Can Land Management Contribute to a Net Carbon Sink and Can it be Monitored Accurately

Dr. Tim Pearson
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Winrock International
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- A mission-driven nonprofit business
- Committed to innovative ideas; Providing technical and project management services to implement on-the-ground projects
- Rockefeller family tradition of international philanthropy
Winrock’s mission is to empower the disadvantaged, increase economic opportunity and sustain natural resources across the globe.
Our Global Reach

Innovative approaches in agriculture, natural resources management, clean energy, and leadership development.
Ecosystem Services Unit

Science-based approach to develop tools, build capacity, methodologies, and technical guidance for broad audiences.

Cutting-edge ecosystem services evaluation from forests, watersheds, and agriculture.

Climate change mitigation activities and sustainable land use management.

- Ecosystem Services Assessment
- Pay for Services and for Performance
- Tool Development
- GHG Support
- Commodity Sustainability
Humans can reduce emissions with clean energy and energy efficiency.

Humans can manage lands to reduce sources and enhance sinks to mitigate emissions.
Carbon Pools

Above Ground
Live Trees

Above Ground Non-tree
Woody

AG non-tree non-woody
vegetation

Dead wood

Litter

Belowground
Live Trees (roots)

Soil or Peat
Carbon
Greenhouse gas emissions by economic sectors

Total: 49 Gt CO₂-eq (2010)

- Electricity and heat production: 25%
- AFOLU: 24%
- Buildings: 6.4%
- Transport: 14%
- Industry: 21%
- Other energy: 9.6%
- Energy: 1.4%
- Industry: 11%
- Transport: 0.3%
- Buildings: 12%
- AFOLU: 0.87%

Direct GHG emissions
Indirect CO₂ emissions
Global anthropogenic CO₂ emissions

Quantitative information of CH₄ and N₂O emission time series from 1850 to 1970 is limited

- Fossil fuels, cement and flaring
- Forestry and other land use

Cumulative CO₂ emissions

- 1750
- 1970
- 2011

(winrock.org)
AFFORESTATION / REFORESTATION
IMPROVING FOREST MANAGEMENT
REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION
AGRICULTURAL LAND MANAGEMENT
HOW MUCH CAN BE STORED

- **Forests:**
  - Annual sequestration: up to 12 t CO\textsubscript{2} per ac per yr
  - Stock after 50 years: 92 – 550 t CO\textsubscript{2} per ac

- **Grasslands:**
  - Annual sequestration: up to 4 t CO\textsubscript{2} per ac per yr
  - Stock after 50 years: 28 – 275 t CO\textsubscript{2} per ac
WHAT DOES THIS MEAN?

- One ton of carbon dioxide =
  - Emissions from a family car every 2½ months
  - Household use of heating/cooking fuel every 4 months (4yrs in Hawaii; 6 wks in Maine)
  - Household use of electricity every 6 wks
  - Refrigerator every 15 months
Offsetting Potential?

- IPCC estimates:
  - > 6% of global emissions can be offset by activities in AFOLU sector at <$20 / t CO₂
  - Almost 15% at <$100 / t CO₂
History of Climate Change Mitigation

- Earth Summit in Rio in 1992 -> UNFCCC
- Kyoto Protocol 1997, entered into force 2005
  - CDM – 7,801 registered projects, 1.9 billion CERs issued
- Voluntary Market?
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  - CDM – 7,801 registered projects, 1.9 billion CERs issued
- Voluntary Market?
- REDD+ - Reduce Emissions from Deforestation and Forest Degradation and Foster Conservation, Sustainable Management of Forests, and Enhancement of Forest Carbon Stocks
- Paris Agreement 2015
  - 195 signatories. < 2 degree raise, seeking < 1.5 degrees
  - Nationally Determined Contributions
Measuring Forests and Agriculture
Traditional Approaches

- Ground measurement
- Estimation of carbon stocks
- Based on long standing forestry expertise
Achieving Precision

- **Accurate but not precise**
- **Precise but not accurate**
- **Accurate and Precise**

**Accuracy and Precision**
- **Accuracy**: agreement between the true value and repeated measured observations or estimations.
- **Precision**: illustrates the level of agreement among repeated measurements of the same quantity.

