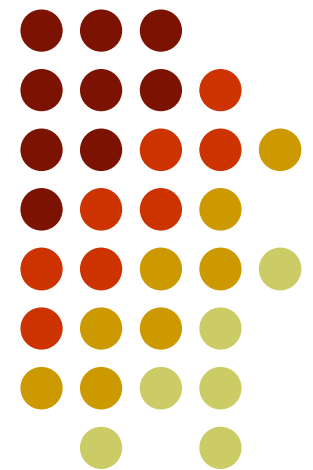


GHG Inventory from LULUCF Sector

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Institutions involved in LULUCF – GHG Inventory



1. Indian Institute of Science
2. FSI
3. NRSC
4. ICFRE: FRI

GHG emissions from LULUCF Sector



- **Globally land use sectors account for**
 - 20% of CO₂ & 17% of CO₂ eq. GHG emissions
 - Global emissions = **5.9** GtCO₂-eq,
 - Large **uncertainty = 1.8–9.9** GtCO₂-eq
- **LULUCF sector**
 - India: Marginal **source of 14** Mt CO₂ - NATCOM I
 - China: Net **sink of 407** Mt CO₂ - NATCOM I
 - Brazil: Net **source of 776** Mt CO₂ - NATCOM I

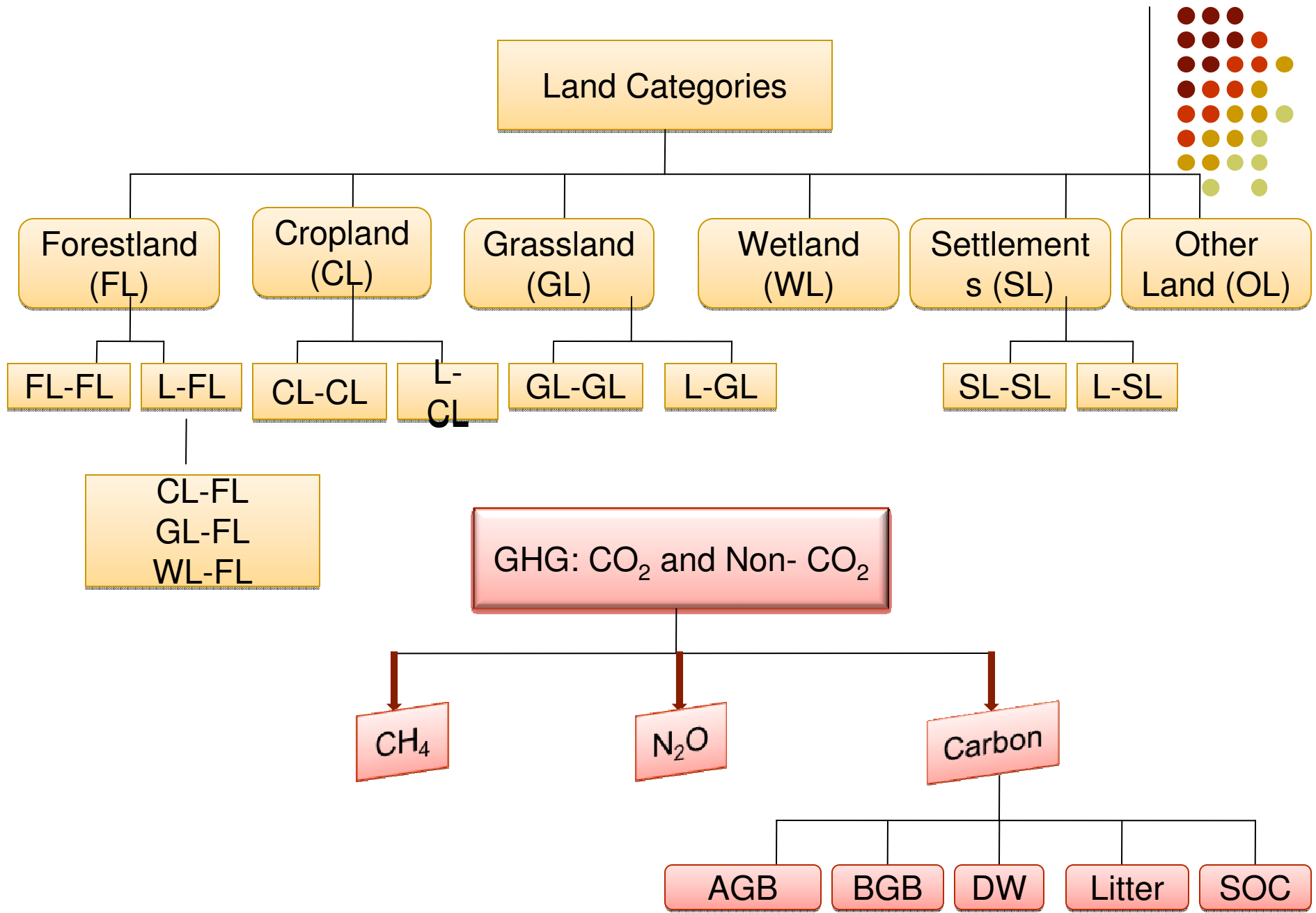
IPCC Developed 3 Guidelines for LULUCF Inventory



