Carbon loss associated with land use change and wildfires in tropical peatlands

Louis Verchot, Kristell Hergoualc'h, Daniel Murdiyarso

THINKING beyond the canopy

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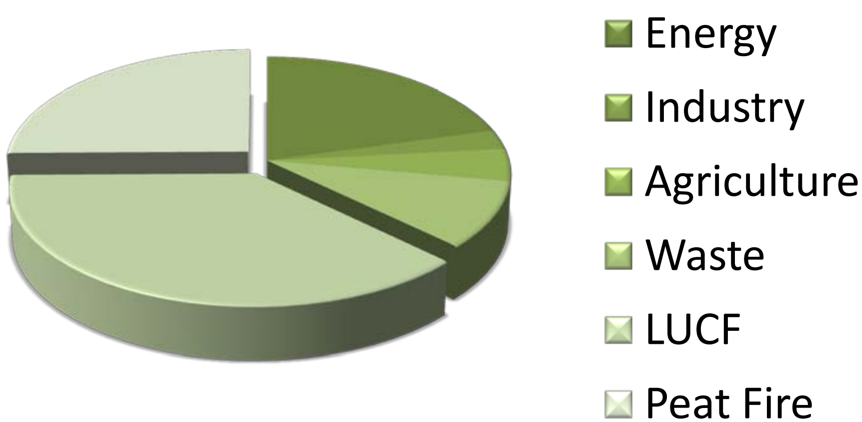
Indonesia is #5 in the top 10 list of polluters

Country	$MtCO_2e$	World Total	CO_2e Per Person
China	7,216	16.4%	5.5
United States of America	6,931	15.7%	23.5
European Union (27)	5,329	12.1%	10.9
Brazil	2,856	6.5%	15.3
Indonesia	2,046	4.6%	9.3
Russian Federation	2,028	4.6%	14.2
India	1,870	4.2%	1.7
Japan	1,387	3.1%	10.9
Germany	1,005	2.3%	12.2
Canada	808	1.8%	25.0

Indonesia's emissions

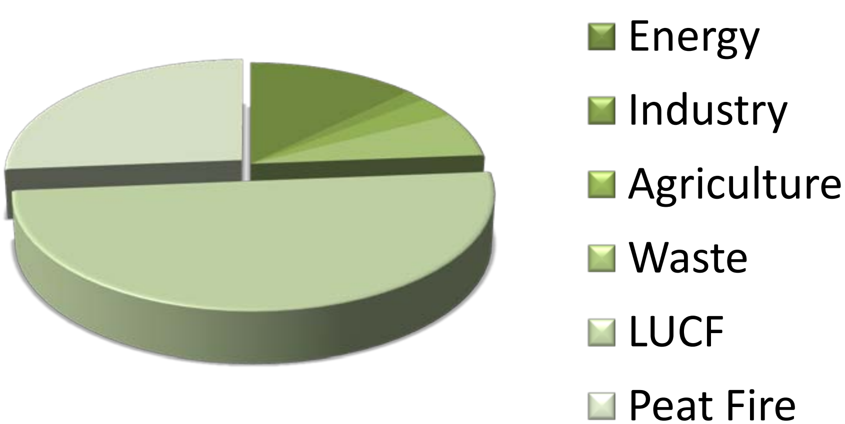
Average between 2001 and 2005:
~ 1.8 billion tons

