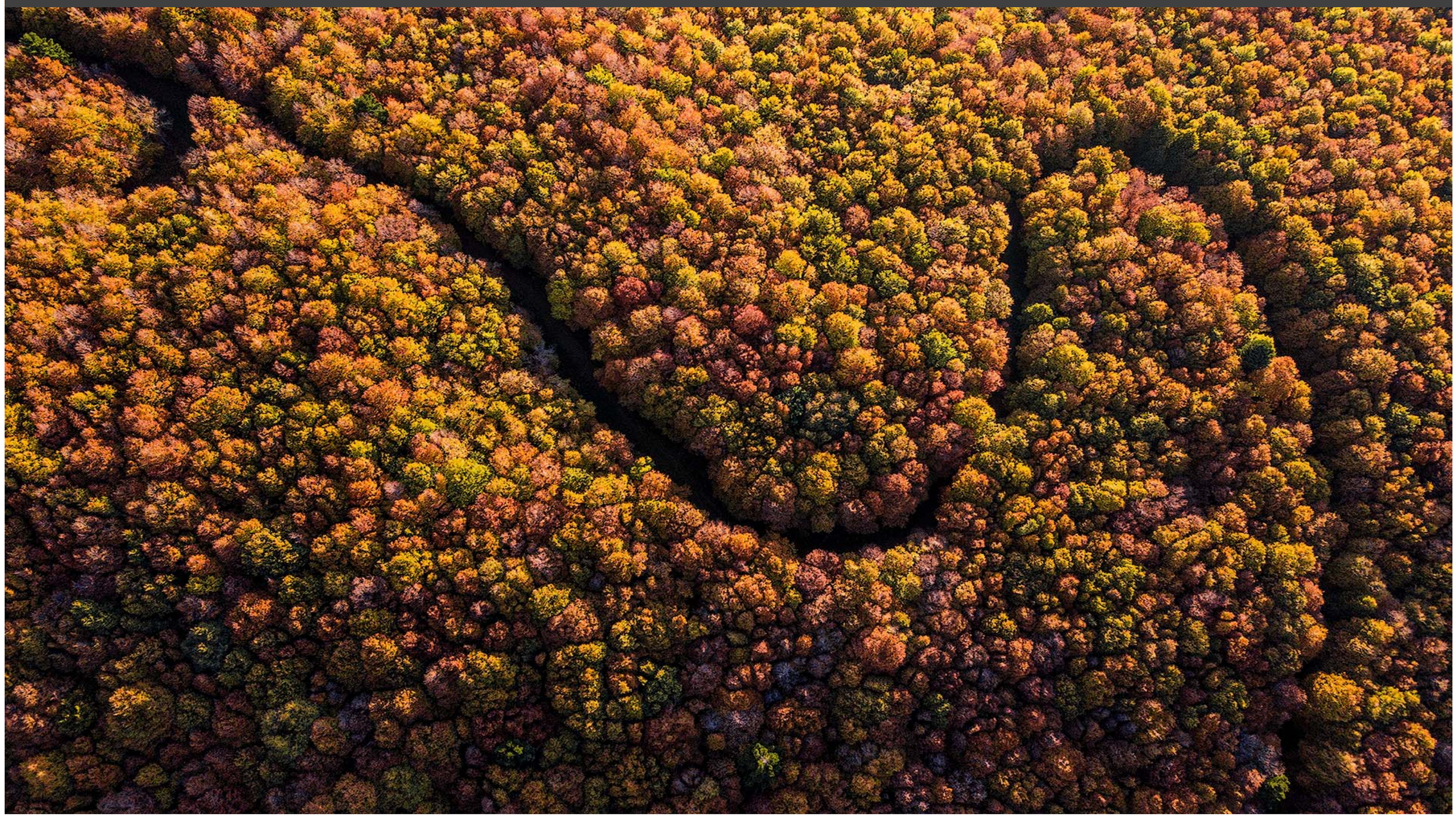
LULUCF: GHG inventory
bottom-up data/model requirements



Marina Vitullo

ISPRA - Institute for Environmental Protection and Research

Reporting on all emissions by sources and removals by sinks from **managed lands**, which are considered to be **anthropogenic;** emissions and removals for unmanaged lands are not reported .

CO_2

fluxes between the atmosphere and ecosystems are primarily controlled by uptake through plant photosynthesis and releases via respiration, decomposition and combustion of organic matter.

