Indonesia’s wetland ecosystems: Challenges & opportunities for CC mitigation

Daniel Murdiyarso
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
Deep to very deep (7.2 Mha = 19 GtC)
Shallow to deep (5.8 Mha = 11 GtC)
Shallow to moderate (8.0 Mha = 3 GtC)

1990
2002

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>400 Mha (528 Pg)</td>
<td></td>
</tr>
<tr>
<td>Tropics</td>
<td>40 Mha (191 Pg)</td>
<td></td>
</tr>
<tr>
<td>SE Asia</td>
<td>35-40 Mha</td>
<td>25-30 Mha</td>
</tr>
<tr>
<td>Indonesia</td>
<td>21 Mha (33 Pg)</td>
<td>17 Mha (?)</td>
</tr>
</tbody>
</table>
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

Protocols for the measurement, monitoring, and reporting of structure, biomass, and carbon stocks in mangrove forests.

- Trees > 5 cm dbh measured in 7m radius ($A = 153.9 \text{ m}^3$)
- Wood debris transects (4 per plot, all plots)
- Trees < 5 cm dbh measured in 2m radius ($A = 12.6 \text{ m}^3$) (all plots)

Marine ecotone

Plot: 1

Addition of an optional 0.5 ha area plot (40 x 125 m) to measure large diameter trees if they are present in mangrove.
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)
Opportunities for reducing greenhouse gas emissions in tropical peatlands

D. Mardiyansari, K. Hergoualc’h, and L. V. Verchot

Center for International Forestry Research, Palembang, Indonesia

Edited by Keith S. Del Tredici, Columbia University, New York, NY, and approved October 12, 2010 (received for review October 22, 2009)

The global peatland area is more than 30% of the Earth’s land area, and its degradation and conversion are significant contributors to greenhouse gas emissions. Peatlands, particularly those in Indonesia and Malaysia, are expected to contribute 70 Tg CO₂ equivalent emissions to the atmosphere by 2030, with most of the emissions occurring due to conversion and degradation. Peatlands store large amounts of carbon, with up to 1000 t CO₂/ha in peat deposits. Peat degradation releases carbon to the atmosphere, contributing to climate change. Peat decomposition is a slow process, with most of the carbon released in the first 25 years after land conversion, with the remainder released over a longer period. The rapid clearing of peatlands for agriculture and other uses, particularly in Indonesia and Malaysia, has led to significant deforestation and forest degradation, with the latter being the most significant source of carbon emissions.

Potential strategies for reducing greenhouse gas emissions from peatlands include sustainable forest management, conservation of intact peatlands, and reforestation of degraded peatlands. Reforestation can sequester carbon and reduce emissions, but it is a slow process, with trees taking several years to establish and grow. Conservation of intact peatlands is another effective strategy, as it prevents carbon release and sequesters carbon in the peat.

For Indonesia and Malaysia, the potential for reducing greenhouse gas emissions from peatland conversion is significant. The conversion of peatlands for agriculture and other uses results in significant carbon losses, with up to 1,500 t CO₂/ha during the first 25 years. The rapid clearing of peatlands for agriculture and other uses, particularly in Indonesia and Malaysia, has led to significant deforestation and forest degradation, with the latter being the most significant source of carbon emissions.

The significance of peatland conversion for greenhouse gas emissions is highlighted by the fact that peatlands store large amounts of carbon, with up to 1000 t CO₂/ha in peat deposits. Peat decomposition is a slow process, with most of the carbon released in the first 25 years after land conversion, with the remainder released over a longer period. The rapid clearing of peatlands for agriculture and other uses, particularly in Indonesia and Malaysia, has led to significant deforestation and forest degradation, with the latter being the most significant source of carbon emissions.

Potential strategies for reducing greenhouse gas emissions from peatlands include sustainable forest management, conservation of intact peatlands, and reforestation of degraded peatlands. Reforestation can sequester carbon and reduce emissions, but it is a slow process, with trees taking several years to establish and grow. Conservation of intact peatlands is another effective strategy, as it prevents carbon release and sequesters carbon in the peat.

For Indonesia and Malaysia, the potential for reducing greenhouse gas emissions from peatland conversion is significant. The conversion of peatlands for agriculture and other uses results in significant carbon losses, with up to 1,500 t CO₂/ha during the first 25 years. The rapid clearing of peatlands for agriculture and other uses, particularly in Indonesia and Malaysia, has led to significant deforestation and forest degradation, with the latter being the most significant source of carbon emissions.