2005



Average emission year: 2.0 billion tonnes of CO_2

2002

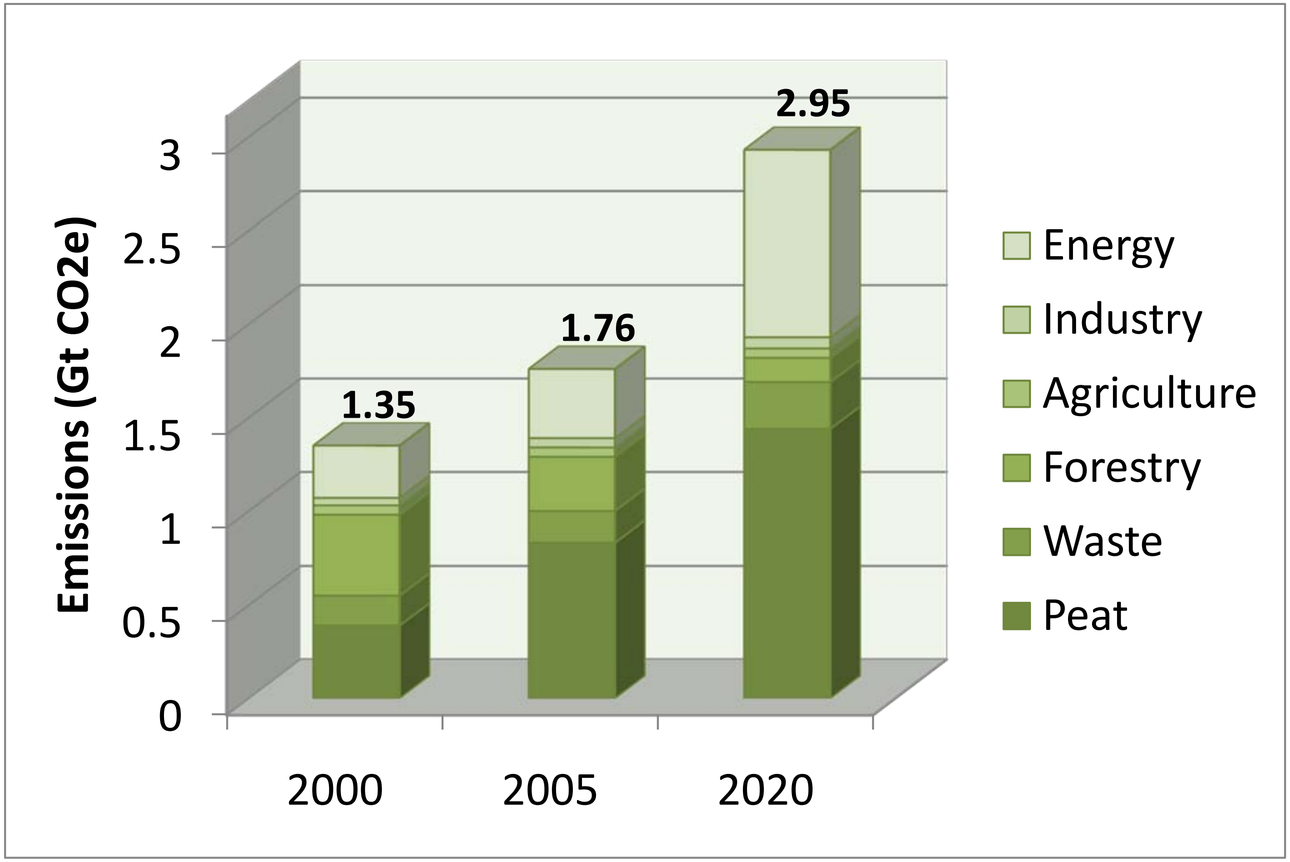


High emission year: 2.6 billion tonnes of CO_2

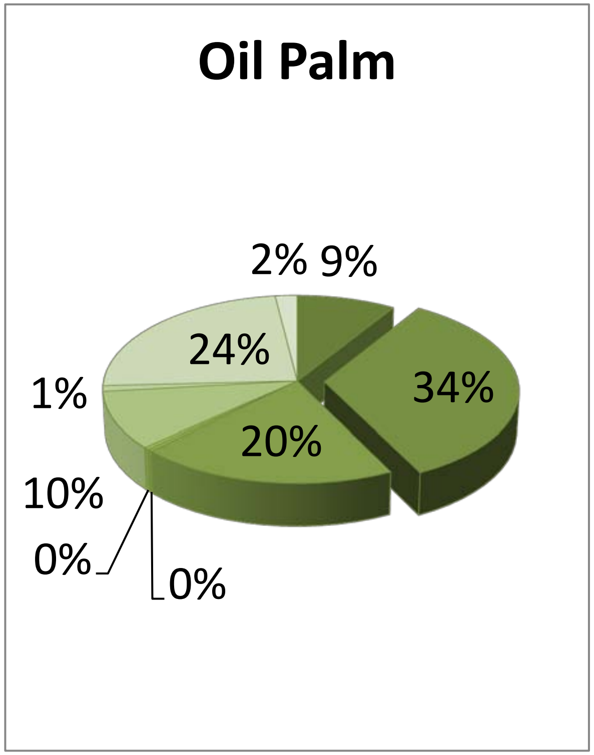
Data source: Min. Envi. Jakarta

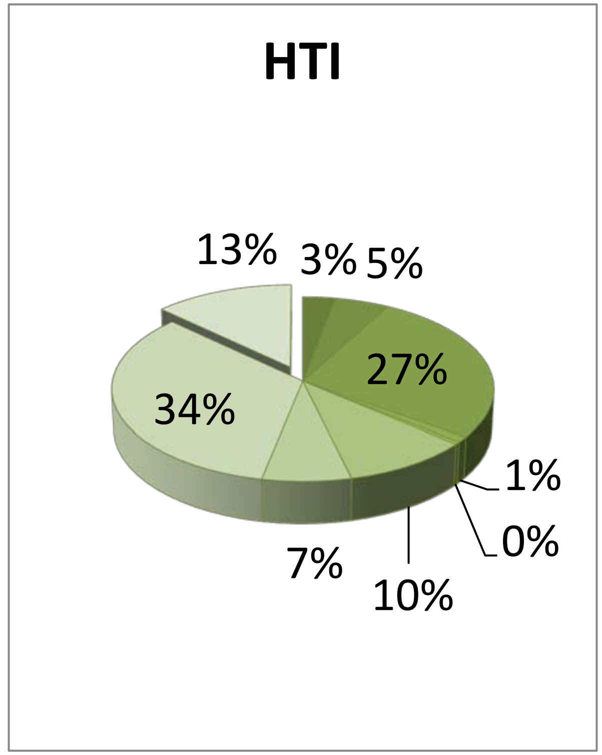
BAPENAS estimates that the problem will grow

