

INVENTARISASI EMISI GAS RUMAH KACA DARI SEKTOR KEHUTANAN : METODE IPCC GUIDELINE

*Inventory of Green Gas House Gasses Emission from Forestry Sector:
IPCC Guideline Method*

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ABSTRACT

Forestry Sector which in the context of climate change is included as LULUCF sector (Land use, land use change and forestry), is an important sector that should be covered in the activity of green house gas (GHG) inventory. Forestry plays important role in carbon cycle. In global level, contribution of LULUCF sector was 18 %, meanwhile in national level, it contributed to about 74 % of total GHG emission. For inventory of GHG, IPCC (International Panel on Climate Change) has developed methods that have been broadly applied by countries ratifying the UNFCCC. Indonesia is encouraged to apply the IPCC Guideline method for its GHG inventory in order to obtain accurate and reliable results for international recognition. IPCC GL method divides land class into six land categories namely forest land, cropland, grassland, wetland, settlement and other land. Application of IPCC GL method requires more comprehensive data and information covering forestry and agriculture sector. Moreover, local specific information is required related to emission/removal factors, not only using IPCC default values, to get higher Tier (Tier 2 or 3)

Keywords: *Green House Gas inventory, IPCC GL, LULUCF Sector*

ABSTRAK

Sektor Kehutanan yang dalam konteks perubahan iklim termasuk kedalam sektor LULUCF (*Land use, land use change and forestry*) adalah salah satu sektor penting yang harus dimasukkan dalam kegiatan inventarisasi gas rumah kaca (GRK). Kehutanan memainkan peranan penting dalam siklus karbon. Di tingkat global, kontribusi sektor LULUCF sebesar 18 %, sedangkan di tingkat nasional mencapai 74 %. Untuk kepentingan inventarisasi gas rumah kaca, IPCC (*International Panel on Climate Change*) telah mengembangkan metode yang telah diaplikasikan secara luas oleh negara-negara yang meratifikasi UNFCCC. Indonesia penting untuk menerapkan metode IPCC Guideline dalam inventarisasi gas rumah kaca agar hasil inventarisasi lebih akurat dan terpercaya sehingga diakui oleh internasional. Metode IPCC GL membagi kelas lahan kedalam enam kategori yaitu *forest land, cropland, grassland, wetland, settlement* dan *other land*. Aplikasi metode IPCC GL memerlukan data dan informasi yang lebih komprehensif mencakup tidak hanya sektor kehutanan tapi juga sektor pertanian. Selain itu diperlukan informasi spesifik mencakup faktor emisi yang tidak hanya menggunakan angka *default* yang ada dalam IPCC GL guna mendapatkan ketelitian yang lebih tinggi (Tier 2 atau 3).

Kata Kunci : *Inventarisasi Gas Rumah Kaca, IPCC Guideline, Sektor LULUCF*

I. PENDAHULUAN

Salah satu kewajiban negara-negara yang meratifikasi konvensi perubahan iklim (UNFCCC) adalah melaporkan kegiatan mengatasi perubahan iklim melalui penyusunan National Communication. Saat ini Indonesia sedang menyusun Second National Communication, dan salah satu bab penting yang harus dilaporkan adalah emisi gas rumah kaca.

Sektor Kehutanan yang dalam konteks perubahan iklim termasuk ke dalam sektor LULUCF (*Land use, land use change and forestry*) adalah salah satu sektor penting yang harus dimasukkan dalam kegiatan inventarisasi gas rumah kaca. Kehutanan memainkan peranan penting dalam siklus karbon. Laporan Stern (2007) menyebutkan kontribusi sektor LULUCF sebesar 18 %, sedangkan di Indonesia *First National Communication* melaporkan LULUCF sebesar 74 %. Sebagian besar pertukaran karbon dari atmosfer ke biosfir daratan terjadi di hutan. Status dan pengelolaan hutan akan sangat menentukan apakah suatu wilayah daratan sebagai penyerap karbon (*net sink*) atau pengemisi karbon (*source of emission*).

