUISA
13000
12800
12600
12400
12200
12000
11800
11600
11400
11200
11000
1980
1990
2000
2010
2020
2030
2040

Estonia

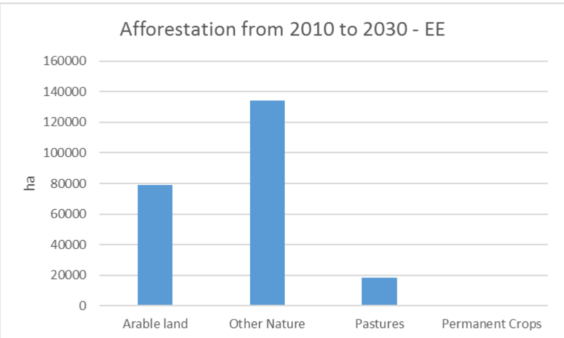
The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).	The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).





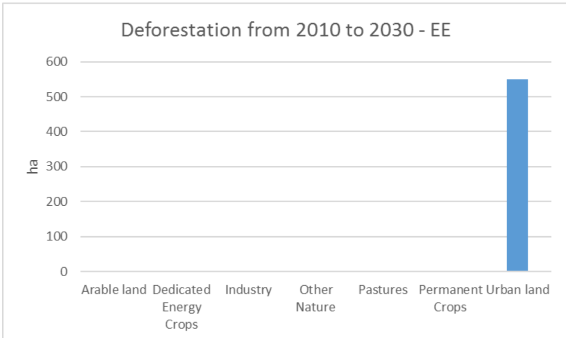
Afforestation

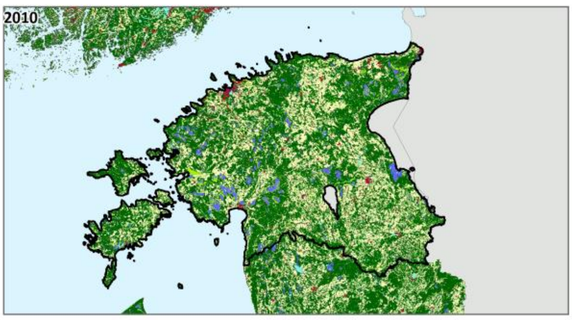
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).

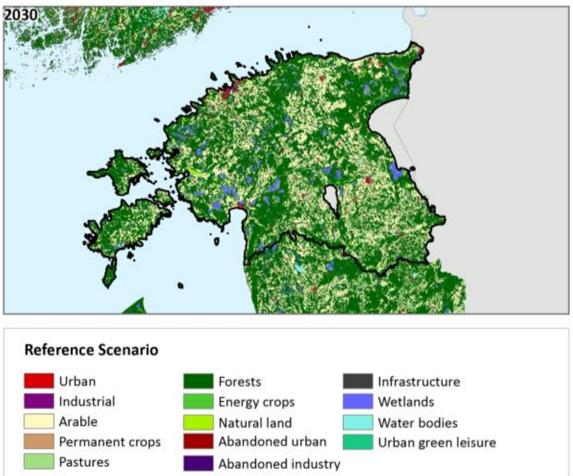


Deforestation

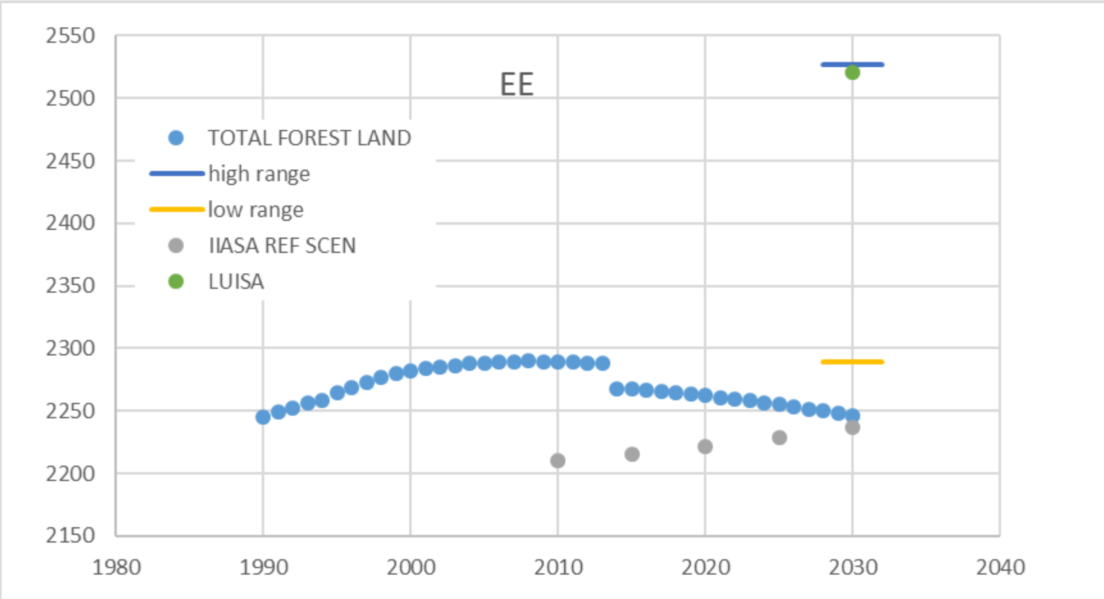
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).







The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).



<u>Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)</u>

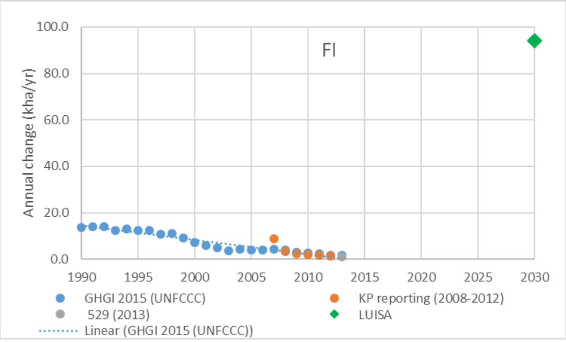
In the Reporting Under Art. 10(459) there are no projections of land use changes. There are projections of emissions and removals.

Land abandonment is due to insufficient forest planting and to lack of afforestation of the non-used arable land. Restoring the water regime of abandoned peat extraction sites would allow afforestation activities and recreation of bogs. Grasslands should continue to decline in the near future, mainly due to natural afforestation.

Finland

<table>
<tr>
<td>

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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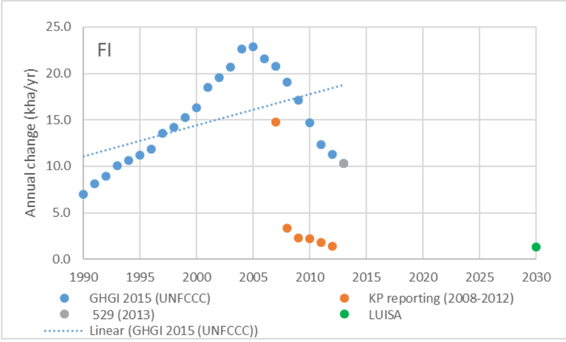
The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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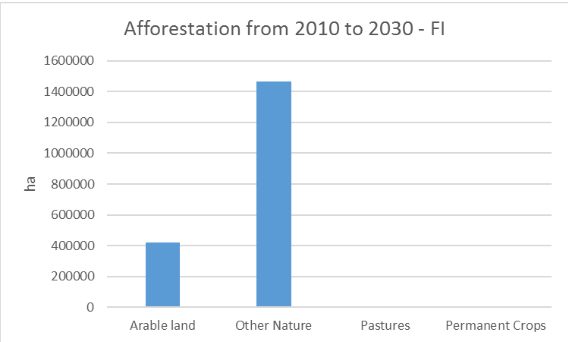
Afforestation

Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



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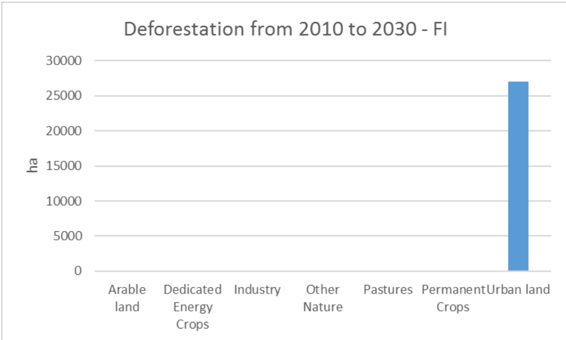
Deforestation

Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).



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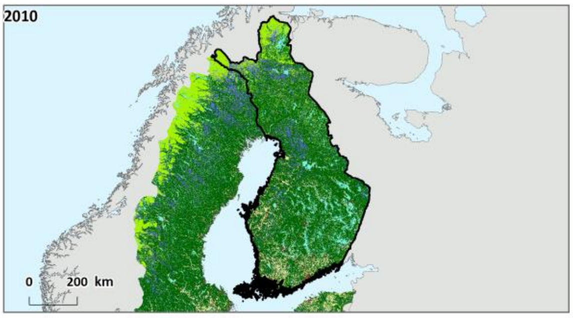

The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).

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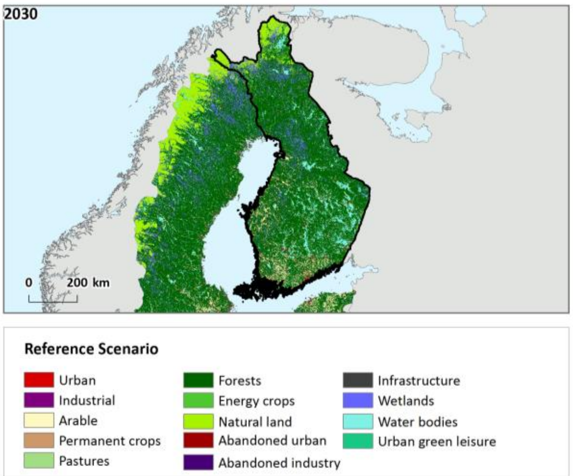

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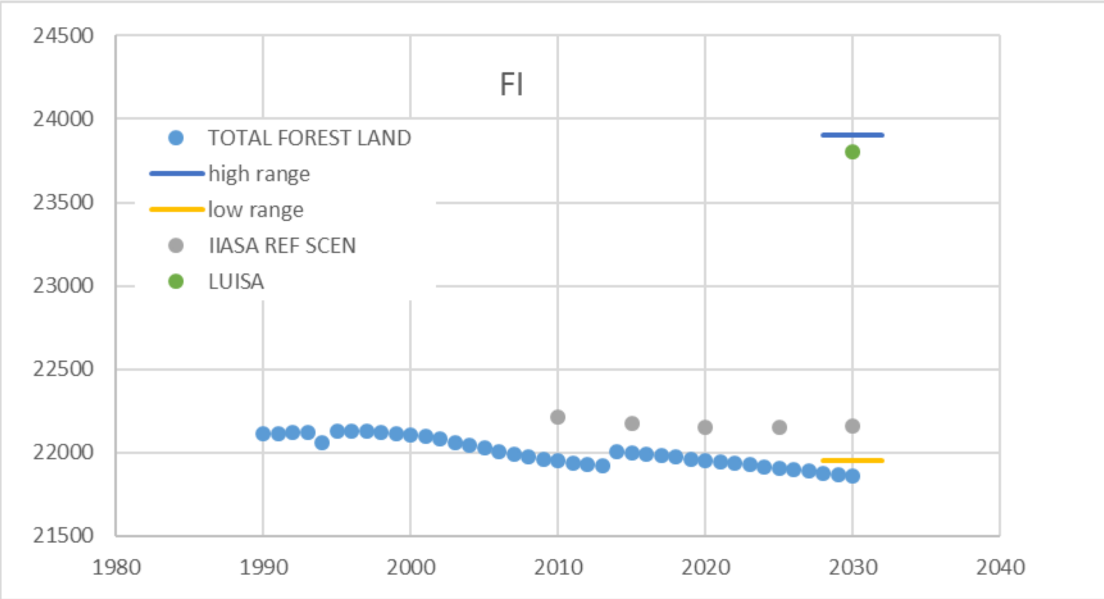
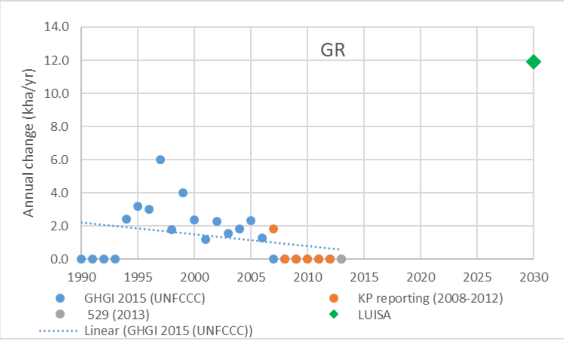


Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

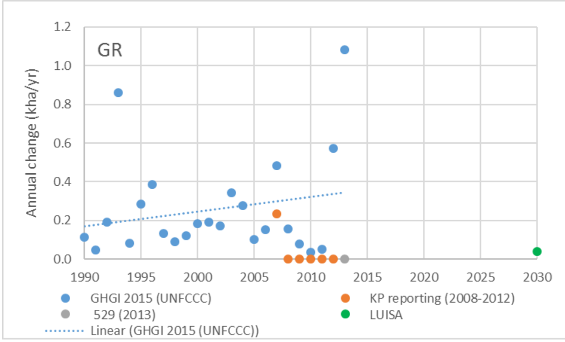
Sustainable management of forests in Finland is based on legislation, good practices and soft law instruments such as guidelines for good forest management and certification. AR has low priority.
Studies indicate that the most efficient measure to reduce emissions from cropland would be to reduce the area of cultivated organic soils by afforestation.

Greece

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual chanes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).

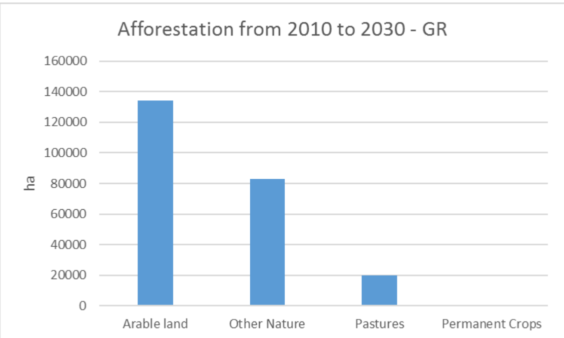


The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



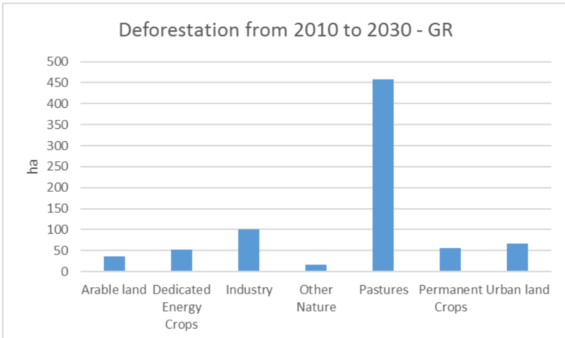
Afforestation

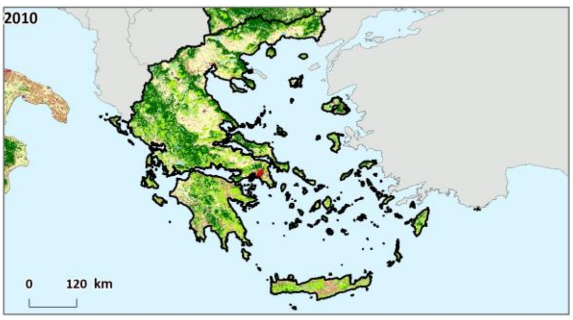
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



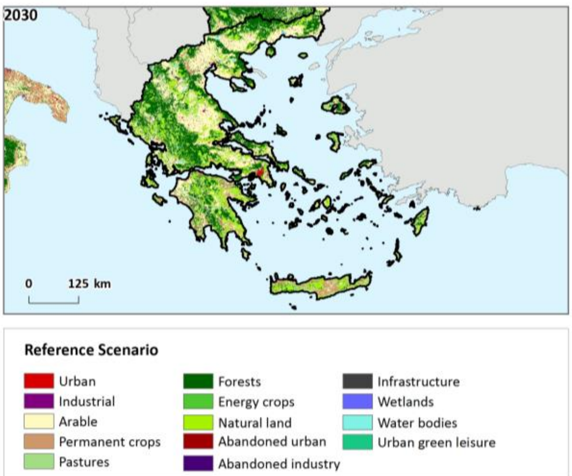
Deforestation

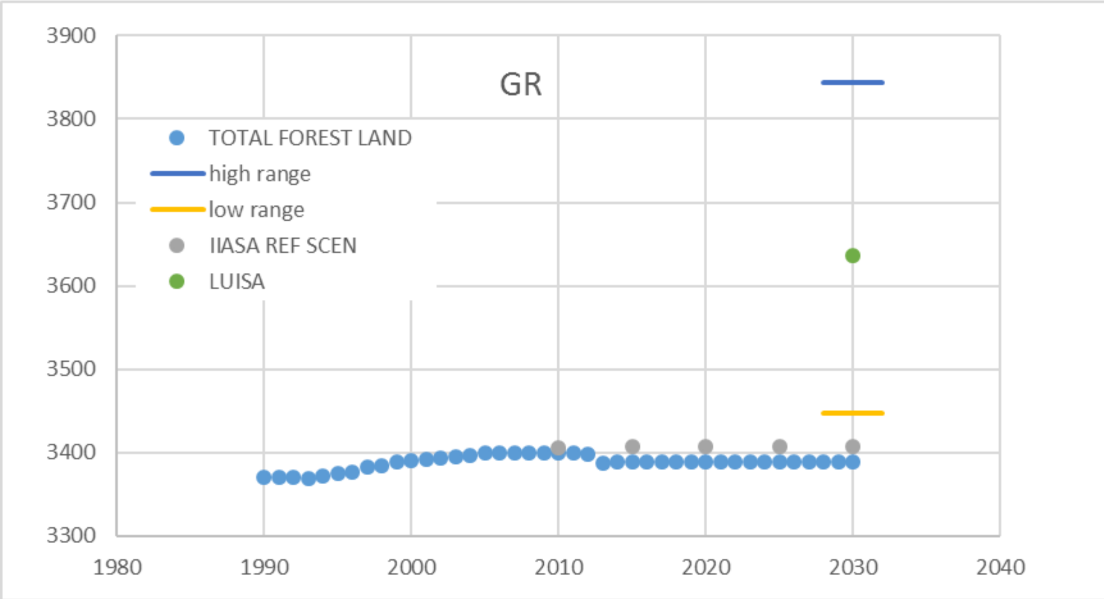
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).



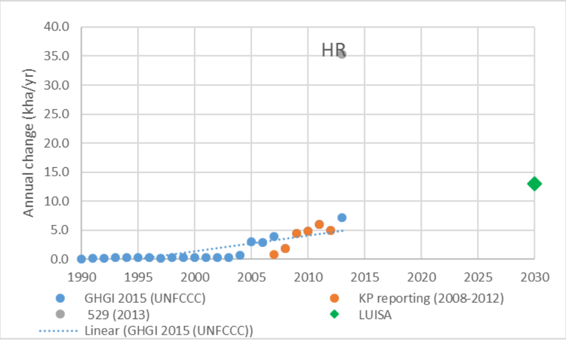


Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

Afforestation and creation of forest land is included in the Rural Development Program (RDP).

Croatia

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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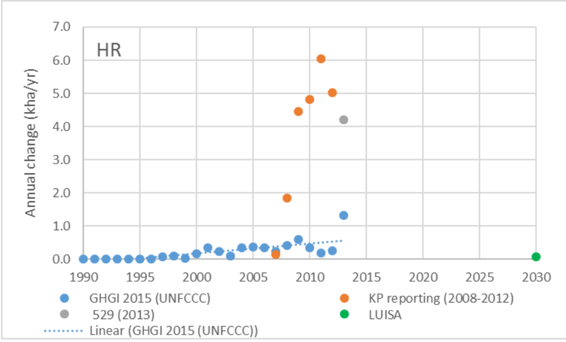
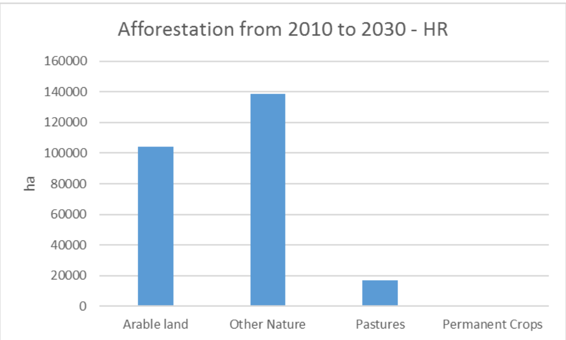


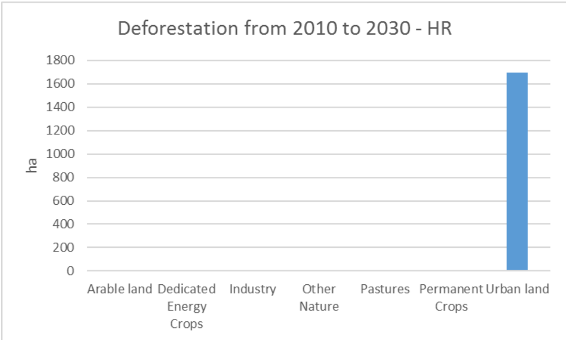
Afforestation

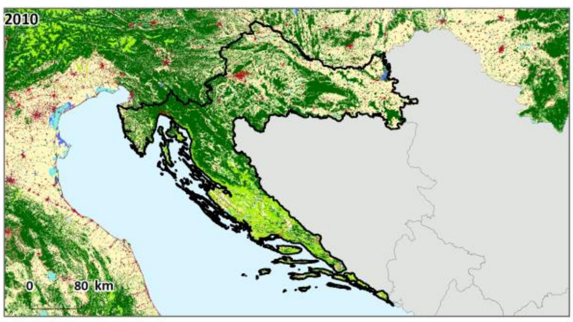
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).

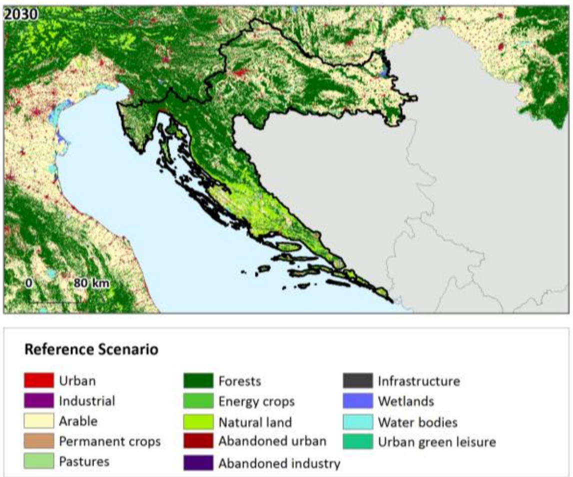


Deforestation

Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).







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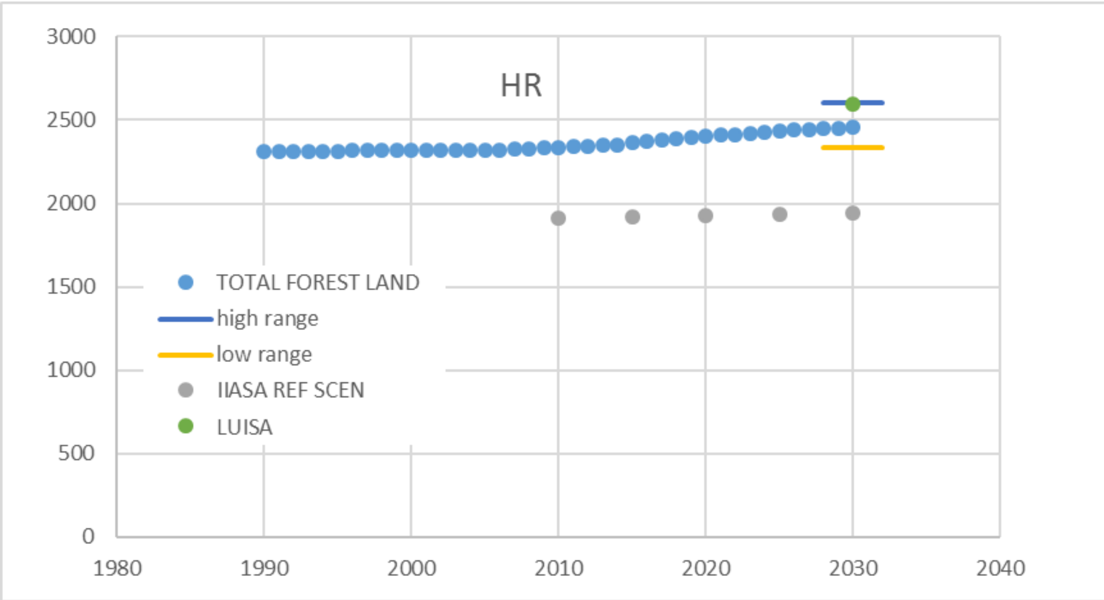
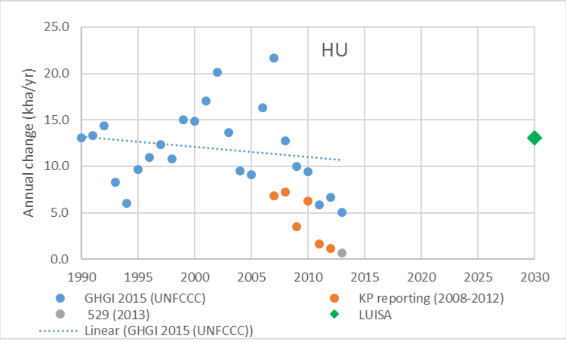


Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

AR is supported by provisions of the Forest Act.

Hungary

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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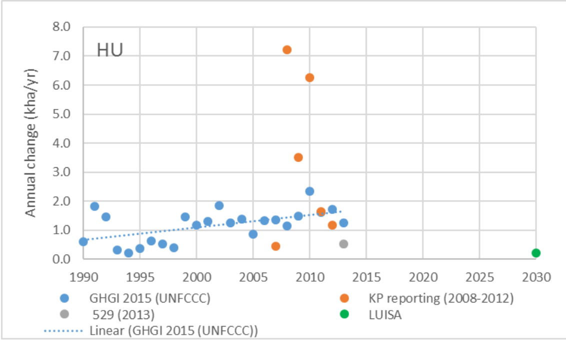
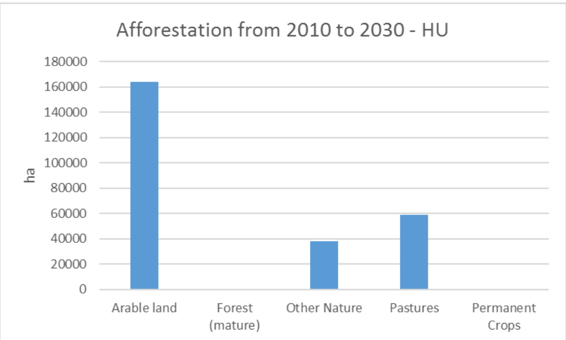


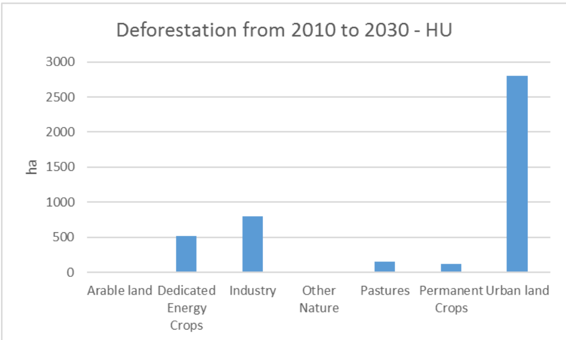
Afforestation

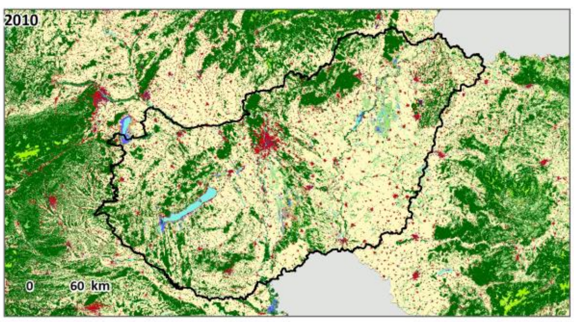
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



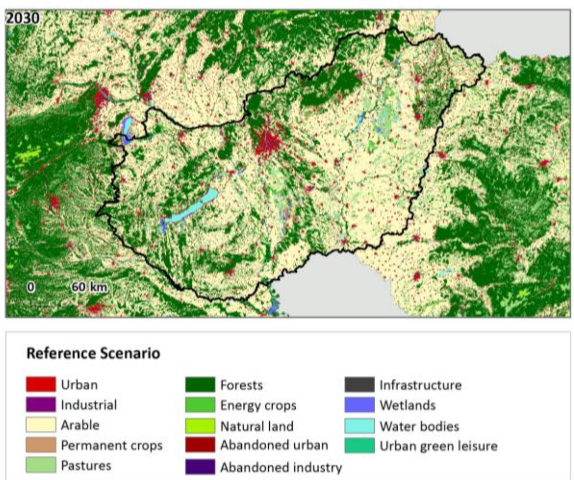
Deforestation

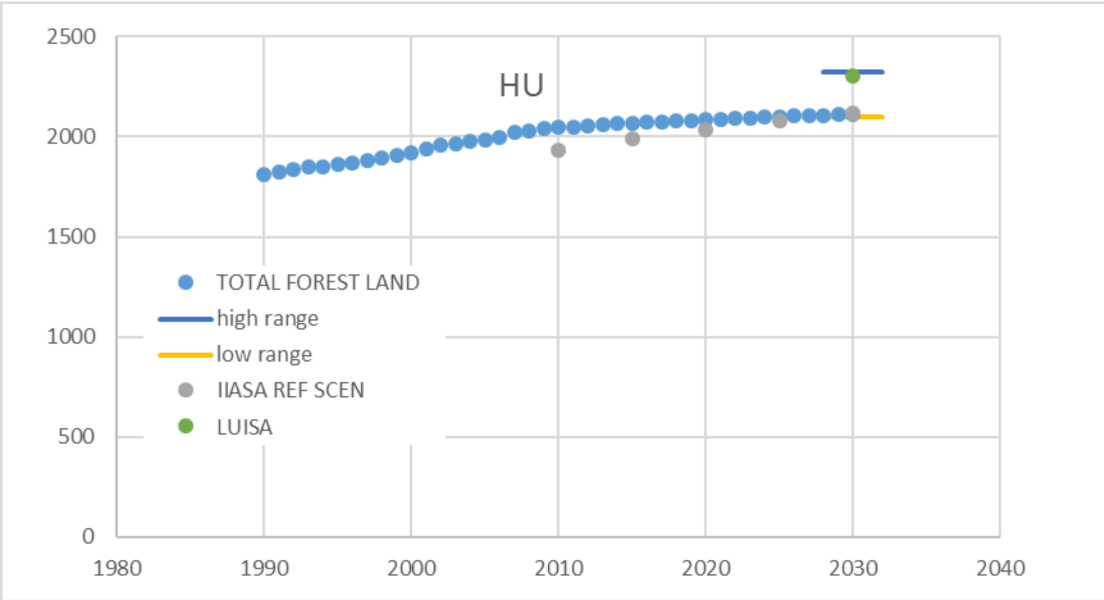
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





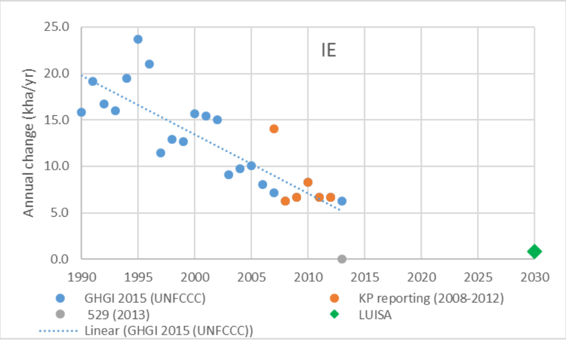
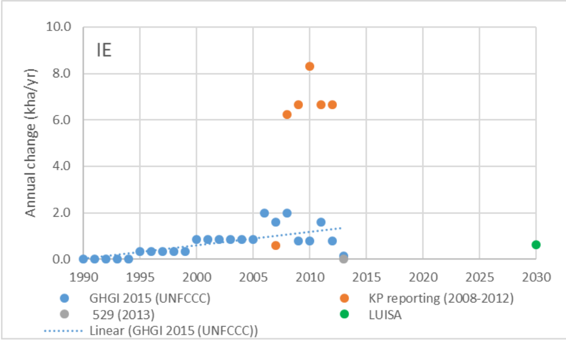
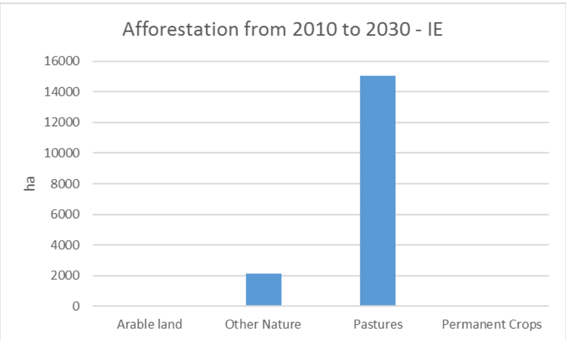
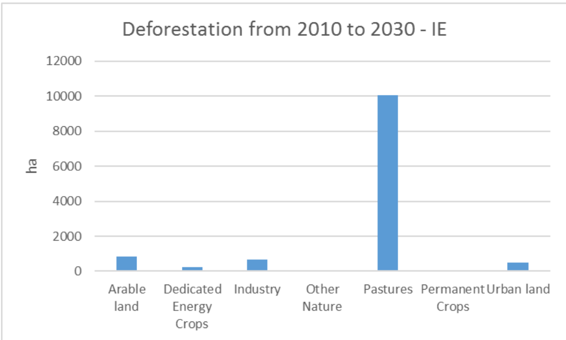
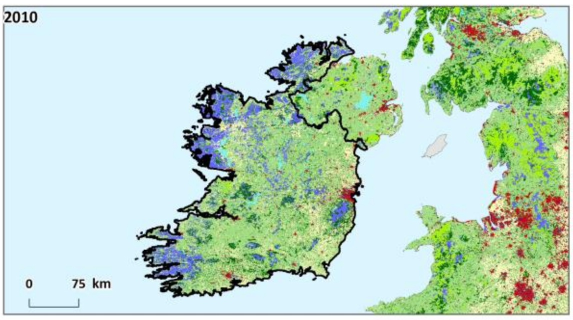
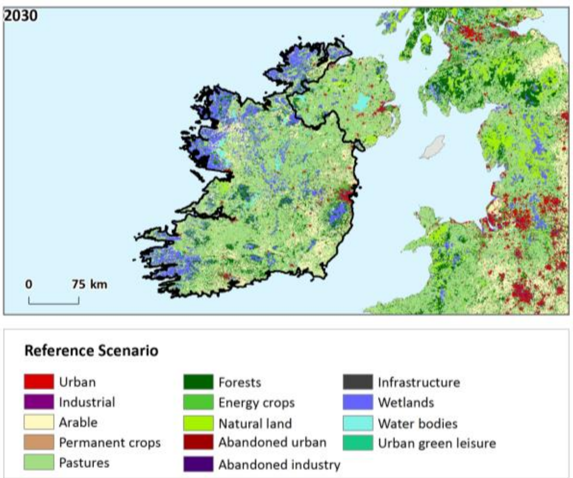
The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).

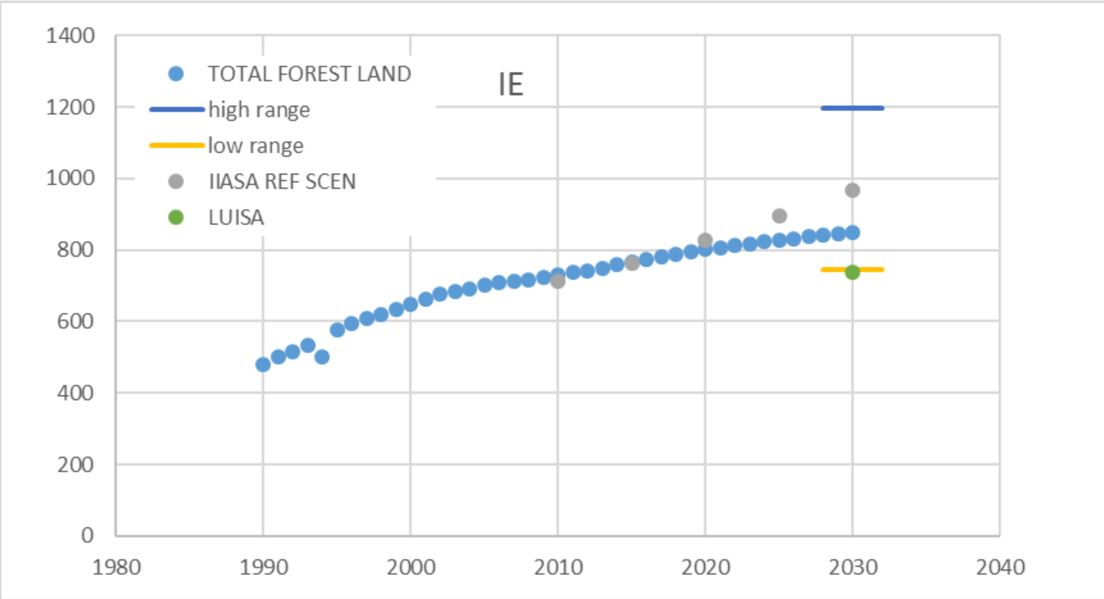




Hungary substantially increased afforestation programs with funds from national and EU sources.

Ireland

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr). 	The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr). 
Afforestation Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha). 	**Deforestation** Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha). 
 The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).	



Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

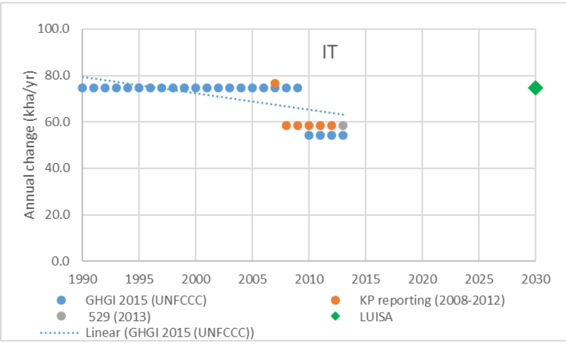
As Ireland's forest cover is, at 10%, one of the lowest in Europe, the Afforestation Grant and Premium Scheme provides a package to encourage planting of forests by compensating forest owners towards the costs of forestry establishment and for the income foregone during the maturation of the timber crop.

According to REPORTING UNDER ART 10(459), afforestation since 1990 is reported at about 300,000 ha, it has been incentivised under EU and state afforestation grants and premiums schemes. Currently, afforestation and associated measures are 100% state funded. It is expected that the afforestation rate will be 8,000 ha per year to 2020.

Policies in force: Afforestation Grant and Premium Scheme in Ireland as approved under the National Development Plan 2007 to 2013.

Italy

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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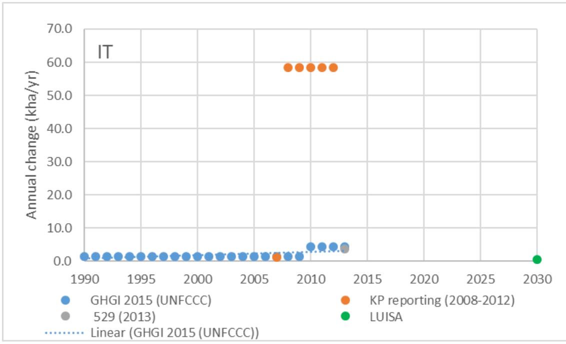
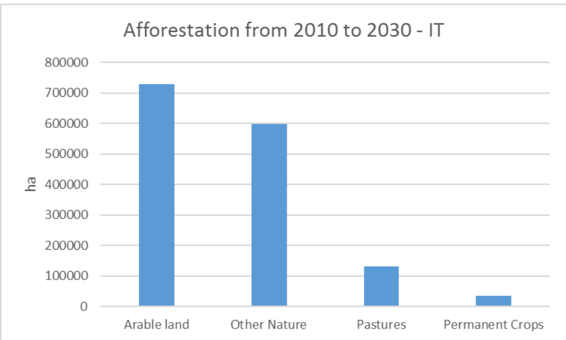


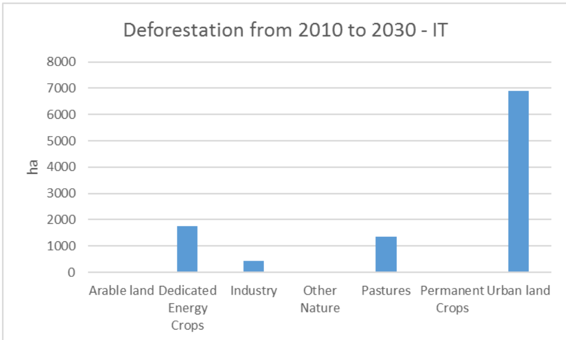
Afforestation

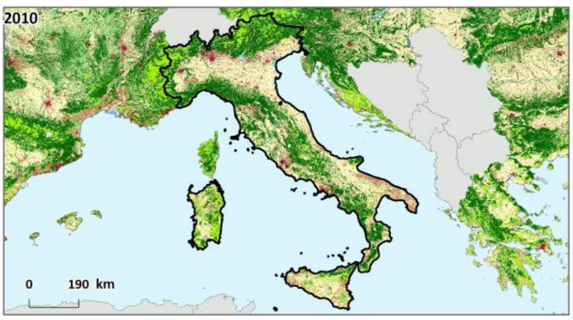
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



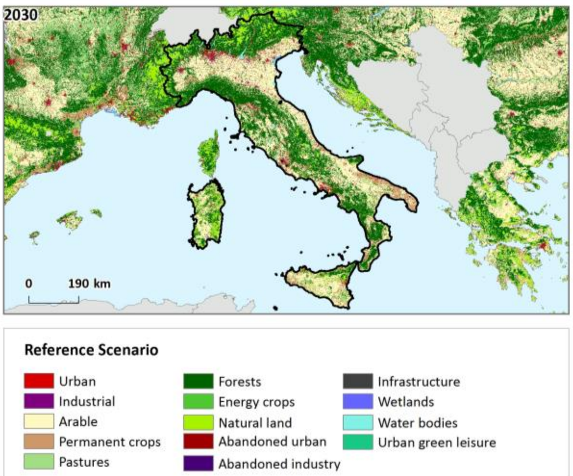
Deforestation

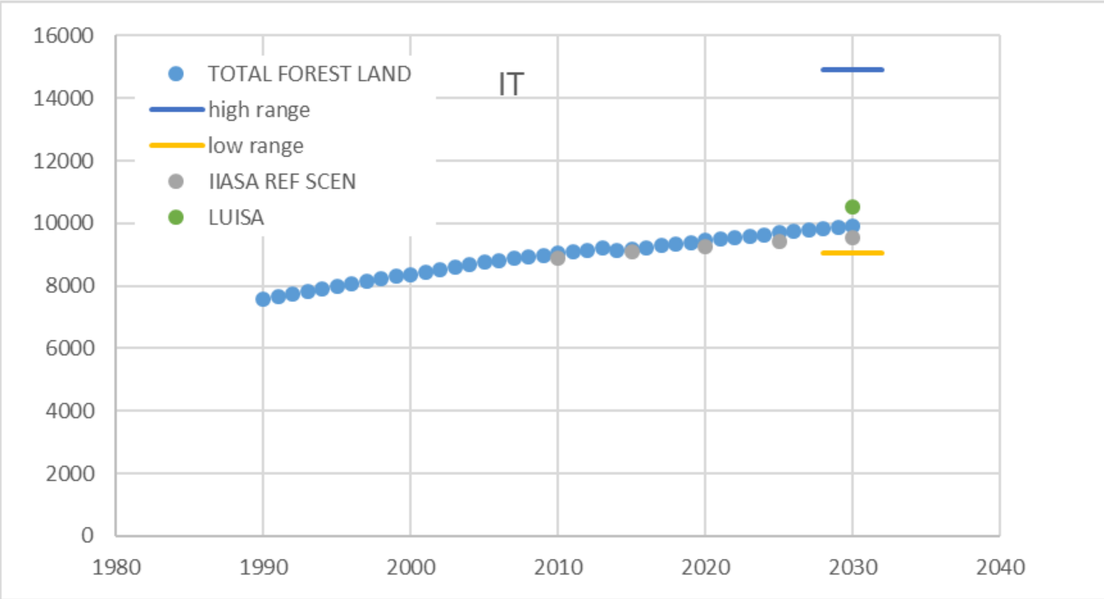
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).



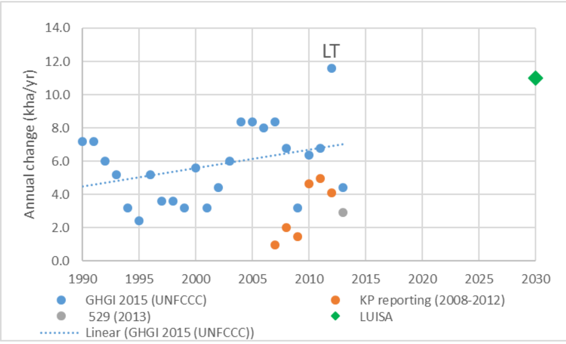


Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

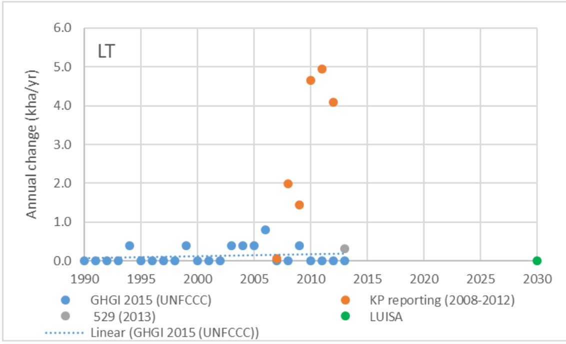
In art 10 reporting there is nothing specific on afforestation. It is mentioned that EUCLIMIT results are used for future projections.

Lithuania

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the AR rate estimated with LUISA and are the 2010-2030 average (kha/yr).