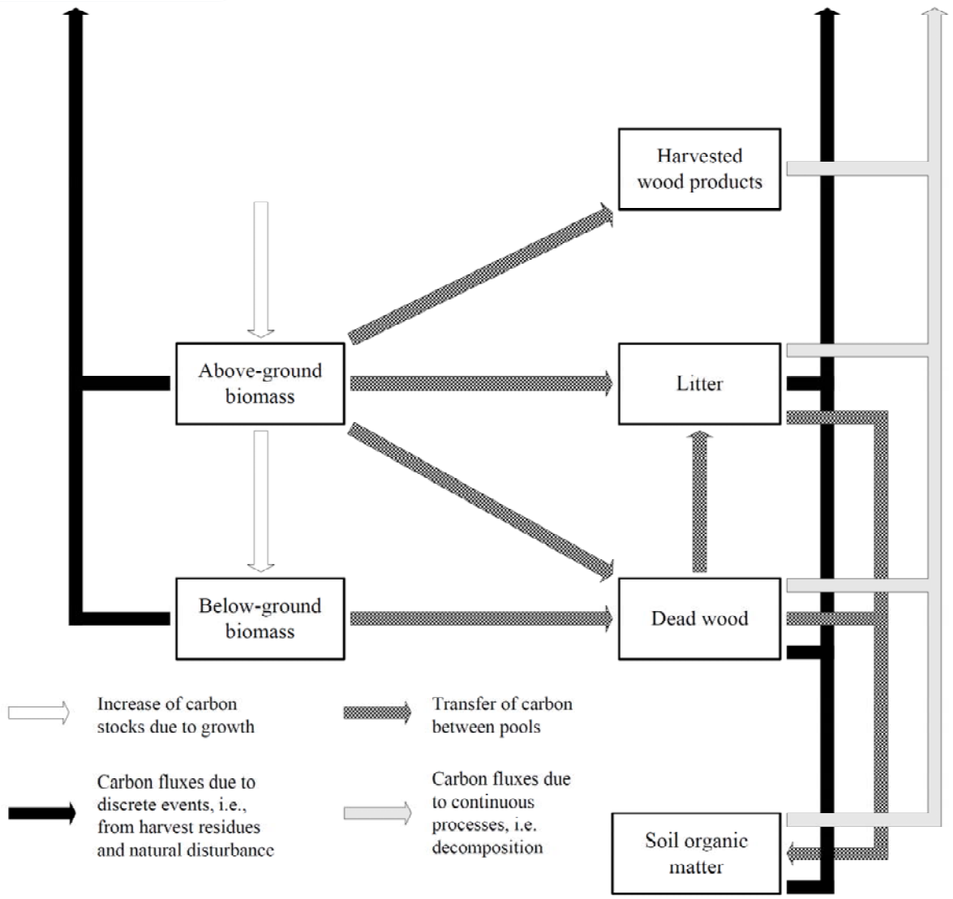
N_2O

N_2O is primarily emitted from ecosystems as a by-product of nitrification and denitrification

CH_4

CH_4 is emitted through methanogenesis under anaerobic conditions in soils, and during incomplete combustion while burning organic matter

LULUCF sector



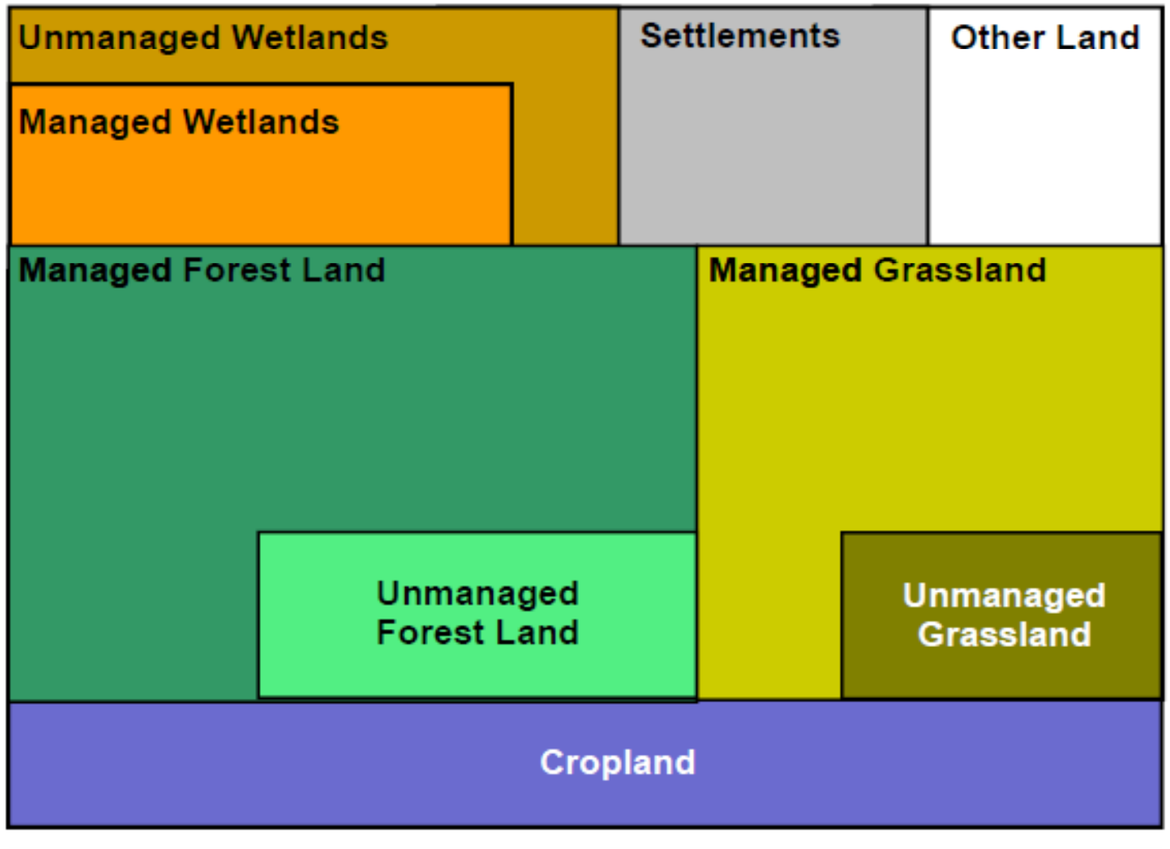
UNFCCC	Kyoto Protocol
A. Forest land	**A. Article 3.3 activities**
1. Forest land remaining forest land	A.1. Afforestation and reforestation
2. Land converted to forest land	A.2. Deforestation
B. Cropland	**B. Article 3.4 activities**
1. Cropland remaining cropland	B.1. Forest management
2. Land converted to cropland	B.2. Cropland management
C. Grassland	B.3. Grazing land management
1. Grassland remaining grassland	
2. Land converted to grassland	
D. Wetlands	
1. Wetlands remaining wetlands	
2. Land converted to wetlands	
E. Settlements	
1. Settlements remaining settlements	
2. Land converted to settlements	
F. Other land	
1. Other land remaining other land	
2. Land converted to other land	
G. Harvested wood products	