Di Indonesia estimasi penghitungan emisi tahun 1990an menunjukkan hasil yang sangat bervariasi yaitu antara 41 - 163 juta ton, dengan serapan karbon antara 187 - 337 juta ton (Boer *et al.*, 1999). Variasi ini disebabkan oleh perbedaan *activity data* (misalnya luas hutan, luas *grassland*, konversi dan penggunaan lahan lainnya), konsumsi kayu, faktor emisi, metode pengukuran serta asumsi yang digunakan dalam analisis. Studi tersebut mengindikasikan bahwa Indonesia adalah penyerap karbon (*net sink*). Meskipun demikian, pada First National Communication, Indonesia menunjukkan sebagai negara pengemisi gas rumah kaca (GRK) (INC, 2000). Perubahan status dari *net sinker* menjadi *net emitter* disebabkan terutama oleh faktor dimasukkannya sektor LULUCF dalam penghitungan emisi dan serapan karbon.

Laporan-laporan selanjutnya menunjukkan Indonesia sebagai emiter ke 3 di dunia (Peace, 2007). Apabila tanpa LULUCF laporan WRI (Baumert *et al.* 2005) menunjukkan Indonesia di peringkat 15.

Tabel (Table) 1. Negara-negara pengemisi GRK, tanpa LULUCF (*GHGs emitter countries, without LULUCF*)(WRI, 2005)

Negara/Country	MtCO ₂ equivalent	% of world GFGS
1. United States	6,928	20.6
2. China	4,938	14.7
3. EU-25	4,725	14.0
4. Russia	1,915	5.7
5. India	1,884	5.6
6. Japan	1,317	3.9
7. Germany	1,009	3.0
8. Brazil	851	2.5
9. Canada	680	2.0
10. United Kingdom	654	1.9
11. Italy	531	1.6
12. South Korea	521	1.5
13. France	513	1.5
14. Mexico	512	1.5
15. Indonesia	503	1.5
16. Australia	491	1.5
17. Ukraine	482	1.4
18. Iran	480	1.4
19. South Africa	417	1.2
20. Spain	381	1.1
21. Poland	381	1.1
22. Turkey	355	1.1
23. Saudi Arabia	341	1.0
24. Argentina	289	0.9
25. Pakistan	285	0.8
Top 25	27,915	83
Rest of World	5,751	17
Developed	17,355	52
Developing	16,310	48

Notes: Data is for 2000. Totals exclude emissions from international bunker fuels and land use change and forestry.

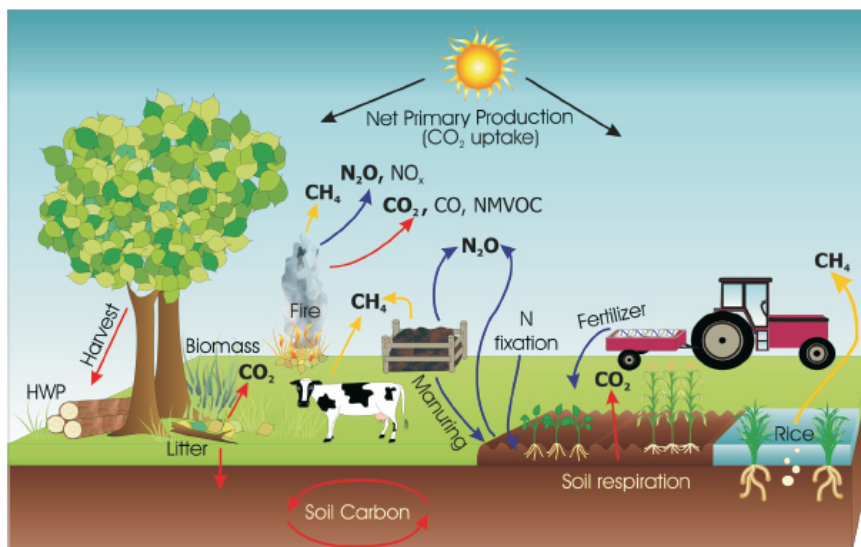
Tabel (Table) 2. Negara pengemisi GRK terbesar di dunia (juta ton Co2 e) (*The greatest GHGs emitter countries in the world. (million tonnes (O2 e))*(Peace, 2007)

Emission sources	United States	China	Indonesia	Brazil	Rusia	India
Energy ²	5,752	3,720	275	303	1,527	1,051
Agriculture ³	442	1,171	141	398	118	442
Forestry ⁴	(403)	(47)	2,563	1,372	54	(40)
Waste ⁵	213	174	35	43	46	124
Total	6,005	5,017	3,014	2,316	1,745	1,577