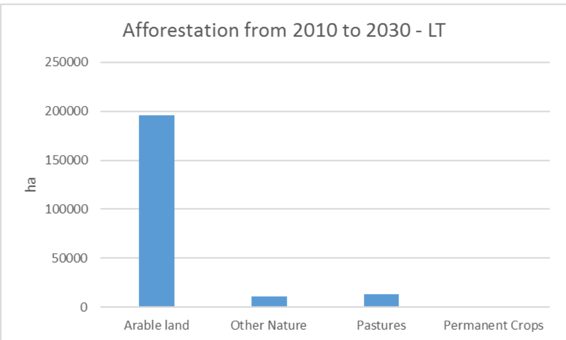


The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the DEF rate estimated with LUISA and are the 2010-2030 average (kha/yr).



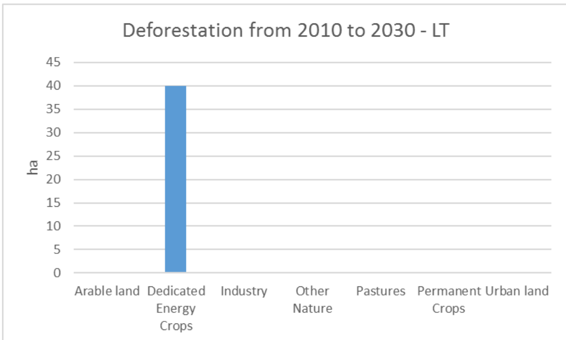
Afforestation

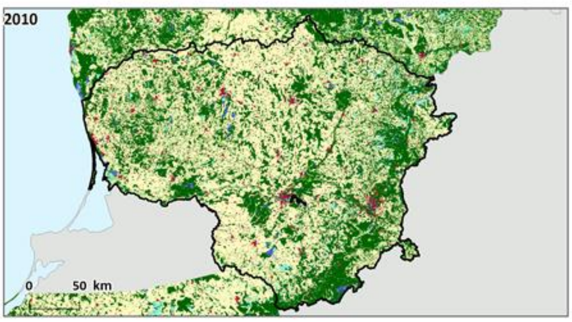
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



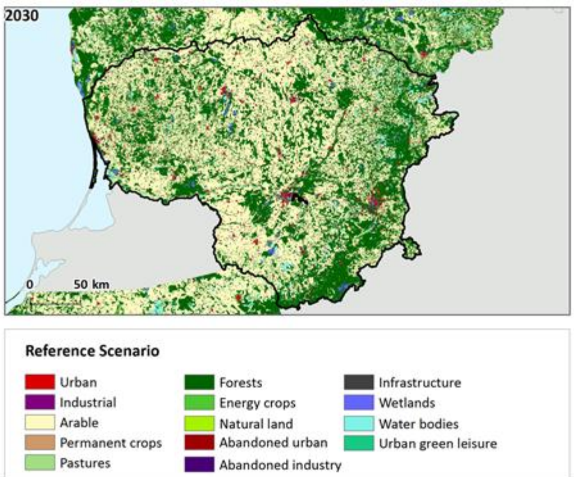
Deforestation

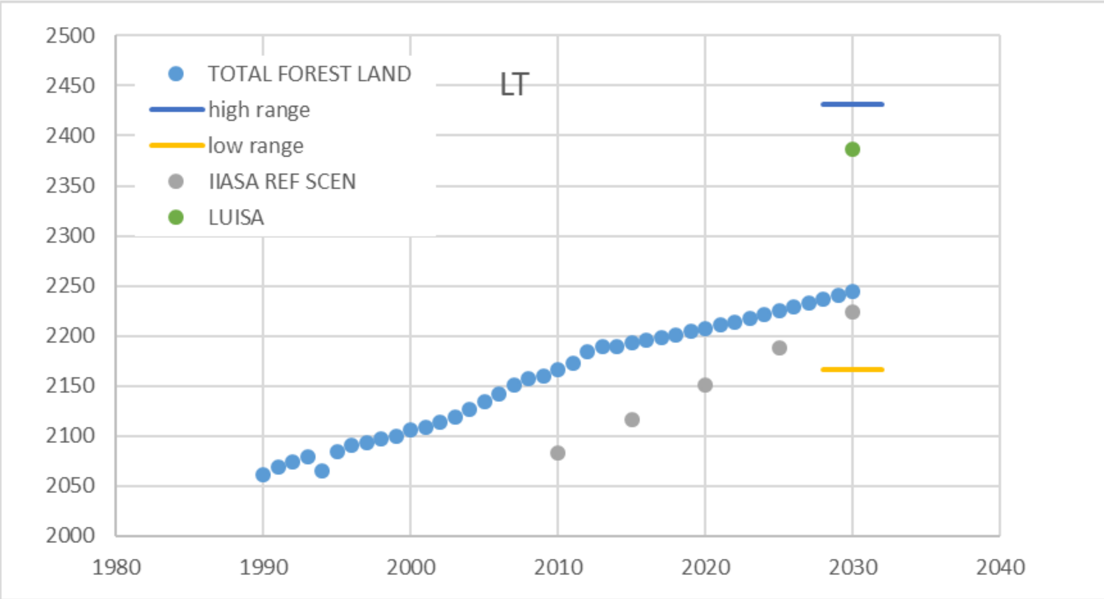
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).





Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

According to the National Land Service under Ministry of Agriculture there are more than 168,000 ha of land not used for agriculture or unfit for use; 72% of such land belongs to the State and is aimed to be afforested in the near future. A similar target is also set in the Master Plan for the territory of the Republic of Lithuania. However, this process is slowed down by incomplete land reform, problems related to the transfer of free land from the state land fund to managers of state-owned forests for afforestation, as well as legal restrictions linked with afforestation of land that has relatively high productivity.

The area subject to AR was 34,630 ha in 2012. There could be two moment distinguished in the time series of 1990–2012 describing the AR trend line. The first time period of artificial afforestation/reforestation has started in 1990-2000 and is related with Lithuanian history. After the restoration of Independence in 1990's forest expansion was the key priority among politicians therefore afforested and reforested areas constituted to more than 500 ha annually. But this number was steadily decreasing in 1994. After the spruce dieback which hardly hit the Lithuanian forest in 1994, afforestation and reforestation rates again returned to the 1990's level. Another two huge increases in AR area were recorded in 2001-2007 (result of the storm damages in 2001) and 2009-2011 (introduction of the EU support schemes for AR). Afforestation and reforestation resulted in a net removal of -195.9 $GgCO_{2eq}$.

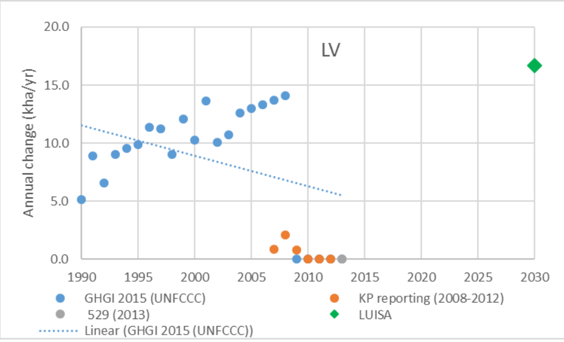
Croplands are assumed to be decreasing, because with no additional national incentives farmers' inertia to go for crop productionn would increase.

Forest land area could be expected to increase by 0.2–0.3% based on current situation. Increase in forest land area mostly depends on support from national programs for afforestation of abandoned lands and RDP.

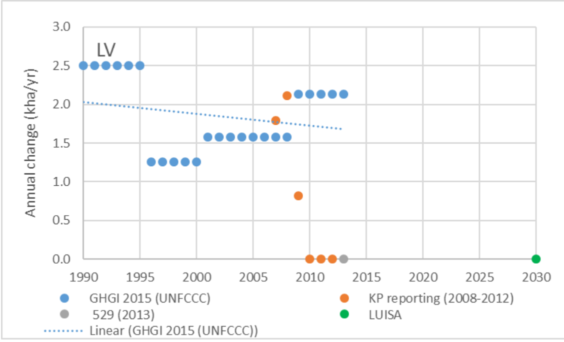
National Forest Area Development Program 2012-2020 approved by Resolution No 569 of the Government of the Republic of Lithuania of 23 May 2012, sought to increase forest coverage of the country up to 34.2% by 2020 by afforestation of abandoned lands and lands that are not suitable to be used for agricultural activities, and to encourage people financially to plant forests in private and state-owned lands, to develop forest regeneration on a genetic-ecological basis with selectively valuable and qualitative forest increasing matter.

Latvia

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).

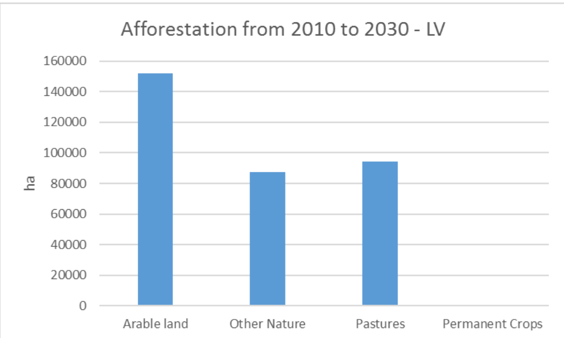


The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



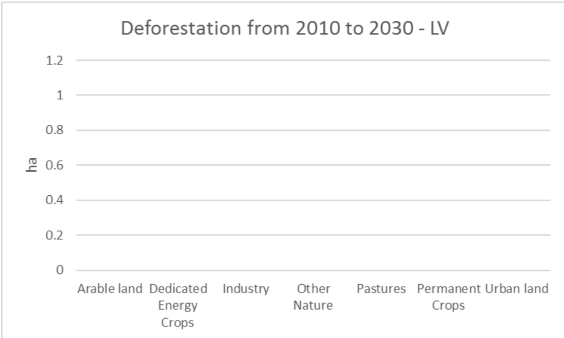
Afforestation

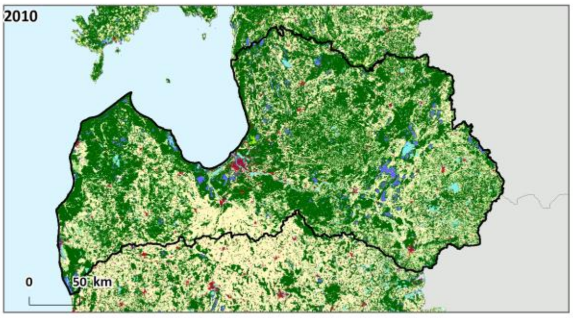
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



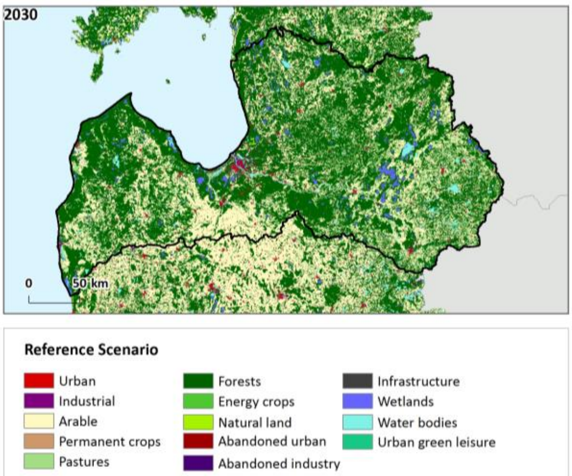
Deforestation

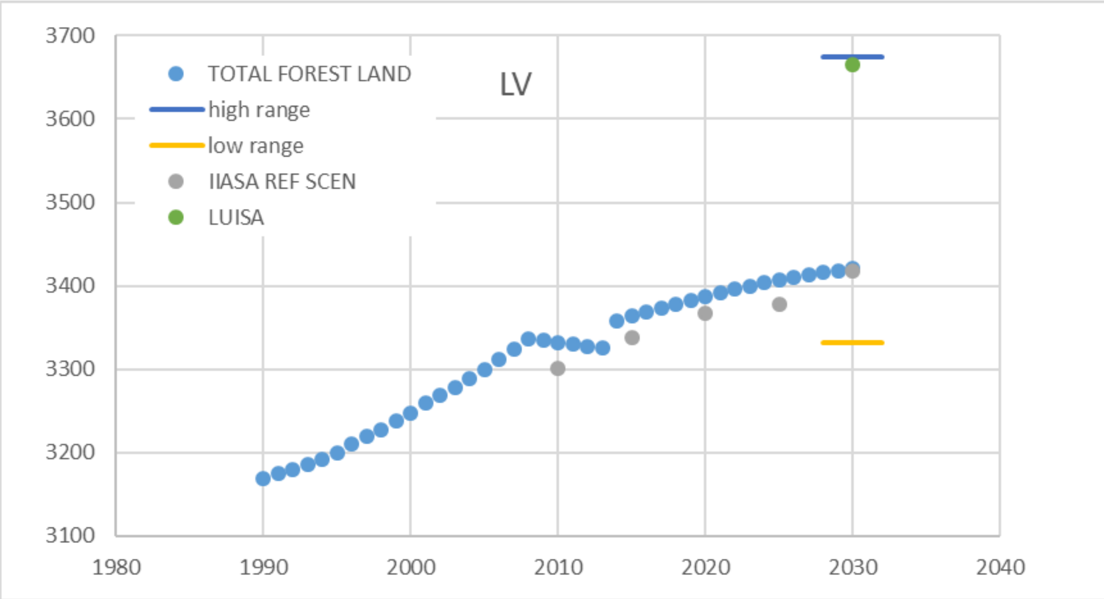
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).





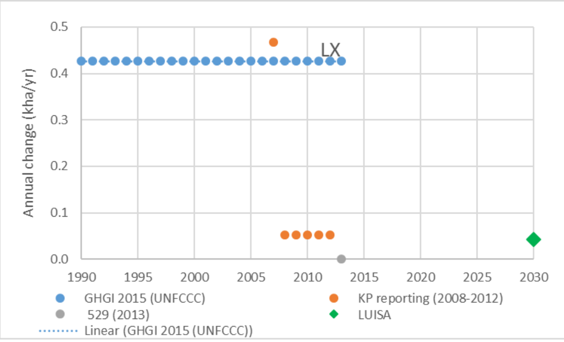
Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

Due to insufficient use of support to afforestation of the abandoned land and improvement of stand quality in naturally afforested areas, the value of forests in afforested lands in Latvia is much lower as compared to forest land remaining forest and the carbon accumulation potential of new forest stands will not be fully utilized. Two of the most frequent scenarios are occurring in this case – either afforestation (natural or human induced) or land is brought back to normal agricultural production.

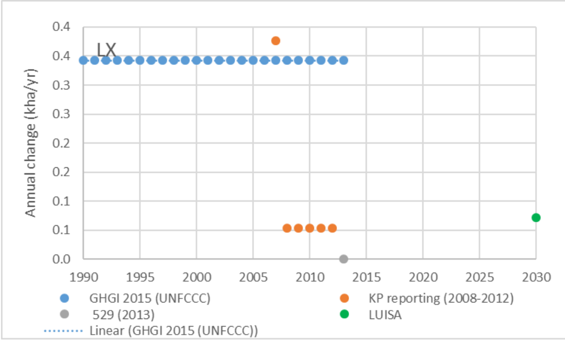
Grassland area is decreasing due to afforestation and due to conversion of abandoned farmlands back to crop production. The reduction of the grassland area takes place mainly due to afforestation of pastures and perennial grasslands and by conversion of the latest category to cropland. Grasslands are likely to continue to decline in the near future, mainly due to afforestation of less valuable lands and conversion to cropland of more fertile fields.

Luxemburg

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).

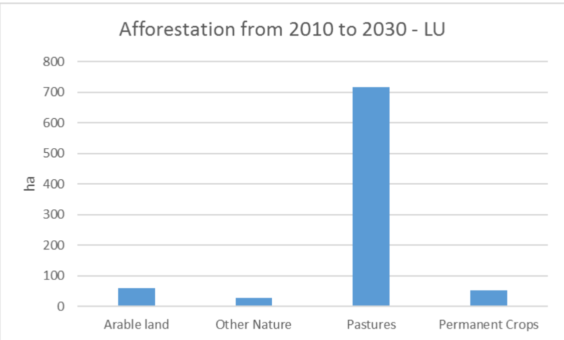


The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



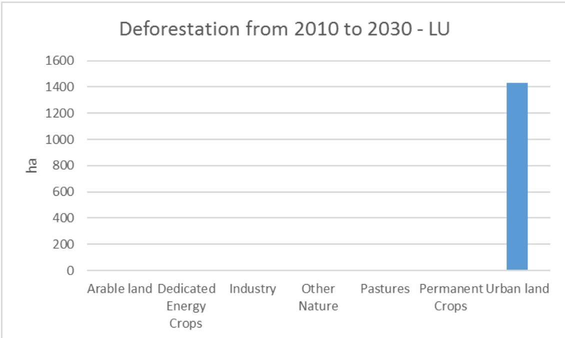
Afforestation

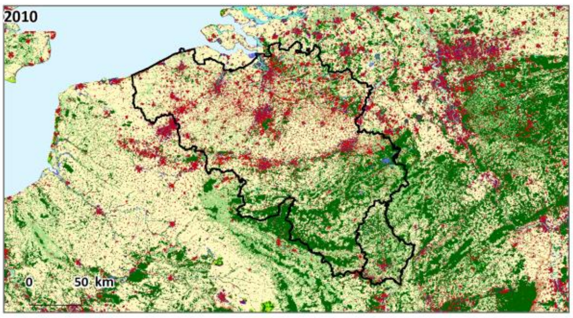
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



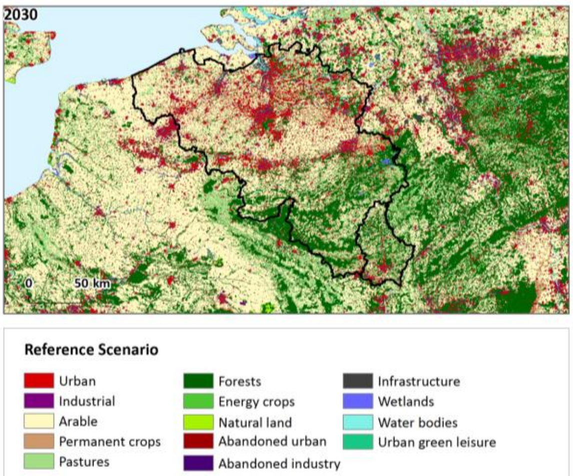
Deforestation

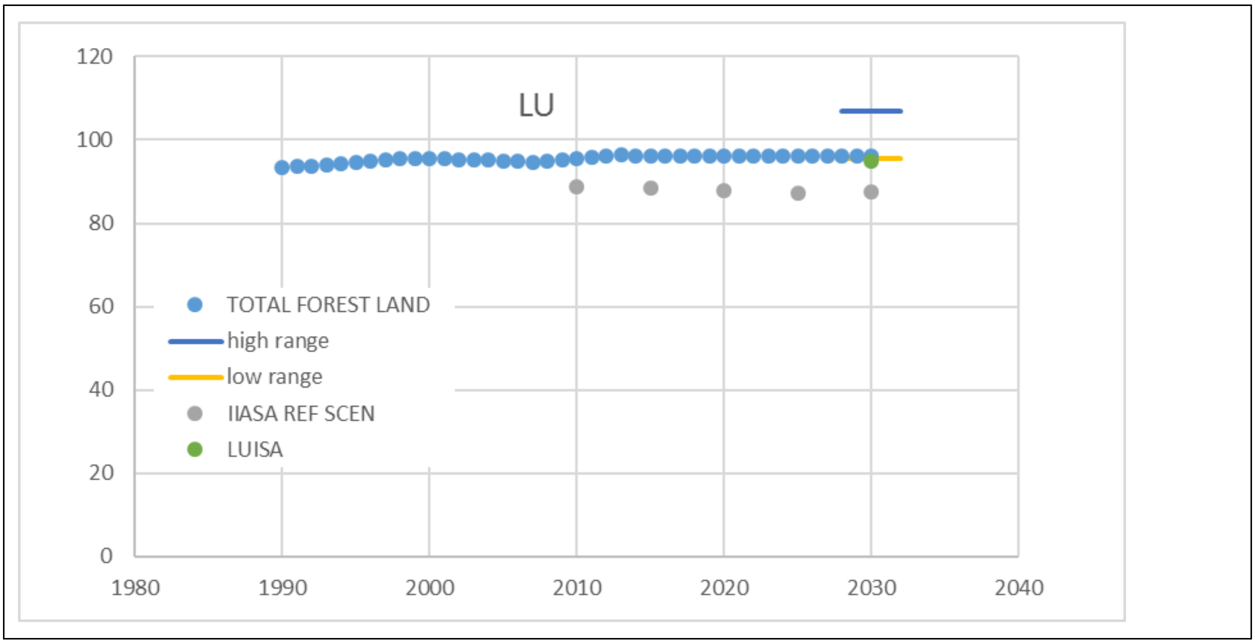
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).





The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).




LU
120
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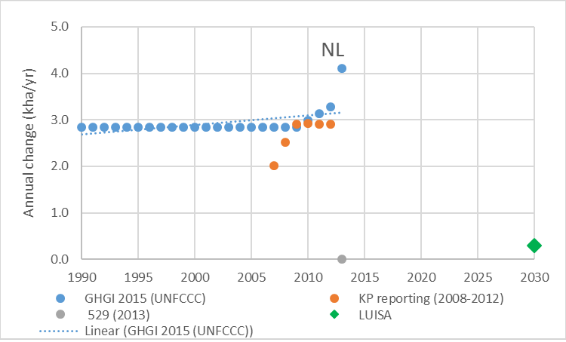
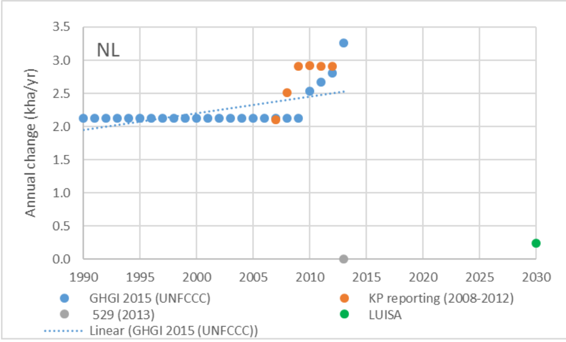
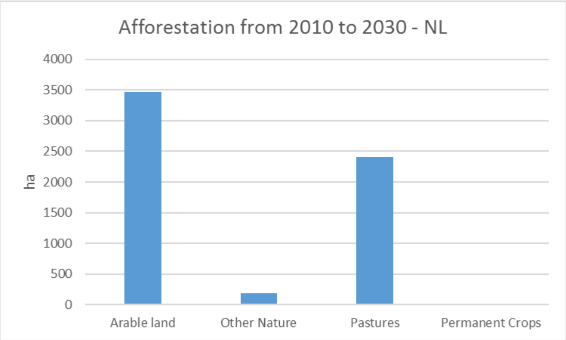
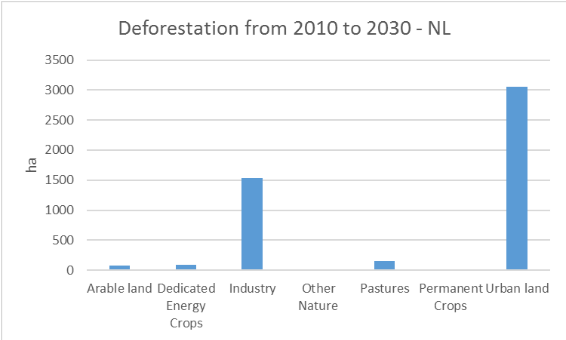
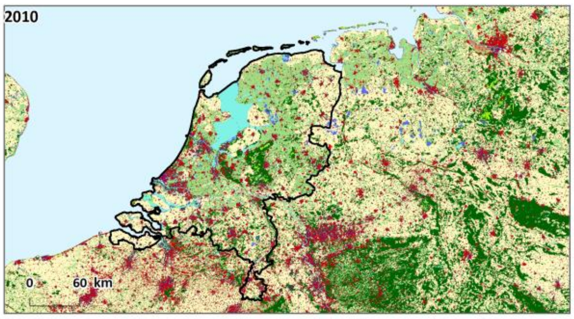
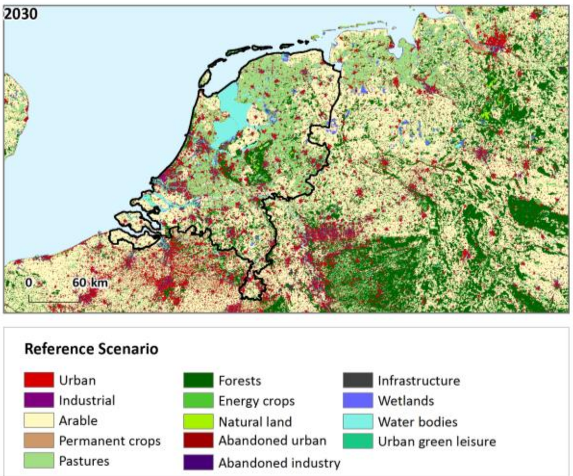
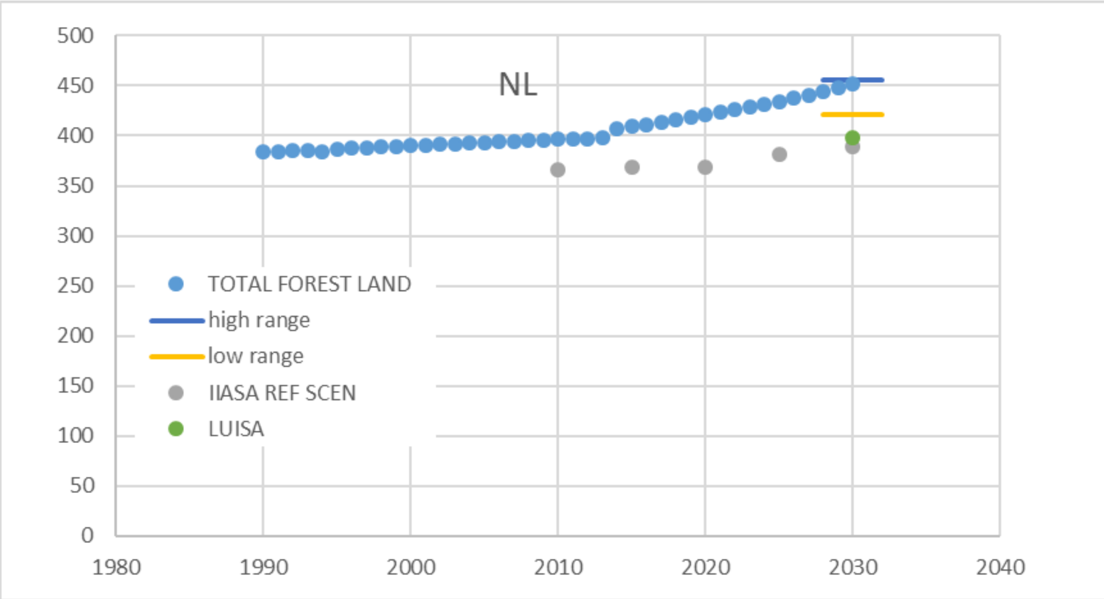
0
1980
1990
2000
2010
2020
2030
2040
TOTAL FOREST LAND
high range
low range
IIASA REF SCEN
LUISA

Netherlands

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr). 	The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr). 
Afforestation Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha). 	Deforestation Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha). 
 The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).	

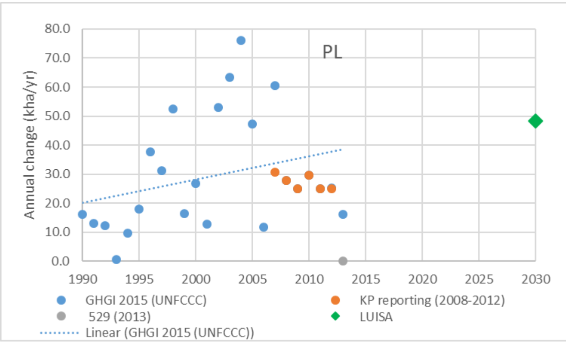


Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

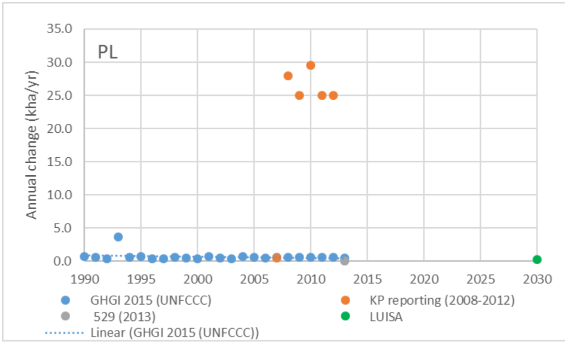
Over the past decades, forest policy in the Netherlands has been integrated into the nature policy, which reflects the change towards multi-purpose forests in which more functions are combined (e.g. nature, recreation). The development of a nature network is a central theme of the nature (and forest) policy. The nature network is a cohesive network of high-quality nature wetland and terrestrial reserves. 560,000 ha of this network was completed by 2011. The aim is to have converted an additional 80,000 ha into nature reserves by 2027. Part of this will be achieved through afforestation and reforestation, which over time will also contribute to increasing removals from LULUCF. The scale of such afforestation is, however, not known yet.

Poland

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).

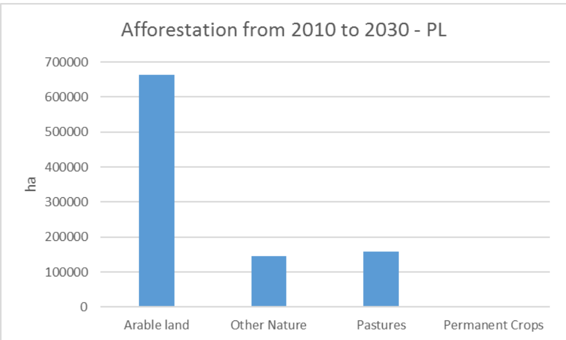


The graph shows: in blue the Forest Land converted to other land, 1990-2013 (GHGI 2015 - UNFCCC), in orange deforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **DEF rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



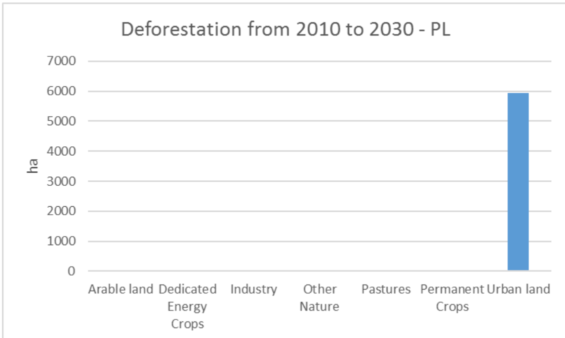
Afforestation

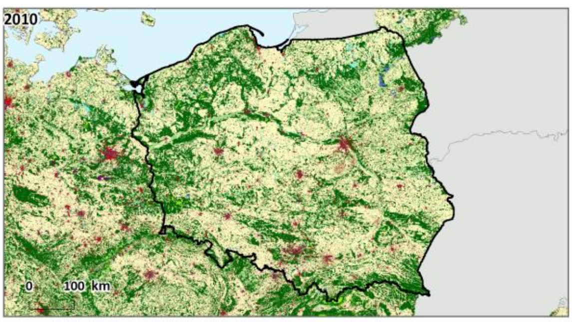
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



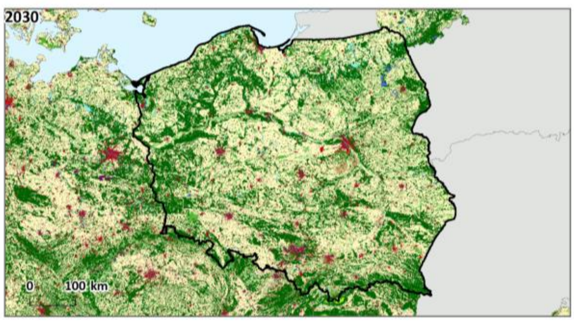
Deforestation

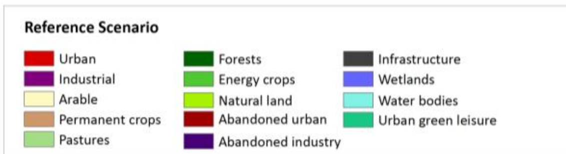
Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).

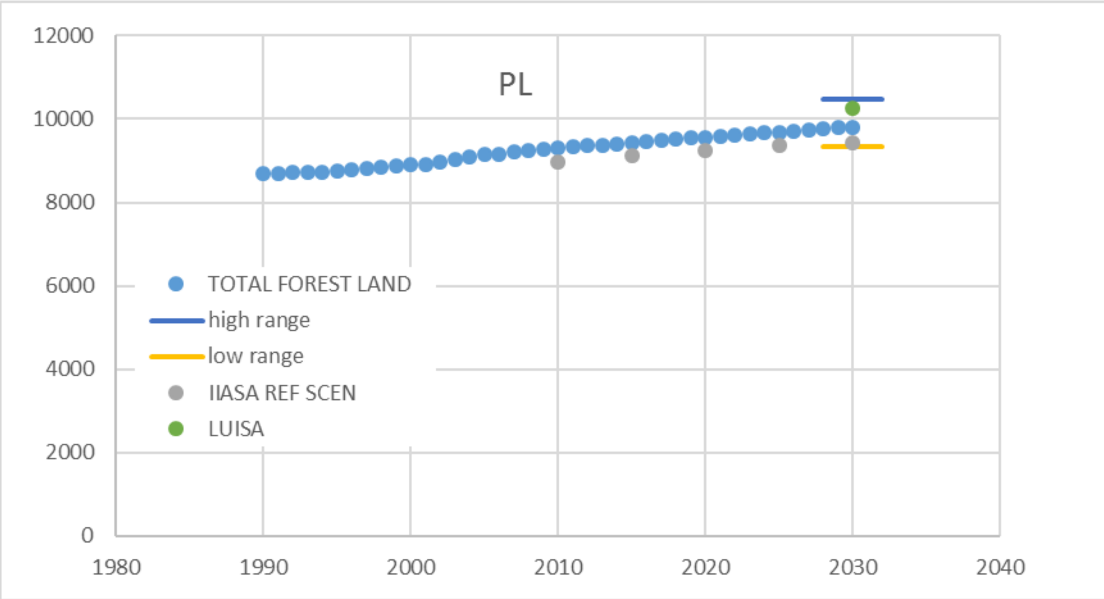




The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).







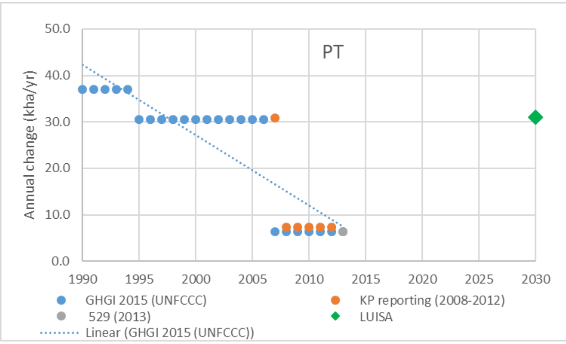
Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

The strategic planning document in effect is the National Programme for the Augmentation of the Forest Cover adopted in 1995 (NPAFC) which sets out the target of enhancing forest cover in Poland to 30% by 2020 (now it is 29.3%) and 33% in 2050. Since 2004 afforestation projects have been carried out with funds from the Rural Development Programme.

The compensation for afforestation was financed from the resources of the Agency for Restructuring and Modernisation of Agriculture. However, since 2004 the rate of afforestation has been falling probably because of factors such as competition from direct payments to support agricultural production, increase of the required minimum size of the afforestation plot, the exclusion of permanent grassland from afforestation and the designation of Natura 2000 sites.

Portugal

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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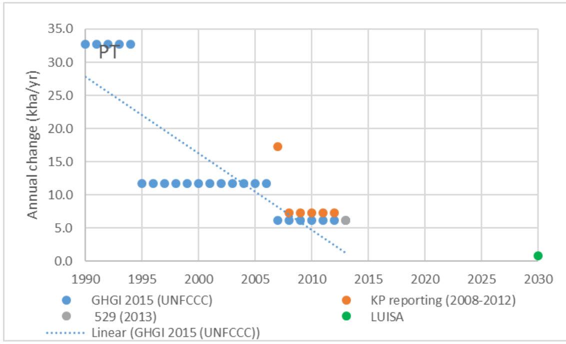
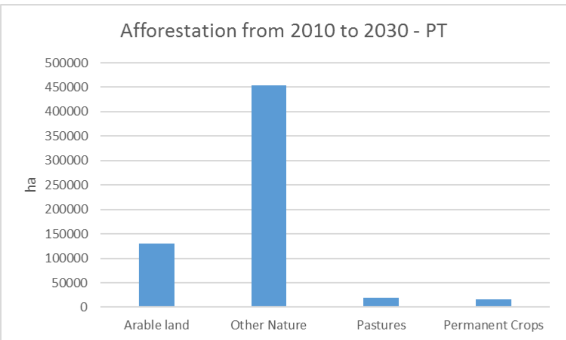


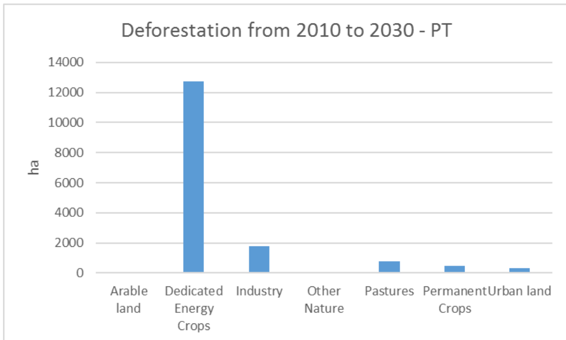
Afforestation

Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).

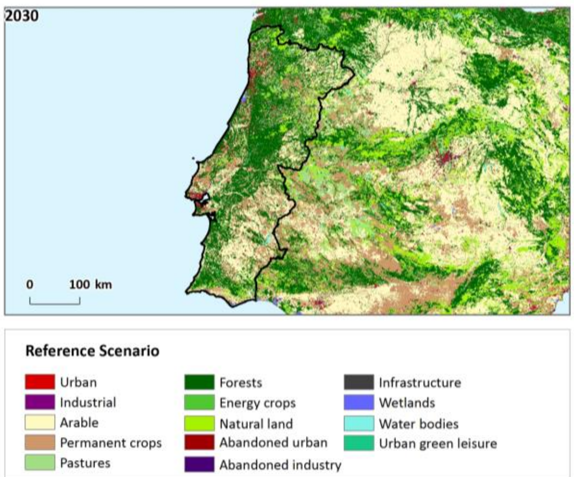


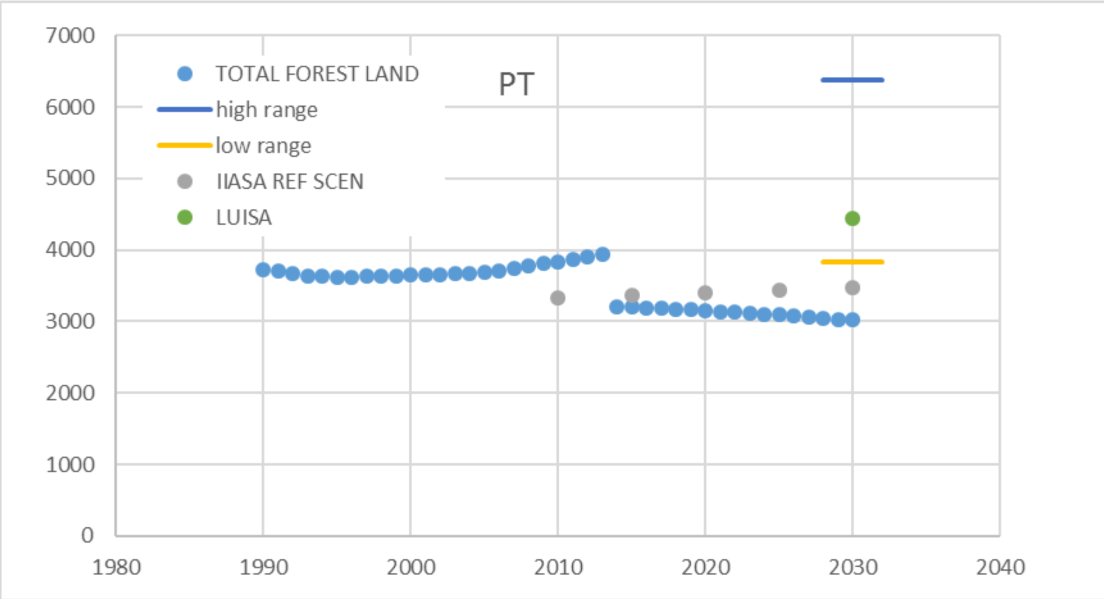
Deforestation

Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).



The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).

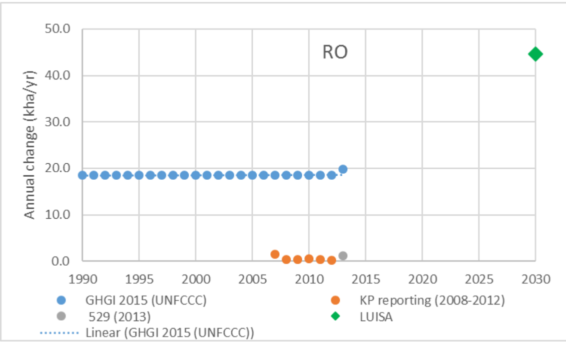




<u>Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)</u> Rural Development Plan contains specific measures to promote sequestration, reduce emissions and promote energy efficiency in agriculture, grasslands and forestry. A review of the National Forest Strategy has recently been adopted by the Council of Ministers and is awaiting publication in the official journal. This strategy identifies contributions from the forestry sector to climate change policies, both in mitigation and adaptation.

Romania

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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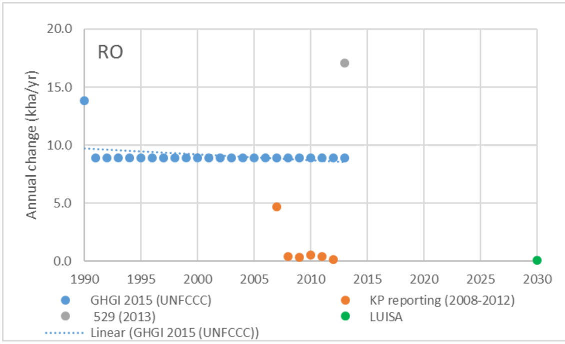
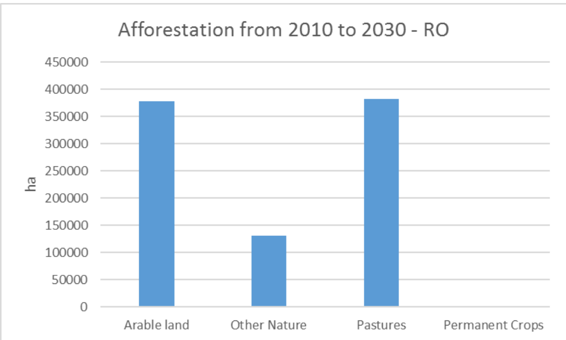


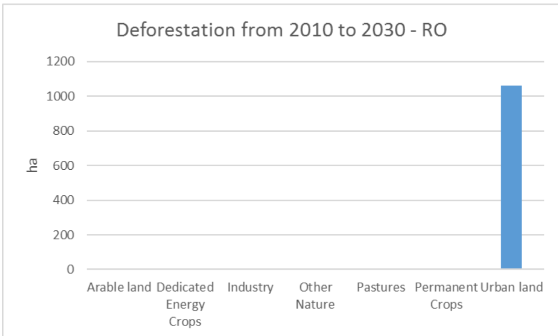
Afforestation

Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).

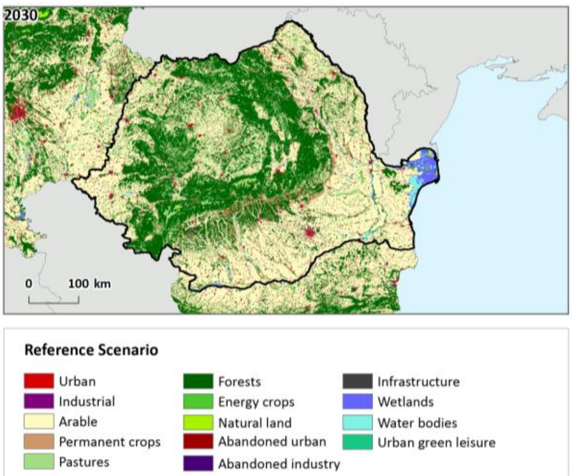


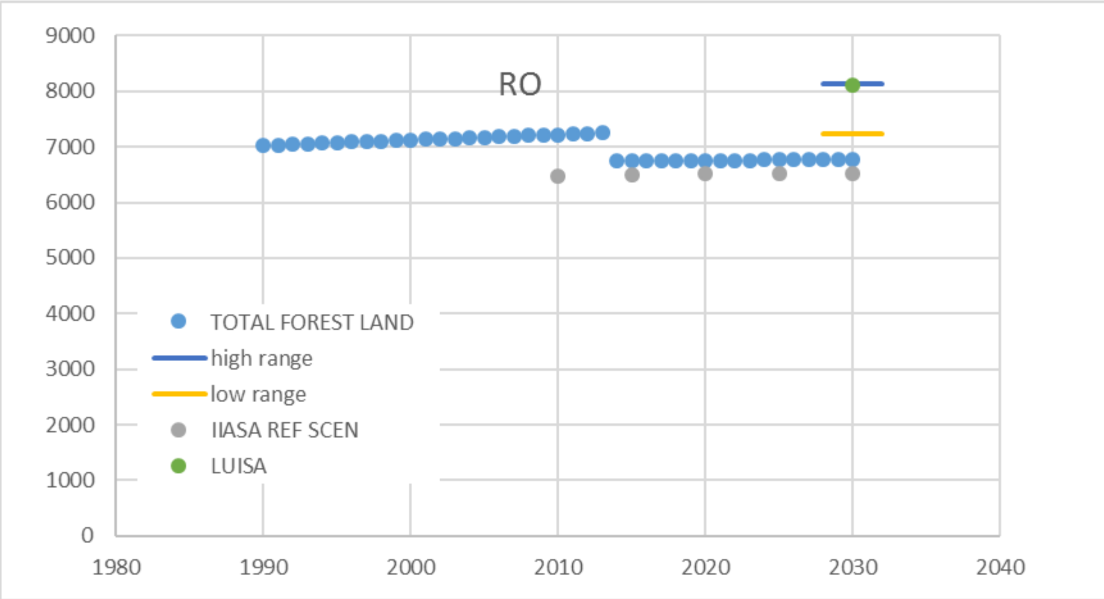
Deforestation

Results from LUISA modelling platform: land use changes from forest land from 2010 to 2030 (ha).