	Reporting *GHG emissions and removals from*	**Accounting** *Accounting of GHG emissions and removals towards emissions reduction targets*
UNFCCC	LULUCF categories	no accounting
Kyoto Protocol	*Forest Management*	Reference level
	Afforestation-Reforestation-Deforestation	Gross net
	Cropland Management, Grazing land Management, Wetlands draining and rewetting, Revegetation	Net-net accounting

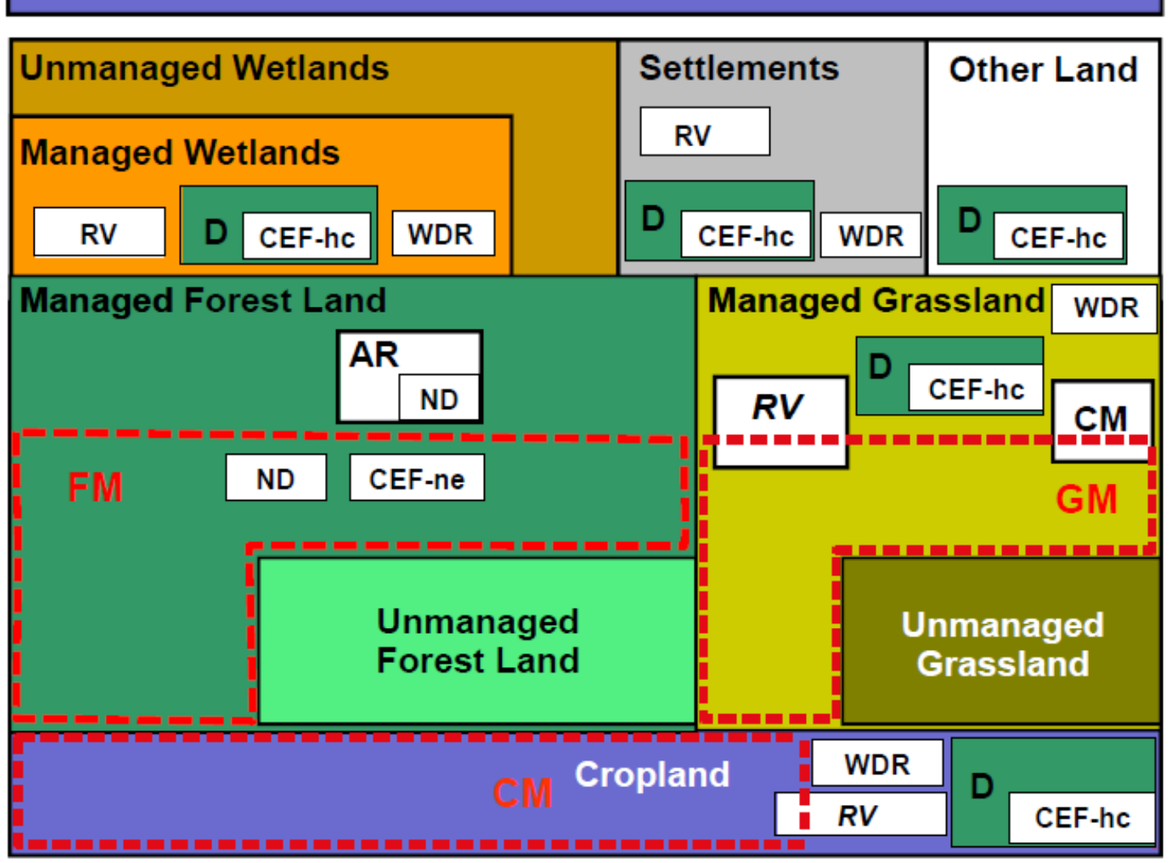
LULUCF reporting and accounting

Before Paris Agreement

Land Classification

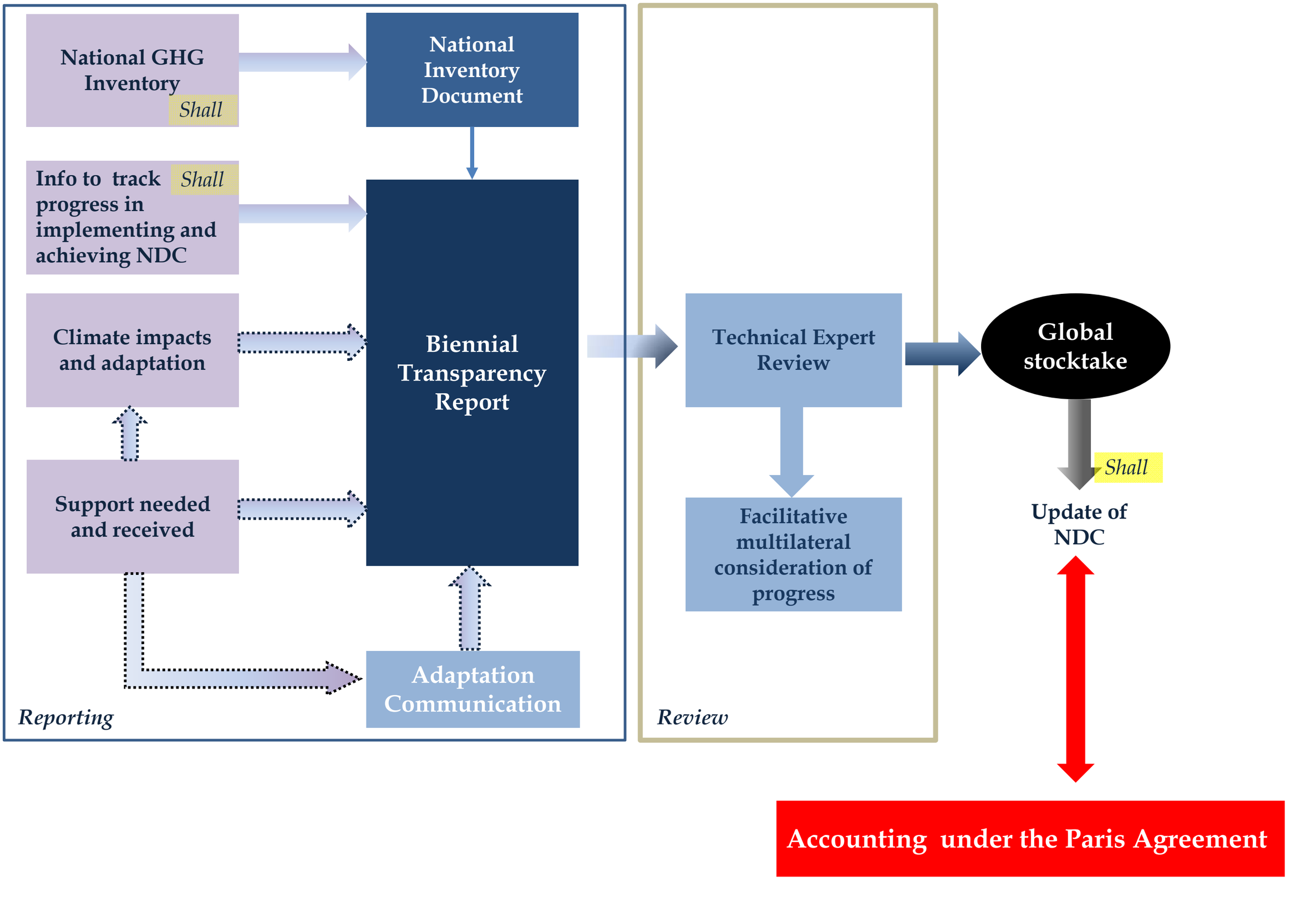


under UNFCCC



under Kyoto Protocol

The Enhanced Transparency Framework

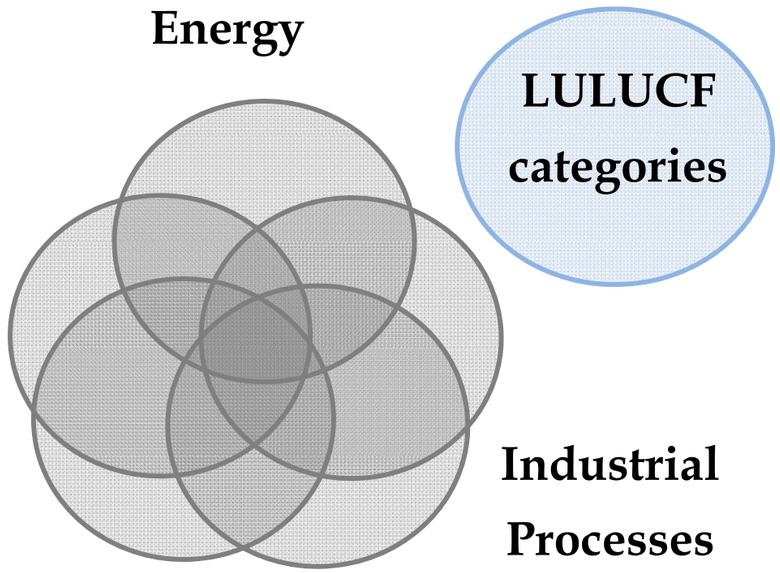


Reporting and accounting under Paris Agreement

CO_2 CH_4 N_2O HFCs PFCs SF_6 NF_3

Article 4

1. In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.



Reporting

Accounting for Parties' nationally determined contributions (NDC)

→ Parties account for emissions and removals in accordance with methodologies and common metrics assessed by the IPCC;

Tonnes of CO_2 equivalent for economy wide targets

→ Parties whose NDC cannot be accounted for using methodologies covered by IPCC guidelines provide information on their own methodology used.

Different metrics, following the NDC' elements (i.e. share of renawables, hectares of forested lands, energy efficiency, etc.)

Accounting

Land representation

A **consistent land representation** is needed for LULUCF estimation of GHG emissions and removals.

