

Indonesia's wetland ecosystems:

Challenges & opportunities for CC mitigation

Daniel Murdiyarso

CIFOR

Thinking beyond the canopy

Center for International Forestry Research



Outline

- **Introduction**
  - What are defined as wetlands?
  - Mangroves and peatlands
- **Capacity building**
  - Training Workshop
  - Measurement campaigns
  - International Workshop
- **How science can be best used?**
  - Outreach
    - Scientific publications
    - UNFCCC
    - IPCC
  - Network
    - Blue carbon working group
    - FAO
    - UNEP
- **The way forward**

Mangroves

- Indonesia has ca. 3 million ha or 23% world's mangrove area
- Deforestation rate 50,000-80,000 ha/yr
- There are more mangroves in Indonesia than any continents



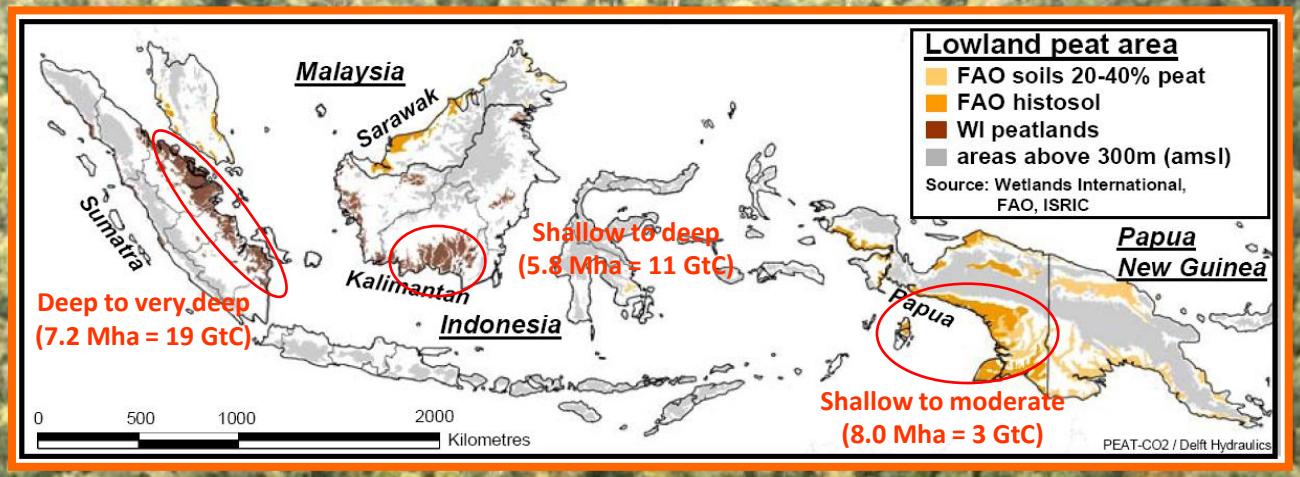



Estuarine *Bruguiera sp.*

Nypa palm



Peatlands distribution in Indonesia



		1990	2002
Global	400 Mha (528 Pg)		
Tropics	40 Mha (191 Pg)		
SE Asia		35-40 Mha	25-30 Mha
Indonesia		21 Mha **(33 Pg)**	17 Mha (?)

Emerging challenges:
pulpwood plantations

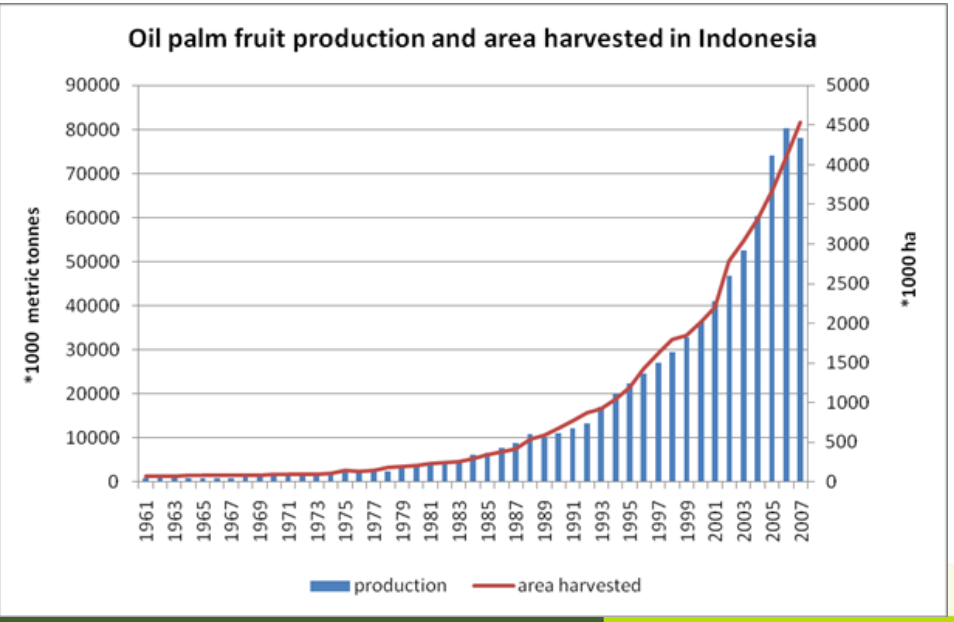




Controlling water level in Acacia plantation, Riau Province

Ever expanding oil palm plantation





- Intensifying plantation
- On degraded mineral soils
- Avoid peatlands
- Re-assess land banking
- Use moratorium clauses
- Revenue from palm oil: $16 B/yr

