Model/Metode Formula Perhitungan Emisi Gas Rumah Kaca yang telah dikembangkan dalam Lingkup Pertanian, Kehutanan dan Penggunaan Lahan (*Agriculture, Forestry and Other Land Use*/AFOLU)

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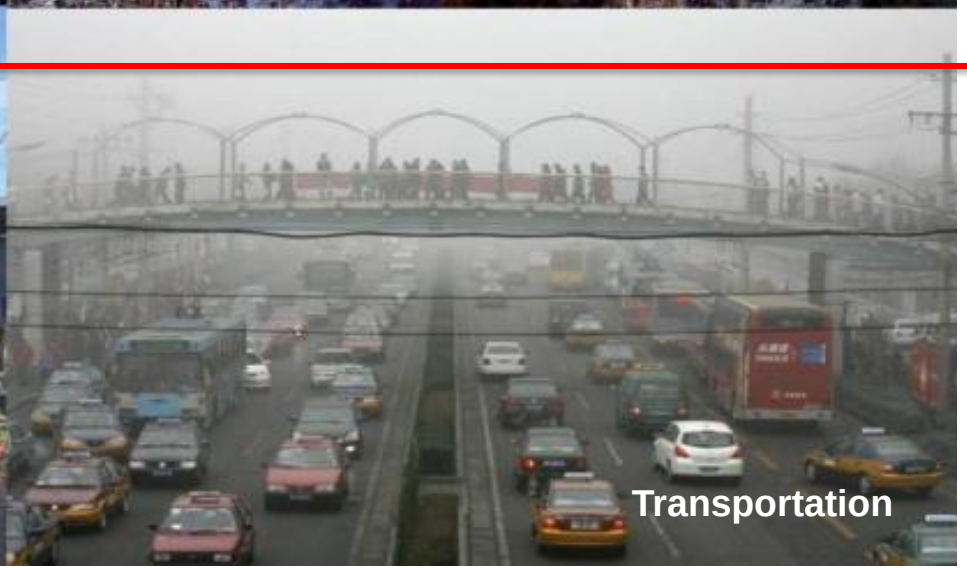
Disampaikan dalam Focus Group Discussion Pembahasan Rencana Pengembangan RL dan MRV System untuk BioCF, Bogor 14-15 Juni 2019

Faktor Penyebab Perubahan Iklim

Sumber: www.tempo.co.id

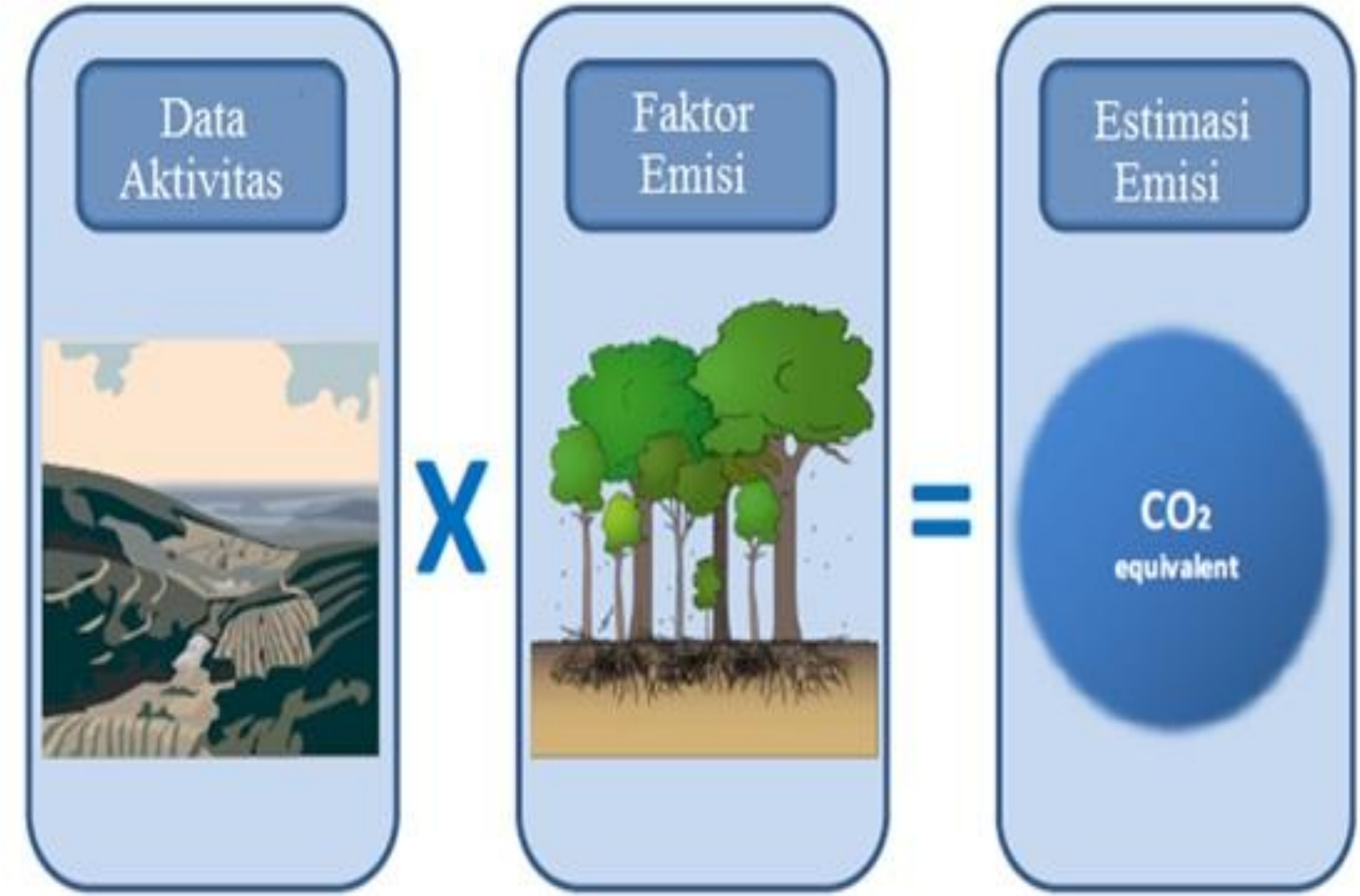
Faktor Penyebab Perubahan Iklim



Mitigasi dan Adaptasi Perubahan Iklim

- **Mitigasi** dalam kamus John M. Echols dan Hassan Shadily memiliki arti yaitu pengurangan. A*daptation* atau **adaptasi** artinya penyesuaian diri. Kedua istilah ini menyangkut strategi menghadapi perubahan iklim.
- **Mitigasi** ==> usaha yang dapat dilakukan adalah mengurangi sebab pemanasan global dari sumbernya, gunanya agar laju pemanasan itu melambat
- **Adaptasi** ==> pada saat bersamaan dapat dilakukan persiapan diri untuk beradaptasi dengan perubahan yang ada, sehingga diharapkan akan ditemukan suatu titik temu yang menjamin kelangsungan hidup manusia.

Penghitungan Emisi Gas Rumah Kaca (Emisi GRK)

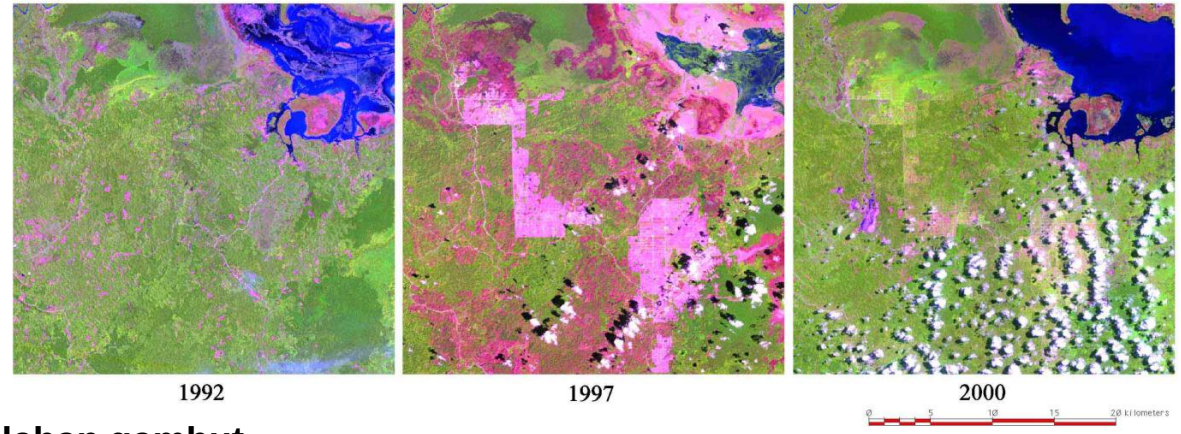


Sumber: IPCC Good Practice Guidance (2003), IPCC Guideline (2006)

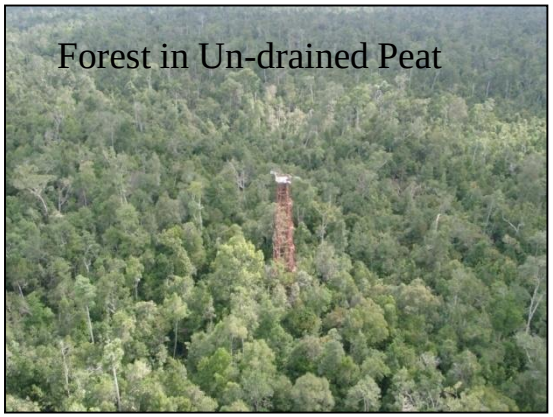
Data Aktivitas

Data aktivitas	Data aktivitas *antropogenic* (manusia) yang mengakibatkan keluarnya emisi GRK per satuan pengukuran tertentu