The land representation has to be complete:
- *total land area of country has to be represented*
- *managed and unmanaged land has to be reported*

The **three approaches** may be used to represent areas of land-use for the IPCC categories:

→ **Approach 1: total land use area (no data on conversions)**

represents land-use area totals within a defined spatial unit (such as a country, province or municipality). Only the net changes in land-use area can be tracked through time

→ **Approach 2: total land use area, including changes between categories**

Provides land use changes both from and to a category. Tracking changes without spatially-explicit location data (i.e. locations of specific land-use and land-use conversions are not known).

→ **Approach 3: spatially-explicit land use conversion data**

both spatially and temporally consistent and explicit. Sample-based, survey-based and wall-to-wall methods can be considered Approach 3

The **three** main **methods** for estimating areas of land-use and land-use change are:

→ **Sample based methods**: from ground surveys (such as a national forest inventory or national land survey) or remote sensing. Sample-based methods provide an accurate statistical representation of land-use and land-use change but do not provide information on every specific area of the land territory (i.e. is not wall-to-wall spatially explicit);

→ **wall-to-wall maps** of land cover and land cover change that, when combined with other data, can be used to generate land-use and land-use change information.

→ **statistical survey methods**, to collect information on land-use and land-use change and land management practices; this data is often used in combination with other data to develop a complete land use estimate

These methods are not mutually exclusive; for example, wall-to-wall methods typically require samples for calibration, validation and uncertainty analysis, and some sample methods require wall-to-wall maps for scaling as well as for dimensioning the sample size and designing the sample grid.

TABLE 3.6A (NEW)
EXAMPLES OF DIFFERENT DATA INPUTS AND METHODS TO DERIVE IPCC LAND-USE CLASSES AND THE RESULTING APPROACHES (1, 2 OR 3)[1]

Method	Approach 1	Approach 2	Approach 3
Sample-based methods	• Single sample • Temporary sample units	• Samples collected from permanent units but changes only tracked across two consecutive sample periods.	• Permanent and consistent georeferenced ground plots. • Continuous and consistent samples using remote sensing data.
Survey-based methods	• Single census at one point in time. • Repeat census but without reference to previous censuses.	• General surveys between two periods. • National census data that can refer a past period.	• Specific survey designs that identify activities through time for each land unit within a known region.
Wall-to-Wall methods	• Single map • Inconsistent maps developed at different times.	• Inconsistent maps through time combined with Approach 2-type samples (e.g. using maps as stratifications). • Maps developed using consistent methods changes tracked across two consecutive maps only not tracked through a time-series of maps.	• Tracking pixels / land units using time-series consistent data.

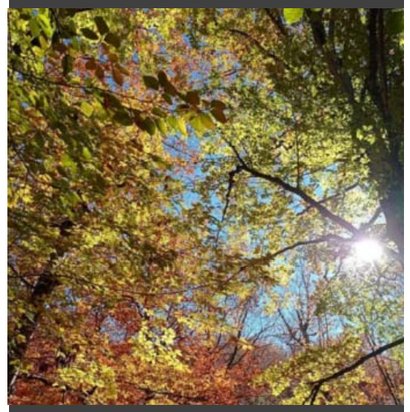
LULUCF reporting

Land use classification 1971-2018

Land use changes(*20yrs transition period*)

Emissions/Removals for each LU category/pool/gas

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals [1), (2)]	CH_4 [(2)]	N_2O [(2)]	NO_x	CO	NMVOC
	(kt)					
4. Total LULUCF	-36909.40	6.82	1.59	4.86	183.02	7.16
A. Forest land	-33471.74	3.16	0.00	0.04	84.72	3.32
1. Forest land remaining forest land	-27772.38	2.72	0.00	0.04	72.98	2.86
2. Land converted to forest land	-5699.36	0.44	0.00	0.01	11.74	0.46
B. Cropland	-95.73	0.04	0.21	0.06	1.18	0.05
1. Cropland remaining cropland	-930.95	0.04	0.00	0.06	1.18	0.05
2. Land converted to cropland	835.22	NO	0.21	NO	NO	NO
C. Grassland	-8395.76	3.62	0.11	4.76	97.12	3.80
1. Grassland remaining grassland	-2002.43	3.62	0.11	4.76	97.12	3.80
2. Land converted to grassland	-6393.33	NO	NO	NO	NO	NO
D. Wetlands [(3)]	52.69	NO	NO	NO,NE	NO,NE	NO,NE
1. Wetlands remaining wetlands	NO,NE	NO	NO	NE	NE	NE
2. Land converted to wetlands	52.69	NO	NO	NO	NO	NO
E. Settlements	5184.58	NO,NE,NA	1.22	NO,NA	NO,NA	NO,NA
1. Settlements remaining settlements	NO	NO	NO	NO	NO	NO
2. Land converted to settlements	5184.58	NA	1.22	NA	NA	NA
F. Other land [(4)]	NO	NO	NO	NO	NO	NO
1. Other land remaining other land						
2. Land converted to other land	NO	NO	NO	NO	NO	NO
G. Harvested wood products [(5)]	-183.45					
H. Other ***(please specify)***	NO	NO	NO	NO	NO	NO