The two maps show land use in LUISA in 2010 (on the left) and 2030 (on the right).





Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

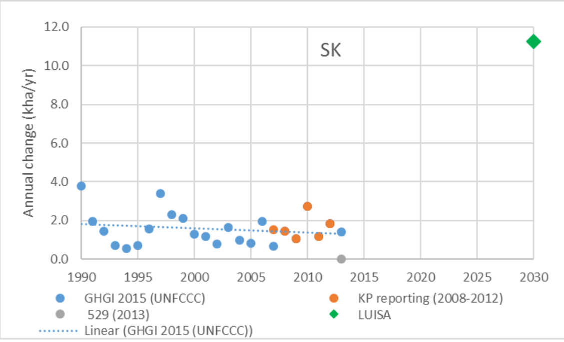
Afforestation/reforestation area in pre-1990 was some 12-15kha/year and decreased in post-1990 to some 1kha/year in average. High afforestation rate in pre-1990 was the consequence of the implementation of an ambitious national program of forestry development of that time ruling communist party. Low afforestation rate in post-1990 was caused by land privatization, lack of funding and incentives for afforestation on private lands. In the same time, natural expansion of forests occurred on large areas of grazing land because of their abandonment under decrease of animal husbandry and disorganization of former agricultural cooperatives.

According to various national policy documents, it is technically and financially possible to afforest some 10kha per year (excluding forest belts establishment and revegetation) during the period 2013-2020, in addition to the historical annual average.

The opportunities for afforestation that are being largely considered are abandoned agricultural areas in the southern part of Romania.

Slovakia

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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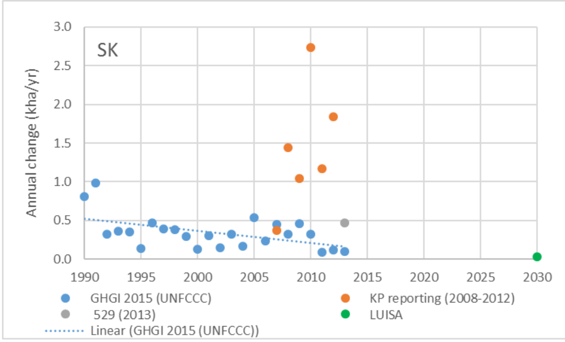
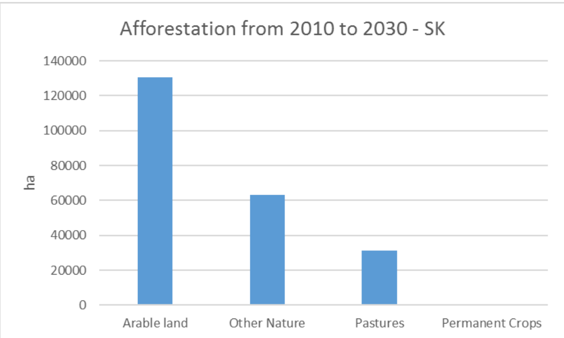


Afforestation

Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



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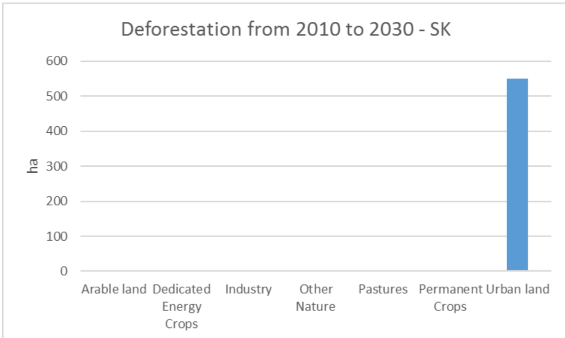

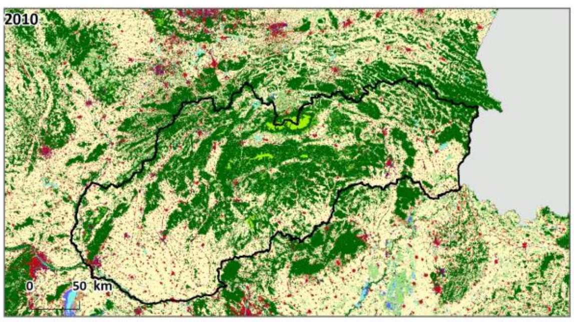

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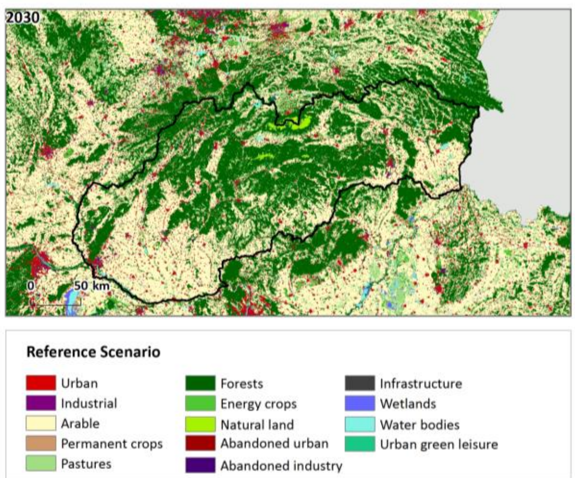
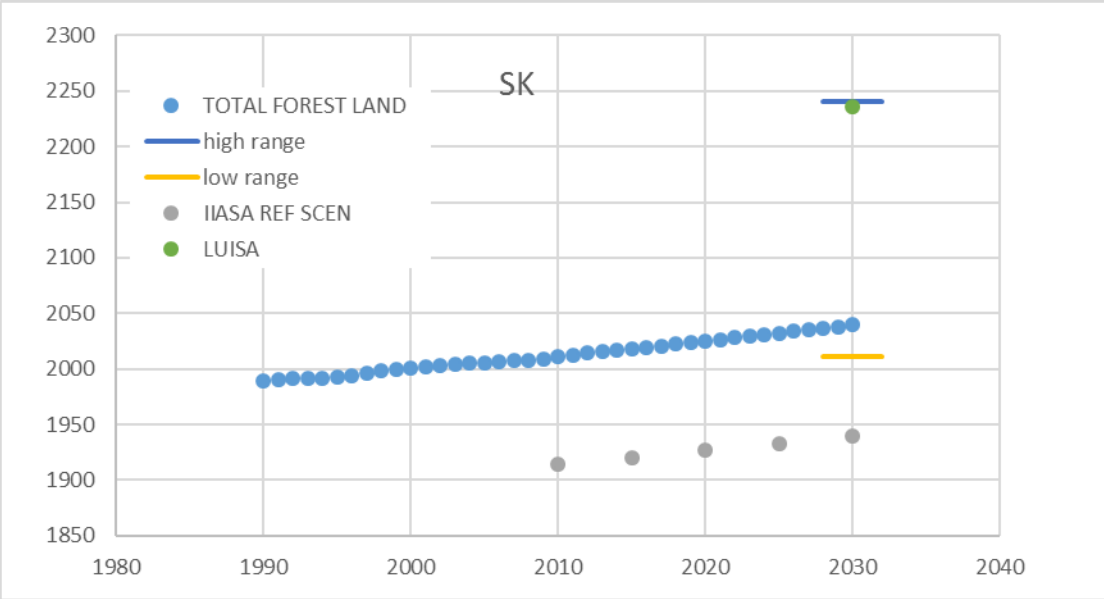




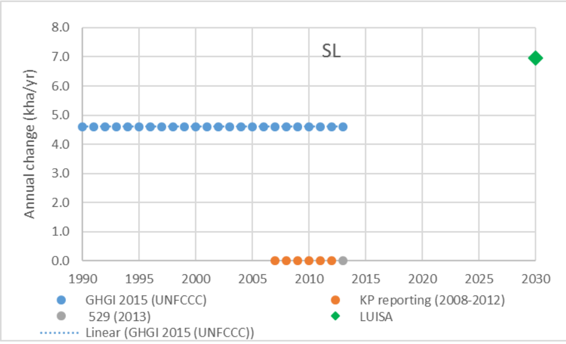
<u>Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)</u>

Afforestation programs are promoted through the Rural Development Programme of the Slovak Republic 2007-2013, taking into account the National Forest Program (NFP) and the Action Plan of NFP for 2009-2013. Before 2010, the conversion of agricultural land to forest land was approved within these programmes for 15 projects covering 100 ha in total. Such kind of conversion was not of interest for farmers due to unbalanced application of direct support schemes between agricultural and forestry sectors. Further limitation was in forestry legislation setting obligations related to forest management without any compensation of related expenses.

The Rural Development Programme is the main instrument for mitigation measures: (i) Afforestation of 800 ha of low productive soil by fast growing trees and the first afforestation of 600 ha of agricultural land by 2015; (ii) Grassing of 50,000 ha of arable land by 2015; (iii) Afforestation of 23,000 ha of agricultural land by 2020.

Slovenia

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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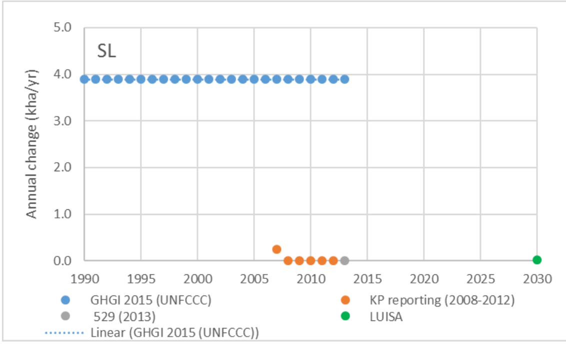

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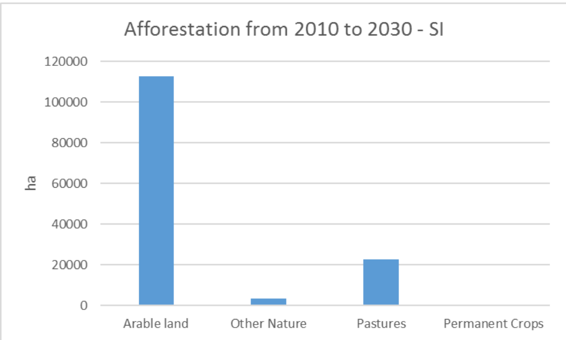
Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



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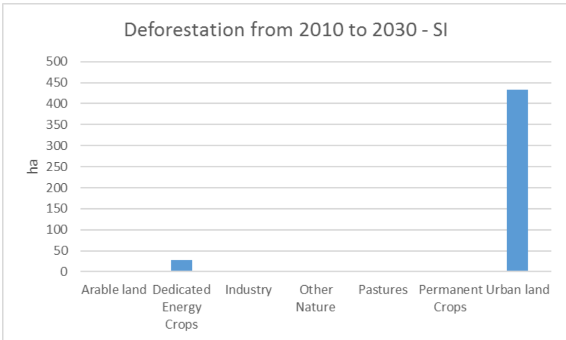

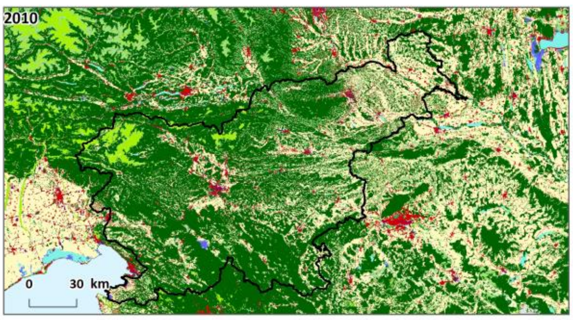

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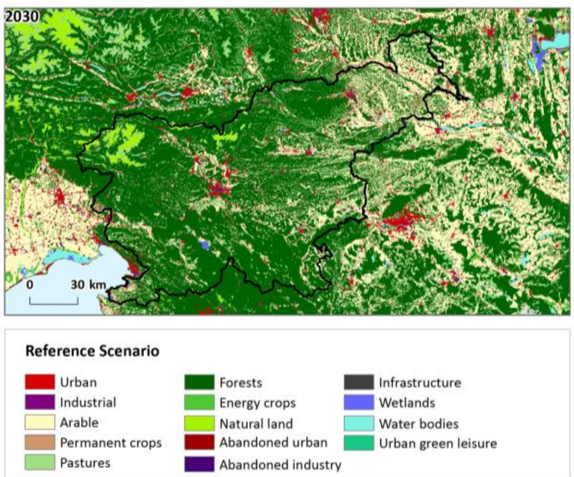
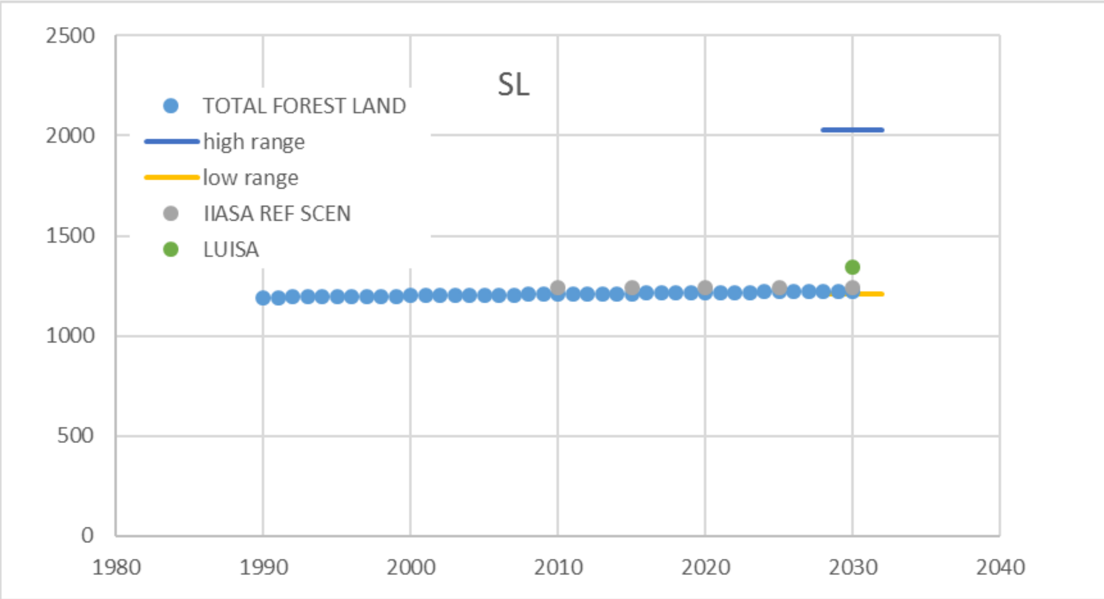


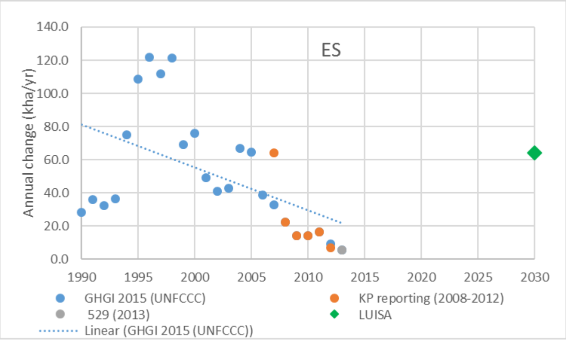


Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

According to the land use structure on Slovenian farms, there is 53% utilised agricultural land, 42% forest, 2.5% abandoned, non-cultivated agricultural land and 2% barren land. In recent years, the area of all managed agricultural land has decreased a little, however this is more or less due to abandoned grasslands and pastures, where the process of spontaneous afforestation is the most intense.

Spain

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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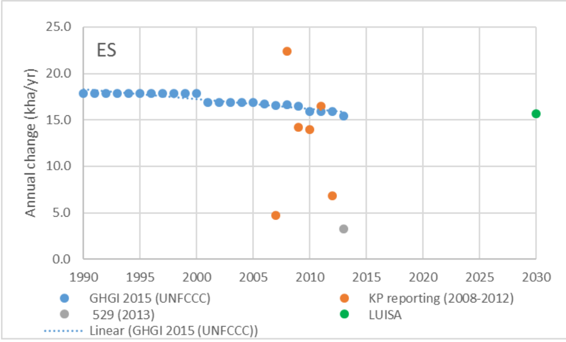

Afforestation

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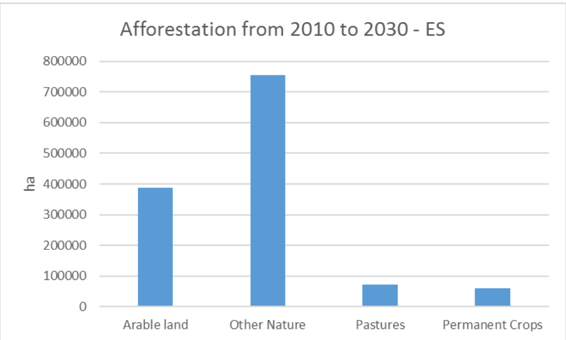

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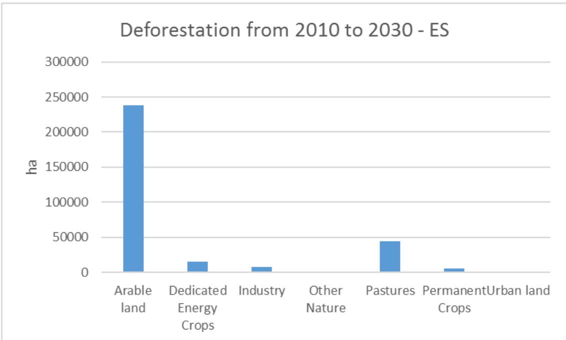

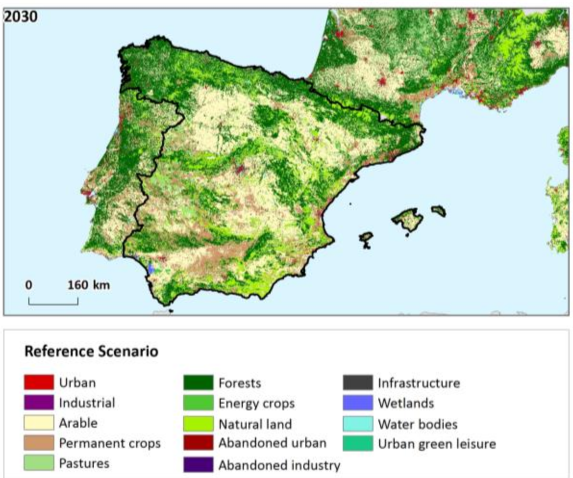

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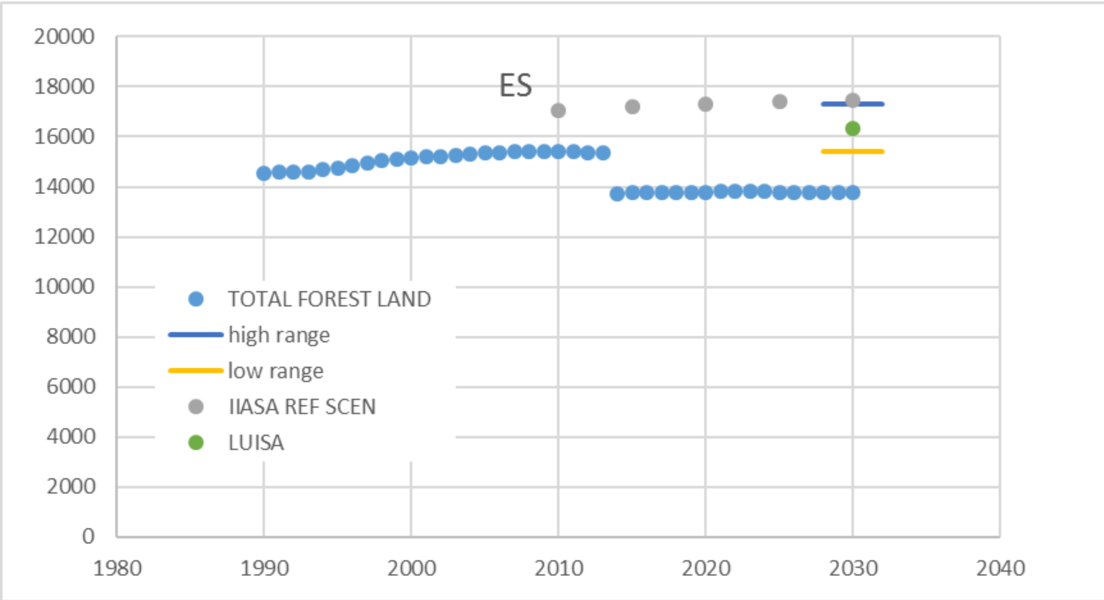

Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)

In the forest plan (Plan Forestal Español 2002-2032) there is the goal of increasing the area of forest properties and of achieving economic efficiency for sustainable forest management.

Sweden

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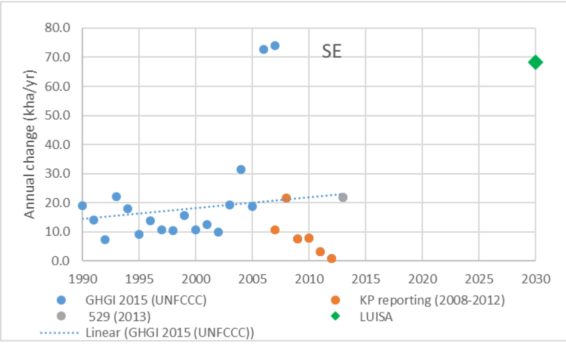
The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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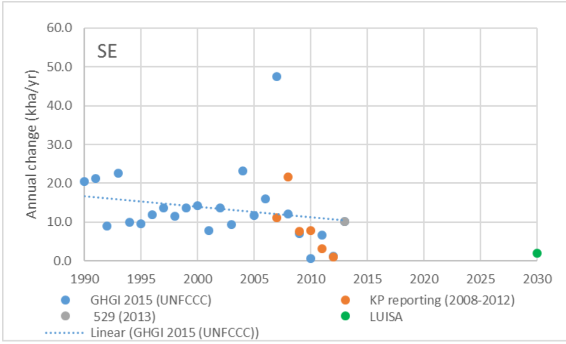

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Afforestation

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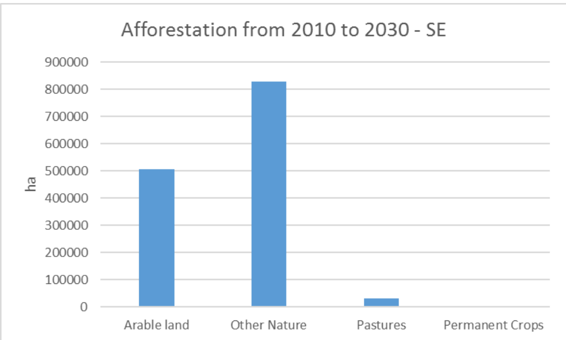

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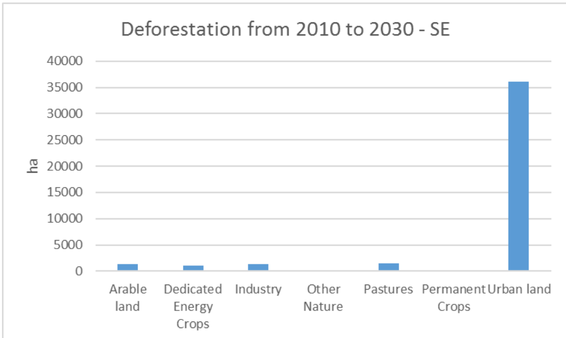

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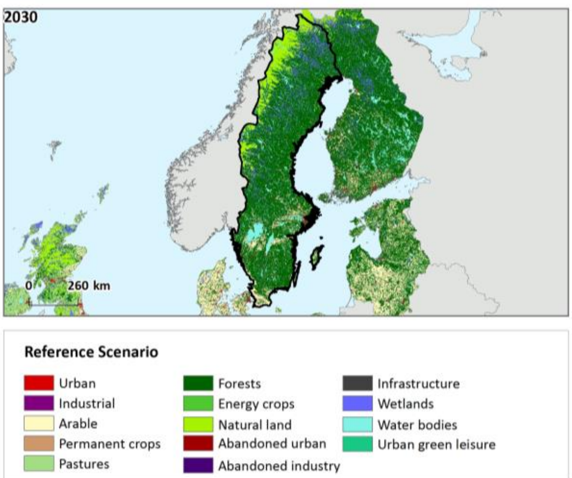

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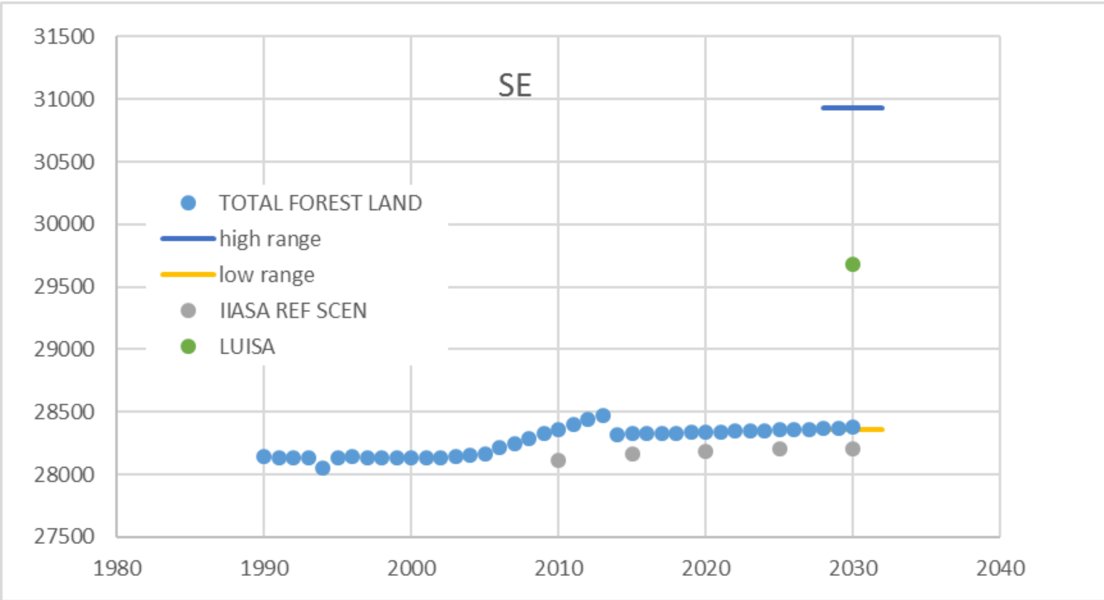
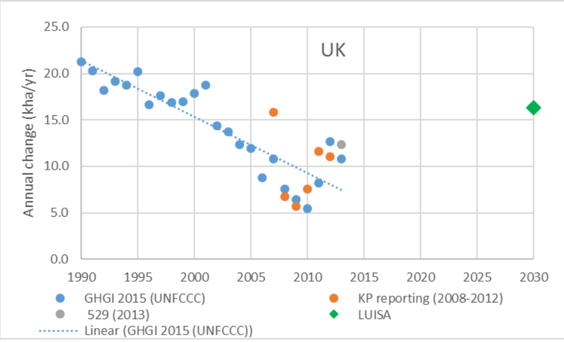


<u>Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)</u>

Both the activities Afforestation Reforestation (AR) and Deforestation (D) are relatively uncommon in Sweden. In 2012 AR and D represented an accumulated area since 1990 of approximately 230,000 hectares respectively. Around 10,000 hectares are afforested each year. Also the annual deforestation area is around 10,000 hectares.

UK

The graph shows: in blue the Land converted to forest land, 1990-2013 (GHGI 2015 - UNFCCC), in orange afforestation/reforestation, 2008-2012 (KP reporting) and in grey the 2013 afforestation/reforestation, (529-2013). All values are expressed as annual changes (kha/yr). The green dot represents the **AR rate** estimated with LUISA and are the 2010-2030 average (kha/yr).



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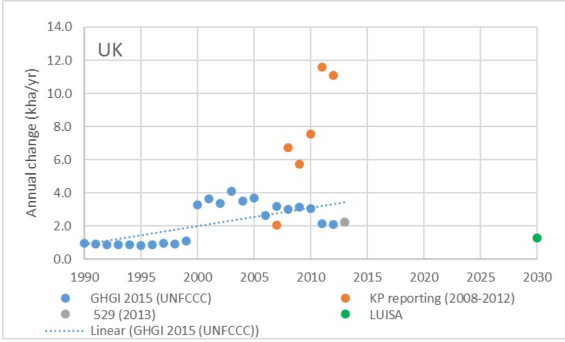
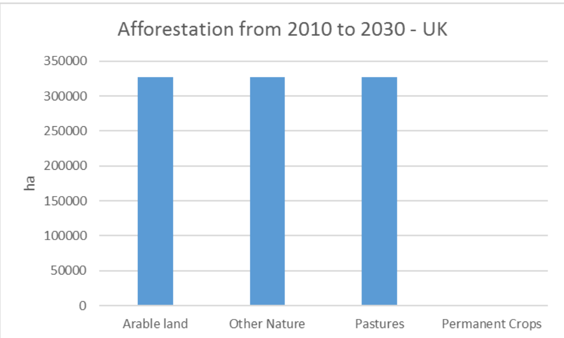


Afforestation

Results from LUISA modelling platform: land use changes to forest land from 2010 to 2030 (ha).



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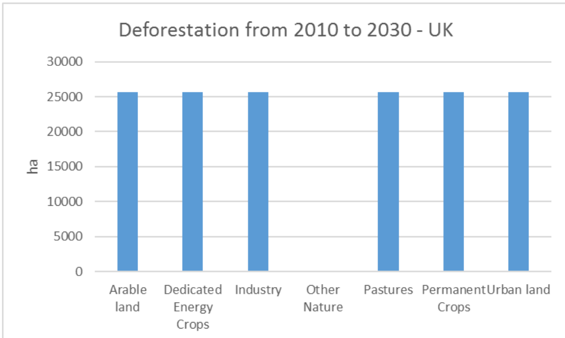

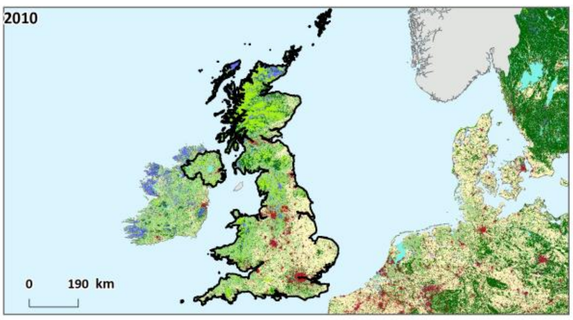

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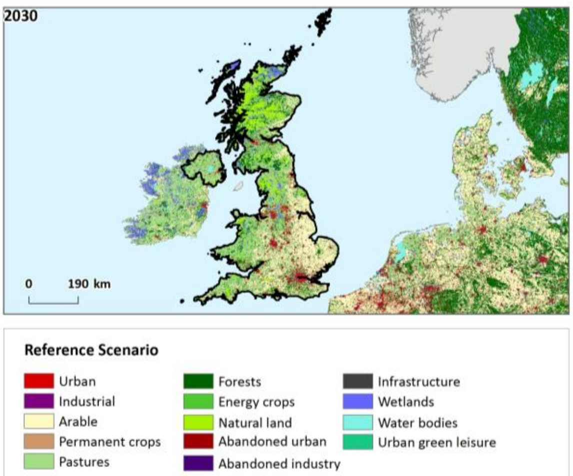

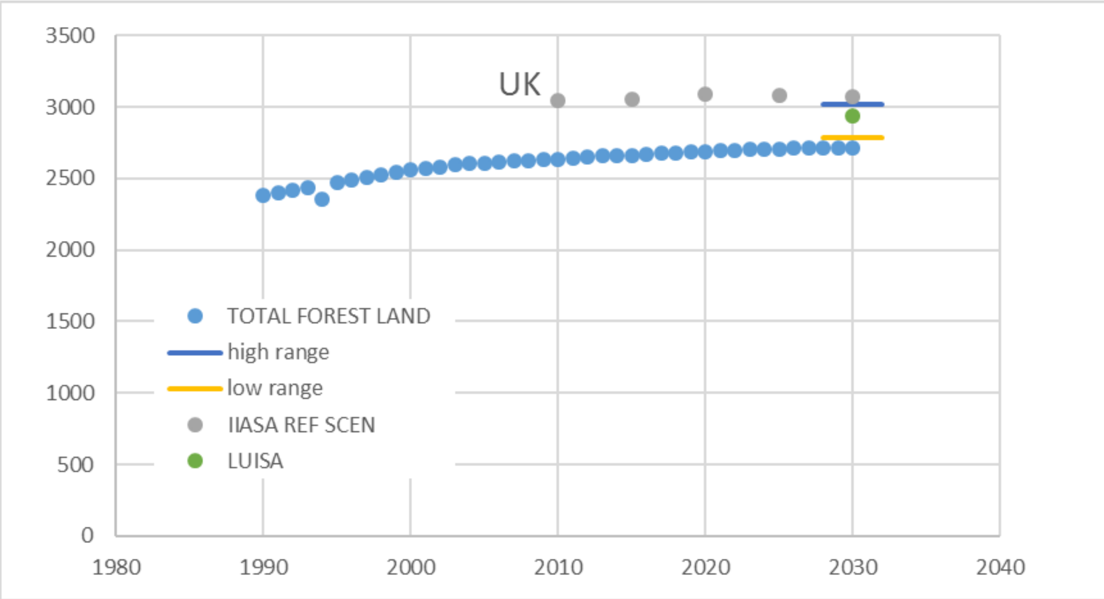

<u>Comments on expected future AR/D rates, current policies and past trends (Reporting Under Art. 10(459)</u>

The increase in forest area has been 2% in the past (after the application of Reg 2080/92), the second highest (after IE) among EU MS (du Breil de Pontbriand, 2000).

The CCC identified potential for an additional 1 MtCO2/yr abatement by 2030 through afforestation.

Woodland creation (AR): High additional mitigation potential estimated in 0-30 Mt CO2 (Over 5years UK GHGI48)

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ANNEX 4
CHANGES IN SOIL C-STOCKS FOR CROPLAND AND GRAZING LAND

Contract n° 33920-2015 NFP

Administrative agreement

340202/2015/705777/CLIMA.A.2

Roland Hiederer, Simone Rossi Giacomo Grassi
Coordination by Giacomo Grassi

2016

Table of contents

1 Introduction

In the Communication "*Europe 2020*"[225] the European Commission outlined a strategy to overcome the economic crisis and defined five key targets where the European Union should be in 2020. The framework of the efforts within the EU and national authorities to achieve these targets is provided by seven "*flagship initiatives*"[226]. One of these initiatives under the sustainable growth target is the "*Resource-efficient Europe*"[227]. The approach for achieving the targets of the initiative is detailed in the Commission Communication "*Roadmap to a Resource Efficient Europe*"[228] (RREM).

The 2020 land milestone proposed in the RREM has as main purpose to control and reduce the rate of artificial land take in the European territory. One of the indicators used to evaluate the impact of land take is the change in the stocks of carbon in organic compounds in the soil (C-Stock). The target of the indicator is that soil organic matter (SOM) levels do not decrease overall and increase for soils currently with less than 3.5% organic matter (equivalent to 2.0% organic carbon).

Land use from 2010 onwards was projected based on an update of the Reference Scenario of the RREM defined by DG ENER and DG CLIMA (Baranzelli *et al*., 2015). The update complies with the "EU Energy, Transport and GHG emission trends until 2050 – Reference Scenario 2013" (Lavalle *et al*., 2013). In the Reference Scenario land use is driven by demographic and economic trends. The update to the Reference Scenario includes additional measures, such as the greening measures under the *Common Agricultural Policy* (CAP), biodiversity or the habitat protection.

The land use estimates were generated by the modeling platform *Land-Use-based Integrated Sustainability Assessment* (LUISA). These projected spatial data from LUISA provided the input parameters for the land use factor for the *Intergovernmental Panel on Climate Change* (IPCC) Tier 1 method for estimating CO_2 emissions and sinks from *Land Use, Land-Use Change, and Forestry* (LULUCF).

2 Method for Estimating C-Stocks from Land Use Change

Changes in land use and cover may cause significant changes in the amount of organic material in the soil, which is composed to 58% of carbon. The carbon of the soil organic material is exchanged with atmospheric carbon, mainly in form of carbon dioxide (CO_2). A method of estimating changes in CO_2 from the effect of changes in land use on *soil organic carbon* (SOC) stocks is detailed by the *Intergovernmental Panel on Climate Change* (IPCC, 2006). For estimating *greenhouse gas* (GHG) emissions resulting from anthropogenic activities leading to changes in land use and cover IPCC distinguishes three levels or Tiers with increasing complexity. The most generic method is defined by Tier 1.

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[225] COM(2010) 2020 final http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF

[226] http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/flagship-initiatives/index_en.htm

[227] COM(2011) 21 http://ec.europa.eu/resource-efficient-europe/pdf/resource_efficient_europe_en.pdf

[228] COM(2011) 571 final http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

2.1 Concept of IPCC Tier 1

The Tier 1 method for mineral soils is based on the supposition that the flux of carbon between the atmosphere and the soil has a propensity towards a state of equilibrium. Changes to this status of equilibrium lead to changes in C-stocks until a new stable level of C-stocks is reached. In the intermediate period soils may act as sources or sinks of atmospheric carbon.

2.1.1 Equilibrium and Rate of Change

Following changes in land use and cover the state of equilibrium is reached after 20 years. This model is symmetric with respect to the direction of the C-stock changes, i.e. the annual change in C-stock is the same whether it occurs from A to B or B to A. Other models of changes in C-stocks after a change in land use or management may be used in higher Tier methods.

The assumption of a linear and a progressive model for the rate of change in C-stocks after a change in land use is graphically illustrated in Figure 153.

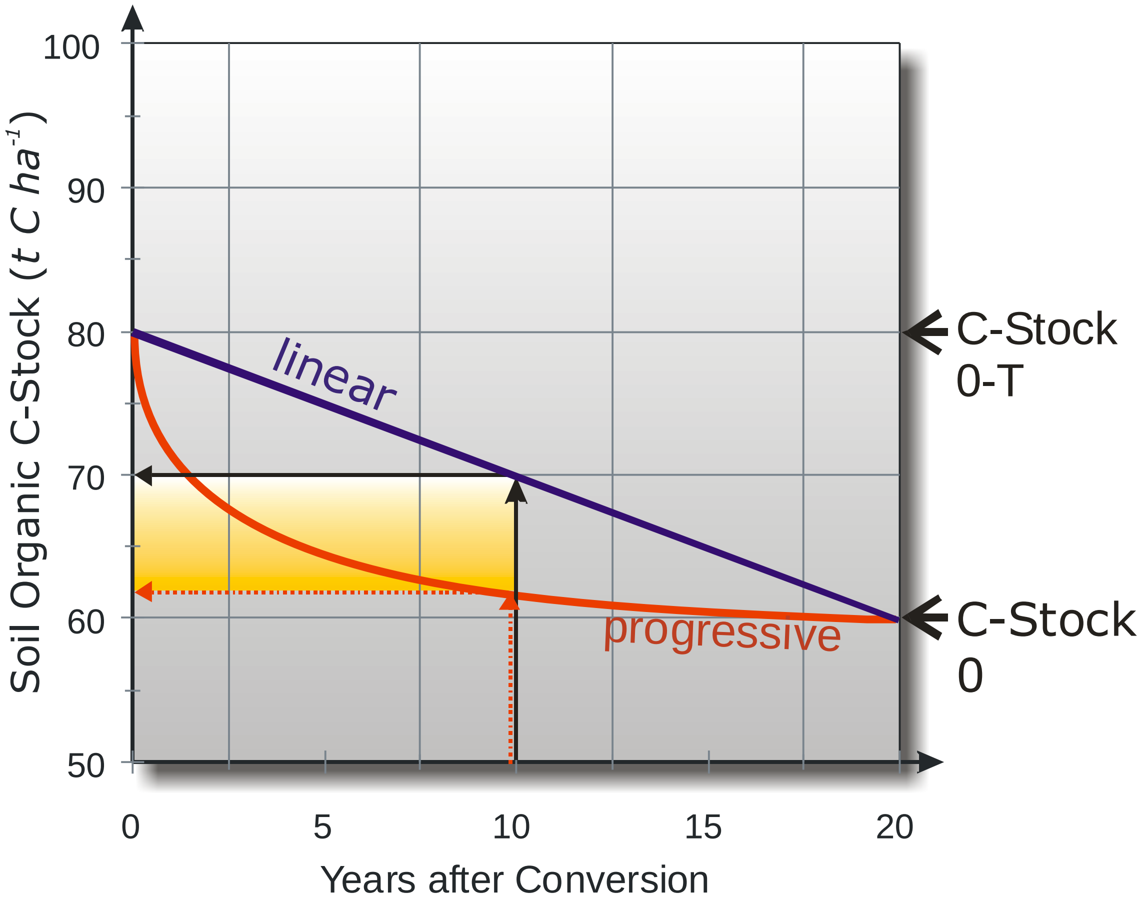


Figure 153: Linear vs. Progressive Rate of Change in C-Stocks over 20 Years

The annual rate of change varies with the number of years after the conversion. The literature suggests that this is a more realistic assumption when land use leads to losses in SOC, such as from grazing land to cropland. Progressive models of annual changes in C-stocks may also be asymmetric, i.e. depend on the direction of change, since losses on SOC take place at a faster rate than accumulation of organic matter.

2.1.2 C-Stocks under Native Vegetation

For estimating the C-stock of a state of equilibrium Tier 1 starts with defining *default reference soil organic carbon stock* (SOC_{REF}) for mineral soils is the SOC density under conditions of native vegetation, i.e. without anthropogenic influence. The values are defined for the topsoil layer from 0 to 30 cm, where most of the changes in SOC are expected to be found. Values are specified for a combination of 6 soil types of mineral soils and 9 climate regions. An example of finding the SOC_{REF} value for a high activity clay soil in a cold temperate moist climate region is presented in Figure 154.

Climate Region \ Soil Type		HAC	LAC	Sandy	Spodic	Volcanic	Wetland
Boreal		68		10	117	20	146
Cold temperate	dry	50	33	34		20	87
	moist	95	85	71	115	130	
Warm temperate	dry	38	24	19		70	88
	moist	88	63	34		80	
Tropical	dry	38	35	31		50	86
	moist	65	47	39		70	
	wet	44	60	66		130	
	montaine	88	63	34		80	

Figure 154: Example of Default Reference Soil Organic Carbon Stock under Cold Temperate Moist Climate Region

In the example the climate region is "Cold temperate, moist" and the soil is classified as "High activity clay". The corresponding value for SOC_{REF} is 95 $t\ C\ ha^{-1}$ *for 0-30cm*.

2.1.3 Factors leading to Changes in Soil C-Stocks

Under Tier 1 the factors considered to lead to deviations from the reference soil C-stocks are changes in land use type (F_{LU}), management (F_{MG}) and input (F_I). The C-stock is calculated by applying the factors as variations from the default reference C-stock as:

$$SOC_a = \sum (SOC_{REF} * F_{LU} * F_{MG} * F_I * A)$$

where

SOC_a	SOC stock in year a
SOC_{REF}	default reference C-stock under native vegetation
F_{LU}	land use factor
F_{MG}	management factor
F_I	input factor
A	area

The factor values can be combined to form a Land Use System Factor (F_{LUS}). Changes in any of the defining factors lead to subsequent changes in SOC stocks.

2.1.4 Calculating Changes in C-Stocks

These SOC stocks are established for a base year and for the conditions after *n* years. For mineral soils changes in C-stocks, and as a consequence in CO_2 emissions, are then calculated as the difference in SOC stocks between the two points in time. The IPCC Tier 1 method assumes that after a change in any of the factors SOC stocks reach an equilibrium after 20 years with a fixed annual rate of change (IPCC, 2003).

The difference in SOC stocks after *n* years is thus calculated as:

$$\Delta SOC_n = (SOC_{a+20} - SOC_a) * \frac{n}{20}$$

where

SOC_n	change in C-stock from year *a* to year *a+n*
SOC_a	SOC stock for LUS in year *a*
SOC_{a+20}	SOC stock for LUS in year *a+n, n* < 20 years

For organic soils a different approach is used. Instead of calculating changes in C-stocks as for mineral soils annual default emissions factors are defined by climate region. The factors are applied as long as the conditions for organic soils are met.

For cropland the relative C-stock change factors for land use (F_{LU}), management practice (F_{MG}) and input regime (F_I) are given in Table 5.5 (IPCC, 2006). The corresponding values for grassland are specified in Table 6.2 (IPCC, 2006). For other land use types the factors given in the relevant chapters of the *Guidelines* were used.

A schematic presentation of the Tier 1 factors defining a LUS for cropland is given in Figure 155.

Factor type		F_{LU} Land Use				F_{MG} Management			F_I Inputs			
Climate Region		Long-term cultivated	Paddy rice	Perennial tree crop	Set-aside (>20yrs)	Full tillage	Reduced tillage	No tillage	Low	Medium	High, no manure	High, with manure
Boreal		0.80	1.10	1.00	0.93	1.00	1.02	1.10	0.95	1.00	1.04	1.37
Cold temperate	dry	0.80	1.10	1.00	0.93	1.00	1.02	1.10	0.95	1.00	1.04	1.37
	moist	0.69	1.10	1.00	0.82	1.00	1.08	1.15	0.92	1.00	1.11	1.44
Warm temperate	dry	0.80	1.10	1.00	0.93	1.00	1.02	1.10	0.95	1.00	1.04	1.37
	moist	0.69	1.10	1.00	0.82	1.00	1.08	1.15	0.92	1.00	1.11	1.44
Tropical	dry	0.58	1.10	1.00	0.93	1.00	1.09	1.17	0.95	1.00	1.04	1.37
	moist	0.48	1.10	1.00	0.82	1.00	1.15	1.22	0.92	1.00	1.11	1.44
	wet	0.48	1.10	1.00	0.82	1.00	1.15	1.22	0.92	1.00	1.11	1.44
	montaine	0.64	1.10	1.00	0.88	1.00	1.09	1.16	0.94	1.00	1.08	1.41

$F_{LUS(0)}$ = 1.00 = 1.00

$F_{LUS(0\text{-}T)}$ = 0.69 * 1.00 * 1.11 = 0.77

D_C-STOCK = (1.00 - 0.77) * 95.0 = + 22.2 *t C ha^{-1}* over 20 yrs

Figure 155: Example of Land Use System Factors for Cropland remaining Cropland

Land use category FLU changes from "long-term cultivated" to "set-aside". For "set-aside" management and input factors are not applicable.