Contoh : **1. Alih fungsi hutan**



2. Pengeringan lahan gambut



Faktor Emisi

Faktor Emisi

Emisi GRK yang dihasilkan per satuan pengukuran tertentu data aktivitas *antropogenic* (manusia), misalnya : tCO2e/ha

Contoh : untuk penghitungan Faktor emisi pada lahan

5 Pool Karbon

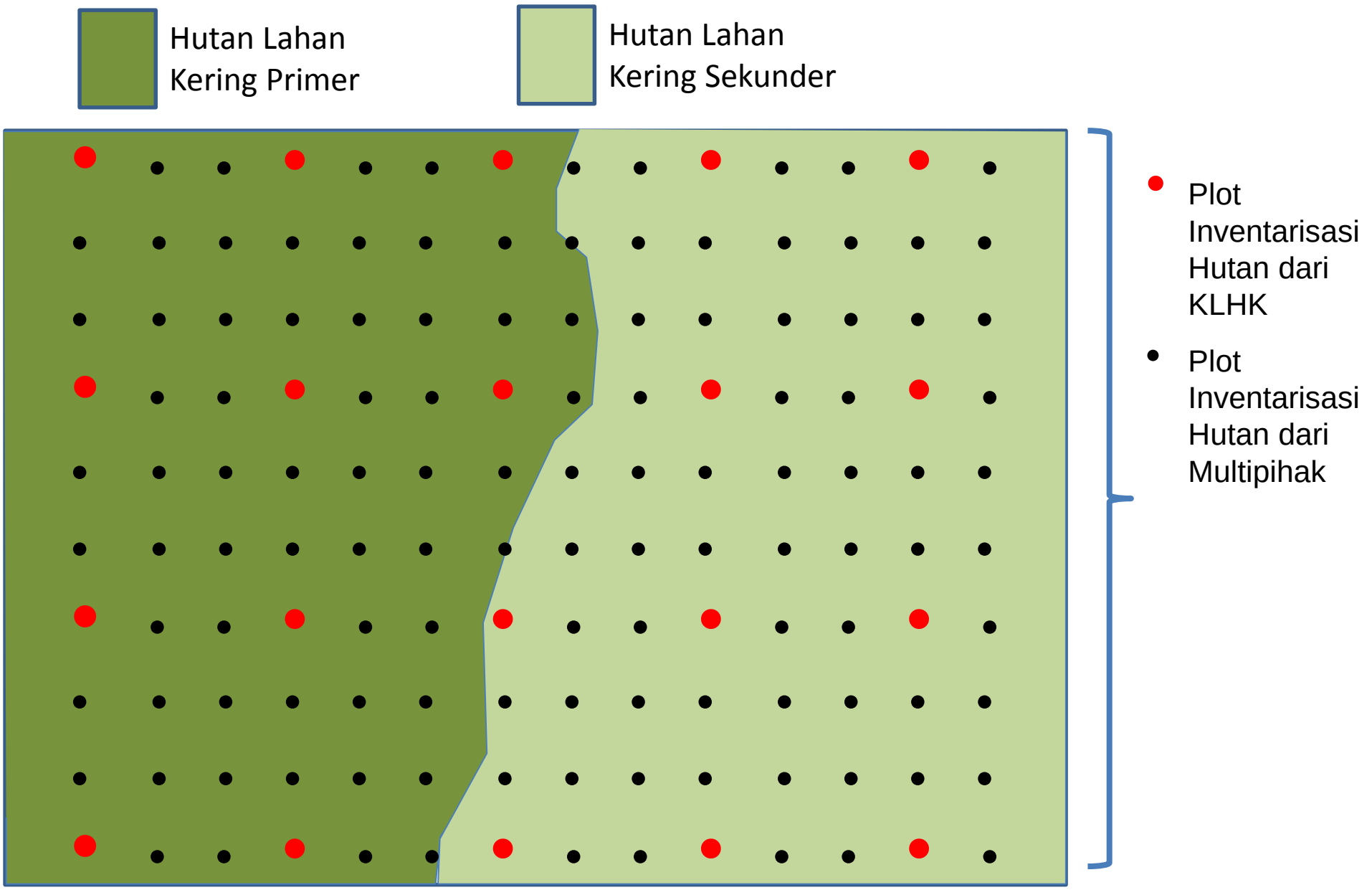
Emisi dari atas tanah (*ABOVE GROUND*)

Pendekatan	**Variabel yang diukur**
Penghitungan Karbon Tersimpan	Biomassa Tegakan Hutan
	Biomassa Tumbuhan bawah (semak belukar)
	Kayu Mati, Serasah, dll

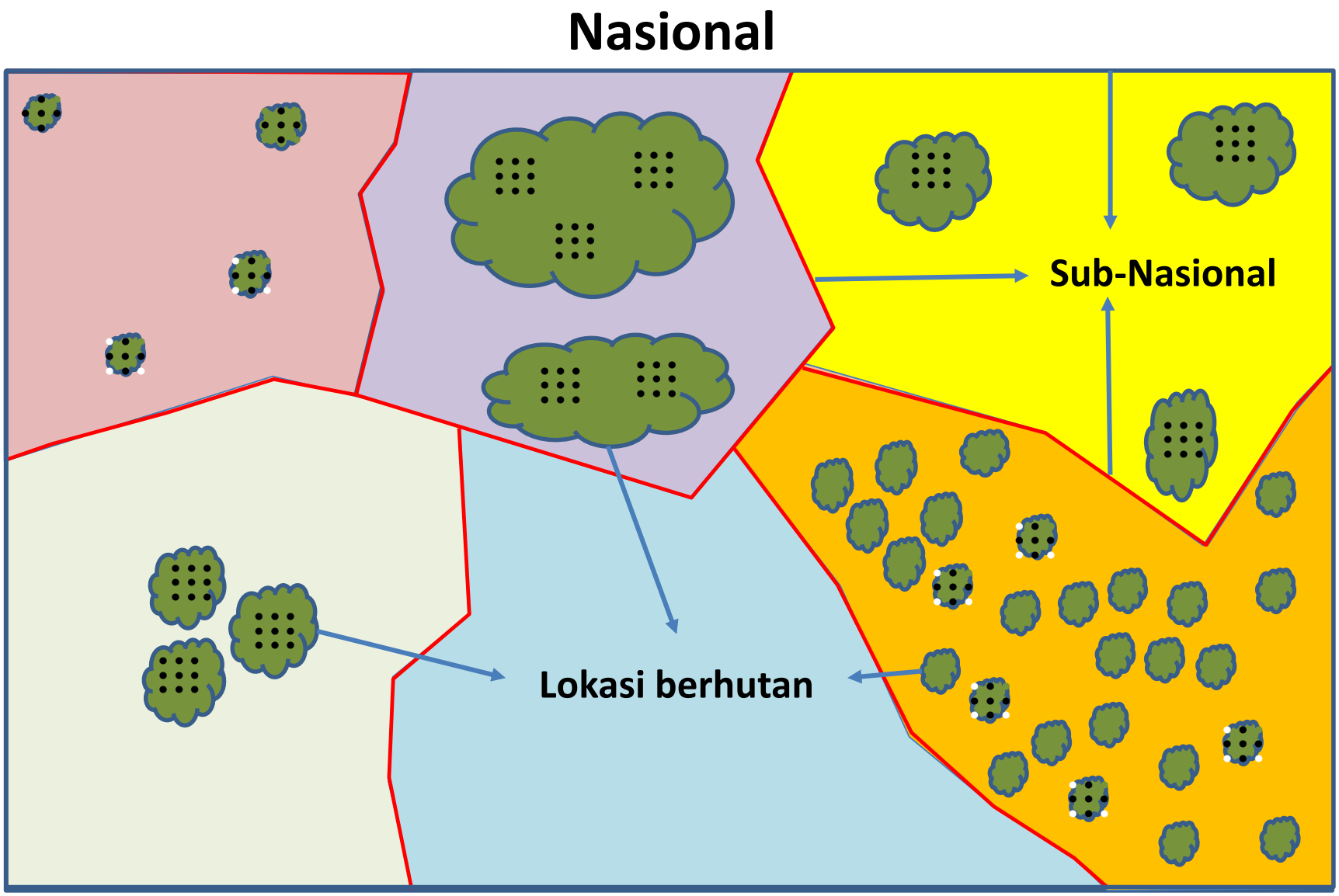
Emisi dari bawah tanah

Pendekatan	**Variabel yang diukur**
Penghitungan Karbon Tersimpan	Biomassa Akar Pohon
	Karbon dalam tanah dan gambut

