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Monitoring activities of deforestation and forest  
degradation in REDD+ project sites:

Recommendations for the use of remote sensing on  
measurement of forest cover change

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for

Global Comparative Study on REDD

- Synergies between component 2 and 3

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# 1 Introduction

The international community recognizes reducing emissions from deforestation and forest degradation (REDD) and increasing forest carbon stocks as a critical component of national and international strategies for mitigating climate change. To support the endeavor of producing a post-2012 climate agreement, CIFOR is conducting a four-year global comparative research project on first-generation REDD project sites and national REDD initiatives in selected countries across Latin America, Africa, and Asia.

The goal of the global comparative research project is to provide REDD policy-makers and practitioner communities with the information, analysis and tools they need to ensure effective and cost-efficient reduction of carbon emissions with equitable impacts and co-benefits – including poverty reduction, enhancement of non-carbon ecosystem services, and protection of local livelihoods, rights and tenure. The project consists of four components: (1) national REDD initiatives (policy processes and strategies); (2) REDD project sites; (3) monitoring and reference levels; and (4) knowledge sharing (CIFOR, 2009).

As part of the global process agreed in Bali (COP13), and leading up to 2012 and an international agreement on REDD, a series of local/subnational ‘demonstration activities’<sup>1</sup> is being planned and implemented by a range of agencies, including NGOs, the private sector, bilateral donors and multilateral agencies. Component two of the global comparative research project is directed towards maximizing learning from the first generation of demonstration activities. This component will focus on the degree to which REDD demonstration activities are effective, efficient and equitable, and deliver co-benefits (the 3E criteria). A comparative analysis of the first generation of REDD demonstration activities and national strategies will be made to provide an independent review of early REDD experience. The global REDD community intends to learn from this first generation of activities, and thereby enhance design of the second generation of local/subnational activities, as well as draw lessons from the local activities for REDD national and global policies.

All REDD initiatives are required to develop a system for measuring and reporting emission reductions. Component three of the global comparative research aims to support better and more cost-efficient measurement and monitoring systems for REDD projects and national REDD schemes by developing new knowledge and a new approach for assessing national and subnational reference scenarios to help set emissions reduction targets.

Based on the experiences for REDD projects, the measuring and reporting systems have five key tasks that must be carried out to be able to calculate the impact of the project on emissions:

1. Determination of monitoring areas, which generally include reference regions, project regions and leakage regions (maybe national).

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<sup>1</sup> We use this term advisedly, recognizing that in some countries the term “demonstration activity” implies formal national approval and sponsorship, whereas many of the early REDD projects fall outside of this restrictive definition.

2. Determination of reference emissions (including non-CO<sub>2</sub> emissions from fires), which will serve as a reference-level against which project emission reductions will be assessed and credited.
3. Determination of deforestation and degradation areas in reference, project and leakage regions.
4. Determination of carbon stocks and changes.
5. Determination of non-CO<sub>2</sub> emissions from soils (CH<sub>4</sub> in swamp forests, N<sub>2</sub>O in some upland forests) and fires in reference, project and leakage regions.

National REDD activities should foster sub-national implementation and projects need to engage with national-level greenhouse-gas (GHG) monitoring and accounting activities to register carbon (credits) and ensure contribution and verification to countrywide reduction targets. There is little practical experience in implementing this in different country circumstances. It is important to develop this experience and expand the applicability of the monitoring methodologies. To do this, there is a need to establish a link between component two and three of the project. All changes that happen because of REDD+ mitigation activities at the project sites need to be monitored. GIS and remote sensing data are very suitable to detect forest cover change between the 'before' and 'after' phases at intensive and extensive sites, as well as in the control sites for verification. Depending on the level of detail required, additional ground measurements have to be made.

The goal of this report is to make recommendations to the global comparative study on how to conduct research in years 2-4 on measuring the effectiveness of REDD+ in the selected project sites.

This study will be conducted in project sites that are located in five countries spread over three continents: Brazil in South America, Tanzania and Cameroon in Africa and Vietnam and Indonesia in South-East Asia. A REDD project selected for C2 research might be either intensive or extensive. At intensive sites research is conducted at the village level and at the household level. At extensive sites research is only conducted at the village level.

The next chapter contains the objectives and approach, followed by data and methods in chapter three. In chapter four the results are presented on the monitoring requirements, the existing remote sensing data sources, the capacities for conducting the research and recommendations per site. Institutional collaborations and budget considerations are discussed and the terms of reference for the research in the years 2-4 of the global comparative study is presented. Chapter five concludes with the key recommendations and a summary.

## 2 Objectives and approach

The overall goal of this report is to make recommendations to the global comparative study on measuring the effectiveness of REDD+ in a selection of project sites. To accomplish this goal, a detailed work plan has been defined with several activities and outputs to address the different objectives, see table 1.

*Table 1. Objectives, activities and outputs.*

<b>Defined objective</b>	<b>Activities and outputs</b>
Become thoroughly familiar with the technical guidelines, methods, research instruments and progress of Component 2;	Review materials provided by C2 activities and researchers and discussion during visit at CIFOR headquarters.
Understand the aims and progress of joint C2-C3 work at REDD research sites.	
Review the adequacy of remote sensing data (including images and land cover classification methods) available from project proponents (at intensive and extensive sites) for research on the extent and causes of forest cover change at the study sites.	Assess the capacity analysis survey and data conducted by CIFOR (from project proponents) and provide the review based on the information on available capacity and data and understanding of the forest changes (drivers and processes).
Assess the need and options for employing remote sensing data to evaluate deforestation and degradation before and after in project area, and in control and intervention villages;	Propose a monitoring strategy (for remote sensing data primarily) for each project site where capacity and data assessments are available. The plan includes a suggestion on what remote sensing data should be acquired in addition to already existing ones.
Ascertain the kinds of imagery that have to be acquired or accessed and processed by CIFOR to conduct the BACI research on forest cover change.	
Assess the adequacy of CIFOR professional staff and GIS equipment and data for carrying out the research.	Visit CIFOR in Bogor and discuss the required activities and capacities with relevant CIFOR staff.
Summarize and make recommendations to GCS-REDD.	Prepare the report (30 pages).

## 3 Data and methods

### 3.1 Overview of project sites

Table 2 gives an overview of the REDD+ project sites that are currently studied by the global comparative research project. The project sites are spread over South America, Africa and Southeast Asia and include three sites in Brazil, three in Indonesia, one in Vietnam, two in Tanzania and two sites in Cameroon. For the CED site in Cameroon, two proponent appraisals were available (Nkol. Enyeng and Nomedjoh), because these are different 2 regions covered by the site. Therefore, we will treat this project site as 2 separate sites in the rest of the report.

Table 2. Overview of REDD+ project sites.

Country	REDD+ project site	Total project area (ha)
Brazil	Acre – Feijó Manuel Urbano	5500000
Brazil	Noroeste de Mato Grosso (Cotriguaçu)	938600
Brazil	Transamazônica	31745
Cameroon	CED, Nkol.Enyeng	1022
Cameroon	CED, Nomedjoh	1950
Cameroon	Mt. Cameroon	?
Indonesia	Aceh	750000
Indonesia	Kabupaten Ketapang provinsi Kalimantan Barat	89375
Indonesia	KFCP, Kapuas District, Central Kalimantan	120000
Vietnam	Cat Tien district, Lam Dong province	55408
Tanzania	TaTEDO Kahama	?
Tanzania	Kilosa	50000

The areas that are covered by the projects differ much between the sites and range from 1022 up to 5.500.000 ha. From two sites the total area was not reported. The total project area of Noroeste de Mato Grosso is 108000 km<sup>2</sup>, but the forest area of Cotriguaçu, where they plan to monitor forest cover change, is 938600 ha.

### 3.2 Analysis of project proponent appraisals and site narratives

The project proponents were interviewed by the component 2 survey and field teams by means of different questionnaires. This resulted in proponent appraisals which provided amongst others details on the project sites, the circumstances (drivers of deforestation) in the sites, and the activities that are planned to implement REDD+. The information that was most relevant for this research was extracted from the appraisals. This included questions about the drivers and processes that cause deforestation and degradation. Other questions concerned the forest intervention goals at the village level and the plans to generate measurable reductions in carbon emissions at the project level. This information is very important in order to make recommendations for monitoring deforestation and degradation with use of remote sensing.