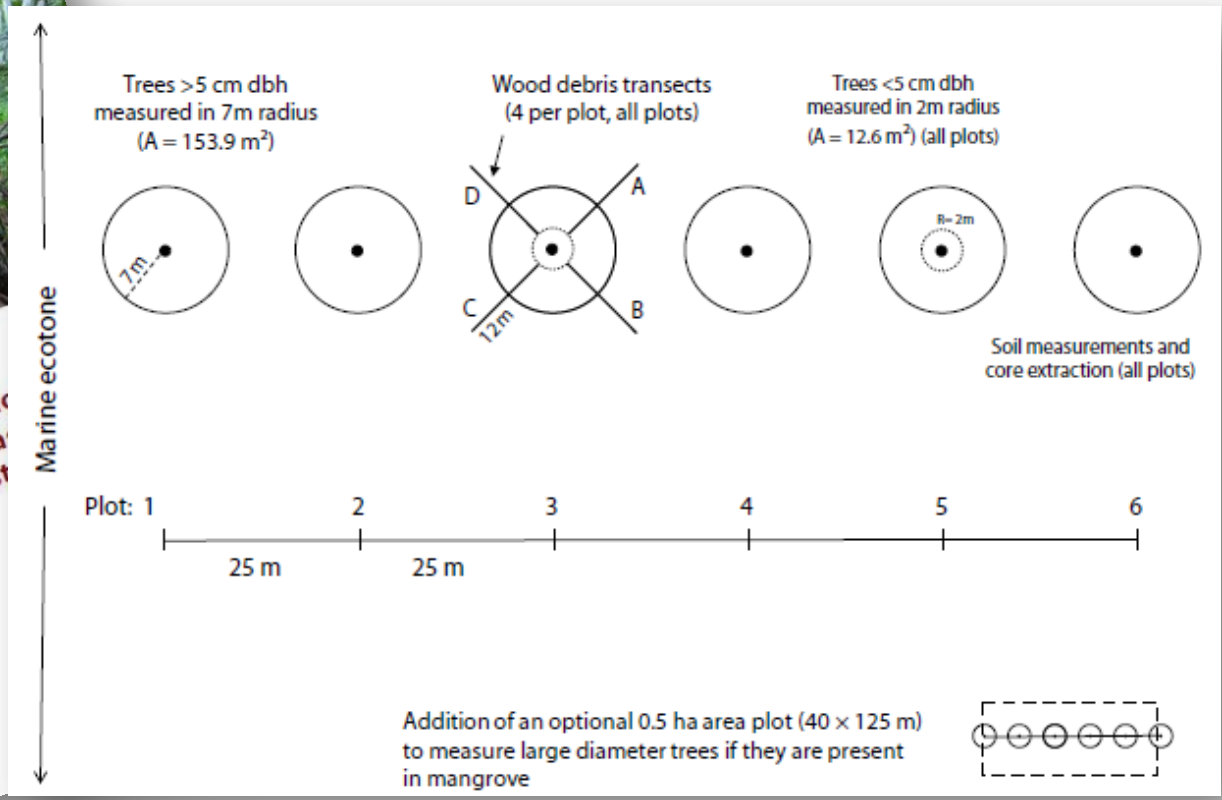
Tropical Wetlands Initiatives for Climate Adaptation and Mitigation

(TWINCAM)

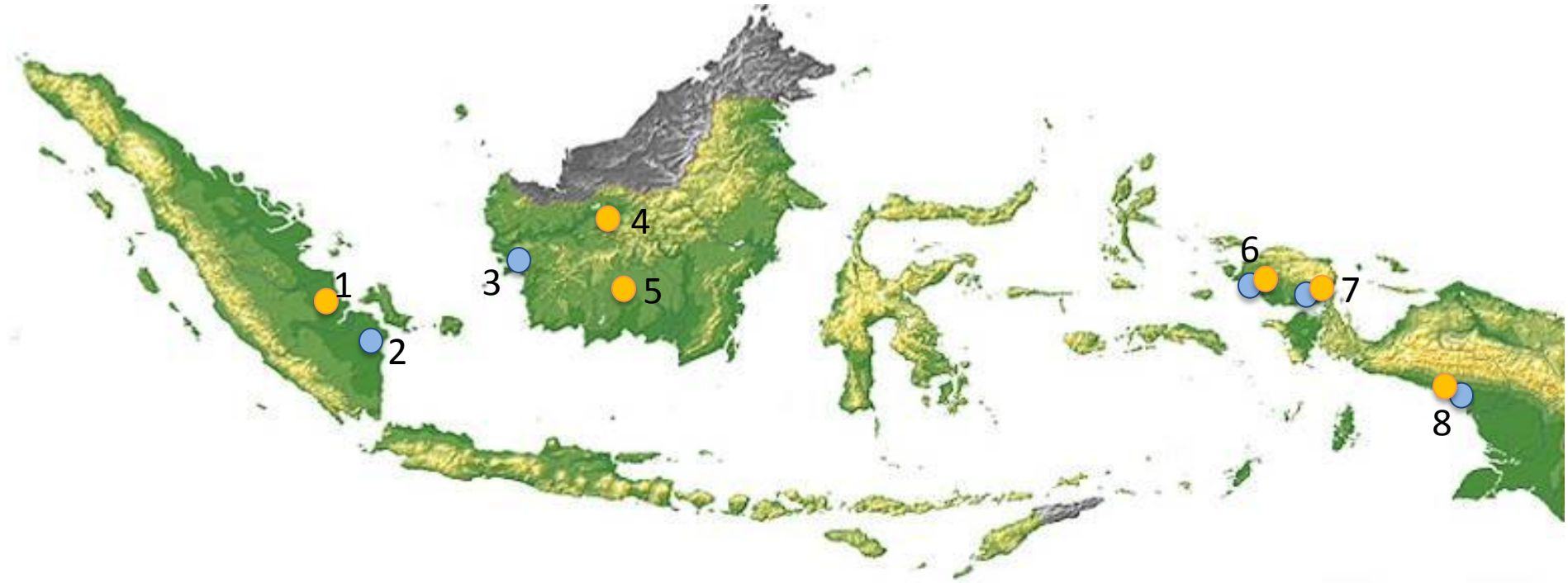


Sampling protocol





TWINCAM sites in Indonesia



Ecosystems

- Peatlands
- Mangroves

Sites

1 Berbak
2 Sembilang
3 Kubu Raya
4 Danau Sentarum
5 Sebangau
6 Teminabuan
7 Bintuni
8 Timika

In Kalimantan – as deep as 14 m



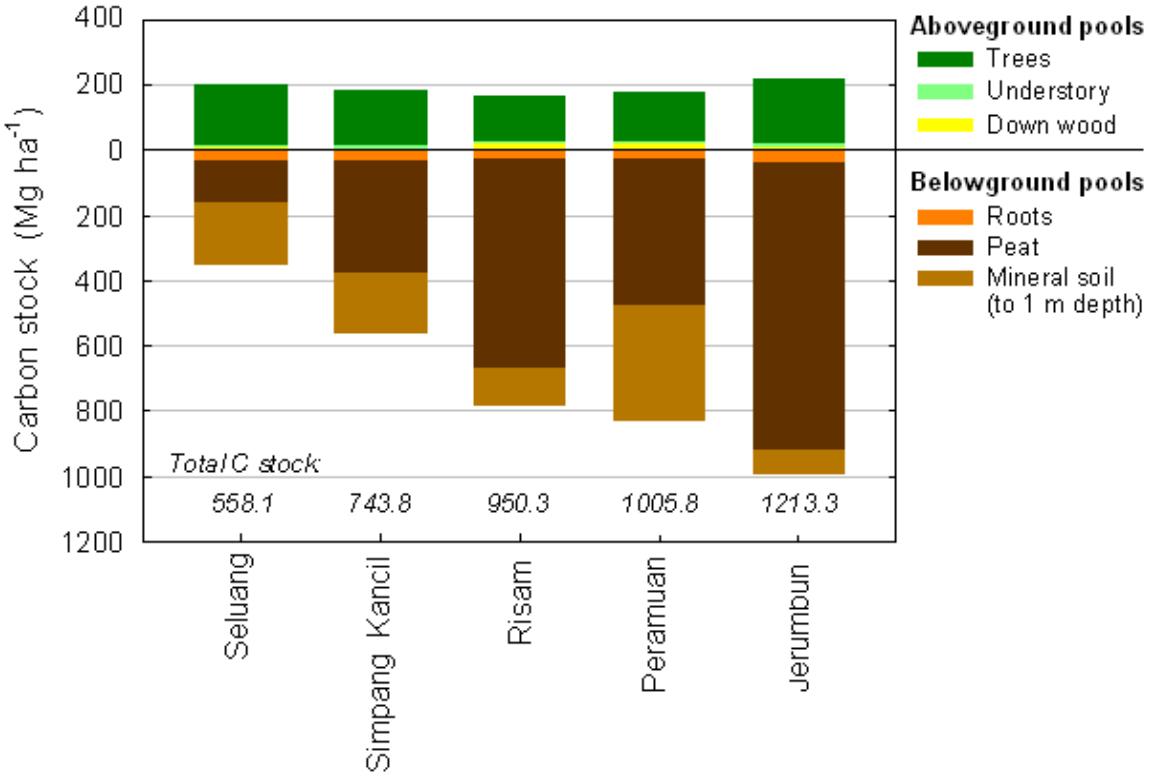








Large belowground pools: peatlands



Murdiyarso et al. (2009)

