Building nation forest carbon monitoring capabilities using the GOFC REDD sourcebook

GOFC-GOLD Land Cover Office, FSU Jena, Germany
www.gofc-gold.uni-jena.de
Trajectory of Global Fossil Fuel Emissions

- Actual emissions: CDIAC
- Actual emissions: EIA
- 450ppm stabilisation
- 650ppm stabilisation

- A1FI
- A1B
- A1T
- A2
- B1
- B2

50-year constant growth rates to 2050

- B1 1.1%
- A1B 1.7%
- A2 1.8%
- A1FI 2.4%

Observed 2000-2006 3.3%

Raupach et al. 2007, PNAS; Canadell et al 2007, PNAS
REDD and implementation

- Starting REDD implementation:
  - National carbon accounting capacities
  - National REDD implementation strategy and activities

- Tools for estimating, accounting, reporting on REDD:
  - IPCC Good Practice Guidelines and Guidance
  - Stronger role for satellite remote sensing
  - Dedicated research and case studies

- 2005: Establishment of GOFC-GOLD REDD working group
  - Promote satellite monitoring as objective and efficient approach in developing countries
  - Forest changes can be monitored with confidence for assessing and comparing historical and future rates of deforestation
  - Consensus technical guidance are in development (REDD sourcebook)
Earth observation contribution to UNFCCC-REDD

GOFC-GOLD working group est.
1st GOFC-GOLD workshop
ED/ GOFC SBSTA Side event +
GTOS submission I

1st SBSTA workshop
Subm. of view by parties I

2005

GTOS/ GOFC report

2nd GOFC-GOLD workshop
ESA/ GOFC Side event + booth
GTOS submission II

2nd SBSTA workshop
Subm. of view by parties II

2006

1.+ 2. REDD Sourcebook draft

3rd GOFC-GOLD workshop
ESA/ GOFC-GOLD side event
GTOS submission III

3rd SBSTA workshop
Subm. of view by parties III + IV

2007

GTOS/ GOFC -GOLD side event
PNG / GOFC-GOLD side event

PNG / GOFC-GOLD side event
Informal REDD workshop

2008

GTOS submission III

2009

3rd SBSTA workshop

GOFC-GOLD

COP11 Montreal
SBSTA 24

WINROCK/ GOFC-GOLD side event

COP12 Nairobi
SBSTA 26

3rd SBSTA workshop

COP13 Bali
SBSTA 28

COP14 Poznan
SBSTA 30

Subm. of view by parties II

Subm. of view by parties III + IV

2006 2007 2008 2009
Sourcebook version COP13.2

Version COP13.2 includes:

- Edits from comments received through international review process
- Updated sections, i.e. on fire monitoring, accuracy assessment, national forest inventories …

http://www.gofc-gold.uni-jena.de/redd
Acknowledgement

Sponsors of the Global Terrestrial Observing System:

Sourcebook authors:

Core authors: Frederic Achard, Sandra Brown, Ruth De Fries, Giacomo Grassi, Martin Herold, Danilo Mollicone, Carlos Souza Jr.

Contributing authors: Barbara Braatz, Ivan Csiszar, Diane Davies, Bill de Groot, Sandro Federici, Nancy Harris, Suvi Monni, Devendra Pandey, Tim Pearson, David Shoch, Curtis Woodcock

Support for GOFC-GOLD REDD working group and Sourcebook preparation:
Sourcebook objectives

1. to provide transparent methods that are designed to produce estimates of changes in forest area and carbon stocks from deforestation and degradation
   - in a format that is user-friendly

2. to complement the IPCC GPG-LULUCF (2003) and IPCC Guidelines-AFOLU (2006) by providing additional explanation, clarification and enhanced methodologies for obtaining and analyzing key data

3. to support REDD early actions and readiness mechanisms on national level
Chapter 1 and 2: Introduction and definitions

Chapter 3

Estimation of carbon stocks

Chapter 4

Chapter 5
Estimation of CO₂ emissions

Chapter 6
Guidance on reporting of CO₂ emissions
Implementation remarks

1. Building a national forest carbon monitoring system is a process (that can start now):
   • Assessment of existing national capacities and available data
   • Methods and guidance exist