The following questions from the appraisals were used for our analysis of the project sites:

8. *What is the total area covered by the project?*

9. *How does the project plan to generate measurable reductions in net carbon emissions?*

*Possible answers:*

- *Avoid/ reduce deforestation*
- *Avoid/ reduce degradation*
- *Restore, rehabilitate, or enhance carbon stocks in existing forest (improved forest management)*
- *Af/reforest or regenerate new forest*
- *A combination of the above*
- *Other (e.g.peatland rehabilitation)*

12. *Which GIS spatial layers are available for monitoring forest cover?*

13. *Can you provide satellite imagery to our researchers?*

14. *If yes (to question 13), please provide details of satellite imagery that is available? (ie satellite data or analysis of satellite data on forest types, cover and condition)*

19. *What REDD related activities have you already undertaken or are planning to undertake in the next six months? (E.g. land regularization, participatory mapping, carbon baseline, socio-economic baseline etc.)*

24. *Please describe the criteria for selecting villages to participate in the project?*

*Question at the village level:*

27b. *What are the main pressures on forests?*

*Possible answers:*

1. *Large-scale agriculture (for example, by agribusiness)*
2. *Large-scale ranching (for example, by agribusiness)*
3. *Large-scale plantations (timber or perennials such as oil palm)*
4. *Small-scale traditional agriculture (for example, swidden by local inhabitants)*
5. *Small-scale frontier agriculture (for example, slash and burn by colonists)*
6. *Small or medium ranchers*
7. *Large-scale timber harvest (legal mechanized extraction by companies)*
8. *Large-scale timber harvest (illegal mechanized extraction by companies)*
9. *Small-scale legal timber harvest (low-technology, by small local operators)*
10. *Small-scale illegal timber harvest (low-technology, by small local operators)*
11. *Subsistence fuelwood/charcoal collection*
12. *Commercial fuelwood/charcoal collection*
13. *Non-wood forest products harvesting*
14. *Other, specify (forest fire, mining, etc.)*

*Question at the village level:*

27c. *What are the forest intervention goals?*

*Possible answers:*

*DF = Reduced Deforestation*

*DG = Reduced Degradation*  
*En = Enhanced stocks*  
*AF = Afforestation*  
*NO = none*

29. *What method is the project using for assessing forest cover?*

*Possible answers:*

- *Remote Sensing*
- *Ground thruthing*
- *Community / household perceptions of change*

The questions from the appraisals that were used to determine the monitoring requirements were the questions 9, 27b and 27c. They provided information on the main pressures on forest and the plans and goals of the projects to reduce carbon emissions. For assessing the monitoring capacities of the projects and the monitoring status questions 12, 13, 14 and 29 were used. Questions 19 and 24 gave a general impression of the circumstances in the project villages.

In addition, site narratives were analyzed to assess the drivers of deforestation at the project level. The drivers were translated and put into the same categories as used for question 27b from the proponent appraisals.

### **3.3 GIS data**

The exact locations of the project sites and village boundaries have to be known in order to search for satellite imagery that covers the project areas. GIS data of the project sites boundaries only were available for the site Transamazonia in Brazil. The village locations were available for all three sites in Indonesia, for the sites CED, Nkol.Enyeng and Mt Cameroon in Cameroon, and for the two sites in Tanzania. Table 3 describes the current status of available GIS data for the project boundaries and village locations. For the other two sites in Brazil, the site CED, Nomedjoh in Cameroon and the site in Vietnam none of this information could be obtained yet.

*Table 3. Availability of GIS data for project boundaries and village locations.*

<b>COUNTRY</b>	<b>REDD+ PROJECT SITE</b>	<b>Centre location</b>	<b>Project boundaries</b>	<b>Location of villages</b>
Brazil	Acre – Feijó Manuel Urbano	-	-	-
Brazil	Noroeste de Mato Grosso (Cotriguaçu)	-	-	-
Brazil	Transamazônica	+	+	-
Cameroon	CED, Nkol.Enyeng	-	-	+
Cameroon	CED, Nomedjoh	-	-	-
Cameroon	Mt. Cameroon	-	-	+
Indonesia	Aceh	-	-	+
Indonesia	Kabupaten Ketapang provinsi Kalimantan Barat	-	-	+
Indonesia	KFCP, Kapuas District, Central Kalimantan	-	-	+
Vietnam	Cat Tien district, Lam Dong province	-	-	-
Tanzania	TaTEDO Kahama	-	-	+
Tanzania	Kilosa	-	-	+



Figure 1 shows the locations of the project sites and villages in Brazil, Cameroon, Tanzania and Indonesia, for which GIS data were available.

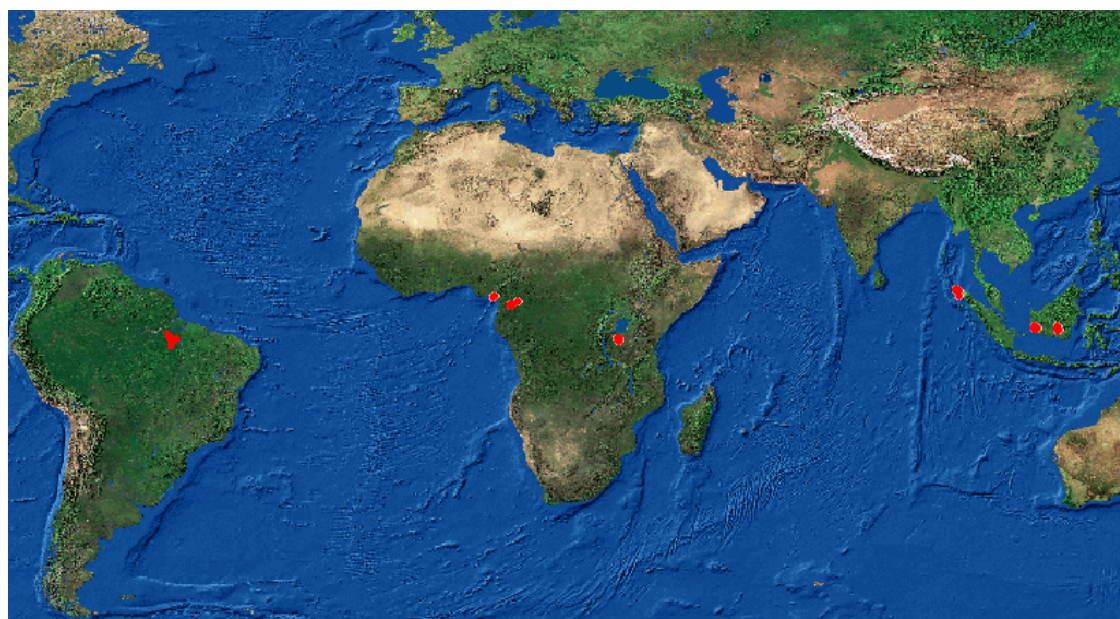


Figure 1. Locations of project sites and villages in Brazil, Cameroon, Tanzania and Indonesia.

### 3.4 Satellite data archives

Remote sensing techniques are very suitable to monitor changes in forest areas. Depending on the planned scale for monitoring, coarse, medium or high resolution data can be used. Different types of data from optical sensors at a variety of resolutions and with different costs involved are available for monitoring deforestation, as indicated in table 4.

Table 4. Utility of optical sensors at multiple resolutions for deforestation monitoring (GOFC-GOLC, 2009).

