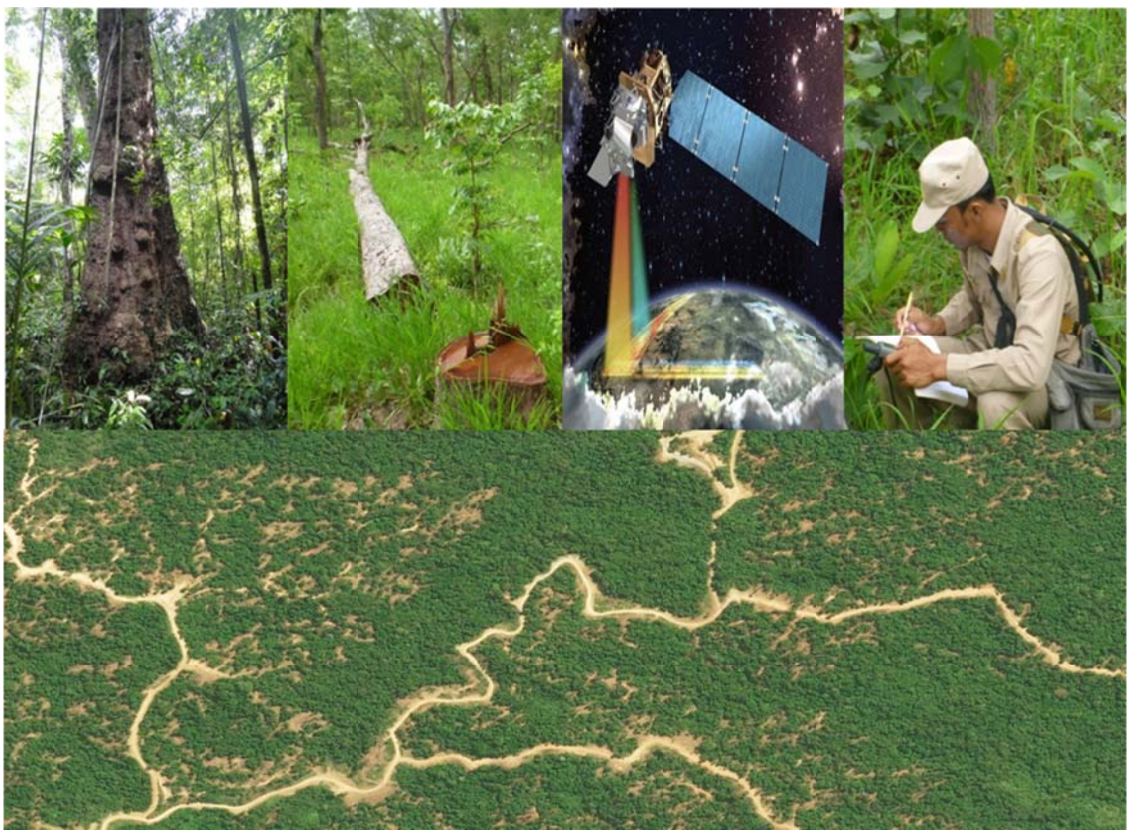
Measuring and Monitoring Forest Degradation in Asia: A Regional Review



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Abstract

A review of USAID-supported climate change mitigation projects in Asia was conducted by the USAID Lowering Emissions in Asia's Forests (USAID LEAF) program and the United States Forest Services (USFS) International Programs, in support of USAID LEAF's efforts to identify regional best practices and to progress towards development of cost-effective project and national systems for detecting, measuring, monitoring and reporting greenhouse gas emissions from forest degradation. The review considered achievements and implementation challenges in eight USAID sustainable landscape projects across nine countries in Asia. Key findings and recommendations are presented for those implementing and supporting efforts to develop and implement systems to measure and monitor forest degradation.

This review is part of a broader collaboration between USAID LEAF and the USFS International Programs to provide guidance and build capacity on measuring and monitoring forest degradation. Other work completed under this collaboration includes:

- Field assessments of sub-national landscapes in Cambodia, Laos and Vietnam, completed in mid-2012.
- Regional experts meeting "International Workshop on Monitoring Forest Degradation in Southeast Asia" held in Bangkok in November 2012.
- Historical degradation assessment in four landscapes, one each in Laos, PNG, Thailand and Vietnam using Google Earth Engine imagery and CLASLite software.
- Regional workshop on "Moving on From Experimental Approaches to Advancing National Systems for Measuring and Monitoring Forest Degradation across Asia" held in Bangkok in June 2015.

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Executive Summary

Globally, it is estimated that approximately 100 million hectares of forest are disturbed annually, which is nearly 10 times greater than the area impacted by deforestation (Herold et al. 2011). Although methods to detect and monitor deforestation are well-established, there has been increasing interest in developing techniques for measuring and monitoring forest disturbance and the resulting changes to carbon stocks. USAID and the governments of nine Asian countries are now exploring cost-effective, national systems for detecting, monitoring, measuring and reporting emissions from forest degradation.

This review completed by the United States Forests Service and the USAID Lowering Emissions in Asia's Forests (USAID LEAF) project aimed to:

1) understand how USAID-supported emissions reduction projects are measuring, monitoring, and mitigating GHG emissions from forest degradation activities;

2) identify common factors for success and challenges to implementation; and

3) recommend actions to support implementation of forest degradation measurement and monitoring systems in the region.

To evaluate the current status of forest degradation monitoring in eight USAID mitigation projects, a framework for analysis was established by developing a standardized questionnaire concerning various aspects of forest degradation monitoring[1] (see Annex). Specific sections included questions on forest degradation definitions, emissions estimates, accounting approaches, monitoring methods, data sources, mitigation activities, and monitoring challenges and successes. Projects were evaluated individually by contacting project chiefs of party and/or senior technical advisers and arranging interviews to discuss the current status of their forest degradation monitoring work, following the framework of the questionnaire. The responses from all of the projects were then summarized and analyzed for commonalities and variations in approaches to the various aspects to the measurement monitoring process.

It must be noted that no USAID project has an indicator specifically focused on either building capacity in measuring and monitoring forest degradation or emission reduction potential from degradation mitigation actions. Therefore this review does not imply either success or failure of a project, but rather uses a standardized framework to reveal best practices from which lessons may emerge to support further development of cost-effective national systems for forest degradation monitoring.

[1] The questionnaire is based on the monitoring framework outlined in. *Technical Guidance Series for the Development of a National or Subnational Forest Monitoring System for REDD+: Forest Degradation Guidance and Decision Support Tool* (Goslee et al. 2015), that was developed by Winrock International and the United States Forest Service for the USAID LEAF program. Available at: http://www.leafasia.org/library/forest-degradation-guidance-and-decision-support-tool

The aggregate area of the landscapes covered by the eight evaluated projects, and located in nine countries, is approximately 24.7 million hectares. Sizes of landscapes ranged from small, individual protected forests up to entire districts or provinces. **Drivers of degradation** were varied. Selective logging of forests (including legal and illegal logging, either for household and commercial use) is the most common driver across the projects reviewed. Other drivers, such as fuelwood collection, shifting agriculture, grazing, and fire, are also common but have a less uniform distribution. In some landscapes, specific local drivers have been identified, such as clearing of understory saplings for farm/garden use, and encroachment into forests by urban or agricultural expansion. **Actors or agents** either directly or indirectly responsible for forest degradation activities include commercial activities (both legal and illegal), governments through land management policies that allow or encourage degradation activities, or through lack of enforcement of existing law designed to protect forests, and local populations which live in close proximity to forest land and are often dependent upon the forest for basic necessities such as fuel for cooking and lumber for house construction.

Of the eight USAID projects evaluated, four (CREL, Forest-PLUS, Hariyo Ban, and B+WISER) are currently implementing a forest degradation monitoring system. A fifth project (USAID LEAF in Lam Dong Province Vietnam) was not evaluated in this report but has recently proposed a forest measuring and monitoring program that encompasses degradation within the Provincial REDD+ Action Plan. Of these programs, CREL, Hariyo Ban, and B+WISER have only just commenced monitoring degradation, and due to insufficient data, no analysis has been completed yet. The Forest-PLUS program reported that it is monitoring only in small demonstration sites located within its project landscapes. While no project is explicitly working on national forest measuring systems, all are supporting capacity and technical developments within their respective landscapes. USAID LEAF's work in Lam Dong has included proposed variations to Vietnam's National Forest Inventory program to strengthen degradation measuring and monitoring mechanisms. SFB, USAID LEAF/USFS (in PNG and Laos landscapes) and VFD are in the early stages of investigating a degradation measuring and monitoring system, while IFACS is not planning to monitor forest degradation for their landscapes.