2. Capacity building as key factor for “readiness phase”:
   • Technical monitoring capabilities
   • IPCC compliant estimation, accounting and reporting

3. Start conservative with motivation to improve monitoring system over time
## Building national capabilities

<table>
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<th>Important components</th>
<th>Practical considerations</th>
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<tr>
<td><strong>FOREST AREA CHANGE</strong></td>
<td>Primary source: Landsat-type satellite data</td>
</tr>
<tr>
<td>Deforestation</td>
<td>Starting point for historical assessment 1990-2005 (3 time steps minimum) Build basic satellite data proc. capabilities</td>
</tr>
<tr>
<td>Monitoring of forest degradation</td>
<td>Relevance and characteristics for human-induced carbon emissions Definition of suitable monitoring system</td>
</tr>
<tr>
<td>Forest fire and burned area</td>
<td></td>
</tr>
<tr>
<td>Accuracy assessment</td>
<td>Using best/translucent methods and efforts for continuous improvement Prepare for statistically robust approach</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>CHANGE in CARBON STOCKS</strong></th>
<th>Primary source: ground/inventory data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing stratifications and forest carbon estimates</td>
<td>Inventory of available data Decide on carbon pool/TIER level to report</td>
</tr>
<tr>
<td>Towards improved carbon stock change estimations</td>
<td>New inventory including other carbon pools Stratification in relevant areas/forest types</td>
</tr>
</tbody>
</table>

**ACCOUNTING & REPORTING** Provide conservative estimates
At 3rd GOFC-GOLD symposium 13.10.08:

- Degradation/regrowth – Achard/DeFries
- Biomass burning – Justice
- Evolving technologies – Held
- Data collection at local/national level – Van Laake/Mayaux
Degradation More Difficult

1. More severe degradation (area/intensity) results in more distinct indicators for efficient monitoring

2. Monitoring degradation requires understanding and emission significance of human processes
   - Define on efficient, long term observation approach given relevant processes

3. Assessment of degraded forest area and the carbon stocks changes per unit area:
   - More reliance on ground data/pilot studies
   - Remote sensing data to assess the area affected
   - Ground measurements required for carbon stock change
   - Current data/knowledge uncertain on area/emission factors
Change in forest areas remaining as forest (degradation)

1. Inventory based approaches, field surveys, and forest statistics (i.e. logging concessions and harvest estimates)

2. Remote sensing to detect degraded area:
   - Direct detection of degradation processes (canopy damage):
     - Landsat-type data with annual observations
     - Very high-resolution datasets (IKONOS type)
     - Hot spot sampling approach maybe effective
   - Indirect approaches:
     - Detecting required infrastructure and its changes (roads, log landings)
     - Concept of intact versus non-intact forests
     - Suitable also for historical periods

3. Operational fire monitoring systems
### Direct approaches to detect forest degradation

<table>
<thead>
<tr>
<th>Highly Detectable</th>
<th>Detection limited &amp; increasing data/effort</th>
<th>Detection very limited</th>
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</thead>
<tbody>
<tr>
<td>• Deforestation</td>
<td>• Selective logging</td>
<td>• Harvesting of most non-timber plants products</td>
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<tr>
<td>• Forest fragmentation</td>
<td>• Forest surface fires</td>
<td>• Old-mechanized selective logging</td>
</tr>
<tr>
<td>• Recent slash-and-burn agriculture</td>
<td>• A range of edge-effects</td>
<td>• Narrow sub-canopy roads (&lt;6-m wide)</td>
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<tr>
<td>• Major canopy fires</td>
<td>• Old-slash-and-burn agriculture</td>
<td>• Understory thinning and clear cutting</td>
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<td>• Major roads</td>
<td>• Small scale mining</td>
<td>• Invasion of exotic species</td>
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<tr>
<td>• Conversion to tree monocultures</td>
<td>• Unpaved secondary roads (6-20-m wide)</td>
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<tr>
<td>• Hydroelectric dams and other forms of flood disturbances</td>
<td>• Selective thinning of canopy trees</td>
<td></td>
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<tr>
<td>• Large-scale mining</td>
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(Using Landsat-type observations)