Sensor & resolution	Examples of current sensors	Minimum mapping unit (change)	Cost	Utility for monitoring
Coarse (250-1000 m)	SPOT-VGT (1998- ) Terra-MODIS (2000- ) Envisat-MERIS (2004 - )	~ 100 ha ~ 10-20 ha	Low or free	Consistent pan-tropical annual monitoring to identify large clearings and locate "hotspots" for further analysis with mid resolution
Medium (10-60 m)	Landsat TM or ETM+, Terra-ASTER IRS AWiFs or LISS III CBERS HRCCD DMC SPOT HRV	0.5 - 5 ha	Landsat & CBERS are free from 2009; <\$0.001/km <sup>2</sup> for historical data \$0.02/km <sup>2</sup> to \$0.5/km <sup>2</sup> for recent data	Primary tool to map deforestation and estimate area change
Fine (<5 m)	IKONOS QuickBird Aerial photos	< 0.1 ha	High to very high \$2 -30 /km <sup>2</sup>	Validation of results from coarser resolution analysis, and training of algorithms

In general, changes in forest area (deforestation and af/reforestation) can be monitored with medium resolution (30m) remote sensing data like Landsat. All Landsat data from US archive (USGS) are freely available since the end of 2008. Landsat-4 and 5 TM data are available for the period from 1982 until present. Landsat-7 ETM+ data are available for the period of 1999 until present. To detect areas of degradation, such as selective logging and forest fires, which usually happen in smaller areas, higher resolution data (<5m) are needed. Those data are not for free. High resolution Quickbird images can be searched for and acquired via Google earth. Those images are available for the years 2002 until present. It is almost impossible to detect changes in the understory of the forests with commonly available satellite monitoring, for example caused by subsistence fuel wood or charcoal collection, or non-wood forest products harvesting. In such a case it is necessary to take ground measurements.

In the scope of this research, the USGS archive (via <http://earthexplorer.usgs.gov>) has been searched for available Landsat 4-5 and Landsat 7 images and Google Earth has been searched for availability of Quickbird images which cover the REDD+ project sites. For the site Transamazonia in Brazil images were searched which fell within the borders of the total project area. For the other sites in Cameroon, Tanzania and Indonesia village points were known and images were searched which covered the GIS village point locations.

### **3.5 GIS and RS capacity assessment at CIFOR**

An assessment of the GIS and remote sensing monitoring capacities and data availability was made during several interviews with the CIFOR staff. This gave an overview of what data and capacities are available and which further steps need to be taken to build more capacities for performing the remote sensing monitoring part of the global comparative research project.

## **4 Results**

### **4.1 Use of remote sensing for monitoring**

The effectiveness of REDD for the project/village sites will be measured through analysis of remote sensing/GIS data on land cover in both the project area as a whole and in the specific study villages. At the intensive sites, our intention is to assess land cover in both the “before” and “after” phases in both intervention and control villages.

The remote sensing/GIS data will come from various sources:

- Proponents that have imagery (raw or classified) that is reliable enough for use and that will have a longitudinal (before and after) dimension;
- Acquisition of imagery or classification of imagery in cases where proponent data are inadequate or unavailable;
- Acquisition and classification of imagery covering control sites in cases (probably all) where the proponents are not analyzing land cover in our control villages.

The first step in analyzing carbon emissions and removals will be an assessment of proponent MRV systems. Component 3 will conduct a survey of MRV capacity at all intensive sites in collaboration with Component 2. This means that someone from C3 and/or C2 will contact the person responsible for MRV in each proponent organization. Following this survey, selected proponents will be invited to attend a regional workshop to improve MRV capacity. The goal of this workshop will be to help raise the MRV capacity of all proponents to a minimum standard of adequacy.

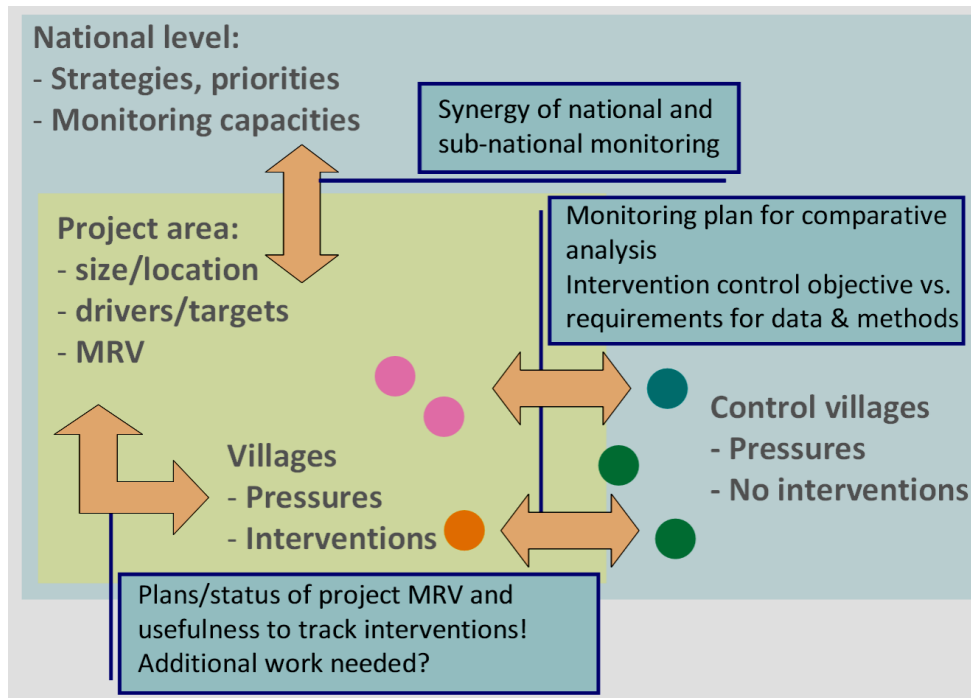


Figure 2. Monitoring components and interlinkages or relevance for the project.

Figure 2 shows some of the relevant components and interlinkages. Each project will conduct its own monitoring activities that the C2 activities should build upon or help to improve (capacity building). Where possible, synergies with the national level activities should be explored – this is discussed in section 4.5 of the report. The most important technical work is required for the comparative monitoring of interventions and controls.

The C2 implementation on MRV is aiming to rely on remote sensing data as much as practicable and possible, as indicated in the Component 2 technical guidelines. The main goal is to track human activities over time, i.e. to compare pre- and post intervention activities and forest carbon impacts in intervention and control sites, and to verify if activities have changed. In fact, no change (in future periods) would be a relevant finding in this context. One key issue is the need for consistent time series data and for historical data to measure change and activities using remote sensing. Such data indicate the impact of activities on forest (canopy cover) cover and land cover. It provides efficient, proven methods that allow not only for comparability across time but also among different sites and locations. Depending on the severity of impact on the forest canopy, there might be limitations for tracking all types of activities using satellite data.

Remote sensing can help to track activities and areas affected, but ground surveys are essential to measure carbon stock and change. Since all projects are expected to provide some kind of carbon monitoring, synergies with project proponent monitoring efforts are foreseen, in particular on the use of local emission factors. However, additional ground surveys for carbon may be needed in some locations. The need for ground surveys versus remote sensing (or both) will be determined as part of this study and should then be further elaborated to allow for best use of resources, i.e. integrating monitoring data from national, project, village level and from different GCS component work.

## 4.2 Monitoring requirements

In the different REDD+ project sites various processes (pressures) are affecting the forest and cause deforestation and degradation. To address these issues, the project proponents defined a REDD+ strategy and made plans to reduce carbon emissions at project level. In addition, in some cases, they defined forest intervention goals at village level. The monitoring and data requirements depend on these processes, plans and goals, because they determine what exactly needs to be monitored. However, not all sites reported on the pressures and goals, which makes it more difficult to determine what and how to monitor. For 11 of the 12 sites the carbon reduction plans at the project level were reported. Seven of them also gave information about the forest intervention goals at village level and only 5 of these 7 sites provided full information on all monitoring issues, including the pressures on the forest.

Figure 3 shows the plans of the project proponents to generate measurable reductions in net carbon emissions in the whole project area. For one site (Aceh, Indonesia) no information was obtained about these plans. The other 11 sites all reported to avoid/reduce deforestation and degradation (REDD). Eight of the sites also mentioned the aim to restore, rehabilitate, or enhance carbon stocks and five sites to af/reforest or regenerate new forest, which are all activities under REDD+. One site in Indonesia (KFCP, Kapuas District, Central Kalimantan) also planned to undertake peatland rehabilitation.