**Monitoring Cost**
- **($1000$s)**

<table>
<thead>
<tr>
<th>Precision Level</th>
<th>Monitoring Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>Variable: 350</td>
</tr>
<tr>
<td>10%</td>
<td>Fixed: 300</td>
</tr>
<tr>
<td>20%</td>
<td>Variable: 250</td>
</tr>
<tr>
<td>30%</td>
<td>Fixed: 200</td>
</tr>
</tbody>
</table>
Ground Measurement

- **Strengths**
  - Potential high accuracy and precision

- **Weaknesses**
  - High cost
  - Some areas are difficult to impossible to access
Remote Sensing?

- Can solve problems of access and cost
- Essential for determining areas associated with changes in land cover
- But....
- Satellites can’t directly measure stored carbon
- They can:
  - Measure relative greenness
  - Measure heat spots
  - Even measure carbon dioxide flux
Remote Sensing

Spectral Imagery

MODIS  Landsat  ASTER  IKONOS / Quickbird / Rapideye

500 m  60 cm

Multiple acres of deforestation  Roads  Individual Trees
Remote Sensing

- Limitations of spectral imagery
  - Can’t penetrate the canopy
  - Cloud cover

- Alternatives?
  - Radar
  - LiDAR – light detection and ranging (pulsed laser)
LiDAR

Use of LiDAR to assess carbon stocks
Forest Degradation?
Forest Degradation

- Significant

<table>
<thead>
<tr>
<th>Activity</th>
<th>Annual emission (Gt CO$_2$e year$^{-1}$)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degradation</td>
<td>2.06</td>
<td>25</td>
</tr>
<tr>
<td>Timber</td>
<td>1.09</td>
<td>53</td>
</tr>
<tr>
<td>Woodfuel</td>
<td>0.62</td>
<td>30</td>
</tr>
<tr>
<td>Fire</td>
<td>0.35</td>
<td>17</td>
</tr>
<tr>
<td>Deforestation</td>
<td>6.22</td>
<td>75</td>
</tr>
</tbody>
</table>

Fig. 2 Proportion of total forest emissions from forest degradation for the 74 countries included in this study
Fig. 3 Spatial distribution of forest degradation emissions and percent of total forest emissions for: a, b total degradation emission by region within countries, c, d timber extraction emissions (only national level), e, f woodfuel emissions, and g, h fire emissions
Extracted volumes

Tree fall damage
Emissions from infrastructure

Haul roads

Skid trails
LiDAR-based approach

- LiDAR capture over two concessions paired with ground data collection
- Web-based interactive planning tool
- Provides science-based and objective assessment of the impacts of land management decisions
- Used to inform decision-making on land use management, sustainable development and climate change adaptation
- Highly accessible
- No-GIS skills needed
- Underlain with extensive data and spatial land and hydrological modeling

https://www.winrock.org/westool/
### Table 1: Summary of the effects of deforestation on sediment loss

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>Sediment Loss on 2000-2015 (%)</th>
<th>Sediment Loss in 2015</th>
<th>Change in Sediment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantation</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Cropland</td>
<td>12%</td>
<td>9.09</td>
<td>116.32</td>
</tr>
<tr>
<td>Mosaic crolpdl</td>
<td>5%</td>
<td>4.87</td>
<td>7535</td>
</tr>
<tr>
<td>Urban/Built</td>
<td>0%</td>
<td>0.12</td>
<td>2</td>
</tr>
<tr>
<td>Forest</td>
<td>0%</td>
<td>1.22</td>
<td>0%</td>
</tr>
<tr>
<td>Vetland</td>
<td>0%</td>
<td>1.22</td>
<td>0%</td>
</tr>
<tr>
<td>Water</td>
<td>0%</td>
<td>1.22</td>
<td>0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>12%</td>
<td>12.22</td>
<td>13,750</td>
</tr>
</tbody>
</table>

### Table 2: Summary of the effects of deforestation on nitrate loss

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>Deforestation on 2000-2015 (%)</th>
<th>Avg Nitrate Loss in 2015 (kg ha⁻¹ year⁻¹)</th>
<th>Total Nitrate Loss in 2015 (t)</th>
<th>Change in Nitrate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantation</td>
<td>0%</td>
<td>0.747</td>
<td>0.747</td>
<td>0%</td>
</tr>
<tr>
<td>Cropland</td>
<td>12%</td>
<td>0.877</td>
<td>0.955</td>
<td>49%</td>
</tr>
<tr>
<td>Mosaic crolpdl</td>
<td>5%</td>
<td>1.070</td>
<td>0.329</td>
<td>4%</td>
</tr>
<tr>
<td>Urban/Built</td>
<td>0%</td>
<td>0.195</td>
<td>0.195</td>
<td>0%</td>
</tr>
<tr>
<td>Forest</td>
<td>0%</td>
<td>1.50</td>
<td>1.50</td>
<td>0%</td>
</tr>
<tr>
<td>Vetland</td>
<td>0%</td>
<td>-</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td>Water</td>
<td>0%</td>
<td>-</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>12%</td>
<td>0.239</td>
<td>2.65</td>
<td>42%</td>
</tr>
</tbody>
</table>