Let’s touch the base



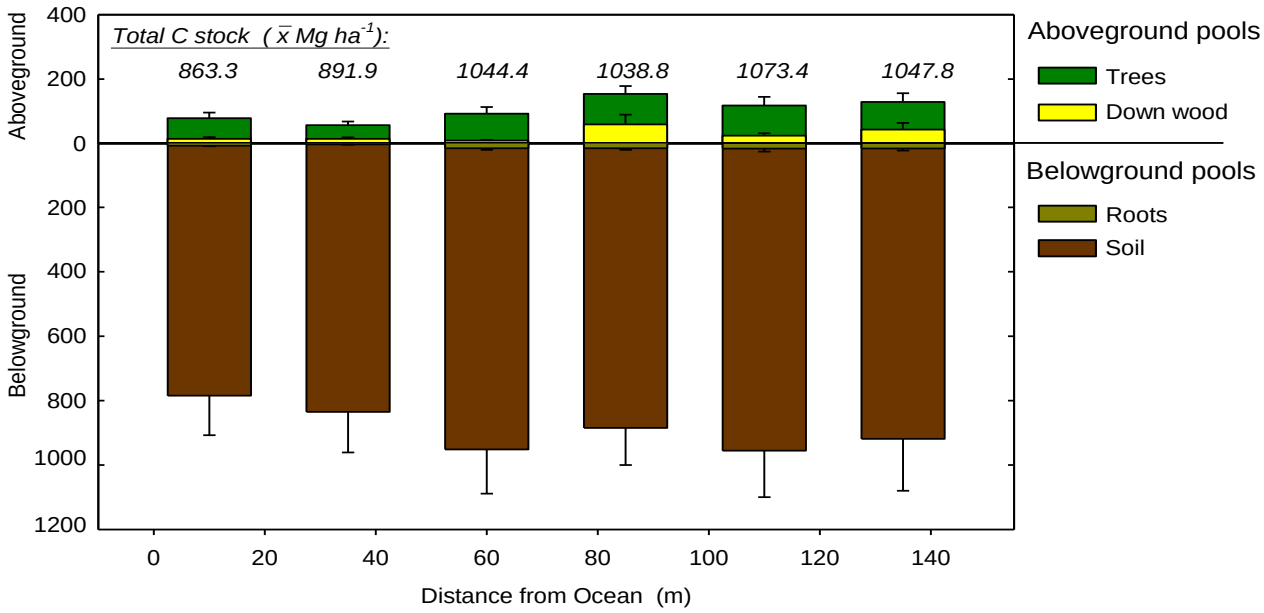






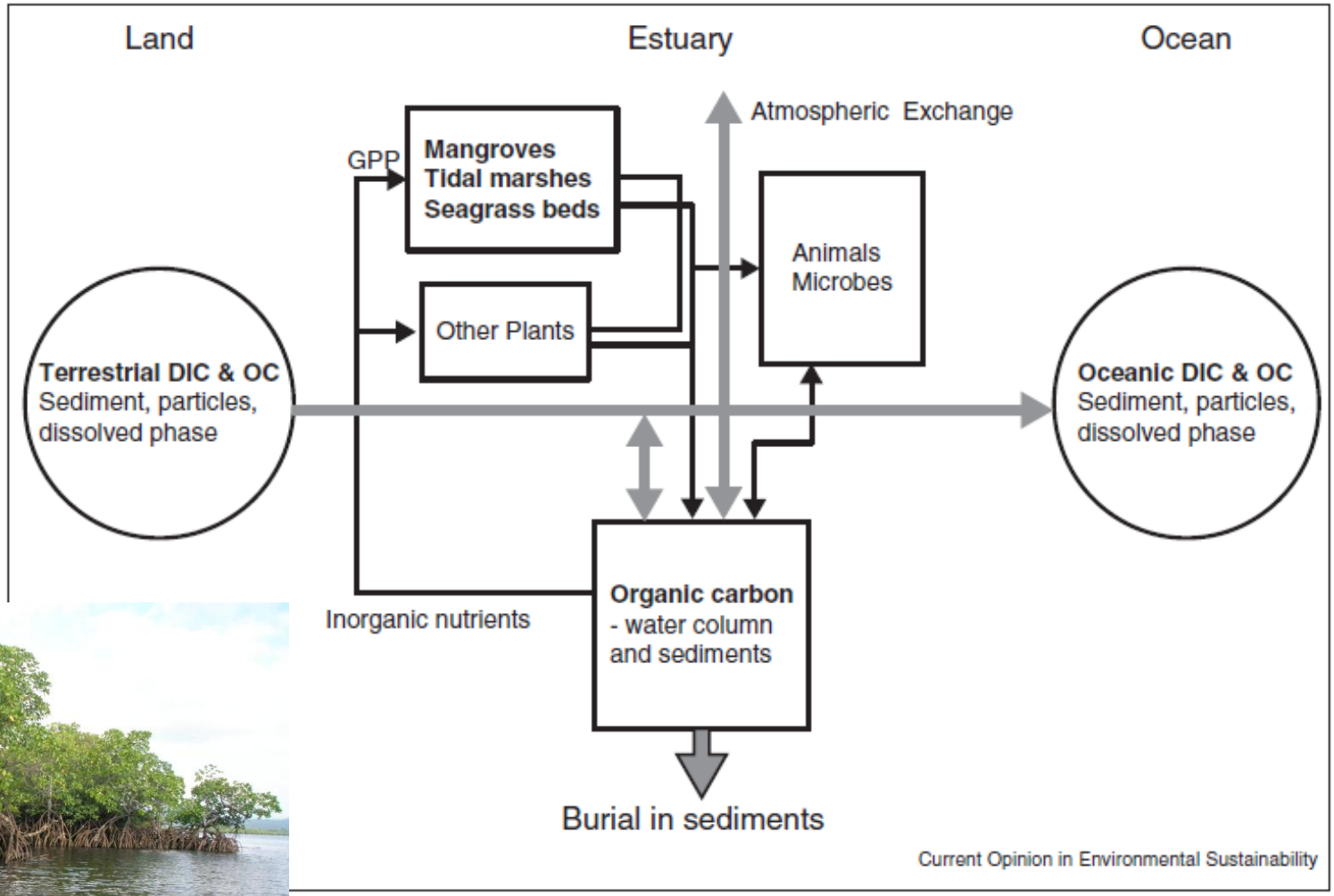


Large belowground pools: mangroves



Murdiyarso et al. (2009)

Burial of organic C in autotrophic mangroves





Hopkinson *et al.* (2012)

How science can be best used?