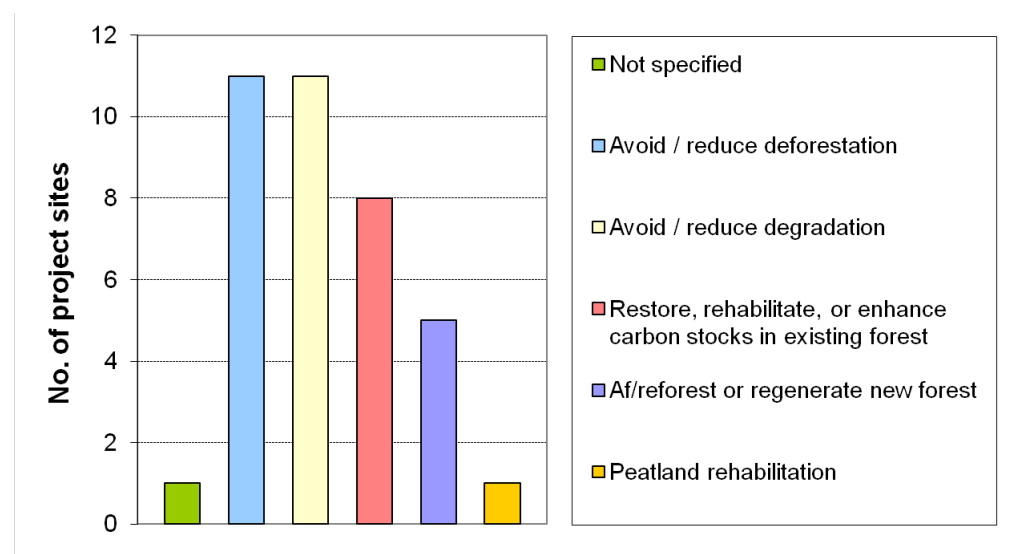


Figure 3. Plans to reduce carbon emissions at project level .The number of project sites is 12, multiple plans could be reported by each project site.

An overview of the forest intervention goals at village level is presented in figure 4. The 7 sites that reported their forest intervention goals, used all 4 possible answering options from the proponent appraisal, which largely overlaps with their plans at the project level.

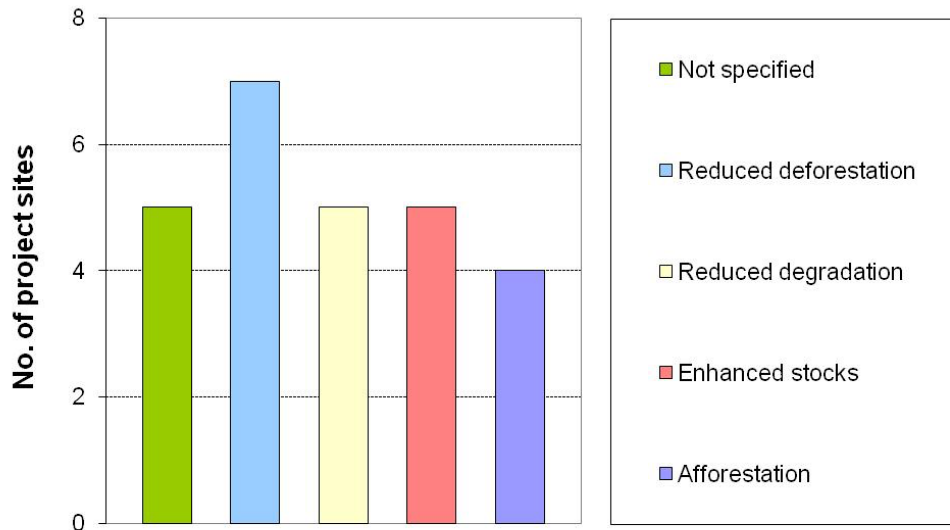


Figure 4. Forest intervention goals at village level. The number of project sites is 12, multiple plans could be reported by each project site.

Figure 5 gives an overview of the drivers of deforestation for the project sites in Brazil, Indonesia and Tanzania. Information for Cameroon was missing. The most occurring drivers are large scale (illegal) logging activities and other large scale activities like land clearance and forest fires.

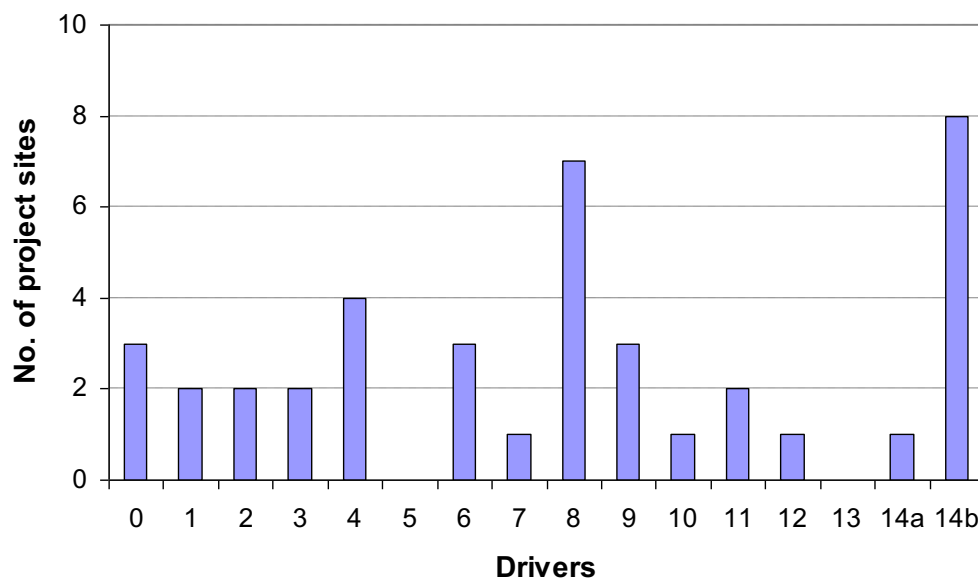


Figure 5. Drivers of deforestation at project level, N=12.

Legend key: 0. Not specified, 1. Large-scale agriculture (for example, by agribusiness), 2. Large-scale ranching (for example, by agribusiness), 3. Large-scale plantations (timber or perennials such as oil palm), 4. Small-scale traditional agriculture (for example, swidden by local inhabitants), 5. Small-scale frontier agriculture (for example, slash and burn by colonists), 6. Small or medium ranchers, 7. Large-scale timber harvest (legal mechanized extraction by companies), 8. Large-scale timber harvest (illegal mechanized extraction by companies), 9. Small-scale legal timber harvest (low-technology, by small local operators), 10. Small-scale illegal timber harvest (low-technology, by small local

operators), 11. Subsistence fuelwood/charcoal collection , 12. Commercial fuelwood/charcoal collection, 13. Non-wood forest products harvesting, 14. Other, (forest fire, mining, etc.) – a) small scale; b) large scale

Figure 6 shows the main pressures on the forest at village level for the 5 sites that reported on this. Most of the pressures concerned small-scale processes due to local actors or subsistence land use and local markets, like small-scale agricultural activities, small-scale illegal timber harvest or subsistence fuel wood / charcoal collection. Only one site mentioned large-scale activities (plantations) as pressure on the forest (KFCP, Kapuas District, Central Kalimantan).