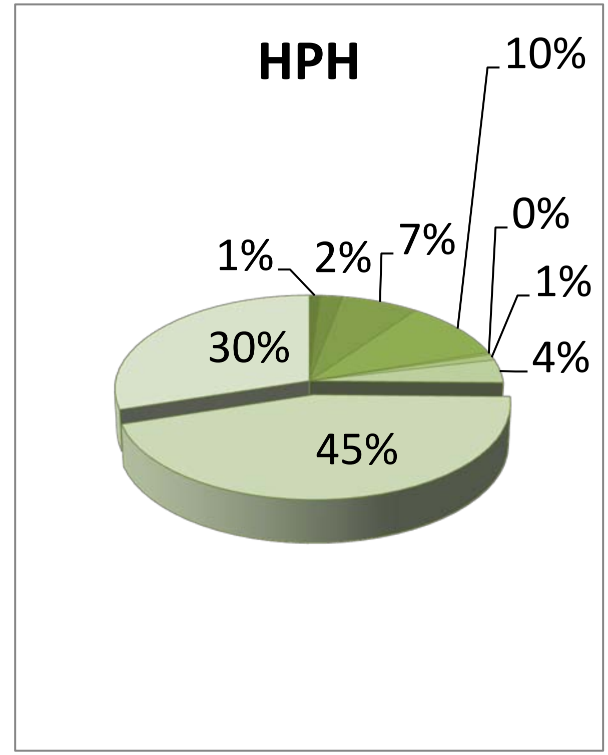
Under BAU, peat will become the main source of emissions. In 2005-06, peat land accounts for almost 50% of national emissions, while its contribution to Indonesia's total GDP is only about USD1.06 billion (0.26%)



LAND COVER OF LICENSED PEAT LANDS







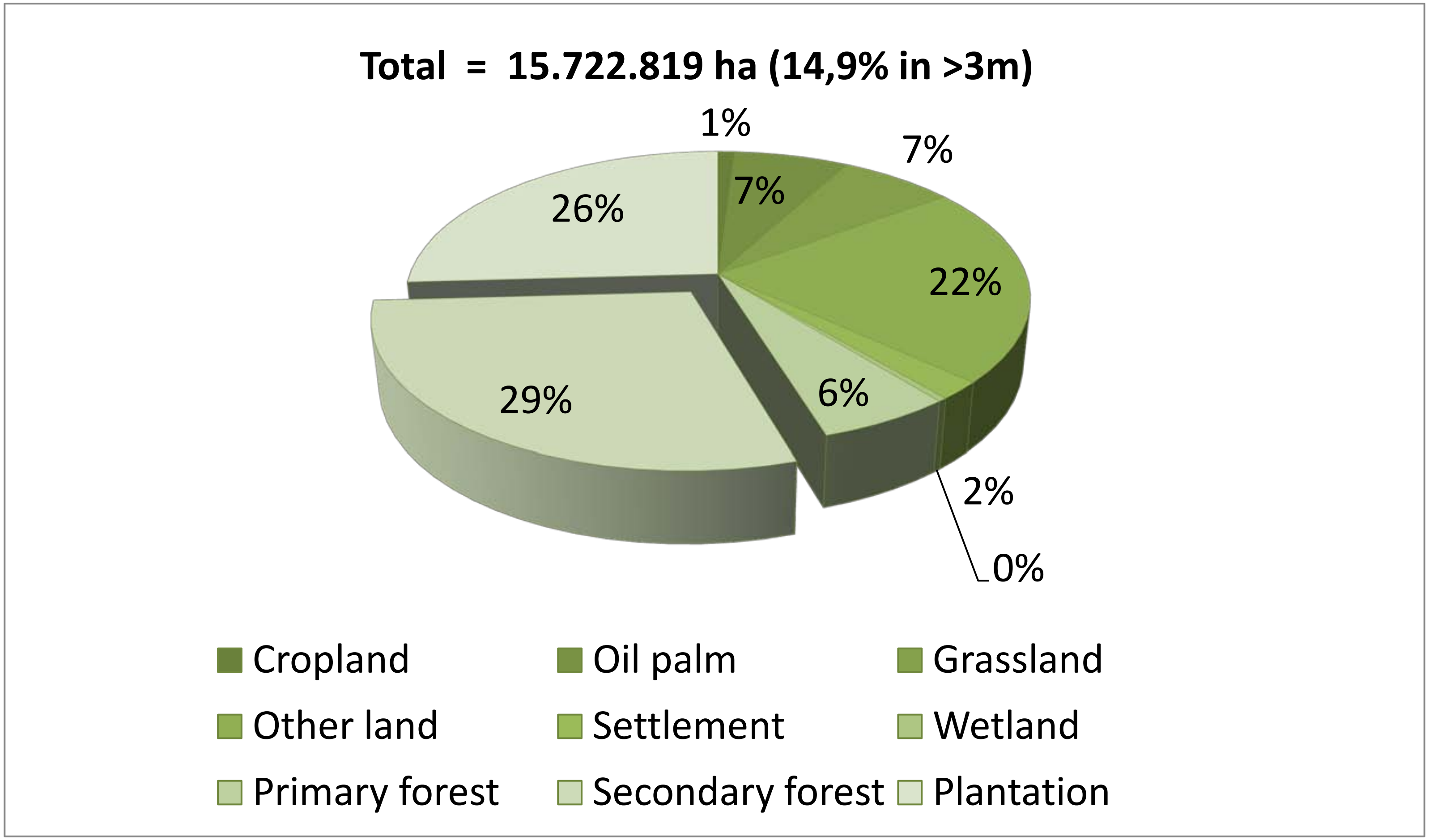
Total = **842.498** ha (20% in >3m)