### Table 3: Summary of the effects of deforestation on ground water recharge

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>Deforestation on 2000-2015 (%)</th>
<th>Avg water recharge in 2015 (m)</th>
<th>Total ground water recharge in ground water recharge</th>
<th>Change in ground water recharge (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantation</td>
<td>0%</td>
<td>0.415</td>
<td>530.33</td>
<td>0%</td>
</tr>
<tr>
<td>Cropland</td>
<td>12%</td>
<td>0.486</td>
<td>80.18</td>
<td>0%</td>
</tr>
<tr>
<td>Mosaic crolpdl</td>
<td>5%</td>
<td>0.234</td>
<td>9,028.49</td>
<td>0%</td>
</tr>
<tr>
<td>Urban/Built</td>
<td>0%</td>
<td>-</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td>Forest</td>
<td>0%</td>
<td>0.934</td>
<td>9,638.98</td>
<td>0%</td>
</tr>
<tr>
<td>Vetland</td>
<td>0%</td>
<td>-</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td>Water</td>
<td>0%</td>
<td>-</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>12%</td>
<td>0.857</td>
<td>9,638.98</td>
<td>-7%</td>
</tr>
</tbody>
</table>
What makes WESTool Unique?

- **Integrates assessment** of both ecosystem services and Climate Change
- **Farm-scale to country analysis** allowing for integrated planning anywhere in Cambodia
- **Online interactive interface**, accessible to all
- **Historical and potential future impacts** on ecosystem services and Climate Change
- **Provides objective, standardized analyses** for use by local, regional, national government, communities, or private companies
Built as GHG calculator for Grow Asia’s projects

Transforms ‘Key Performance Indicator’:
- Time-consuming
- Expensive
- Uncomparable
- Fast
- Free
- Objective
- Comparable

Covers: cocoa, coffee, corn, tea, rice, potatoes, and horticulture
Using the Grow Asia COUNTER

1. Select country and province

2.

3. Currently, I’m growing Cacao

4. What fertilizers do you apply?

140  of  Urea

kg/he/year

Add a synthetic one  or  Add a manure
Using the Grow Asia COUNTER

Review results and compare to adjusted inputs…

**SCENARIO 1**

**Country:** Indonesia

**Region:** Aceh

**Crop:** Cacao

**Area:** 100.0 ha

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**Your current estimated emissions are:**

91.31 t of CO₂ per year

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**Emission Sources**

- **Soil Management**
- **Agroforestry removals**
- **Synthetic fertilizers**
- **Manure**
- **Urea hydrolysis**
- **Liming**
- **Pesticides & herbicides**
- **Fossil fuels**

---

**Find out here how alternative practices could reduce your emissions**

- **Annual Production:** 0.7
  - 1 per ha
- **Synthetic fertilizers:** 140 kg/ha/year
- **Manures:**
  - **Yes**
- **Agroforestry practices?**
- **Lime:** 800.0 kg/ha/year
- **Dolomite:**
- **Pesticides and/or herbicides amount:** 0.8 kg/ha/year
- **Diesel for transportation:** 1000.0 liters
Using the Grow Asia COUNTER

Review results and compare to adjusted inputs...

SCENARIO 2

Indonesia  
Cacao  100.0 ha

Current practices  
91.31  
Potential future  -306.984

- Cut urea application by half (70 kg/ha/year)
- Apply 1000 kg/ha/yr of dry manure

Introducing alternative practices would change your emissions by:

-5.69

t of CO$_2$e per year

Emission Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Current practices</th>
<th>Potential future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agroforestry removals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic fertilizers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure</td>
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<td>Urea hydrolysis</td>
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<td>Liming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pesticides &amp; herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fossil fuels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Find out here how alternative practices could reduce your emissions

Annual Production
0.7 t per ha

Synthetic fertilizers
70 kg/ha/year

Manures
1000 kg/ha/year

Agroforestry practices?
Yes

winrock.org
THANK YOU

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