The **significance of emissions** from forest degradation as a proportion of total forest sector emissions varies by landscape. In all four projects that are implementing monitoring (CREL, Forest-PLUS, Hariyo Ban, and B+WISER), the proportion of emissions from forest degradation is currently unknown. In all landscapes, lack of reliable data at an appropriate scale prevents the estimation of emissions from degradation by activity beyond first-order estimates. New approaches to rapidly provide first order estimates of forest degradation have been explored by USAD LEAF/USFS. Google Earth Engine Landsat images were combined to produce cloud free images, which were analyzed with the CLASLite software program to detect disturbances in the forest canopy. Early outcomes from this work suggest useful preliminary results can be obtained. While relatively rapid processes now exist, care must be exercised when interpreting the results.

Forest-PLUS, Hariyo Ban, and B+WISER reported that they are pursuing a land-based **accounting approach** through measuring all forest canopy cover change from deforestation, degradation, and enhancements in a given area, irrespective of the source of the change. One project (CREL) uses an activity-based monitoring approach which monitors changes in forest carbon stocks from understory tree removal for non-timber uses. However, only live biomass removals (i.e. tree stumps) are measured; the removal of dead wood (presumably for fuel) is excluded from the monitoring because it is so intensively collected that it is not possible to accurately measure the cumulative biomass removed over time.

Of the three projects that are currently investigating monitoring systems, USAID LEAF landscapes in Houaphanh, Laos and Madang, PNG are exploring a land-based approach to provide a first-order estimate of forest degradation rates. VFD is implementing a study to compare the two accounting approaches but is also now considering land-based accounting.

Analysis of forest canopy change through **remotely sensed imagery** is often a critical component of cost-efficient detection and mapping of degradation. It is clear from the experience of the various projects that no single imagery will meet the needs for monitoring all types of forest degradation in all landscapes. Spatial and temporal image availability, cost, technical capacity, and monitoring objectives must be considered when making decisions on the appropriate imagery source or sources to use.

All four projects that are currently implementing monitoring are collecting **ground-based inventory** data. The purpose of collecting the data includes validating the results of remotely sensed forest canopy cover change and measuring changes in forest biomass to estimate changes in carbon stocks due to degradation activities. The sample design, data collection protocols, and relationship to the respective national forest inventories vary widely.

Several factors can **constrain accurate and cost-effective monitoring** of forest degradation in the region. Common challenges faced by some or all of the projects include:

- Lack of a clear, measurable definition for forest degradation.
- Uncertainty regarding which accounting approach to use (land-based or activity-based).
- Lack of sufficient cloud/haze-free imagery for change detection.
- Some degradation activities may not be detectable by remote sensing.
- Ground inventory data collection can be expensive and time-consuming.
- Complex land ownerships can inhibit collection of ground inventory data.
- Available data may be insufficient to calculate emissions factors.
- Insufficient funding or trained staff inhibits the expansion of monitoring demonstration sites to larger landscapes.

- Monitoring deforestation may be a higher national priority than monitoring forest degradation.
- Lack of national direction reduces incentive for sub-national jurisdictions or projects to monitor degradation.

The following **recommendations** were developed based on this assessment of the USAID-supported projects in the Asia region. However, they could also apply to other projects or in the development of national systems for measuring and monitoring forest degradation:

- Clearly define forest degradation in a way that is measurable and is consistent with REDD+ guidelines and project objectives.
- Clearly describe accounting approaches and emissions factor development methods that are consistent with the project's institutional resources and technical capacity.
- Replicate and scale-up successful measurement and monitoring methods in the region.
- Utilize available tools (USAID LEAF's Forest Degradation Guidance and Decision Support Tool, the World Bank Forest Carbon Partnership Facility's REDD+ Decision Support Toolbox, and the Global Forest Observation Initiative (GFOI) forest carbon assessments methods and guidelines) to assist decision-making.
- Establish a regional forest degradation working group to facilitate knowledge sharing and collaboration.
- Develop a framework for comparing emissions and drivers across borders in the region.

While achievements to date have been limited, this analysis reveals important 'lessons learned' which can inform and contribute to the development of national systems, in which resources are allocated commensurate with the significance and scale of GHG emissions associated with forest degradation.

Acronyms

B+WISER	Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience
CF	Community Forestry
CLiPAD	Climate Protection through Avoided Deforestation project
CMO	Co-management Organizations
CREL	Climate-Resilient Ecosystems and Livelihoods
FAO	Food and Agricultural Organization of the United Nations
Forest-PLUS	Partnership for Land-Use Science
FSI	Forest Survey of India
FCPF	Forest Carbon Partnership Facility
FRA	Forest Resource Assessment
GFOI	Global Forest Observation Initiative
GHG	Greenhouse Gas
IFACS	Indonesia Forest and Climate Support
LAWIN	Law Enforcement and Wildlife Indicators Tool
LEAF	USAID Lowering Emissions in Asia's Forest project
NFI	National Forest Inventory
REDD+	Reduced Emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
R-PP	Readiness Preparation Proposal
SFB	Supporting Forests and Biodiversity
SMART	Spatial Monitoring and Reporting Tool
USAID RDMA	United States Agency for International Development Regional Development Mission for Asia
USFS	United States Forest Service
VFD	Vietnam Forests and Deltas

Contents

Introduction

Deforestation and forest degradation are major global sources of greenhouse gas emissions that contribute to accelerated climate change. In recent years, various estimates have been calculated for emissions from degraded forests. The International Tropical Timber Organization has estimated that as many as 850 million hectares of tropical forests could be in a degraded condition (ITTO 2002). Herold et al. (2011) proposed that human-caused disturbances result in annual degradation of approximately 100 million hectares of forests globally, which is nearly 10 times greater than the area impacted by deforestation. The Intergovernmental Panel on Climate Change (IPCC 2003) noted that in the tropics, changes in land cover categories that constitute degraded forest declined from 35 million hectares between 1980 and 1990 to 23.8 million hectares in the period of 1990 to 2000. A recent study by the Food and Agriculture Organization of the United Nations (FAO 2015) concluded that global emissions from forest degradation has more than doubled in the last decade, from an average annual emission of 0.4 Gt CO^2 per year in the period 1991–2000 to an average annual emission of 1.0 Gt CO^2 between 2011 and 2015. This also represented one-quarter of all net emissions from forests during that time period.

Although methods to detect and monitor deforestation are well-established, there has been increasing interest in developing techniques for monitoring changes to carbon stocks in disturbed forests. Deforestation is also often preceded by forest degradation (Asner 2002, DeFries 2007). Conversely, policies to reduce deforestation through forest protection actions may lead to increased degradation in nearby unprotected forests.

Forest degradation has proven to be more difficult to detect and measure with the tools commonly used to monitor deforestation. The lack of a broadly accepted definition of forest degradation, the diversity of forest types, and the varying economic and cultural uses of forests in the region further complicate the development of forest degradation monitoring systems. Many recent assessments for developing REDD+ capacity in the Asia-Pacific region have noted the need for addressing issues regarding monitoring of forest degradation (Romijin et al. 2012, RECOFTC 2012, UNREDD 2012).

The United States Agency for International Development Regional Development Mission for Asia (USAID RDMA) project ‘Lowering Emissions in Asia’s Forests’ (USAID LEAF) aims to strengthen capacities of developing countries in the Asia region to produce meaningful and sustainable reductions in greenhouse gas (GHG) emissions from the forestry-land use sector. A key component of this work has been the collaborative partnership with the United States Forest Service (USFS) to provide technical assistance on measuring and monitoring forest degradation. Under this partnership, an assessment of options for monitoring forest degradation impacts at the sub-national level in targeted USAID LEAF landscapes was completed in Cambodia, Laos, and Vietnam (Halperin and Turner 2013, Halperin and Mortenson 2013, Manley et al. 2013) with an expert's meeting held in 2012 to discuss lessons learned from the sub-national assessments and operational aspects of other forest degradation monitoring approaches.