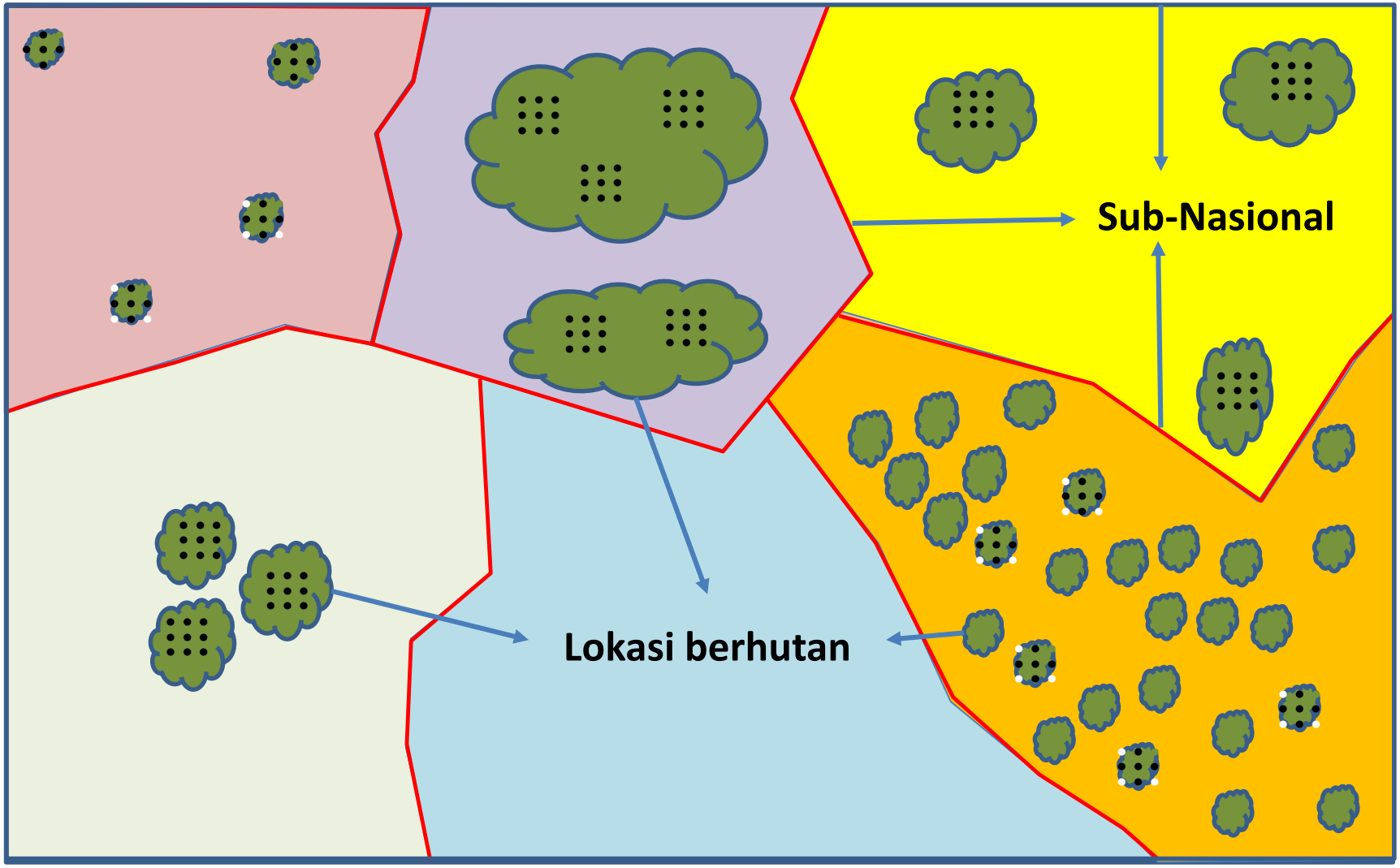
Inventarisasi Karbon Hutan terintegrasi yang terkait MRV



Pengukuran Karbon Hutan secara Multipihak



Bagaimana Sistem Inventarisasi Hutan terintegrasi secara Nasional?



Faktor Emisi Hutan (Stok Karbon Hutan 1)

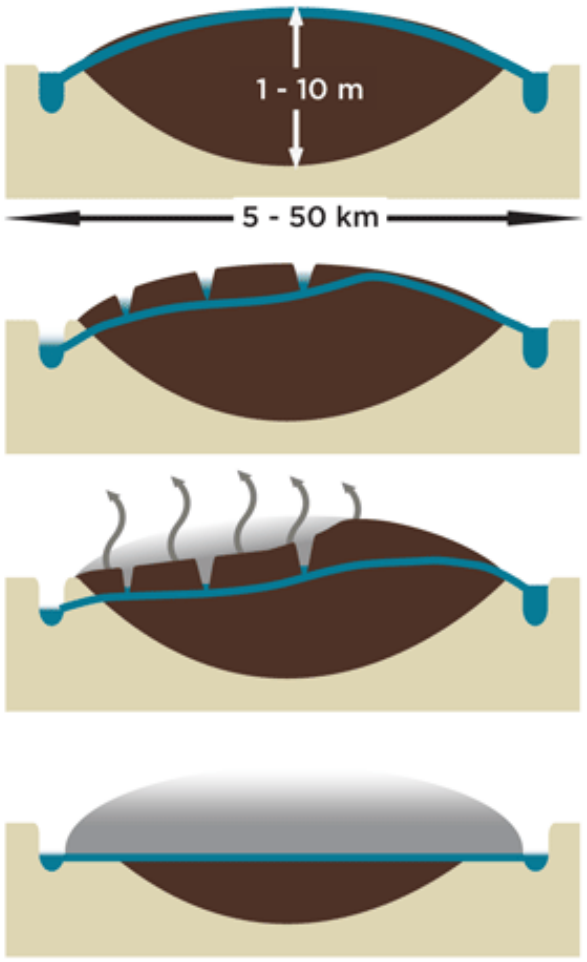
Forest type	Main island	Mean AGB (t ha^{-1})	95% Confidence Interval (t ha^{-1})		N of plot measurement
Primary Dryland Forest	Bali Nusa Tenggara	274.4	247.4	301.3	52
	Jawa	Nd	nd	nd	nd
	Kalimantan	269.4	258.2	280.6	333
	Maluku	301.4	220.3	382.5	14
	Papua	239.1	227.5	250.6	162
	Sulawesi	275.2	262.4	288.1	221
	Sumatera	268.6	247.1	290.1	92
	Indonesia	266.0	259.5	272.5	874
Secondary Dryland Forest	Bali Nusa Tenggara	162.7	140.6	184.9	69
	Jawa	170.5	na	na	1
	Kalimantan	203.3	196.3	210.3	608
	Maluku	222.1	204.5	239.8	99
	Papua	180.4	158.5	202.4	60
	Sulawesi	206.5	194.3	218.7	197
	Sumatera	182.2	172.1	192.4	265
	Indonesia	197.7	192.9	202.5	1299

- Forest carbon stocks were derived from 4,450 measurement data available from Permanent Sample Plot (PSP) of National Forest Inventory (NFI) of 1989 – 2013.
- PSP for mangrove forest has not been found, so carbon stock for mangrove (primary and secondary) were derived from the closest related research (e.g. Krisnawati *et al*., 2012; Donato., *et al*., 2011; Murdiyarso *et al*., 2009)

Faktor Emisi Hutan (Stok Karbon Hutan 2)

Forest type	Main island	Mean AGB (t ha^{-1})	95% Confidence Interval (t ha^{-1})		N of plot measurement
Primary Swamp Forest	Bali Nusa Tenggara	Na	na	na	na
	Jawa	Na	na	na	na
	Kalimantan	274.8	269.2	281.9	3
	Maluku	Na	na	na	na
	Papua	178.8	160.0	197.5	67
	Sulawesi	214.4	-256.4	685.2	3
	Sumatera	220.8	174.7	266.9	22
	Indonesia	192.7	174.6	210.8	95
Secondary Swamp Forest	Bali Nusa Tenggara	Na	na	na	na
	Jawa	Na	na	na	na
	Kalimantan	170.5	158.6	182.5	166
	Maluku	Na	na	na	na
	Papua	145.7	106.7	184.7	16
	Sulawesi	128.3	74.5	182.1	12
	Sumatera	151.4	140.2	162.6	160
	Indonesia	159.3	151.4	167.3	354
Primary Mangrove Forest[a]	Kalimantan	263.9	209.0	318.8	8
Secondary Mangrove Forest[b]	Kalimantan	201.7	134.5	244.0	12

Emisi karena pengeringan di lahan gambut



Natural situation:
- Water table close to surface
- Peat accumulation from vegetation over thousands of years

Drainage:
- Water tables lowered
- Peat surface subsidence and CO_2 emission starts

Continued drainage:
- Decomposition of dry peat: CO_2 emission
- High fire risk in dry peat: CO_2 emission
- Peat surface subsidence due to decomposition and shrinkage

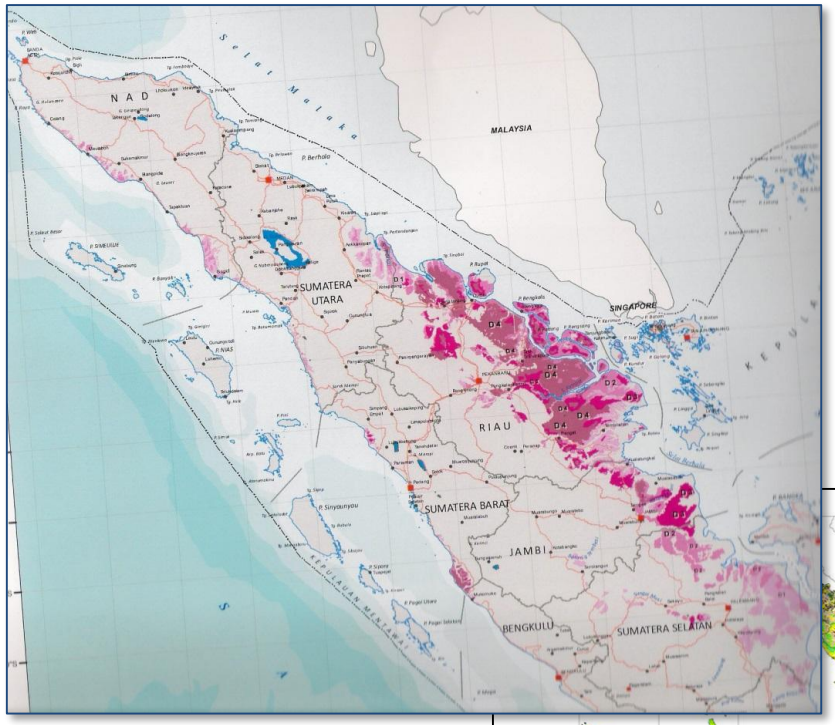
End stage:
- Most peat carbon above drainage limit released to the atmosphere within decades,
- unless conservation / mitigation measures are taken