Dari tabel tersebut terlihat besarnya kontribusi sektor kehutanan terhadap emisi GRK. Selanjutnya untuk kepentingan inventarisasi GRK diperlukan data yang akurat dan metode yang diakui internasional untuk melaporkan perkembangannya. Sampai saat ini metode penghitungan emisi yang dikeluarkan oleh IPCC (*International Panel on Climate Change*) adalah metode yang digunakan oleh seluruh negara yang meratifikasi UNFCCC. Untuk negara Non-Annex 1 dapat menggunakan revised IPCC 1996 guideline sementara itu negara maju yang masuk dalam negara Annex 1 sejak tahun 2005 wajib menggunakan metode dalam LULUCF GPG 2003. Meskipun demikian, negara non-Annex 1 disarankan agar juga menggunakan LULUCF-GPG 2003 atau 2006 IPCC Guideline (AFOLU).

II. METODE INVENTARISASI GAS RUMAH KACA (GRK) MENGGUNAKAN IPCC 2006 GUIDELINE

Dalam kaitannya dengan perubahan iklim, sektor kehutanan dapat berfungsi sebagai pengemisi karbon (*emitter*) dan penyerap karbon (*sinker*), sebagaimana terlihat pada Gambar 1 berikut:



Gambar (Figure) 1. Sumber emisi dan serapan GRK untuk sektor Agriculture, Forestry and Land Use (AFOLU) (*Source of emission and GHGs sinker for agriculture, Forestry and Land use Sector*) (Sumber/Source: IPCC 2006)

Dalam gambar tersebut terlihat bahwa selain CO₂, sektor AFOLU juga mengemisi GRK lainnya seperti N₂O dan CH₄. Gas-gas ini memiliki potensi pemanasan global (GWP) yang lebih besar dibandingkan dengan CO₂. Tabel 3 menunjukkan jenis gas rumah kaca dan besarnya potensi gas tersebut terhadap pemanasan global.

Table (Table) 3. Komponen GRK dan potensinya terhadap pemanasan global (*Component of GHGs and the potency towards global warming*)

Komponen GRK (<i>Component of GHGs</i>)	Potensi Pemanasan Global (<i>Global Warming Potency/GWP</i>)
Carbon Dioxide, CO ₂	1
Methane, CH ₄	23
Nitrous Oxide, N ₂ O	296
Hydrofluorocarbons, HFC	120 – 12.000
Perfluorocarbons, PFC	5.700 – 11.900
Sulfur Hexafluoride	22.200

Sumber/Source : IPCC Third Assessment Report (2001)

IPCC telah mengembangkan metode inventarisasi GRK sejak tahun 1996, yaitu melalui IPCC Guideline revised 1996, IPCC Good Practice Guidance 2003 dan IPCC Guideline 2006.

Dalam IPCC GL 1996, kategori LUCF terdiri dari :

1. *Changes in forest and other woody biomass stocks*
2. *Forest and grassland conversion*
3. *Abandonment of croplands, pastures, plantation forests or other managed lands*
4. *CO₂ emissions and removals from soils*
5. *Others*

IPCC GL 1996 tersebut direvisi melalui GPG 2003 dan terakhir IPCC GL 2006. Aplikasi IPCC GL 2006 akan menghasilkan inventarisasi yang lebih baik, mengurangi ketidakpastian (*reduced uncertainty*), konsisten pembagian kategori lahan, estimasi serapan dan emisi GRK untuk seluruh kategori lahan, stock karbon (*carbon pool*) yang relevan serta non CO₂ gas (berdasarkan analisis *key source/sink category*). Hal ini berimplikasi pada penyediaan data untuk *activity data* dan faktor emisi terhadap seluruh kategori lahan, *carbon pool* dan non-CO₂ gas yang terkait.

LULUCF IPCC GPG 2006, membagi kategori lahan kedalam 6 kategori yaitu: (1) Forest land, (2) Grassland, (3) Cropland, (4) Wetland, (5) Settlement, and (6) Other land. Setiap kategori tersebut memiliki potensi GRK masing-masing tergantung dari kegiatan yang terjadi pada masing-masing penggunaan lahan. Kategori lahan dapat dijelaskan sebagai berikut:

(1) Forest Land

This category includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but in situ could potentially reach the threshold values used by a country to define the Forest Land category.

(2) Cropland

This category includes cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category.