kha	FL	CL	GL	WL	SL	OL	Totale Italia
1970	6,916	11,203	9,423	510	1,423	658	30,133.601
1971	6,947	11,192	9,398	510	1,429	658	30,133.601
1972	6,978	11,181	9,373	510	1,434	658	30,133.601
1973	7,009	11,169	9,348	510	1,440	658	30,133.601
1974	7,040	11,158	9,322	510	1,445	658	30,133.601
1975	7,071	11,147	9,297	510	1,451	658	30,133.601
1976	7,083	11,174	9,252	510	1,456	658	30,133.601
1977	7,095	11,201	9,207	510	1,462	658	30,133.601
1978	7,107	11,228	9,163	510	1,467	658	30,133.601
1979	7,119	11,256	9,118	510	1,473	658	30,133.601
1980	7,131	11,283	9,073	510	1,478	658	30,133.601
1981	7,145	11,219	9,117	510	1,484	658	30,133.601
1982	7,159	11,156	9,161	510	1,489	658	30,133.601
1983	7,173	11,093	9,205	510	1,495	658	30,133.601
1984	7,186	11,030	9,249	510	1,500	658	30,133.601
1985	7,200	10,966	9,293	510	1,506	658	30,133.601
1986	7,278	10,941	9,213	510	1,534	658	30,133.601
1987	7,356	10,916	9,132	510	1,561	658	30,133.601
1988	7,434	10,891	9,052	510	1,589	658	30,133.601
1989	7,512	10,866	8,971	510	1,616	658	30,133.601
1990	7,590	10,841	8,891	510	1,644	658	30,133.601
1991	7,668	10,857	8,768	511	1,672	658	30,133.601
1992	7,746	10,874	8,646	511	1,699	658	30,133.601
1993	7,824	10,891	8,523	511	1,727	658	30,133.601
1994	7,902	10,908	8,400	512	1,754	658	30,133.601
1995	7,980	10,924	8,278	512	1,782	657	30,133.601
1996	8,058	10,837	8,259	513	1,810	657	30,133.601
1997	8,136	10,749	8,241	513	1,837	657	30,133.601
1998	8,213	10,662	8,223	514	1,865	657	30,133.601
1999	8,291	10,574	8,204	514	1,892	657	30,133.601
2000	8,369	10,487	8,186	515	1,920	656	30,133.601
2001	8,447	10,365	8,202	515	1,948	656	30,133.601
2002	8,525	10,244	8,218	516	1,975	656	30,133.601
2003	8,603	10,122	8,233	516	2,003	656	30,133.601
2004	8,681	10,000	8,249	517	2,030	656	30,133.601
2005	8,759	9,879	8,265	517	2,058	656	30,133.601
2006	8,814	9,769	8,292	518	2,086	655	30,133.601
2007	8,868	9,660	8,318	518	2,113	655	30,133.601
2008	8,923	9,551	8,345	519	2,141	655	30,133.601
2009	8,978	9,355	8,464	526	2,156	655	30,133.601
2010	9,032	9,159	8,584	534	2,170	655	30,133.601
2011	9,087	9,096	8,570	541	2,185	655	30,133.601
2012	9,142	9,033	8,555	549	2,200	655	30,133.601
2013	9,196	8,971	8,541	556	2,214	655	30,133.601
2014	9,251	8,908	8,527	564	2,229	655	30,133.601
2015	9,305	8,845	8,513	571	2,244	655	30,133.601
2016	9,360	8,883	8,401	576	2,258	655	30,133.601
2017	9,415	8,920	8,289	581	2,273	655	30,133.601
2018	9,469	8,958	8,178	586	2,288	655	30,133.601

		1990						*total 1989*
		Forest	**Grassland**	**Cropland**	**Wetlands**	**Settlements**	**Other Land**	
1989	**Forest**	**7,511**				0.72		*7,512*
	Grassland	78.68	**8,891**	0.00	0.00	1.73		*8,971*
	Cropland		0	**10,841**	0.00	25		*10,866*
	Wetland				**510**			*510*
	Settlements					**1,616**		*1,616*
	Other Land					0.00	**658**	*658*
	total 1990	*7,590*	*8,891*	*10,841*	*510*	*1,644*	*658*	30,134
	Land converted to:	78.7	0.0	0.0	0.0	27.6	0.0	

20 years matrix		1990						*total 1971*
		Forest	**Grassland**	**Cropland**	**Wetlands**	**Settlements**	**Other Land**	
1971	**Forest**	**6,901**				14.4		*6,916*
	Grassland	689	**8,566**	136	0.00	33		*9,423*
	Cropland		325	**10,704**	0.00	174		*11,203*
	Wetland				**510**			*510*
	Settlements					**1,423**		*1,423*
	Other Land					0.00	**658**	*658*
	Total 1990	*7,589.8*	*8,890.9*	*10,840.5*	*510.1*	*1,644.0*	*658.3*	30,134
	Land converted to:	688.5	325.0	136.1	0.0	220.8	0.0	