Total = **2.014.794** ha (31% in >3m)

Total = **2.811.280** ha (24% in >3m)

- Cropland
- Oil palm
- Grassland
- Other land
- Settlement
- Wetland
- Primary forest
- Secondary forest
- Plantation

LAND COVER OF NON-LICENSED PEAT LANDS



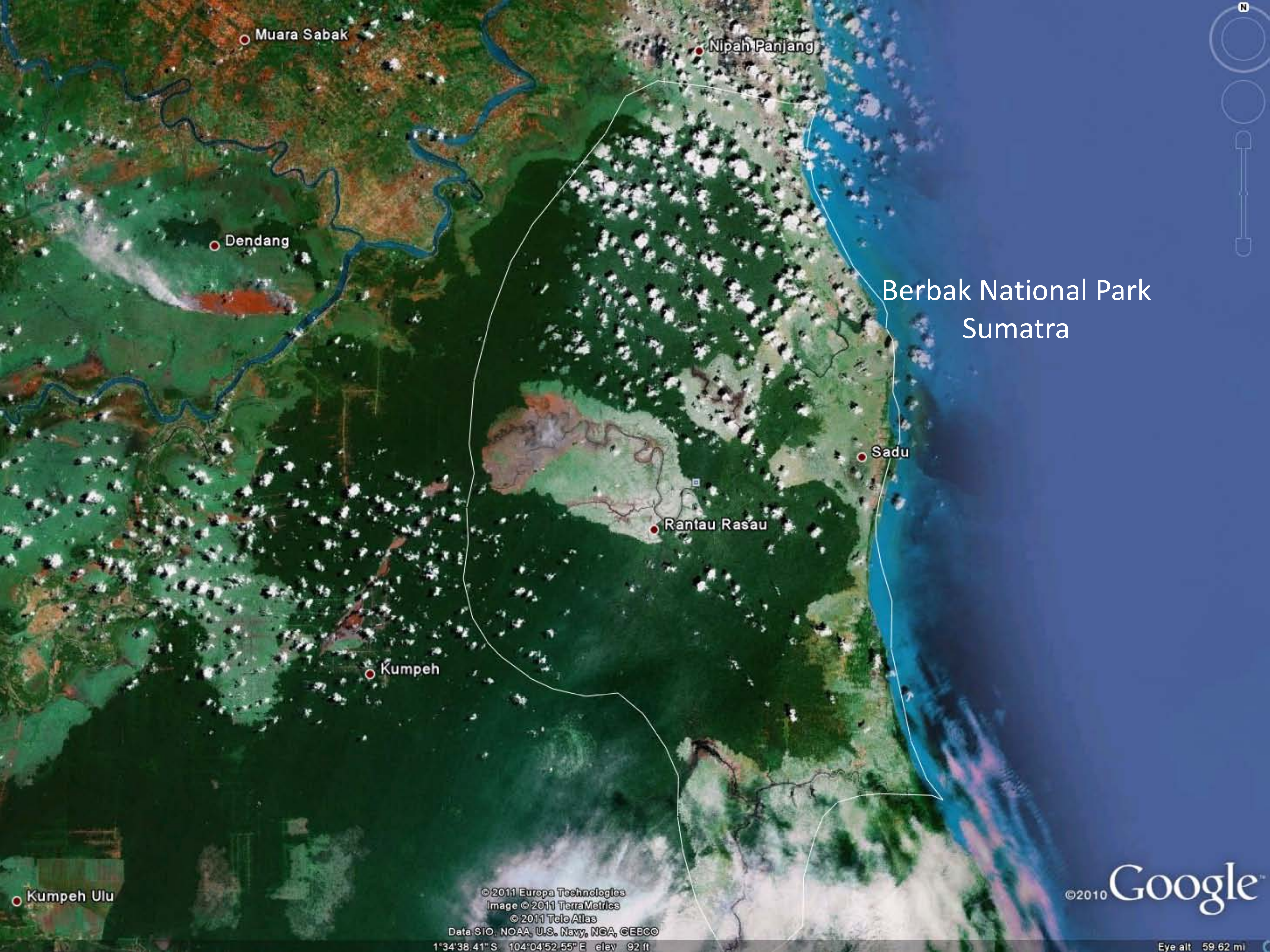

Berbak National Park
Sumatra
Muara Sabak
Nipah Panjang
Dendang
Sadu
Rantau Rasau
Kumpeh
Kumpeh Ulu
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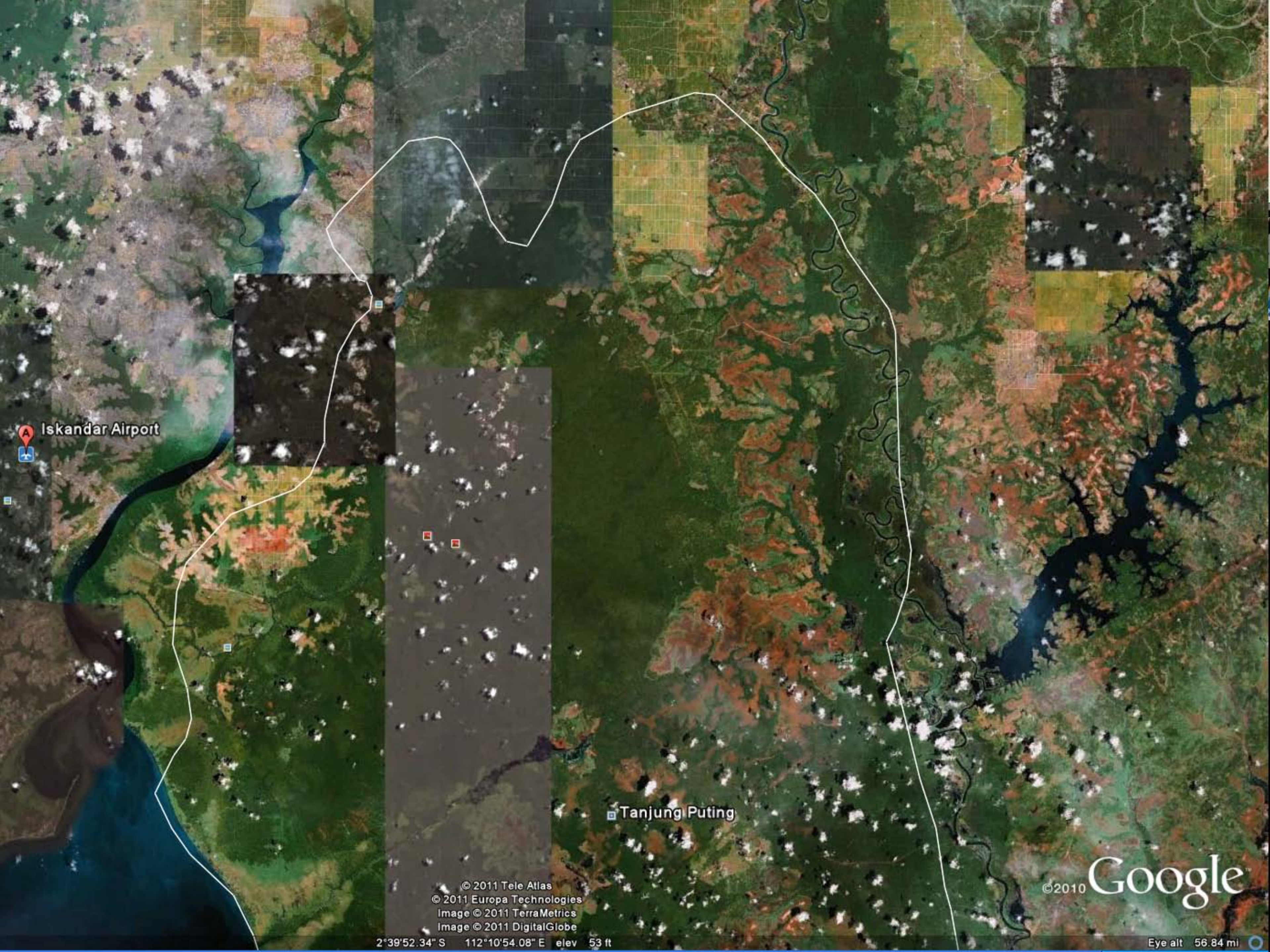
Image © 2011 TerraMetrics
© 2011 Tele Atlas
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
1°34'38.41" S 104°04'52.55" E elev 92 ft
Eye alt 59.62 mi
©2010 Google



Iskandar Airport
Tanjung Puting
© 2011 Tele Atlas
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Image © 2011 TerraMetrics
Image © 2011 DigitalGlobe
2°39'52.34" S 112°10'54.08" E elev 53 ft
Eye alt 56.84 mi
©2010 Google

Tropical Peat forests
(freshwater wetlands)

- There are about 441,000 km^2 of tropical peatlands ~11% of the total peatland area; volume is ~18 - 25% (Page et al. 2010).
- Southeast Asia is home to 25 million hectares of peatlands, or 56% of all tropical peatlands.
- Total C storage in these ecosystems may be among the largest forest C pools on Earth. Yet data are lacking quantifying these globally significant carbon stores.