- Measuring GHG fluxes from drained peat swamp and fire emissions
- Quantifying C-stocks change from forests conversions
- Monitoring LUCC (100,000 ha/y in 2000-2005)





GoI – Informed decision: peatlands

SPECIAL FEATURE

Opportunities for reducing greenhouse gas emissions in tropical peatlands

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The upcoming global mechanism for reducing emissions from deforestation and forest degradation in developing countries should include and prioritize tropical peatlands. Forested tropical peatlands in Southeast Asia are rapidly being converted into production systems by introducing perennial crops for lucrative agribusiness, such as oil-palm and pulpwood plantations, causing large greenhouse gas (GHG) emissions. The Intergovernmental Panel on Climate Change Guidelines for GHG Inventory on Agriculture, Forestry, and Other Land Uses provide an adequate framework for emissions inventories in these ecosystems; however, specific emission factors are needed for more accurate and cost-effective monitoring. The emissions are governed by complex biophysical processes, such as peat decomposition and compaction, nutrient availability, soil water content, and water table level, all of which are affected by management practices. We estimate that total carbon loss from converting peat swamp forests into oil palm is 59.4 ± 10.2 Mg of CO_2 per hectare per year during the first 25 y after land-use cover change, of which 61.6% arise from the peat. Of the total amount (1,486 ± 183 Mg of CO_2 per hectare over 25 y), 25% are released immediately from land-clearing fire. In order to maintain high palm-oil production, nitrogen inputs through fertilizer are needed and the magnitude of the resulting increased N_2O emissions compared to CO_2 losses remains unclear.

drainage | respiration | gain-loss approach | stock-difference approach

Globally, peatlands cover an area of 400 million hectare, which is equivalent to 3% of the Earth's land area. These ecosystems store a large fraction of terrestrial carbon, as much as 528 Pg (Pg = 1×10^{15} g), or one-third of global soil carbon (1, 2). This quantity is equivalent to the amount of carbon that would be emitted to the atmosphere from burning fossil fuels at the current annual global rate (approximately 7 Pg in 2007) for the next 75 y.

One-third of the carbon stored in peatlands (191 Pg) is located in the tropics (3, 4), of which 60% is in Southeast Asia with an estimated area of 25 million hectare (Mha). The majority (84%) of Southeast Asian peatlands are found in Indonesia (around 21 Mha), whereas Malaysia harbors 2–2.5 Mha. Thailand has around 45,000 ha, and relatively small areas are found in Vietnam, Brunei, and the Philippines (5).

Tropical peatlands are an important terrestrial carbon pool, but they are highly vulnerable and have become a major source of carbon emissions that requires policy changes to allow mitigation measures to take place. During the period of 2000–2005, the deforestation rate in Indonesian peatlands was estimated around 0.1 Mha per annum (6). Adding to this, the area of peatlands burnt during the big fire in 1997 was 2.12 Mha (7).

The main driver of tropical peatlands deforestation is the development of oil-palm and pulpwood plantations (8). Indonesia and Malaysia, which currently account for 85% of the world's supply of crude palm oil, aim at supplying Chinese, Indian, and European markets. If crude palm oil demand increases, there could be much more pressure on the forested land in the region. For example, in order to substitute 1% of fossil fuel use with biofuels for electricity production, Europe would consume the oil production of at least 2 Mha of oil-palm plantations (9).

It was estimated that converting a hectare of forest to palm-oil production yields net present values (NPV) of $3,835–$9,630 to land owners (10, 11). The conversion is more profitable than leaving the forests standing for carbon credits from voluntary markets of $614–$994 per hectare although belowground carbon in peatland is also considered. Unless post-2012 global climate policies create significant financial incentives to overcome the economic drivers of deforestation, reducing emissions from deforestation and forest degradation (REDD) will not be able to compete financially with factors that expand oil-palm agriculture (12).

The Bali Action Plan paves the way for REDD implementation as a climate change mitigation measure (13). The Action Plan invites countries to consider policy approaches and creates the opportunity for positive incentives on issues relating to improved forest management, including conservation, sustainable management of forests, and enhancement of forest carbon stocks, known as "REDD+." Because the rules and modalities of REDD+ are to be decided, it is now the right time to promote the peatlands sector to be included in the new climate regime under the REDD+ schemes.

In this review we explore existing data for these ecosystems and suggest areas for scientific support in meeting the methodological challenges to assess greenhouse gas (GHG) emissions from tropical peatlands. Identifying research gaps with respect to improved management in these carbon-rich ecosystems merits significant elaboration to support effective REDD+ implementation.

Current Status and Trends of Tropical Peatlands

Peatland Development. In 1981, "planned deforestation" in Indonesia was legislated, involving 30 Mha of conversion forests (14). In addition to plantation forests, most of the conversions were allocated for agricultural land development, such as oil palm. Furthermore, in early 2009, the government of Indonesia issued a regulation that allows the development of oil-palm plantations in peatlands with peat depth less than 3 m, which could potentially trigger further deforestation and peatlands degradation.

In late May 2010, however, a letter of intent (LoI) between the government of Indonesia and the government of Norway on cooperation on REDD+ was signed. The Norwegian government pledge of $1 billion will trigger (*i*) the development of REDD+ strategies to address key drivers forest and peatland-related emissions, (*ii*) the establishment of an independent REDD+ agency and an independent monitoring, reporting, and verification institution, and (*iii*) the financial mechanisms. Thus far, the LoI has generated extensive debates across government agencies, private sectors, and civil society regarding opportunity costs, institution settings, and new regulatory framework.

Author contributions: D.M. and L.V.V. designed research; D.M. and K.H. performed research; D.M., K.H., and L.V.V. analyzed data; and D.M., K.H., and L.V.V. wrote the paper.

The authors declare no conflict of interest.

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ENVIRONMENTAL SCIENCES
AGRICULTURAL SCIENCES

- C-loss due to peatland conversion 60 tCO2/ha/y or 1,500 tCO2/ha during the first 25 yrs
- 25% are released immediately from land-clearing fire



GoI – Informed decision: mangroves

nature geoscience

LETTERS

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Mangroves among the most carbon-rich forests in the tropics

Daniel C. Donato[1]*, J. Boone Kauffman[2], Daniel Murdiyarso[3], Sofyan Kurnianto[3], Melanie Stidham[4] and Markku Kanninen[5]

Mangrove forests occur along ocean coastlines throughout the tropics, and support numerous ecosystem services, including fisheries production and nutrient cycling. However, the areal extent of mangrove forests has declined by 30–50% over the past half century as a result of coastal development, aquaculture expansion and over-harvesting[1–4]. Carbon emissions resulting from mangrove loss are uncertain, owing in part to a lack of broad-scale data on the amount of carbon stored in these ecosystems, particularly below ground[5]. Here, we quantified whole-ecosystem carbon storage by measuring tree and dead wood biomass, soil carbon content, and soil depth in 25 mangrove forests across a broad area of the Indo-Pacific region—spanning 30° of latitude and 73° of longitude—where mangrove area and diversity are greatest[4,6]. These data indicate that mangroves are among the most carbon-rich forests in the tropics, containing on average 1,023 Mg carbon per hectare. Organic-rich soils ranged from 0.5 m to more than 3 m in depth and accounted for 49–98% of carbon storage in these systems. Combining our data with other published information, we estimate that mangrove deforestation generates emissions of 0.02–0.12 Pg carbon per year—as much as around 10% of emissions from deforestation globally, despite accounting for just 0.7% of tropical forest area[6,7].