A further collaborative work program between USAID LEAF and the USFS Remote Sensing Application Centre commenced in mid-2015. This work aims to rapidly assess historical degradation rates (2000-2013) in four landscapes using medium resolution Landsat satellite imagery. Preliminary results from Houaphan Province, Laos and Madang Province, PNG are presented in this report, but no analysis from Lam Dong Province, Vietnam or the Maesa Kogma Man and the Biosphere Reserve, Thailand had been completed at the time of this review.

Other significant work on degradation completed under the USAID LEAF program includes:

- Development of the 'Forest Degradation Guidance and Decision Support Tool' (Goslee et al. 2015).
- An activity-based approach to measuring emissions from forest logging in peninsular Malaysia.
- A landscape-level approach to quantify historical forest degradation rates using national forest inventory data in Lam Dong Province, Vietnam (in partnership with the Lam Dong Department of Agriculture and Rural Development).

USAID also supports a number of other significant efforts to measure and monitor degradation in climate change mitigation projects across Asia (see figure 1). The objectives of this review are to:

1) understand how USAID-supported emissions reduction projects are measuring, monitoring, and mitigating GHG emissions from forest degradation activities;
2) identify common factors for success and challenges to implementation; and
3) recommend actions to support implementation of forest degradation measurement and monitoring systems in the region.

The eight USAID-supported projects evaluated in this report cover landscapes in nine countries across Asia (Figure 1):

- Bangladesh: Climate-Resilient Ecosystems and Livelihoods (CREL)
- Cambodia: Supporting Forests and Biodiversity (SFB)
- India: Partnership for Land-Use Science (Forest-PLUS)
- Indonesia: Indonesia Forest and Climate Support (IFACS)
- Laos: USAID LEAF/USFS
- Nepal: Hariyo Ban

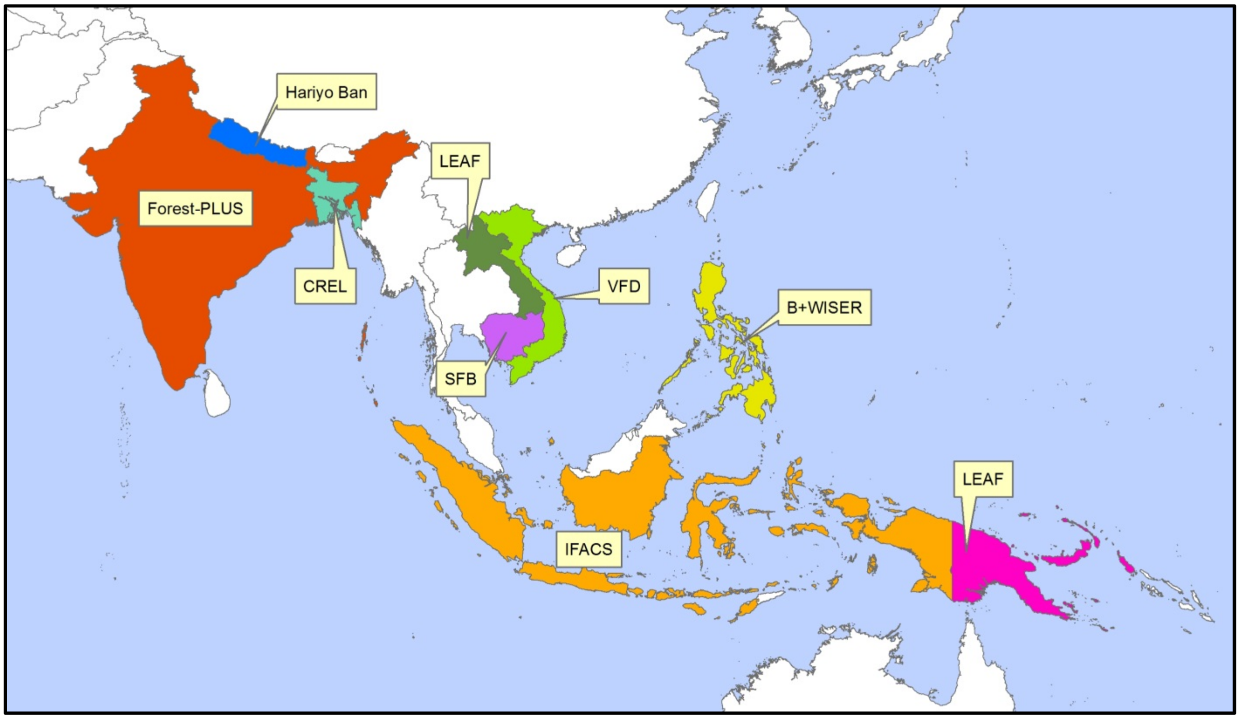

Figure 1. Map of countries with USAID-supported projects evaluated in the review of forest degradation measurement and monitoring in the Asia region.

- Philippines: Biodiversity and Watersheds Improved for Stronger Economy and Ecosystem Resilience (B+WISER)
- Papua New Guinea (PNG): USAID LEAF/USFS
- Vietnam: Vietnam Forests and Deltas (VFD), and USAID LEAF in Lam Dong Province (in collaboration with Lam Dong Department of Agriculture and Rural Development)

Landscape Overview

Location and Extent

The aggregate area of the landscapes covered by the eight evaluated projects is approximately 24.7 million hectares (Table 1). The landscapes range in size from small, individual protected forests up to entire districts or provinces.

Degradation Drivers/Activities

It is important to identify the drivers (i.e. human activities) that are the main causes of forest degradation on a landscape, not only to inform the selection of the most appropriate monitoring method, but also to help target mitigation actions that will be most likely to reduce

Table 1. Location and land area of focus landscapes for USAID-supported projects in the Asia-Pacific region evaluated for status of forest degradation measuring and monitoring on their landscapes.

Country	Project	Focus landscapes	Area (million ha)
Bangladesh	CREL	Twenty-two forested landscapes (protected areas) across the country.	0.68
Cambodia	SFB	Eastern Plains and Prey Long Forest	1.00
India	Forest-PLUS	Shimoga (Shimoga District, Karnataka State); Hoshangabad (Madhya Pradesh State); Rampur (Himachal Pradesh State); Sikkim (Sikkim state)	4.00
Indonesia	IFACS	Eight landscapes on three islands in the Indonesian archipelago: Aceh Selatan and Aceh Tenggara (Sumatra), Ketapang and Katingan (Kalimantan), and Sarmi, Mamberamo, Mimika and Asmat (Papua)	11 .00
Laos	LEAF/USFS	Houaphanh Province	1.74
Nepal	Hariyo Ban	Terai Arc (southern lower plains), Chitwan Annapurna (middle of southern foothills)	1.32
Philippines	B+WISER	7 sites across the Philippines: Mindoro Island, Negros Island, Luzon Island (3 sites), Mindanao Island (2 sites)	0.78
Papua New Guinea	LEAF/USFS	Madang Province	2.91
Vietnam	VFD	Thanh Hoa and Nghe An Provinces	1.25

the impact of these activities. The suite of degradation activities that are the main drivers of degradation, as well as the identity of their actors/agents, can vary by landscape (Table 2). Selective logging of forests (including legal and illegal logging, and for household and commercial use) is the most common driver across the projects reviewed. Other drivers, such as fuelwood collection, shifting agriculture, grazing, and fire, are also common but have a less uniform distribution. In some landscapes, specific local drivers have been identified, such as clearing of understory saplings for farm/garden use, and encroachment into forests by urban or agricultural expansion.

Actors or agents may be either directly or indirectly responsible for forest degradation activities. Commercial businesses are often the driving force behind extractive activities in forests, as they seek and collect forest resources for sale either locally or for export to other areas. Commercial activities range from small, village-based charcoal production to corporations selectively harvesting timber from large areas of forest. Commercial forest degradation activities may be either legal or illegal. Governments may also engage in

Table 2. Major drivers (human activities) causing forest degradation in the landscapes of the evaluated USAID-supported projects in the Asia region.