In the example the change in C-stock over 20 years amounts to an increase of 22.2 t C ha^{-1}, equivalent to a removal of 4.01 t CO_2 $ha^{-1}yr^{-1}$.

For grazing land the land use system factors and their respective coefficients are given in Figure 156.

Factor type		F_{LU} Land Use	F_{MG} Management				F_I Inputs	
Climate Region		Grazing Land	Improve	Nominal / non degr.	Moderately degraded	Severely degraded	Medium	High
Boreal		1.00	1.14	1.00	0.95	0.70	1.00	1.11
Cold temperate	dry	1.00	1.14	1.00	0.95	0.70	1.00	1.11
	moist	1.00	1.14	1.00	0.95	0.70	1.00	1.11
Warm temperate	dry	1.00	1.14	1.00	0.95	0.70	1.00	1.11
	moist	1.00	1.14	1.00	0.95	0.70	1.00	1.11
Tropical	dry	1.00	1.17	1.00	0.97	0.70	1.00	1.11
	moist	1.00	1.17	1.00	0.97	0.70	1.00	1.11
	wet	1.00	1.17	1.00	0.97	0.70	1.00	1.11
	montaine	1.00	1.16	1.00	0.96	0.70	1.00	1.11

$F_{LUS(0)}$ = 1.00 * 0.95 [* 1.00] = 0.95

$F_{LUS(0-T)}$ = 1.00 * 1.00 [* 1.00] = 1.00

D_C-STOCK = (0.95 - 1.00) * 95.0 = -4.75 *t C ha*$^{-1}$ over 20 yrs

Figure 156: Example of Land Use System Factors for Grazing Land remaining Grazing Land

In the example management on grazing land changes from "nominal" to "moderately degraded". Under the soil and climatic conditions this change in management would be estimated as leading to a loss of 4.75 *t C ha*$^{-1}$ over 20 years.

2.1.5 Emission Factors for Organic Soils

Organic soils are roughly correlated with lower temperatures and higher rainfall. Hence, in Europe organic soils are more prevalent at higher latitudes. When organic soils are subject to cropland or grazing land management they are generally drained. This lowering of the water table results in exposure of the soil organic material to oxygen which in turn leads to the loss of organic material in form of mainly CO_2. Because the material is lost the method of estimating CO_2 emissions from changes in soil C-stock over a fixed depth, as for mineral soils, is not appropriate for organic soils, Instead, IPCC provides emission factors which vary by land use categories and broad climate region. Annual emissions of CO_2 from managed organic soils are calculated as:

$$C_{CLIM}^{c} = A_{CLIM}^{c} * EF_{CLIM}^{c} \left[tCyr^{-1} \right]$$

where

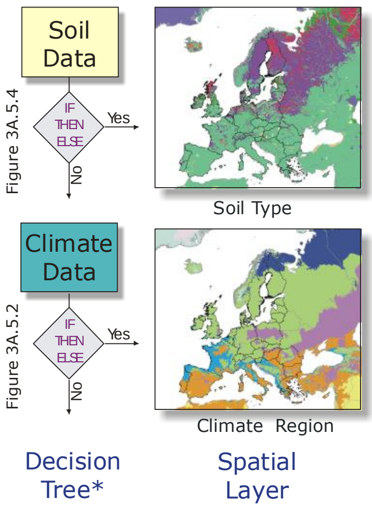
C	annual C-emission from organic soils for land use category *c* and climate region *CLIM*
A	area of organic soil for land use category *c*
c	land use category
CLIM	IPCC climate region

2.2 Tier 1 Implementation in Spatial Database

The Tier 1 method of estimating soil C-stocks and changes is implemented as a spatial database. Data are processed using a *Geographic Information System* (GIS). The spatial raster layers use a grid-spacing of 1 km projected according to the *European Terrestrial Reference System 1989* (ETRS89) *Lambert Azimuthal Equal Area* (LAEA) Coordinate Reference System (Annoni, *et al*., 2001). All spatial data, including ancillary thematic layers, are adjusted to the same geographic coverage, including a common land/sea mask.

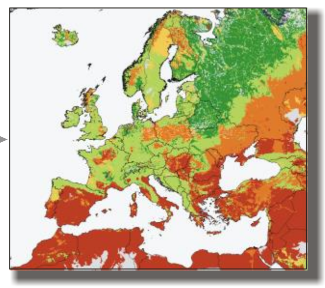
2.2.1 Default Reference Soil Organic C- Stocks

The *Default Reference Soil Organic C- Stocks* SOC_{REF} were developed as spatial layers with pan-European coverage. In the classification of the soil type and climate region the process follows the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006). A spatial layer of *Default Reference Soil Organic C- Stocks* is generated from combining the soil types with the climate region layers and assigning the corresponding C-stock values to the combinations, as shown in Figure 157.



Climate Region \ Soil Type		HAC	LAC	Sandy	Spodic	Vulcanic	Wetland
Boreal		68		10	117	20	146
Cold temperate	dry	50	33	34		20	87
	moist	95	85	71	115	130	
Warm temperate	dry	38	24	19		70	88
	moist	88	63	34		80	
Tropical	dry	38	35	31		50	86
	moist	65	47	39		70	
	wet	44	60	66		130	
	montaine	88	63	34		80	

Table 2.3*



Spatial Layer

Default Reference Soil Organic C-Stocks (SOC_{REF})
t C ha^{-1} in 0-30 cm depth

Figure 157: Combining Soil and Climate Data to Spatial Layer of Default Reference Soil Organic C-Stocks

- **Soil Data**

  The spatial layer for the IPCC organic and mineral soil types are derived from combining the European Soil Database (ESDB)[229] and the Harmonized World Soil Database (HWSD)[230] V.1.2.1. To make use of all information of the soil databases a version was employed where soil typologies were mapped to a single spatial layer instead of only the dominant typological unit for an area (Hiederer, 2013).

- **Climate Data**

  The IPCC classification scheme for the default climate regions is presented in *Figure 3A.5.2 Classification scheme for default climate regions* (IPCC, 2006). The meteorological data used to generate the *Climate Region* layer is the *WorldClim Global Climate Data*[231]. The information on elevation was provided by the *SRTM 30 arc second v2.1* data[232].

  Given the characteristics of the source data (monthly averages) the classification scheme for default climate regions was modified with respect to separating tropical from other climate regions. The aggregated climate data does not allow to fully comply with the first condition of the classification scheme, i.e. using the threshold of 7 days of frost per year to delineate tropical climates. For Europe this should not lead to any deviations in the delineation of climate regions since there are practically no tropical regions.

The resulting spatial layer is presented in Figure 158.

[229] Download page: http://eusoils.jrc.ec.europa.eu/ESDB_Archive/ESDBv2/index.htm
[230] Project page: http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/
[231] Download page: http://www.worldclim.org/current
[232] Download page: http://dds.cr.usgs.gov/srtm/version2_1/SRTM30/

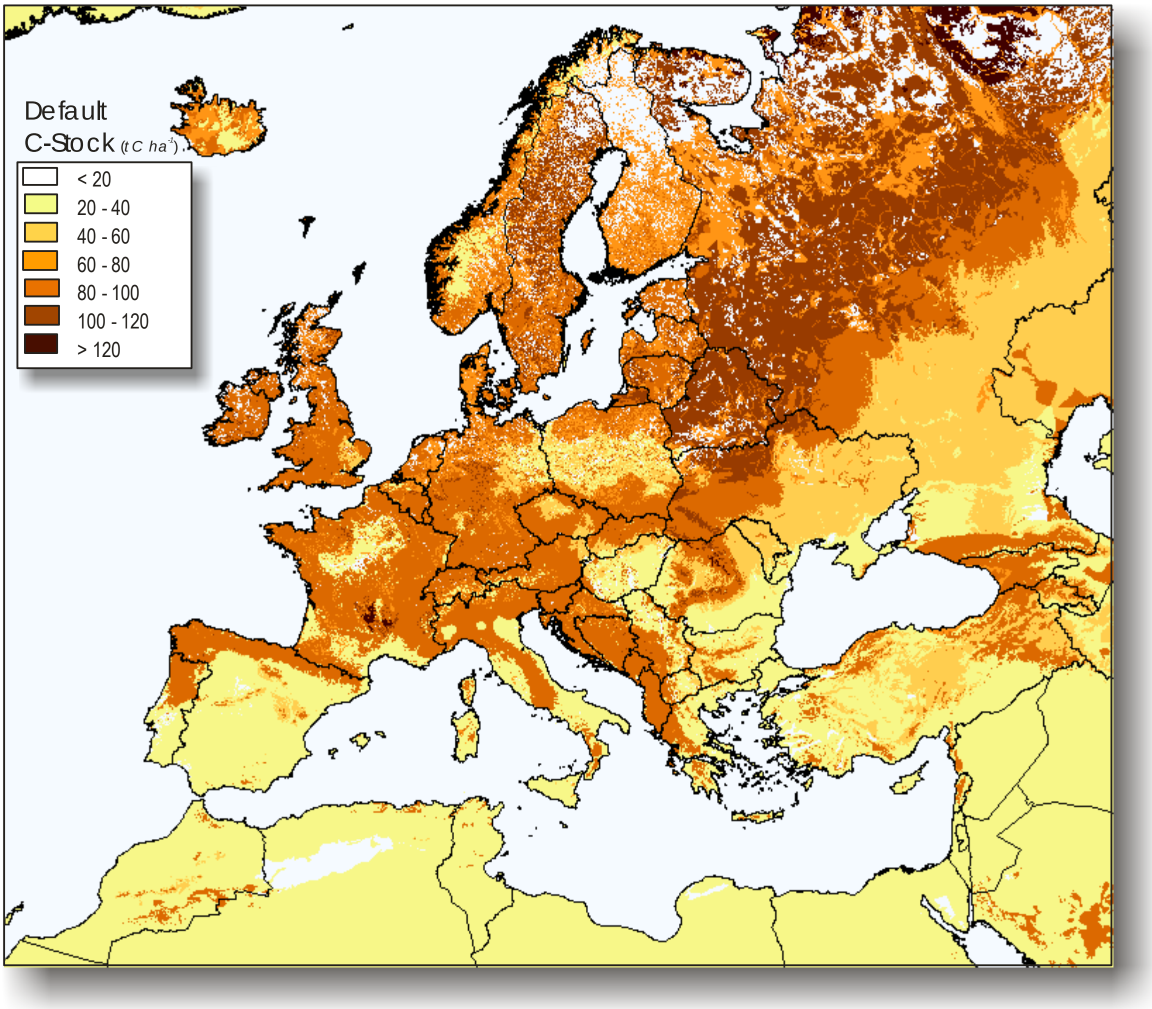


Figure 158: Default Reference Soil Organic C- Stocks

In Europe the spatial allotment of *Default Reference Soil Organic C-Stock* values is dominated by the climate regions. This is largely the consequence of the wide distribution of *High Activity Clay* soil types. By definition the layer shows no values for areas without soil and where organic soils are present.

For organic soils equivalent spatial layers of annual emission factors according to Table 5.6 (cultivated) and Table 6.3 (drained grassland) are produced. The layers are derived from the interception of the spatial layers of the distribution of organic soils with the climate regions.

2.2.2 Emission Factors for Organic Soils

Organic soils are roughly correlated with lower temperatures and higher rainfall. Hence, in Europe organic soils are more prevalent at higher latitudes. When organic soils are subject to cropland or grazing land management they are generally drained. This lowering of the water table results in exposure of the soil organic material to oxygen which in turn leads to the loss of organic material in form of mainly CO_2. Because the material is lost the method of estimating CO_2 emissions from changes in soil C-stock over a fixed depth, as for mineral soils, is not appropriate for organic soils, Instead, IPCC provides emission factors which vary by land use categories and broad climate region. Annual emissions of CO_2 from managed organic soils are calculated as:

$$C^{c}_{CLIM} = A^{c}_{CLIM} * EF^{c}_{CLIM} \left[tCyr^{-1} \right]$$

where

C	annual C-emission from organic soils for land use category *c* and climate region *CLIM*
A	area of organic soil for land use category *c*
c	land use category
CLIM	IPCC climate region

The emissions in $t\ C\ yr^{-1}$ can be converted to CO_2 emissions by applying a factor to 3.67. The emission factors for drained cropland and grazing land organic soils per year are given in Table 10.

Table 10: Annual Emission Factors for Drained Cropland and Grazing Land Organic Soils

Climate Region	Cropland Emission Factor $t\ C\ ha^{-1}\ yr^{-1}$	Grazing Land Emission Factor $t\ C\ ha^{-1}\ yr^{-1}$
Tropical Wet	20.0	5.00
Tropical Moist	20.0	5.00
Tropical Dry	20.0	5.00
Tropical Montane	20.0	5.00
Warm Temperate Moist	10.0	2.50
Warm Temperate Dry	10.0	2.50
Cool Temperate Moist	5.0	0.25
Cool Temperate Dry	5.0	0.25
Boreal Moist	5.0	0.25
Boreal Dry	5.0	0.25

Polar regions: not specified in IPCC, 2006.

While for tropical and warm temperate climate regions the emission factors are 4 times higher for cropland than for grazing land organic soils, the ratio increases to a factor of 20 cool temperate and boreal climates.

2.2.3 Identifying Land Use Categories

For reporting under the *United Nations Framework Convention on Climate Change* (UNFCCC) the 6 land use classes are designed to cover all managed land. The Kyoto Protocol distinguishes 7 activities on land for reporting GHG emissions. Both classifications have in common that they only concern managed areas. However, there are also areas considered to be in their native state and land that has been abandoned. To allow for changes between land use categories all land areas have to be covered, not just the areas where cropland and grazing land management takes place. Land may also be subjected to more than one activity. An example is livestock grazing in forest. Yet, land can only be account for once and therefore has to belong to only one activity. In these cases a hierarchical system is applied to solve the conflict.

The land area is classified into 9 major categories according to land use factor for estimating variations in soil C-stocks. The classes are:

- Grassland/grazing land
- Long-term cultivated
- Paddy rice
- Perennial / tree crops
- Set aside (<20 yrs)
- Native Ecosystems
- Wetlands
- Artificial
- Other areas

Not considered for EU28 are "shifting cultivation and fallow rotation systems".

The cropland sub-categories are set at the same level as other major land use categories for conceptual and computational reasons. Only the cropland activity is divided into sub-categories (for estimating C-stocks from land use changes on mineral soils). The major categories are therefore the land use types to which management and input factors apply where specified.

- **Grassland / Grazing Land**

  Grazing land is land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced. Generally has vegetation dominated by perennial grasses[233].

  The land use type is not further subdivided. For the management factor four conditions describing the status of the grazing land are distinguished. Grazing land classified as "*improved*" it is characterized by one of the two conditions of input. Where managed grazing land is no longer subject to management the status reverts to the default for the category.

- **Cropland Categories**

  Cropland is land on which agricultural crops are grown and land temporarily set-aside from crop production[234].

  Cropland is sub-divided into four land use types:

  - *Long-term Cultivated*

    Area that has been continuously managed for > 20 years, to predominantly annual crops.

  - *Wetland (paddy) rice*

    Long-term (>20 years) annual cropping of wetland (paddy rice).

  - *Perennial / Tree crop*

    Trees & shrubs with herbaceous crops, orchards, vineyards and plantations, except where these lands are Forest Land.

  - *Set-aside*

    Land set at rest for one or several (<20) years before being cultivated again.

[233] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 6
[234] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5.1

For the type "*long-term cultivated*" the management factor relates to the degree to which soil tillage is applied. The level of input of organic material to the soil is divided into four classes. No differentiation in management or input is made for the other cropland types.

A specific sub-category for cropland is abandoned land. This is not land temporarily taken out of production (set-aside), but land no longer subjected to management practices. Over time such land would revert to the native status. The fore, such areas are assigned the land use factor of native vegetation.

- **Native Ecosystem**

  This category contains non-managed areas, but also managed forest land. The latter is included because for mineral soil C-stocks IPCC Tier 1 uses a single activity factor.

- **Wetlands**

  Wetlands contains mainly non-managed areas. Wetlands used for grazing or cropland are generally drained and hence fall under one of these categories. Wetlands may in some cases be used without drainage, such as paludiculture.

- **Artificial Land**

  Separating artificial areas form other land areas is a requirement of the use of the RREM Reference Scenario. One of the objectives of defining the conditions for the scenario are specifically aimed at evaluating the effect of urbanisation.

  In this study a land use system factor is applied in which urban areas are treated as a mixture of sealed areas and open surfaces a land use factor of 0.5 may be applied to the default SOC stocks of artificial areas. The SOC stocks available for management measures thus decrease by 50% in new artificial areas and the sealed areas are lost to act as SOC sources or sinks (Beyer, *et al*., 2001; Pouyat, *et al*., 2002).

The land use categories are derived from Corine Land cover data for 2006[235]. For Greece data from Corine LC2000 were used. A map illustrating the geographic distribution of cropland and grazing land for EU 28 is presented in Figure 159.

[235] Download page: http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster

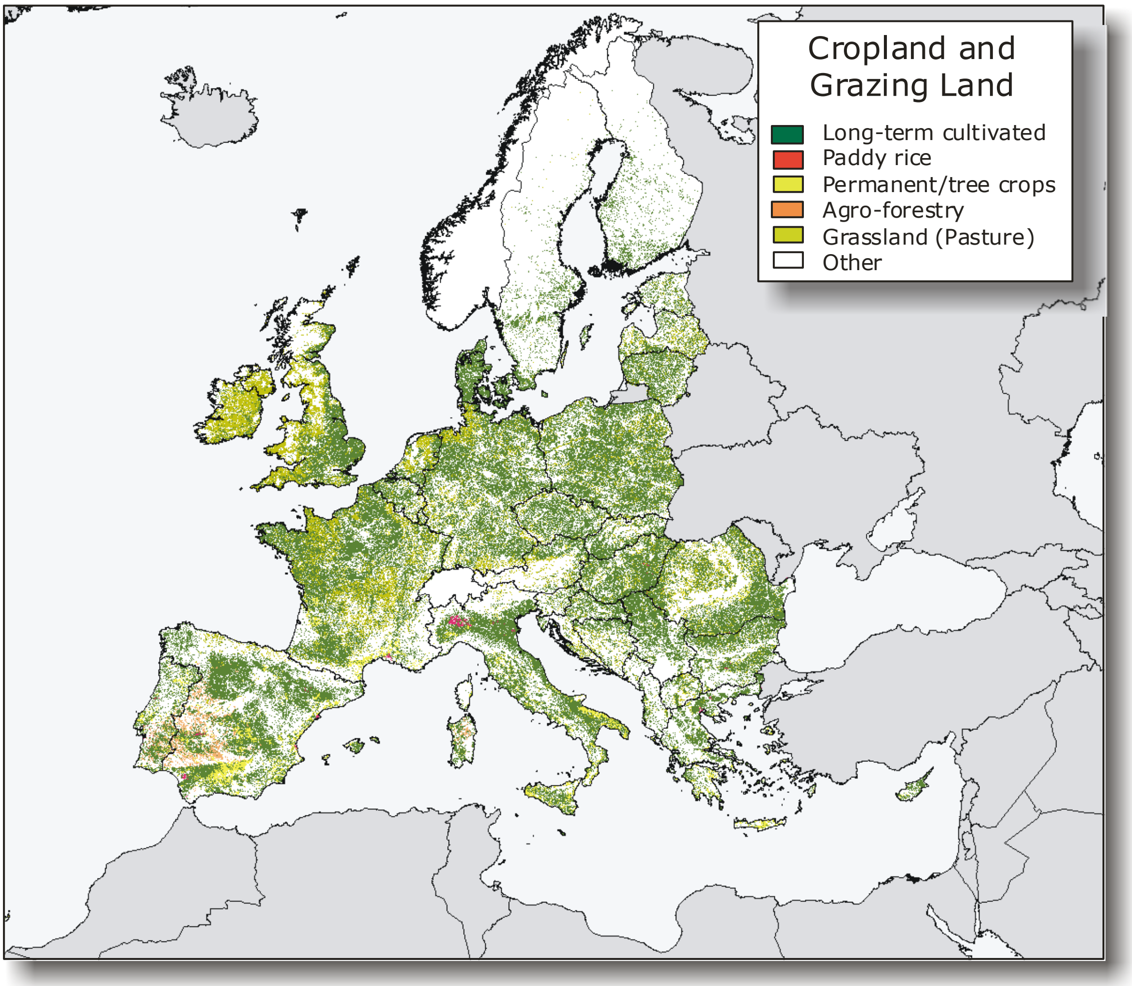


Figure 159: Land Use for Cropland and Grazing Land Management from CORINE LC 2006

The map demonstrates that for most EU Member States the area under cropland and grazing land forms the dominant land use, with the exception of Finland and Sweden, where forest is the dominant land use.

Using Corine data for the purpose of identifying the major land use categories is not without ambiguity. Particular items are:

- **Land cover vs. land use**

  Corine data represents land cover rather than land use. This is not so much an issue for cropland, because any cropland is managed and the purpose for planting a crop is not a deciding factor in the estimation of C-stock changes.

  Quite different is the situation for identifying grazing land from land cover data. The same land cover may have very different levels of anthropogenic influence. Signs of management activities of land with herbaceous vegetation cover are inherently difficult to detect from the data used to generate Corine data (satellite images). The Corine legend distinguishes between "2.3.1. Pastures" and "3.2.1. Natural grassland". Natural grassland is mostly assigned to areas "…in high mountains, on steep slopes with difficult access, in territories under nature conservation, or in military areas" (Lima, 2005).

Areas other than grassland may also be grazed, such as heathland ("3.2.2. Moors and heathland" in Corine legend), but are considered unmanaged as long as grazing is occasional.

- **Land cover Mosaics**

  Another source of ambiguity are the classes of land cover mosaics in the Corine legend (under 2.4. Heterogeneous agricultural areas). The classes are intended to characterize areas of heterogeneous landscapes at scale 1:100,000 (Lima, 2005). However, it was found that the extent of these areas is frequently overestimated (Feranec, *et al*., 2007).

For estimating soil C-stocks from changes in land use an area has to be assigned to one and only one land use category. Using proportions of land use categories assigned to an area would result in an unwieldy system when applying a matrix of spatially explicit conversions between land use categories. Assigning a landscape mosaic to a particular land use can be aided by comparing the areas to Eurostat statistical data on land use by region[236].

2.3 IPCC Organic Soils

For the identification of organic soils for cropland and grazing land the use of land cover data is of very limited value. When organic soils, such as areas of peat, are identified in the land cover data the use is rarely growing crops or for regular grazing of domestic livestock. Where cropland or grazing land management occurs on organic soils the land cover is generally derived from the vegetation cover, not the underlying soil type.

Areas of cropland and grazing land were therefore delineated based on the soil data and not the land cover information. However, the definition of what constitutes organic soils differs between the taxonomy for classifying soil types and IPCC. Both use as criteria depth, organic carbon content, clay content and duration of saturation by water.

The main difference between the definition of organic soils of the World Reference Base for soil resources (WRB) and the IPCC classification concerns the criterion of the thickness of the organic material in the horizon.

- **WRB**

  The WRB specifies as one of the depth conditions the presence of a histic or folic horizon *"… 40 cm or more thick and starting within 30 cm from the soil surface"* (FAO, 1998). There are some variations to the definition of organic soils depending on the revision of the WRB (Couwenberg, 2011). However, these variations to the WRB definition do not change the matter.

- **IPCC**

  As concerns the thickness criterion for organic soils according to IPCC the organic horizon must have a *"…thickness of 10 cm or more. A horizon less than 20 cm thick must have 12 percent or more organic carbon when mixed to a depth of 20 cm"* (IPCC, 2003).

Therefore, a soil may be classified as "organic" under the IPCC definition and as "mineral" when using WRB taxonomy, because the depth criterion of 40cm is not include for soils deeper than 10 cm. As a consequence the area of organic soils derived from soil taxonomy data may be less than what would classified following the IPCC definition, but

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[236] http://ec.europa.eu/eurostat/data/database

not more. Instead of using the soil taxonomy the IPCC definition can be applied to soil data which contain quantitative values for the defining criteria, such as the HWSD.

As a procedure organic soils take precedence over mineral soils, i.e. are identified first. All soils not classified as organic are minerals and further classified according to Figure 3A.5.4of IPCC, 2006.

3 Results

The changes in soil C-stocks resulting from modeled changes in land use as provided by LUISA were assessed for 10-year periods, using 2010 as the base year. The year 2010 was used since this is the starting point of the Reference Scenario. It is assumed that after 2010 the changes in management and input for a land use category are stable.

Changes in soil C-stock changes are calculated for all grid cells and land use categories, but aggregated to administrative units for reporting. For mapping the data the administrative units are NUTS Level 2, for presenting statistics in form of tables NUTS Level 0 (Member State) is more suitable.

3.1 Land Use Changes for EU28

The changes in land use categories under the Reference Scenario from 2010 to 2020 are summarized in Table 11.

Table 11: Relative Changes in Land Use for Period 2010 to 2020 based on 2020 Area

2010 to 2020	Land Use Category					
	Grazing Land	Cropland	Native Ecosystem	Wetland	Artificial	Other
	%	%	%	%	%	%
Grazing Land	95.2	0.4	4.4	0.0	0.0	0.0
Cropland	0.7	96.3	3.0	0.0	0.0	0.0
Native	0.8	0.9	98.3	0.0	0.0	0.0
Wetland	0.0	0.0	0.0	100.0	0.0	0.0
Artificial	0.6	2.5	1.3	0.0	95.6	0.0
Other	0.0	0.0	0.0	0.0	0.0	100.0

The table shows the changes in land use relative to the area in 2020. The information on land use change is arranged in rows. For 95.2% of grazing land in 2020 the land use is not changed from 2010. 4.4% of the grazing land in 2020 comes from converting land of a native ecosystem. For cropland 3% of the cropland in 2020 is converted native ecosystem land. However, for artificial surfaces the main contribution comes from cropland (2.5% of the artificial areas of 2020).

The changes in land use categories from 2020 to 2030 relative to 2030 as modeled under the Reference Scenario are summarized in Table 12.

Table 12: Relative Changes in Land Use for Period 2020 to 2030 based on 2030 Area

2020 to 2030	Land Use Category					
	Grazing Land	Cropland	Native Ecosystem	Wetland	Artificial	Other
	%	%	%	%	%	%
Grazing Land	98.7	0.3	1.0	0.0	0.0	0.0
Cropland	0.5	98.4	1.2	0.0	0.0	0.0
Native	0.2	0.5	99.3	0.0	0.0	0.0
Wetland	0.0	0.0	0.0	100.0	0.0	0.0
Artificial	0.4	2.3	1.1	0.0	96.2	0.0
Other	0.0	0.0	0.0	0.0	0.0	100.0

For the period from 2020 to 2030 conversions between land use categories are in general less pronounced than for the previous decade. The main conversion is from cropland to artificial areas, where 2.3% of the 2030 artificial areas are on former cropland. In the land use model the areas of wetlands and other land use are presumed stable over the periods.

Grazing land decrease in the scenario by 1.6% from 2010 to 2020 and 1.4% from 2020 to 2030. During the first decade over 90% of grazing land is converted to native ecosystem, i.e. abandoned (74% for the second period).

Overall, the area of cropland increases over the decades with 2.2% for 2010 to 2020 and 0.6% from 2020 to 2030. A more detailed scrutiny of the changes by land use shows that the increase in area can be assigned to the emergence of energy crops on cropland. The area of long-term cultivated crops actually decreases by 1.1% over the first period and 1.2% over the second period.

Under the modelled land use changes of the Reference Scenario the area of artificial land use category increases over both periods (4.6% for 2010 to 2020 and 3.9 % for 2020 to 2030). Approximately 50% of the new artificial areas are former cropland.

3.2 Changes Soil C-Stocks

Changes in soil C-stocks resulting from changes in land use for the two decades and the main categories are presented Table 13.

Table 13: Changes in Soil C-Stocks for 2010 to 2020 and 2020 to 2030 for EU28

Changes in	Land Use Category					
C-Stocks	Grazing Land	Cropland	Native Ecosystem	Wetland	Artificial	Other
Period	%	%	%	%	%	%
2010 to 2020	-1.9	3.2	-1.9	0.0	6.6	0.0
2020 to 2030	-1.7	1.0	-0.6	0.0	3.7	0.0

The data indicate a strong increase in soil C-stocks under artificial surfaces and, to a lesser degree, for cropland at the expense of grazing land and native ecosystems. Over 20 years the soil C-stock of all land areas decreases by 0.15%.

The changes in soil C-stock presented for EU28 the land use categories were computed as:

$$\Delta SOC^c = \frac{SOC^c_{a+10} - SOC^c_a}{SOC^c_{a+10}} * 100[\%]$$

where

SOC^c	relative change in C-stock from year *a* to year *a*+10 years for land use category *c*
SOC_a	SOC stock for land use category *c* in year *a*
SOC_{a+20}	SOC stock for land use category *c* in year *a+10 years*

In the computations the areas of the land use categories are those at the time of the assessment (2010, 2020 and 2030). As a consequence, the areas are not constant over time. The relative changes thus represent the variations in soil C-stocks attributable to a land use category, not the SOC density, which would be expressed as the mass per unit area.

The decrease of soil C-stock for grazing land is predominantly the result of the decrease in grazing land and to a minor degree the consequence of a conversion of less suitable land to grazing land.

The increase of soil C-stock on cropland stems from the introduction of second generation energy crops. The crops are ligneous or herbaceous, but multi-annual. The areas under these crops are thus not ploughed and treated as grassland or agro-forestry. The increase in soil C-stocks under artificial surfaces is purely the consequence to the expansion of these areas at the expense of other areas.

It should be noted that the increases in soil C-stocks for cropland and artificial areas are the result of the assumptions made and targets set under the Reference Scenario. The changes in land use and subsequently soil C-stocks are more pronounced for the first decade than for the period 2020 to 2030 and apparent already in 2015. As a consequence, any comparison to data reported by EU Member States on changes in soil C-stocks should allow for the introduction of new energy crops under the Reference Scenario.

A sectorial view of relative changes in soil C-stocks by EU Member State is presented in Table 14.

Table 14: Changes in Soil C-Stocks for Cropland and Grazing Land for 2010 to 2020 and 2020 to 2030 relative to Land Use at Period End for EU Member States

Changes	**Cropland**		**Grazing Land**	
in C-Stocks	in 2020	in 2030	in 2020	in 2030
	2010 to 2020	2020 to 2030	2010 to 2020	2020 to 2030
Country	%	%	%	%
Austria	0.25	0.74	0.06	0.12
Belgium	-0.02	-0.02	0.16	0.30
Bulgaria	-0.51	-0.30	0.12	0.13
Cyprus	-0.86	-1.80	-0.56	-0.56
Czech Republic	-0.05	0.54	0.00	0.00

Denmark	-0.01	-0.01	0.14	0.21
Estonia	-0.56	-0.79	0.08	0.09
Finland	-7.90	-13.12	0.00	0.13
France	0.04	0.12	0.14	0.15
Germany	0.46	0.69	0.04	0.09
Greece	-1.49	-1.57	0.43	0.44
Hungary	0.44	0.55	0.02	0.02
Ireland	-0.52	-0.71	0.03	0.04
Italy	0.08	0.08	0.06	0.09
Latvia	-3.18	-3.88	0.00	0.00
Lithuania	-0.33	0.15	0.00	0.00
Luxembourg	-0.21	-0.23	0.65	0.91
Malta	-0.10	0.24	0.00	0.00
Netherlands	-0.30	-0.23	0.01	0.12
Poland	0.91	1.61	0.02	0.08
Portugal	-0.31	-0.58	0.05	0.05
Romania	-0.08	-0.10	0.07	0.09
Slovakia	-0.25	0.32	0.10	0.27
Slovenia	-0.33	0.72	0.04	0.36
Spain	-0.73	-0.77	0.05	0.05
Sweden	-7.72	-10.96	0.02	0.07
United Kingdom	0.06	0.32	0.02	0.06
Croatia	-0.63	-0.78	0.06	0.06
TOTAL	**-0.24**	**-0.26**	**0.07**	**0.10**

The changes over the period are expressed relative to the soil C-stocks at the end of a period and for the area of the land use category at that time. Thus, the area of the land use sector is constant and changes are per unit area. For example, for cropland the soil C-stock changes cover cropland remaining cropland and any other land converted to cropland by the end of the period. Cropland converted to grazing land is included under grazing land, but cropland converted to forest or other artificial surfaces is lost.

The soil C-stocks under cropland decrease for both decades (-0.24% and -0.26%), while the soil C-stocks for grazing land slightly increase (+0.07% and +0.10%).

It should be noted that this trend in soil C-stocks is intrinsic to the method used to represent areas. Cropland has the lowest soil C-stocks. As a consequence, any changes from another category to cropland will result in a decrease in soil C-stocks for that category when expressed relative to the area of cropland at the end of the period. The losses in C-stocks are not the losses on cropland, but those of the land converted to cropland. Similarly, the gains in spoil C-stocks for grazing land originate not in changes on grazing land, but in the conversion of some cropland to grazing land.

In order to evaluate the effect of management or input on cropland or grazing land the areas and land use categories have to be kept constant over time, i.e. the analysis is limited to areas of cropland remaining cropland and grazing land remaining grazing land. This study concentrated on the effect of changes in land use under the RREM Reference Scenario and the management and input factors were kept constant after 2010. Therefore, soil C-stocks would not change for areas remaining in a land use category.

3.3 C-Emissions from Organic Soils

Under Tier 1 emissions of carbon from organic soils can be estimated from the area of organic soils under cropland or grazing land management and the climate region by generic emission factors.

3.3.1 Area of Organic Soils

From the IPCC soil classification schema the area of organic soils covers 6.4% of the total land area of EU28. A summary of the portion of the area of organic soils by land use category is presented in Table 15.

Table 15: Relative Areas of Organic Soils by Land use Category for EU28

Organic Soil Area Share	**Land Use Category**					
	Grazing Land	Cropland	Native Ecosystem	Wetland	Artificial	Other
Period	%	%	%	%	%	%
2010	4.6	1.9	8.2	51.8	2.5	14.5
2020	4.7	1.9	8.3	51.8	2.5	14.5
2030	4.8	2.0	8.3	51.8	2.5	14.5

Most of the area of the wetland category is on organic soils (51.8%). This can be expected since water saturation is one of the main conditions for forming organic soils.

On grazing land organic soils cover just less than 5% of the area, while approx. 2% of cropland is found on organic soils. These figures are averages for EU28 and large regional variations exist.

3.3.2 Emissions from Organic Soils for Cropland and Grazing Land

The decadal emissions of organic soils for cropland and grazing land by country are given in Table 16.

Table 16: Emissions from Cropland and Grazing Land for Organic soils by Country

Organic Soils Emissions	Cropland			Grazing Land		
	2010 to 2020	2020 to 2030	2010 to 2030	2010 to 2020	2020 to 2030	2010 to 2030
Country	*Mt C*	*Mt C*	*Mt C*	*Mt C*	*Mt C*	*Mt C*
Austria	0.3	0.3	0.5	0.0	0.0	0.1
Belgium	0.4	0.4	0.8	0.0	0.0	0.1
Bulgaria	3.9	3.9	7.8	0.1	0.1	0.2
Cyprus	0.0	0.0	0.0	0.0	0.0	0.0
Czech Republic	0.5	0.5	1.0	0.0	0.0	0.0
Denmark	3.3	3.3	6.6	0.0	0.0	0.0
Estonia	7.3	7.9	15.1	0.1	0.1	0.2
Finland	8.3	10.9	19.2	0.0	0.0	0.0
France	13.6	13.8	27.5	0.8	0.7	1.5
Germany	26.6	26.7	53.3	1.2	1.2	2.4
Greece	4.6	4.7	9.3	0.0	0.0	0.0
Hungary	13.1	13.1	26.2	0.9	0.9	1.8
Ireland	6.0	6.3	12.2	1.4	1.4	2.9
Italy	2.4	2.4	4.9	0.0	0.0	0.0
Latvia	5.5	6.2	11.7	0.2	0.2	0.3
Lithuania	13.8	14.1	27.9	0.2	0.2	0.3
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	5.3	5.1	10.4	0.5	0.5	0.9
Poland	36.9	36.4	73.3	1.0	1.0	1.9
Portugal	0.6	0.6	1.1	0.0	0.0	0.0
Romania	0.5	0.5	0.9	0.0	0.0	0.0
Slovakia	0.1	0.1	0.2	0.0	0.0	0.0
Slovenia	0.5	0.5	1.0	0.0	0.0	0.0
Spain	1.1	1.1	2.2	0.1	0.1	0.2
Sweden	9.4	11.8	21.2	0.1	0.1	0.2
United Kingdom	5.2	5.3	10.6	0.7	0.7	1.4
Croatia	0.0	0.0	0.1	0.0	0.0	0.0
TOTAL	**169.1**	**175.7**	**344.7**	**7.3**	**7.3**	**14.6**

According to the estimates the annual emissions from cropland for 2010 to 2030 are 17.2 *Mt C* yr^{-1} and *0.73 Mt C* yr^{-1} for grazing land for EU28. The significantly lower annual emissions from grazing land organic soils are the result of the default emission factors for the land use categories and, to a lesser extent, the consequence of a different distribution across climate regions. Grazing land organic soils tend to be in the cooler climate regions while in warmer climates organic soils are used for cropland instead of grazing land.

The largest annual emissions from organic soils for the combined land use categories are found in Poland (3.8 Mt C yr^{-1}) and Germany (2.8 Mt C yr^{-1}). Other countries with large areas of organic soils show lower emissions due to the smaller areas under cropland and grazing land.

4 Summary

The land use changes modeled for the RREM Reference Scenario for the periods 2010 to 2020 and 2020 to 2030 are estimated to lead to an increase in cropland and artificial areas at the expense of grazing land and natural ecosystems. The increase in artificial surfaces, such as urban areas, industrial zones and infrastructures, by 8.7% over 20 years are a result of the economic and demographic trends that are part of the Reference Scenario.

The increase in the area of cropland and soil C-stocks under cropland is attributed to the introduction of multi-annual energy crops. Without these crops the area of cropland would decrease by 2.3% from 2010 to 2030 and soil C-stocks are estimated to decrease by 3.0% over the same period.

The area of grazing land contracts by 3.0% over 20 years while the soil C-stocks on grazing land decrease by 4.6%. The change from grazing land, as the changes in cropland, are no least the result of some land abandonment.

Annual C-emissions from cropland were estimated at 17.2 Mt C yr^{-1} and 0.7 Mt C yr^{-1} for grazing land organic soils. These C-emissions from drained organic soils amount to 90% of the emissions of mineral soils across all land use categories.

In the evaluation of the results the assumptions and targets of the Reference Scenario concerning energy crops were found to largely determine changes in soil C-stock on cropland, but not on grazing land. Without the stipulations of the Reference Scenario soil C-stocks may not develop in the same direction. The study also found that in order to provide comparative and complete emission estimates the changes in land use and soil C-stocks should cover all land areas and not be limited to cropland and grazing land. Otherwise methodological peculiarities in the treatment of areas over time may lead to biased results.

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ANNEX 5
EU LULUCF country factsheets

Contract n° 33920-2015 NFP

Administrative agreement

340202/2015/705777/CLIMA.A.2

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Coordination by Giacomo Grassi

2016

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The JRC AFOLU factsheets

The AFOLU factsheets are aimed at presenting the available information on AFOLU data for each country in a concise way, by means of short texts, tables, and charts. A factsheet is also available for the EU as a whole.

Each factsheet is composed by different sections. The *Current Situation* section offers an overview of the trends and key drivers in Agriculture and LULUCF sectors within the country, along with charts on past trends for Agriculture and LULUCF as a whole and LULUCF subcategories according to the official submissions of Member States to the UNFCCC.

A summary table collects past data and projections figures from Member States as well as from models run at the JRC and IIASA.

The section on *Agriculture and LULUCF mitigation strategies* presents the available information on mitigation measures for Agriculture and LULUCF identified by the MS within their 6th National Communication and within the Article 10 report submitted in the framework of Decision 529/2013/EU.

The following section (*Agriculture and LULUCF mitigation options and potentials for the 2030 framework*) is focused on the estimations obtained within different modelling efforts ongoing at the JRC. For Cropland Management and Grazing Land Management the CAPRESE project estimated the Soil Organic Carbon mitigation potentials in cropland for different options (e.g. conversion of arable land to grassland, use of cover crops, etc.) and grouped them in three scenarios according to the possible adoption of such practices. The IPCC Tier 1 modelling effort estimated the gains/losses of C stocks by 2030 under a reference scenario due to land use conversion driven by demographic/economic trends. For Forestry, the Carbon Budget Model (CBM) is used to estimate source/sink potentials along with additional mitigation potential, discussing the possible driving forces (e.g. ageing, harvesting) and comparing the results with those obtained by IIASA in its Impact Assessment.

The Business as Usual (BAU) accounting and the additional mitigation potential obtained from the different models in the different categories are also summarized in the final bar chart.

The datasets used to prepare the factsheets are the following:

- Official country data: these include the official submissions of Member States to the UNFCCC for the reporting under the Convention and under the Kyoto Protocol (KP) and the data included in the National Communications. Also projections submitted to the Commission within the Article 10 Reports under the Decision 529/2013/EU were considered in the factsheets.
- JRC data: these include data produced in different activities at the JRC. In particular:
  - CBM data: estimations produced with the Carbon Budget Model, a modelling framework originally developed in Canada and adapted to European conditions at the JRC that simulates the dynamics of all forest carbon stocks required under the Kyoto Protocol (aboveground biomass, belowground biomass, litter, dead wood and soil organic carbon) (Pilli et al. 2013, 2016).
  - CAPRESE data: mitigation potential and scenario simulations produced in the framework of the CAPRESE project (CArbon PREservation and SEquestration in agricultural soils) using the CENTURY model, a process-based model designed to simulate C, Nitrogen (N), Phosphorous (P) and Sulphur (S) dynamics in natural or cultivated systems, using a monthly time step (Lugato et al. 2014).
  - IPCC Tier 1 modelling data: estimations of soil organic carbon variations in cropland and grassland soils produced with a GIS-based implementation of the IPCC Tier 1 methodology (Hiederer et al 2013) and reference scenario data.

- Reference scenario 2016: data modelled by IIASA for the LULUCF sector using different models (GLOBIOM and G4M/EPIC/GAINS) (in press).

Austria

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 10% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (CP1: 2008-2012): 7.6 $MtCO_{2eq}$, reduced by 1.0 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 11% of national GHGs (average 1990-2012), decreasing over time (average CP1: -3.1 $MtCO_{2eq}$, sink decreased by 6.8 $MtCO_{2eq}$ from 1990). Main drivers: lower sink from forest land (due to increased harvest). For CP1, credits from AR (2.0 $MtCO_{2eq}$/yr) and debits from D (-0.6 $MtCO_{2eq}$/yr). No other activity was elected in CP1.

Fig. 1. Past trends of Agriculture and LULUCF

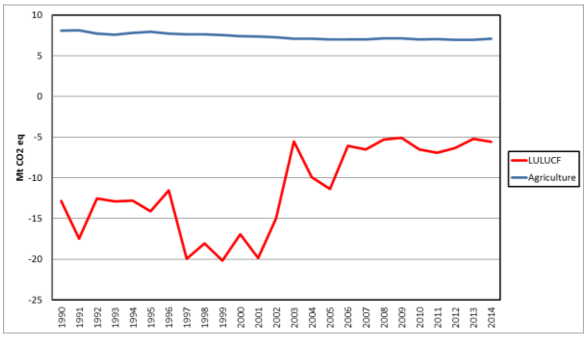


Fig. 2. Past trends of specific LULUCF categories

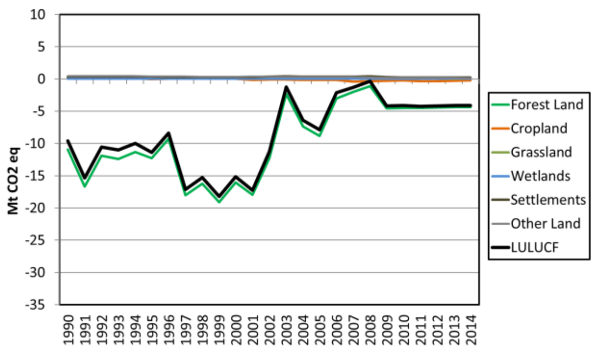


Table 17- state of play for LULUCF and Agriculture, and summary of available projections

Austria		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-7.8	(3)	-1.8	(3)	-306.9	-5.2	-10.8	(4)		-1.4	-8.6	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-2.7	(7)
	AR			-2.0		-1.5	-2.2	-3.2	(5)		-2.7	-3.9	(5)	-1.5	-2.7	(6)		-3.3	(6)		-0.6	(7)
	D			0.7		0.8	0.5	0.3	(5)		0.3	0.2	(5)	0.8	0.4	(6)		0.2	(6)		-0.1	(7)
	CM	0.0		-0.4		0.1	0.1	-0.1	(5)		0.1	-0.3	(5)	0.1	0.0	(6)		-0.1	(6)		-0.4	(7)
	GM	-0.1		-0.1		0.2	0.0	0.0	(5)		0.1	0.0	(5)	0.3	0.1	(6)		0.1	(6)		0.0	(7)
	total (UNFCCC)	-17.5		-6.0			-6.8		(5)		-3.6		(5)									
Agriculture (2)	Soils N_2O	2.2	(3)	1.9	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	5.8		5.0					(5)				(5)			(6)			(6)			(7)
	total	8.1		7.0		7.7	7.3		(5)	7.7	7.3		(5)	-0.4	-0.8	(6)	-0.4	-0.8	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Identified mitigation measures include a 20% increase in the share of farmland used for organic farming, and the promotion of raw materials for biofuels production. Current emissions from agriculture are projected to increase slightly in the "with measures scenario" until 2020 (+2 % from 2011) and to stabilize afterwards. The trend is mainly influenced by livestock numbers and milk yield. Measures described in the Austrian agri-environmental programme, taken into account in the "with additional measures" scenario, lead to a decrease of emissions after 2011 (about 1–2 % until 2020 and 2030). The sector amounts to 9 % of total GHG emissions in 2011 and that share is not expected to change until 2030.