Deforestation and land-use change currently account for 8–20% of global anthropogenic carbon dioxide (CO_2) emissions, second only to fossil fuel combustion[7,8]. Recent international climate agreements highlight Reduced Emissions from Deforestation and Degradation (REDD+) as a key and relatively cost-effective option for mitigating climate change; the strategy aims to maintain terrestrial carbon (C) stores through financial incentives for forest conservation (for example, carbon credits). REDD+ and similar programs require rigorous monitoring of C pools and emissions[8,9], underscoring the importance of robust C storage estimates for various forest types, particularly those with a combination of high C density and widespread land-use change[10].

Tropical wetland forests (for example, peatlands) contain organic soils up to several metres deep and are among the largest organic C reserves in the terrestrial biosphere[11–13]. Peatlands' disproportionate importance in the link between land use and climate change has received significant attention since 1997, when peat fires associated with land clearing in Indonesia increased atmospheric CO_2 enrichment by 13–40% over global annual fossil fuel emissions[11]. This importance has prompted calls to specifically address tropical peatlands in international climate change mitigation strategies[7,13].

Overlooked in this discussion are mangrove forests, which occur along the coasts of most major oceans in 118 countries, adding ~30–35% to the global area of tropical wetland forest over peat swamps alone[4,6,12]. Renowned for an array of ecosystem services, including fisheries and fibre production, sediment regulation, and storm/tsunami protection[2–4], mangroves are nevertheless declining rapidly as a result of land clearing, aquaculture expansion, overharvesting, and development[2–6]. A 30–50% areal decline over the past half-century[1,3] has prompted estimates that mangroves may functionally disappear in as little as 100 years (refs 1,2). Rapid twenty-first century sea-level rise has also been cited as a primary threat to mangroves[14], which have responded to past sea-level changes by migrating landward or upward[15].

Although mangroves are well known for high C assimilation and flux rates[16–22], data are surprisingly lacking on whole-ecosystem carbon storage—the amount which stands to be released with land-use conversion. Limited components of C storage have been reported, most notably tree biomass[17,18], but evidence of deep organic-rich soils[22–25] suggests these estimates miss the vast majority of total ecosystem carbon. Mangrove soils consist of a variably thick, tidally submerged suboxic layer (variously called 'peat' or 'muck') supporting anaerobic decomposition pathways and having moderate to high C concentration[16,20,21]. Below-ground C storage in mangrove soils is difficult to quantify[5,21] and is not a simple function of measured flux rates—it also integrates thousands of years of variable deposition, transformation, and erosion dynamics associated with fluctuating sea levels and episodic disturbances[15]. No studies so far have integrated the necessary measurements for total mangrove C storage across broad geographic domains.

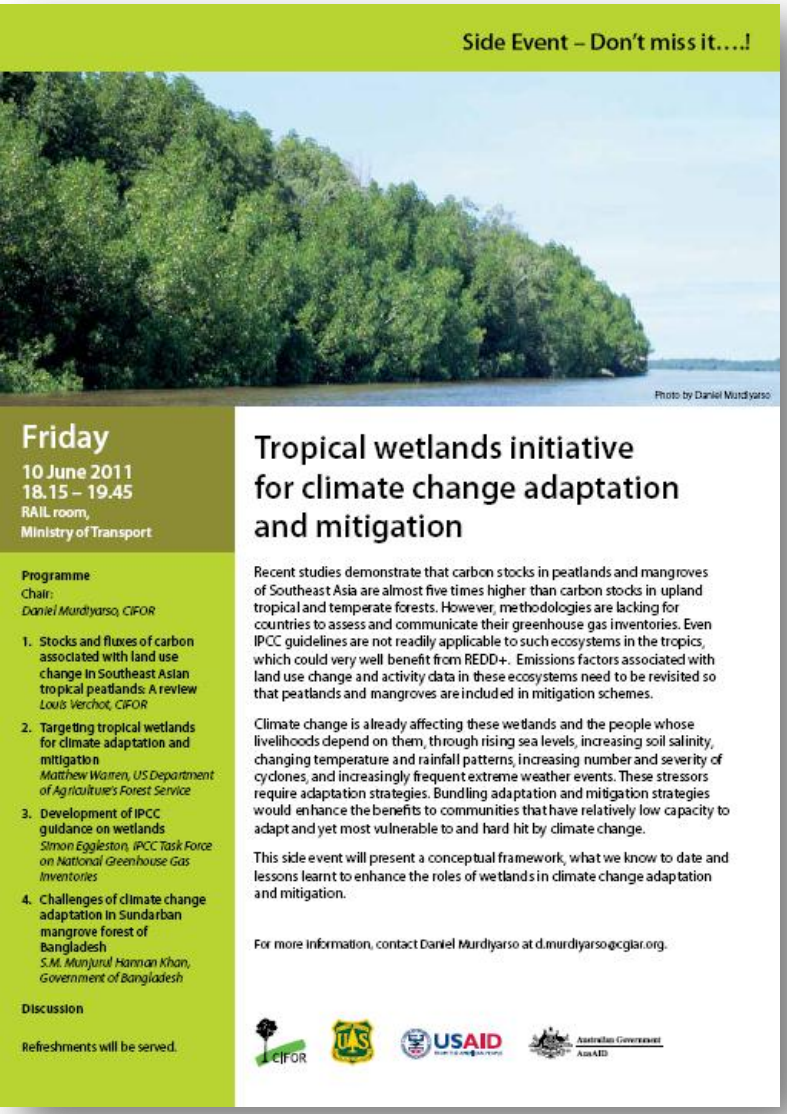
In this study we quantified whole-ecosystem C storage in mangroves across a broad tract of the Indo-Pacific region, the geographic core of mangrove area (~40% globally) and diversity[4,6]. Study sites comprised wide variation in stand composition and stature (Fig. 1, Supplementary Table S1), spanning 30° of latitude (8° S–22° N), 73° of longitude (90°–163° E), and including eastern Micronesia (Kosrae); western Micronesia (Yap and Palau); Sulawesi, Java, Borneo (Indonesia); and the Sundarbans (Ganges-Brahmaputra Delta, Bangladesh). Along transects running inland from the seaward edge, we combined established biometric techniques with soil coring to assess variations in above- and below-ground C pools as a function of distance from the seaward edge in two major geomorphic settings: estuarine/river-delta and oceanic/fringe. Estuarine mangroves ($n = 10$) were situated on large alluvial deltas, often with a protected lagoon; oceanic mangroves ($n = 15$) were situated in