Project	Forest Degradation Driver					
	Selective Logging	Fuelwood	Shifting Cultivation	Grazing	Fire	Other
CREL		Household, Commercial		Household		Understory non-timber products (Household)
SFB	Household, Commercial, Government	Household Commercial				
Forest-PLUS	Government	Household		Household	Household	
IFACS	Commercial		Household			Agricultural expansion (Commercial, Government)
USAID LEAF (Houaphan)	Household, Government		Household		Household	
Hariyo Ban	Household, Commercial	Household		Household	Household	Urban encroachment (Household, Commercial, Government)
B+WISER	Household, Commercial	Commercial	Household			
USAID LEAF (Madang)	Household, Government		Household			
VFD	Household, Commercial					

commercial operations, but are more likely to be an agent of forest degradation through land management policies that allow or encourage degradation activities, or through lack of enforcement of existing laws designed to protect forests.Local populations are often identified as critical stakeholders in the degradation process. These households usually live in close proximity to forest lands and are dependent upon the forest for basic necessities such as fuel for cooking and lumber for house construction.

Assessment Methods

To evaluate the current status of forest degradation monitoring in the eight USAID mitigation projects, a framework for analysis was established by developing a standardized questionnaire concerning various aspects of forest degradation monitoring (see Annex). Specific sections included questions on forest degradation definitions, emissions estimates, accounting approaches, monitoring methods, data sources, mitigation activities, and monitoring challenges and successes. The sections were largely based on the framework outlined in the recently developed Forest Degradation Guidance and Decision Support Tool (Goslee et al. 2015).

Projects were evaluated individually by contacting project chiefs of party and/or senior technical advisers and arranging an interview to discuss the current status of their forest degradation monitoring work, following the framework of the questionnaire. The responses from all of the projects were then summarized and analyzed for commonalities and variations in approaches to the various aspects to the measurement monitoring process.

It must be noted that no USAID project has an indicator specifically focused on either building capacity in measuring and monitoring forest degradation or emission reduction potential from degradation mitigation actions. Therefore this review does not imply success or failure, but simply uses the standardized framework to reveal common challenges, achievements and best practices from which lessons may emerge to support further development of cost-effective national systems.

Current Status of Degradation Monitoring

Of the eight USAID projects evaluated, four (CREL, Forest-PLUS, Hariyo Ban, and B+WISER) are currently implementing a forest degradation monitoring system. A fifth project (USAID LEAF in Lam Dong Province Vietnam) was not evaluated in this report but has recently proposed a forest measuring and monitoring program that encompasses degradation within the Provincial REDD+ Action Plan. Of these programs, CREL, Hariyo Ban, and B+WISER reported a partial implementation of degradation monitoring, due to their monitoring having been only recently initiated, and due to the insufficient amount of data collected to date for analysis. The Forest-PLUS program reported that it is monitoring only in small demonstration sites located within its project landscapes. Therefore, only a small fraction of the landscape included within its program responsibility is actually being monitored for forest degradation. While no project is explicitly working on national forest measuring systems, all are supporting capacity and technical developments within their respective landscapes. USAID LEAF's work in Lam Dong has included proposed variations to the National Forest Inventory program to strengthen degradation measuring and monitoring mechanisms.

SFB, USAID LEAF/USFS (in PNG and Laos landscapes) and VFD are also in the early stages of exploring a degradation measuring and monitoring system. IFACS in Indonesia is not planning to monitor forest degradation in its landscapes. Some common reasons given by projects for not monitoring forest degradation include:

- Insufficient financial and/or technical capacity to monitor large landscapes at frequent intervals.

- Relatively short project timelines.
- Degradation is not a significant source of emissions in some landscapes.
- Emissions factors at appropriate scales are not available.
- Difficulty in tracking emissions from spatially overlapping degradation activities.

Technical and capacity challenges may inhibit the implementation of a degradation monitoring system in some areas. For example, persistent and widespread cloud cover can prevent the use of remote sensing to detect forest degradation. Cloud cover has been a major issue in analyzing satellite imagery to monitor canopy cover change in Madang province, PNG. In addition, the difficult terrain and complex land ownerships in Madang inhibit sufficient ground inventory data collection. In India, multiple degradation activities often overlap in a given area, which makes it difficult to spatially track emissions by activity. In Laos, neither the project nor their government partners have adequate human resources and technical capacity to fully implement degradation monitoring in a large and diverse landscape such as Houaphanh province.

The relatively short life-span of funded projects can also influence the status and priority of forest degradation monitoring. For example, SFB in Cambodia reported that the relatively short duration of the project (five years) does not provide enough time to design and implement a forest degradation monitoring program, so the project focuses instead on implementing mitigation activities that are achievable during the life of the project, such as improving livelihoods in order to reduce degradation threats to forests. All of the projects in this review receive "Sustainable Landscapes" funding, which requires them to implement activities which either reduce land-based emissions or create conditions that will lead to emission reductions. Therefore, implementation of mitigation actions may take precedence over monitoring changes in emissions over time, or monitoring efforts may focus on emissions from deforestation as they are easier to detect and measure.

In some landscapes, the emissions from forest degradation may constitute a small proportion of total forest-sector emissions. In the IFACS focus areas in Indonesia, the proportion of emissions from degradation is relatively low compared to that from deforestation. Therefore, the project has determined that it would not be cost-effective to develop a monitoring system for landscapes in which emissions from forest degradation are small compared to emissions from deforestation. Another important reason why some projects are not monitoring degradation is that a baseline estimate of carbon stocks at an appropriate scale against which to measure change due to degradation activities is currently not available.

Some of the evaluated projects are currently considering implementing a measuring and monitoring system for forest degradation in the near future. In Cambodia, increasing pressure on the forests of Prey Long and a shift in funds to that landscape may allow the SFB project to begin emphasizing forest degradation monitoring. Winrock International is currently investigating methodologies for measuring and monitoring degradation for the VFD program. Also, the VFD program is attempting to convene a group to discuss monitoring in Vietnam and enhance the capacity of forest rangers to collect ground-based data. USAID LEAF and the USFS are currently investigating and testing a system for measuring forest canopy cover changes based on analysis of historical Landsat imagery in Houaphanh, Laos and Madang, PNG (in addition to Maesa Kogma Man and the Biosphere Reserve, Thailand, and Lam Dong Province, Vietnam). Monitoring Objectives

Forest degradation monitoring plans are generally not stand-alone documents but are rather included as part of an overall project implementation plan. The four projects currently implementing monitoring in their landscapes have developed the following objectives for forest degradation monitoring:

- CREL: Monitor change in the biophysical condition of the forest due to forest products being extracted.
- Forest-PLUS: Estimate changes in forest carbon stocks by forest type, due to deforestation, forest degradation, and/or enhancements.
- Hariyo Ban: Detect forest degradation through changes in the canopy cover class from the baseline.
- B+WISER: Detect conversion from ‘closed’ forest to ‘open’ forest as an indicator of degradation.

CREL reported that change detection using forest inventory plots had provided some useful results, and if continued, the degradation monitoring objectives would be met. Forest-PLUS reported that they were able to meet their monitoring objectives for degradation using fractional downscaling of Forest Survey of India (FSI) estimates of forest carbon stocks. Forest-PLUS uses FSI’s estimate of total forest carbon within forest type, but downscales the spatial distribution to pixel-level resolution. In Nepal, a forest cover base line map was developed in 2011, which identified different forest canopy cover classes. But canopy cover change measurements will not be reported until 2016, making it difficult for Hariyo Ban to assess progress. B+WISER used national forest cover data from 2003 and 2010 to detect conversion from ‘closed’ forest to ‘open’ forest, but felt that their monitoring objectives were not met. This is mainly because the broad definition of forest degradation creates difficulty in accurately measuring changes in forest carbon stocks using land-based measurements, and there was no analysis of further change in open forests in 2003 that remained open in 2010. Also, community patrols record degradation activities but do not collect measurement data (e.g. area, canopy change, etc.). Therefore, neither source of data is sufficient for B+WISER to accurately quantify emissions from degradation.