LULUCF. Policies and measures in this sector aim at maintaining biodiversity, productivity, regeneration, capacity and vitality of forests. Emissions from LULUCF show an increasing trend until 2020 and are projected to change from a net sink of 3.8 Mt CO_2eq in 2012 to a net source of 2.9 Mt CO_2eq in 2015 and of 4.4 Mt CO_2eq in 2020. These data cover forest land remaining forest land, which is quantitatively the most important subsector. No projections are currently available for the period beyond 2020. The 2020 value has thus been assumed to remain constant for the period up to 2030.

Agriculture and LULUCF mitigation options and potentials for the 2030 framework

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 0.79 tCO_2/ha/yr), use of cover crops (0.2 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.19 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.12 MtCO_2/yr beyond BAU for a more economical-oriented scenario up to 0.42 MtCO_2/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock of 0.25 MtCO_2/yr for cropland and of 0.045 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits). Estimates for CM and GM in 2020 and 2030 in tab 1 come from IIASA (after calibration with country's GHG inventory, done by JRC).

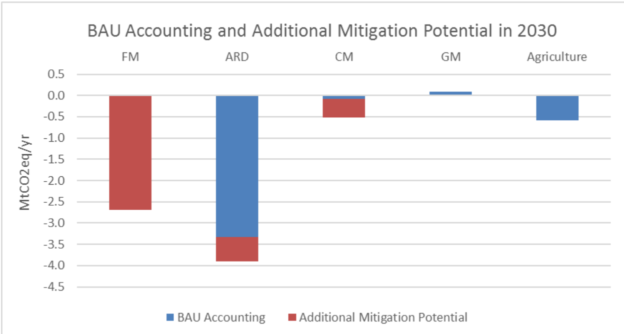
Forestry

For FM, in CP2 Austria predicts a significant increase in harvest (+50% relative to 2005), which is the reason of their expected drop of current sink in 2020.

By 2030, CBM predicts a sink of -8.6 MtCO_2/yr for the impact assessment scenario and an additional mitigation potential of -2.7 MtCO_2/yr, for -10% harvest.

For AR, CBM estimates relevant BAU credits in 2030 (3.9 MtCO_2/yr), with limited

additional mitigation potential.

Fig. 3. Marginal abatement cost curves for 2020 for agriculture	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).** For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the 'additional mitigation potential' (red) derived from sensitivity analysis.
No information available.	*Base year (1990) country total GHGs (without LULUCF): 78.8 $MtCO_{2eq}$/yr* *Credits and debits from CM and GM should be considered with a lot of caution because can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.* 

Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Belgium

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 7% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (2008-2012): 9.4 $MtCO_{2eq}$, reduced by 2.0 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation and swine manure management for CH_4.

LULUCF: net sink offsetting about 1% of national GHGs (average 1990-2012), slightly increasing over time (average CP1: -1.2 $MtCO_{2eq,}$ sink increased by 0.4 $MtCO_{2eq}$ from 1990). Main drivers: increased removals in forest land and conversion to grassland, increased emissions from conversion to cropland and to settlements, and decreased emissions from grassland remaining grassland. For the CP1 more debits from D (0.5 $MtCO_{2eq}$/yr) than credits from AR (-0.3 $MtCO_{2eq}$/yr)

Fig. 1. Past trends in Agriculture and LULUCF

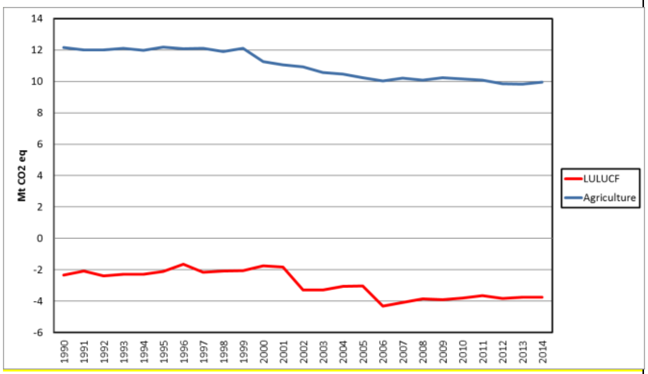


Fig. 2. Past trends of specific LULUCF categories

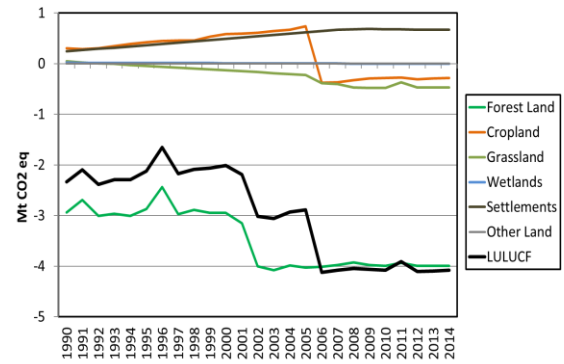


Table 18- state of play for LULUCF and Agriculture, and summary of available projections

Belgium		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-2.9	(3)	-3.7	(3)	-2.5	-3.4	-1.8	(4)		-3.4	-3.7	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.2	(7)
	AR			-0.3			-0.3	-0.6	(5)		-0.4	-0.6	(5)		-0.5	(6)		-0.5	(6)		-0.2	(7)
	D			0.5			0.2	0.2	(5)		0.1	0.1	(5)		0.2	(6)		0.1	(6)		-0.1	(7)
	CM	0.3		-0.4			1.7	0.2	(5)		1.5	0.1	(5)		0.6	(6)		0.5	(6)		-0.4	(7)
	GM	-0.1		-0.6			-0.3	0.0	(5)		-0.3	0.0	(5)		-0.1	(6)		-0.1	(6)		0.0	(7)
	total (UNFCCC)	-2.1		-3.8		0.8	-2.1		(5)	0.9	-2.5		(5)									
Agriculture (2)	Soils N_2O	4.4	(3)	3.3	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	7.6		6.4					(5)				(5)			(6)			(6)			(7)
	total	12.2		9.8		9.6	11.0		(5)		10.7		(5)	-2.6	-1.1	(6)		-1.5	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Belgium plans to implement measures related to the rational use of energy in agriculture and greenhouse crops, the reduction of CH_4 and N_2O emissions from fertilisers and manure, no tillage on permanent grassland, and a reduction in the inputs in cereals, natural grassland and grassland. Belgium foresees an increase in livestock population (dairy cattle, swine, poultry) between 2010 and 2020. CH_4 and N_2O emissions are expected to decrease in 2020.

LULUCF. Policies and measures include maintaining the carbon storage potential in forests, restricting deforestation and encouraging reforestation, preserving the ecological stability of forests, supporting biomass production for energy purposes, and limiting drainage of wetlands. LULUCF is a net carbon sink in Belgium. The average annual CO_2 absorption is approximately -1 $MtCO_2eq$. No specific projections are available for this sector except for forest management, where a business as usual scenario was used to estimate the Forest management reference level.

Agriculture and LULUCF mitigation options and mitigation potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 4.7 tCO_2/ha/yr), ley cropping systems (0.7 tCO_2/ha/yr), use of cover crops (0.6 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.7 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.1 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.4 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock resulting in emissions of 0.15 $MtCO_2$/yr for cropland and a sink of 0.04 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Belgium predicts (through IIASA/EFI/JRC data) a slight decrease in the sink, despite constant harvest.

By 2030, CBM predicts a FM sink of -3.7 $MtCO_2$/yr for reference scenario, and an additional mitigation potential of 0.2 $MtCO_2$/yr for -10% harvest. IIASA predicts in 2030 a FM sink of 3.4 $MtCO_2$/yr with an expected strong increase (+55%) in harvest.

For ARD, CBM estimates slightly increasing AR sink, fully compensating emissions from D in 2030. IIASA predicts for 2030 a AR sink of 0.4, slightly smaller than CBM.

Fig. 3. Marginal abatement cost curves for 2020 for agriculture

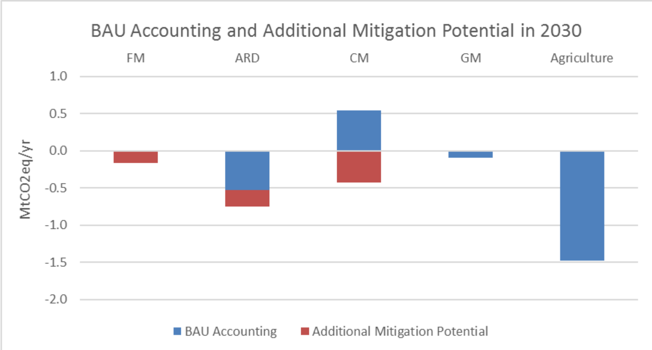
No information available.

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 104.7 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Bulgaria

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 11% of national GHGs excluding LULUCF (average 1990-2012), strongly decreasing over time (average 1[st] Commitment Period (CP1: 2008-2012): 6.1 $MtCO_{2eq}$, reduced by 11.7 $MtCO_{2eq}$ from 1990). Main drivers: significant decrease of CH_4 emissions from swine manure management and cattle and sheep enteric fermentation and decrease of N_2O emissions from agricultural soils.

LULUCF: net sink offsetting about 14% of national GHGs (average 1990-2012), decreasing over time (average CP1: -8.3 $MtCO_{2eq,}$ reduced by 5.2$MtCO_{2eq}$ from 1990). Main drivers: significant decrease of removals from forest land. For CP1, small credits from AR (0.8 $MtCO_{2eq}$/yr) and debits from D (0.1 $MtCO_{2eq}$/yr). FM not elected.

Fig. 1. Agriculture & LULUCF: past trends and CP1 accounting

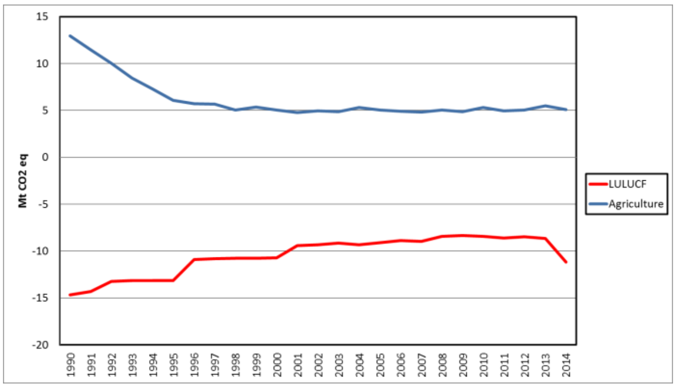


Fig. 2. Past trends of specific LULUCF categories

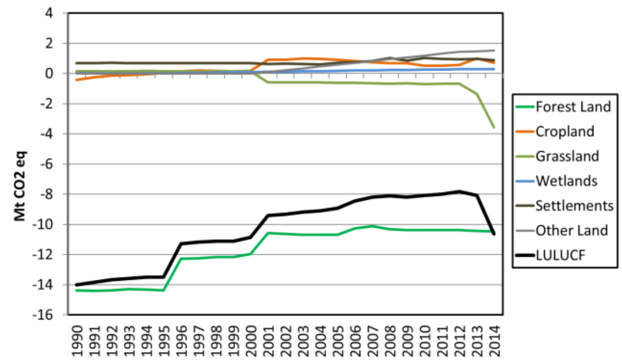


Table 19- state of play for LULUCF and Agriculture, and summary of available projections

Bulgaria		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-13.8	(3)	-9.7	(3)	-8.0	-9.6	-7.4	(4)		-8.7	-5.9	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.2	(7)
	AR			-0.7			-1.5	-2.8	(5)		-2.3	-3.2	(5)		-2.1	(6)		-2.8	(6)		-1.2	(7)
	D			0.1			0.1	0.0	(5)		0.1	0.0	(5)		0.1	(6)		0.0	(6)		0.0	(7)
	CM	-0.4		0.6			1.5	1.7	(5)		1.4	1.5	(5)		2.0	(6)		1.9	(6)		-0.9	(7)
	GM	0.1		-0.7			-0.7	0.0	(5)		-0.8	0.0	(5)		-0.5	(6)		-0.5	(6)		0.0	(7)
	total (UNFCCC)	-14.3		-8.5		-11.8	-10.2		(5)		-10.3		(5)									
Agriculture (2)	Soils N_2O	5.1	(3)	3.2	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	7.7		2.2					(5)				(5)			(6)			(6)			(7)
	total	13.0		5.5		6.7	5.4		(5)	7.3	5.5		(5)	-6.3	-7.5	(6)	-5.7	-7.4	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. This sector has not implemented significant measures to reduce emissions. The past GHG reduction is a direct consequence of the overall decline in farming since 1988. The reduction of emissions from stock-breeding follows the decrease in the number of livestock. Bulgaria included only one planned measure into the 6th NC, i.e. incorporation of straw residuals. The projections indicate an increase in emissions by 2020.

LULUCF. The main strategic documents containing measures for the LULUCF sector is the Third National Action Plan on Climate Change (NAPCC) for the period 2013-2020. The 1st priority axis combines measures to increase the sequestration of GHG associated with increase of the areas like forests, pastures and meadows as GHG sinks, and measures for their sustainable maintenance in order to increase the amount of biomass. The 2nd priority affects the storage of C stocks in forests and envisages restoration and maintenance of forest shelter belts and new anti-erosion afforestation. The 3rd priority is focused on the potential of forests to capture carbon and on plans to increase tree density. The 4th priority is aimed at the long-term retention of carbon in wood products. A sink by about -11.2 $MtCO_{2eq}$ is mentioned as result of future LULUCF activities within the NAPCC.

Agriculture and LULUCF mitigation options and mitigation potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.49 tCO_2/ha/yr), ley cropping systems (0.68 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.40 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.26 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.87 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab.1) estimated a loss in C stock resulting in an emission of 1.5 $MtCO_2$/yr for cropland and of 0.01 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Bulgaria predicts (through IIASA/EFI/JRC data) a slight decrease in the FM sink, despite slightly decreasing harvest.

By 2030, CBM predicts a sink of -5.9 $MtCO_2$/yr for reference scenario and an additional mitigation potential of 0.2 $MtCO_2$/yr for -10% harvest. IIASA predicts a -8.7 $MtCO_2$/yr sink in 2030 and a constant harvest.

For ARD, CBM estimates relevant BAU credits in 2030 (3.2 $MtCO_2$/yr), with 1.2 $MtCO_2$/yr additional mitigation potential. The AR sink predicted by IIASA in 2030 is -2.4 $MtCO_2$/yr.

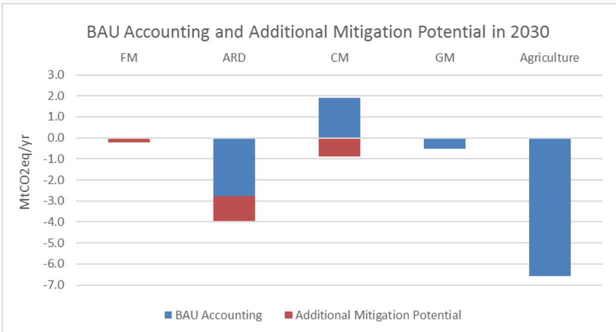
Fig. 3. Marginal abatement cost curves for 2020 for agriculture

No information available.

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab.1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1988) country total GHGs (without LULUCF): 121.8 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Czech Republic

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 6% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1[st] Commitment Period (CP1: 2008-2012): 8.2 $MtCO_{2eq}$, reduced by 8.1 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation CH_4.

LULUCF: net sink offsetting about 4% of national GHGs (average 1990-2012), decreasing over time (average CP1: -6.1 $MtCO_{2eq,}$ sink increased by 2.6 $MtCO_{2eq}$ from 1990 but in average the sector's trend shows a reduction of the sink). Main drivers: removals form forest land. For CP1, credits from AR and FM (0.3 and 1.2 $MtCO_{2eq}$/yr) and debits from D (0.2 $MtCO_{2eq}$/yr).

Fig. 1. Agriculture & LULUCF: past trends and CP1 accounting

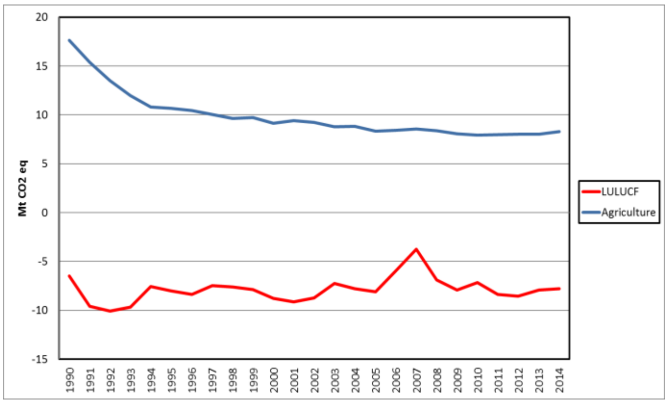


Fig. 2. Past trends of specific LULUCF categories

Table 20- state of play for LULUCF and Agriculture, and summary of available projections

Czech Republic		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-4.5	(3)	-5.7	(3)	-4.7	-5.9	-4.2	(4)	-2.9	-5.1	-3.2	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-1.7	(7)
	AR			-0.4			-0.5	-0.7	(5)		-0.8	-1.0	(5)		-0.6	(6)		-0.9	(6)		-0.2	(7)
	D			0.2			0.2	0.1	(5)		0.1	0.0	(5)		0.1	(6)		0.1	(6)		0.0	(7)
	CM	0.1		0.0		0.2	0.1	0.0	(5)	0.2	0.0	-0.5	(5)	0.1	-0.1	(6)	0.1	-0.4	(6)		-1.0	(7)
	GM	-0.2		-0.6		-0.3	-0.4	0.0	(5)	-0.3	-0.5	0.0	(5)	-0.1	0.0	(6)	-0.2	-0.1	(6)		0.0	(7)
	total (UNFCCC)	-9.6		-7.8		-1.9	-6.6		(5)	-2.9	-6.4		(5)									
Agriculture (2)	Soils N_2O	5.5	(3)	3.0	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	10.8		4.8					(5)				(5)			(6)			(6)			(7)
	total	17.6		8.0		7.8	6.9		(5)	7.6	6.9		(5)	-9.8	-10.7	(6)	-10.0	-10.7	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario).

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. The Czech Republic has been in the process of completing the preparation for the Partnership agreement for the programming period 2014-2020. The most important measures in the draft agreement are the increased energy efficiency of production and technology processes in agriculture and aquaculture, the increased carbon sequestration in agriculture and forestry, the reduction of landscape fragmentation, the increased soil protection against erosion and degradation, especially in cropland. Measures aiming at reducing the CH_4 and N_2O emissions in this sector focus primarily on reducing the application of nitric fertilizers, catch crops use, development of organic farming, introduction of modern technologies, and controlled fermentation of waste plant. Lower application of fertilizer and reduced field runoffs form one of the declared objectives in existing policies. A slight increase in emissions by 2030 for scenario with measures is caused by anticipated growth in the number of livestock required to meet domestic demand and exports of animal-related commodities.

LULUCF. Czech Republic predicts a slight increase of forest land, grassland and wetlands area, while the cropland area will slightly decrease towards 2030. The shift from dominant spruce forests to a mixed forest type with higher share of hardwood, such as oak or beech is expected. The projected LULUCF sink decreases of -1.92 $MtCO_2eq$ in 2020 (WEM scenario) or -2.38 $MtCO_2eq$ (WAM scenario), which represent respectively a 59% and 54% decrease compared to 2012. Removals are expected to increase in 2030 (-2.94 $MtCO_2eq$ for WEM and -3.34 $MtCO_2eq$ for WAM scenario).

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 2.1 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.70 tCO_2/ha/yr), and cover crops (0.61 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.3 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.99 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a removal of 0.5 $MtCO_2$/yr for cropland and an emission of 0.005 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Czech Republic predicts (through IIASA/EFI/JRC data) a slight decrease in the FM sink, due to slightly increasing harvest.

By 2030, CBM predicts a sink of -3.2 $MtCO_2$/yr for reference scenario and an additional mitigation potential of -1.7 $MtCO_2$/yr for -10% harvest scenario. In 2030 IIASA predicts a

FM sink of 5.1 $MtCO_2$/yr with a nearly constant harvest.

For ARD, both CBM and IIASA estimate rather modest BAU credits in 2030 (-1 and -0.7 $MtCO_2$/yr respectively).

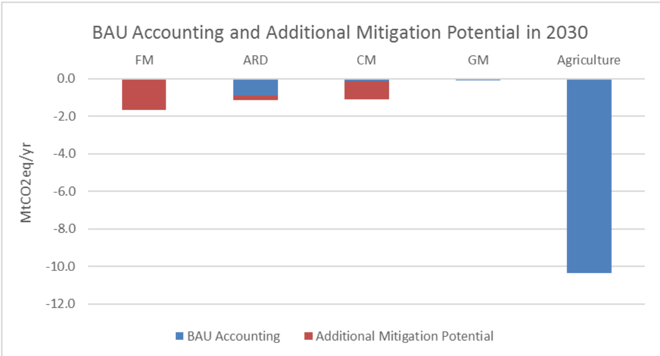
Fig. 3. Marginal abatement cost curves for 2020 for agriculture

No information available.

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 195.3 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Germany

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 7% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time. 1st Commitment Period (CP1:2008-2012): 69.9 Mt CO_{2eq}, reduced by 17.9 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 1% of national GHGs (average 1990-2012), decreasing over time (average CP1: sink of -5.0 $MtCO_{2eq}$, decreased by 19.5 $MtCO_{2eq}$ from 1990). Main drivers: large decrease of removals in forest land (trend affected by estimation method), organic soils emissions under cropland and grassland and increase emissions from conversion to settlements. Relevant emissions from cultivation of organic soils. For CP1, credits from AR and FM (5.7 and 4.5 $MtCO_{2eq}$/yr) and debits from D (2.3 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture & LULUCF

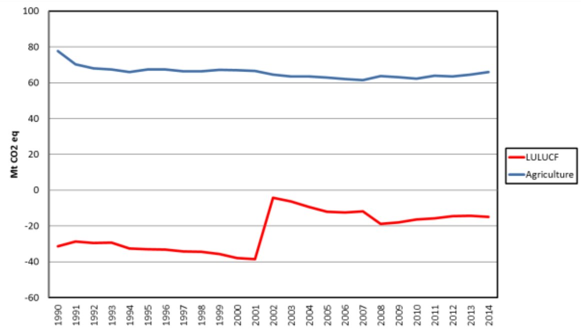


Fig. 2. Past trends of specific LULUCF categories

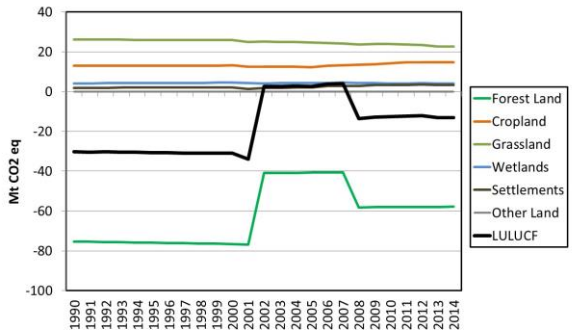


Table 21- state of play for LULUCF and Agriculture, and summary of available projections

Germany		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-70.3		-53.1		-22.4	-47.8	-45.3	(4)		-41.9	-36.3	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-1.4	(7)
	AR			-5.0			-6.6	-7.6	(5)		-8.1	-9.6	(5)		-7.1	(6)		-8.9	(6)		-2.0	(7)
	D		(3)	2.7	(3)		2.6	2.0	(5)		1.1	0.9	(5)		2.3	(6)		1.0	(6)		-0.6	(7)
	CM	11.8		13.4			28.9	7.5	(5)		28.0	6.4	(5)		6.4	(6)		5.4	(6)		-6.1	(7)
	GM	25.3		22.5			8.8	0.4	(5)		8.0	0.3	(5)		-20.7	(6)		-21.1	(6)		0.0	(7)
	total (UNFCCC)	-28.8		-16.6			-14.1		(5)		-12.8		(5)									
Agriculture (2)	Soils N_2O	28.0		25.7					(5)				(5)			(6)			(6)			(7)
	Livestock	47.8	(3)	34.8	(3)				(5)				(5)			(6)			(6)			(7)
	total	77.7		64.6		68.0	62.4		(5)	66.0	60.9		(5)	-9.7	-15.3	(6)	-11.7	-16.8	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. The German 6th NC does not include yet the reform of the CAP for the period after 2014. Planned policies and measures include the application of good agricultural and environmental practices, extensification and restructuring of the dairy sector. Germany predicts a decrease for livestock population for 2030. The number of cattle will decrease, and in 2030 will be 14.4% lower than in 2005. A 13.8% decrease in pig production is foreseen between 1990 and 2030. The impact of these changes and of the associated land use shows an overall decrease of CH_4 emissions from fermentation and manure management in 2030. This reduction is primarily due to the decrease in the numbers of dairy and non-dairy cattle. Total N_2O emissions from manure management and agricultural soils is foreseen to decrease by 4% between 2005 and 2030, and N_2O emissions decrease by 16.3% between 1990 and 2030. Agricultural CH_4 and N_2O emissions decrease by 5.8% between 2005 and 2030 and by 20.9% between 1990 and 2030 to 65,784 ktCO_2eq. in 2030. The measures under the CAP are essentially focused on maintaining the carbon stocks in agricultural soils at the current level.

LULUCF. Planned policies and measures listed in 6th NC focus on safeguarding and increasing the ability of forests for C sequestration as sinks while avoiding GHG emissions; increasing the sequestration offered by harvested wood products and increasing the share of wood products which offer prolonged carbon sequestration. CL and GL projection to 2020 take into account that a generally complete compensation bid for grassland conversion should be applied in farmland. The "scenario with measures" comes from an emissions reduction of 1.6 million tonnes of CO2, or 4% of emissions from arable and grassland management in 2020 compared with the 2008-2012 period, or by 1.8 million tonnes CO2 or 5% compared to 1990. Projections in Forestry sector were not taken into consideration in the German 6th NC. The German government is reviewing whether the 2017 Projection Report might include this sector and, if so, in what form. The following general mitigation measures are theoretically and technically possible in the German forest and timber management sector: increase forest cover, reducing emissions from forest management and wood utilization: change in the rotation periods, forest conversion/conversion structure (multi-layered mixed forests), cascade use of wood, substitution of energy-intensive products by wood products, rewetting of forest bogs.

Agriculture and LULUCF mitigation options and potentials for the 2030 framework

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 3.4 tCO_2/ha/yr), insertion of cover crops in the rotation schemes (0.8 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.7 tCO_2/ha/yr), and ley cropping system (0.5 tCO2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 0.9 MtCO_2/yr beyond BAU. The IPCC Tier 1 method for mineral soils estimated an emission of 6.4 MtCO_2/yr for cropland and of 0.3 MtCO_2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits). Models used by the MS do not estimate organic soils emissions in grasslands.

Forestry

Germany predicted a strong increase in harvest in CP2 and consequently a low sink in FMRL. By contrast, latest GHGI showed higher sink than in CP1, due to a decrease in harvest (presumably mainly due to crisis). Unless harvest will raise as expected, Germany will have large FM credits in CP2.

By 2030, CBM predicts a sink of 36.3 $MtCO_2$/yr for reference scenario and an additional mitigation potential of 1.4 $MtCO_2$/yr for -10% harvest. IIASA foresees a sink of 41.9 $MtCO_2$/yr in 2030.

For AR, CBM predicts a slightly increasing sink in 2030 in line with IIASA. The additional mitigation potential according to CBM is around 2 $MtCO_2$/yr.

Fig. 3. Marginal abatement cost curves for 2020 for agriculture

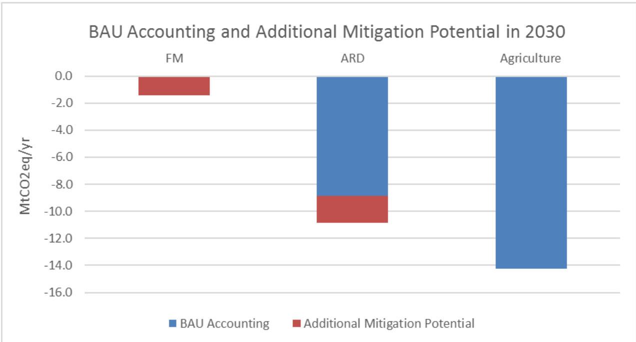
No information found

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 1246 $MtCO_{2eq}$/yr .

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.

Remove GM and explain this because the lack of org soil in models result would create an apparent big credit when comparing 2030 to 1990



NB: CM and GM are not displayed as organic soils emissions are not estimated in the models used by the MS and this may lead to misleading accounting when comparing 2030 projections with 1990 data.

Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Denmark

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 15% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (1st Commitment Period (CP1: 2008-2012): 9.7 $MtCO_{2eq}$, reduced by 2.8 $MtCO_{2eq}$ since 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation, manure management for CH_4.

LULUCF: emissions equal to 4% of national GHGs excluding LULUCF (average 1990-2012), becoming a sink at the end of the CP1 (CP1: sink of -0.5 $MtCO_{2eq,}$ source of 5.3 $MtCO_{2eq}$ in 1990). Main drivers: decrease emissions from cropland, specifically from organic soil and liming of agricultural soils, and significant increase of removals from forest. For CP1, credits from AR, FM and CM (0.03, 0.23 and 1.65 $MtCO_{2eq}$/yr) and debits from D and GM (0.08 and 0.11 $MtCO_{2eq}$/yr).

Fig. 1. Agriculture & LULUCF: past trends and CP1 accounting

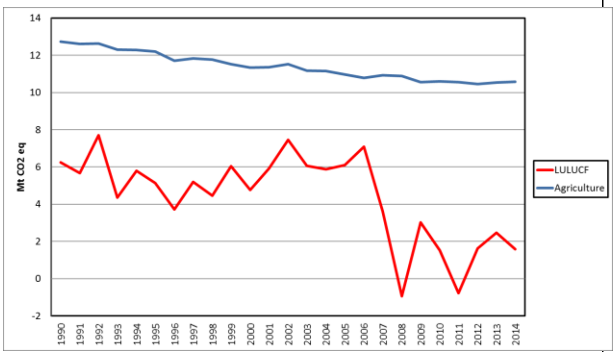


Fig. 2. Past trends of specific LULUCF categories

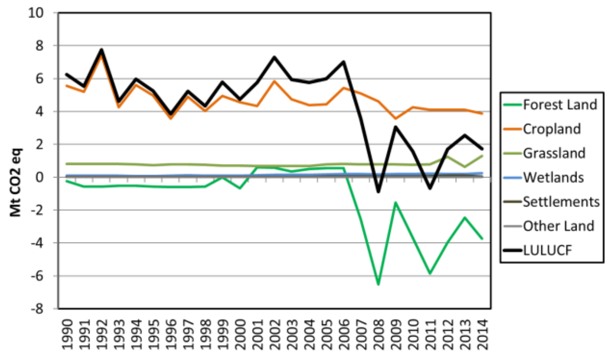


Table 22- state of play for LULUCF and Agriculture, and summary of available projections

Denmark		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-0.2	(3)	-4.7	(3)	0.4	0.2	1.5	(4)	-0.1	0.3	2.2	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		0.0	(7)
	AR			0.4		-0.8	-0.5	-1.0	(5)	-0.8	-0.9	-1.4	(5)	-0.8	-0.8	(6)	-0.8	-1.1	(6)		-0.3	(7)
	D			0.1		0.1	0.2	0.1	(5)	0.1	0.2	0.1	(5)	0.1	0.1	(6)	0.1	0.1	(6)		-0.1	(7)
	CM	5.6		4.1		3.6	3.7	1.2	(5)	3.5	2.7	1.2	(5)	-2.0	-3.1	(6)	-2.1	-3.6	(6)		-0.9	(7)
	GM	0.8		0.8		0.7	0.3	0.0	(5)	0.7	0.4	0.0	(5)	-0.1	-0.6	(6)	-0.1	-0.6	(6)		0.0	(7)
	total (UNFCCC)	5.7		0.9			3.9		(5)		2.6		(5)									
Agriculture (2)	Soils N_2O	5.4	(3)	3.8	(3)	4.7			(5)	4.6			(5)	-0.7		(6)	-0.7		(6)			(7)
	Livestock	6.7		6.5		4.2			(5)	4.2			(5)	-2.5		(6)	-2.5		(6)			(7)
	total	12.7		10.5		8.9	10.2		(5)	8.9	10.4		(5)	-3.8	-2.5	(6)	-3.9	-2.4	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Denmark expects a decrease of total GHG emissions in Agriculture by a 32% in 2035, corresponding to 8.86 $MtCO_2eq$, as a result of a decrease in emissions from manure management and from synthetic fertilisers. The decrease in emissions from synthetic fertiliser is due to a reduction in the agricultural area and implementation of ammonia reduction technology. The country wants to keep constant the number of dairy cattle with increased milk production from 2013 to 2035. No significant changes in N-excretion as well is in the allocation of the subcategories of non-dairy cattle; heifers, bulls and suckling cattle is expected until 2035. The number of sows is assumed to stay at the same level, production of weaners and fattening pigs will increase. All other livestock categories has been kept at a level equivalent to average production conditions in 2006-2010, until 2035. The CH_4 emission will nearly remain unchanged from 2011 to 2035. The decrease in emissions from manure corresponds to an increase in emissions from enteric fermentation. Furthermore, emission reductions are also affected by a decrease in N leaching and a decrease in the total area of cultivated organic soils.

LULUCF. Denmark expects that the whole LULUCF sector will be a net source of 3 Mt CO2 eq. in 2035. Until 2035 the emission trend is expected to be relatively stable. The major reason for this is that agricultural organic soils have been depleted for degradable organic matter and that the agricultural mineral soils are in an equilibrium state. Afforestation is expected to continue to take place in Denmark with an estimated rate of 1 745 hectare per year. Together with a very small deforestation rate, the C-stock in the Danish forest is expected to increase in the future. Agricultural regulations will reduce the area with cultivated agricultural organic soils further in the future, but there will still be a large net emission from these soils. Only limited conversion from forest or wetlands into cropland or grassland has occurred is expected to occur in the future. A decrease in cropland is expected. The conversion will mainly from Cropland to Forest, Grassland and Settlements.

No updated information concerning LULUCF in the Art.10 report

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 2.58 tCO_2/ha/yr), insertion of cover crops in the rotation schemes (0.41 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.51 tCO_2/ha/yr), and ley cropping system (0.35 tCO2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 0.9 $MtCO_2$/yr beyond BAU. The IPCC Tier 1 method for mineral soils estimated a loss in C stock resulting in an emission of 1.2 $MtCO_2$/yr for cropland and a removal of 0.01 $MtCO_2$/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry
Denmark is the only EU MS with FMRL being a (small) source in CP2. By 2030, CBM predicts a source in FM of 2.2 $MtCO_2$/yr for the reference scenario and a low additional mitigation potential (0.05 $MtCO_2$/yr) for -10%harvest. IIASA foresees in 2030 a sink of 0.3 $MtCO_2$/yr. For AR, CBM predicts a small increasing sink in 2030 (1.4 $MtCO_2$/yr) and a modest additional potential mitigation. IIASA predicts an even lower sink of 0.8 $MtCO_2$/yr.

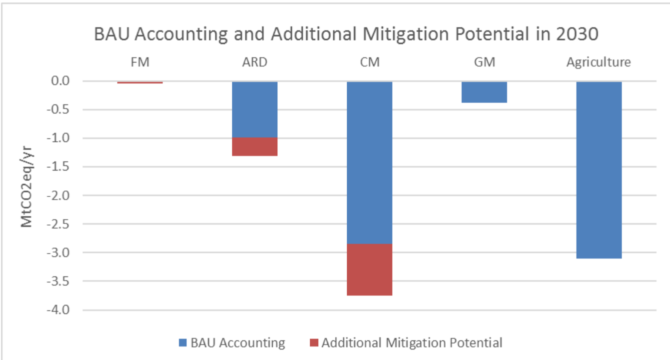
Fig. 3. Marginal abatement cost curves for 2020 for agriculture

No information found

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 69.4 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

France

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 17% of national GHGs excluding LULUCF, decreasing over time (average 1990-2012: 96.2 $MtCO_{2eq}$, reduced by 8.3 $MtCO_{2eq}$ from 1990 to 1st Commitment Period (CP1: 2008-2012)). Main drivers of emissions: agricultural soils for N_2O; cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 6% of national GHGs, increasing over time (average 1990-2012: -35.6 $MtCO_{2eq}$, sink increased by 12.3 $MtCO_{2eq}$ from 1990 to CP1). Main drivers: increased removals in forest land and lands converted to grassland, emissions from conversion to cropland and settlements, emissions from forest fires. For CP1, credits from AR and FM (each with 8.9 MtCO2eq/yr) and debits from D (14.6 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF

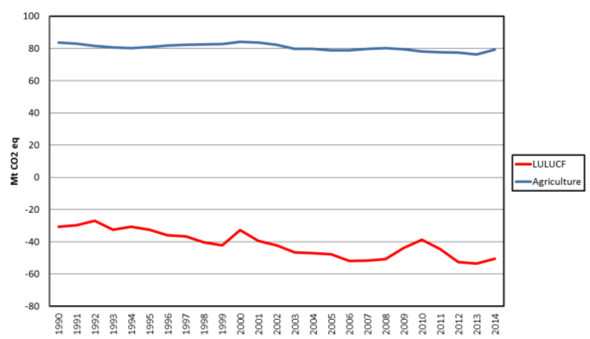


Fig. 2. Past trends of specific LULUCF categories

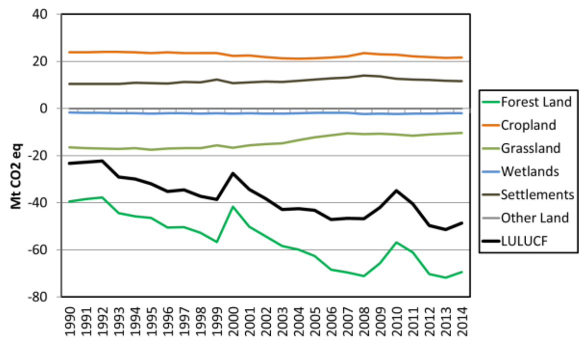


Table 23- state of play for LULUCF and Agriculture, and summary of available projections

France		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-34.8	(3)	-56.8	(3)	-67.4	-34.3	-34.2	(4)		-26.8	-40.7	(5)	0.0	0.0	(6)	0.0	0.0	(6)		-6.8	(7)
	AR			-8.2			-11.8	-13.3	(5)		-15.5	-16.3	(5)		-12.6	(6)		-15.9	(6)		-4.6	(7)
	D			12.0			10.3	5.9	(5)		7.0	4.0	(5)		8.1	(6)		5.5	(6)		-2.5	(7)
	CM	17.9		16.7			19.7	4.6	(5)		20.6	4.2	(5)		-5.7	(6)		-5.5	(6)		-7.1	(7)
	GM	-19.5		-14.0			-14.7	-0.1	(5)		-15.0	-0.2	(5)		12.1	(6)		11.9	(6)		0.0	(7)
	total (UNFCCC)	-29.6		-46.1			-30.9		(5)		-29.7		(5)									
Agriculture (2)	Soils N_2O	36.8	(3)	33.5	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	44.8		40.6					(5)				(5)			(6)			(6)			(7)
	total	83.6		76.2		87.7	73.8		(5)		72.8		(5)	4.1	-9.8	(6)		-10.8	(6)			(7)

*Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC)

AGRICULTURE is the third largest source of GHGs (over 21% in 2011), contributing 74% of CH_4 and 89% of N_2O emissions. The implementation of new policies permits a reduction of 20% in GHG emissions by 2020 in this sector compared with 1990. The reduction of N_2O emissions through better control of nitrogen fertilization and tackling organic nitrogen surpluses, remains a priority issue for the sector. The setting up of a thousand methane recovery units by 2020 should bring about a reduction of 0.95 Mt CO_2 eq. y^{-1} by that time. The measures of the EU CAP contribute indirectly to the maintenance and growth of carbon stores on parcels of land and in soils (especially measures promoting soil cover in autumn and winter, measures promoting hedges and agroforestry, or the agro-environmental grassland payment).

LULUCF. 6th NC does not include the new/updated projections for LULUCF. LULUCF data comes from the 5th NC. Forestry's contribution to the GHG reduction policy is based on three sections: the sustainability of carbon stores in forests and their mobilization, carbon storage in wood products, substitution of wood for fossil fuels. France expects a reduction in the size of the forest carbon sink in 2020, because increasing the surface area for forest would not be enough to make up for the loss of carbon storage resulting from increases in wood harvest and use for energy purposes. A very significant increase is provided for the harvesting of fuelwood under the form of wood chips. Land conversions are assumed to be constant.

No updated information concerning LULUCF in the Art.10 report

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (*CENTURY model*) estimated the maximum mitigation potentials for: conversion of arable land to grassland (sink of 3.5 tCO_2/ha/yr), insertion of cover crops in rotation schemes (0.75 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.81 tCO_2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 7.1 $MtCO_2$/yr beyond BAU. The *IPCC Tier 1 method* for mineral soils preliminary estimate for agricultural land use changes an emission of 4.2 (CM) and a removal of 0.19 (GM) $MtCO_2$/yr by 2030 under a reference scenario. For organic soils a possible relevant mitigation option is rewetting/increasing the water table. *CAPRI* identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

A recent study from INRA highlights a strong additional mitigation potential for the agricultural sector by 2030, mainly for N_20 from soils (10-32 $MtCO_2$/yr compared to current levels, depending on the calculation method, see Annex).

Forestry

For FM, the sink is highly dependent on future harvest. For CP2, the FMRL foresees a modest increase in harvest by 2020 (+6% compared to 2010) and a small decrease of the sink (note that the official FMRL is 67.4 $MtCO_2$/yr, shown in table 1 from 2020, in not comparable with latest GHG Inventory because a significant recalculation occurred after FMRL submission). By 2030, CBM predicts a sink of 40.7 $MtCO_2$/yr for reference scenario with an additional mitigation potential of 6.8 $MtCO_2$/yr for -10% harvest. IIASA foresees a declining sink of 26.8 $MtCO_2$/yr in 2030 due to increasing harvest.

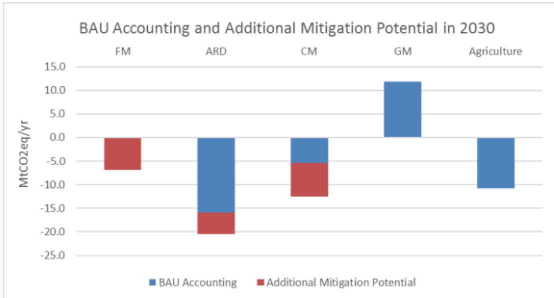
For AR, CBM predicts an increasing sink up to about 16.3 $MtCO_2$/yr in 2030 (similar values are modelled by IIASA), with significant additional potential. Both CBM and IIASA expects by 2030 a strong reduction in D emissions compared to CP1.

Fig. 3 Marginal abatement cost curves for 2020 for agriculture (INRA 2014):

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr) For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 549 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Estonia

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 7% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (CP1: 2008-2012): 1.3 $MtCO_{2eq}$, reduced by 1.9 $MtCO_{2eq}$ from 1990). Main drivers: direct agricultural soils emissions for N_2O; mature dairy cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 24% of national GHGs (average 1990-2012), decreasing over time (average CP1: -4.5 $MtCO_{2eq,}$ sink decreased by 4.3 $MtCO_{2eq}$ from 1990). The sector has resulted in a source for 2000-2003 due to intensive forest harvest. Main driver emissions and removals reported under forest land and removals reported under grassland. Organic soils are a significant source of emissions. For CP1, small credits from AR (0.1 $MtCO_{2eq}$/yr) and debits from D (0.6 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF (GHGI 2015)

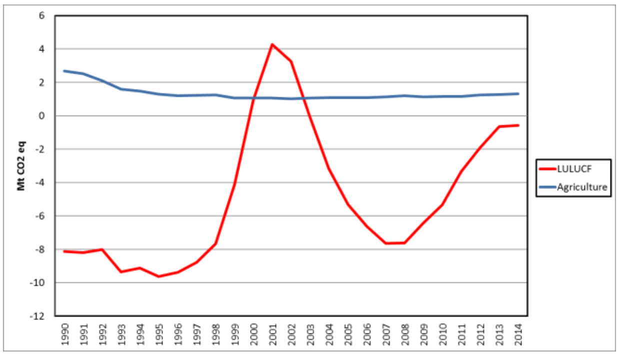


Fig. 2. Past trends of specific LULUCF categories (GHGI 2015)

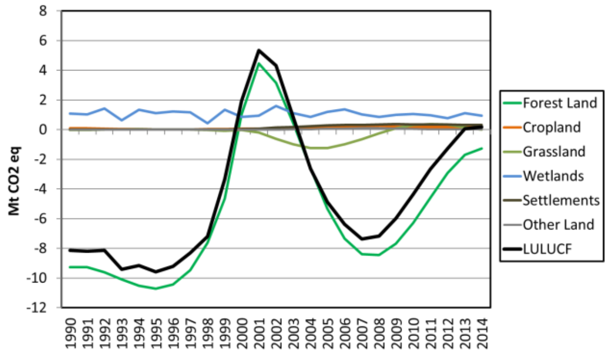


Table 24- state of play for LULUCF and Agriculture, and summary of available projections

Estonia		1990		2010		2020				2030				2020			2030					
all numbers are in $MtCO_{2eq}$ / yr		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-9.3	(3)	-5.3	(3)	-2.7	1.9	-0.3	(4)	-2.8	2.6	1.3	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.4	(7)
	AR			-0.7			-0.7	-0.5	(5)		-0.9	-0.6	(5)		-0.6	(6)		-0.8	(6)		-0.1	(7)
	D			0.4			0.5	0.1	(5)		0.2	0.1	(5)		0.3	(6)		0.1	(6)		0.0	(7)
	CM	0.1		0.2		0.1	0.1	3.0	(5)	0.1	0.0	3.1	(5)	0.0	1.4	(6)	0.0	1.5	(6)		-0.2	(7)
	GM	0.0		0.1		-0.1	0.1	0.0	(5)	-0.1	0.0	0.0	(5)	-0.1	0.1	(6)	-0.1	0.1	(6)		0.0	(7)
	total (UNFCCC)	-8.2		-4.9			1.8		(5)		2.0		(5)									
Agriculture (2)	Soils N_2O	1.1	(3)	0.5	(3)	0.7			(5)	0.7			(5)	-0.4		(6)	-0.4		(6)			(7)
	Livestock	1.5		0.7		0.6			(5)	0.6			(5)	-1.0		(6)	-1.0		(6)			(7)
	total	2.7		1.3		1.3	1.3		(5)	1.3	1.3		(5)	-1.4	-1.4	(6)	-1.4	-1.4	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. The Estonian Rural Development Plan 2014-2020 was adopted by the government on 22 May 2014. The objectives of the plan are the rural competitiveness, the sustainable management of natural resources and the balanced territorial development of rural areas. Further greening measures are set by the CAP. GHG emissions from the agriculture sector are not expected to vary significantly between 2010-2030. A small increase of 1.6 per cent is foreseen in this period, due to an increase in the number of cattle and in the amount of fertilizers used in agricultural lands. The most appropriate measures for Estonia in order to pursue the mitigation potential related to cropland management are the following: support for growing plants of local varieties, support for environmentally friendly management, support for the establishment of protective forest on agricultural land, organic farming, support for environmentally friendly horticulture, crop diversification measure and ecological focus area protection.