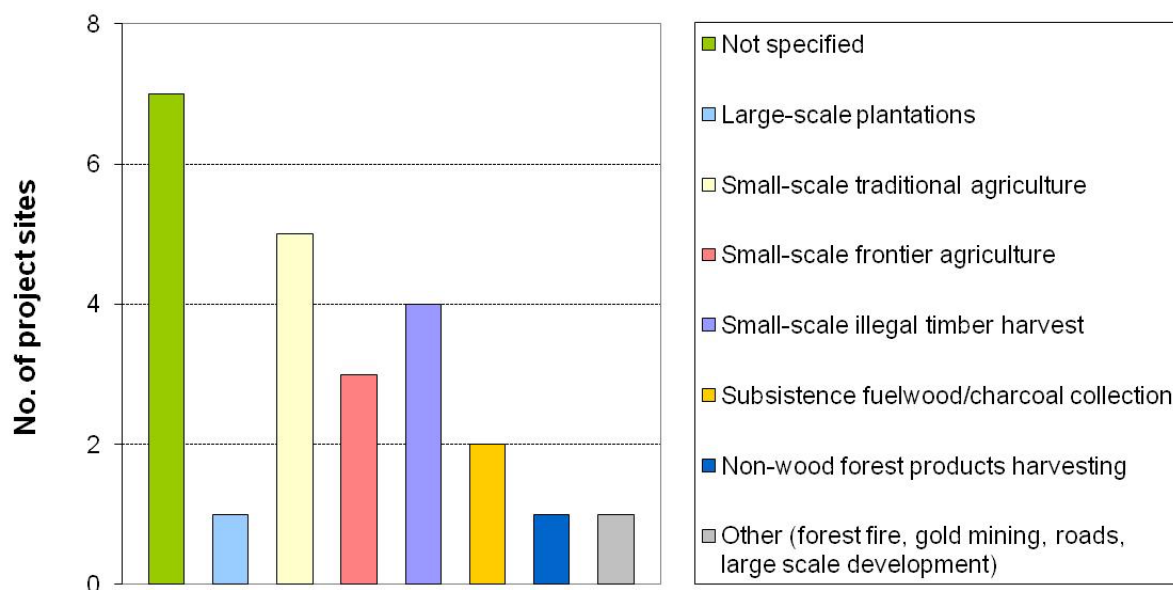


Figure 6. Main pressures on forests at village level. The number of project sites is 12, multiple plans could be reported by each project site.

If you want to monitor the drivers of deforestation and degradation, you have to look at the pressures that are affecting the forest cover. Large scale pressures can be monitored with medium resolution satellite imagery, for small scale pressures high resolution imagery is needed. For some small scale activities that occur on the ground and can therefore not be observed with use of remote sensing, it is necessary to perform ground measurements. Table 5 shows all the main pressures that could occur in the forest (possible answers in proponent appraisal) and which data are needed to detect the area that is affected.

Table 5. Main pressures on the forest and monitoring requirements for detecting the area affected.

	Main pressures on forest	Detection of area affected		
		Medium resolution satellite monitoring	High resolution satellite monitoring	Ground measurements
1	Large-scale agriculture	+	+	+
2	Large-scale ranching	+	+	+
3	Large-scale plantations	+	+	+
4	Small-scale traditional agriculture	-	+	+
5	Small-scale frontier agriculture	-	+	+
6	Small or medium ranchers	-	+	+

7	Large-scale legal timber harvest	+	+	+
8	Large-scale illegal timber harvest	+	+	+
9	Small-scale legal timber harvest	-	+	+
10	Small-scale illegal timber harvest	-	+	+
11	Subsistence fuelwood/charcoal collection	-	-	+
12	Commercial fuelwood/charcoal collection	-	-	+
13	Non-wood forest products harvesting	-	-	+
14	Other, specify (forest fire, mining, etc.)			
	a) small scale	-	+	+
	b) large scale	+	+	+

Table 6 summarizes the data that are required to monitor according to the forest intervention goals at the village level. Deforestation and afforestation can be detected with medium resolution satellite data, because this mainly concerns larger homogeneous areas. For monitoring degradation it is necessary to use high resolution data. For monitoring enhanced carbon stocks ground measurements are needed, this can not be detected from space.

*Table 6. Forest intervention goals at the village level and data needed for monitoring.*

	<b>Forest intervention goals at village level</b>	<b>Data requirements</b>
1	Reduced deforestation	Medium resolution satellite data
2	Reduced degradation	High resolution satellite data
3	Enhanced stocks	Ground measurements
4	Afforestation	Medium resolution satellite data

Table 7 gives an overview of the data that are needed to monitor according to the carbon reduction plans at the project level. The same kind of data requirements apply as for the forest intervention goals.

*Table 7. Plans to reduce carbon emissions at the project level and data needed for monitoring.*

	<b>Plans to reduce carbon emissions at project level</b>	<b>Data requirements</b>
1	Avoid / reduce deforestation	Medium resolution satellite data
2	Avoid / reduce degradation	High resolution satellite data
3	Restore, rehabilitate, or enhance carbon stocks in existing forest	Ground measurements
4	Af/reforest or regenerate new forest	Medium resolution satellite data
5	Peatland rehabilitation	Ground measurements

### **4.3 Satellite data sources for monitoring**

Table 8 shows an inventory of available satellite data per project site, for which the GIS locations were known. The high resolution Quickbird data are grouped by year and cover one or more villages per site. One or two Landsat scenes were usually enough to cover all the villages in the project sites. The Catalog ID for Quickbird images and the path and row number and ID for Landsat images can be used to

download or purchase the images. The starting letters of the ID of the Landsat images indicate from which sensor they are: LT4 – from Landsat-4, LT5: from Landsat-5, LE7: from Landsat-7. For Quickbird all available images are listed. For Landsat, if available, 1 image per year is listed, with a maximum cloud cover of 50%. Images from Landsat-7, acquired after 2003, are partly affected due to a failure in the scan line corrector resulting in black stripes in some parts of the images. It depends on the location of the villages if the quality of these images is still good enough for use.



Table 8. Availability of satellite images for monitoring purposes in the different project sites.

(NB: The images for Tanzania are based on a set of village points for which it is not known if they belong to the site TaTEDO Kahama or Kilosa. It is assumed that the village points belong to both village.)

REDD+ project site	Quickbird		Landsat-4-5 TM and Landsat 7	
	Available images	Cloud cover	Available images	Cloud cover
Tanzania – TaTEDO Kahama / Kilosa	-		<b>Path: 171 Row: 63</b> Date: 1994/12/18, ID: LT51710631994352XXX02, 10% Date: 1995/03/08, ID: LT51710631995067XXX02 0% Date: 1999/09/03, ID: LE71710631999246AGS01 0.54% Date: 2000/07/19, ID: LE71710632000201EDC00 0% Date: 2001/11/11, ID: LE71710632001315SGS00 8.85% Date: 2002/11/30, ID: LE71710632002334SGS02 1.45% Date: 2003/02/02, ID: LE71710632003033SGS00 0.02% Date: 2008/09/19, ID: LT51710632008263MLK00 4% Date: 2009/06/18, ID: LT51710632009169JSA00 0% Date: 2010/02/13, ID: LT51710632010044MLK00 10%	
Indonesia - Aceh	<b>2002</b> Catalog ID: 1010010000D28B03 Quality: 90 Catalog ID: 10100100017E0F03 Quality: 7	7% 3%	<b>Path: 131 Row: 56</b> Date: 1999/08/10, ID: LE71310561999222SGS00 12.19% Date: 2000/05/08, ID: LE71310562000129SGS00 6.04% Date: 2001/08/15, ID: LE71310562001227SGS00 7.33%	

	<p><b>2008</b></p> <p>Catalog ID: 1010010008151206 Quality: 99</p> <p>Catalog ID: 1010010008151204 Quality: 99</p> <p>Catalog ID: 1010010008151204 Quality: 99</p> <p><b>2009</b></p> <p>Catalog ID: 10100100093DA404 Quality: 99</p> <p>Catalog ID: 1010010009C0FB02 Quality: 9</p>	<p>49%</p> <p>84%</p> <p>84%</p> <p>27%</p> <p>4%</p>	<p>Date: 2002/05/14, ID: LE71310562002134SGS00</p> <p>Date: 2003/02/10, ID: LE71310562003041SGS00</p> <p>Date: 2004/06/12, ID: LT51310562004164BKT00</p> <p>Date: 2005/04/20, ID: LE71310562005110PFS00</p> <p>Date: 2006/07/04, ID: LT51310562006185BKT00</p> <p>Date: 2007/04/10, ID: LE71310562007100SGS00</p> <p><b>Path: 131 Row: 57</b></p> <p>Date: 1999/08/10, ID: LE71310571999222SGS00</p> <p>Date: 2000/03/05, ID: LE71310572000065SGS05</p> <p>Date: 2003/12/27, ID: LE71310572003361ASN01</p> <p>Date: 2004/05/19, ID: LE71310572004140PFS03</p> <p>Date: 2005/02/07, ID: LT51310572005038BKT00</p> <p>Date: 2006/07/04, ID: LT51310572006185BKT00</p> <p>Date: 2007/04/10, ID: LE71310572007100SGS00</p> <p>Date: 2008/07/01, ID: LE71310572008183PFS00</p> <p>Date: 2009/02/10, ID: LE71310572009041SGS00</p> <p>Date: 2010/01/12, ID: LE71310572010012SGS00</p>	<p>6.03%</p> <p>22.02%</p> <p>25%</p> <p>17.67%</p> <p>0%</p> <p>16.69%</p> <p>14.11%</p> <p>6.46%</p> <p>28.83%</p> <p>2.93%</p> <p>7%</p> <p>3%</p> <p>5.55%</p> <p>11.63%</p> <p>0.56%</p> <p>4.69%</p>
Indonesia - Central Kalimantan	<b>2008</b>		<b>Path: 118 Row: 61</b>	

