

Section Summary

Nophea Sasaki¹

Although deforestation has been the main focus of international debate in REDD+, forest degradation could emit even more carbon emissions because forest degradation can take place in any accessible forest. Accounting for emission factors requires the use of stock-change or gain-loss approach depending on the forests in questions. Ground based field measurements are a critical basis for both approaches. Carbon stocks in logged forests could vary highly depending to some extent on logging intensity and collateral damages.

Obtaining area estimates, or activity data, of degraded forest requires remote sensing but without clear definition of “forest degradation”, it may not be possible using traditional remote sensing. Change detection techniques, along with information on logging planning and operations, become important to derive the activity data. The challenge is that information on degraded forest caused by unplanned logging is difficult to obtain because such logging is not easy to detect at a landscape or regional scale. At local scales, for example in a REDD+ project site, unplanned logging could however be tracked.

Monitoring forest degradation, and related carbon emissions and biodiversity loss, requires understanding of how trees were selectively harvested. Experience in tropical forest management suggests that in many instances, forest degradation is caused by unsustainable felling of commercially valuable timber species for immediate profits. This was found to be true in northeastern Cambodia, which was documented in a case study by Sasaki et al. (this volume).

- Unplanned selective logging for timber is a major driver of forest degradation as commercially valuable timber species are likely to be harvested. For example, in Southeast Asia highly expensive timber from trees such as *Dalbergia cochinchinensis* can be sold by the kilogram. In this case, any individuals with a chainsaw can fell trees and transport their timber for sale, even without a road network. Unplanned logging makes it difficult to monitor the degradation because location of the felled trees is not known.
- With planned selective logging, often all marketable trees (i.e., with diameter greater than 30 cm) are harvested. The harvested area is still forest by current definitions but between 40 and 50% of pre-harvest carbon stocks (Sasaki et al. this volume) could be lost. Resulting net carbon emissions will depend on the intensity of extraction methods, post harvest wood residue, post harvest growth rates, and amount of carbon in harvested wood products.
- Monitoring forest degradation at landscape or regional scale with affordable costs needs tools and resources that can relate forest canopy loss to biomass loss from individual trees or, more likely, a group of tree species according to their plant functional types with remote sensing technology. There is a strong need for improved allometric relationships to relate forest canopy parameters to biomass.

¹United Graduate School of Applied Informatics, Harborland Center Building 22F, 1-3-3 Hiagashikawasaki-cho, Chuo-ku, Kobe, 650-0044, Japan
Corresponding author: nopsasaki@gmail.com

Financing incentives require political commitment from developing countries and all logging companies should have a minimum number of certified foresters to carry out logging planning and operations. With the aid of GPS and GIS technology, a transparent platform for tracking local activities could help monitor forest degradation.

Full accounting for carbon emissions from tropical forest degradation needs an understanding of two important variables, namely the activity data and emission factors relevant to the forests in question. As an example, Winrock International has proposed two methods for estimating net carbon emissions for forest harvesting practices in Guyana.

- Method 1: a standard approach of using medium resolution imagery to monitor the expansion of logging infrastructure into non-logged areas to obtain activity data combined with ground plots and the stock-change method for emission factors. Emission factors are the difference between C of unlogged and logged forests. However, the condition of logged forests is likely to be highly variable depending on forest type, logging intensity, location, growth rate, and the post-harvesting human activities. These conditions will increase uncertainty of pre- and post-harvest carbon stock estimates.
- Method 2: a combination of data sources such as timber extraction rates, management plans, and very high-resolution imagery for activity data combined with ground measurements in active logging gaps/concessions and the gain-loss method for emission factors. Estimating logging gaps in active timber concessions could be done using change detection technique and the loss in live biomass caused all harvesting activities, such as felling, damage to the residual stand, and creation of skid trails, log landings, and roads are then linked to the unit of timber removed (e.g. cubic meters).
- The carbon stock emissions from skid trail creation can be obtained from ground measurements by mapping and measuring the area of a sample of skid rails using GPS and measuring the damaged trees along the trails—such data can be linked to timber extraction rates.

Costs are another concern in forest carbon monitoring. The European Union's project on the Impacts of Reducing Emissions from Deforestation and Forest Degradation and Enhancing Carbon Stocks (I-REDD+) work package 4 focuses on community based monitoring. Community based monitoring offers great potential for lowering costs while providing direct tree measurement. Direct tree measurements on the ground are necessary as part of the ground truthing activities to check the correctness of the remote sensing based activity data. Direct tree measurements are also paramount for developing biomass estimates in either stock-change or gain-loss methodologies.

- I-REDD+'s study sought to evaluate the accuracy and cost effectiveness of monitoring performed by local communities versus professional foresters in four study sites in China, Vietnam, Indonesia and Laos. Community members were trained in establishing sample plots, measuring trees and using simple field protocols.
- A total of 289 sample plots were established between 2011 and 2012 and both local communities and professional foresters were involved in measuring trees in all these plots. Comparison of the carbon stock estimates between the two groups

show that there was no significant difference except in forest types with very high biomass. Although the initial costs of training community members were high, community's involvement in forest monitoring can significantly reduce the costs on salaries, transportation, accommodation and other costs compared to that when professional foresters were hired.

- In addition, the involvement of communities in monitoring can directly be linked to effective benefit sharing from REDD+ and improvement of forest governance. Accordingly, if carbon stocks are measured locally, communities are likely to put more efforts on managing their forested areas for carbon and biodiversity conservation.

Main challenges and opportunities

- Monitoring forest degradation requires the development of a tool that can relate the loss of canopy cover of individual trees or group of individual trees to carbon stocks. By so doing, one can monitor carbon and biodiversity loss at the landscape or regional scale.
- Unmanaged harvesting for fuel wood and charcoal production is very difficult to monitor with precision. Tree stump surveys are one way to detect these activities and estimate associated carbon stock losses.
- In managed areas, it is possible to use a stock-change approach. However, even with proper stratification by year of harvest and extraction rate, intensive sampling may be needed to obtain reasonable precision of carbon emission estimates. Intensive fieldwork is also needed to establish the models for loss-gain approaches. Although once the models are established they can be used cost-effectively.
- Accounting for carbon storage in harvested wood products needs a life cycle assessment of the products in questions. This is necessary because carbon emissions from wood products depend very much on turnover rates and these rates depend on how the products are used.
- Accounting for carbon in post-harvest wood residue will require post-harvest surveys to estimate the 'dead wood' carbon pool, as well as knowledge of decay rates. Otherwise, wood residue could be considered a "committed emission".
- Carbon removals during regrowth after logging (i.e., sequestration) need to be accounted for to estimate net emissions. Removals can be estimated by collecting data in a chronosequence of logging gaps. Accurate information on site history will be needed along with repeated measurements of permanent sample plots.
- Involvement of local people (communities) in forest monitoring activities could achieve significant cost reduction while increasing the sense of responsibility of local people for protecting their forests for carbon and related benefits.