Water table
Peat dome
Clay / sand
Stream channels
former extent of peat dome

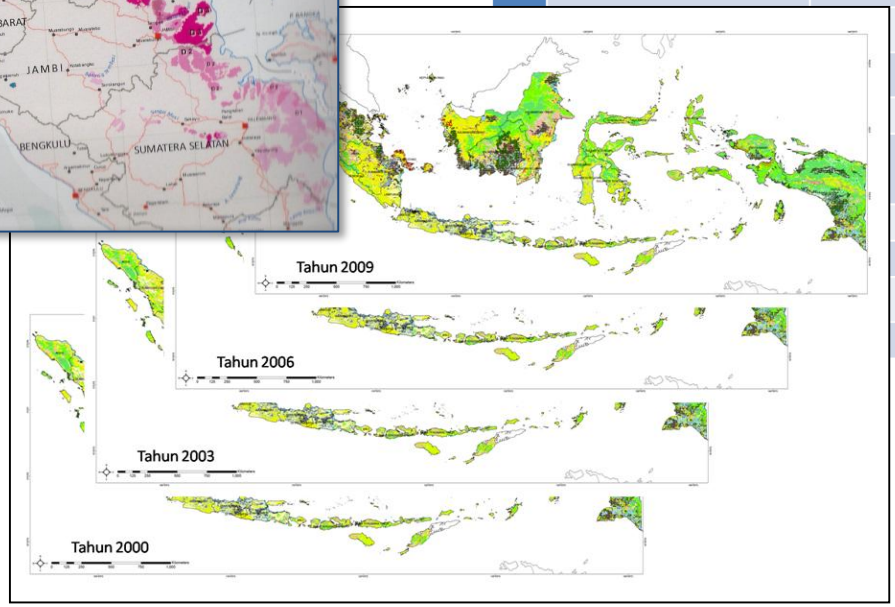
Sumber : www.theicct.org

Perhitungan emisi karena pengeringan di lahan gambut

(1) Data Aktivitas



(Peta lahan gambut)

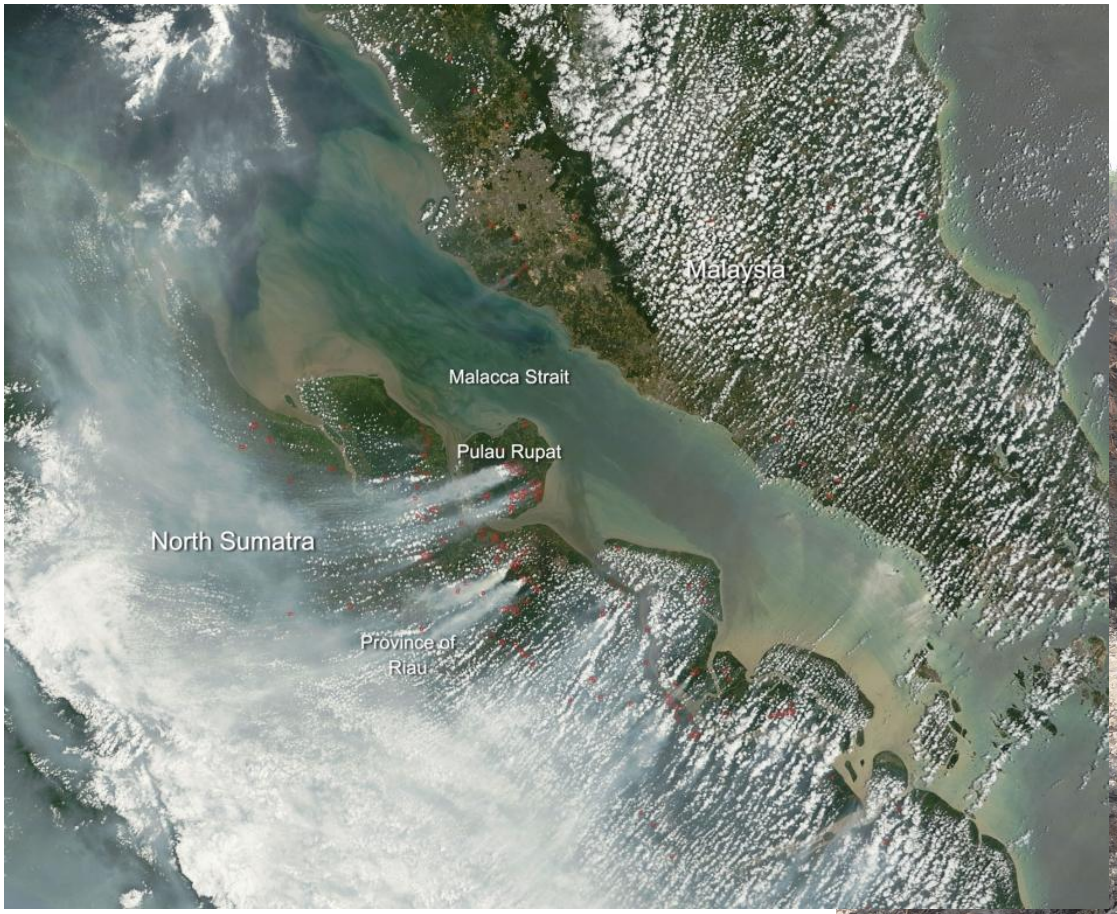


(Peta Perubahan Tutupan Lahan)

(2) Faktor Emisi (IPCC, 2013)

No.	Land cover	Emission (t CO2 ha^{-1} th^{-1})	95% confidence interval		Remarks
1.	Primary forest	0	0	0	IPCC (2006)
2.	Secondary forest	19	-3	35	IPCC (2013)
3.	Plantation forest	73	59	88	IPCC (2013)
4.	Estate crop	40	21	62	IPCC (2013)
5.	Pure dry agriculture	51	24	95	IPCC (2013)
6.	Mixed dry agriculture	51	24	95	IPCC (2013)
7.	Dry shrub	19	-3	35	IPCC (2013)
8.	Wet shrub	19	-3	35	IPCC (2013)
9.	Savanna and Grasses	35	-1	73	IPCC (2013)
10.	Paddy Field	35	-1	73	IPCC (2013)
11.	Open swamp	0	0	0	Waterlogged condition, assumed ze
		0	0	0	Waterlogged condition, assumed ze
		51	24	95	Assumed similar to mixed upland ag
		35	-1	73	Assumed similar to grassland
		0	0	0	Assumed zero as most surface is sea concrete.
		51	24	95	Assumed similar to bare land
		51	24	95	IPCC (2013)
		0	0	0	Waterlogged condition, assumed ze
		nd	nd	nd	