1. **Revised 1996 Guidelines for LUCF
– NATCOM - I**

2. **IPCC GPG (Good Practice Guidelines) for LULUCF, 2003**

- **INCCA -MoEF 2007 and NATCOM –II for 2004**
 - **Annex - 1 countries**
3. IPCC – 2006, AFOLU (Agriculture Forest and Other Land Categories)



Comparison of GPG 2003 with IPCC 1996 GL



GPG2003	IPCC 1996GL - default approach
i) Land category based approach covering forest land, cropland, grassland, wetland, settlement and others	i) Approach based on four categories namely 5A to 5D (refer to Section 5.1 of IPCC 1996) All land categories not included such as coffee, tea, coconut etc. Lack of clarity on agro-forestry
ii) These land categories are further sub divided into; <ul style="list-style-type: none"> - land remaining in the same use category - other land converted to this land category 	ii) Forest and grassland categories defined in 5A and 5B differently
iii) Methods given for all carbon pools; AGB, BGB, dead organic matter and soil carbon and all non-CO ₂ gases	iii) Methods provided mainly for aboveground biomass and soil carbon. <ul style="list-style-type: none"> - Assumes as a default that changes in carbon stocks in dead organic matter pools are not significant and can be assumed to be zero, i.e. inputs balance losses. - Similarly, belowground biomass increment or changes are generally assumed to be zero
iv) Key source/sink category analysis provided for selecting significant <ul style="list-style-type: none"> - land categories - sub-land categories - C-pools - CO₂ and non-CO₂ gases 	iv) Key source/sink category analysis not provided
v) Three tier structure presented for choice of methods, Activity Data and Emission Factors	v) Three tier structure approach presented but its application to choice of methods, AD and EF not provided
vi) Biomass and soil carbon pools linked particularly in Tier 2 and 3	vi) Changes in stock of biomass and soil carbon in a given vegetation or forest type not linked

Carbon Pools



Carbon Pool		Description
Living biomass	Above-ground biomass	All biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds and foliage.
	Below-ground biomass	All biomass of live roots. Fine roots of less than 2 mm diameter (the suggested minimum) are often excluded because these often cannot be distinguished empirically from soil organic matter.
Dead organic matter	Deadwood	All non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Deadwood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter.
	Litter	All non-living biomass with a size greater than the limit for soil organic matter (the suggested minimum is 2 mm) and less than the minimum diameter chosen for deadwood (e.g. 10 cm) lying dead and in various states of decomposition above or within the mineral organic soil. This includes the litter layer as usually defined in soil typologies. Live fine roots above the mineral or organic soil (of less than the suggested minimum for below-ground biomass) are included whenever they cannot be empirically distinguished from the litter.
Soil	Soil organic matter	Organic carbon in mineral soils to a specified depth chosen and applied consistently through a time series. Live and dead fine roots within the soil (of less than the suggested minimum for below-ground biomass) are included wherever they cannot be empirically distinguished from the soil organic matter.