LULUCF. Most of the measures related to LULUCF activities were transferred to Estonian Rural Development Programme 2014-2020. The Estonian Forestry Development Programme until 2020 is the official sustainable development strategy for the Estonian forest sector. Its main objective is to ensure productivity and feasibility, and to assure the multifunctional and efficient use of forests. One of the aims is to increase the annual increment of carbon sequestration in forests by implementing appropriate forest management activities like regeneration, cleaning and thinning. Forest area grew steadily since 2004. As there are several EU support schemes at present for agriculture activities, only a slight increase in forest land is foreseen in the next years (mainly due to the conversion of grassland to forest land). The net removal from activities on forest land is expected to be around 2800 Gg CO2eq during 2022-2035 in case of the "WEM" scenario. According to "WAM" scenario, felling rates are expected to increase, reaching 15 mil. m3 in 2020 and starting to decrease again after a few years. From the year 2030 felling rate is expected to be 12 mil. m^3 per year. Therefore, FM and ARD will result in GHG net emissions since 2016 onwards, reaching the maximum in 2021 and being almost balanced out by 2035. Cropland Management is expected to remain a source, but emissions are foreseen to decrease in the period 2013-2035. Grasslands area should continue to decline in the near future, mainly due to natural afforestation. Grazing land Management is expected to act as a sink from 2015 to 2035, reaching its maximum in 2016 (net removal of 144 Gg CO2eq) and decreasing slightly thereafter until 2035. LULUCF status as a sink or a source of GHGs in the future will be determined by the intensity of forest felling, usage of peat soils and practices in CM and GLM. The area of infrastructure and settlements is expanding continuously, at the expense of all other mineral lands. In general, GHG emissions are expected to remain stable or increase in the near future.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.3 tCO_2/ha/yr), use of cover crops (0.8 tCO_2/ha/yr), and adoption of ley cropping systems (0.5 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.05 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.16 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock resulting in emissions of 3.1 $MtCO_2$/yr for cropland and of 0.039 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Estonia predicts (through IIASA/EFI/JRC data) a source, due to assumed increasing harvest (+35%).

By 2030, CBM predicts a FM source of 1.3 $MtCO_2$/yr for the reference scenario, with an additional mitigation potential of -0.4 $MtCO_2$/yr for a -10% harvest. IIASA predicts that FM will be a source in 2030 due to expected increase in harvest.

For ARD, CBM estimates slightly increasing AR sink (0.6 $MtCO_2$/yr), and a reduction of emissions from D in 2030. The AR sink predicted by IIASA in 2030 is higher than CBM's estimates (0.8 $MtCO_2$/yr), and in line with CBM also emissions from D are considerably reduced.

Fig. 3. Marginal abatement cost curves for 2020 for agriculture

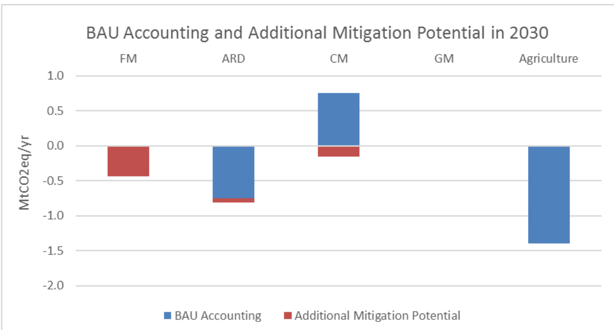
No information available

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 40 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Finland

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 8% of national GHGs excluding LULUCF (average 1990-2012), slightly decreasing over time (average 1st Commitment Period (CP1:2008-2012): 5.8 $MtCO_{2eq}$, reduced by 0.8 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 32% of national GHGs (average 1990-2012), increasing over time (average CP1: -28.4 $MtCO_{2eq}$ increased by 14.7 $MtCO_{2eq}$ from 1990) with interannual variability due to varying harvest rates. Main drivers: increased removals from forest remaining forest, increase emissions from conversions to cropland and wetlands; and decrease emissions in grassland and forest organic soils. For CP1 credits from AR and FM (-0.1 and -3.4 $MtCO_{2eq}$/yr) and debits from D (2.9 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF (GHGI 2015)

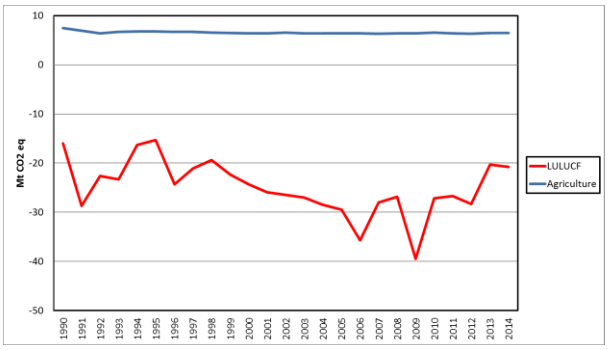


Fig. 2. Past trends of specific LULUCF categories (GHGI 2015)

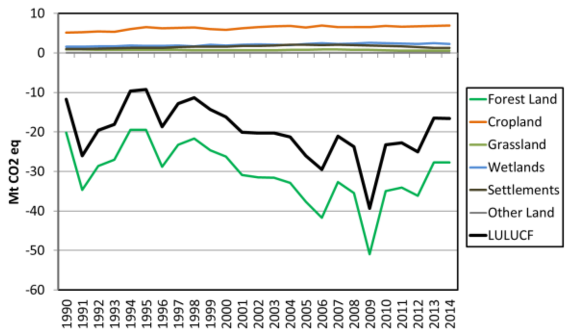


Table 25- state of play for LULUCF and Agriculture, and summary of available projections

Finland		1990		2010		2020				2030				2020			2030					
all numbers are in $MtCO_{2eq}$ / yr		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-22.8	(3)	-39.9	(3)	-20.5	-31.0	-31.8	(4)		-24.1	-27.2	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-3.8	(7)
	AR			-0.5			-0.7	-1.0	(5)		-0.9	-1.2	(5)		-0.9	(6)		-1.1	(6)		-0.1	(7)
	D			3.6			3.0	1.2	(5)		1.1	0.4	(5)		2.1	(6)		0.8	(6)		-0.3	(7)
	CM	4.3		5.0			4.6	6.3	(5)		4.1	9.5	(5)		1.1	(6)		2.5	(6)		-0.5	(7)
	GM	0.8		0.5			0.3	0.0	(5)		0.3	0.0	(5)		-0.6	(6)		-0.6	(6)		0.0	(7)
	total (UNFCCC)	-28.7		-29.7		-11.9	-23.9		(5)		-19.5		(5)									
Agriculture (2)	Soils N_2O	3.7	(3)	3.4	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	3.1		2.8					(5)				(5)			(6)			(6)			(7)
	total	7.5		6.5		5.9	6.0		(5)	FALSE	5.8		(5)	-1.6	-1.5	(6)	-7.5	-1.6	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario).

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Planned policies and measures in the 6th NC include the reduction of nutrient load on the environment, the increase of the area of multiannual crops on organic soils, while maintaining or improving the productive capacity of agricultural land. The quantitative effect of proposed measures were not estimated before the approval of the 2014–2020 programme, with the exception of long-term cultivation of grass on organic soils (-0.56 MtCO2 eq. in 2030). The emissions in agriculture are expected to remain at their current level until the year 2020, but there will be small changes in the distribution of the different emission sources. The decline in livestock numbers will slightly lower the emissions from enteric fermentation and manure management while a slight increase in soil N_2O emissions will compensate that effect. A further slight decrease in emissions is foreseen up to 2030.

LULUCF. This sector is expected to be a net sink in 2020-2030. The Finnish National Forest Programme 2015, estimates that the carbon sink of forests (including trees and soil) will remain at a level of at least 10-20 mil.t CO_2 eq. y^{-1}. The estimate is based on the assumption that loggings will increase by 10–15 mil. m^3/yr and that the use of wood for bioenergy will continue. The sustainable management of forests in Finland is based on legislation, good practices and soft law instruments such as guidelines for good forest management and certification. The maintenance of the forest carbon sink is a measure to improve sustainable forest management, and it is required as a means for conforming to the forest management reference level (–19.3 Mt CO_2) set for Finland for the second commitment period of the Kyoto Protocol. With regard to agricultural soils, CO_2 emissions from croplands and grasslands are not expected to be subject to large changes until 2020.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated maximum mitigation potentials for conversion of arable land to grassland (sink of 2.0 tCO_2/ha/yr), insertion of cover crops in the rotation schemes (0.9 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.48 tCO_2/ha/yr) and ley cropping system (0.35 tCO2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 0.5 $MtCO_2$/yr beyond BAU (Tab. 1). The IPCC Tier 1 method for mineral soils (not shown in Tab. 1) estimates a loss in C stock resulting in 9.5 $MtCO_2$/yr emissions for cropland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

CBM suggests that with the harvest assumptions made in the FMRL, Finland would have significant credits in CP2. However, these credits may be partly apparent, because seem largely due to a methodological inconsistency in their FMRL (identified during the FRML review), which will require a technical correction in CP2.

By 2030, CBM predicts a sink of 27.2 $MtCO_2$/yr for reference scenario, with an additional mitigation potential of 3.8 $MtCO_2$/yr with -10% harvest IIASA foresees a 24.1 $MtCO_2$/yr sink with an increasing harvest.

For AR, CBM predicts a slightly increasing sink in 2030 compared to 2020, with 1.2 $MtCO_2$/yr and low additional mitigation potential. For AR IIASA predicts a lower sink (0.9 $MtCO_2$/yr).

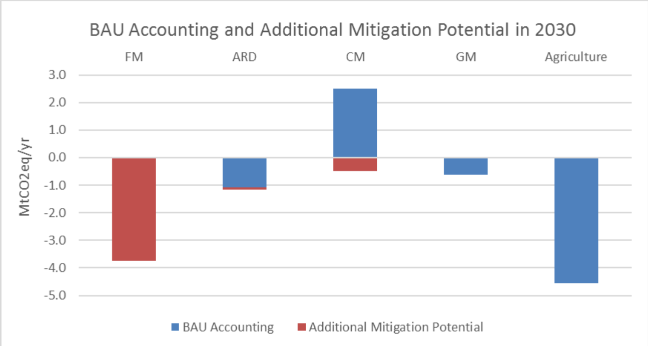
Fig. 3 Marginal abatement cost curves

No information found

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 71.1 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission

Greece

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 8% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (2008-2012): 9.2 $MtCO_{2eq}$, reduced by 2.2 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; sheep and cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 2% of national GHGs (average 1990-2012), slightly increasing over time (average CP1: -2.9 $MtCO_{2eq,}$ sink increased by 0.6 $MtCO_{2eq}$ from 1990). Main drivers: increased removals in forest and conversion to grassland and decreased removals in croplands. For CP1 small credits from AR and FM (0.14 and 0.33 Mt CO_{2eq}/yr) and small debits from D (0.05 $MtCO_{2eq}$/yr)

Areas of possible improvement of GHG inventory

Based on JRC analysis, Greece is recommended to check the following issues: consider to apply a growth rate related to the age of the AR events, develop a complete land use matrix able to capture all the conversions avoiding the notation key NE for activity data, and increase the completeness of the inventory or otherwise include more justifications to show that unaccounted C pools are "not a source".

Fig. 1. Agriculture & LULUCF: past trends and CP1 accounting

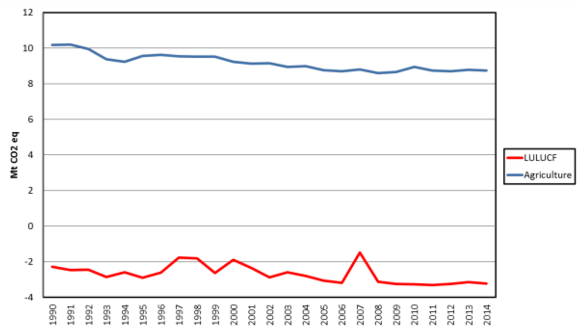


Fig. 2. Past trends of specific LULUCF categories

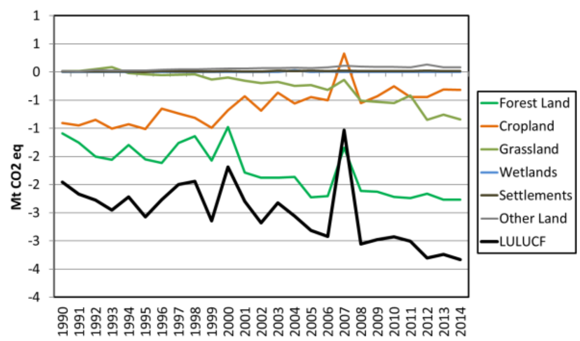


Table 26- state of play for LULUCF and Agriculture, and summary of available projections

Greece		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-1.1	(3)	-2.1	(3)	-1.8	-0.1	-0.9	(4)		0.0	-0.6	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.1	(7)
	AR			-0.1			-0.2	-0.3	(5)		-0.2	-0.3	(5)		-0.2	(6)		-0.2	(6)		0.0	(7)
	D			0.1			0.0	0.1	(5)		0.0	0.0	(5)		0.0	(6)		0.0	(6)		0.0	(7)
	CM	-0.9		-0.4			-0.4	2.7	(5)		-0.4	2.8	(5)		2.1	(6)		2.1	(6)		-0.7	(7)
	GM	0.0		-0.6			-0.7	-0.1	(5)		-0.7	-0.1	(5)		-0.4	(6)		-0.4	(6)		0.0	(7)
	total (UNFCCC)	-2.5		-3.2			-1.4		(5)		-1.3		(5)									
Agriculture (2)	Soils N_2O	4.8	(3)	3.3	(3)	5.0			(5)	5.9			(5)	0.2		(6)	1.2		(6)			(7)
	Livestock	5.2		5.2		3.6			(5)	4.3			(5)	-1.6		(6)	-0.9		(6)			(7)
	total	10.2		8.8		8.8	8.2		(5)	10.4	8.2		(5)	-1.4	-2.0	(6)	0.2	-2.0	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC)

AGRICULTURE. Greece plans to adopt the following measures: reduction in agricultural land use, reduction of agricultural production, adoption of rules for management of farm waste, increase of organic farming, and decrease in the use of synthetic nitrogen fertilizers by 30% beyond the limit defined in cross compliance system. In general, a declining trend in emissions from this sector is expected in the period 2013-2020. The declining trend could be attributed to a reduction in agricultural production and in the use of synthetic nitrogen fertilizers. For the period 2020-2030, an increase in emissions from the agriculture sector is foreseen as a consequence of anticipated economic recovery. Total GHG emissions from agriculture will decrease by 12% towards 2020 (8.8 $MtCO_2$ eq) but will then increase by 18.9% between 2020 and 2030 (10.4 $MtCO_2$ eq). The contribution of agricultural soils to the total emissions of the sector is 58%, while the contribution of enteric fermentation is around 35%. Although N_2O emissions from synthetic fertilizers and animal manure, and CH_4 emissions from cattle production (kg CH_4/head) remain constant for 2010 to 2020, the total N_2O and CH_4 emissions are expected to decrease due to reduction of fertilizer use and the decrease of livestock population.

LULUCF. The targets of the Greek policy regarding the LULUCF sector are the conservation and the protection of existing forest land, its gradual increase, as well as the improvement of the degraded forest lands. Additional identified measures are the prevention of forest fires, the reforestation of burnt and degraded (flood and erosion protection) forest lands, and the adaptation of forest management to climate change. An slight increase of LULUCF removals towards 2020 is expected along with a slight reduction of removals (-2.6 $MtCO_2$ eq.) in 2030.

No updated information concerning LULUCF in the Art.10 report

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 2.36 tCO_2/ha/yr), use of ley cropping systems (0.5 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.86 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.2 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.66 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated emissions of 2.7 $MtCO_2$/yr for cropland and removals of 0.08 $MtCO_2$/yr by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Greece used historical data to set FMRL (no projections), predicting a nearly stable sink.

By 2030, CBM predicts a sink of -0.6 $MtCO_2$/yr for reference scenario and an additional mitigation potential of 0.1 for -10% harvest. IIASA predicts a decrease of the FM sink reaching 0.9 $MtCO_2$/yr in 2030 due to increasing harvest by 2030.

For AR, CBM estimates a stable sink around 0.3 $MtCO_2$/yr in 2030. The AR sink predicted by IIASA is lower than CBM (0.17 $MtCO_2$/yr in 2030).

Fig. 3. Marginal abatement cost curves for 2020 for agriculture

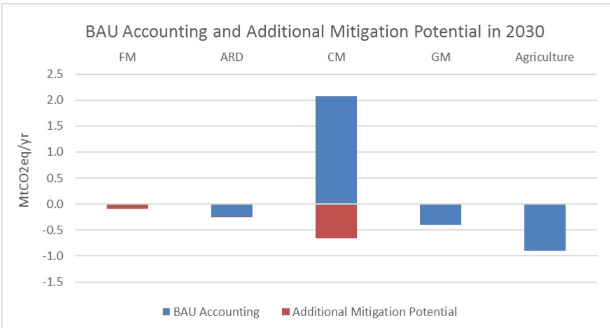
No information available.

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 104.8 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Croatia

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 13% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (CP1: 2008-2012): 3.5 $MtCO_{2eq}$, reduced by 1.2 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 28% of national GHGs (average 1990-2012), decreasing over time (average CP1: -6.7 $MtCO_{2eq,}$ sink decreased by 0.2 $MtCO_{2eq}$). Main drivers: removals from forest land and emissions from cropland and conversion to settlements. For CP1, small credits from AR and FM (0.2 and 1.0 $MtCO_{2eq}$/yr) and small debits from D (0.2 $MtCO_{2eq}$/yr).

Fig. 1. Agriculture & LULUCF: past trends and CP1 accounting

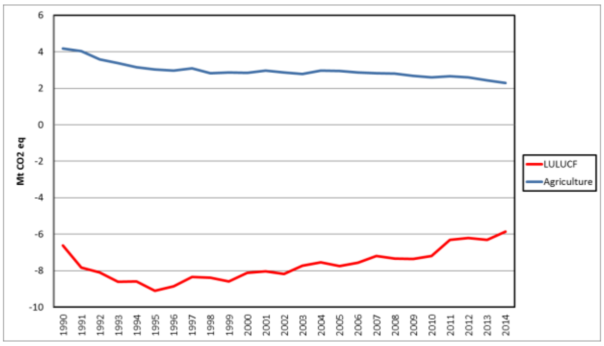


Fig. 2. Past trends of specific LULUCF categories

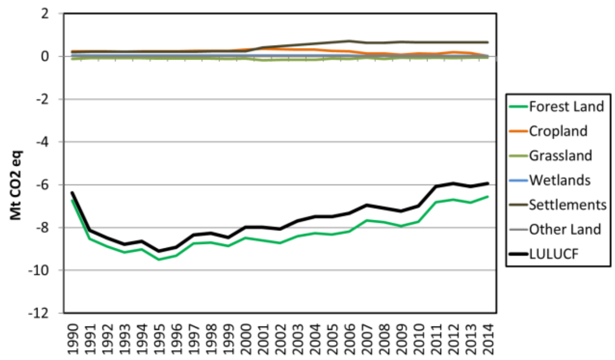


Table 27- state of play for LULUCF and Agriculture, and summary of available projections

Croatia		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-6.7	(3)	-7.3	(3)	0.0	-3.8	-4.0	(4)		-4.1	-3.8	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.9	(7)
	AR			-0.1			-0.3	-0.3	(5)		-0.5	-0.3	(5)		-0.3	(6)		-0.4	(6)		-0.1	(7)
	D			0.1			0.1	0.0	(5)		0.0	0.0	(5)		0.0	(6)		0.0	(6)		0.0	(7)
	CM	0.2		0.1			0.2	0.2	(5)		0.2	0.3	(5)		0.0	(6)		0.0	(6)		-0.2	(7)
	GM	-0.1		-0.1			-0.2	0.0	(5)		-0.2	0.0	(5)		0.0	(6)		0.0	(6)		0.0	(7)
	total (UNFCCC)	-7.8		-6.9			-4.0		(5)		-4.6		(5)									
Agriculture (2)	Soils N_2O	1.5	(3)	1.0	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	2.7		1.3					(5)				(5)			(6)			(6)			(7)
	total	4.2		2.4		3.7	2.7		(5)	3.9	2.8		(5)	-0.5	-1.5	(6)	-0.3	-1.4	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC)

AGRICULTURE. Croatia prepared a "Study about possibilities of applying measures to reduce GHG emissions in the agricultural sector". The projections indicate an increase in emissions by 2020 due to increasing numbers of livestock and expansion of agricultural areas. In all scenarios, emissions in 2030 remain the same as in 2025.

LULUCF. Croatia assumed that in the period up to the 2030 no significant variations in emissions/removals will occur, as the management systems will remain unchanged. In the category of state owned forests and private forests, it is assumed that the harvesting will have the same intensity as in 2012, while in the category of state forests managed by other legal bodies it was assumed that harvesting operations will be the average value of the last five years. Afforestation on new areas will follow the trend in period 1990-2012. No increase in forest areas is expected. Deforestation will continue with the same pace as in the last five years.

No updated information concerning LULUCF in the Art.10 report

Agriculture and LULUCF mitigation options and mitigation potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 4.4 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.8 tCO_2/ha/yr), and use of cover crops (0.7 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.04 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.17 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a quite limited loss in C stock resulting in emissions of 0.28 $MtCO_2$/yr for cropland and a sink of 0.004 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Croatia predicts a decrease in the sink, due to an assumed increasing harvest by 2020 (+40%; this seems to contradict the information on the NC).

By 2030, CBM predicts a FM sink of 3.8 $MtCO_2$/yr under the reference scenario, and 0.9 $MtCO_2$/yr as additional mitigation potential for +10% harvest. IIASA predicts in 2030 a quite stable FM sink of 4.1 $MtCO_2$/yr, slightly higher than CBM.

For ARD, CBM estimates a quite stable AR sink around 0.3, with an 0.1 $MtCO_2$/yr additional mitigation potential. The AR sink predicted by IIASA is a bit higher than CBM's estimates,

being at 0.54 $MtCO_2$/yr.

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Fig. 3. Marginal abatement cost curves for 2020 for agriculture

No information available.

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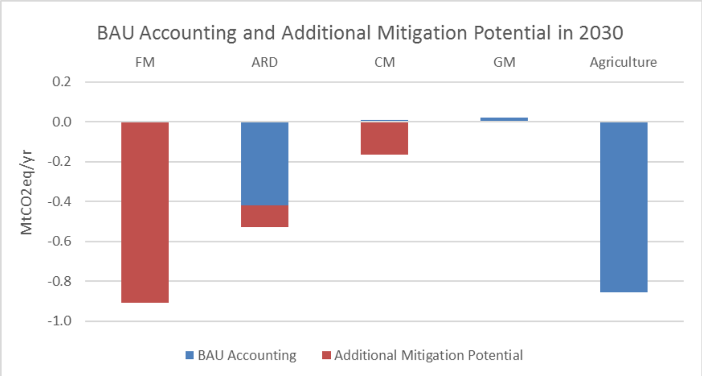
Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 34.8 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



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Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Hungary

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 13% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (CP1: 2008-2012): 8.7 $MtCO_{2eq}$, reduced by 6.5 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation and manure management of swine for CH_4.

LULUCF: net sink offsetting about 4% of national GHGs (average 1990-2012), increasing over time (average CP1: -4.1 $MtCO_{2eq,}$ sink increased by 2.1 $MtCO_{2eq}$ from 1990). Main drivers: increase removals in forest land and cropland. For CP1, credits from AR and FM (1.2 and 1.1 $MtCO_{2eq}$/yr) and small debits from D (0.1 $MtCO_{2eq}$/yr).

Fig. 1. Agriculture & LULUCF: past trends and CP1 accounting

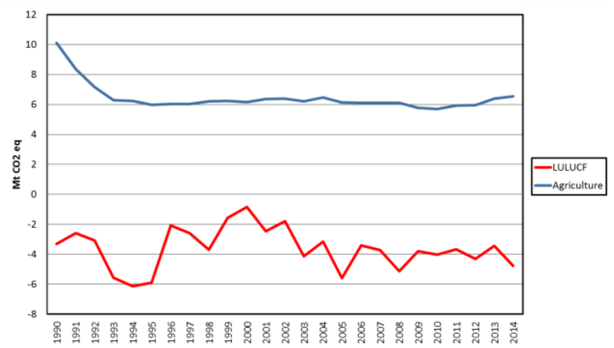


Fig. 2. Past trends of specific LULUCF categories

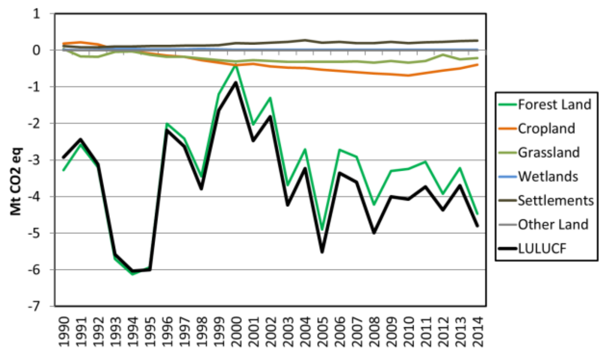


Table 28- state of play for LULUCF and Agriculture, and summary of available projections

Hungary		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-2.9		-2.2		-1.0	-1.2	0.1	(4)		-1.2	0.6	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.8	(7)
	AR			-1.3			-2.3	-3.2	(5)		-3.1	-3.2	(5)		-2.8	(6)		-3.1	(6)		-0.9	(7)
	D			0.1			0.1	0.1	(5)		0.1	0.0	(5)		0.1	(6)		0.1	(6)		0.0	(7)
	CM	0.1	(3)	-0.7	(3)		-1.4	4.5	(5)		-1.5	4.4	(5)		1.4	(6)		1.3	(6)		-1.3	(7)
	GM	0.0		-0.3			0.2	0.3	(5)		0.2	0.3	(5)		0.3	(6)		0.3	(6)		0.0	(7)
	total (UNFCCC)	-2.6		-4.2		-1.8	-4.6		(5)		-5.5		(5)									
Agriculture (2)	Soils N_2O	3.8		3.2					(5)				(5)			(6)			(6)			(7)
	Livestock	5.8	(3)	3.0	(3)				(5)				(5)			(6)			(6)			(7)
	total	10.1		6.4		9.9	6.9		(5)	9.9	6.6		(5)	-0.2	-3.2	(6)	-0.2	-3.5	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC)

AGRICULTURE. The National Rural Strategy and the Swine Strategy (Governmental Decree 1323/2012) are the most important Hungarian initiatives to reduce emissions. The NRS intends to favour the middle and small holder agricultural production structure. The strategy aims at improving the ecological performances of agricultural production and the spread of ecological agriculture. In animal husbandry the Swine Strategy set the goal to increase the number of pigs in the country from the current ca. 3 Million to 6 Million. In the poultry sector, inland consumption of meat and egg is aimed to be covered by national production. The grazing livestock should be maintained stable based on the grassland potential of the country. The GHG emissions from agriculture will increase reaching 9.5-10.0 Mt CO_2 eq in 2020.

LULUCF. The National Forest Programme 2006 - 2015 sets as a strategic objective the maintenance and possibly the increase of the current level of afforestation. According to this objective, the annual conversion of 3-6 kha of cropland and 2-4 kha of grassland to forest is planned. Additionally, the goal is to stabilize the increasing trend of soil friendly cultivation practices, such as direct sowing and reduced tillage until 2025. Hungary assumes an increase of harvest from 8 millions of m^3/yr to 10 millions m^3/yr by 2020, and then its stabilization until 2025. Hungary assumes that afforestation will occur on poor soil, with predominantly slow growing species, and at a rate of 5 ka each year until 2025. In the WAM scenario this area can be increased to 10 kha by 2025 (with a slow but steady increase each year), using predominantly fast growing species on better sites. In the forests remaining forests category, the net removals would slowly decrease even if the rate of harvests were stable. This is due to the current age class structure and the distribution of the current forests over site fertility. Future harvests will change this structure and distribution over time, which will affect the total net woody increment.

No updated information concerning LULUCF in the Art.10 report

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

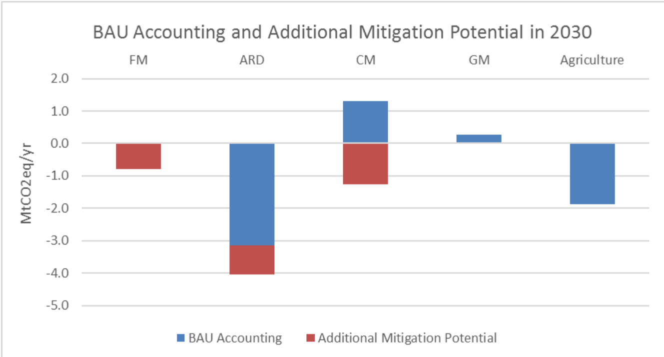
The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.9 tCO_2/ha/yr), ley cropping systems (0.6 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.5 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.4 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 1.3 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated emissions for 4.419 $MtCO_2$/yr for cropland and of 0.34 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Hungary predicts (through IIASA/EFI/JRC data) a slight decrease in the sink, due to higher assumed harvest (+20%).

By 2030, CBM predicts a FM source of 0.6 $MtCO_2$/yr for the reference scenario and an additional mitigation potential of 0.8 $MtCO_2$/yr for -10% harvest. IIASA predicts in 2030 a quite stable sink of 1.2 $MtCO_2$/yr.

For ARD, CBM estimates an almost constant AR sink till 2030 around 3.2 $MtCO_2$/yr. By contrast, IIASA predicts an increasing AR sink, reaching 3.1 $MtCO_2$/yr.

Fig. 3. Marginal abatement cost curves for 2020 for agriculture	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).**
No information available.	For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis. *Base year (1985-87) country total GHGs (without LULUCF): 94.1 $MtCO_{2eq}$/yr.* *Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.* 

Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Ireland

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 31% of national GHGs excluding LULUCF, decreasing over time (average 1990-2012: 19.4 $MtCO_{2eq}$, reduced by 1.7 $MtCO_{2eq}$ from 1990 to 1[st] Commitment Period (CP1:2008-2012)). Main drivers: agricultural soils for N_2O; cattle enteric fermentation and manure management for CH_4.

LULUCF: net sink offsetting about 4% of national GHGs (average 1990-2012: -2.2 $MtCO_{2eq}$, sink increased by 1.5 $MtCO_{2eq}$ from 1990 to CP1), increasing over time. Main drivers: increased removals from conversion to forest, emissions/removals from conversion from/to cropland and grassland, organic soil under forest land, and settlement expansion. For CP1, significant credits from AR (3.6 $MtCO_{2eq}$/yr) and small debits from D (0.3 $MtCO_{2eq}$/yr). FM not elected.

Fig. 1. Past trends of Agriculture and LULUCF

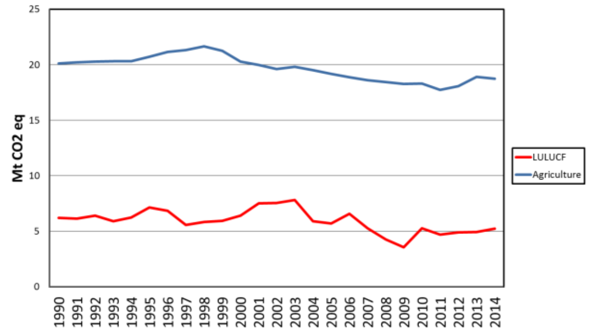


Fig. 2. Past trends of specific LULUCF categories

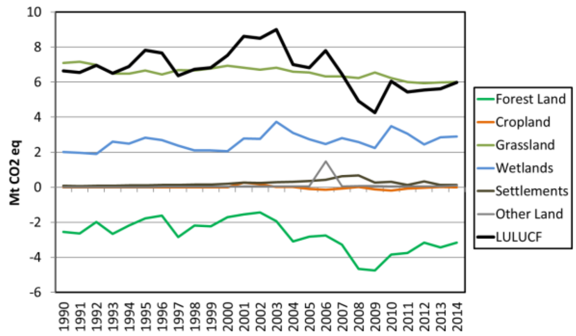


Table 29- state of play for LULUCF and Agriculture, and summary of available projections

Ireland		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-2.7	(3)	-0.8	(3)	-0.1	-1.1	-2.2	(4)	3.7	-0.4	-1.9	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.1	(7)
	AR			-3.4		-5.1	-2.8	-6.2	(5)	-5.0	-3.5	-6.8	(5)	-5.1	-4.5	(6)	-5.0	-5.2	(6)		-1.8	(7)
	D			0.3		0.6	0.2	0.2	(5)	0.7	0.2	0.1	(5)	0.6	0.2	(6)	0.7	0.2	(6)		-0.1	(7)
	CM	0.0		-0.1			0.3	2.5	(5)		0.3	2.7	(5)		1.4	(6)		1.5	(6)			(7)
	GM	6.7		5.5			0.0	0.5	(5)		-0.1	0.5	(5)		-6.4	(6)		-6.5	(6)		0.0	(7)
	total (UNFCCC)	6.1		4.5			-3.4		(5)		-3.5		(5)									
Agriculture (2)	Soils N_2O	6.5	(3)	6.1	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	13.2		12.3					(5)				(5)			(6)			(6)			(7)
	total	20.1		18.9		19.4	20.4		(5)	19.4	21.5		(5)	-0.7	0.2	(6)	-0.7	1.4	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Ireland's 6th NC predicts an increase in emissions by 12% between 2011 and 2020 as a result of the targets set out in Food Harvest 2020 (BAU scenario). This is mainly driven by a projected increase in the dairy cow numbers (following the abolition of milk quotas in 2015), in the sheep and pig population, and in fertilizer nitrogen use. Planned policies and mitigation measures up to 2020: retention of permanent grassland, crop diversification, reduce stocking densities on land, improve the management of organic manures and chemical fertilizers, increase the organic farming on 5% of utilizable agricultural area, retained permanent grasslands in good condition, reducing the age of cattle slaughtered (reduce CH_4 emissions). A further increase in emissions is foreseen up to 2030.

LULUCF. The new National Forestry Programme 2014-2020 aims at encourage private landowners to plant trees and replant after felling, with the goal to increase forest cover from current 10% to 17% in 2030 (which means doubling past AR rate). This programme included additional afforestation activities of 8,000 ha per year and an annual premium for 15 years to land owners to afforest and maintain plantations in good health. According to the submission under the Article 10 of Decision 529 (2013), these additional afforestation activities are expected to increase the removal potential by 233 Gg CO_2 eq. per year over the CP2, reaching 1009 Gg CO_2 eq. per year over the period 2021-2030. If the strategic afforestation target of 15,000 ha per year is met, additional removals of 219 and 1,101 Gg CO_2 eq. per year are expected for the periods 2013-2020 and 2021-2030, respectively. Current levels of deforestation are ca. 2.4 times higher than pre-2005 levels. The reduction to the pre-2005 level (ca. 500 ha per year) could result in a potential reduction of emissions of ca. 250-1,500 Gg CO_2 eq. over the period 2013-2020. Deforestation is primarily related to conversion back to pastures and wind farm projects on previously forested areas. In terms of Forest Management, the level of harvest is the most important factor influencing the sequestration. The Forestry Act 2014 limits emissions through a felling licence which requires high levels of replanting as a standard condition. A recent climate change report (CCPR 2012) mentions a potential increase of the sink in GM and a reduction of emissions from peatland by 2050.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

JRC. The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 4.6 tCO_2/ha/yr), insertion of cover crops in the rotation schemes (1.1 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.9 tCO_2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 0.3 $MtCO_2$/yr beyond BAU. The IPCC Tier 1 method for mineral soils estimate an emission of 2.7 $MtCO_2$/yr for CM and of 0.5 $MtCO_2$/yr for GM by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

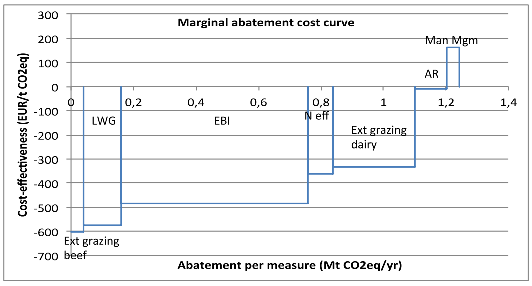
OTHER SOURCES. For Agriculture, O'Brien et al. (2014) estimate by 2020 a potential of 1.2 Mt CO_{2eq}/yr beyond BAU, mainly in livestock. IIASA (Gains/Epic) estimate by 2030 a decrease of Agriculture emissions by 0.9 $MtCO_2$/yr compared to 1990, and an increase in GM sink by 0.5 $MtCO_2$/yr by 2030.

Forestry

For FM, CBM foresees a sink of -1.9 $MtCO_2$/yr by 2030 under a reference scenario, with a small additional mitigation potential for -10% harvest, while IIASA expects a smaller sink (0.4 $MtCO_2$/yr).

For AR, CBM estimates in 2030 a stable sink compared to 2020 of 6.8 $MtCO_2$/yr with an additional potential of 1.8 $MtCO_2$/yr for -10% harvest. IIASA predicts a lower sink for AR in 2030 (3.5 $MtCO_2$/yr) than CBM. D is considered very small by both CBM and IIASA, which provide similar estimates.

Fig. 3 Marginal abatement cost curves for 2020 for agriculture (O'Brien et al., 2014) and AR (abatement from CBM; costs from Moran et al., 2011).

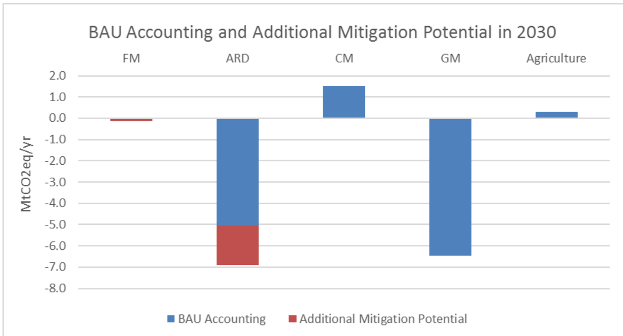


From left to right: Extended grazing season – beef; Increased daily weight gain beef cattle (LWG); Accelerated gains in the genetic merit of dairy cows as measured by the Economic Breeding Index (EBI); Increased nitrogen efficiency; Extended grazing season – dairy; Afforestation; Manure management.

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 56.1 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Italy

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 7% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (2008-2012): 34.5 $MtCO_{2eq}$, reduced by 6.3 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation, manure management and rice cultivation for CH_4.

LULUCF: net sink offsetting about 4% of national GHGs (average 1900-2012), increasing over time (average CP1: -24.5 $MtCO_{2eq,}$ sink increased by -20.9 $MtCO_{2eq}$ from 1990). Main drivers: increased removals from forest land, increased removals in grassland, significant emission form conversion to settlements and wildfires in forests and grasslands. For CP1 significant credits from AR and FM (6.8 and 10.1 Mt CO_{2eq}/yr) and debits from D (1.9 Mt CO_{2eq}/yr).

Fig. 1. Past trends in Agriculture and LULUCF:

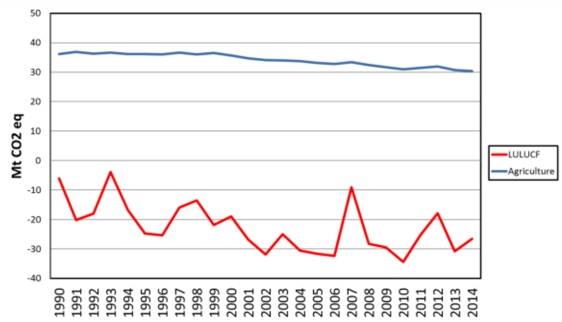


Fig. 2. Past trends of specific LULUCF categories

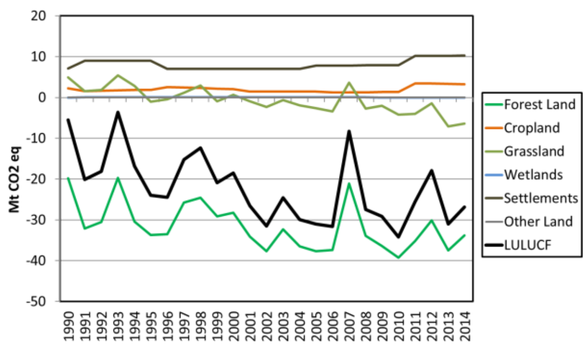


Table 30- state of play for LULUCF and Agriculture, and summary of available projections

Italy		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-16.8		-27.9		-22.2	-20.7	-21.2	(4)		-18.1	-16.2	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-1.5	(7)
	AR			-7.1			-11.7	-9.6	(5)		-14.8	-10.9	(5)		-10.6	(6)		-12.9	(6)		-1.5	(7)
	D		(3)	1.9	(3)		0.2	0.1	(5)		0.2	0.2	(5)		0.1	(6)		0.2	(6)		-0.1	(7)
	CM	2.1		2.1		-8.7	2.2	0.7	(5)	-6.1	2.6	0.7	(5)	-10.8	-0.7	(6)	-8.2	-0.5	(6)		-2.5	(7)
	GM	-1.0		-6.0		-4.4	-2.8	0.0	(5)	-4.4	-3.1	0.0	(5)	-3.3	-0.4	(6)	-3.3	-0.5	(6)		0.0	(7)
	total (UNFCCC)	-20.2		-27.0			-32.7		(5)		-33.2		(5)									
Agriculture (2)	Soils N_2O	11.3		9.5		15.6			(5)	15.6			(5)	4.3		(6)	4.3		(6)			(7)
	Livestock	22.5	(3)	19.2	(3)	16.2			(5)	16.0			(5)	-6.4		(6)	-6.5		(6)			(7)
	total	36.2		30.8		33.4	30.6		(5)	33.4	30.0		(5)	-2.8	-5.6	(6)	-2.8	-6.2	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. No planned policies and measures concerning agriculture towards 2030 are mentioned in 6th NC. For this sector the total emissions are stable or continue to decline slightly. In particular, Italy expects a reduction of agriculture emissions compared to 2010 equal to -2.0%, -2.3%, and -2.5% for 2015, 2020 and 2030. Emission trends are due to the reduction in activity data such as the number of animals, the cultivated surface/crop production, and the use of nitrogen fertilizers, mainly linked to Common Agricultural Policy (CAP) measures. The main drivers for GHGs emission reductions are given by manure management (-17.6% in 2030), this source accounts for 18.3% of total agricultural emissions in 2010.

LULUCF. The 6th NC does not provide clear information on projections. It is mentioned that forestry/LULUCF will be a sink of about -32 MtCO_2 eq. in 2020 and -29.5 MtCO_2 eq. in 2030. Apparently these estimates refer to forest land and come from the extrapolation of the available time series. The Decision 529/2013/EU (LULUCF) Article 10 Report indicates that FMRL for Italy is equal to -22,17 Mt CO2 eq. per year applying a first-order decay function for (HWP) and to –21,182 Mt CO2 eq. per year assuming instantaneous oxidation of HWP. It also reports the projections for CL (-8.65/-6.073 Mt CO2 eq.) and GL (-4.358/-4.363 Mt CO2 eq.) related to 2020 and 2030.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 2.43 tCO_2/ha/yr), adoption of ley cropping systems (0.47 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.6 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.70 MtCO_2/yr beyond BAU for a more economical-oriented scenario up to 2.51 MtCO_2/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated emissions of 5.2 MtCO_2/yr for cropland and a removal of 0.85 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits). Estimates for CM and GM in 2020 and 2030 in tab 1 come from IIASA (after calibration with country's GHG inventory, done by JRC)

Forestry

For FM, in CP2 Italy predicts (IIASA/EFI/JRC estimates done for FMRL) a decrease of FM sink, due to a significant increase in harvest (+26% relative to 2005).

By 2030, CBM predicts a sink of 16.2 MtCO_2/yr, under the reference scenario, with an additional mitigation potential of 1.5 MtCO_2/yr for -10% harvest. For 2030, IIASA

predicts a sink of 14.8 $MtCO_2$/yr with an increasing harvest. For AR, CBM estimates relevant BAU credits in 2030 (10.9 $MtCO_2$/yr), with limited additional mitigation potential (1.5 $MtCO_2$/yr). IIASA predicts an increase in AR sink reaching 14.8 $MtCO_2$/yr in 2030.