(3) Grassland

This category includes rangelands and pasture land that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastoral systems, consistent with national definitions.

(4) Wetlands

This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

(5) Settlements

This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions.

(6) Other Land

This category includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available. If data are available, countries are encouraged to classify unmanaged lands by the above land-use categories (e.g., into Unmanaged Forest Land, Unmanaged Grassland, and Unmanaged Wetlands). This will improve transparency and enhance the ability to track land-use conversions from specific types of unmanaged lands into the categories above.

Kategori lahan dalam IPCC 2006, apabila dihubungkan dengan pembagian kelas hutan yang ada dilakukan oleh Departemen Kehutanan (Badan Planologi) Indonesia dapat dikelompokkan sebagai berikut :

Tabel (Table) 4. Pembagian kategori hutan Indonesia ke dalam IPCC GL 2006 (*Category of Indonesian forest area into IPCC GL 2006*)

	Kategori IPCC 2006	Kategori Hutan/Forest area category
1.	Forest Land (FL)	Hutan Lahan Kering Primer (UD)
2.	Forest Land (FL)	Hutan Rawa Primer (UD)
3.	Forest Land (FL)	Hutan Mangrove Primer (UD)
4.	Forest Land (FL)	Hutan Lahan Kering Sekunder (D)
5.	Forest Land (FL)	Hutan Rawa Sekunder (D)
6.	Forest Land (FL)	Hutan Mangrove Sekunder (D)
7.	Forest Land (FL)	Hutan Tanaman
		Area Penggunaan Lain (APL)/Other Uses Land
8.	Grassland (GL)	Belukar
9.	Wetland (WL)	Belukar rawa
10.	Other Land (OL)	Tanah terbuka
11.	Wetland (WL)	Rawa
12.	Cropland (CL)	Pertanian
13.	Cropland (CL)	Pertanian campur semak
14.	Cropland (CL)	Transmigrasi
15.	Settlement (S)	Permukiman
16.	Grassland (GL)	Padang rumput
17.	Cropland (CL)	Sawah
18.	Cropland (CL)	Perkebunan
19.	Other Land (OL)	Tambak
20.	Other Land (OL)	Bandara
21.	-	Air
22.	-	Awan

Hasil dari penghitungan emisi dan serapan GRK disajikan dalam tabel yang merupakan format umum dalam pelaporan hasil inventarisasi GRK yaitu :

Tabel (Table) 5. Format pelaporan umum hasil inventarisasi GRK sektor LULUCF (*Format of general reporting on the result of GHGs inventory, LULUCF sector*)

GHG Source and sink categories	Net CO ₂ Emission / removals	CH ₄	N ₂ O	NO _x	CO
	(Gg)				
Total Land Use Categories					
A. Forest Land					
A.1. FL remaining FL					
A.2. Land converted to FL					
B. Crop Land					
B.1. CL remaining CL					
B.2. Land converted to CL					
C. Grass Land					
C.1. GL remaining GL					
C.2. Land converted to GL					
D. Wet Land					
D.1. WL remaining WL					
D.2. Land converted to WL					
E. Settlements					
E.1. Set. Remaining Set.					
E.2. Land converted to Set.					
F. Other Lands					
F.1. OL. Remaining OL.					
F.2. Land converted to OL.					
G. Other (<i>specify</i>)					
Biomass burning					
Liming					

Untuk mengisi tabel tersebut yang merupakan ringkasan dari hasil perhitungan inventarisasi gas rumah kaca, IPCC telah mengembangkan tabel-tabel dalam format Microsoft Excel. Pengisian data ke dalam tabel *excell* memerlukan informasi yang rinci mencakup data kegiatan (*Activity Data*), misalnya perubahan lahan dan luas hutan yang tetap sebagai hutan, luas tanaman pertanian, luas padang rumput dan sebagainya. Selain itu diperlukan informasi mencakup faktor emisi atau *removal* yang lokal spesifik seperti data pertumbuhan (MAI) untuk berbagai jenis hutan atau tanaman.