- Tropical peat forests are excellent candidates for inclusion in REDD+ strategies, but critical information on carbon pools and land use is needed in order to be effective.

Methodological approaches

Stock difference approach

Before

After

C_F

C_{OP}

$$C_{loss} = C_F - C_{OP}$$

$$C_{loss}\ \text{rate} = C_{loss} / \text{time}$$

Input-output approach

Before

After

$C_{in\ F}$ $C_{out\ F}$

$C_{in\ OP}$ $C_{out\ OP}$

ΔC_F

$= C_{in\ F} - C_{out\ F}$

ΔC_{OP}

$= C_{in\ OP} - C_{out\ OP}$

$$C_{loss}\ \text{rate} = \Delta C_F - \Delta C_{OP}$$

$$C_{loss} = C_{loss}\ \text{rate} \times \text{life time}$$

Tropical peat lands store large amounts of carbon

- Total storage 81.7 – 91.9 Gt C (Page et al. 2011)
- Indonesia has the largest area of tropical peats
  - 210 000 – 270 000 Km^2
  - Estimated Carbon stock : 55 ± 10 Gt (Jaenicke et al. 2008)
  - Average 5.5. m peat depth (Page et al. 2011)

Carbon loss estimates

Literature review

- Southeast Asian peatlands
- C stocks, peat C fluxes
- 56 studies

2 publications

- Murdiyarso D, Hergoualc'h K, Verchot LV (2010) Opportunities for reducing greenhouse gas emissions tropical peatlands. PNAS 107, 19655-19660.
- Hergoualc’h K., Verchot L.V. (2011) Stocks and fluxes of carbon associated with land-use change in Southeast Asian tropical peatlands: a review. Global Biochemical Cycles. 25:GB2001, doi:10.1029/2009GB003718.