Author contributions: K.H. and L.V.V. designed research; K.H. and K.H.-C. performed research; K.H., K.H.-C., and L.V.V. analyzed data; and K.H. wrote the paper. The authors declare no conflict of interest.

Potential strategies for reducing greenhouse gas emissions from peatlands include sustainable forest management, conservation of intact peatlands, and reforestation of degraded peatlands. Reforestation can sequester carbon and reduce emissions, but it is a slow process, with trees taking several years to establish and grow. Conservation of intact peatlands is another effective strategy, as it prevents carbon release and sequesters carbon in the peat.

For Indonesia and Malaysia, the potential for reducing greenhouse gas emissions from peatland conversion is significant. The conversion of peatlands for agriculture and other uses results in significant carbon losses, with up to 1,500 t CO₂/ha during the first 25 years. The rapid clearing of peatlands for agriculture and other uses, particularly in Indonesia and Malaysia, has led to significant deforestation and forest degradation, with the latter being the most significant source of carbon emissions.

Potential strategies for reducing greenhouse gas emissions from peatlands include sustainable forest management, conservation of intact peatlands, and reforestation of degraded peatlands. Reforestation can sequester carbon and reduce emissions, but it is a slow process, with trees taking several years to establish and grow. Conservation of intact peatlands is another effective strategy, as it prevents carbon release and sequesters carbon in the peat.

For Indonesia and Malaysia, the potential for reducing greenhouse gas emissions from peatland conversion is significant. The conversion of peatlands for agriculture and other uses results in significant carbon losses, with up to 1,500 t CO₂/ha during the first 25 years. The rapid clearing of peatlands for agriculture and other uses, particularly in Indonesia and Malaysia, has led to significant deforestation and forest degradation, with the latter being the most significant source of carbon emissions.

Potential strategies for reducing greenhouse gas emissions from peatlands include sustainable forest management, conservation of intact peatlands, and reforestation of degraded peatlands. Reforestation can sequester carbon and reduce emissions, but it is a slow process, with trees taking several years to establish and grow. Conservation of intact peatlands is another effective strategy, as it prevents carbon release and sequesters carbon in the peat.

For Indonesia and Malaysia, the potential for reducing greenhouse gas emissions from peatland conversion is significant. The conversion of peatlands for agriculture and other uses results in significant carbon losses, with up to 1,500 t CO₂/ha during the first 25 years. The rapid clearing of peatlands for agriculture and other uses, particularly in Indonesia and Malaysia, has led to significant deforestation and forest degradation, with the latter being the most significant source of carbon emissions.

Potential strategies for reducing greenhouse gas emissions from peatlands include sustainable forest management, conservation of intact peatlands, and reforestation of degraded peatlands. Reforestation can sequester carbon and reduce emissions, but it is a slow process, with trees taking several years to establish and grow. Conservation of intact peatlands is another effective strategy, as it prevents carbon release and sequesters carbon in the peat.
Mangroves among the most carbon-rich forests in the tropics

Daniel C. Donato1-6, J. Boone Kauffman2, Daniel Murdiyarso3, Sdyan Kurnianto1, Melanie Stidham4 and Markku Kanneinen2

Mangroves occur along coastlines throughout the tropics, and support numerous ecosystem services, including fisheries production and nutrient cycling. However, the total extent of mangrove forests has declined by 30–50% over the past half century as a result of coastal development, aquaculture expansion, and overharvesting. Carbon emissions resulting from mangrove loss are uncertain, owing in part to a lack of trend data and the amount of carbon stored in these ecosystems, particularly belowground. Here, we quantify 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 5° of latitude and 73° of longitude—from mangrove area and diversity are greatest. 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 soils range from 0.5 to more than 3 m in depth and account 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—enough to offset 10% of emissions from deforestation globally, despite accounting for only 7.7% of tropical forest area.

Deforestation and land-use change currently account for 6–9% of global anthropogenic carbon dioxide (CO2) emissions, second only to fossil fuel combustion. Recent international climate change agreements highlight reduced emissions from Deforestation and Degradation (REDD+) as a key and cost-effective option for mitigating climate change, the strategy 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, 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.

Tropical wetland forests (for example, peatlands) contain organic soils up to several meters deep and are among the largest organic C reservoirs in the terrestrial biosphere. 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 CO2 by 13–44% over global annual fossil fuel emissions. This importance has prompted calls to specifically address tropical peatlands in international climate change mitigation strategies.