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- Provide numerous ecosystem services
- Deforestation 30–50% over the past half century due to coastal development
- Resulting carbon emissions of 0.2-1.2 billion tons Carbon per year
- 10% of global emissions due to deforest-ation (0.7% of total tropical forest area)





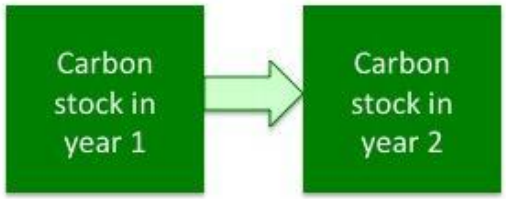
UNFCCC SBSTA Side event

- SBSTA-32 identified the limitation of the IPCC 2006 for GHGs National Inventory
- Invited IPCC to hold an Expert Meeting to "*explore the need to clarify methodological issues related to...wetlands…*
- Synergizing adaptation strategies and measures

➢ Tropical wetlands should be in the agenda

IPCC Guidelines – 2006

Stock-change approach



$$\Delta C = (C_{t2} - C_{t1}) / (t_2 - t_1)$$

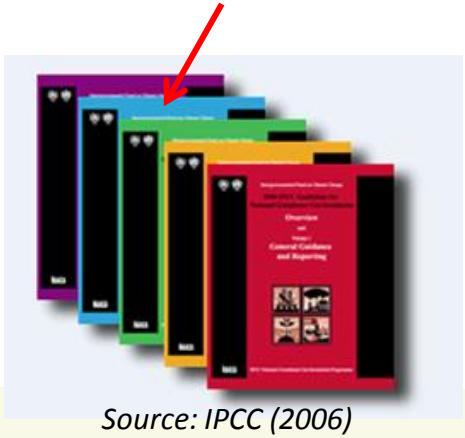
Where:

ΔC = annual carbon stock change in pool (t C/yr)

ΔC_{t1} = carbon stock in pool at time t_1 (t C)

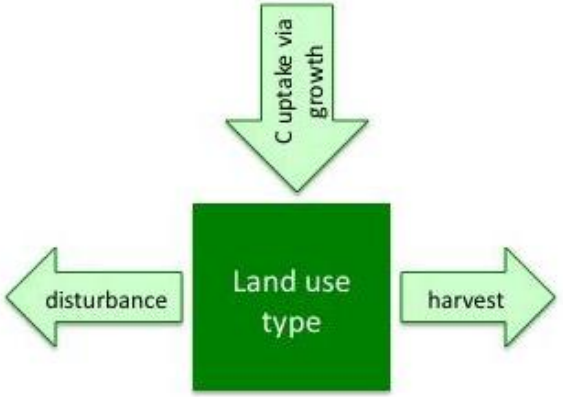
ΔC_{t2} = carbon stock in pool at time t_2 (t C)

Vol. 4 AFOLU



Source: IPCC (2006)

Flux difference approach



$$\Delta C = \Delta C_{gain} - \Delta C_{loss}$$

Where:

ΔC = annual carbon stock change in pool (t C/yr)

ΔC_{gain} = annual gain in carbon (t C/ yr)

ΔC_{loss} = annual loss in carbon (t C/ yr)

IPCC Guidelines – 2006

TABLE 7.1
SECTIONS ADDRESSING MAJOR GREENHOUSE GAS EMISSIONS FROM MANAGED WETLANDS

Land-use category/GHG	Peatlands	Flooded Land
Wetlands Remaining Wetlands		
CO_2	Section 7.2.1.1	No Guidance [1]
CH_4	No Guidance [2]	Appendix 3
N_2O	Section 7.2.1.2	No Guidance [3]
Lands Converted to Wetlands		
CO_2	Section 7.2.2.1	Section 7.3.2.1 and Appendix 2
CH_4	No Guidance [2]	Appendix 3
N_2O	Section 7.2.2.2	No Guidance [3]

m *Flooded land Remaining Flooded land* are covered by carbon stock change estimates of land change (e.g., soils) upstream of the Flooded Land.

from peatlands is negligible after drainage during conversion and peat extraction.

m Flooded Land are included in the estimates of indirect N_2O from agricultural or other run-off.



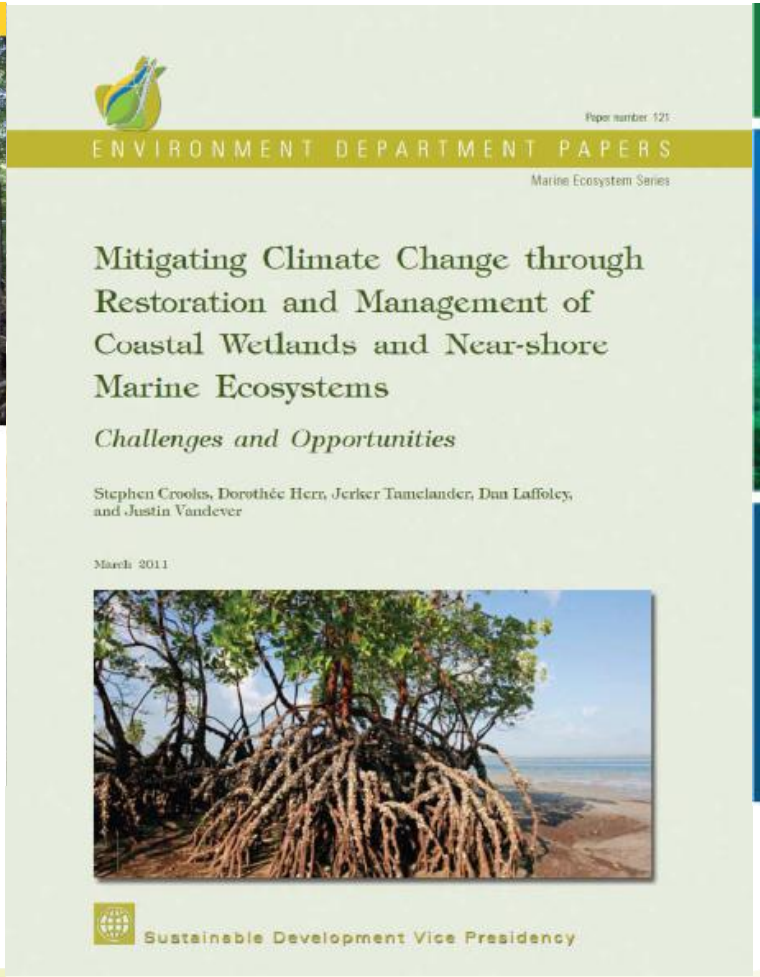
Source: IPCC (2006)

2013 IPCC Supplement: Wetlands

1. Introduction
2. Cross-cutting guidance on organic soils
3. Rewetting and restoration of peatlands
4. Coastal wetlands
5. Other freshwater wetlands
6. Constructed wetlands –wastewater treatment
7. Good practice and implications for reporting

International Blue Carbon WG (CI, IUCN, UNEP, World Bank)