Carbon loss from wildfires

Stock change approach

Land-use type before fire	C stock loss (Mg C ha^{-1})		
	Burnt vegetation	Burnt peat	Total
Intact forest	152 ± 36	285 ± 67	436 ± 77
Logged forest	35 ± 36	285 ± 67	320 ± 77
Oil palm plantation	32 ± 9	285 ± 67	316 ± 67
Acacia plantation	28 ± 2	285 ± 67	313 ± 68

C loss: 65 – 90% from peat

Peat forest conversion to oil palm

Combination of the 2 methodological approaches

Stock difference approach: Aboveground biomass C loss

Input – output approach: Peat C loss

Peat C stocks: Difficulties & Limits

- Bulk density
  - Presence logs
  - High water table level

Peat domes are very large and difficult to measure accurately

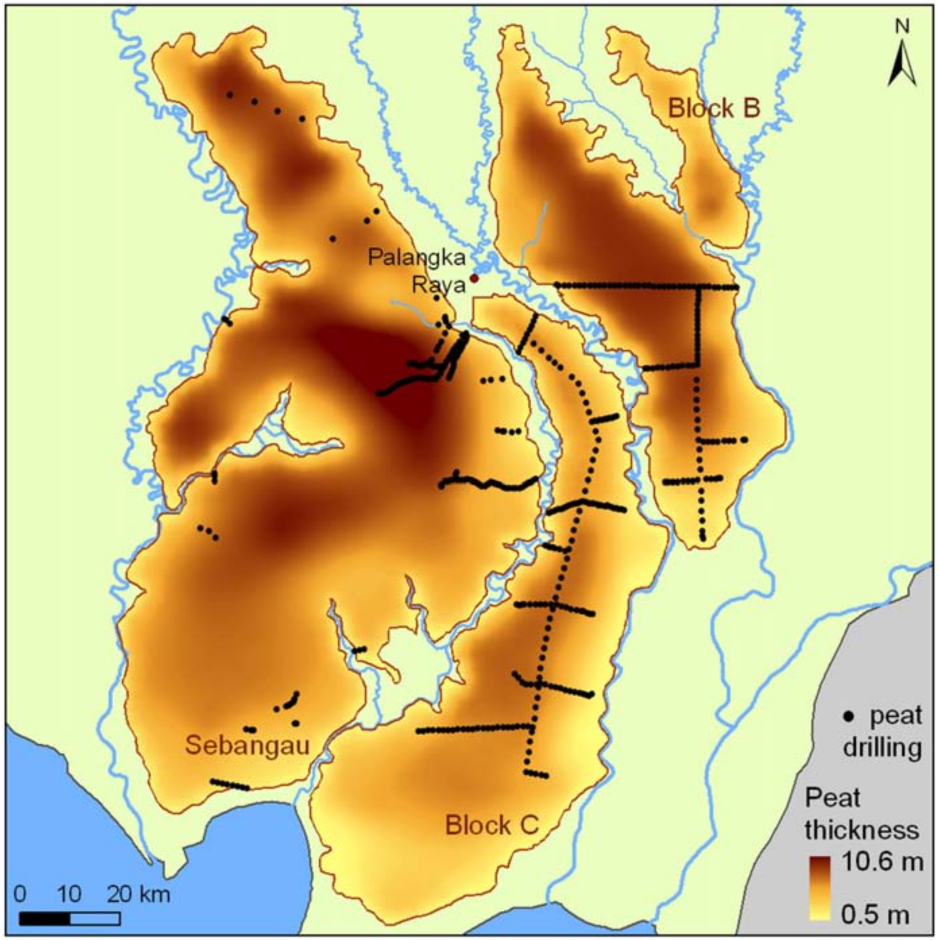
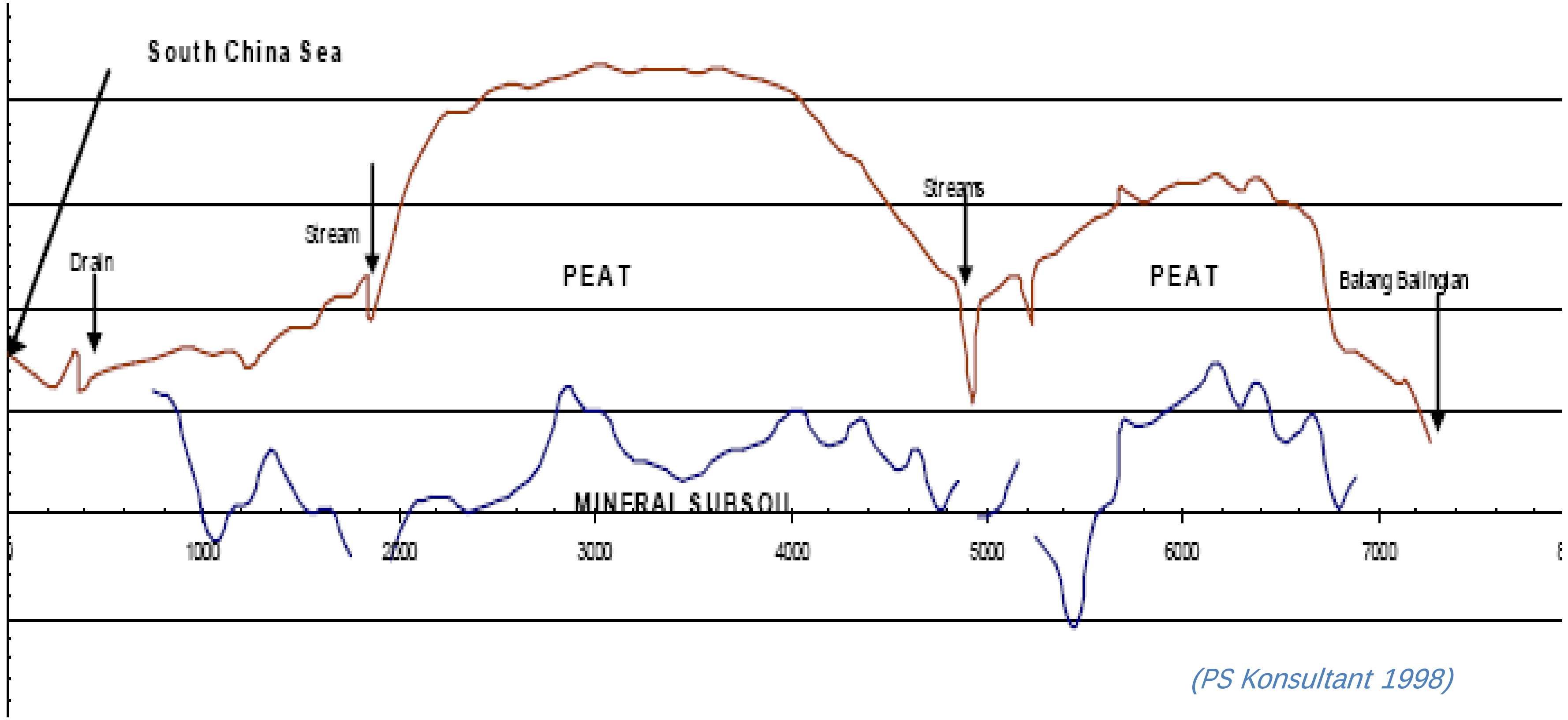