Definitions

Before emissions from forest degradation can be successfully measured and monitored, the meaning of the term 'forest' must be defined, and the characteristics of a degraded forest must be described. Definitions for 'forest' used by most projects are generally similar to the Food and Agriculture Organization of the United Nations (FAO) standard forest definition (10 percent tree cover, 5 meter average tree height, 0.5 hectare area) (FAO 2000, 2015). Most USAID projects are using national definitions, but some project-specific definitions were also developed (Table 3).

Definitions of 'forest degradation' are generally project-specific, as national definitions have not been developed in most countries. Four projects (including three that are currently monitoring forest degradation) have developed working definitions of forest degradation (Table 4). In addition, IFACS has defined forest degradation, although the project is not specifically measuring and monitoring it.

Table 3. Definitions of forest land used by USAID-supported projects in the Asia region.

Project	Min. tree cover (%)	Min. tree height (m)	Min. forest area (ha)	Reference	Comments
CREL	10	5	0.5	National REDD+ Readiness Preparation Proposal (R-PP)	
SFB	10	5	0.5	National R-PP (2011)	Some discussion in R-PP about increasing minimum cover to 20%.
Forest-PLUS	10	N/A	1.0	FSI India State of Forest Report (2011)	The Forest Rights Act of 2006 defines forest land as any area ever recorded as forest in government records.
IFACS	N/A	N/A	N/A	N/A	IFACS identifies forests using criteria for High Conservation Value (Brown et al. 2013), also carbon stock criteria.
LEAF/Laos	20	5	0.5	National definition	Palm and bamboo are defined as non-forest.
Hariyo Ban	10	5	0.5	FAO (2000)	The government can declare any land to be forest, regardless of current tree cover.
B+WISER	10	5	0.5	FAO (2000)	
LEAF/PNG	10	3	1.0	National definition	
VFD	10	5	0.5	National definition	Palm and bamboo are defined as forest.

Table 4. Definitions of forest degradation used by USAID-supported projects in the Asia region.

Project	Forest Degradation Definition
CREL	A forested area with any evidence of human impact, including stumps.
SFB	None.
Forest-PLUS	None.
IFACS	Primary forest that has changed to secondary forest as evidenced by human disturbance e.g. logging, fire, regrowth.
LEAF (Laos)	Persistent change in forest canopy cover over a five year period.
Hariyo Ban	Change in tree canopy cover from a higher canopy cover class to a lower canopy class.
B+WISER	Conversion from closed to open canopy forest.
LEAF (PNG)	Persistent change in forest canopy cover over a five year period.
VFD	None.

None of the definitions include a specific measure or threshold for forest carbon stock changes due to degradation.

The remaining projects have not yet defined forest degradation for their landscapes. VFD reports that Vietnam's National Forest Inventory (NFI) does track changes in forest 'quality' (stocks of standing timber), which could potentially be related to degradation. However, the lack of a clear definition of forest degradation will make it difficult for these projects to progress in designing and implementing a system for measuring and monitoring forest degradation on their landscapes.

Forest Degradation Emissions Estimates

Estimates of Significance

The significance of emissions from forest degradation as a proportion of total forest sector emissions varies by landscape. In all four projects that are implementing monitoring, the proportion of emissions from forest degradation is currently unknown. In all landscapes, lack of reliable data at an appropriate scale prevents the estimation of emissions from degradation by activity beyond first-order estimates. Table 5 is a summary of the current status of degradation emissions estimates by the projects.

Table 5. Status of USAID project forest degradation emissions estimates.

Project	Status of forest degradation emissions estimates
CREL	Degradation is considered by the project to be a significant source of forest sector emissions, maybe the most significant in Bangladesh.
SFB	Unknown due to lack of data.
Forest-PLUS	Activities are being tracked, but emissions from each activity is not assessed. It is extremely difficult to assign emissions to a specific driver of degradation, due to spatial overlap of drivers.
IFACS	Not significant. Emissions are mostly from deforestation due to large-scale plantation (palm oil or acacia) conversion and associated peatland burning.
LEAF/Laos	Emissions haven't been calculated yet, but preliminary imagery analysis suggests that degradation is almost at the same areal extent as deforestation.
Hariyo Ban	A major source of emissions in Nepal, estimated by the project to be about 12 percent of total emissions.
B+WISER	Degradation is probably significant, but imprecise definitions and no formal accounting for degradation prevents accurately estimating emissions.
LEAF/PNG	Emissions have been estimated for deforestation, but not degradation. Preliminary image analysis results indicate that up to 50 percent of past emissions (2000-2012) are due to forest degradation. In 2012, canopy cover loss from degradation was more than that from deforestation.
VFD	The significance of degradation varies by province; approximately 20 percent for Nghe An, less than 10 percent for Thanh Hoa. The national government submitted a 20 percent estimate in their REDD+ Readiness Plan Idea Note (R-PIN). Across Vietnam, rates from forest degradation are generally around 50% (FCPF estimate).

Emissions Accounting Approach

Two accounting approaches can be used to track emissions from forest degradation: land-based and activity-based (IPCC 2000). Three of the four projects that are currently implementing monitoring (Forest-PLUS, Hariyo Ban, and B+WISER) responded that they are pursuing a land-based accounting approach through measuring all forest canopy cover change from deforestation, degradation, and enhancements in a given area, irrespective of the source of the change. One project (CREL) uses an activity-based monitoring approach which monitors changes in forest carbon stocks from understory tree removal for non-timber uses. However, only live biomass removals (estimated from measurement of tree stumps) are considered; the removal of dead wood (presumably for fuel) is excluded from the monitoring because it is so intensively collected that it is not possible to accurately measure the cumulative biomass removed over time.

Of the three projects that are currently investigating monitoring systems, USAID LEAF landscapes in Houaphanh, Laos and Madang, PNG are exploring a land-based approach to provide a first-order estimate of forest degradation rates. VFD is implementing a study to compare the two accounting approaches but is also now considering land-based accounting.

One of the important criteria for measuring emissions from forest degradation is the time interval between measurements. Generally, shorter measurement intervals are desired for monitoring forest degradation, because the effects of degradation activities are often spatially limited and can be rapidly obscured over time, making their detection and measurement more difficult. For example, gaps in the forest canopy created by selective logging can be closed in just a few years by vigorous growth of understory trees as well as adjacent intact overstory trees. This may result in failure to detect forest canopy disturbance when using time-series satellite imagery.

The frequency of measurement used by projects that have implemented monitoring varies between 3 and 7 years. Thompson et al. (2013) recommend a measurement frequency of 3 to 5 years for most indicators of a degraded forest. This would allow sufficient time for changes to occur, while not missing rapid canopy disturbance and recovery events. However, the frequency of measurement is often beyond the control of a project and is instead dependent on the timing of data sources, such as suitable imagery, forest inventory sampling intervals, forest cover map updates, or forest patrol reports. One project (CREL) is uncertain if its initial degradation monitoring effort will be repeated in the future by government authorities.

Measurement and Monitoring Methods

Remote Sensing

Analysis of remotely sensed imagery is often a critical component of cost-efficient detection and mapping of degradation as indicated by forest canopy cover change, as well as other uses such as detection of the sources of degradation. However, choosing appropriate imagery sources and analysis methods for a particular study area can be quite complex. The spatial resolution of available imagery, topographic relief of the landscape, intensity of forest disturbances, and characteristics of forest vegetation all affect the ability to detect and measure forest degradation by remote sensing (Miettinen et al. 2014). In addition, cost can be a major factor in choosing an imagery product, with free imagery such as Landsat being favored for several landscapes. Technical capacity for imagery acquisition and analysis is sometimes also a limiting factor. Some projects are reliant on other entities such as government agencies for their remote sensing needs, so they may have few options for influencing the desired product. Table 6 lists the source of remotely sensed imagery for the projects currently implementing forest degradation monitoring systems.