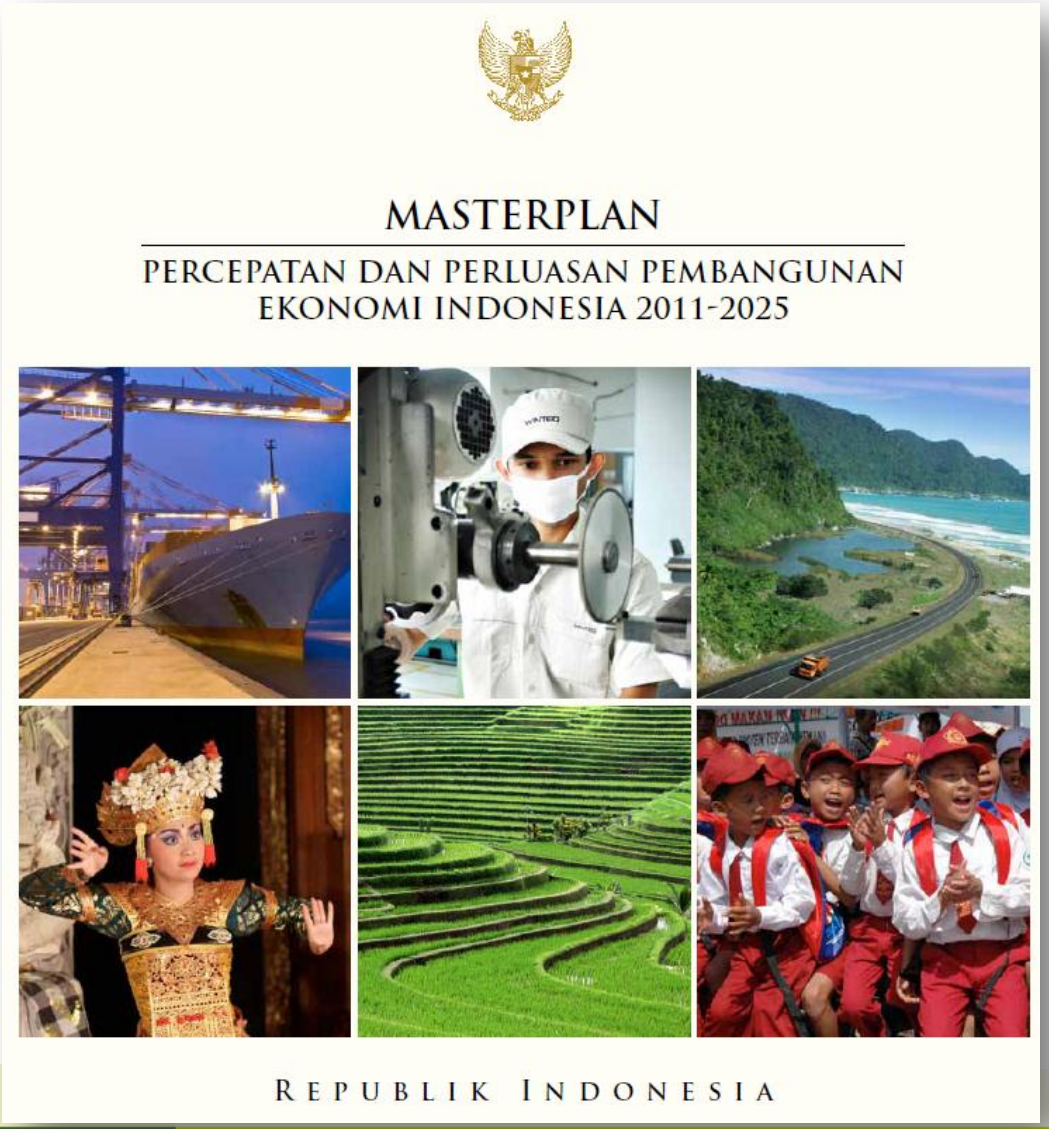






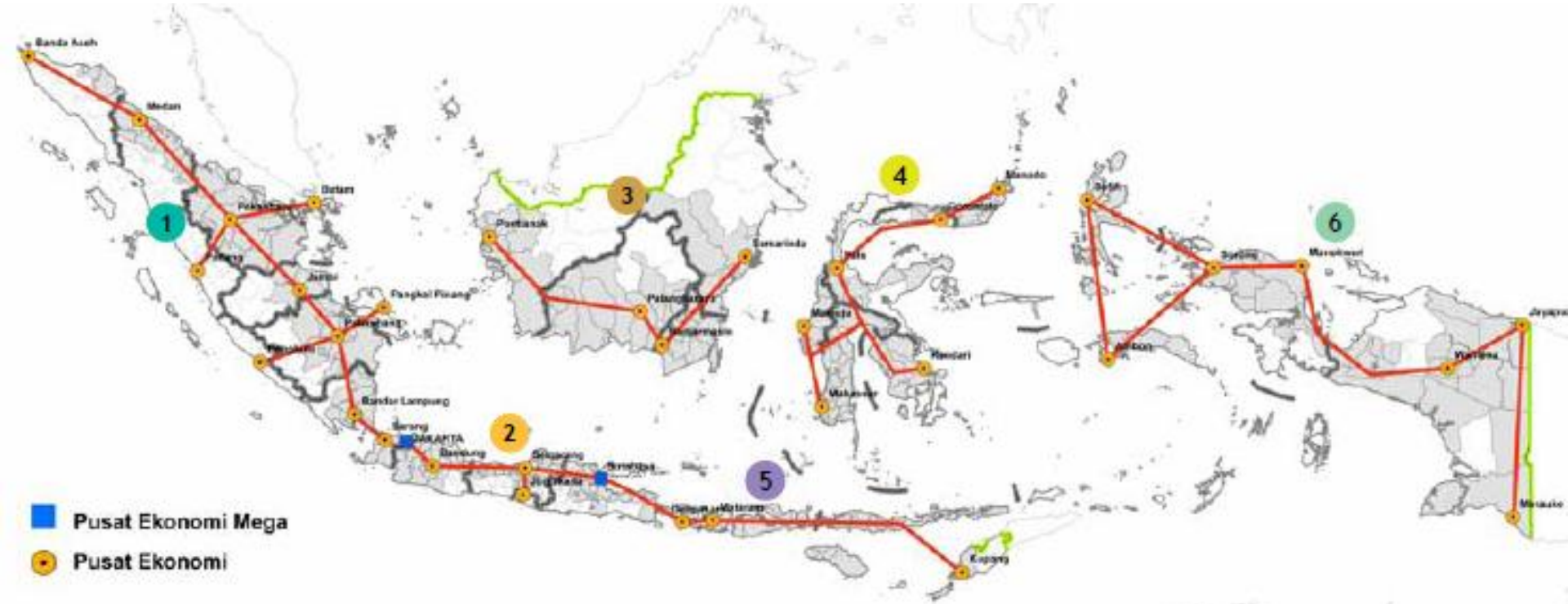
CIFOR

For you to ponder upon



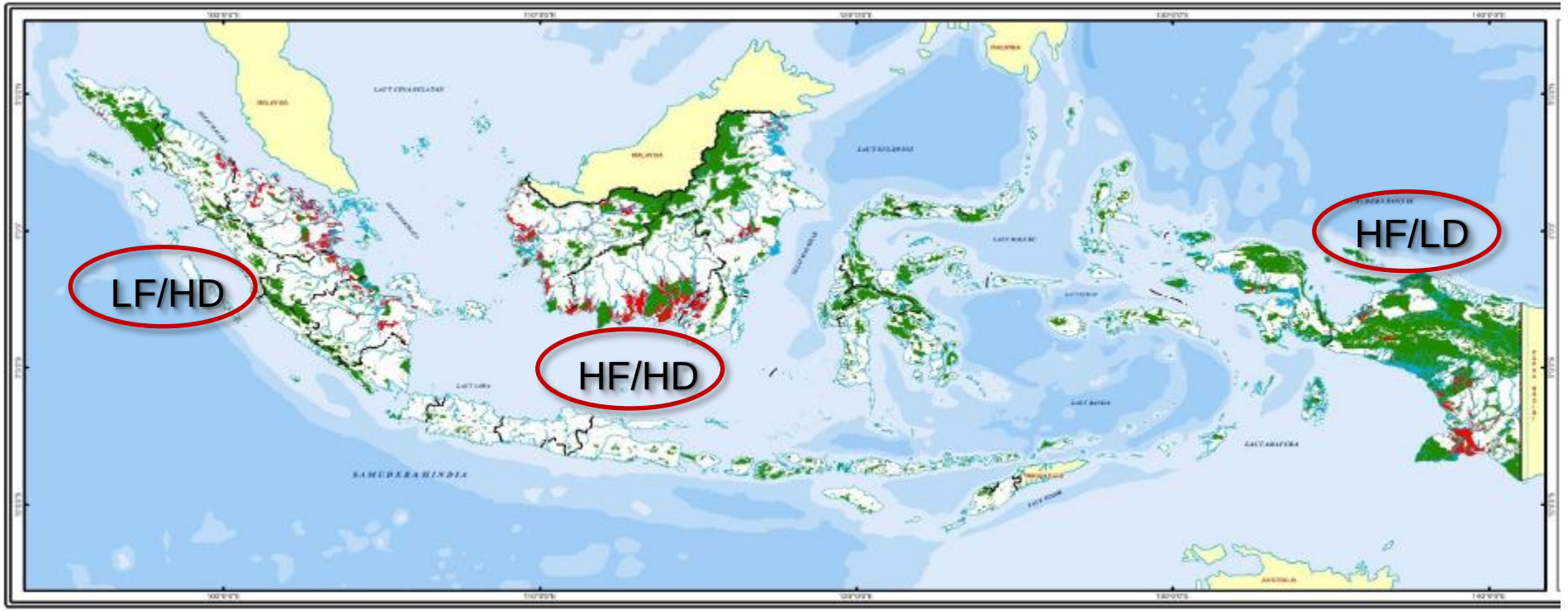
Indonesia is divided into six corridors

Corridor means connectivity (*i.e*. infrastructure)



Forest moratorium: how extensive?

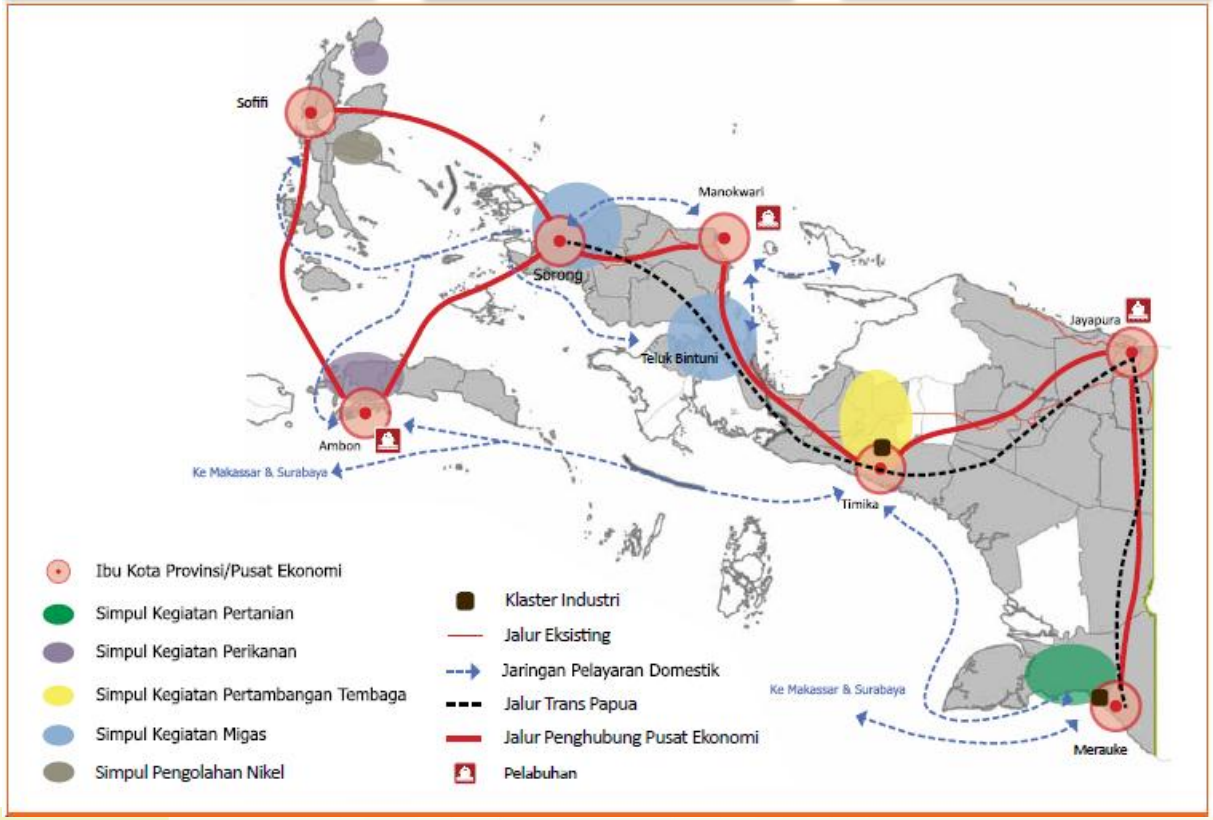
http://appgis.dephut.go.id/appgis/petamoratorium2.html



Type	Area (Ha)		
	PIPIB I	Rev. PIPIB II	Change
Conservation Area	21.528.532	21.637.907	+109.375
Protected Forest	29.700.268	29.581.356	-118.912
Peat Land	10.680.261	5.922.993	-4.757.268
Primary Forest	7.235.012	8.391.073	+1.156.061
Overall Moratorium Area	**69.144.073**	**65.533.328**	**-3.610.744**

Papua Economic Corridor

Theme	Economic Center	Main Economic Activity
• Center for food production, fisheries, energy and mining	• Sofifi, Ambon • Sorong • Manokwari, Timika • Jayapura, Merauke	• Food estate, MIFEE • Oil and gas • Copper, Nickel • Fisheries







Thinking beyond the canopy

Center for International Forestry Research

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