	Catalog ID: 1010010008401F0B Quality: 99	56%	Date: 1999/10/02, ID: LE71180611999275SGS00 Date: 2000/07/16, ID: LE71180612000198EDC00 Date: 2001/08/20, ID: LE71180612001232EDC00 Date: 2002/01/27, ID: LE71180612002027SGS00 Date: 2003/02/15, ID: LE71180612003046SGS00 Date: 2004/05/16, ID: LT51180612004137BKT00 Date: 2005/08/07, ID: LT51180612005219BKT00 Date: 2006/05/30, ID: LE71180612006150EDC00 Date: 2007/05/17, ID: LE71180612007137EDC00 Date: 2008/05/19, ID: LE71180612008140EDC00 Date: 2009/08/10, ID: LE71180612009222EDC00	21.3% 3.7% 1.17% 24.32% 5.33% 15% 6% 33.69% 33.44% 13.49% 31.61%
Indonesia - West Kalimantan	<b>2008</b> Catalog ID: 101001000894B101 Quality: 99  Catalog ID: 10100100083CCE0E Quality: 99  <b>2009</b> Catalog ID: 10100100094B0901 Quality: 99  Catalog ID: 101001000A223D01 Quality: 99	34% 13% 26% 18%	<b>Path: 120 Row: 61</b> Date: 1990/12/26, ID: LT41200611990360XXX03 Date: 1999/12/03, ID: LE71200611999337SGS00 Date: 2000/05/11, ID: LE71200612000132SGS00 Date: 2001/05/14, ID: LE71200612001134SGS00 Date: 2002/05/17, ID: LE71200612002137SGS00 Date: 2004/07/01, ID: LT51200612004183BKT00 Date: 2005/01/17, ID: LE71200612005017EDC00	40% 18.02% 15.69% 19.63% 6.09% 13% 10.01%

			Date: 2006/09/25, ID: LT51200612006268BKT00	25%
			Date: 2007/04/13, ID: LE71200612007103EDC00	11.29%
			Date: 2008/06/18, ID: LE71200612008170EDC00	23.55%
			Date: 2009/08/08, ID: LE71200612009220EDC00	7.04%
			Date: 2010/07/10, ID: LE71200612010191EDC00	21.28%
			<b>Path: 121 Row: 61</b>	
			Date: 1990/12/01, ID: LT41210611990335XXX03	10%
			Date: 1999/08/20, ID: LE71210611999232SGS00	0.61%
			Date: 2000/12/28, ID: LE71210612000363EDC00	35%
			Date: 2001/06/22, ID: LE71210612001173SGS00	4.39%
			Date: 2002/08/28, ID: LE71210612002240SGS00	0%
			Date: 2003/05/27, ID: LE71210612003147EDC00	25.89%
			Date: 2004/06/22, ID: LT51210612004174BKT00	18%
			Date: 2005/08/12, ID: LT51210612005224BKT00	18%
			Date: 2006/06/04, ID: LE71210612006155EDC00	11.35%
			Date: 2007/08/10, ID: LE71210612007222EDC00	28.77%
			Date: 2008/09/29, ID: LE71210612008273PFS00	14.46%
			Date: 2009/04/25, ID: LE71210612009115EDC00	16.56%

			Date: 2010/06/15, ID: LE71210612010166SGS00	5.06%
Cameroon - Mt Cameroon	-		<b>Path: 187 Row: 57</b>  Date: 1990/11/29, ID: LT41870571990333AAA03 Date: 1992/12/20, ID: LT41870571992355XXX02 Date: 1999/12/08, ID: LE71870571999342EDC00 Date: 2000/12/10, ID: LE71870572000345EDC00 Date: 2001/12/29, ID: LE71870572001363EDC00 Date: 2002/01/30, ID: LE71870572002030EDC00 Date: 2003/01/01, ID: LE71870572003001SGS00 Date: 2005/11/06, ID: LE71870572005310EDC00 Date: 2006/12/27, ID: LE71870572006361EDC00 Date: 2007/12/30, ID: LE71870572007364ASN00 Date: 2008/01/31, ID: LE71870572008031EDC00 Date: 2009/11/17, ID: LE71870572009321EDC00 Date: 2010/04/10, ID: LE71870572010100EDC00	40% 40% 17.58% 15.72% 34.16% 21.55% 17.64% 28.61% 26.79% 47.68% 19.77% 31.37% 13.72%
Cameroon - Nkol Enyeng	-		<b>Path: 184 Row: 58</b>  Date: 2000/03/24, ID: LE71840582000084EDC00 Date: 2001/02/07, ID: LE71840582001038EDC00	20.33% 25.36%

			Date: 2002/12/27, ID: LE71840582002361SGS00	5.33%
			Date: 2003/05/04, ID: LE71840582003124ASN00	12.78%
			Date: 2004/03/19, ID: LE71840582004079ASN01	32.98%
			Date: 2005/05/09, ID: 2005/05/09	44.08%
			Date: 2007/01/07, ID: LE71840582007007ASN00	22.24%
			Date: 2008/03/30, ID: LE71840582008090ASN00	43.56%
			Date: 2009/12/30, ID: LE71840582009364ASN00	9.16%
			Date: 2010/04/21, ID: LE71840582010111ASN00	37.11%
Brazil - Transamazonia	There are multiple images covering different parts of the whole project area for the years <b>2003, 2005, 2008 and 2009</b> . Due to lack of village point locations the exact Catalog IDs can not be reported.		<b>Path: 225 Row: 62</b>	
			Date: 1999/08/12, ID: LE72250621999224EDC00	24.69%
			Date: 2000/08/14, ID: LE72250622000227AGS00	33.00%
			Date: 2001/08/17, ID: LE72250622001229EDC00	15.49%
			Date: 2002/06/17, ID: LE72250622002168EDC00	10.58%
			Date: 2003/05/19, ID: LE72250622003139EDC00	25.42%
			Date: 2004/08/17, ID: LT52250622004230CUB00	18%
			Date: 2005/08/04, ID: LT52250622005216CUB00	5%
			Date: 2006/06/20, ID: LT52250622006171CUB00	0%
			Date: 2007/06/23, ID: LT52250622007174CUB00	0%
			Date: 2008/09/05, ID: LE72250622008249EDC00	6.09%

			Date: 2009/08/07, ID: LE72250622009219EDC00	3.45%
			Date: 2010/07/25, ID: LE72250622010206EDC00	16.33%
			<b>Path: 225 Row: 63</b>	
			Date: 1992/07/07, ID: LT42250631992189XXX02	30%
			Date: 1999/09/29, ID: LE72250631999272EDC00	43.26%
			Date: 2000/05/26, ID: LE72250632000147AGS00	0.47%
			Date: 2001/08/17, ID: LE72250632001229EDC00	0.10%
			Date: 2002/03/29, ID: LE72250632002088AGS01	22.20%
			Date: 2003/05/19, ID: LE72250632003139EDC00	3.88%
			Date: 2004/08/17, ID: LT52250632004230CUB00	2%
			Date: 2005/08/04, ID: LT52250632005216CUB00	0%
			Date: 2006/06/04, ID: LT52250632006155CUB00	0%
			Date: 2007/06/23, ID: LT52250632007174CUB00	0%
			Date: 2009/07/30, ID: LT52250632009211CUB00	11%
			Date: 2010/07/25, ID: LE72250632010206EDC00	2.55%

#### 4.4 Project capacities and monitoring status

Many projects intend to use RS data, but they could not specify the data that they will use (figure 7 – left side). Only three project sites (Kabupaten Ketapang in Indonesia, Cat Tien district in Vietnam and Kilosa in Tanzania) provided details on what type of satellite data they will use for monitoring forest cover change. They mentioned they plan to use Landsat and SPOT data which are medium resolution satellite data (figure 6 – right side). They did not mention high resolution datasets, which are needed for monitoring degradation. The other sites did not provide details on satellite data, but some of them listed the institutions and contact persons who can provide them with data. Among them are some well known remote sensing institutions like IMAZON and the University of Maryland. From the analysis of the proponent appraisals it became apparent that monitoring activities have not started yet in the project sites, or at least this is not reported. The projects seem to be in a very early stage of defining their project goals, strategies and monitoring activities.