Peres et al., (2006) TREE
Mapping Burned Forests with Landsat Image (Souza Jr. et al., 2005)
Mapping Burned Forests with Landsat Image (Souza Jr. et al., 2005)
Proposed Table of Content (for COP-14 in Poznan)

1. INTRODUCTION

2. METHODOLOGICAL SECTION

3. PRACTICAL EXAMPLES FOR DATA COLLECTION

4. GUIDANCE ON REPORTING

New sections shown in RED
Proposed Table of Content (for COP-14 in Poznan)

1. INTRODUCTION
   1.1 Purpose and Scope of the Sourcebook
   1.2 Issues and Challenges

2. METHODOLOGICAL SECTION
   2.1 Guidance on Monitoring of Changes in Forest Area
       Monitoring of Deforestation
       Monitoring of Forest Degradation
       Monitoring of Forest regrowth
   2.2 Estimation of Carbon Stocks
   2.3 Methods for estimating $\text{CO}_2$ Emissions from Deforestation & Degrad.
   2.4 Methods for estimating GHG's emissions from biomass burning
   2.5 Estimation of uncertainties
   2.6 Status of evolving technologies
3. PRACTICAL EXAMPLES FOR DATA COLLECTION
   3.1 Overview of annex-I GHG’s national inventories on LULUCF
   3.2 Overview of the existing forest area changes monitoring systems
   3.3 National forest inventories
   3.4 National carbon assessment through carbon budget model
   3.5 Forest inventories at community level
   3.6 Forest carbon assessment at project level

4. GUIDANCE ON REPORTING
Forest fire observations

- Forest fires occur annually in all vegetation zones causing direct release of GHG to atmosphere
- Under UNFCCC reporting provision, countries have to report on GHG’s emissions from biomass burning
  - Observation and assessment in research phase
- Coarse resolution sensors provide near-real time, operational information
- Moderate resolution (30m) sensors provide more detailed information over limited areas
- Satellite fire observation objectives:
  - extent and intensity of ongoing fires
  - area, severity and impact of burns
  - support for fire early warning systems
# Fire observations and their usefulness for national REDD implementation

<table>
<thead>
<tr>
<th>Approach</th>
<th>Information</th>
<th>REDD objective</th>
<th>Suitability</th>
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<tbody>
<tr>
<td>Pre-fire</td>
<td>Early warning system</td>
<td>Protect forest areas at risk and address leakage and permanence</td>
<td>Most suitable for countries with significant amount of wildland fires and known fire regimes</td>
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<tr>
<td>Active fire</td>
<td>Hot spot satellite data</td>
<td>Fire relief and active emissions reduction</td>
<td>Most suitable for countries with large number of small-scale deforestation fires</td>
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<tr>
<td>Post-fire</td>
<td>Burned area estimates</td>
<td>Support estimation of areas of deforestation and degradation</td>
<td>All countries with forest loss due to fire</td>
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</table>
Consideration of evolving technologies

- Sourcebook describe readily available following IPCC good practice guidance for:
  - Derive activity/area change data
  - Data on carbon stocks and carbon stock changes

- New technologies and approaches for monitoring changes in forest area, forest degradation and carbon stocks that:
  - are potentially useful for REDD implementation
  - have not been operationally for national level assessments
  - may provide additional data and certainty
  - may not be available for all developing countries
  - implementation usually requires an additional resources
  - further pilot cases and international coordination needed
  - their utility may be enhanced in coming years depending on data acquisition, access and scientific developments
Current availability of fine-scale satellite data sources and capacities for global land cover change observations

<table>
<thead>
<tr>
<th>Satellite observation system/program</th>
<th>Technical observation challenges solved</th>
<th>Access to information on quality of archived data worldwide</th>
<th>Continuous observation program for global coverage</th>
<th>Pre-processed global image datasets generated &amp; accessible</th>
<th>Image data available in mapping agencies for land change analysis</th>
<th>Capacities to sustainably produce/use map products in developing countries</th>
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<td>LANDSAT TM/ETM</td>
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<td>ASTER</td>
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<td>SPOT HRV (1-5)</td>
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<td>CBERS 1-3</td>
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<td>IRS / Indian program</td>
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<td>ALOS/PALSAR + JERS</td>
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<td>ENVISAT ASAR, ERS 1/2</td>
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<td>TERRARSAR-X</td>
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<td>IKONOS, GEOEye</td>
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<td>ICESAT/GLAS (LIDAR)</td>
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(Note: dark gray=common or fully applicable, light gray=partially applicable/several examples, white=rare or no applications or examples)
Evolving technologies remarks