Some projects are currently investigating cost-effective remote sensing sources appropriate for detecting degradation. USAID LEAF/Laos and USAID LEAF/Madang are currently evaluating the use of Landsat 5 and 7 imagery combined into cloud-free, time-series composites (2000-2012 imagery; 2-year interval) using Google Earth Engine, and analyzed by sub-pixel spectral un-mixing using CLASlite image analysis software (Asner et al. 2009). VFD is investigating the use of SPOT 6 (1.5m panchromatic, 6m multispectral) and Landsat for degradation monitoring because the Vietnam government has historically relied on SPOT 5 (2.5m panchromatic, 10m multispectral) and Landsat for their land cover mapping.

It is clear from the experience of the various projects that no single imagery will meet the needs for monitoring all types of forest degradation in all landscapes. Spatial and temporal image availability, cost, technical capacity, and monitoring objectives must be considered when making decisions on the appropriate imagery source or sources to use. Medium resolution imagery may be sufficient for first-order estimates with higher uncertainty, but for more detailed estimates with lower uncertainty, higher resolution imagery will likely be needed,

Table 6. Remotely sensed imagery sources used by USAID projects for forest degradation monitoring.

Project	Imagery	Pixel Resolution (m)	Primary Use
CREL	RapidEye	5.0	Land cover mapping only. Not used for detecting degradation.
Forest-PLUS	Landsat 5,7,8 IRS-ResourceSat 1,2 (LISS III) Worldview 2	30.0 23.5 0.5	Canopy cover change by fractional cover downscaling of land use/land cover maps.
Hariyo Ban	Landsat RapidEye Worldview 1	30.0 5.0 0.5	Canopy cover change detection by temporal change in NDVI.
B+WISER	Landsat ALOS AVNIR	30.0 10.0	Canopy cover change detection by visual interpretation.
LEAF	Landsat 5,7	30.0	Canopy cover change detection using composited images and spectral un-mixing.

which will require more financial resources and a higher technical capacity for image acquisition and analysis.

Ground-Based Inventory

All four projects that are currently implementing monitoring are collecting ground-based inventory data. The purpose of collecting the data includes validating the results of remotely sensed forest canopy cover change and measuring changes in forest biomass to estimate changes in carbon stocks due to degradation activities. The sample design, data collection protocols, and relationship to the respective national forest inventories varies widely:

- CREL: A systematic grid of 600 nested inventory plots has been established across the forest landscapes. The density of the sampling grid varies for each protected area in order to get a sufficient number of plots for each area. Winrock International's standard operating procedures for forest carbon measurement (Walker et al. 2015) were merged with the Bangladesh Forest Department's plot inventory procedures for the sampling design and data collection. Although the country's NFI is not currently a repetitive inventory, the sample design was structured in a way that could be incorporated into future NFI inventories.
- Forest-PLUS: Field plots are integrated into the NFI and are used to detect and quantify the extent and impact of degradation drivers. The field inventory protocol includes collecting data on the human usage/human disturbance of forests. Also, random stratified sampling based on forest types occurs within the project's targeted landscapes.
- Hariyo Ban: Local community forestry (CF) user groups must complete an inventory of their forests every five years and calculate timber volume and canopy cover and use this information to update their Forest Operational Plan. A new NFI was recently completed; however, it does not currently include the inventory data from the CF groups. These data will be included in future NFI cycles.
- B+WISER: Although there is currently no formalized NFI in place, a national Forest Resource Assessment (FRA) measured 365 forest plots between 2003 and 2005. A subset of 75 to 90 plots will be re-measured by the government for the next FRA report which is due in 2017. The project is collecting activity data from forest patrols using the SMART software.

Ground inventory data are also being collected in some landscapes that are not currently being monitored for forest degradation. In Houaphanh, the Climate Protection through Avoided Deforestation (CliPAD) project is conducting a province-wide biomass assessment to develop emissions factors and a reference level for the province. In Madang, USAID LEAF is conducting ground inventory in the province to assess the accuracy of the Hansen et al. (2013) global forest change data set, which estimates forest loss, and the pilot Google Earth Engine/CLASLite imagery analysis. Ground inventory points in Madang are generated by selecting random pixels from imagery-based maps with areas stratified by level of accessibility. These sites are then located on the ground using GPS coordinates, and a standard set of questions is used to verify changes in canopy cover that is detected by imagery analysis.

Emissions Factor Calculation

The underlying objective for most forest degradation measuring and monitoring is to provide a reliable estimate of the GHG emissions that result from changes in forest carbon stocks due to degradation activities. The programs currently implementing forest degradation monitoring use the following methods to calculate emissions factors:

- CREL: Forest carbon stock change is calculated from stump measurements which are then applied to allometric tree volume equations. Most of the sample plots are in previously degraded forest, so data are not available for reference carbon stocks in un-degraded forest. However, if live trees in plots were also measured, this could provide pre-degradation stocks to be measured over time.
- Forest-PLUS: Based on canopy cover changes detected by optical and SAR remote-sensed imagery verified in ground-truth plots inventoried by the Forest Survey of India, Forest Research Institute, and Iora Ecological Solutions. Emissions from deforestation and forest degradation are combined.
- Hariyo Ban: Emissions factor estimates are not specifically calculated either for pre-degradation or post-degradation. Canopy cover change is linked to forest degradation but without any empirical modeling or calculations.
- B+WISER: Above-ground biomass is measured using Saatchi et al. (2011) and Baccini et al. (2012). Below ground biomass is estimated using IPCC (2006) default values based on estimated AGB. The government is using commercial timber volume data to calculate emission factors.

Mitigation of Forest Degradation

Mitigation actions are included in most project plans to help reduce forest degradation in their respective landscapes. Mitigation activities currently being implemented include the following:

- CREL: Implementing livelihoods improvement projects, and establishing forest co-management organizations (CMOs) in communities.
- SFB: Implementing livelihoods improvement projects, and supporting community forest management (currently small scale, but highly effective).

- Forest-PLUS: Conducting forest intervention demonstrations with the expectation that partners will continue them and scale up. Public awareness/education campaigns are highlighting fire management, sustainable use of non-timber forest products, community forest governance mechanisms, and the consequences of degradation to livelihoods.
- IFACS: High Conservation Value and High Carbon Stock forests are identified for conservation set-asides. Assistance is provided to forest products concessionaires to implement reduced impact logging practices, and to communities to help develop agroforestry and fire management plans.
- USAID LEAF/Laos: The management plan for the Nam Xam National Biodiversity Conservation Area in eastern Houaphanh includes improving livelihoods, forest restoration, forest monitoring/patrolling, and education on regulations. CliPAD has developed a similar set of mitigation actions at the provincial level.
- Hariyo Ban: Established biogas systems in 7,000 households to provide alternatives to fuelwood, and planning to scale up World Wildlife Fund's operational Gold Standard biogas project already generating credits; promoting improved wood-fuel cook stoves in cold, high-elevation areas where use of biogas digester units is not feasible; providing tree seedlings for reforestation of private lands; providing firefighting equipment and training for CF user groups.
- B+WISER: For field detection of degradation activities the project is using the SMART software tool, which is also linked to the Landscape and Wildlife Indicators (LAWIN) law enforcement software tool.
- USAID LEAF/PNG: No mitigations are currently being implemented, but provincial planning to reduce emissions is in progress, but not yet completed.
- VFD: The project is promoting community forest management and co-management of special-use forests and improving of livelihoods in degradation hotspots.

Measuring and monitoring of mitigation implementation is being conducted by some projects, using the following methods:

- CREL: The project monitoring and evaluation framework contains several metrics for monitoring the CMOs. However, it does not track impact of mitigation actions on reduced degradation rates.
- SFB: Subjective assessment of implemented activities is used for annual/inter-annual reporting.
- Forest-PLUS: Forest work plans include requirements for measuring and monitoring field activities.

- IFACS: The project's performance management plan contains several indicators that track implementation of project activities and their respective targets over the five-year life of the project (IFACS 2013).
- USAID LEAF/Laos: Some forest patrolling has been conducted by community groups of the Nam Xam Protected Area.
- Hariyo Ban: Bi-annual monitoring is conducted for biogas plant and improved cook stove function and performance; improvement of forest fire control efforts is monitored to assess effectiveness of equipment/training for local CF User Groups; the project is also monitoring implementation of rehabilitation activities in degraded areas.
- B+WISER: Evaluation and improvement of field patrols is accomplished through the SMART tool. The Department of Environment and Natural Resources monitors illegal logging with checkpoints and other infrastructure to detect and confiscate illegally harvested logs.
- VFD: Implementation of the project mitigation plan is currently being monitored on a limited basis.