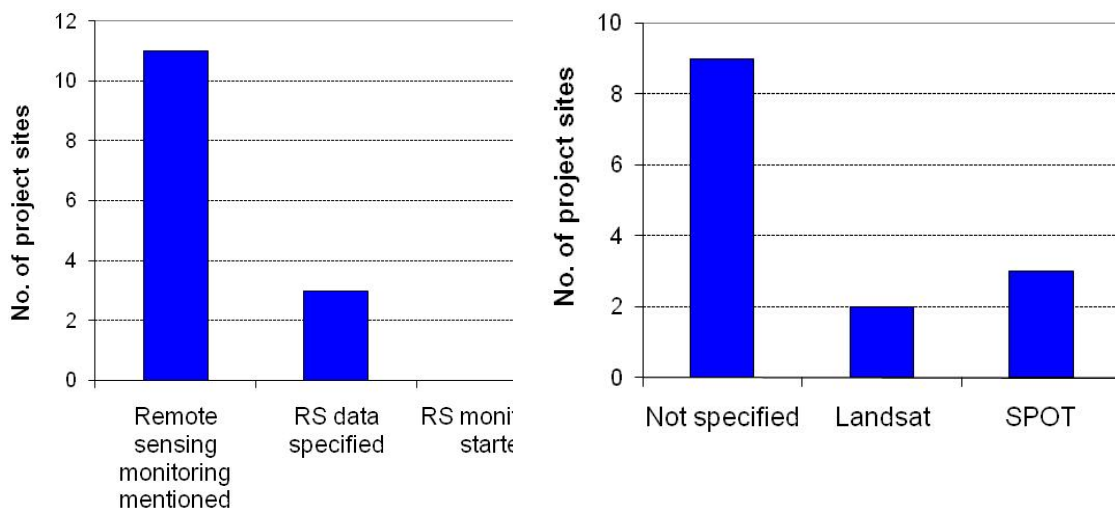


Figure 7. Status of monitoring for assessing forest cover (left side) and availability of satellite data (right side), N=12.

#### 4.5 Link to national level activities

A national REDD+ strategy needs to encourage specific local implementation actions. In this context, a national carbon monitoring system would reflect more detail and accuracy in these action areas, and, more specifically, a national estimation and reporting system needs to include sub-national or action area measurement plans.

In several countries REDD pilot and demonstration projects have already generated some experience and it may be possible to draw lessons from these regarding MRV. However, there are considerable differences between the project and that national approach. Firstly, while the data collected in association with such projects may give important indications of the likely gains and losses of carbon associated with different types of management activity, monitoring at project level often brings with it high costs relating to dealing with leakage and additionality, and there are other transaction



costs involved; in a national approach, apart from benefits of economies of scale, many of these problems may be circumvented.

Secondly, existing pilot projects are local and often specialized in scope, for example located in areas with little or no conflict (i.e. land tenure), in areas of “high-risk, high-carbon” forests, and addressing only one, or a small handful of drivers. Broader issues that are important for REDD+ effectiveness ( e.g. relating to national regulatory frameworks, addressing land use policy, and involving the agriculture and energy sector), are not taken into account, nor, of course, the requirements of national MRV systems and baselines. Thus, the lessons that can be learned from pilot projects may be rather limited in particular for the smaller project sites. A potential problem for many countries in moving from the project scale to the national programme will be incompatibilities with respect to existing definitions of forest, since in many countries woodlands, and particularly secondary and degraded woodlands, and not considered forests and not included in national forest statistics.

Projects can benefit from national level activities with respect to monitoring forest cover change and estimating carbon stocks. Projects could collaborate with national institutions and make use of the national efforts and data sources and, in return, may feed back into the national-level activities. Countries with some available data would be Brazil and Indonesia for example. To address the international requirements from the UNFCCC negotiations and the IPCC GPG the countries studied take different approaches for implementing REDD MRV and are aiming for specific MRV solutions at the national level.

To provide some information on the status of the national MRV activities for each country, results are presented from the Component 3 study (monitoring and reference levels) on national monitoring efforts. Various global information sources were analyzed and different indicators were derived to assess the current national capabilities, and to make recommendations for capacity development for each country. All indicators that were used to assess current monitoring and reporting capacity are presented in table 9 for the 6 country cases.

*Table 9. Country-specific indicators for the case study countries (Herold, 2009).*

Country	Engage-ment in UNFCCC REDD process	Completeness of GHG inventory	Forest area change monitoring capacity	Forest inventory capacity	Remote Sensing technical challenges	Proportion of tree canopy cover > 40%	Amount of intact forest	Importance of fire/ biomass burning	Carbon storage in forest soils
<b>Bolivia</b>	high	advanced	good	very low	low	high	some	medium	some
<b>Brazil</b>	high	advanced	very good	limited	low	high	high	medium	some
<b>Cameroon</b>	medium	low	limited	good	medium	high	some	medium	some
<b>Indonesia</b>	medium	advanced	very good	good	medium	high	some	medium	large
<b>Tanzania</b>	medium	advanced	some	very low	low	low	some	high	some
<b>Vietnam</b>	high	advanced	very good	good	low	medium	some	medium	large

Main findings were that the majority of the countries have limitations in their ability to provide a complete and accurate estimation of forest loss and greenhouse gas (GHG) emissions. The six country cases form a representative sample of all 99 tropical non-Annex I countries. Three of the country cases have limited engagement in the UNFCCC REDD process and lack some experience in application of the IPCC

guidelines. Cameroon has an incomplete estimation and reporting system of national GHG inventories, whereas the other 5 countries have a more complete GHG inventory. The existing capabilities to continuously measure forest area changes and changes in forest carbon stocks as part of a national forest monitoring system differ much between the countries. For some country cases, there is a shortage in availability of useful satellite data sources for REDD monitoring (i.e. Cameroon). This can be due to a lack of receiving stations, persistent cloud cover, seasonality issues, topography or inadequate data access infrastructure. Table 10 summarizes some of the country circumstances for 5 of the country cases. Although the countries have rather similar amount of forest cover remaining, the current rates of deforestation, the issues and problems related to REDD (i.e. drivers) and the approaches taken to address REDD MRV are rather different. Cameroon, Indonesia and Tanzania face particular challenges for REDD implementation, like high current deforestation rates and significant emissions from forest degradation. They require investments for a more comprehensive observation, towards Tier 3 level measurements. This emphasizes that despite the international requirements coming from the UNFCCC negotiations and the IPCC GPG, countries are aiming for specific MRV solutions. More details from the different country cases can be found in appendix 1.

Table 10. Country circumstances for 5 country cases (Herold, 2010).