Fig. 5. Peat thickness model of selected peat domes in Central Kalimantan. Kriging interpolation was applied using 542 peat drilling values and a correlation function between the peat dome surface and peat thickness.

Source: Jaenecke et al., 2008

Peat C stocks: Difficulties & Limits

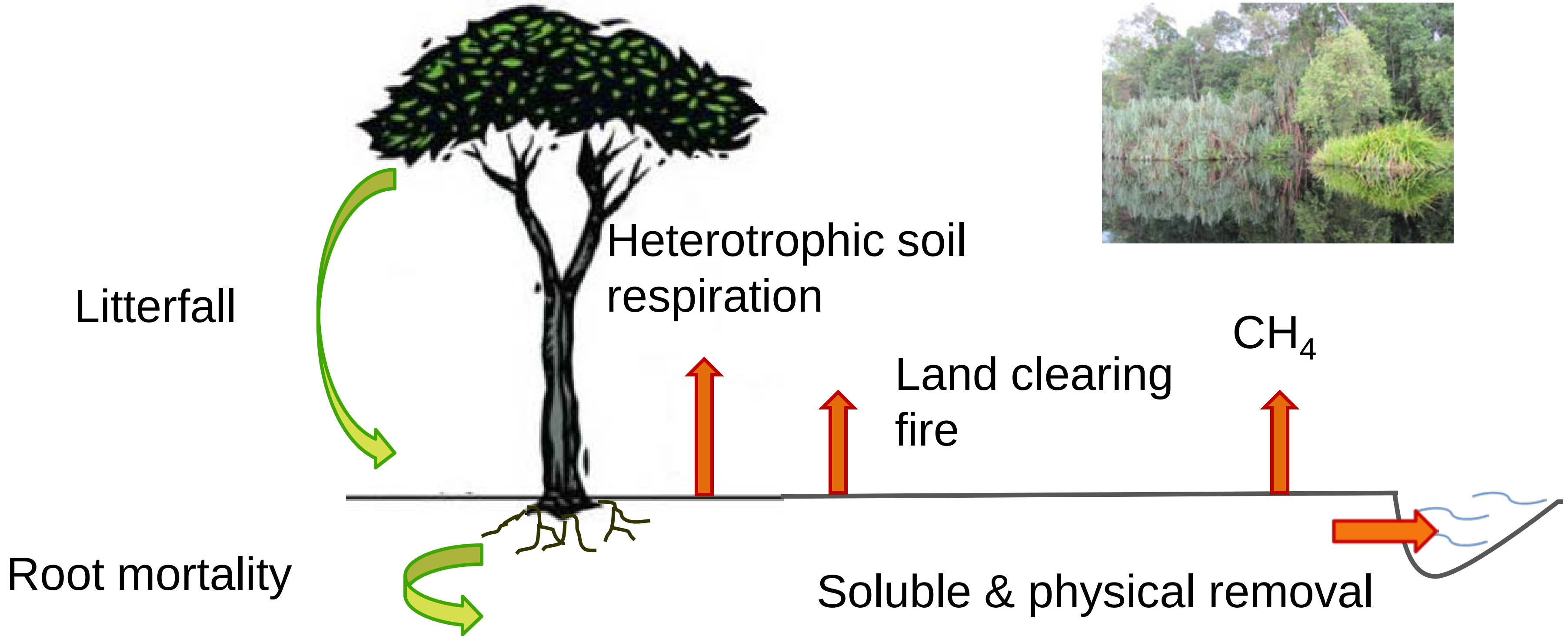
Peat depth (up to 20 m), limited number profiles