Monitoring Successes

Despite the formidable technical and operational obstacles to measuring and monitoring forest degradation, some successes have been achieved in the USAID projects that were reviewed. Often these successes are the result of assessing and adapting to local conditions and developing and implementing a measuring and monitoring system that fits the particular local and national circumstances.

In Bangladesh, CREL reported that they have successfully quantified changes in carbon stocks due to the extensive degradation that occurs within forest protected areas within the country. Because degradation activities in these protected areas are concentrated in the understory and usually do not result in overstory canopy disturbance, detection using remote sensing analysis is difficult. However, CREL found that because these degradation activities were widespread and somewhat evenly distributed, it was possible to estimate carbon stock changes by establishing a systematic grid of inventory plots in which stumps of harvested understory trees are measured. Allometric tree volume equations applied to the stump measurements were used to estimate biomass loss. The inventory is designed to be integrated into the future implementation of the country's NFI. This type of Measuring, Reporting and Verification system could prove suitable for other areas in the region with similar high populations and intensive, widespread degradation.

The B+WISER project is promoting the use of the Spatial Monitoring and Reporting Tool (SMART) tool (http://www.smartconservationsoftware.org/) by forest patrols to collect degradation activity data while conducting their field duties. Using the SMART tool, forest monitoring of degradation activities can be accomplished over large areas with more accuracy and efficiency than manual methods. Although the tool does not quantify emissions from forest degradation, it provides important data on the location and intensity of degradation activities. These data can in turn inform inventory sampling design, as well as aid the interpretation of canopy cover changes detected from remote sensing or develop models for spatially predicting the occurrence of degradation activities on a landscape.

Recently, USAID LEAF and the US Forest Service began investigating methods to create time-series composites of publicly available satellite imagery for detecting changes forest canopy cover due to degradation. In some landscapes such as Madang in Papua New Guinea, persistent cloud cover can prevent detection of canopy cover changes, especially those of small scale and/or short duration. Google Earth Engine (https://earthengine.google.org) is a free internet-based software platform that can spatially stack multiple satellite images of a site to obtain a nearly cloud-free composite image over a growing season, which can then be used to locate and quantify canopy disturbances in forested areas by comparing with previous composites. The CLASlite software program (http://claslite.carnegiescience.edu/en/) automates the canopy change detection by spectral un-mixing to detect the proportion of live vegetation, dead vegetation, and bare substrate within a single image pixel. It also corrects for remaining cloud shadows and atmospheric haze that may be present in some images. It is hoped that if it is successful in accurately detecting small-scale canopy changes, this monitoring system could be a low-cost method of monitoring forest degradation activities.

Monitoring Challenges

Several factors can constrain accurate and cost-effective monitoring of forest degradation in the Asia region. Common challenges faced by some or all of the projects include:

- Lack of a clear, measurable definition for forest degradation.
- Uncertainty regarding which accounting approach to use (land-based or activity-based).
- Lack of sufficient cloud/haze-free imagery for change detection.
- Some degradation activities may not be detectable by remote sensing.
- Ground inventory data collection can be expensive and time-consuming.
- Complex land ownerships can inhibit collection of ground inventory data.
- Available data may be insufficient to calculate emissions factors.
- Insufficient funding or trained staff inhibits the expansion of monitoring demonstration sites to larger landscapes.
- Monitoring deforestation may be a higher national priority than monitoring forest degradation.

- Lack of national direction reduces incentives for sub-national jurisdictions or projects to monitor degradation.

One of the major constraints in measuring and monitoring forest degradation is the lack of a clear, precise definition. Several projects have developed a working definition for forest degradation for their landscapes; however some definitions are broad and would be difficult to measure quantitatively. For example, degradation may be defined as change from 'closed' to 'open' canopy forest, but this change is determined by subjective visual interpretation of remotely sensed imagery. In addition, this definition does not account for natural open-canopied forests, and it does not capture cumulative degradation that may occur in previously degraded open forests.

Several projects noted that the lack of reliable data in various forms prevents them from implementing degradation monitoring in their landscapes. Examples of data deficiencies include lack of spatially and temporally sufficient forest inventory and activity data for carbon stock-change or gain-loss analysis. A national forest inventory can be a useful source of ground inventory data; however, some countries have not implemented an NFI, and some NFI's have only been partially implemented. In addition, NFI's may not collect data at sufficient spatial intensity or at a frequency to be useful for measuring stock-changes due to forest degradation, nor for validation of remote sensing imagery analysis. These data deficiencies are often a result of funding limitations and lack of trained staff for collecting and analyzing monitoring data. In landscapes where monitoring has been partially implemented, the lack of resources and trained staff can inhibit the application of pilot or demonstration projects across larger landscapes.

Another major challenge is the often high cost of measuring and monitoring at a sufficient scale to reliably detect and measure degradation impacts. Intensive ground inventory across large landscapes can be prohibitively expensive, so some monitoring systems rely heavily on remotely sensed data, such as satellite imagery, to detect and measure changes in forest cover, which is assumed to represent degradation impacts. Although some satellite imagery is available free to the public, it often requires complex processing by specialists before it can be used in analysis. High-resolution imagery, which is desired for detecting small-scale disturbances from forest degradation, must often be purchased, and it can be expensive to acquire such imagery for large landscapes and at a sufficient time interval to detect and interpret small-scale forest canopy disturbances. It should be also be noted that some degradation impacts such as understory clearing, fire, and fuelwood collection may not be detectable even with high-resolution imagery.

In some landscapes, measurement and monitoring of deforestation is a higher priority, and this can reduce the resources available to monitor forest degradation. Lack of national direction with regard to accounting for emissions from forest degradation can also reduce the incentive for sub-national jurisdictions or projects to move forward with monitoring efforts. In this situation, a strategy to incorporate degradation monitoring as much as feasibly possible into methods already established for deforestation monitoring should be considered.

Recommendations

The following recommendations were developed based on this assessment of the USAID-supported projects in the Asia-Pacific region. However, these recommendations could also apply to other project-based forest degradation monitoring efforts in the region, or in the development of national systems for measuring and monitoring forest degradation.

1. **Clearly define forest degradation in a way that is measurable and is consistent with REDD+ guidelines and project objectives.**

   Without a well-defined concept of forest degradation, establishing meaningful monitoring objectives and thresholds will be problematic. To be applicable in the context of REDD+, a forest degradation definition should always include measurable criteria (indicators and/or thresholds) for changes in forest carbon stocks due to anthropogenic activities, although other values such as biodiversity or ecosystem services could be included as needed. Goslee et al. (2015) defines forest degradation as "the reduction in the forest carbon stocks by at least 10% and persisting for 5 years or more," while acknowledging that jurisdictions may choose to revise these threshold criteria as needed to better fit their local circumstances.

2. **Clearly describe accounting approaches and emissions factor development methods that are consistent with the project's institutional resources and technical capacity.**

   To increase confidence and consistency in emissions estimates, the accounting method that projects and countries will use to measure and monitor changes in carbon stocks (land or activity based) and the method used to develop emissions factors (stock-difference or gain-loss) needs to be determined based on the types of remote sensing, ground inventory, and degradation activity data available, as well as institutional capacities for implementing the chosen methods.

   In general, only countries with highly developed national forest inventories will be capable of implementing a robust land based accounting approach. The inventory sample design will need to be of sufficient density to detect statistically significant changes in carbon stock due to localized degradation activities. It is unlikely that this can be achieved using a widely spaced (several kilometer interval) NFI plot grid, or one that is sampled infrequently (e.g. more than 5 years). In this case, consideration should be given to increasing plot density and/or inventory frequency in areas where degradation is known or suspected to be occurring, in order to increase the probability of detecting changes caused by small-scale activities such as selective logging or fuelwood gathering.