TABEL-TABEL SPREADSHEETS YANG DIGUNAKAN UNTUK MENGHITUNG GAS RUMAH KACA (GRK) SEKTOR AGRICULTURE, FORESTRY AND LAND USE (AFOLU) (IPCC, 2006)

Sector	Agriculture, Forestry and Other Land Use					
Category	Forest Land Remaining Forest Land: Annual increase in biomass (includes above-ground and below-ground biomass)					
Category code	3B1a					
Sheet	1 of 4					
Land-use category	Area of Forest Land Remaining Forest Land (A)	Average annual above-ground biomass growth (G _w) (tonnes dm ha ⁻¹ yr ⁻¹)	Ratio of below-ground biomass to above-ground biomass (R)	Average annual biomass growth above- and below-ground (G _{TOTAL}) (tonnes dm ha ⁻¹ yr ⁻¹)	Carbon fraction of dry matter (CF)	Annual increase in biomass carbon stocks due to biomass growth (ΔC _G) (tonnes C yr ⁻¹)
Initial land use	Subcategories for reporting year	Tables 4.9, 4.10 and 4.12	zero (0) or Table 4.4	G _{TOTAL} = GW * (1+R)	0.5 or Table 4.3	ΔC _G = A * G _{TOTAL} * CF
FL	(a) Undisturb					
	(b) Disturb					
	(c) Plantation					
Total						

Keterangan Satuan :

Tonne bg dm = *tonne below ground dry matter* (ton berat kering biomas bawah tanah)

Tonne ag dm = *tonne above ground dry matter* (ton berat kering biomas atas tanah)

Tonne dm = *tonne dry matter* (ton berat kering biomas)

Sector		Agriculture, Forestry and Other Land Use						
Category		Forest Land Remaining Forest Land: Loss of carbon from wood removals						
Category code		3B1a						
Sheet		2 of 4						
Equation		Equation 2.2						
Equation		Equation 2.12						
Land-use category	Annual wood removal	Biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark)	Ratio of below-ground biomass to above-ground biomass	Carbon fraction of dry matter	Annual carbon loss due to biomass removals			
	(H) (m ³ yr ⁻¹)	(BCEF _R) [tonnes of biomass removals (m ³ of removals) ⁻¹]	(R) [tonnes bg dm (tonne ag dm) ⁻¹]	(CF) [tonnes C (tonne dm) ⁻¹]	(L _{wood-removals}) (tonnes C yr ⁻¹)			
Initial land use	Land use during reporting year	Subcategories for reporting year						
			(a)	Table 4.5	zero (0) or Table 4.4	0.5 or Table 4.3	$L_{\text{wood-removals}} = H * BCEFR * (1+R) * CF$	
			(b)					
Total								

Sector		Agriculture, Forestry and Other Land Use						
Category		Forest Land Remaining Forest Land: Loss of carbon from fuelwood removals						
Category code		3B1a						
Sheet		3 of 4						
Equation		Equation 2.13						
Equation		Equation 2.2						
Land-use category	Subcategories for reporting year	Annual volume of fuelwood removal of whole trees	Biomass conversion and expansion factor for conversion of removals in merchantable volume to biomass removals (including bark)	Ratio of below-ground biomass to above-ground biomass	Annual volume of fuelwood removal as tree parts	Basic wood density	Carbon fraction of dry matter	Annual loss carbon due to fuelwood removal
		(FG _{trees})	(BCEF _R)	(R)	(FG _{part})	(D)	(CF)	(L _{fuelwood})
Initial land use	Land use during reporting year	(m ³ yr ⁻¹)	[tonnes of biomass removals (m ³ of removals) ⁻¹]	[tonnes bg dm (tonne ag dm) ⁻¹]	(m ³ yr ⁻¹)	tonnes m ⁻³	[tonnes C (tonne dm) ⁻¹]	(tonnes C yr ⁻¹)
		FAO statistics	Table 4.5	Table 4.4	FAO statistics	Tables 4.13 and 4.14	Table 4.3	$L_{fuelwood} = [FG_{trees} * BCEF_R * (1+R) + FG_{part} * D] * CF$
	(a)							
	(b)							
	(c)							
FL	FL							
Total								