Subsidence is a result of compaction, shrinkage and oxidation

Source: Peter van der Meer & Caspar Verwer

C fluxes into and out of the peat



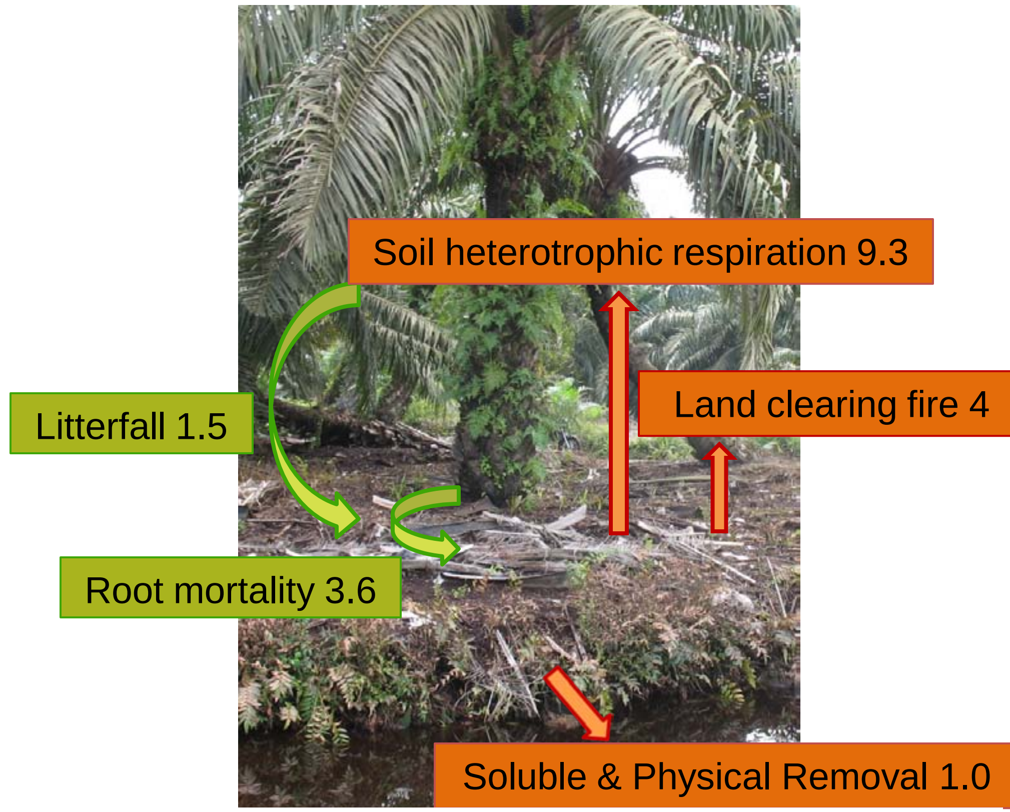
Heterotrophic soil respiration = peat oxidation = peat decomposition

Heterotrophic soil respiration = Total soil respiration - root respiration

Peat C balances in the forest and in the oil palm plantation

Before

After



$\Delta C_{peat\ F} = 0.75$ Mg C ha^{-1} y^{-1}

= **19 Mg C ha^{-1} 25 y**

$\Delta C_{peat\ OP} = C_{in\ peat} - C_{out\ peat}$

= - 9.2 Mg C ha^{-1} y^{-1}

= **- 230 Mg C ha^{-1} 25 y**

Peat forest conversion to oil palm plantation

Before

After

$\Delta C_{peat\ F} = 19$ Mg C ha^{-1} 25 y

$C_{Abvgrnd\ biomass\ F} = 180$ Mg C ha^{-1}

- 249 Mg C ha^{-1} 25 y

-156 Mg C ha^{-1} 25 y

$\Delta C_{peat\ OP} =$ - 230 Mg C ha^{-1} 25 y

$C_{Abvgrnd\ biomass\ OP} = 24$ Mg C ha^{-1}

$\Rightarrow$

C loss = 405 Mg C ha^{-1} over 25 years

C loss: 61 % from peat

Conclusions

- Very large carbon loss
- C loss: 60-90% from the peat

⇒ **REDD** mechanism should **prioritize peat swamp forests**

- Gaps knowledge on C cycle in tropical peatlands

⇒ Greenhouse gas accounting methods: heterotrophic soil respiration (N inputs), allometric models specific to peat swamp forests

- N_2O: Global warming potential 300

⇒ Increase in N_2O emissions due to land-use change in tropical peatlands?

CGIAR

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