Goslee et al. (2015) recommend an activity-based accounting in most situations as the most cost-effective approach to measuring emissions from forest degradation, because the data collection requirement is generally less substantial than land based accounting. An additional advantage of activity based accounting is the ability to track both CO_2 and non-CO_2 emissions by activity, which can provide useful information when evaluating the effectiveness of emissions reduction efforts. However, measuring emissions by activity generally requires more complex methods for emissions factor development, including the decision to use either stock-change or gain-loss to calculate emissions. In areas where forest degradation is intense, or multiple degradation activities are occurring in the same area, land based accounting may simplify tracking net emissions and removals over time.

3. **Replicate and scale-up successful measurement and monitoring methods in the region.**

   Several projects identified the need for better access to satellite imagery and robust analytical tools to detect canopy cover changes. USAID LEAF and the US Forest Service is currently investigating methodology using Google Earth Engine (https://earthengine.google.org/) for rapid, cost efficient processing of multiple satellite images to obtain cloud-free composites, which is an identified need in parts of the region that experience persistent cloud cover or haze. They are also evaluating the accuracy of the CLASlite image analysis software (http://claslite.carnegiescience.edu/en/) to analyze the composite images to detect forest canopy cover changes due to degradation. If this methodology proves to be sufficiently accurate and cost-efficient in the pilot landscapes, it could potentially be used to develop first-order estimates of emissions from canopy-disturbing degradation activities in the region.

4. **Utilize available tools to assist decision-making.**

   Several tools have recently been developed to assist countries and projects in making informed decisions on the level of investment that they should commit to measurement and monitoring forest degradation, and to develop robust monitoring systems.

   Winrock International and the Forest Carbon Partnership Facility recently developed a web-based REDD+ Decision Support Toolbox for the assisting countries in making decisions regarding implementing their REDD+ programs (https://redd-dst.ags.io/accounts/login/). The tool includes modules for estimating the significance of degradation activities, deciding which activities to include in a REDD+ program, and calculating first-order estimates of emissions from different degradation activities. USAID LEAF's Forest Degradation Guidance and Decision Support Tool (http://www.leafasia.org/library/forest-degradation-guidance-and-decision-support-tool) provides assistance in the determining the significance of emissions from forest degradation, and provides guidance on how and when to monitor and measure forest degradation, and how to incorporate forest degradation into the framework of a broader REDD+ measurement and monitoring plan.

The Global Forest Observation Initiative (GFOI) has recently developed a set of methods and guidelines for estimating changes in forest carbon stocks from deforestation and forest degradation, to support countries in their effort to build national forest monitoring systems (http://www.gfoi.org/methods-guidance/). These methods and guidelines help ensure that forest carbon assessments are credible, comparable and transparent.

5. **Establish a regional forest degradation working group to facilitate knowledge sharing and collaboration.**

   Communication among projects and countries to exchange information on degradation monitoring will be important to ensure that the most current methods are incorporated into monitoring systems and consistency is maintained across the region as much as possible. A recommended approach to facilitate this exchange is to establish an Asia regional forest degradation working group consisting of technical experts and project leaders, as well as members of support organizations and government agencies. This working group could communicate using an internet-based platform, along with occasional workshops, in which members can share information on the latest research and standard operating procedures related to forest degradation monitoring, as well as share experiences from monitoring in their particular landscape settings. It could also serve as a forum for helping projects and countries to resolve issues that may inhibit implementation of degradation monitoring in their jurisdictions.

   Possible platforms for a working group for forest degradation monitoring include the SilvaCarbon partnership for monitoring and managing forest and terrestrial carbon (http://egsc.usgs.gov/silvacarbon/node/30.html), the Global Forest Observations Initiative (http://www.gfoi.org/), the Agriculture, Forestry and Land Use (AFOLU) Working Group within the Asia Low Emissions Development Strategies (LEDS) Partnership (http://asialeds.org/), or the ReCaREDD (Regional Capacities for REDD+) project of the European Commission Joint Research Centre (https://ec.europa.eu/jrc/en). Potential web platforms for information and data exchange could include SERVIR Mekong (http://www.nasa.gov/mission_pages/servir/index.html), which is a joint venture between the National Aeronautics and Space Administration (NASA) and USAID.

6. **Develop a framework for comparing emissions and drivers across borders in the region.**

A standard, region-wide definition of forest degradation would facilitate cross-border sharing of data and methodologies. However, it may be difficult to achieve due to the differing sets of degradation drivers and monitoring objectives among landscapes in the region, as well as the varying technical and funding capacities of governments and their partners. A possible solution could be to develop a definition for each degradation activity (selective logging, shifting agriculture, etc.), with specific criteria (indicators and/or thresholds) designed for detection and measurement of biomass loss from each activity. The overall definition of forest degradation for a particular landscape would depend on the suite of activities that are causing the degradation. A measurement and monitoring system could then be developed using an activity-based approach. In areas with overlapping activities, a method for estimating proportional emissions would need to be developed.

Conclusion

The desired outcome of this review of current forest degradation monitoring experiences in Asia is to support and advance the development of cost-efficient and reliable forest degradation measurement and monitoring systems in the region. In the USAID projects reviewed, small successes have been achieved. But there is still considerable work required to establish fully functional and sustainable measuring and monitoring systems and integrating them into national forest inventories. Most of the projects have not yet implemented a degradation monitoring system, and the projects that have a monitoring system in place are currently in the early stages of their implementation. Nevertheless, this analysis reveals important 'lessons learned' which can inform considerations for on-going or future investments in measuring and monitoring forest degradation.

The results and recommendations of this regional assessment were presented in a workshop on forest degradation monitoring held recently in Bangkok, Thailand (Stephen et al. 2015). It is anticipated that the information from this review will ultimately contribute to development of national systems that explicitly recognize the scale and extent of forest degradation, and help ensure that sufficient resources are allocated to robustly measure and monitor GHG emissions associated with forest degradation.

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Annex: Project Evaluation Questionnaire

1.0 Project Information

1. Where is the landscape the project is considering measuring and monitoring forest degradation? What size is the area?

2. Is measuring and monitoring forest degradation currently being implemented?

    a. If no, what are the reasons why degradation is not being monitored? Could degradation monitoring potentially be implemented in the near future?

    b. If yes, has a forest degradation measuring and monitoring plan been developed? What are the objectives of this plan?

2.0 Defining Forest Degradation

1. What is the definition of a forest , and what is the reference source?

2. What is the working definition of forest degradation?

3. What are the main activities (drivers) contributing to forest degradation?

4. Who is responsible for these activities?

3.0 Estimating the Significance of Forest Degradation

1. Are emissions from degradation significant (>10% of total forest sector emissions) in your jurisdiction?

2. If emissions do not meet the above criteria, are there specific conditions within the project area that justify including forest degradation in REDD+?

3. What proportion of total emissions from forest degradation does each activity contribute?

4.0 Accounting Approach

1. Is the selected accounting approach activity-based, land-based, or a combination?

2. How often is each degradation activity being measured?

3. Which degradation activities (drivers) were excluded, and why?

4. Are objectives being met by the accounting approach and current monitoring methods?

5.0 Data Needs and Gaps

1. How is data for each activity (ie timber harvesting, fuelwood collection, fires, shifting cultivation or over grazing) being calculated?

    a. What remote sensing products are being used?

    b. What ground based inventory techniques being used?

    c. Is the work linked to the country's National Forest Inventory?

2. How are emission factors being developed?

    a. How are post degradation forest biomass stocks being calculated?

    b. How are pre degradation forest biomass stocks being calculated?

    c. What default values are being used for the carbon pools (assuming above ground live carbon is being measured?)

    d. Is the work linked to the country's National Forest Inventory?

6.0 Mitigation of Forest Degradation

1. Have mitigation actions been taken to reduce forest degradation in the project area?

2. Is the implementation of mitigation actions being measured and monitored?

7.0 Challenges and Lessons Learned

1. What challenges has the project faced in measuring and monitoring forest degradation?

2. How were these challenges overcome?

3. What other successes have been achieved?

4. What lessons have been learned?

5. What further technical inputs (data, equipment, methodology, etc.) could help the project to more accurately and efficiently measure, monitor, or mitigate degradation?

8.0 Other Projects

1. Are there other projects in your country or other places in the Asia region that you believe are successful and innovative?

    Do you have contact names and details for me to follow up on these additional projects?