- New sections on evolving technology to be added to the GOFC-GOLD sourcebook:
  - Evolving technologies and data sources – potential of methods not considered operational today
  - Usefulness for monitoring historical changes versus future capabilities
  - Suitable approaches for communication status, progress, and requirements to achieve progress for data collection procedures and interpretation methods

- Importance of synergy among different data sources

- Evolving approaches for collecting in-situ data
New Sections on evolving technologies

- SAR – Draft Section from Joseph Kellendorfer, Dirk Hoeckman, Ake Rosenqvist
- LIDAR – Draft Section Mike Wulder - (concentrate on airborne technologies at this point, carbon stocks, useful for sampling and site-based verification)
- Fine resolution (purpose, eg for use in validation and accuracy assessment) (Caccetta & ?)
- Hyperspectral (include short section on technology and potential future applications (Asner, Held?)
- Thermal Imagery (forest fire radiative power estimation) (draft by Justice & Chuvieco)
- Data integration tasks - Draft from Mike Wulder
- Recommendation section
- Table on outputs (measurements) vs technology options
Need for accuracy assessment

- Simple area estimation for land category:
  - use as indicated in map
  - common but (often) biased

- Accuracy assessment using a sample of higher quality data as integral part of national monitoring/accounting

- IPCC GPG: uncertainties should be quantified and reduced as far as practicable

- 2 different objectives:
  - Assess accuracy of land/use (change) map
  - Adjust area estimates (if validation shows bias)

- For REDD - accuracy assessment as process
  - using best efforts and continuous improvement while working towards a robust assessment in the future
  - for future commitment periods: robust accuracy assessment in place
Accuracy assessment procedures

Consensus methods exist for assessing the accuracy of remote sensing-derived (single-date) land cover maps:


- Implementation steps for robust approach:
  - **Sample design:** a probability sampling design is the preferred approach for selecting reference locations
  - **Response design:** protocols to determine the reference or ground condition label and comparison to map labels
  - **Analysis design:** includes estimation formulas and analysis procedures for accuracy reporting, i.e. error matrix, accuracies and errors of omission and commission

- Often errors of omission and commission are not equal
- Use accuracy information on bias in the map to adjust area estimates and also to provide the confidence intervals
Practical considerations

- Robust approach may not be achievable or practicable i.e. monitoring historical land changes in developing countries
- Verification should build confidence, improve knowledge of potential errors and is used for continuous improvements
- If no thorough accuracy assessment is possible or practicable, recommendation to:
  - apply the best suitable mapping method in a transparent manner
  - consistency assessment allow some estimation of the quality
  - work backwards from most recent time (more reference data)
- Information without a proper statistical sample can be useful in understanding the basic error structure:
  - Confidence values provided by interpretation or classification
  - Qualitative examinations/comparison with other maps
  - Systematic review and judgments by local and regional experts
  - Comparisons with non-spatial and statistical data
Recent GOFC-GOLD REDD group Activities

1. 20/21. Oct. 08: attended informal REDD method Meeting at UNFCCC Secretariat
   - Focus on monitoring forest degradation
   - http://unfccc.int/methods_science/redd/items/4579.php

2. 17-19. Nov. 08: Capacity development organized by Coalition for Rainforest Nations
   - GOFC-GOLD co-organizer, focus on area change
   - More than 30 countries present

3. 26-28. Nov. 08: Expert consultation on national forest monitoring and assessment at UN FAO
   - New requirements from REDD

4. 3. Dec.08: Sourcebook side event at UNFCCC COP 14 hosted by PNG
Web resources

- **GOFC-GOLD REDD sourcebook:**
  - http://www.gofc-gold.uni-jena.de/redd

- **Global Terrestrial Observing System (GTOS):**
  - http://www.fao.org/gtos/

- **GOFC-GOLD:**

- **GOFC-GOLD land cover project office:**
  - http://www.gofc-gold.uni-jena.de/