Fig. 3. Marginal abatement cost curves for 2020 for agriculture

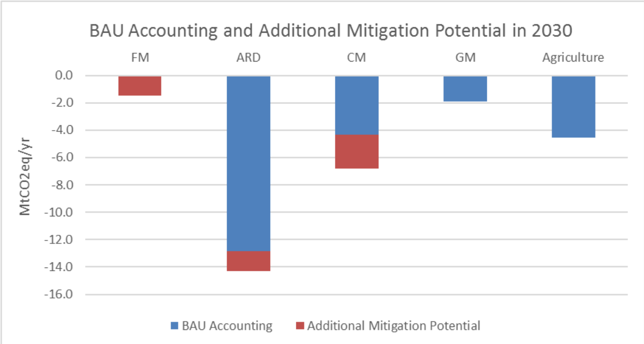
No information available

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year country total GHGs (without LULUCF) : 521.9 $MtCO_2eq$.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Lithuania

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 22% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (CP1: 2008-2012): 5.0 $MtCO_{2eq}$, reduced by 5.3 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; swine manure management and cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 28% of national GHGs (average 1990-2012), increasing over time but with some years resulting in a source of emissions due to natural disturbances, (average CP1: -9.7 $MtCO_{2eq,}$ sink increased by 5.4 $MtCO_{2eq}$ from 1990). Main drivers: removals from forest land and grasslands and emissions from conversion to cropland. For CP1, credits from AR and FM (-0.2 and -1.0 $MtCO_{2eq}$/yr) and debits from D (0.1 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF (GHGI 2015)

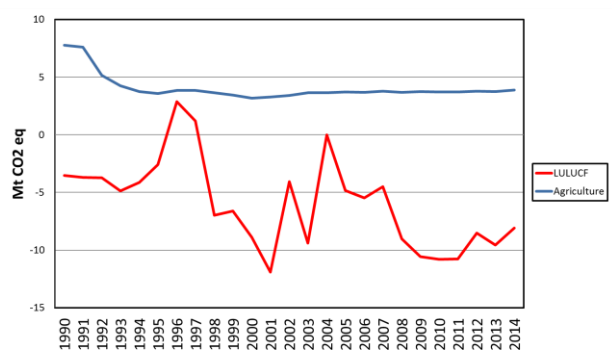


Fig. 2. Past trends of specific LULUCF categories (GHGI 2015)

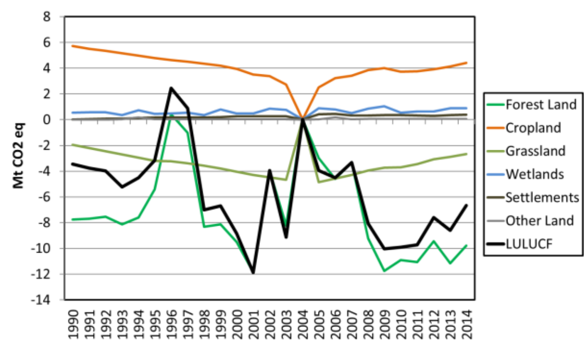


Table 31- state of play for LULUCF and Agriculture, and summary of available projections

Lithuania		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-7.1	(3)	-9.8	(3)	-4.6	-7.7	-8.0	(4)		-7.8	-7.9	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.5	(7)
	AR			-1.2			-1.2	-1.3	(5)		-1.6	-1.8	(5)		-1.2	(6)		-1.7	(6)		-0.5	(7)
	D			0.0			0.0	0.0	(5)		0.0	0.0	(5)		0.0	(6)		0.0	(6)		0.0	(7)
	CM	5.3		3.6			3.6	5.2	(5)		3.5	4.9	(5)		-0.9	(6)		-1.1	(6)		-0.4	(7)
	GM	-2.0		-3.6			-3.4	0.1	(5)		-3.5	0.1	(5)		0.3	(6)		0.2	(6)		0.0	(7)
	total (UNFCCC)	-3.7		-9.9		-12.0	-8.7		(5)	-12.5	-9.5		(5)									
Agriculture (2)	Soils N_2O	2.4	(3)	1.7	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	5.3		2.0					(5)				(5)			(6)			(6)			(7)
	total	7.8		3.7		5.7	5.4		(5)	5.9	5.5		(5)	-2.1	-2.4	(6)	-1.8	-2.3	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. A Regional Development Plan for 2014-2020 is under development. A 2% decrease in dairy cattle population is expected by 2020, and again another 0.4% per year decrease until 2030. An 8% increase in non-dairy cattle population is expected during 2015-2020. Swine population is expected to increase by 5.5% up to 2020 and by 1% per year for 2020-2030.

LULUCF. Lithuania plans to increase the forest area by 3% by 2020, reaching 34% of the land area. Forest will then remain stable until 2030. Afforestation is planned to increase by nearly 3 kha per year reaching an area of approximately 100-120 kha, mainly on abandoned land and land unsuitable for agricultural purposes. Croplands are assumed to be decreasing, converted mainly to grassland. Lithuania expects that more than -9.8 Mt CO_{2eq} to be removed annually in 2012-2020 and increase of CO_2 removals in the LULUCF sector reaching -12.5 $MtCO_{2eq}$ in 2030.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

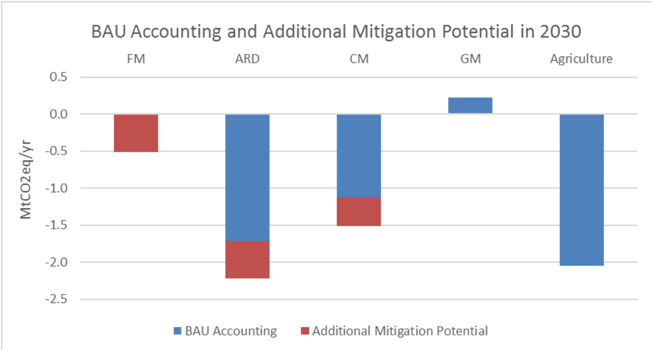
The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.2 tCO2/ha/yr), use of cover crops (0.5 tCO2/ha/yr), ley cropping systems (0.4 tCO2/ha/yr) and reduced tillage and crop residues incorporation (0.4 tCO2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.1 MtCO2/yr beyond BAU for a more economical-oriented scenario up to 0.4 MtCO2/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock resulting in 1.3 MtCO2/yr for cropland and of 0.07 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

In 2011, for FMRL in CP2, Lithuania predicted (through IIASA/EFI/JRC data) a decrease in the sink, despite a slight decrease in harvest. Given the significant changes in GHG inventory since 2011, a technical correction to FM is surely needed.

By 2030, CBM predicts a FM sink of 7.9 $MtCO_2$/yr for reference scenario, with an additional mitigation potential of -0.5 $MtCO_2$/yr for -10% harvest. In line with CBM, IIASA predicts in 2030 a sink of 7.8 $MtCO_2$/yr.

For ARD, CBM estimates increasing AR sink, up to -1.8 $MtCO_2$/yr in 2030. The AR sink predicted by IIASA is comparable to CBM's estimates (1.6 $MtCO_2$/yr).

Fig. 3. Marginal abatement cost curves for 2020 for agriculture	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).** For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.
No information available.	*Base year (1990) country total GHGs (without LULUCF): 47 $MtCO_{2eq}$/yr.* *Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.* 

Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Latvia

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 20% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (2008-2012): 2.3 $MtCO_{2eq}$, reduced by 3.6 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation, cattle enteric fermentation for CH_4.

LULUCF: net sink, decreasing over time. Note that the GHGI 2015 (shown in Fig 1 and 2) significantly recalculated the whole time series (much lower sink) mainly due to new data from NFI. Table 1 is still based on GHGI 2014 (because it includes credits accounted in CP1). Main drivers: significant removals from forest land and emissions from organic soils and croplands. For CP1 significant credits from AR and FM (-0.3 and -2.2 Mt CO_{2eq}/yr) and debits from D (1.2 Mt CO_{2eq}/yr).

Fig. 1. . Agriculture & LULUCF: past trends and CP1 (GHGI 2015)

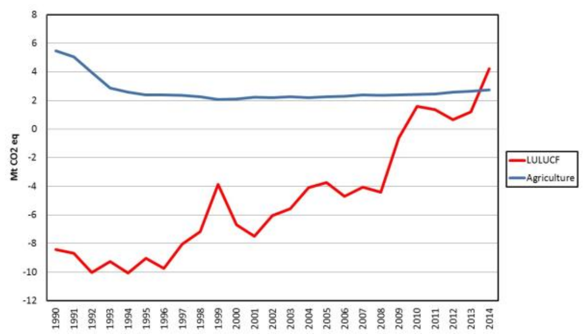


Fig. 2. Past trends of specific LULUCF categories (GHGI 2015)

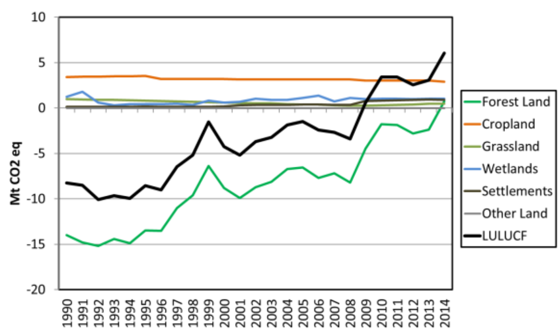


Table 32- state of play for LULUCF and Agriculture (GHGI 2014), and summary of available projections

Latvia		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-14.6	(3)	-4.2	(3)	-16.3	-1.8	-8.9	(4)		-0.7	-7.5	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-1.1	(7)
	AR			-0.3			-0.8	-0.8	(5)		-1.5	-1.2	(5)		-0.8	(6)		-1.3	(6)		-0.1	(7)
	D			1.2			4.2	2.8	(5)		0.5	0.2	(5)		3.5	(6)		0.3	(6)		-0.1	(7)
	CM	2.8		2.5			1.0	3.5	(5)		0.9	3.9	(5)		-0.5	(6)		-0.3	(6)		-0.2	(7)
	GM	0.9		0.2			-0.5	0.1	(5)		-0.5	0.1	(5)		-1.1	(6)		-1.1	(6)		0.0	(7)
	total (UNFCCC)	-8.7		-0.3		-18.3	2.0		(5)	-13.5	-1.3		(5)									
Agriculture (2)	Soils N_2O	2.3	(3)	1.6	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	2.7		1.0					(5)				(5)			(6)			(6)			(7)
	total	5.5		2.6		3.1	2.1		(5)	4.6	2.1		(5)	-2.3	-3.3	(6)	-0.8	-3.3	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and the Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. A sharp increase of total GHG emissions is expected, with +2% in 2015, +35% by 2020 and close to +100% by 2030 when compared to 2010, although 2030 emissions remain lower than those in 1990. The National Development Plan for 2014–2020 sets targets to increase the percentage of cultivated land (with respect to the total agricultural land) by 95% until 2020 as well as to expand the organic farming area by 15% in 2030. Dairy and non-dairy cows are expected to increase respectively by 34% and by 80% by 2030 compared to 2010, leading to a 73% increase of CH_4 emissions. CH4 emissions from manure management are expected to double following a 60% increase of cattle, 77% of swine, 200% of sheep and 23% of poultry. The foreseen increasing use of anaerobic digesters as manure management system should limit the growth of N_2O emissions from manure management. The calculated amounts of synthetic N fertilizers are linked to a planned significant increase of areas for agricultural crops; the cultivation of histosoils will be however reduced.

LULUCF. Net removals in 2030 will decrease by -13.5 $MtCO_{2eq}$ due to the reduction of the gross increment in forest land due to the ageing of forests, and to conversions from grassland to cropland. Net emissions from forest land, including deforestation and afforestation, will reach -16.7 $MtCO_{2eq}$ in 2030. Contrary to what is written in the agricultural section, the LULUCF section in NC6 says that the cultivation of organic soils is not expected to decrease until 2030. By 2030 grassland will become a net sink. The net annual GHG emissions in LULUCF will increase to 5.1 $MtCO_{2eq}$ by 2020 and to 7.4 $MtCO_{2eq}$ by 2030. The implemented measures include the increase of the felling stock in forest land by 10% during 2015-2020 in comparison with 2009-2013, increasing deforestation to build new settlements (mostly roads), and conversion of grasslands to cropland in abandoned farmlands not used in production for at least 10 years. According to the projection with already implemented measures, the net CO_2 removals in forest land will be reduced in 2020 by 67% and in 2030 by 95% compared to 2012. GHG emissions in cropland will increase in 2020 by 12 % and in 2030 by 11 % in comparison to 2012.

Agriculture and LULUCF mitigation options and potentials for the 2030 framework

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.0 tCO_2/ha/yr), use of cover crops (0.7 tCO_2/ha/yr), and ley cropping system (0.6 tCO_2/ha/yr), while the contribution of reduced tillage and crop residues incorporation is quite less relevant compared to what happens in other countries (between 0.15 and 0.2 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.06 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.2 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated emissions of 3.9 $MtCO_2$/yr for cropland and emissions for 0.06 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, or legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Latvia predicts (through IIASA/EFI/JRC data) a slight decrease in the sink, mainly due to slightly increasing harvest. The significant recalculation in GHGI 2015 will require an important technical correction.

By 2030, CBM predicts a FM sink of -7.5 $MtCO_2$/yr for reference scenario, with an additional mitigation potential of 1.1 $MtCO_2$/yr. IIASA foresees in 2030 a significant drop of FM sink (reaching 0.7 $MtCO_2$/yr, about 1.2 $MtCO_2$/yr below 2020 estimates).

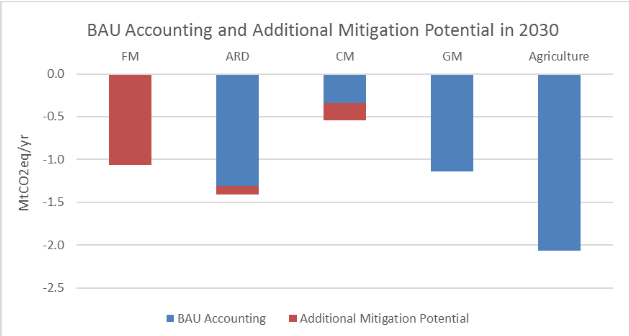
For ARD, CBM estimates an increasing AR sink (1.2 $MtCO_2$/yr in 2030). The AR sink predicted by IIASA is comparable to CBM's estimates (1.5 $MtCO_2$/yr).

Fig. 3 Marginal abatement cost curves

No information available.

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 26.1 $MtCO_2eq$. Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Luxemburg

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 6% of national GHGs excluding LULUCF (average 1990-2012), slightly decreasing over time (average 1st Commitment Period (CP1:2008-2012)): 0.7 $MtCO_{2eq}$, reduced by 0.1 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation and swine manure management for CH_4.

LULUCF: net sink offsetting about 3% of national GHGs (average 1990-2012), slightly increasing over time (average CP1: -0.4 $MtCO_{2eq,}$ sink increased by 0.8 $MtCO_{2eq}$ from 1990), sector change from small source to small sink. Main drivers: increased removals from forest and conversions to grassland and decrease emissions from conversions to settlements. For CP1, small credits from AR (0.1 $MtCO_{2eq}$/yr) and small debits from D (0.03 $MtCO_{2eq}$/yr). FM not elected.

Fig. 1. past trends OF Agriculture and LULUCF

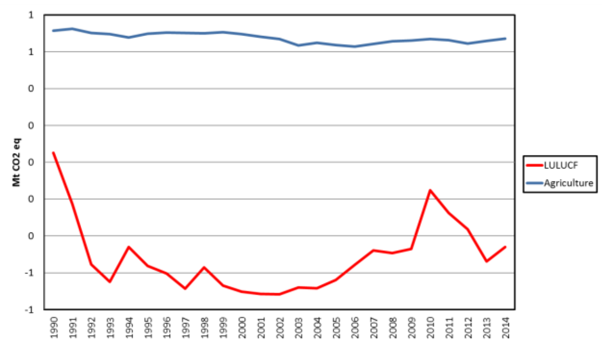


Fig. 2. Past trends of specific LULUCF categories

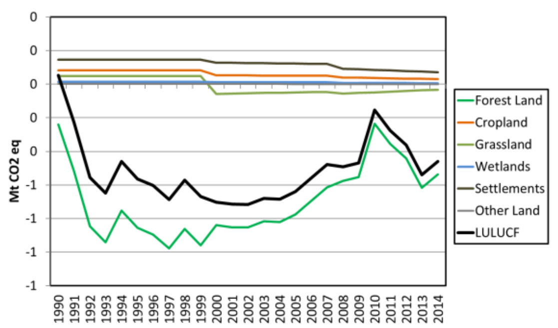


Table 33- state of play for LULUCF and Agriculture, and summary of available projections

Luxembourg		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	0.1	(3)	-0.3	(3)	-0.4	-0.3	-0.3	(4)		-0.2	-0.2	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		0.0	(7)
	AR			-0.2			-0.1	-0.1	(5)		-0.2	-0.1	(5)		-0.1	(6)		-0.2	(6)		0.0	(7)
	D			0.0			0.3	0.2	(5)		0.2	0.1	(5)		0.2	(6)		0.1	(6)		0.0	(7)
	CM	0.0		0.0			0.0	0.0	(5)		0.0	0.0	(5)		0.0	(6)		0.0	(6)			(7)
	GM	-0.1		-0.1			-0.1	0.0	(5)		-0.1	0.0	(5)		0.1	(6)		0.1	(6)		0.0	(7)
	total (UNFCCC)	-0.2		-0.4			-0.1		(5)		-0.3		(5)									
Agriculture (2)	Soils N_2O	0.2	(3)	0.2	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	0.5		0.5					(5)				(5)			(6)			(6)			(7)
	total	0.7		0.7		0.6	0.7		(5)	0.5	0.7		(5)	-0.2	-0.1	(6)	-0.2	0.0	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC)

AGRICULTURE. Development of the following agro-forestry activities: mixing agricultural activities (crops, livestock) and forestry. Luxemburg forecasts a decrease of total GHG emissions in the agriculture sector (-24%) up to 2030, reaching 0.6 M t CO_{2eq}. The 6th NC does not include any national projections of specific agricultural practices.

LULUCF. Luxembourg plans optimisation of carbon storage in forests as well as in cultivated land. There are no quantitative projections for anthropogenic GHG emissions and removals for forestry activities. It was actually foreseen that these activities would not result in significant net sinks. Because Luxembourg's relative forest surface is rather high (35% of country area), there is no strong demand for afforestation or reforestation. Early deforested area is more or less constant and low. It is more likely that the country forest area will remain constant or will slightly decline. There are no estimates for the LULUCF sector projections.

The Art.10 report is not available.

Agriculture and LULUCF mitigation options and potentials for the 2030 framework

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 4.8 tCO_2/ha/yr), use of cover crops (0.9 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (1.2 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 2000 tCO_2/yr beyond BAU for a more economical-oriented scenario up to 6000 tCO_2/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock resulting in 0.004 $MtCO_2$/yr for cropland and a removal of 0.02 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

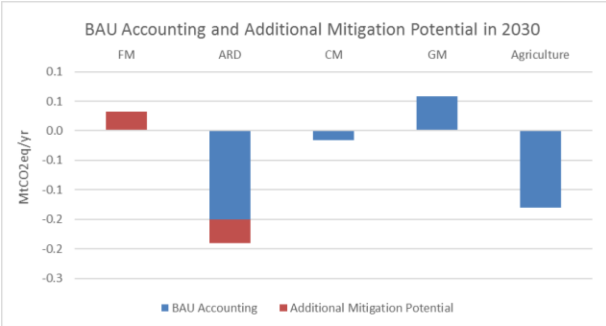
Forestry

For FM, in CP2 Luxembourg predicts (through IIASA/EFI/JRC data) a slight decrease in the sink, despite constant harvest.

By 2030, CBM predicts a FM sink of 0.16 $MtCO_2$/yr. IIASA predicts a decrease of FM sink reaching 0.25 $MtCO_2$/yr in 2030, associated to slight increase in harvest.

For ARD sink in 2030 is considered quite small by both CBM and IIASA.

Fig. 3 Marginal abatement cost curves	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).** For each activity, the average of MS+model data in tab. 1 are shown for the BAU

No information available.	accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis. Base year (1990) country total GHGs (without LULUCF): 12.9 Mt CO_{2eq}. *Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.* 

Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Malta

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 4% of national GHGs excluding LULUCF (average 1990-2012), increasing and after decreasing over time (average 1[st] Commitment Period (CP1: 2008-2012): 0.1 $MtCO_{2eq}$, increased by 0.01 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; swine manure management and cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 0.3% of national GHGs (average 1990-2012), increasing over time (average CP1: -0.01$MtCO_{2eq,}$ sink increased by 0.02 $MtCO_{2eq}$ from 1990). Mata only estimates carbon stock changes in forest land and cropland being the main driver of the trend the increase of living biomass in cropland.

Fig. 1. Past trends in Agriculture and LULUCF

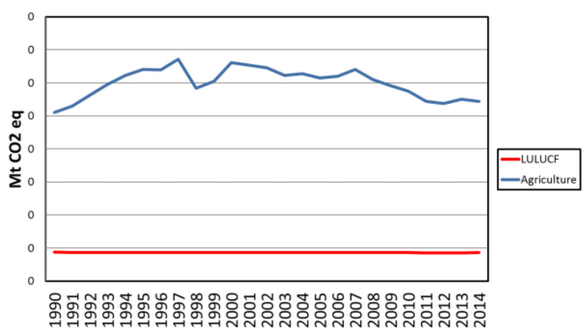


Fig. 2. Past trends of specific LULUCF categories

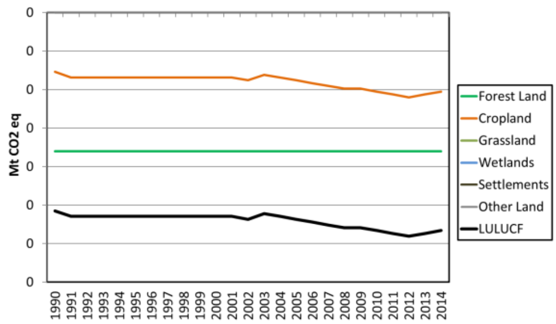


Table 34- state of play for LULUCF and Agriculture, and summary of available projections

Luxembourg		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	0.1	(3)	-0.3	(3)	-0.4	-0.3	-0.3	(4)		-0.2	-0.2	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		0.0	(7)
	AR			-0.2			-0.1	-0.1	(5)		-0.2	-0.1	(5)		-0.1	(6)		-0.2	(6)		0.0	(7)
	D			0.0			0.3	0.2	(5)		0.2	0.1	(5)		0.2	(6)		0.1	(6)		0.0	(7)
	CM	0.0		0.0			0.0	0.0	(5)		0.0	0.0	(5)		0.0	(6)		0.0	(6)			(7)
	GM	-0.1		-0.1			-0.1	0.0	(5)		-0.1	0.0	(5)		0.1	(6)		0.1	(6)		0.0	(7)
	total (UNFCCC)	-0.2		-0.4			-0.1		(5)		-0.3		(5)									
Agriculture (2)	Soils N_2O	0.2	(3)	0.2	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	0.5		0.5					(5)				(5)			(6)			(6)			(7)
	total	0.7		0.7		0.6	0.7		(5)	0.5	0.7		(5)	-0.2	-0.1	(6)	-0.2	0.0	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario).

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. In Maltese agriculture, future greenhouse gas emission trends may be influenced both by measures taken to address directly emissions or measures that indirectly contribute towards decreasing emissions, and by inherent trends in activity in the sector. In animal husbandry for example, the restructuring of the sector to conform to animal welfare, food safety, veterinary and waste management requirements, particularly those arising from EU legislation, will lead directly to a decrease in emissions due to reduced activity or reduction in emissions from the realization of the requirements already mentioned. Land under cultivation is also decreasing and water scarcity could further compound this trend; this could have a beneficial effect in terms of greenhouse gas emissions.

LULUCF. Sink in forests is not expected to be major factor in Malta's GHGI. While a small increase in the net removal effect has been estimated for the period from 2012 to 2020, as a result of a foreseen further effort to plant new trees and shrubs, for the purposes of projecting emissions savings, further tree planting after 2020 is not foreseen. The level of carbon sequestration increases from 2012 to 2020 by 0.00289 $MtCO_2eq$ in projections with existing measures. This will increase following continued planting of 10000 trees/shrubs per year over the period.

Agriculture and LULUCF mitigation options and potentials

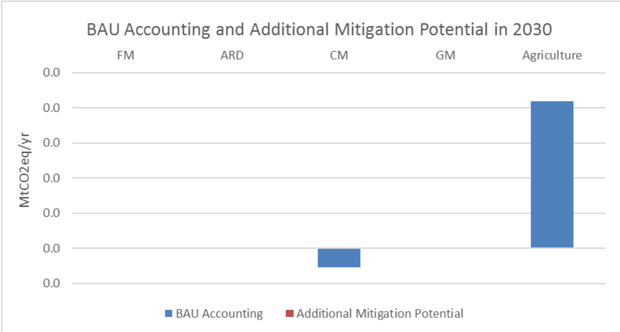
Agriculture, CM and GM

The IPCC Tier 1 method for mineral soils estimated a loss in C stock resulting in 0.001 MtCO2/yr removals for cropland under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

Not available

Fig. 3 Marginal abatement cost curves Not available	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).** For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from sensitivity analysis. *Base year (1990) country total GHGs (without LULUCF): 2.2 MtCO2eq/yr.*

	Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI. 

Netherlands

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 9% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (CP1: 2008-2012): 16.4 $MtCO_{2eq}$, reduced by 6.1 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; enteric fermentation from mature dairy cattle for CH_4.

LULUCF: source of emissions of about 1% of national GHGs (average CP1: 3.1 $MtCO_{2eq,}$ rather constant and increasing in recent years of the CP1). Main drivers: increase removals from forest land, significant emissions from organic soils in grassland and increase emissions from Cropland and Settlements. For CP1, credits from AR (0.6 $MtCO_{2eq}$/yr) and debits from D (-1 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF

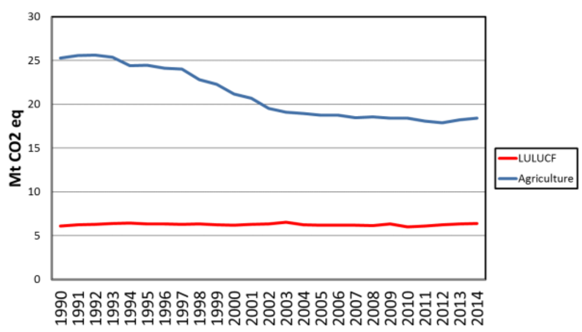


Fig. 2. Past trends of specific LULUCF categories

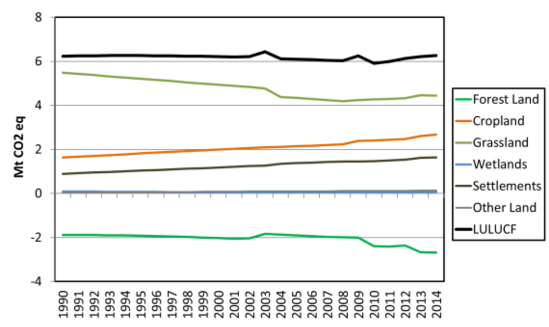


Table 35- state of play for LULUCF and Agriculture, and summary of available projections

Netherlands		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-1.9		-1.9		-1.4	-0.5	-1.2	(4)		-0.4	-1.1	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.1	(7)
	AR			-0.4		-1.0	-0.5	-1.0	(5)		-0.7	-1.1	(5)	-1.0	-0.8	(6)		-0.9	(6)		-0.3	(7)
	D		(3)	1.0	(3)	1.8	0.5	0.2	(5)		0.3	0.1	(5)	1.8	0.3	(6)		0.2	(6)		-0.1	(7)
	CM	1.6		2.3			0.8	2.0	(5)		0.8	1.9	(5)		-0.2	(6)		-0.2	(6)		-0.5	(7)
	GM	5.1		3.8			3.3	0.2	(5)		3.4	0.1	(5)		-3.3	(6)		-3.3	(6)		0.0	(7)
	total (UNFCCC)	6.2		6.2			3.6		(5)		3.5		(5)									
Agriculture (2)	Soils N_2O	9.1		5.0					(5)				(5)			(6)			(6)			(7)
	Livestock	16.0	(3)	13.1	(3)				(5)				(5)			(6)			(6)			(7)
	total	25.3		18.2			19.7		(5)		19.6		(5)		-5.6	(6)		-5.7	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. The Netherlands plans to reduce emissions in the agricultural and horticultural sector to 5-6 Mt of CO2 in 2020. CO_2 emissions from the agricultural sector (excluding machinery) are expected to decline from 10.4 in 2010 to 6.9 Mt CO_2 by 2020 with planned policies. Emissions reduction, even beyond 2020, is expected thanks to the increasing use of renewable sources energy and energy efficiency improvements; on the other hand, the area of horticulture is expected to increase. Non-CO_2 emissions are also expected to decline due to CH_4 emissions reduction due to increased digestion of manure for energy production and N_2O emissions reduction due to less fertilizer use, "precision soil cultivation" and changes in cattle management.

LULUCF. The Netherlands plan to convert an additional 80 kha into nature reserves by 2027 thanks to afforestation and reforestation. Given the age class structure of the Dutch forests, there is a slow decrease in the removals from forest land remaining forest land. As yet, no significant changes have been assumed for the projections for land converted to forest land. Emissions from D are projected to increase to 1.834 $MtCO_2$ in 2020. Removals from AR will increase -0.982 $MtCO_2$ in 2020. The removals under forest management decrease to -2.113 Mt CO_2. Emissions from cultivated organic soils are a key source of emissions from the LULUCF. These emissions mainly result from drainage and ground surface lowering and are estimated at 4.246 $MtCO_2$ annually.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 5.6 tCO_2/ha/yr), use of cover crops (0.7 tCO_2/ha/yr), ley cropping systems (sink of 0.6 tCO_2/ha/yr) and reduced tillage and crop residues incorporation (0.6 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.12 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.48 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock resulting in 1.9 $MtCO_2$/yr for cropland and of 0.13 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 The Netherlands predicts (through IIASA/EFI/JRC data) a slight decrease in the sink, despite a stable harvest.

By 2030, CBM predicts a FM sink of -1.1 $MtCO_2$/yr, with a small additional mitigation potential for -10% harvest. IIASA predicts in 2030 a decline of FM sink which will be around 0.35 $MtCO_2$/yr in 2030 despite a stable harvest. Overall, an effect of age class structure seems evident.

For ARD, CBM estimates a 10% increase in AR sink from 2020 to 2030, when it will be of 1.1 $MtCO_2$/yr, more than offsetting the emissions from D. The AR sink predicted by IIASA in 2030 is 0.7 $MtCO_2$/yr.

Fig. 3 Marginal abatement cost curves

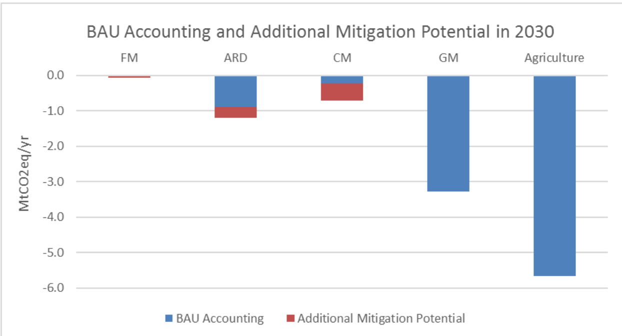
No information available

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 221.5 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Poland

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 9% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (1st Commitment Period (CP1:2008-2012): 37.5 $MtCO_{2eq}$, reduced by 16.8 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils and manure solid storage for N_2O; cattle enteric fermentation and swine manure management for CH_4.

LULUCF: net sink offsetting about 7% of national GHGs (average 1990-2012), increased over time (CP1: -31.4 $MtCO_{2eq,}$ sink increased by 5.9 $MtCO_{2eq}$ from 1990). Main drivers: increased removals from forest land, reduce emissions from cropland and grassland; notable decreased of emissions from liming. For CP1, credits from AR and FM (2.5 and 3.0 $MtCO_{2eq}$/yr) and small debits from D (0.3 $MtCO_{2eq}$/yr)

Fig. 1. Past trends of Agriculture and LULUCF

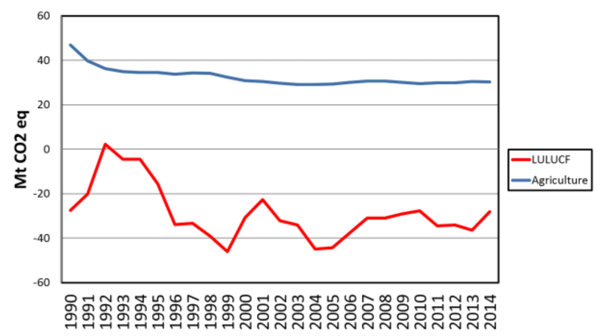


Fig. 2. Past trends of specific LULUCF categories

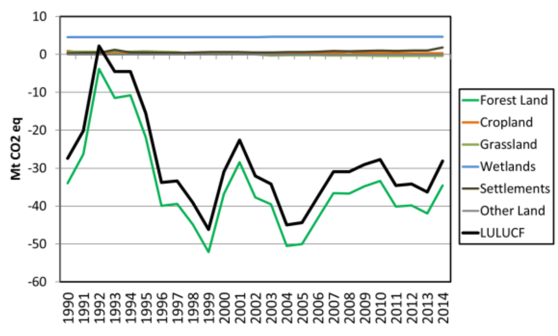


Table 36- state of play for LULUCF and Agriculture, and summary of available projections

Poland		1990		2010		2020				2030				2020			2030					
all numbers are in $MtCO_{2eq}$ / yr		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-33.8	(3)	-34.3	(3)	-27.1	-30.6	-34.5	(4)		-21.8	-28.9	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		0.1	(7)
	AR			-2.6		-8.0	-5.4	-3.5	(5)	-10.2	-7.6	-5.1	(5)	-8.0	-4.4	(6)	-10.2	-6.4	(6)		-0.7	(7)
	D			0.3		0.2	0.2	0.1	(5)	0.2	0.1	0.0	(5)	0.2	0.1	(6)	0.2	0.0	(6)		0.0	(7)
	CM	0.9		0.4			0.7	9.9	(5)		0.4	7.6	(5)		4.3	(6)		3.1	(6)		-4.0	(7)
	GM	0.6		-0.4			0.1	0.3	(5)		-0.2	0.3	(5)		-0.4	(6)		-0.6	(6)		0.0	(7)
	total (UNFCCC)	-20.2		-31.3			-35.0		(5)		-29.1		(5)									
Agriculture (2)	Soils N_2O	17.2	(3)	13.7	(3)	18.2			(5)	19.5			(5)	1.0		(6)	2.3		(6)			(7)
	Livestock	27.0		15.8		16.9			(5)	18.3			(5)	-10.1		(6)	-8.7		(6)			(7)
	total	46.8		30.4		35.1	32.7		(5)	37.8	34.6		(5)	-11.7	-14.1	(6)	-9.0	-12.3	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Poland's 6th NC predicts gradual increase of CH_4 and N_2O emissions to 12.6 $MtCO_2$ eq. and 25.2 $MtCO_2$ eq. respectively in 2030 as a consequence of emission increase in enteric fermentation, manure management and agricultural soils. The following policies and mitigation measures were planned for implementations by 2020: rationalisation of the use of nitrogen fertilisers and energy management in agriculture, including energy production from biomass from waste, liquid manure and solid manure; improvements in animal feeding techniques, feed management and animal keeping systems.

LULUCF. Poland expects a decrease of CO_2 removals, reaching a reduction of 31% of CO_2 removals from the base year in 2030 for whole LULUCF sector. According to both 6th NC and Art. 10, AR sink is foreseen to increase and FM sink is foreseen to decrease. The CO_2 emissions from D remains constant. Planned policies and measures as foreseen in the 6th NC include: increasing of forest cover to 30% in 2020 and 33% after 2050; restitution and rehabilitation of forest ecosystems (monoculture into mixed stands); regeneration of degraded and neglected tree-stands; the enhancement of timber logging at the level of about 50–60% of the current increment; the afforestation of agricultural and non-agricultural land; preferences for crops with high CO_2 capture.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 2.1 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.5 tCO_2/ha/yr), insertion of cover crops in the rotation schemes (0.5 tCO_2/ha/yr), and ley cropping system (0.5 tCO2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 4 $MtCO_2$/yr beyond BAU. The IPCC Tier 1 method (not shown in tab. 1) for mineral soils estimated a loss in C stock resulting in 7.58 $MtCO_2$/yr for cropland and of 0.3 for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For CP2, Poland predicted a strong increase in FM harvest (+26% relative to 2005) and consequently a significant decrease of the FM sink within the FMRL.

By 2030, CBM predicts a slightly decreasing sink in FM reaching 29 MtCO2/yr, a trend observed also by IIASA (21.8 MtCO2/yr in 2030). Additional mitigation potential is estimated by CBM in 0.1 MtCO2/yr for -10% harvesting. The decrease in the FM sink is observed despite the harvest used by both models remains approximately constant over time (this suggest a possible effect of ageing forest). For AR, CBM predicts a slightly increasing sink in 2030, and a modest additional mitigation potential. By contrast, IIASA (G4M) foresees a bigger increase of AR sink in 2030 reaching 7.6 MtCO2/yr.

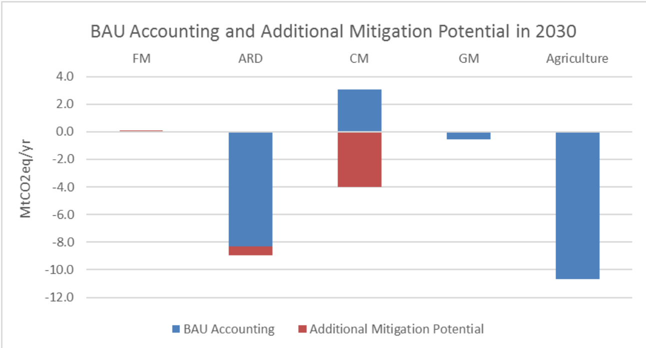
Fig. 3. Marginal abatement cost curves for 2020 for agriculture

No information found

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}/yr$).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1988) country total GHGs (without LULUCF): 472.9 $MtCO_{2eq}/yr$. Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Portugal

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 11% of national GHGs excluding LULUCF (average 1990-2012), slightly decreasing over time (1st Commitment Period (CP1:2008-2012): 7.3 $MtCO_{2eq}$, reduced by 0.8 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation, swine manure management for CH_4.

LULUCF: net sink offsetting about 15% of national GHGs (average 1990-2012), increasing over time (CP1: -15.7 $MtCO_{2eq,}$ sink increased by 13.4 $MtCO_{2eq}$ from 1990). Main drivers: increased removals from forest and land converted to other land, decrease emissions from land converted to cropland and grassland and increase emissions from land converted to settlement; emissions from biomass burning. For CP1, credits from AR (6.7 $MtCO_{2eq}$/yr) FM, CM and GM (0.8, 3.4, and 1.1 $MtCO_{2eq}$/yr), debits from D (1.9 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF

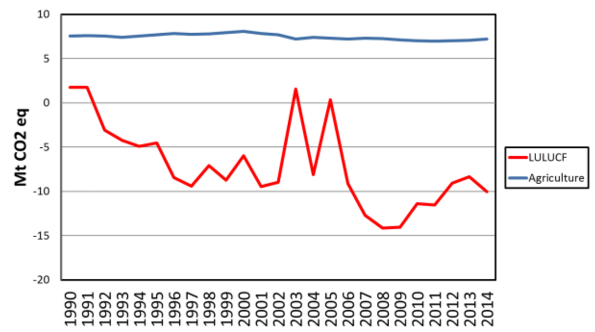


Fig. 2. Past trends of specific LULUCF categories

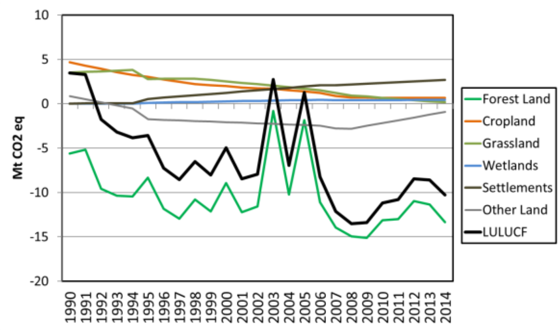


Table 37- state of play for LULUCF and Agriculture, and summary of available projections

Portugal		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-2.1	(3)	-8.5	(3)	-6.8	-5.9	-11.2	(4)		-5.5	-11.6	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-1.6	(7)
	AR			-4.9			-6.6	-1.9	(5)		-7.3	-2.3	(5)		-4.3	(6)		-4.8	(6)		-0.5	(7)
	D			1.9			1.3	0.6	(5)		1.0	0.4	(5)		0.9	(6)		0.7	(6)		-0.3	(7)
	CM	3.3		0.2			0.2	0.4	(5)		0.2	0.5	(5)		-3.0	(6)		-3.0	(6)		-0.3	(7)
	GM	1.4		0.2			0.1	0.0	(5)		0.1	0.0	(5)		-1.4	(6)		-1.4	(6)		0.0	(7)
	total (UNFCCC)	1.8		-12.0			-10.9		(5)		-11.6		(5)									
Agriculture (2)	Soils N_2O	2.3	(3)	2.1	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	5.0		4.7					(5)				(5)			(6)			(6)			(7)
	total	7.5		7.0		7.1	7.7		(5)	6.7	8.0		(5)	-0.4	0.1	(6)	-0.8	0.5	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario).

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC)

AGRICULTURE. Policies and Measures for this sector: reduction in CH_4 emissions resulting from manure management through the conversion of medium and large manure management systems to anaerobic biodigestors with energy recovery. Portugal predicts the increase in total emissions by 24% (scenario without measures) between the 2015 and 2030 for Agriculture/Forestry/Fisheries categories. They predicts increase of emissions for all GHGs (CO_2 - 21%, CH_4 - 45%, N_2O - 23%.) The projected CH_4 emissions decrease from 196 Gg CO_2eq. in 2015 to 178 Gg CO_2eq. in 2030 as a consequence of emission's decease in enteric fermentation, manure management, rice cultivation and field burning of residues. The N_2O emissions in 2015 exceed the level of 10.2 Gg CO_2eq. to subsequently fall and in 2030 reaching the 9.6 Gg CO_2eq. as a consequence of emission's decrease in agricultural soils category.

LULUCF. Policies and Measures for sector: promote the sustained increase in forested area, through financial support and incentives to new tree plantations. Increase in the carbon sink capacity of Portuguese forests, through the improvement of forestry management.

No updated information concerning LULUCF in the Art.10 report

Agriculture and LULUCF mitigation options and potentials for the 2030 framework

Agriculture, CM and GM

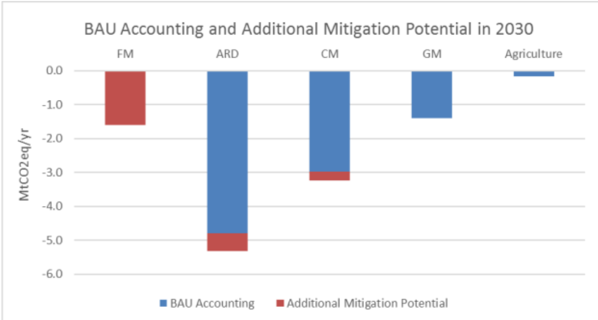
The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.7 tCO_2/ha/yr), reduced tillage and crop residues incorporation (0.4 tCO_2/ha/yr), and ley cropping system (0.4 tCO2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 0.3 $MtCO_2$/yr beyond BAU. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock resulting in 0.5 $MtCO_2$/yr emission for cropland and of 0.001 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For CP2 Portugal foresees a small increase in harvest and a small decrease in sink for FMRL.

By 2030, CBM predicts a FM sink of 11.6 $MtCO_2$/yr for reference scenario with an additional mitigation potential of 1.6 $MtCO_2$/yr for -10% harvest. IIASA foresees a relatively constant harvest and a slightly decreasing FM sink from 2020, reaching 5.5 $MtCO_2$/yr in 2030.

For AR, CBM predicts a slightly increasing sink in 2030, equal to -2.3 $MtCO_2$/yr, with a modest additional mitigation potential. IIASA foresees an increase of AR sink from current levels, reaching 7.3 $MtCO_2$/yr in 2030.

Fig. 3. Marginal abatement cost curves for 2020 for agriculture	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).**
No information found	*For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.* *Base year (1990) country total GHGs (without LULUCF): 60.5 $MtCO_{2eq}$/yr.* *Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.* 

Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Romania

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 15% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (1st Commitment Period (CP1:2008-2012): 19.4 $MtCO_{2eq}$, reduced by 17.3 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle and sheep enteric fermentation for CH_4.

LULUCF: net sink offsetting about 17% of national GHGs (average 1990-2012), increasing over time (CP1: -23.2 $MtCO_{2eq,}$ sink decreased by 1.1 $MtCO_{2eq}$ from 1990). Main drivers: removals from conversion to forest, decrease removals from cropland, and high annual variability on grassland and other land. For CP1, credits from AR and FM (0.38 and 5.4 $MtCO_{2eq}$/yr) and debits from D and RV (1.8 and 0.38 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture & LULUCF

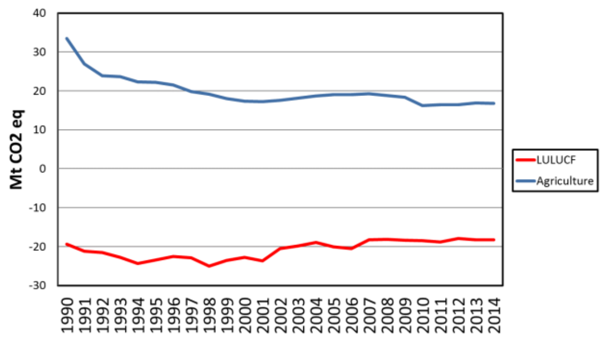


Fig. 2. Past trends of specific LULUCF categories

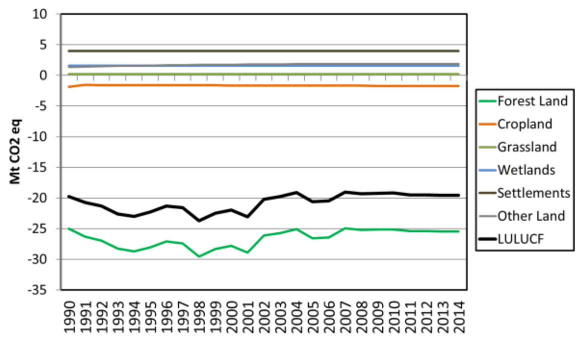


Table 38- state of play for LULUCF and Agriculture, and summary of available projections

Romania		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-21.2		-21.4		-15.8	-13.5	-23.5	(4)		-12.2	-23.4	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-3.8	(7)
	AR			-3.9		-0.5	-5.6	-2.8	(5)		-6.7	-2.5	(5)	-0.5	-4.2	(6)		-4.6	(6)		-0.3	(7)
	D			7.5		4.0	1.4	0.7	(5)		0.3	0.1	(5)	4.0	1.0	(6)		0.2	(6)		-0.1	(7)
	CM	-4.0	(3)	-3.9	(3)	-0.6	-2.2	0.3	(5)		-2.4	0.4	(5)	3.4	3.1	(6)		3.0	(6)		-2.1	(7)
	GM	-1.1		-1.1		-0.1	-0.1	-0.1	(5)		-0.1	-0.1	(5)	1.0	1.0	(6)		1.0	(6)		0.0	(7)
	total (UNFCCC)	-21.2		-18.4			-20.1		(5)		-21.2		(5)									
Agriculture (2)	Soils N_2O	7.5		4.1		10.3			(5)	13.0			(5)	2.9		(6)	5.5		(6)			(7)
	Livestock	25.2	(3)	12.1	(3)	10.3			(5)	10.9			(5)	-14.8		(6)	-14.2		(6)			(7)
	total	33.5		16.9		20.9	16.1		(5)	24.0	15.7		(5)	-12.6	-17.3	(6)	-9.5	-17.8	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Romania predicts in "existing measures" scenario increase of total GHG emissions by 10.2%, between 2011 and 2020. GHG emissions are expected to reach 20.9 Mt CO_2 eq. in 2020. In the "additional measures" scenario emissions will increase by 3.1% and reach 19.5 Mt CO_2 eq. in 2020. A slight increase is foreseen in livestock, while CH_4 emissions from rice crops and agricultural waste burning will remain constant. A reduction of CH_4 emissions is expected to be caused by the improvement of breeding technology (decrease by 10% at 2020 and by 25% at 2030). N_2O emissions will decrease by 25% in 2030, due to modern methods of fertilizer application. Planned policies and mitigation measures up to 2020: improvement of quality of nutrition for cattle, sheep and goats; improvement of manure management to decrease of CH_4 emissions from livestock; improving the efficiency in the use of nitrate fertilizers, stimulating/encouraging the use of equipment for the treatment of waste waters in farming, increasing of the green mass quantity and hay production on the entire surface of pastures and meadows.