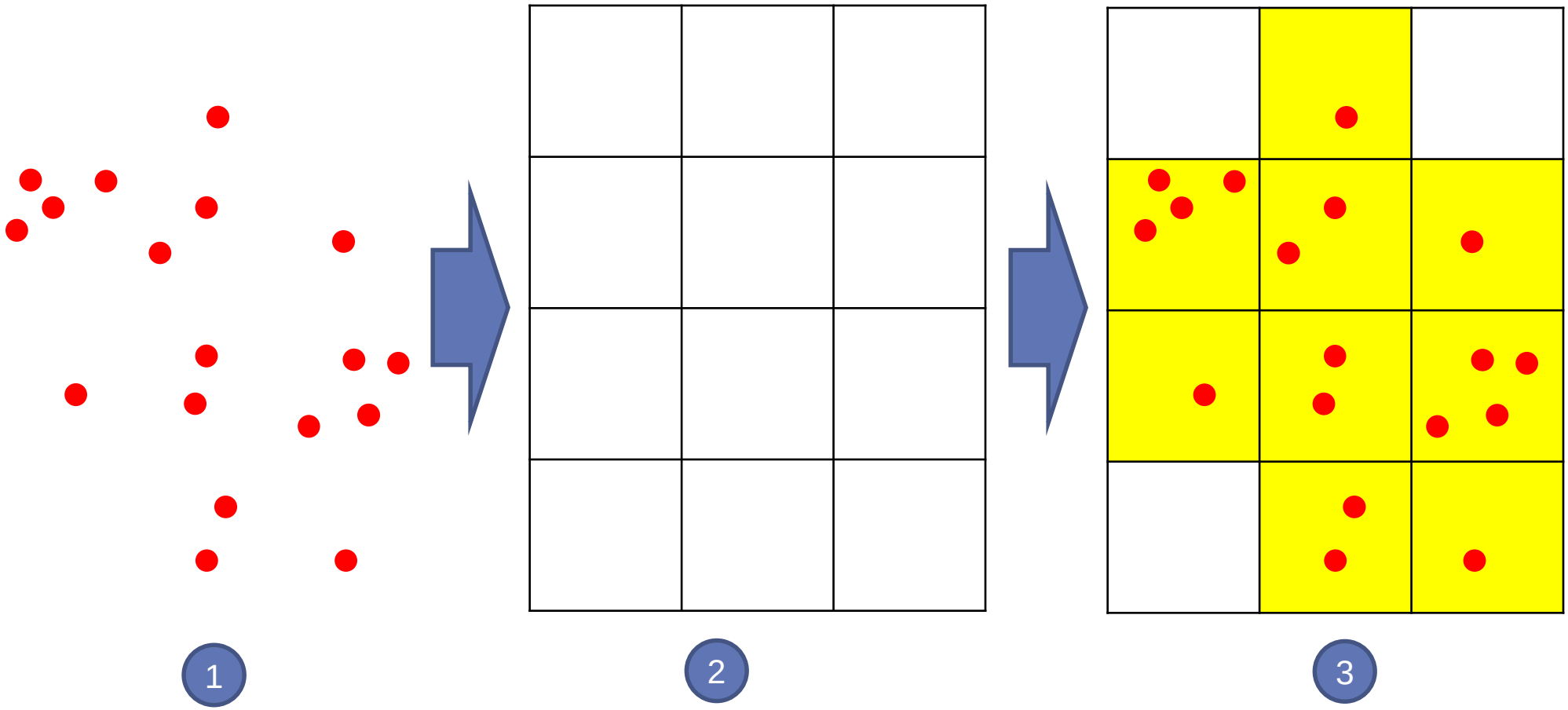
Emisi karena Kebakaran di Lahan Gambut



Sumber : www.nasa.gov

Perhitungan emisi karena pengeringan di lahan gambut (BPREDD+, 2015)

(1) Data Aktivitas



1

Collect annual MODIS Hotspot Data
(< 80% CL)

2

Create 1 x 1 km^2 Grid

3

- Overlay Hotspot data into the Grid.
- Overlaid grid is multiplied by 0.769 km^2, see Ballhorn, et al., 2009

Perhitungan emisi karena pengeringan di lahan gambut

(2) Faktor emisi (di adopsi dari IPCC, 2013)

According to the "2013 Supplement", per unit (ha) emissions are calculated in the following formula:
[Mass of fuel available for combustion] x [Combustion factor] x [Emission factor]

- "Mass of fuel available for combustion" is calculated as follows:
  $A\ (m^2) \times D\ (m) \times BD\ (t/m^3)$
  - A: Per unit area → 1 ha = 10,000 m^2
  - D: Peat depth that is assumed to be burnt (m)
  - BD: Bulk density (t/m^3)
- The default value of the "Combustion factor" is 1.0
- "Emission factor" for CO_2 can be indirectly calculated in the
  CO_2 emissions per dry matter burnt ($g\ kg^{-1}$) = C_{org} x 44/12
  = [($M_s - M_{ash}$) /
  - C_{org} : Organic carbon content (% by weight)
  - M_s : Mass of soil solids = M_{ash} + Mass of organic matter
  - M_{ash}: Mass of ash
  - Conversion factor: 1/1.724 (Conversion of organic matte

Case of Central Kalimantan

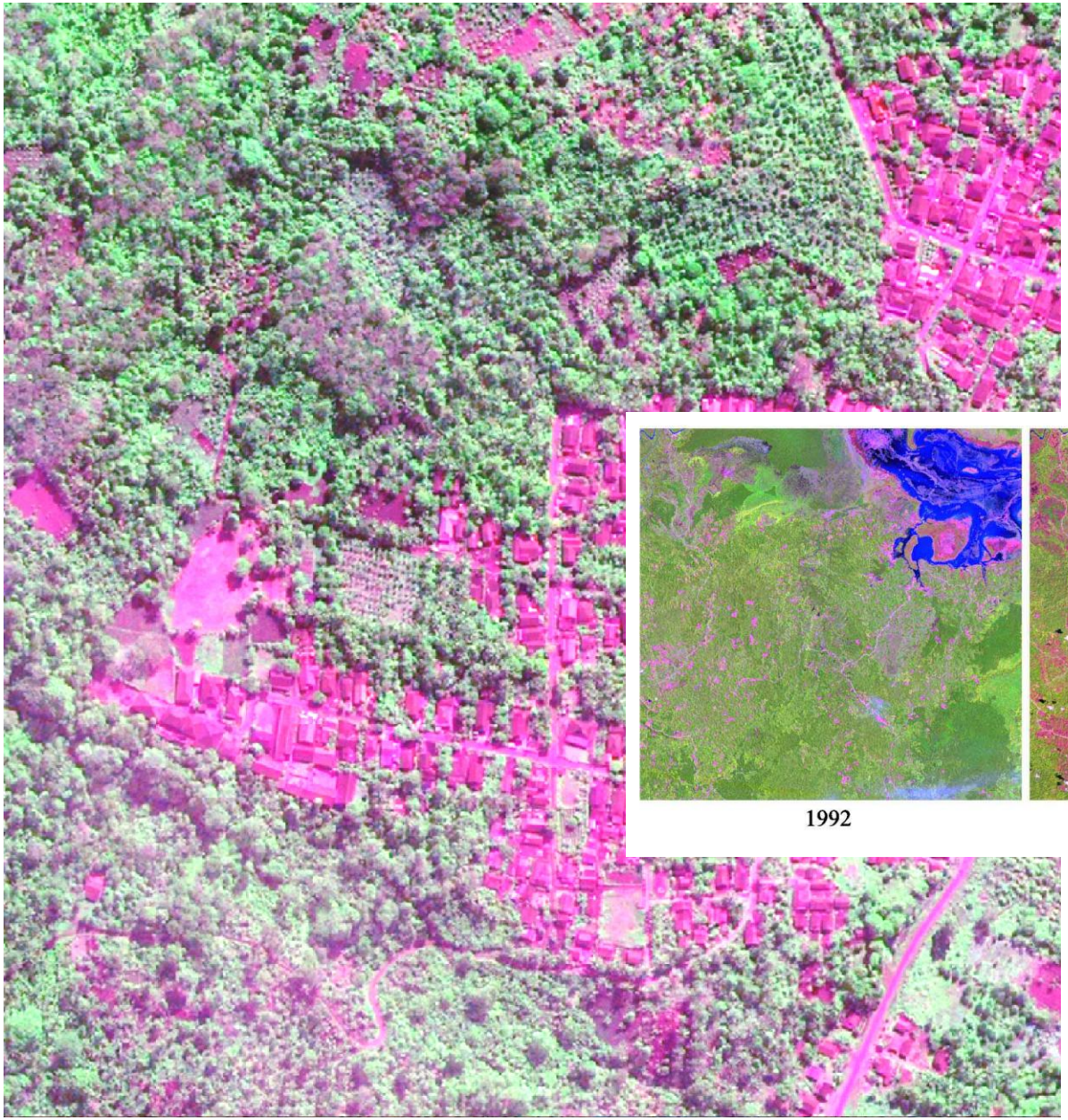
[Mass of fuel available for combustion] x [Combustion factor] x [Emission factor]

- "Mass of fuel available for combustion (mass of dry organic soil fuel)" is calculated as:
  $A\ (m^2) \times D\ (m) \times BD\ (t/m^3) = 3{,}300\ m^3 \times 0.153\ t/m^3 = 504.9\ t/ha$
  - A: Per unit area → 1 ha = 10,000 m^2
  - D[4]: Peat depth of 0.33 m that is assumed to be burnt in case of peat fire
  - BD[5]: Bulk density of 0.153 t/m^3
- The default value of the "Combustion factor" is 1.0
- "Emission factor" for CO_2 can be indirectly calculated in the following manner:
  CO_2 emissions per dry matter burnt ($g\ kg^{-1}$) = C_{org} x 44/12 = [($M_s - M_{ash}$) / M_s] / 1.724 x 44/12
  - C_{org} : Organic carbon content (% by weight)
  - M_s : Mass of soil solids = M_{ash} + Mass of organic matter
  - M_{ash}: Mass of ash
  - M_{ash}/M_s: Ash content (%)[6] = 14.04 %
  - Conversion factor: 1/1.724 (Conversion of organic matter to organic carbon content)

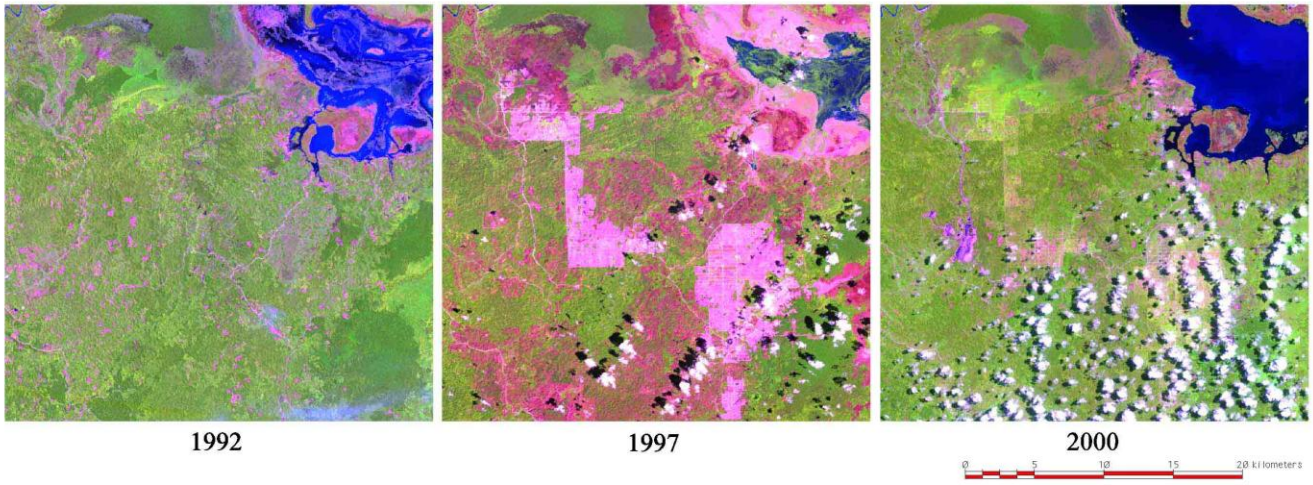
C_{org} = [($M_s - M_{ash}$) / M_s] / 1.724 = [1 – (M_{ash}/M_s)] / 1.724
= 49.86 % (or $kg\ kg^{-1}$)
= 498.6 C $g\ kg^{-1}$ dry matter burnt
C_{org} x 44/12 = 1828.2 CO_2 $g\ kg^{-1}$ dry matter burnt = 1828.2 CO_2 $kg\ t^{-1}$