<table>
<thead>
<tr>
<th>Key Points:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Provide numerous ecosystem services</strong></td>
</tr>
<tr>
<td><strong>Deforestation 30–50% over the past half century due to coastal development</strong></td>
</tr>
<tr>
<td><strong>Resulting carbon emissions of 0.2–1.2 billion tons Carbon per year</strong></td>
</tr>
<tr>
<td><strong>10% of global emissions due to deforestation (0.7% of total tropical forest area)</strong></td>
</tr>
</tbody>
</table>
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

\[ \Delta C = \frac{(C_{t2} - C_{t1})}{(t_2 - t_1)} \]

Where:
\( \Delta C \) = annual carbon stock change in pool (t C/yr)
\( \Delta C_{t1} \) = carbon stock in pool at time \( t_1 \) (t C)
\( \Delta C_{t2} \) = carbon stock in pool at time \( t_2 \) (t C)

Source: IPCC (2006)

Flux difference approach

\[ \Delta C = \Delta C_{\text{gain}} - \Delta C_{\text{loss}} \]

Where:
\( \Delta C \) = annual carbon stock change in pool (t C/yr)
\( \Delta C_{\text{gain}} \) = annual gain in carbon (t C/yr)
\( \Delta C_{\text{loss}} \) = annual loss in carbon (t C/yr)
### Table 7.1

<table>
<thead>
<tr>
<th>Land-use category/GHG</th>
<th>Peatlands</th>
<th>Flooded Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands Remaining Wetlands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>Section 7.2.1.1</td>
<td>No Guidance (^1)</td>
</tr>
<tr>
<td>CH₄</td>
<td>No Guidance (^2)</td>
<td>Appendix 3</td>
</tr>
<tr>
<td>N₂O</td>
<td>Section 7.2.1.2</td>
<td>No Guidance (^3)</td>
</tr>
<tr>
<td>Lands Converted to Wetlands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>Section 7.2.2.1</td>
<td>Section 7.3.2.1 and Appendix 2</td>
</tr>
<tr>
<td>CH₄</td>
<td>No Guidance (^2)</td>
<td>Appendix 3</td>
</tr>
<tr>
<td>N₂O</td>
<td>Section 7.2.2.2</td>
<td>No Guidance (^3)</td>
</tr>
</tbody>
</table>

\(^1\) In Flooded land Remaining Flooded land are covered by carbon stock change estimates of land change (e.g., soils) upstream of the Flooded Land.

\(^2\) From peatlands is negligible after drainage during conversion and peat extraction.

\(^3\) In Flooded Land are included in the estimates of indirect N₂O 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)

Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems
Challenges and Opportunities

Stephen Crooks, Dorothée Herr, Jerker Tanelianö, Dan Laffoley, and Justin Yandle

March 2011

Sustainable Development Vice Presidency
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

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (Ha)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PIPIB I</td>
<td>Rev. PIPIB II</td>
</tr>
<tr>
<td>Conservation Area</td>
<td>21,528,532</td>
<td>21,637,907</td>
</tr>
<tr>
<td>Protected Forest</td>
<td>29,700,268</td>
<td>29,581,356</td>
</tr>
<tr>
<td>Peat Land</td>
<td>10,680,261</td>
<td>5,922,993</td>
</tr>
<tr>
<td>Primary Forest</td>
<td>7,235,012</td>
<td>8,391,073</td>
</tr>
<tr>
<td>Overall Moratorium Area</td>
<td>69,144,073</td>
<td>65,533,328</td>
</tr>
</tbody>
</table>
# Papua Economic Corridor

<table>
<thead>
<tr>
<th>Theme</th>
<th>Economic Center</th>
<th>Main Economic Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center for food production, fisheries, energy and mining</td>
<td>Sofifi, Ambon</td>
<td>Food estate, MIFEE</td>
</tr>
<tr>
<td></td>
<td>Sorong</td>
<td>Oil and gas</td>
</tr>
<tr>
<td></td>
<td>Manokwari, Timika</td>
<td>Copper, Nickel</td>
</tr>
<tr>
<td></td>
<td>Jayapura, Merauke</td>
<td>Fisheries</td>
</tr>
</tbody>
</table>

- Food estate, MIFEE
- Oil and gas
- Copper, Nickel
- Fisheries
THINKING beyond the canopy

Jayapura
Sorong
Sarmi
Teba
Manokwari
Bintuni
Japen
Is.
Teminabuan
Papua natural landscape
Pioneer and peat swamp forests
Alluvial forests
Sago formations
Lowland forests