Equation for estimating C-stock change



Annual carbon stock change for a land-use category is the sum of changes in all carbon pools

$$\Delta C_{LUI} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SC}$$

Where:

ΔC_{LUI} is carbon stock change for a land-use category, AB = above-ground biomass, BB = below-ground biomass, DW = deadwood, LI = litter and SC = soil carbon

Methods for estimating C inventory



1. Carbon gain-loss method

$$\Delta C = \Delta C_G - \Delta C_L$$

2. Carbon stock difference or change (NFI)

$$\Delta C = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Land-use change matrix for 2007 (Area in Mha)



Land-use	Sub-category/strata	2006	2007	Change in area
Forest	Very dense ¹	8.35	8.35	0.00
	Moderately dense ¹	31.99	31.90	-0.09
	Open ¹	28.68	28.84	0.16
	<i>Land converted to forest</i>			0.07
	Sub total Forest area	69.02	69.16	0.14
Cropland	Net sown area	141.06	139.72	-1.34
	Fallow (current fallow)	40.84	41.29	0.45
	Sub total	181.9	181.01	-0.89
Grassland	Grazing land	8.06	8.05	-0.01
	Scrub	21.31	21.12	-0.19
	Other wasteland + Gullied / Ravines	30.73	31.85	1.12
	Shifting cultivation	0.20	0.26	0.06
	<i>Land converted to grassland</i>			0.98
	Sub total	60.30	61.28	0.98
Wetland	Wetland (flooded land)	6.28	6.08	-0.20
Settlement	Settlement ²	2.06	2.07	0.01
	<i>Land converted to Settlements</i>			0.01
Other land	Other land	9.09	9.05	-0.04
	<i>Land converted to other land</i>			-0.04
GRAND TOTAL		328.65	328.65	—

Change in C stock between 2005 and 2007 in forest land category



Carbon pools	C stock in million tons 2005	C stock in million tons 2007	Change in C stock in million tons (2005 - 2007)	CO ₂ removal in million tons during 2007
	A	B	C=A-B	D=C*44/12
Above ground biomass	2337	2349	6	22.0
Below ground biomass	682	685	1.5	5.5
Soil Carbon	4270	4292	11	40.3
Total	7289	7326	18.5	67.8

CO₂ emissions and removals for biomass and soil carbon for land categories; with land remaining in the same categories



Land use categories	MAI in perennial aboveground biomass (t/ha/y) A	MAI in perennial belowground biomass (t/ha/y) ¹ B	MAI in total perennial biomass (t/ha/y) A+B	MAI in soil carbon (t/ha/y) C	MAI in total carbon (t/ha/y) $D = (A + B)/2 + C$	Net DC (Mt C) $E = D \times \text{Area}$	Net change in CO ₂ (Mt) $F = E \times 3.6666$ [+ is emission; - is removal]
Cropland—Cropland	0.130	0.046	0.176	0.220	0.308	56.60	- 207.52
Grassland—Grassland	0.003	0.001	0.004	-0.056	-0.054	-2.86	+10.49
Settlement—Settlement	0.008	0.002	0.010	0.000	0.005	0.01	-0.038
Wetland—Wetland	—	—	—	—	—	—	—
Other land	—	—	—	—	—	—	—

Total GHG emissions from LULUCF for 2007 in Gg



<i>Land use categories</i>	<i>CO₂ emissions/removals (Gg CO₂)</i>	<i>CO₂ loss due to fuelwood use (GgCO₂) leading to net CO₂ emission</i>	<i>Net CO₂ emissions/removal (GgCO₂)</i>
Forestland	-67,800	+87,840	
Cropland	-207,520		
Grassland	+10,490		
Wetland (Flooded land)	NE		
Settlement	-38		
Other land	NO		
TOTAL	-264,868		+87,840

Conclusion



- **LULUCF sector in India is a net sink of carbon = 177 Mt CO₂**
 - Cropland and forest land are a net sink
- **NATCOM I – covered only LUCF sector excluding cropland, grassland etc.**
 - GPG Method includes all the land use categories
- **Thus GPG estimates not comparable with**
 - **the NATCOM I values for India**
 - **with the emissions inventory of China or Brazil**
 - No estimate from China & Brazil using: IPCC-GPG 2003 GL



Limitations and Uncertainties

- **Inventory in LULUCF sector is characterized by**
 - Very high uncertainty
 - Data limitations
 - Inventory is not complete due to data limitations
- **Lack of emission / removal factors according to;**
 - Land categories: forest land, crop land, grass land, wetland, settlements, other land
 - Land use change; crop land left fallow, Grass land converted to crop land or grassland
- **Even Annex –1 estimates have high uncertainties**