CO_2 emissions per ha = 504.9 t/ha x 1 x 1828.2 CO_2 $kg\ t^{-1}$ = 923,058. 18 kg/ha
= 923.1 t/ha

Teknologi pendukung Perhitungan Emisi GRK Lahan

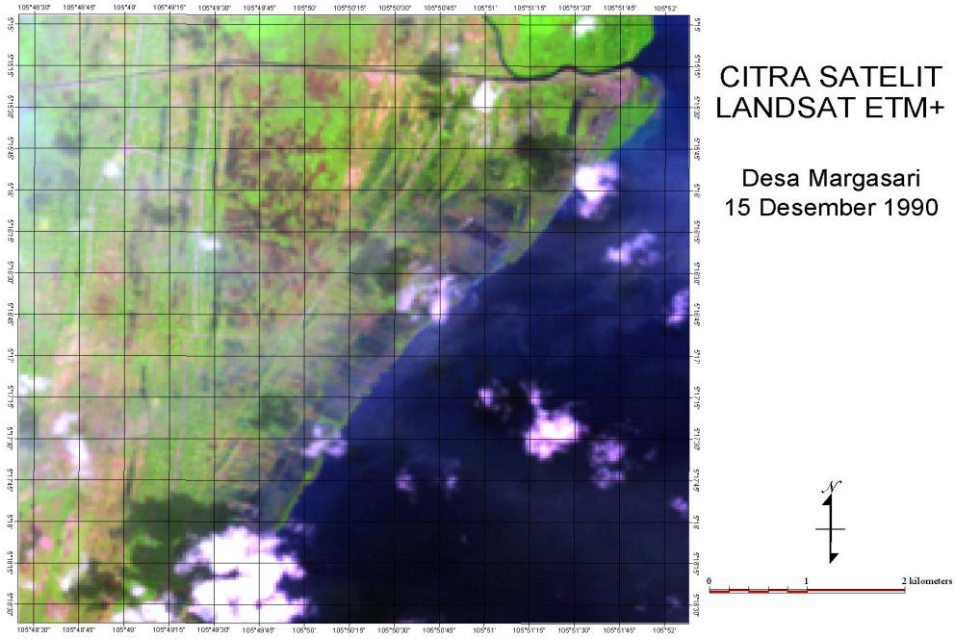


Penggunaan teknologi Penginderaan jauh (Remote Sensing)