Sector		Agriculture, Forestry and Other Land Use										
Category		Forest Land Remaining Forest Land: Loss of carbon from disturbance										
Category code		3B1a										
Sheet		4 of 4										
Equation		Equation 2.2					Equation 2.14					Equation 2.11
Land-use category		Area affected by disturbances ($A_{\text{disturbance}}$)	Average above-ground biomass of areas affected (B_w)	Ratio of below-ground biomass to above-ground biomass (R)	Carbon fraction of dry matter (CF)	Annual other losses of carbon ($L_{\text{disturbance}}$)						Annual decrease in carbon stocks due to biomass loss (ΔC_L)
Initial land use	Land use during reporting year	(ha yr ⁻¹)	(tonnes dm ha ⁻¹)	[tonnes bg dm (tonne ag dm) ⁻¹]	[tonnes C (tonne dm) ⁻¹]	(tonnes C yr ⁻¹)						(tonnes C yr ⁻¹)
		National statistics or international data sources	Table 4.9	zero (0) or Table 4.4	0.5 or Table 4.3	$L_{\text{disturbance}} = A * B_w * (1+R) * CF * fd$						$\Delta C_L = L_{\text{wood-removals}} + L_{\text{fuelwood}} + L_{\text{disturbance}}$
FL	(a)											
	(b)											
	(c)											
Total												

Note: fd = fraction of biomass lost in disturbance; a stand-replacing disturbance will kill all (fd = 1) biomass while an insect disturbance may only remove a portion (e.g. fd = 0.3) of the average biomass C density.

Sector		Agriculture, Forestry and Other Land Use				
Category		Forest Land Remaining Forest Land (FL-FL): Annual carbon loss from drained organic soils				
Category code		3B1a				
Sheet		1 of 1				
Equation		Equation 2.2		Equation 2.26		
Land-use category		Subcategories for reporting year		Land area of drained organic soil (A) (ha)	Emission factor for climate type (EF) (tonnes C ha ⁻¹ yr ⁻¹) Table 4.6	Annual carbon loss from drained organic soils (L _{Organic} = A * EF) (tonnes C yr ⁻¹)
Initial land use	Land use during reporting year	(a)	(b)			
FL	FL	(c)				
Total						

Tabel (Table) 6. Ringkasan tabel-tabel excel yang digunakan dalam inventarisasi GRK sektor Kehutanan menurut IPCC GL 2006 (*Summary of excell's tables used in the inventory of GHGs Forestry Sector, according to IPCC GL 2006*)

Kategori (Category)	Tabel Excel (Excell's Table)
FL-FL	Forest Land Remaining Forest Land: Annual increase in carbon stocks in biomass (includes above-ground and below-ground biomass)
FL-FL	Forest Land Remaining Forest Land: Loss of carbon from wood removals
FL-FL	Forest Land Remaining Forest Land: Loss of carbon from fuelwood removals
FL-FL	Forest Land Remaining Forest Land: Loss of carbon from disturbance
FL-FL	Forest Land Remaining Forest Land (FL-FL): Annual carbon loss from drained organic soils
L-FL	Land Converted to Forest Land: Annual increase in carbon stocks in biomass (includes above- and below-ground biomass)
L-FL	Land Converted to Forest Land: Loss of carbon from wood removals ¹
L-FL	Land Converted to Forest Land: Loss of carbon from fuelwood removals ¹
L-FL	Land Converted to Forest Land: Loss of carbon from disturbance ¹
L-FL	Land Converted to Forest Land: Annual change in carbon stocks in dead organic matter due to land conversion
L-FL	Land Converted to Forest Land: Annual change in carbon stocks in mineral soils
L-FL	Land Converted to Forest Land: Annual change in carbon stocks in organic soils
CL-CL	Cropland Remaining Cropland: Annual change in carbon stocks in biomass
CL-CL	Cropland Remaining Cropland: Annual change in carbon stocks in mineral soils
CL-CL	Cropland Remaining Cropland: Annual change in carbon stocks in organic soils
L-CL	Land Converted to Cropland: Annual change in carbon stocks in biomass
L-CL	Land Converted to Cropland: Annual change in carbon stocks in dead organic matter due to land conversion ¹
L-CL	Land Converted to Cropland: Annual change in carbon stocks in mineral soils
L-CL	Land Converted to Cropland: Annual change in carbon stocks in organic soils
GL-GL	Grassland Remaining Grassland: Annual change in carbon stocks in mineral soils
GL-GL	Grassland Remaining Grassland: Annual change in carbon stocks in organic soils
L-GL	Land Converted to Grassland: Annual change in carbon stocks in biomass
L-GL	Land Converted to Grassland: Annual change in carbon stocks in dead organic matter due to land conversion
L-GL	Land Converted to Grassland: Annual change in carbon stocks in mineral soils
L-GL	Land Converted to Grassland: Annual change in carbon stocks in organic soils
WL-WL	Wetlands Remaining Wetlands: CO ₂ -C emissions from managed peatlands
WL-WL	Wetlands Remaining Wetlands: CO ₂ -C emissions from managed peatlands
WL-WL	Wetlands Remaining Wetlands: CO ₂ -C emissions from managed peatlands
WL-WL	Wetlands Remaining Wetlands: N ₂ O Emissions from peatlands during peat extraction
L-WL	Land Converted to Wetlands: N ₂ O Emissions from land converted for peat extraction
L-WL	Land Converted to Wetlands: CO ₂ Emissions from Land Converted to Flooded land
S-S	Settlements Remaining Settlements: Annual change in carbon stocks in organic soils
L-S	Land Converted to Settlements: Annual change in carbon stocks in biomass
L-S	Land Converted to Settlements: Annual change in carbon stocks in dead organic matter due to land conversion ¹
L-S	Land Converted to Settlements: Annual change in carbon stocks in mineral soils
L-S	Land Converted to Settlements: Annual change in carbon stocks in organic soils
L-OL	Land Converted to Other Land: Annual change in carbon stocks in biomass
L-OL	Land Converted to Other Land: Annual change in carbon stocks in mineral soils
L-OL	Land Converted to Other Land: Annual change in carbon stocks in organic soils
Non CO ₂	Non-CO ₂ emissions
Others	Direct N ₂ O emissions from fertilisation
Others	N ₂ O emissions from drainage of soils
Others	N ₂ O emissions from disturbance associated to land use conversion to cropland
Others	Biomass burning (for every change of land category)
Others	Liming: Annual CO ₂ -C emissions from Liming
Others	Urea Fertilization: Annual CO ₂ emissions from Urea Fertilization
Others	Direct N ₂ O Emissions from Managed Soils