LULUCF. Planned policies and measures in 6th NC: ecological forestry, afforestation of degraded areas unsuitable for agriculture, as well as of non-productive land (including revegetation and forest belts) in 3 periods: till 2016 – 75.000 ha, till 2020 - 60.000 ha, till 2030 - 158.000 ha; sustainable management of forests (harvest at the average level of 24 mil. m^3y^{-1}); implementation of „low till" and „no tillage" technologies for 30% of the area of arable land (in rotation) per year from 2015-2030; decrease the conversion of land with high C stores and conversion to farmland; keeping meadow area in the natural state and implement measures to prevent the over-exploitation and conversion to other uses; conservation of wetlands, biomass increase on permanent woody cropland.

Forest will continue to act as a sink for 2013-2020 under strict application of sustainable forest management practices. Forest Management may register very small credits or even debits over 2013-2020. This is mainly because of likely gradual increase of annual wood harvest from forests until ~21 mil m3 in 2020 and to ~25 mil m3 in 2030, following 2000-2010 trend. According to various national policy documents, it is technically and financially possible to afforest some 10kha per year during the period 2013-2020. This would allow some 50% increase of afforestation/reforestation sink in 2020 compared to the sink attached to historical afforestation rate. Establishment of forest belts and revegetated areas also has a very significant CO2 removal potential. Annual area of 1kha during period 2013-2020, in addition to historical average of 0.74kha/year would lead to 60% increase of associated sink in 2020.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.9 tCO_2/ha/yr), ley cropping system (0.7 tCO2/ha/yr), reduced tillage and crop residues incorporation (0.4 tCO_2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 2.1 $MtCO_2$/yr beyond BAU. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock resulting in 0.35 $MtCO_2$/yr emission for cropland and a removal of 0.08 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For CP2 Romania predicted a rather stable harvest and a decreasing sink in FMRL (based on projections by IIASA-EFI-JRC).

By 2030, CBM predicts a sink in FM of 23.4 $MtCO_2$/yr for the reference scenario and an additional mitigation potential of 3.8 $MtCO_2$/yr for -10% harvest. IIASA foresees a very significant increase of harvest by 2030 compared to current levels, with a sink of 12.2 $MtCO_2$/yr.

For AR, CBM predicts a slightly decreasing sink in 2030 (2.5 $MtCO_2$/yr). By contrast, IIASA foresees an increase of AR sink (being 6.7 $MtCO_2$/yr in 2030).

Fig. 3. Marginal abatement cost curves for 2020 for agriculture

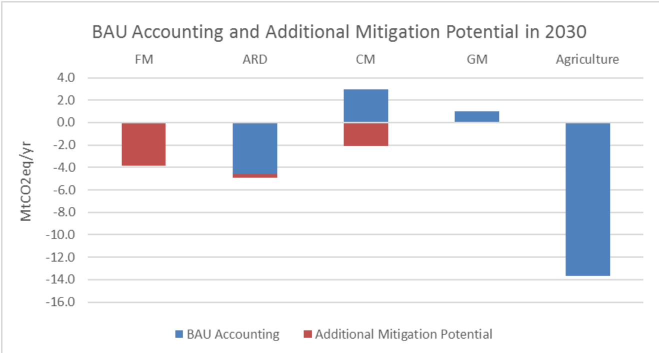
No information found

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1989) country total GHGs (without LULUCF): 251.9 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Slovakia

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 7% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1[st] Commitment Period (CP1: 2008-2012): 3.1 MtCO2eq, reduced by 4.1 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 17% of national GHGs (average 1990-2012), decreasing over time (average CP1: -6.4 $MtCO_{2eq,}$ sink decreased by 2.6 $MtCO_{2eq}$ from 1990). Main drivers: removals from forest land, cropland, grassland. For CP1, credits from AR (0.4 $MtCO_{2eq}$/yr) and debits from D (0.1 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF

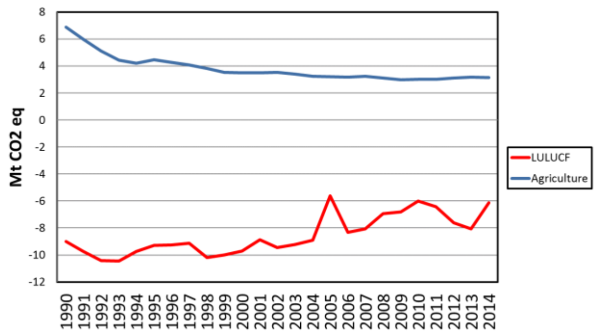


Fig. 2. Past trends of specific LULUCF categories

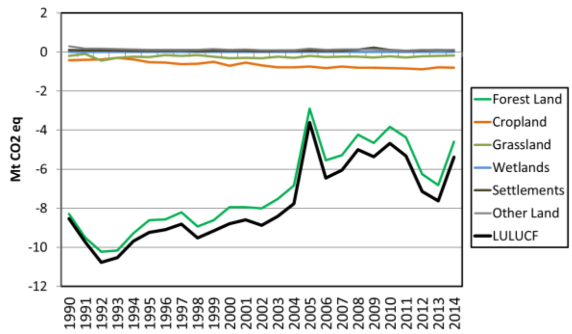


Table 39- state of play for LULUCF and Agriculture, and summary of available projections

Slovakia		1990		2010		2020				2030				2020			2030					
all numbers are in $MtCO_{2eq}$ / yr		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting (Accounted quantity of emissions(+) / removals(-))			BAU accounting			"Additional" mitigation potential in 2030		
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-6.1	(3)	-4.3	(3)	-1.1	-4.1	-3.4	(4)	-9.0	-3.6	-3.1	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.6	(7)
	AR			-0.4		-0.5	-0.6	-0.4	(5)	-0.5	-0.8	-0.6	(5)	-0.5	-0.5	(6)	-0.5	-0.7	(6)		-0.1	(7)
	D			0.1			0.1	0.0	(5)		0.1	0.0	(5)		0.1	(6)		0.0	(6)		0.0	(7)
	CM	-0.6		-0.8		-0.7	-0.6	0.0	(5)	-0.7	-0.7	-0.2	(5)	-0.1	0.3	(6)	-0.1	0.1	(6)		-0.4	(7)
	GM	-0.3		-0.3		-0.3	-0.4	0.0	(5)	-0.3	-0.4	0.0	(5)	0.0	0.1	(6)	0.0	0.1	(6)		0.0	(7)
	total (UNFCCC)	-9.7		-6.8			-5.6		(5)		-5.5		(5)									
Agriculture (2)	Soils N_2O	3.1	(3)	1.6	(3)	1.8			(5)	1.9			(5)	-1.3		(6)	-1.2		(6)			(7)
	Livestock	3.7		1.5		1.2			(5)	1.1			(5)	-2.6		(6)	-2.6		(6)			(7)
	total	6.9		3.2		2.9	2.5		(5)	3.0	2.4		(5)	-4.0	-4.4	(6)	-3.9	-4.4	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario).

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC)

AGRICULTURE. The mitigation potential in agriculture is mostly connected with manure management (storage, application on soil) and animal feeding. Since 2011, no significant policy paper related to climate change mitigation for plant production activities has been approved. Currently, the Rural Development Program for 2014-2020 is being prepared. Total emissions from agriculture are projected to decrease slightly in the "with measures scenario" until 2030. The trend is influenced by policies on the management of enteric fermentation, manure as well as agricultural soils.

LULUCF. Policies and measures in this sector include: maintaining biodiversity, productivity, regeneration, capacity and vitality of forests. Removals from LULUCF show an increasing trend until 2030 and are projected to change from about 6.1 $MtCO_2$ eq. in 2011 to 9.4 Mt eq. in 2020 and of 10.2 Mt CO_2 eq. in 2030. This data covers all land use categories.

No updated information concerning LULUCF in the Art.10 report

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.5 tCO_2/ha/yr), ley cropping system (0.6 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.5 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.1 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.4 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated variations in C stock resulting in 0.2 $MtCO_2$/yr removals for cropland and of 0.03 $MtCO_2$/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

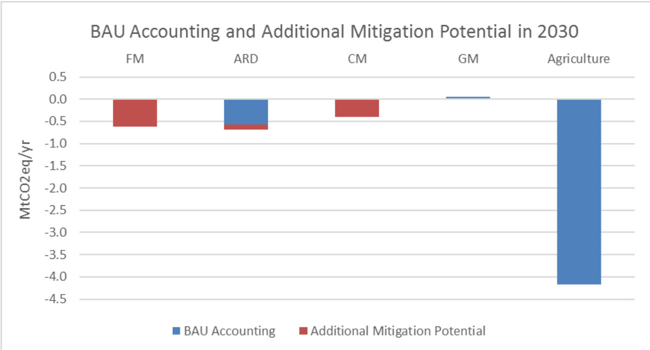
Forestry

For FM, in CP2 Slovakia predicts (through IIASA/EFI/JRC data) a slight decrease in the sink, mainly due to slightly increase in harvest. Significant recalculations occurred since 2011 in GHGI (the sink increase over the whole time series), which will trigger a technical correction of FMRL.

By 2030, CBM predicts a FM sink of 3.1 $MtCO_2$/yr for the reference scenario, with an additional mitigation potential 0f 0.6 MtCO2/yr for -10% harvest. IIASA predicts in 2030 a FM sink of 3.6 MtCO2/yr.

For ARD, CBM and IIASA estimate slightly increasing AR sink trends, respectively 0.56 MtCO2/yr for CBM and 0.76 MtCO2/yr for IIASA.

Fig. 3 Marginal abatement cost curves	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).** For each activity, the average of MS+model data in tab. 1 are shown for the BAU

No information available.	accounting (blue) and the additional mitigation potential (red), derived from sensitivity analysis. *Base year (1990) country total GHGs (without LULUCF): 74.7 MtCO2eq/yr.* *Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.* 

Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Slovenia

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 11% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (CP1: 2008-2012): 1.9 $MtCO_{2eq}$, reduced by 0.2 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle enteric fermentation for CH_4.

LULUCF: net sink offsetting about 17% of national GHGs (average 1990-2012), increasing over time (average CP1: -4.4 $MtCO_{2eq,}$ sink increased by 2.9 $MtCO_{2eq}$ from 1990). Main drivers: trend and increase of removals from forest lands and emissions from cropland, grassland and settlements. For CP1, credits from FM (1.6 $MtCO_{2eq}$/yr) and debits from D (0.3 $MtCO_{2eq}$/yr). Direct-human induced AR is not reported.

Fig. 1. Past trends of Agriculture & LULUCF

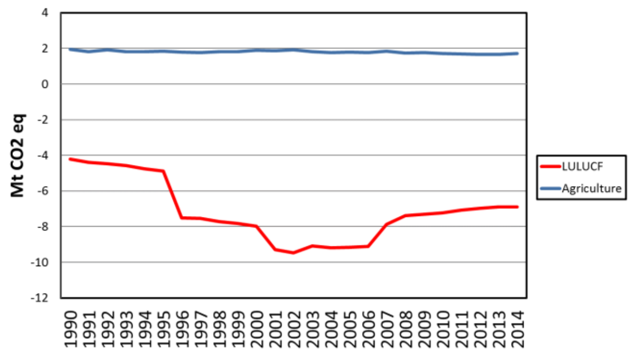


Fig. 2. Past trends of specific LULUCF categories

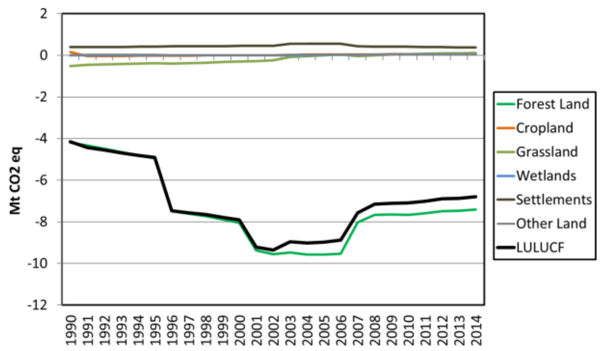


Table 40- state of play for LULUCF and Agriculture, and summary of available projections

Slovenia		1990		CP1		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	IA2013	JRC		MS	IA2013	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-2.8	(3)	-6.3	(3)	-3.2	-3.5	-6.0	(4)	-2.5	-3.3	-6.4	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.3	(7)
	AR			0.0			-1.1	-0.8	(5)		-1.3	-0.7	(5)		-0.9	(6)		-1.0	(6)		-0.1	(7)
	D			0.0		0.3	0.3	0.2	(5)	0.8	0.2	0.1	(5)	0.3	0.2	(6)	0.8	0.1	(6)		-0.1	(7)
	CM	0.4		0.4			0.3	0.2	(5)		0.3	0.0	(5)		-0.1	(6)		-0.2	(6)		-0.1	(7)
	GM	-0.2		-0.3			-0.1	0.0	(5)		0.1	0.0	(5)		0.2	(6)		0.3	(6)		0.0	(7)
	total (UNFCCC)	-1.5		-4.4			-4.1		(5)		-4.0		(5)									
Agriculture (2)	Soils N_2O	0.4	(3)	0.4	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	1.4		1.2					(5)				(5)			(6)			(6)			(7)
	total	1.9		1.7		2.3	1.8		(5)	0.0	1.8		(5)	0.3	-0.2	(6)	-1.9	-0.2	(6)			(7)

* Credits (+) / Debits (-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering all the relevant accounting rules

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHG inventory 2014 (UNFCCC or KP). If data for FM, CM and GM are not available, proxies from UNFCCC reporting are used (FL-FL, CL, GL)

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). IA2013: IIASA (G4M). JRC: CBM using same assumption as IA2013

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). IA2013: IIASA (G4M, GLOBIOM, EPIC,GAINS). JRC: CBM (FM and ARD, same assumption of IA2013), IPCC TIER 1 (CM/GM)

(6) Accounting: FMRL: 0 by definition under BAU; AR&D: gross net (Models: average IA2013 and JRC), CM&GM: net-net 1990 f (Models: average IA2013 and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario).

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Planned policies and measures include the increase in the efficiency of domestic animal production, introduction of anaerobic digesters for biogas production from cattle manure, increase cattle pasture grazing, rational fertilization of agricultural plants with nitrogen. The government adopted the "Resolution on the Slovenian Agriculture and Food Industry Strategic Guidelines until 2020 – Let's secure food for tomorrow" aimed at identify solutions to reduce GHG emissions without reducing the physical extent of agricultural and domestic animal production, but rather going towards a decrease in emissions per unit of produced food. Compared to 2011, emissions from agriculture are expected to increase by 23% and/or by 12% by 2030, as a result of an increase in the number of livestock (bovine and porcine animals) and a minimal increase in fertilization.

LULUCF. Policies and measures in this sector focus on sustainable forest management. The sink resulting from land use and land use change will decrease by 2030. Sink is determined by wood biomass growth, amounting to 12.0 Mt CO_2 in 2011. By 2030, according to the projection, sinks resulting from an increase in forest area will increase to 12.2 Mt CO_2. On the other hand, emissions from changes in land use are estimated to total 2.4 Mt CO_{2eq} for 2011 and, according to the projection with measures, are expected to increase to 3.1 Mt CO_{2eq} by 2030. (NB: the numbers above do not reflect the recent significant recalculations in the GHGI). It is assumed that deforestation will triple by 2040 due to forest land conversions to cropland and settlements (from 500 in 2013 to around 1500 ha/year in 2040), with emissions, according to this scenario, 4 times greater than in 2013, reaching 1.0 $MtCO_{2eq}$ in 2040.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 3.6 tCO_2/ha/yr), use of cover crops (0.7 tCO_2/ha/yr), ley cropping systems (0.6 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.8 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.02 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.06 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock of 0.03 $MtCO_2$/yr for cropland and a removal of 0.02 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Slovenia has a very low FMRL. This is due to an assumption of an extremely high increase in BAU harvest rate in CP2 (more than doubling compared to CP1).

By 2030, CBM predicts a FM sink of 6.4 $MtCO_2$/yr for reference scenario, with an additional mitigation potential of 0.3 $MtCO_2$/yr with -10% harvest. IIASA predicts in 2030 a slight decrease of the sink of FM associated to constant harvest in harvest, reaching 3.2 $MtCO_2$/yr, a lower figure than CBM.

For ARD, CBM estimates a small sink from forest expansion (less than 0.5 MtCO2 - this is not considered in tab 1 because Slovenia does not count this as AR). The AR sink predicted by IIASA is significant (about -1.3 MtCO2).

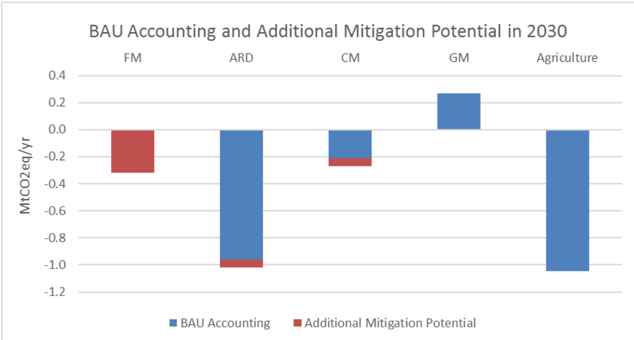
Fig. 3 Marginal abatement cost curves

No information available

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr). For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1986) country total GHGs (without LULUCF): 18.6 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Spain

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 11% of national GHGs excluding LULUCF (average 1990-2012), slightly increasing over time (1st Commitment Period (CP1:2008-2012): 38.2 $MtCO_{2eq}$, increased by 0.5 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; cattle and sheep enteric fermentation and manure management of swine for CH_4.

LULUCF: net sink offsetting about 8% of national GHGs (average 1990-2012), increasing over time (CP1: -33.6 $MtCO_{2eq,}$ sink increased by 10.3 $MtCO_{2eq}$ from 1990). Main drivers: increased removals from conversion to forest and cropland remaining cropland, increase emissions from conversion to cropland, grassland, and settlements; emissions from biomass burning. For CP1, credits from AR (8.7 $MtCO_{2eq}$/yr), FM and CM (2.5 and 0.1 $MtCO_{2eq}$/yr), and small debits from D (0.7 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF

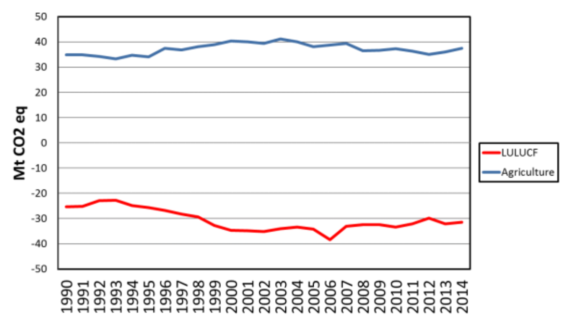


Fig. 2. Past trends of specific LULUCF categories

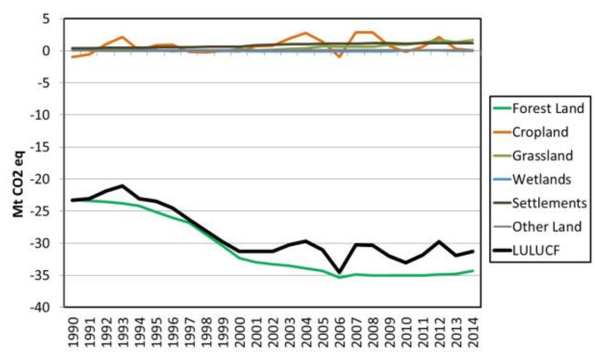


Table 41- state of play for LULUCF and Agriculture, and summary of available projections

Spain		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-23.1	(3)	-26.6	(3)	-23.1	-26.6	-32.2	(4)		-26.4	-36.6	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-2.1	(7)
	AR			-8.5			-8.3	-7.6	(5)		-9.2	-8.3	(5)		-7.9	(6)		-8.7	(6)		-1.0	(7)
	D			2.3			1.4	0.8	(5)		1.9	1.4	(5)		1.1	(6)		1.7	(6)		-0.9	(7)
	CM	-1.1		0.9		-2.7	-1.6	2.6	(5)		-1.4	2.8	(5)	-1.6	1.6	(6)		1.8	(6)		-3.9	(7)
	GM	-0.1		-1.2		1.0	-3.2	0.0	(5)		-5.1	0.0	(5)	1.1	-1.5	(6)		-2.4	(6)		0.0	(7)
	total (UNFCCC)	-25.2		-32.0			-38.4		(5)		-40.2		(5)									
Agriculture (2)	Soils N_2O	12.6	(3)	12.7	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	20.8		21.6					(5)				(5)			(6)			(6)			(7)
	total	34.9		36.0		39.6	37.8		(5)	37.1	37.6		(5)	4.8	2.9	(6)	2.3	2.8	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario)

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. From the Spain's 6th NC is not clear which will be the quantitative impact of the mitigation strategies, however it is predicted a relatively constant emission from agriculture. The most significant variation is assumed between 2020 and 2025 due to an update of the projection of livestock population for the period 2011-2020 which suggest an increase of this activity. On the other hand, it is expected a reduction of this variation, when updated values for the whole time series (i.e. including 2020-2030) becomes available. In this sector, additional mitigation actions were not assessed, therefore values with "mitigation measurements" and with "additional measurements" are equal.

LULUCF. Some mitigations action are quoted but no quantitative effects are provided. According to the 6th NC, removals from this sector present an increase during the first 3 years of the projected period and a relatively constant decrease after. This behaviour is mainly due to the evolution of conversions to forest. Annual AR areas have been reduced between 1998 -2010 and, in addition, areas reforested on nineties are going over 20 years. Both process result in a reduction of areas of new forests with the subsequence reduction in the sink effect since 2012.

Agriculture and LULUCF mitigation options and potentials for the 2030 framework

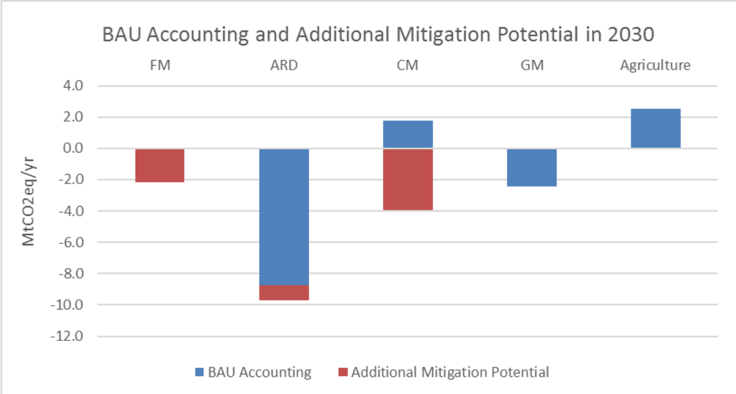
Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 2.7 tCO_2/ha/yr) and reduced tillage and crop residues incorporation (0.8 tCO_2/ha/yr). Combining these potentials with an environmentally-oriented scenario of land use change and management practices, for 2030 it is estimated a mitigation potential of 3.9 $MtCO_2$/yr beyond BAU. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock of 2.752 $MtCO_2$/yr for cropland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For CP2 Spain predicted a slight increase in both harvest and sink in FMRL (based on projections by IIASA-EFI-JRC). By 2030, CBM predicts a sink in FM of 36.6 $MtCO_2$/yr for reference scenario, with an additional mitigation potential of 2.1 $MtCO_2$/yr for a -10% harvest. IIASA foresees sink by about 26.4 $MtCO_2$/yr.

For AR, CBM predicts an increasing sink in 2030 at a level around 8.3 $MtCO_2$/yr with limited additional potential. IIASA foresees a slight increase of AR sink reaching 9.1 $MtCO_2$/yr in 2030.

Fig. 3. Marginal abatement cost curves for 2020 for agriculture	**Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).**
No information found	For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis. *Base year (1990) country total GHGs (without LULUCF): 285.9 $MtCO_{2eq}$/yr .* *Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.* 

Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

Sweden

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 12% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1[st] Commitment Period (CP1: 2008-2012): 7.8 $MtCO_{2eq}$, reduced by 1.3 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; enteric fermentation from mature dairy cattle for CH_4.

LULUCF: net sink offsetting about 54% of national GHGs (average 1990-2012), slightly decreasing over time (average CP1: -35.5 $MtCO_{2eq,}$ reduced by 3.2$MtCO_{2eq}$ from 1990). Main drivers: removals from Forest land remaining Forest land and emissions from land converted to Settlements and Cropland, significant emissions from organic soils in Grassland and increase emissions from Cropland and Settlements. Significant emissions from organic soil in Forest land and Cropland. For CP1, credits from AR (-1.3 $MtCO_{2eq}$/yr) and FM (-4.1 $MtCO_{2eq}$/yr) and debits from D (+3.3 $MtCO_{2eq}$/yr).

Fig. 1. Past trends of Agriculture and LULUCF:

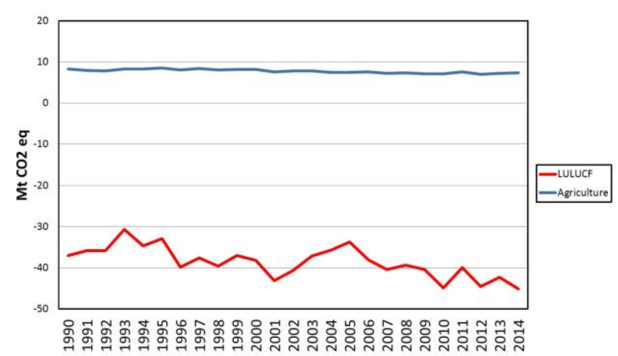


Fig. 2. Past trends of specific LULUCF categories

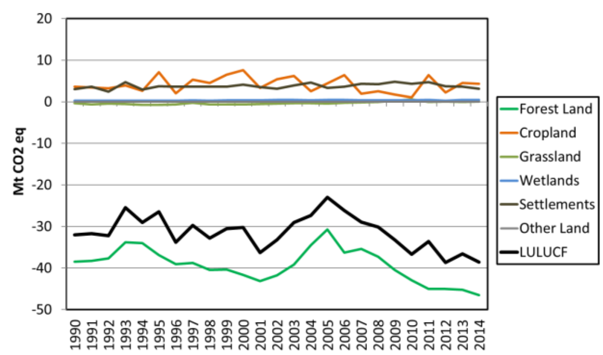


Table 42- state of play for LULUCF and Agriculture, and summary of available projections

Sweden (all numbers are in $MtCO_{2eq}$ / yr)		1990 emissions(+) / removals(-)		2010 emissions(+) / removals(-)		2020 BAU emissions(+) / removals(-) MS	2020 BAU RS2016	2020 BAU JRC		2030 BAU emissions(+) / removals(-) MS	2030 BAU RS2016	2030 BAU JRC		2020 BAU accounting* MS	2020 BAU accounting* Models		2030 BAU accounting* MS	2030 BAU accounting* Models		2030 "Additional" mitigation potential in 2030* MS	2030 "Additional" mitigation potential Models	
LULUCF (1)	FM	-39.5	(3)	-41.3	(3)	-41.3	-44.9	-45.5	(4)		-43.2	-45.1	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-4.8	(7)
	AR			-2.1		-3.0	-2.1	-3.6	(5)		-3.0	-3.8	(5)	-3.0	-2.9	(6)		-3.4	(6)		-0.4	(7)
	D			4.0		3.1	1.8	1.1	(5)		0.8	0.6	(5)	3.1	1.4	(6)		0.7	(6)		-0.5	(7)
	CM	3.3		2.5		1.6	1.5	10.1	(5)		1.3	14.1	(5)	-1.7	2.5	(6)		4.3	(6)		-0.8	(7)
	GM	-0.8		-0.4		-0.1	-0.5	0.0	(5)		-0.9	0.0	(5)	0.7	0.5	(6)		0.4	(6)		0.0	(7)
	total (UNFCCC)	-35.8		-41.8			-44.2		(5)		-45.1		(5)									
Agriculture (2)	Soils N_2O	3.6	(3)	3.2	(3)	4.1			(5)	4.1			(5)	0.5		(6)	0.5		(6)			(7)
	Livestock	4.5		3.9		3.1			(5)	3.1			(5)	-1.4		(6)	-1.4		(6)			(7)
	total	8.3		7.3		7.3	6.8		(5)	7.2	6.9		(5)	-1.0	-1.5	(6)	-1.1	-1.4	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario).

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. There are relatively few policy instruments directly targeted at limiting GHG emissions from Swedish agriculture. Emissions from the agricultural sector have fallen since 1990, and the decline is projected to continue up to 2020-2030. N_2O accounts for a larger percentage reduction than CH_4, but also for a greater share of emissions. The decrease is largely due to the reduction of the numbers of cattle, which will lower the emissions of CH_4 from enteric fermentation and of both CH_4 and N_2O from animal manure. N_2O emissions are also expected to fall as a consequence of the decrease of the area under cereals, a reduced use of mineral fertilisers, a reduction in nitrogen leaching, and a shift to slurry systems in manure management. A smaller dairy herd and the continued decline in the cereal area up to 2020 and 2030 will be accompanied by an increased productivity, thus production will be maintained in 2030 at the same level of today.

LULUCF. Sweden's current forest policy puts great emphasis on sustainable forest management and on conserving biodiversity. Net removals from LULUCF are primarily dependent on the uptake of carbon dioxide in living forest biomass. The projection is based on a long-term sustainable scenario with maximum annual felling in proportion with the annual growth rate, i.e. with no over-felling. In addition, harvesting of forest residues is assumed to increase in response to a growing demand for bioenergy. Annual growth is assumed in the 6th NC to rise by 2% from 2010 to 2020 and by 4% from 2020 to 2030, as a result of assumed changes in climate. With these scenario assumptions, the projection shows a decrease in the net sink up to 2025, followed by a small increase up to 2030 (28 $MtCO_2$ for forest land in 2030). Emission from deforestation could potentially decrease somewhat with new policies on planning of future infrastructure and settlements, e.g. avoiding building roads on land with high carbon content. The Art.10 report foresees for 2020 a sink of -38.83 $MtCO_2$ for FM, -2.99 $MtCO_2$ for AR, emissions of 3.12 and 1.59 $MtCO_2$ respectively for D and CM, and a sink of -0.13 $MtCO_2$ for GM.

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 1.87 tCO_2/ha/yr), use of cover crops (0.72 tCO_2/ha/yr), and reduced tillage and crop residues incorporation (0.54 tCO_2/ha/yr). Combining these potentials within different scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.24 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 0.83 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock generating 14.1 $MtCO_2$/yr for cropland and of 0.02 MtCO2/yr for grassland by 2030 under a reference scenario (due to land use conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

Forestry

For FM, in CP2 Sweden predicts a small decline in the sink associated to a nearly stable harvest.

By 2030, CBM predicts a sink of 45.1 MtCO2/yr for the reference scenario, with 4.77 MtCO2/yr additional mitigation potential in case of -10% harvest. This suggests that the mitigation potential beyond BAU may be relevant in relation to total GHGs. IIASA predicts an approximately stable sink of 43.2 MtCO2/yr in 2030.

For AR, CBM estimates a slightly increasing sink compensating D emissions already in 2020. A similar trend for AR is foreseen by IIASA, which like CBM predicts a very significant decrease in D emissions.

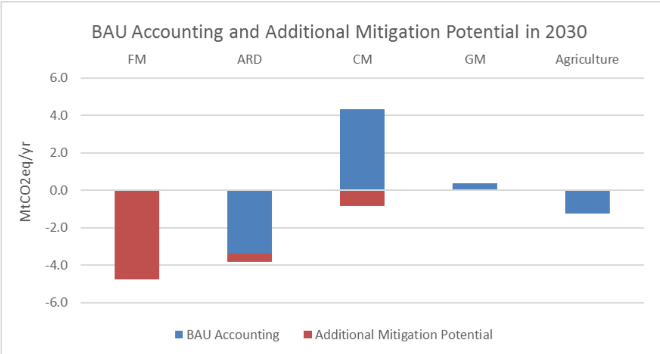
Fig. 3 Marginal abatement cost

No information available

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 72.2 $MtCO_{2eq}$/yr. Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



Disclaimer: The results in the accounting tables and figures should be seen as preliminary (to give a first order of magnitude), since not in all cases it was possible to ensure consistency with latest GHG inventories. Furthermore, the high level of complexity of the data to be assessed and compared may have led to occasional mistakes. The views expressed are purely those of the authors and may not be regarded as stating an official position of the European Commission.

UK

Current situation

Historic trends and key drivers in Agriculture and LULUCF sectors

AGRICULTURE: emissions equal to 9% of national GHGs excluding LULUCF (average 1990-2012), decreasing over time (average 1st Commitment Period (CP1: 2008-2012): 52.7 $MtCO_{2eq}$, reduced by 12.8 $MtCO_{2eq}$ from 1990). Main drivers: agricultural soils for N_2O; enteric fermentation from cattle and sheep and manure management for cattle and swine for CH_4.

LULUCF: net sink offsetting about 1% of national GHGs (average 1990-2012), this sector shifted from net source in 1990-1997 to net sink 1998-2012 (average CP1: -7.1 $MtCO_{2eq,}$). Main drivers: significant increase of removals in conversion to forest and to grasslands and important decrease of emissions from conversion to cropland. Lime application is an important source of emissions and soils in forest (both mineral and organic) an important sink. For CP1, credits from AR and FM (-2.6 and -1.4 $MtCO_{2eq}$/yr) and debits from D (1.1 $MtCO_{2eq}$/yr).

Fig. 1. Agriculture & LULUCF: past trends and CP1 (GHGI 2015)

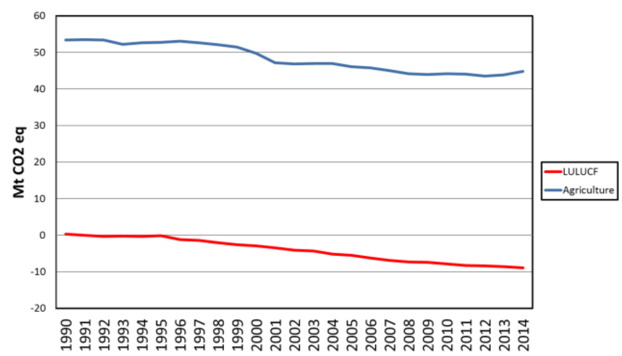


Fig. 2. Past trends of specific LULUCF categories (GHGI 2015)

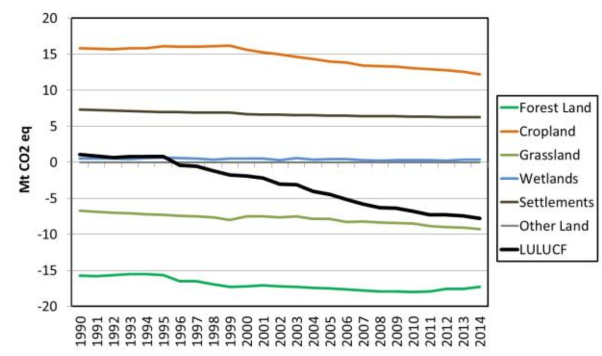


Table 43- state of play for LULUCF and Agriculture, and summary of available projections

United Kingdom		1990		2010		2020				2030				2020			2030					
		emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU emissions(+) / removals(-)				BAU accounting			BAU accounting			"Additional" mitigation potential in 2030		
all numbers are in $MtCO_{2eq}$ / yr														Accounted quantity of emissions(+) / removals(-)								
						MS	RS2016	JRC		MS	RS2016	JRC		MS	Models		MS	Models		MS	Models	
LULUCF (1)	FM	-10.8	(3)	-15.5	(3)	-8.3	-11.1	-10.2	(4)	-6.4	-9.7	-6.0	(5)	*0.0*	*0.0*	(6)	*0.0*	*0.0*	(6)		-0.6	(7)
	AR			-2.4		-3.4	-3.8	-4.8	(5)	-4.8	-4.2	-5.8	(5)	-3.4	-4.3	(6)	-4.8	-5.0	(6)		-0.4	(7)
	D			0.7			1.7	0.7	(5)		1.3	0.5	(5)		1.2	(6)		0.9	(6)		-0.3	(7)
	CM	13.4		11.0			11.5	1.6	(5)		11.1	1.2	(5)		-6.9	(6)		-7.3	(6)		-3.1	(7)
	GM	-7.0		-9.8			-8.9	0.2	(5)		-9.1	0.1	(5)		2.6	(6)		2.5	(6)		0.0	(7)
	total (UNFCCC)	-0.1		-7.8		-10.0	-10.6		(5)	-12.4	-10.6		(5)									
Agriculture (2)	Soils N_2O	16.7	(3)	13.8	(3)				(5)				(5)			(6)			(6)			(7)
	Livestock	34.2		28.4					(5)				(5)			(6)			(6)			(7)
	total	53.4		43.8		45.5	47.0		(5)	44.9	46.5		(5)	-7.9	-6.5	(6)	-8.5	-6.9	(6)			(7)

* Accounted quantity of emissions(+) / removals(-). For Agriculture (N2O, CH4) difference in estimated emissions/removals and 1990. For LULUCF (mainly CO2): estimated emissions/removals considering the accounting rules (see footnote 6)

(1) FM: Forest Management, ARD: Aff./Reforestation+Deforestation. CM: Cropland Management, GM: Grazing land management. Total includes also Settlements, Other lands and org soils not included in CM/GM.

(2) Including also Rice cultivation, Burning crop residues, Cultivation of organic soils

(3) GHGI 2016 (UNFCCC or KP). If data for activities are not available, proxies from UNFCCC land uses are used: FM: FL-FL, AR: L-FL, D: FL-other land uses, CM: CL- (FL-CL), CM: GL - (FL-GL). 2010 = average 2008-2012.

(4) MS: FMRL value (including HWP) in Decision 2/CMP.7 (2011). RS2016 (Reference scenario 2016): IIASA (G4M). JRC: CBM using same assumption as RS2016

(5) MS: Art 10 (LULUCF) or 6th NC (Agriculture). RS2016: IIASA (G4M, GLOBIOM, EPIC,GAINS; data for CM/GM recalibrated with GHGI 2016) JRC: CBM (FM and ARD, same assumption of RS2016) and IPCC TIER 1 (CM/GM)

(6)Accounting: FMRL: 0 by definition under BAU; ARD: gross-net (Models: average IIASA and JRC), CM&GM: net-net 1990 (Models: average IIASA and JRC)

(7) MS: any info from Art 10 or 6th NC (WAM). JRC: CBM (sensitivity analysis: FM+HWP -10% harvest; AR +50% area; D: -50% area), CENTURY (CM, environmentally-driven scenario).

Agriculture and LULUCF mitigation strategies in the 6th National Communication (NC) and Report under LULUCF Decision 529/2013/EU Article 10

AGRICULTURE. Emissions are expected to decrease by 29% in 2020 and 30% by 2030 below 1990 level. CH_4 emissions are expected to decrease due a reduction in livestock numbers and better management, led by the industry-led Agricultural Action Plan. A small decrease in N_2O emissions from fertilisation is expected, whilst emissions from agricultural soils will increase due to the production of wheat and oilseed rape. Rural development programmes for 2014-2020 are currently being developed in Scotland, Wales, Northern Ireland and England. These programmes will deliver agri-environmental-climate schemes, where climate change will be a cross-cutting priority.

LULUCF. The projections indicate that the LULUCF sector will be a net sink of -12.4 $MtCO_{2eq}$ in 2030. FL, CL, GL and SL categories dominate the trend. FL is a declining net sink up to 2030 due to a combination of forest management and changing age class distribution. The CL displays a declining net source for all the main scenarios considered by the Article 10 Report. The GL represents a declining sink under the main scenarios due to reduced rates of conversion of CL to GL. GHG's emissions from WL arise from the extraction of peat which is subject to weather and market conditions. There is no clear trend in this case. SL are projected to slowly increase emissions from 2013 onwards, driven by steady rates of land use conversion to SL. The HWP are projected to be an increasing sink over the period 2013 to 2050. Objectives for forestry in the UK are: increase woodland cover from 10% to 12% by 2060 in England, as set out in the 2013 Forestry and Woodlands Policy Statement; double woodland cover from 6% to 12% by 2056 in Northern Ireland; create an additional 100000 ha of new woodland by 2022 in Scotland, as set out in the 2013 Low Carbon Scotland Report, thus reducing emissions by 4.8 $MtCO_{2eq}$ by 2027. Scotland also aims at abating emissions through greater use of timber in building construction and refurbishment.

In the literature, the total maximum technical potential abatement estimates for 2022 are 23.8 $MtCO_{2eq}$ (Moran et al., 2011); this can be divided between cropland measures (5.0 $MtCO_{2eq}$), soil measures (8.7 $MtCO_{2eq}$), livestock measures (8.0 $MtCO_{2eq}$), and forestry measures (0.1 $MtCO_{2eq}$). About 60% of this abatement can be realized at a negative or null cost, while an additional 20% can be realized at a cost below the 2022 shadow price of carbon (60EUR/tCO_{2eq}).

Agriculture and LULUCF mitigation options and potentials

Agriculture, CM and GM

The CAPRESE project (Century model) estimated the following maximum mitigation potentials: conversion of arable land to grassland (sink of 3.8 tCO_2/ha/yr), use of cover crops and reduced tillage and crop residues incorporation (1 tCO_2/ha/yr for each measure). Combining these potentials within scenarios of land use change and management practices, for 2030 mitigation potentials are estimated ranging from 0.9 $MtCO_2$/yr beyond BAU for a more economical-oriented scenario up to 3.1 $MtCO_2$/yr beyond BAU in the case of an environmentally-oriented scenario. The IPCC Tier 1 method for mineral soils (not shown in tab. 1) estimated a loss in C stock of 1.17 $MtCO_2$/yr for cropland and of 0.071 MtCO2/yr for grassland by 2030 under a reference scenario (due to land conversion driven by demographic/economic trends). For organic soils a possible relevant mitigation option is rewetting/increasing the water table. CAPRI identified a set of mitigation options for the livestock sector, such as changes in feeding practices, agricultural practices (increasing grazing period, increase legumes in temporary grasslands), and manure management (cover slurry pits).

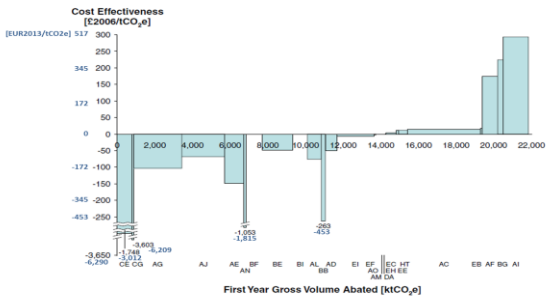
Forestry

For FMRL in CP2, in 2011 UK predicted a sudden decline of FM sink due to higher harvest. The latest GHGI significantly recalculated FM data (this will trigger a FMRL technical correction) and does not show yet the foreseen sink decline.

For FM (including HWP), by 2030 CBM predicts a sink of -6 $MtCO_2$/yr, declining compared to 2020, for reference scenario, and an additional mitigation potential estimated in – 0.6 $MtCO_2$/yr for -10% harvest. Also IIASA predicts a decreasing sink in FM reaching 9.7 $MtCO_2$/yr by 2030, due to a significantly increasing trend in harvest.

CBM estimates relevant BAU credits for AR in 2030 (-5.8 $MtCO_2$/yr), with an 'additional' mitigation potential of about -0.4 $MtCO_2$/yr. IIASA (G4M) predicts a much smaller sink in AR (4.2 $MtCO_2$/yr) and higher debits in D compared to CBM.

Fig. 3 Total UK ALULUCF abatement Maximum Technical Potential 2022 (Moran et al., 2011).



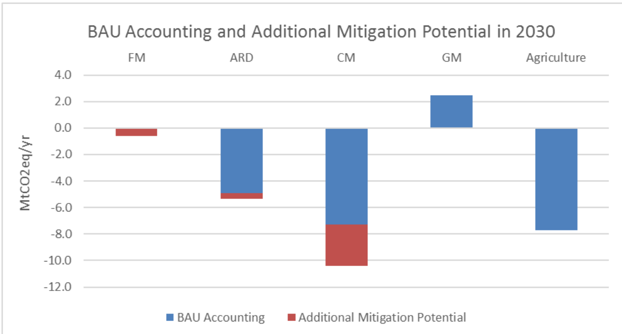
From left to right: CE, CG: Beef animal management; AG, AJ, AE, AN: Crops-soils; BF, BE, BI, BB: Dairy animal management; AL, AD: Crops-soils; EI, EF, EH, EC, EE, EB: On farm anaerobic digestion; AO, AM: Crops-soils; DA: Forestry—afforestation; HT: Centralized anaerobic digestion; AC, AF, AI: Crops-soils; BG: Dairy animal management.

Fig. 4 Estimated mitigation potential by 2030 ($MtCO_{2eq}$/yr).

For each activity, the average of MS+model data in tab. 1 are shown for the BAU accounting (blue) and the additional mitigation potential (red), derived from a sensitivity analysis.

Base year (1990) country total GHGs (without LULUCF): 799.8 $MtCO_{2eq}$/yr.

Credits and debits from CM and GM should be considered with caution because they can be partially affected by the fact that model estimates may be not calibrated with latest GHGI.



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