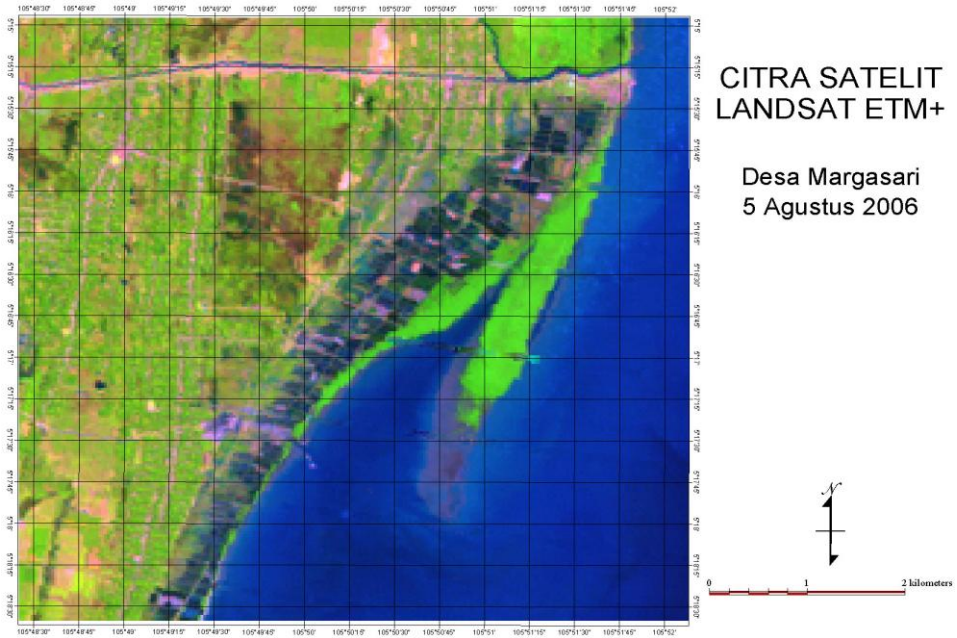
Kutai Barat

Teknologi pendukung Perhitungan Emisi GRK Lahan



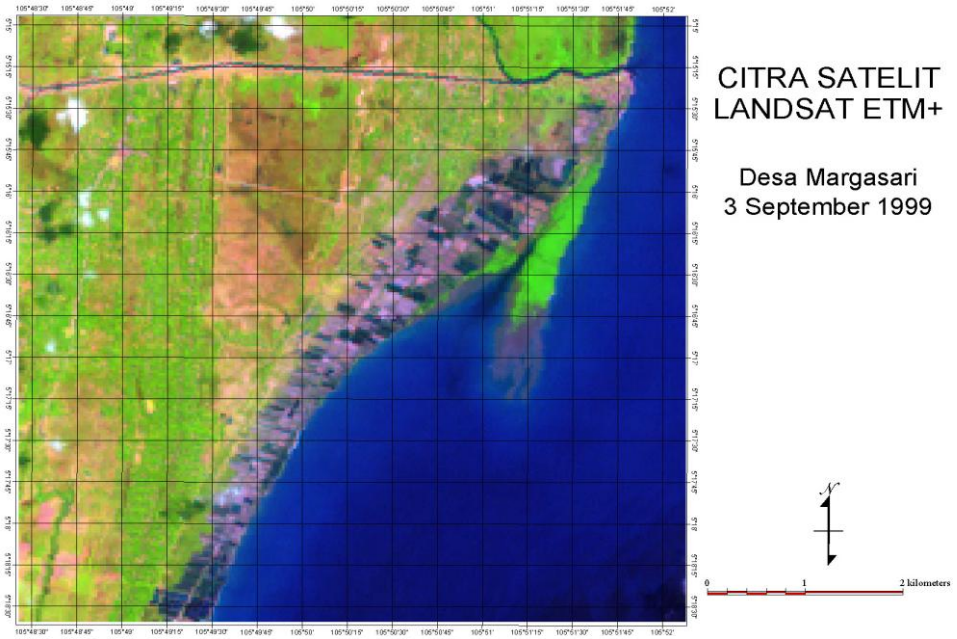
CITRA SATELIT
LANDSAT ETM+

Desa Margasari
15 Desember 1990



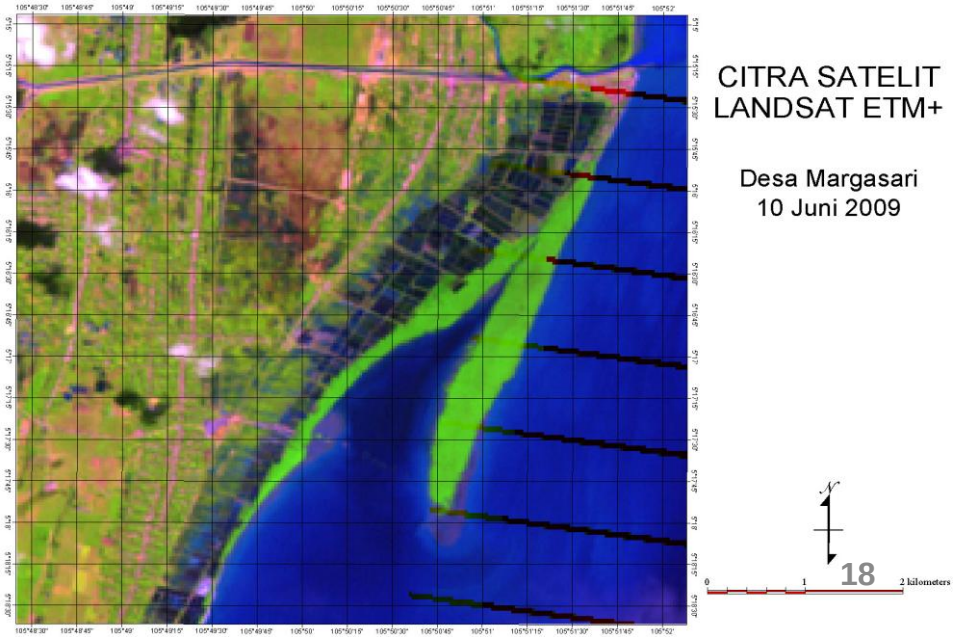
CITRA SATELIT
LANDSAT ETM+

Desa Margasari
5 Agustus 2006



CITRA SATELIT
LANDSAT ETM+

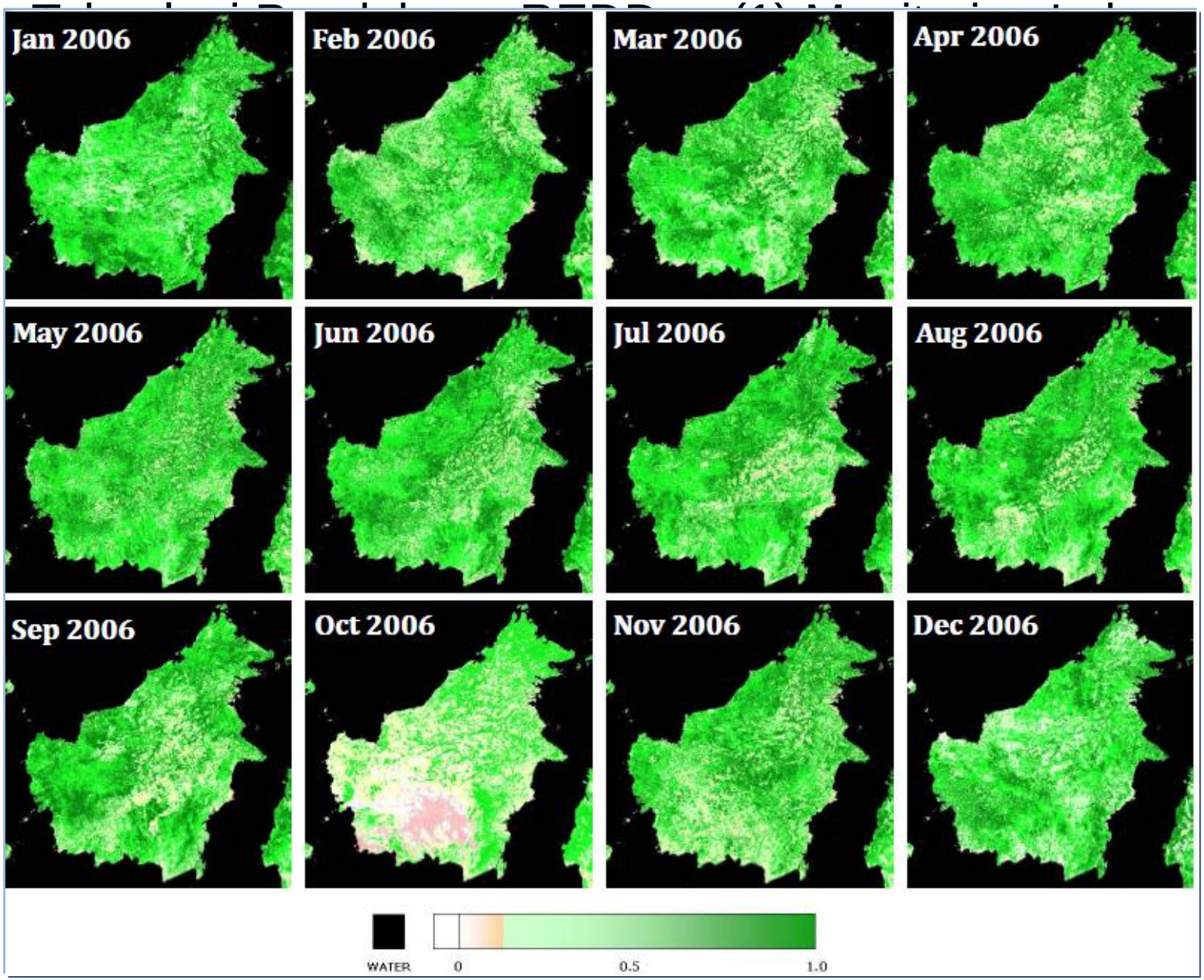
Desa Margasari
3 September 1999



CITRA SATELIT
LANDSAT ETM+

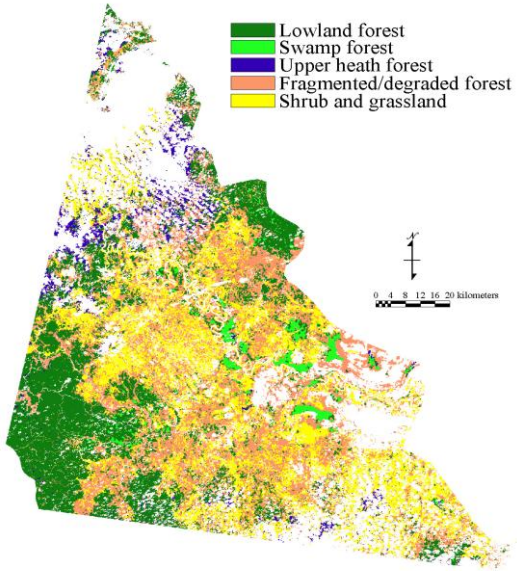
Desa Margasari
10 Juni 2009

Teknologi pendukung Perhitungan Emisi GRK Lahan

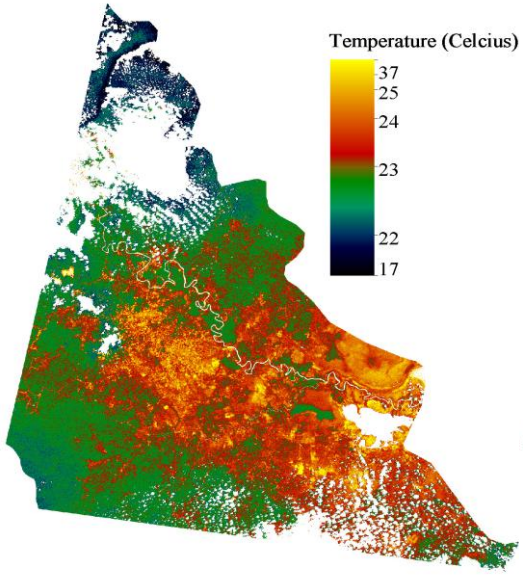


Teknologi pendukung Perhitungan Emisi GRK Lahan (GIS)