III. KESIMPULAN DAN SARAN

A. Kesimpulan

1. Dalam kegiatan inventarisasi gas rumah kaca (GRK), sektor kehutanan yang termasuk dalam sektor *Land Use, Land Use Change and Forestry* (LULUCF) adalah salah satu sektor penting dengan kontribusi di tingkat nasional mencapai 74 %.
2. Metode IPCC Guideline 2006 adalah metode inventarisasi gas rumah kaca yang dikembangkan oleh IPCC (*International Panel on Climate Change*) dan telah diaplikasikan secara luas oleh negara-negara yang meratifikasi UNFCCC.
3. Indonesia penting untuk menerapkan metode IPCC Guideline dalam inventarisasi gas rumah kaca agar hasil inventarisasi lebih akurat dan terpercaya sehingga diakui oleh internasional.
4. Metode IPCC GL 2006 membagi kelas lahan ke dalam enam kategori yaitu *forest land, cropland, grassland, wetland, settlement* dan *other land*. Aplikasi metode IPCC GL memerlukan data dan informasi yang lebih komprehensif mencakup tidak hanya sektor kehutanan tapi juga sektor pertanian. Selain itu diperlukan informasi spesifik mencakup faktor emisi yang tidak hanya menggunakan angka default yang ada dalam IPCC GL guna mendapatkan ketelitian yang lebih tinggi (*Tier 2* atau *3*).

B. Saran

Untuk kepentingan inventarisasi gas rumah kaca dari sektor kehutanan dengan menggunakan metode internasional yang disepakati yaitu IPCC Guideline 2006, beberapa hal perlu dilakukan oleh Indonesia, yaitu :

1. Menyesuaikan sistem monitoring dengan *land category* menurut IPCC (Data dari 23 kelas ke dalam 6 kelas IPCC)
2. Menjaga dan menambah permanen plot untuk mendapatkan estimasi pengukuran karbon pada berbagai kondisi hutan di Indonesia.
3. Kerjasama dengan organisasi penelitian (nasional dan internasional) untuk melakukan penelitian terkait *country specific* (misal data pertumbuhan untuk masing-masing jenis/hutan dan jenis hutan tanaman, potensi karbon, berat jenis dan sebagainya)
4. Membentuk atau menugaskan unit organisasi yang khusus bertanggung jawab terhadap monitoring karbon stok di sektor kehutanan yang juga terintegrasi dengan sektor pertanian.

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