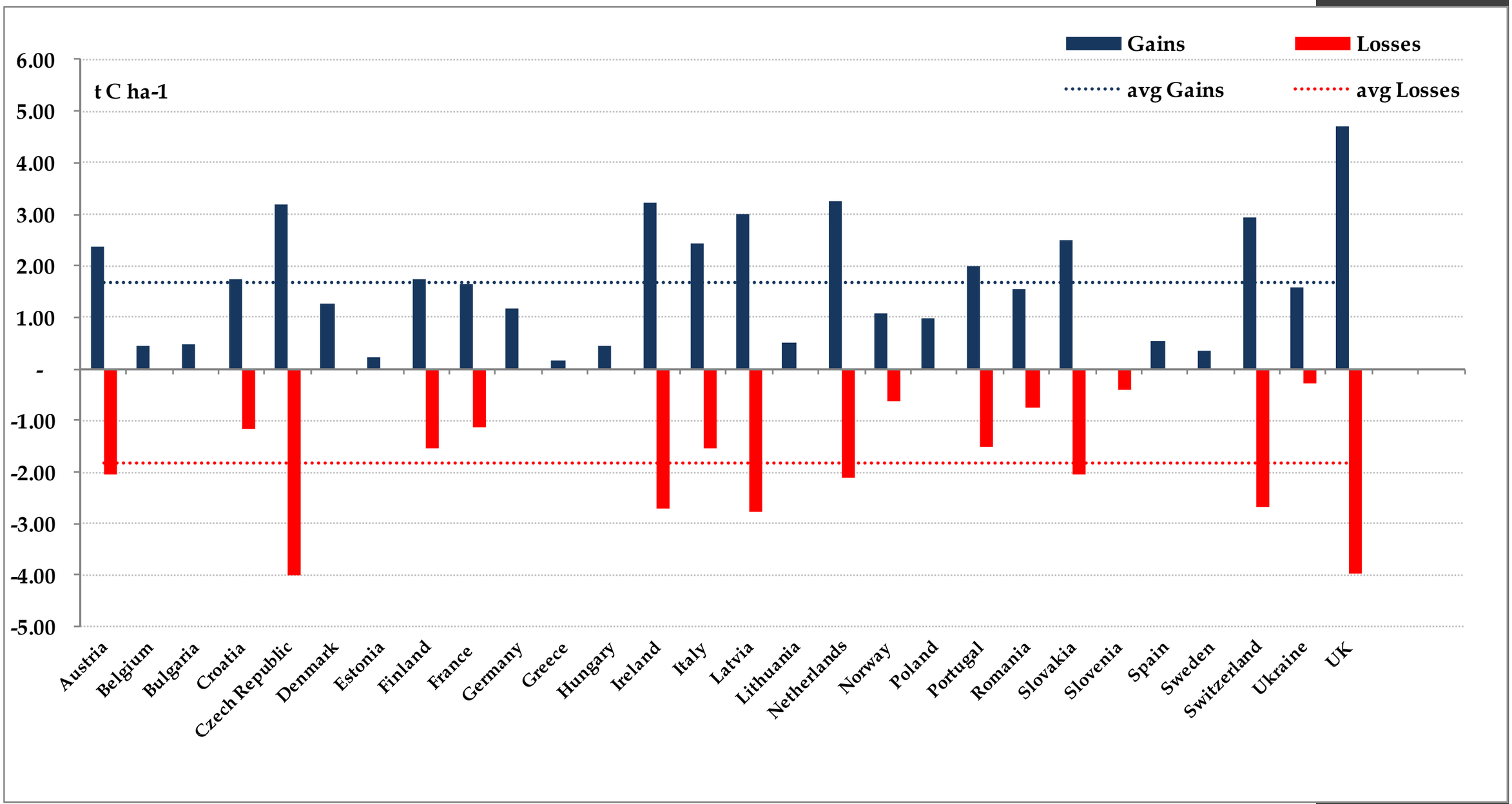
Methods applied in the IPCC categories

2018 submission	FL-FL	L-FL	CL-CL	L-CL	GL-GL	L-GL
AUT 2020 v2	T3	T2,T3	T2,T3	T2,T3	T1,T2	T2,T3
BEL 2020 v1	CS,T2	CS,T1	CS,T2	CS,T1,T2	CS,T2	CS,T1
BGR 2020 v1	T1,T2	T1,T2	T1,T2	T1,T2	T1,T2	T1,T2
HRV 2020 v1	T3	T3	T1,T2	T2	T1	T1
CZE 2020 v1	T2	T2	T2	T1,T2	T1,T2	T1,T2
EST 2020 v1	T1,T2	T1,T2	T1,T2	T2	T1,T2	T2
FIN 2020 v4	T2,T3	T2,T3	T2,T3	T1,T2,T3	T2,T3	T1,T2,T3
FRA 2020 v3	T1,T2	T1,T2	T1,T2	T1,T2	T1,T2	T1,T2
FRK 2020 v1	T1,T2	T1,T2	T1,T2	T1,T2	T1,T2	T1,T2
DEU 2020 v1	CS,T2	CS,T2	T2	T2	T2	T2
GRC 2020 v1	T2	OTH	T1,T2	T1,T2	T2	T1,T2
HUN 2020 v3	T1,T2	T1,T2	T1,T2	T1,T2	T1	T1,T2
ISL 2020 v1	T1,T3	T1,T2,T3	T1	D,T1,T2,T3	T1,T2,T3	T1,T2
IRL 2020 v3	T1,T2,T3	CS,T3	NA	NA	D,T1	T2,T3
ITA 2020 v1	T2,T3	T1,T2	T1,T2	T1	T1,T2,T3	T1
LVA 2020 v3	T2	T2	T1,T2	T1,T2,T3	T1,T2	T1,T2,T3
LIE 2020 v1	T2	T2	T2	T2	T2	T2
LTU 2020 v1	T2	T2	T1,T2	T1,T2	NA	T1,T2
LUX 2020 v1	T1,T2	T1,T2	T1	T1	NA	T1
NLD 2020 v2	T2	T1,T2	T1	CS,T1	CS,T1,T2	CS,T1,T2
NOR 2020 v2	T1,T3	T1,T2,T3	T1,T2	T1,T2,T3	T1,T2	T1,T2,T3
POL 2020 v1	T2	T2	T2	T1	T1,T2	T1
ROU 2020 v9	T3	T1,T2	T1	T1	T1	T1,T2
SVK 2020 v3	T1,T2	T1,T2	T1,T2	T1,T2	NA	T1,T2
SVN 2020 v5	CS,D,T2,T3	CS,D,T2,T3	CS,D,T1,T2	CS,D,T1,T2	D,T1,T2	D,T1,T2
ESP 2020 v1	T1,T2	T1,T2	T1,T2	T1,T2	NA	T1,T2
SWE 2020 v3	T2,T3	T2,T3	T2,T3	T2,T3	T2,T3	T2,T3
CHE 2020 v1	T2,T3	T2	T2,T3	T2	T2,T3	T2
UKR 2020 v2	CS,T1,T2	CS,T1,T2	CS,T1,T3	CS,T1	CS,T1,T3	CS,T1
GBK 2020 v1	CS,T3	CS,T3	CS,D,T1,T3	CS,D,T3	CS,T3	CS,D,T1,T3