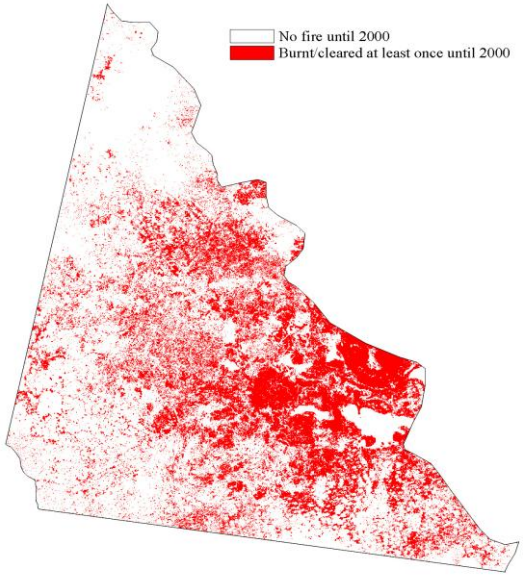
Penutupan lahan



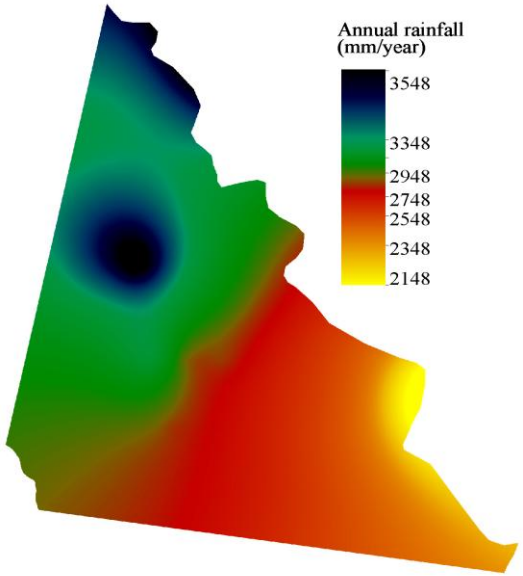
Suhu permukaan



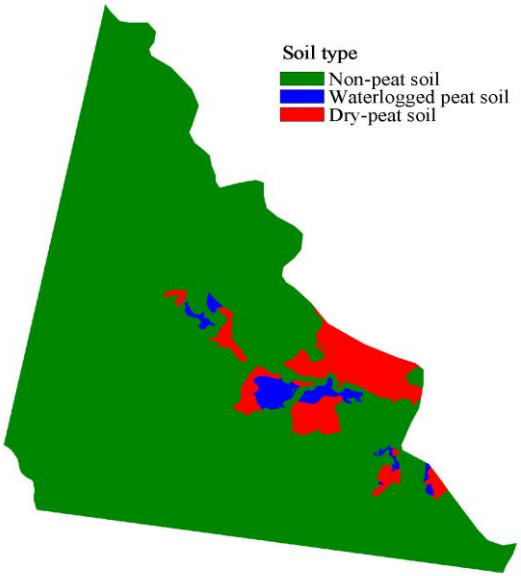
Burnt once



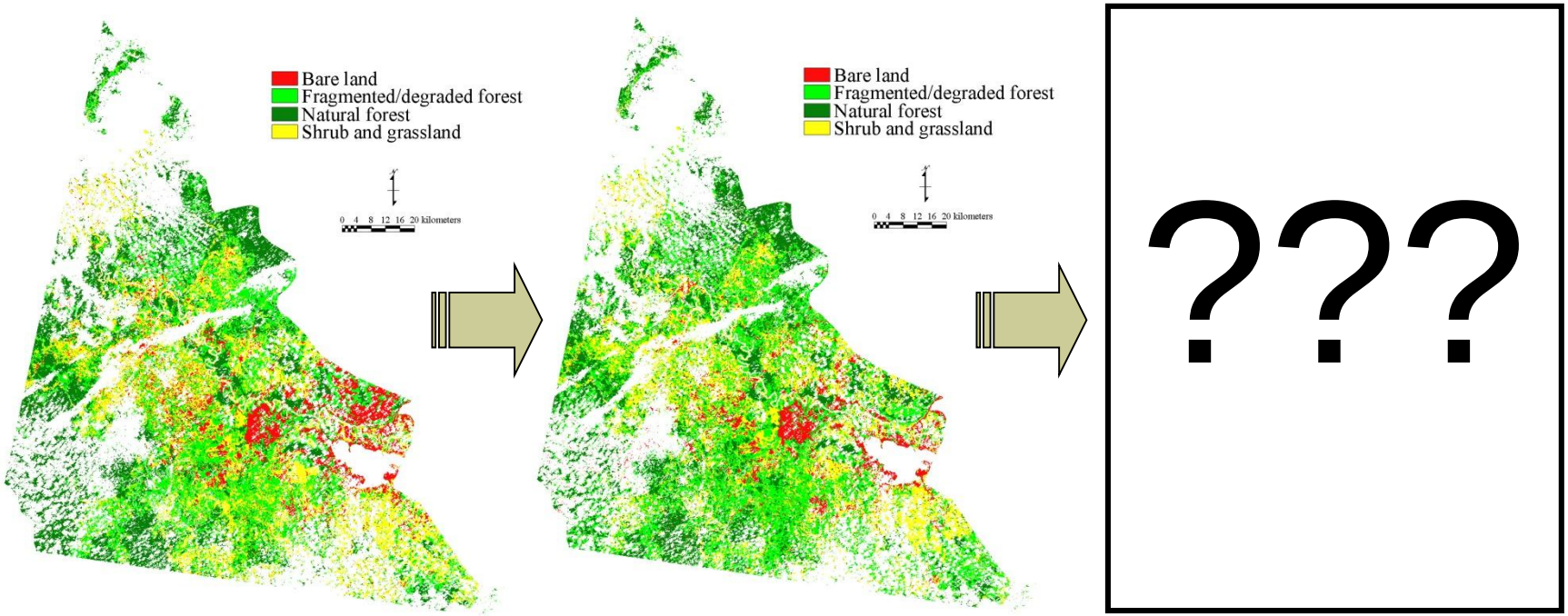
Curah hujan



Jenis tanah



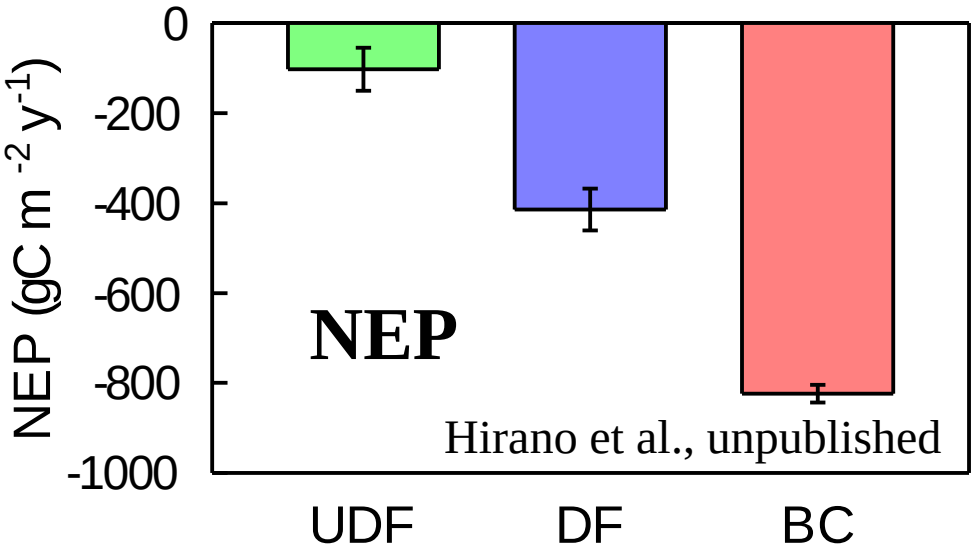
Teknologi pendukung Perhitungan Emisi GRK Lahan (Pemodelan)



2000 2003 2004, 2008, 2015, etc

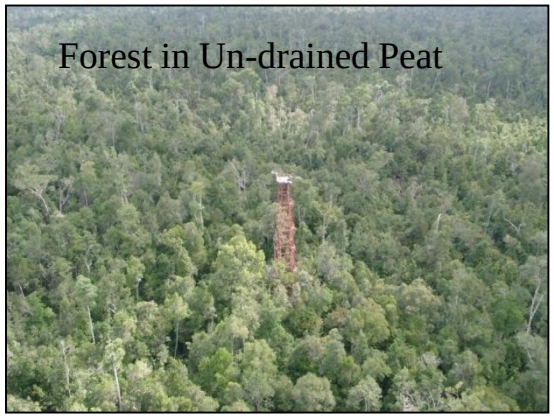
Teknologi pendukung Perhitungan Emisi GRK Lahan (Gambut)

CO_2 is released from all sites (CO_2source)



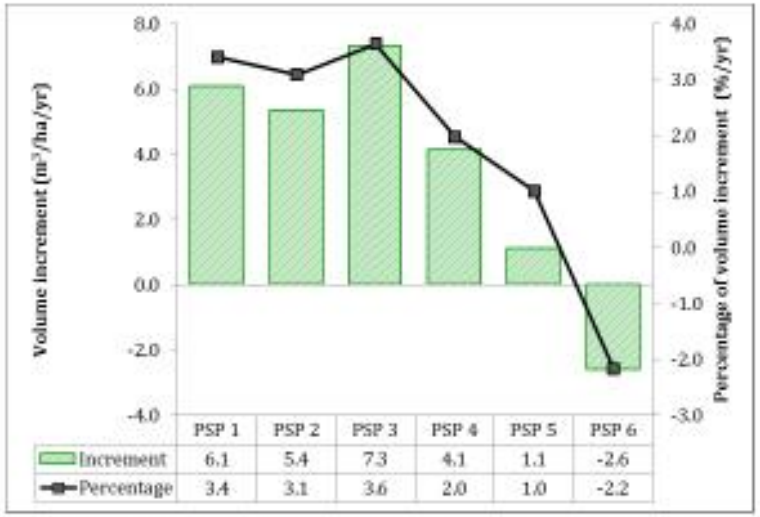
UDF: Forest in Un-drained Peat
DF: Forest in Drained Peat
BC: Land in Drained and Fire-affected Peat

CO_2 emission (8.2 Mt C/M ha/y) from disturbed tropical peatland in Mega Rice Project Area, which equal to 3% CO_2 emission from Japan



Teknologi pendukung Perhitungan Emisi GRK Lahan (Pengelolaan lahan)

(a) Pengelolaan Hutan Lestari (Sustainable Forest Management)



	PSP 1	PSP 2	PSP 3	PSP 4	PSP 5	PSP 6
Increment	6.1	5.4	7.3	4.1	1.1	-2.6
Percentage	3.4	3.1	3.6	2.0	1.0	-2.2

Figure 9. Increment of stand volume at the permanent sample plots of Sari Bumi Kusuma (SBK)

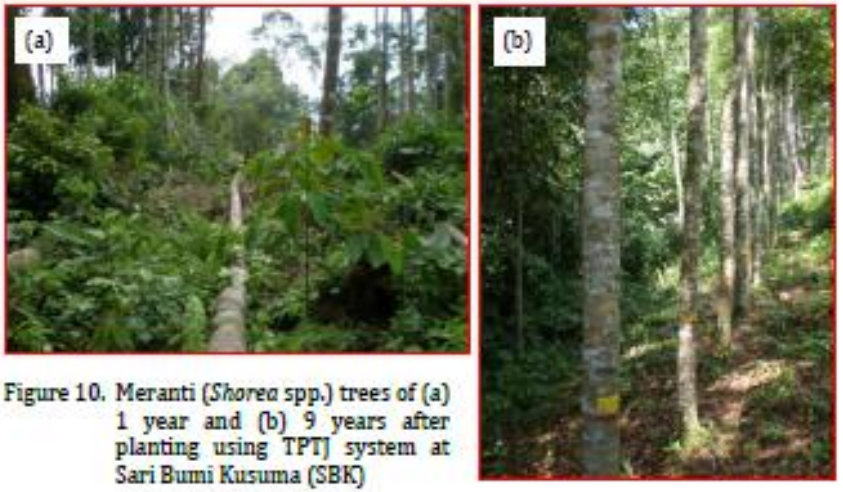


Figure 10. Meranti (*Shorea* spp.) trees of (a) 1 year and (b) 9 years after planting using TPTJ system at Sari Bumi Kusuma (SBK)

(b) Pengelolaan tinggi muka air lahan gambut

Model/Metode Formula Perhitungan Emisi Gas Rumah Kaca yang telah dikembangkan dalam Lingkup Pertanian, Kehutanan dan Penggunaan Lahan (*Agriculture, Forestry and Other Land Use*/AFOLU)

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