EFs in FL-FL

2018 submission	EFs for FL-FL
AUT 2020 v2	CS
BEL 2020 v1	CS
BGR 2020 v1	CS,D
HRV 2020 v1	CS,D
CZE 2020 v1	CS,D
EST 2020 v1	CS,D,OTH
FIN 2020 v4	CS
FRA 2020 v3	CS,D
FRK 2020 v1	CS,D
DEU 2020 v1	CS
GRC 2020 v1	CS,D
HUN 2020 v3	CS,D
ISL 2020 v1	D
IRL 2020 v3	CS
ITA 2020 v1	CS,D
LVA 2020 v3	CS
LIE 2020 v1	CS
LTU 2020 v1	CS,D
LUX 2020 v1	CS,D
NLD 2020 v2	CS
NOR 2020 v2	CS,D
POL 2020 v1	CS
RUS 2020 v3	CS
SVK 2020 v3	CS,D
SVN 2020 v5	CS,D
ESP 2020 v1	CS,D
SWE 2020 v3	CS
CHE 2020 v1	CS,M
UKR 2020 v2	CS,D
GBR 2020 v1	CS

Implied Emission Factors in Forest Land remaining Forest Land category



Methods to estimate C stock changes in biomass

Tier 1

country-specific estimates of activity data and emission/removal factors are not available

✓ *Biomass Gain-Loss Method (IPCC 2006 eq. 2.7)*

Tier 2

country-specific estimates of activity data and emission/removal factors are available or can be gathered at reasonable cost.

✓ *Biomass Gain-Loss Method (IPCC 2006 eq. 2.7)*

✓ *Guidance on the use of allometric models to be used with country specific data to estimate carbon stocks (IPCC 2019 Refinement)*

✓ Guidance on the use of biomass density maps *(IPCC 2019 Refinement)*

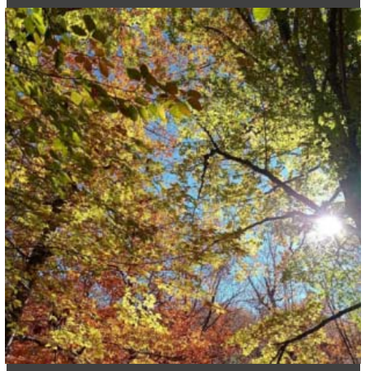
Tier 3

allows for a variety of methods, including process-based models (to be transparently documented and validated). Tier 3 requires use of detailed national forest inventories when the stock-difference method is used (*IPCC 2006 eq. 2.8*).

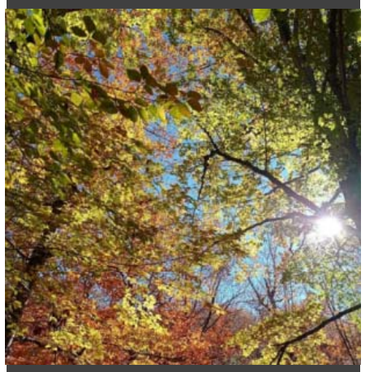
✓ *Guidance on the use of allometric models to be used with country specific data to estimate carbon stocks (IPCC 2019 Refinement)*

✓ Guidance on the use of biomass density maps *(IPCC 2019 Refinement)*

Forest land biomass



Forest land biomass



Use of **biomass maps** for the estimation of carbon emissions at **Tier** 2 and **Tier** 3 levels can be achieved in several ways:

1. **Combination with activity data where a biomass density map provides the base to estimate emission factors**.
   Countries have used such an approach to increase data density in areas under-sampled by ground inventories

2. **Estimate biomass change directly from multi-temporal biomass density maps.**
   consistent and well-calibrated biomass density maps is needed (using ground and remotely sensed data to accurately estimate biomass changes).

3. **Integration of biomass density maps with remote sensing-assisted, time-series of land change and/or with Tier 3 models to spatialize emissions estimates.**
   Critical: ensuring consistency among the different data sources/models, definitions (forest, biomass pools), spatial and temporal data characteristics. Biomass maps uncertainties can propagate to larger area estimates, resulting in higher emissions' uncertainties

Key issues (at least for European countries) for the use of biomass maps in GHG inventories:
- **consistency** with national definition
-**availability** of a robust and consistent **series** of wall-to-wall datasets (take into account that a consistent reporting has to be provided covering years 1990 to current year-2).
- **poor added value** compared to the current extensive use of NFIs data, usually available at very detailed stratification and resolution, and quite low uncertainty

Thank you