	Bolivia	Cameroon	Indonesia	Vietnam	Tanzania	Brazil
<b>Land area (1000 ha)</b>	108,438	47,271	181,157	31,007	88,580	832,513
<b>Forest cover 2010 (%)</b>	52.7	42.1	52.1	44.5	37.7	62.4
<b>Deforestation rate (%)</b>						
<b>1990-2000</b>	4.3	9.0	16.1	-25.2	9.7	5.0
<b>2000-2010</b>	4.8	9.9	5.0	-17.7	10.8	4.8
<b>FRA 2010 reporting</b>						
<b>GS/C<sub>AB</sub>/C<sub>BB</sub>/C<sub>DW</sub>/C<sub>L</sub>/C<sub>S</sub><sup>2</sup></b>	2/1/1/-/1/1	2/1/1/-/1/1	2/1/1/-/-	2/1/1/-/1/1	1/1/1/-/1/1	2/2/1/1/1/1

## 4.6 Recommendations by project site

The table on the next pages contains a summary of the information extracted from the proponent appraisals and general recommendations per project site. For intervention objectives (column 3), information was extracted from the “forest intervention goals at village level” (Q27c), if this was not available, information was taken from the “Plans to reduce carbon emissions at project level was taken” (Q9). The monitoring status reports on the intention to use satellite monitoring, which data they plan to use and if monitoring has started already. Required RS data sources are depending on the pressures which you want to monitor. The column potential link with national level contains information on how projects could benefit from national monitoring efforts. The column archived Landsat and Quickbird data summarizes the satellite images that are available per year. The last column of the table contains general recommendations for each project site on how to start the monitoring process.

<sup>2</sup> GS – Growing Stock, C<sub>AB</sub> – Above-ground Biomass Carbon, C<sub>BB</sub> – Below-ground Biomass Carbon, C<sub>DW</sub> – Dead Wood Carbon, C<sub>L</sub> – Litter Carbon, C<sub>S</sub> – Soil Carbon; 1 means Tier 1 data are available, 2 means Tier 2 data are available

Country	REDD+ project site	Pressures on forest & Intervention objectives	Monitoring status	Required RS data sources: depending on pressures	Potential links with national level	Archived satellite data (Landsat / Quickbird)	General recommendations
Brazil	Acre – Feijó Manuel Urbano	<b>Main pressures:</b> not specified; <b>Intervention objectives:</b> Avoid / reduce deforestation, Avoid / reduce degradation, Restore, rehabilitate, or enhance carbon stocks in existing forest, Af/reforest or regenerate new forest	Intend to use satellite monitoring, satellite data from ECUGO, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest area change monitoring:</b> available and useful	Could not be searched, because data on village locations were not available	Obtain more information on main pressures, acquire GIS data on village locations and project boundaries, search for / acquire Landsat and Quickbird data
Brazil	Noroeste de Mato Grosso (Cotriguaçu)	<b>Main pressures:</b> not specified; <b>Intervention objectives:</b> Avoid / reduce deforestation, Avoid / reduce degradation, Restore, rehabilitate, or enhance carbon stocks in existing forest	Intend to use satellite monitoring, deforestation data from IMAZON, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest area change monitoring:</b> available and useful	Could not be searched, because data on village locations were not available	Obtain more information on main pressures, acquire GIS data on village locations and project boundaries, search for / acquire Landsat and Quickbird data
Brazil	Transamazônica	<b>Main pressures:</b> Small-scale traditional agriculture, <b>Intervention objectives:</b> Reduced deforestation, Reduced degradation, Afforestation	Intend to use satellite monitoring, mentioned to only use field surveys to assess forest cover, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest area change monitoring:</b> available and useful	<b>Landsat:</b> Cloudcover <10%: 2005, 2006, 2007, 2008, 2009; Cloudcover 10-50%: 1999-2004, 2010, <b>Quickbird:</b> multiple images for the years 2003, 2005, 2008 and 2009. Due to lack of village point locations the exact Catalog IDs can not be reported.	Acquire archived Landsat and acquire archived Quickbird data

Country	REDD+ project site	Pressures on forest & Intervention objectives	Monitoring status	Required RS data sources: depending on pressures	Potential links with national level	Archived satellite data (Landsat / Quickbird)	General recommendations
Cameroon	CED, Nkol.Enyeng	<b>Main pressures:</b> Small-scale traditional agriculture, Small-scale frontier agriculture, Small-scale illegal timber harvest, Subsistence fuelwood/charcoal collection; <b>Intervention objectives:</b> Reduced deforestation, Reduced degradation, Enhanced stocks, Afforestation	Intend to use satellite monitoring, satellite data from CED and the global land cover facility from the university of Maryland, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest inventory capacity:</b> available and maybe useful	<b>Landsat:</b> Cloudcover <10%: 2002, 2009; Cloudcover 10-50%: 2000, 2001, 2003-2008, 2010, Quickbird: no	Acquire archived Landsat data; acquire new Quickbird data
Cameroon	CED, Nomedjoh	<b>Main pressures:</b> Small-scale traditional agriculture, Small-scale frontier agriculture, Small-scale illegal timber harvest, Subsistence fuelwood/charcoal collection; <b>Intervention objectives:</b> Reduced deforestation, Reduced degradation, Enhanced stocks, Afforestation	Intend to use satellite monitoring, satellite data from CED, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest inventory capacity:</b> available and maybe useful	Could not be searched, because data on village locations were not available	Acquire GIS data on village locations and project boundaries, search for / acquire Landsat and Quickbird data
Cameroon	Mt. Cameroon	<b>Main pressures:</b> Not specified; <b>Intervention objectives:</b> Reduced deforestation, Enhanced stocks, Afforestation	Intend to use satellite monitoring, data not specified, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements		<b>Landsat:</b> Cloudcover 10-50%: 1990, 1992, 1999-2003, 2005-2010, Quickbird: no	Obtain more information on main pressures, acquire archived Landsat data; acquire new Quickbird data

Country	REDD+ project site	Pressures on forest & Intervention objectives	Monitoring status	Required RS data sources: depending on pressures	Potential links with national level	Archived satellite data (Landsat / Quickbird)	General recommendations
Indonesia	Aceh	<b>Main pressures:</b> Not specified; <b>Intervention objectives:</b> Not specified	Intend to use satellite monitoring, data not specified, monitoring not yet started.	?	<b>Forest area change monitoring:</b> available and useful; <b>Forest inventory capacity:</b> available & maybe useful	<b>Landsat:</b> Cloudcover <10%: 2000-2002, 2006; Cloudcover 10-50%: 1999, 2003-2005, 2007, <b>Quickbird:</b> Cloudcover <10%: 2002, 2009; Cloudcover 10-50%: 2008	Obtain more information on main pressures and intervention objectives; Acquire GIS data on village locations and project boundaries, search for / acquire Landsat and Quickbird data
Indonesia	Katupaten Ketapang provinsi Kalimantan Barat, West Kalimantan	<b>Main pressures:</b> Not specified; <b>Intervention objectives:</b> Avoid / reduce deforestation, Avoid / reduce degradation	Intend to use satellite monitoring, Landsat and SPOT data, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data	<b>Forest area change monitoring:</b> available and useful; <b>Forest inventory capacity:</b> available & maybe useful	<b>Landsat:</b> Cloudcover <10%: 2002, 2005, 2009; Cloudcover 10-50%: 1990, 1999-2001, 2004, 2006-2008, 2010, <b>Quickbird:</b> Cloudcover: 10-50%: 2008, 2009	Obtain more information on main pressures, acquire archived Landsat and acquire archived Quickbird data
Indonesia	KFCP, Kapuas District, Central Kalimantan	<b>Main pressures:</b> Large-scale plantations, Small-scale traditional agriculture, Small-scale frontier agriculture, Small-scale illegal timber harvest, Non-wood forest products harvesting, Other (forest fire, gold mining, roads, large scale development); <b>Intervention objectives:</b> Reduced degradation, Enhanced stocks	Not specified, they need to ask their contact person.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest area change monitoring:</b> available and useful; <b>Forest inventory capacity:</b> available & maybe useful	<b>Landsat:</b> Cloudcover <10%: 2000, 2001, 2003, 2005; Cloudcover 10-50%: 1999, 2002, 2004, 2006-2009, <b>Quickbird:</b> Cloudcover >50%: 2008	Acquire archived Landsat and acquire archived Quickbird data

Country	REDD+ project site	Pressures on forest & Intervention objectives	Monitoring status	Required RS data sources: depending on pressures	Potential links with national level	Archived satellite data (Landsat / Quickbird)	General recommendations
Vietnam	Cat Tien district, Lam Dong province	<b>Main pressures:</b> Small-scale traditional agriculture, Small-scale illegal timber harvest; <b>Intervention objectives:</b> Reduced deforestation	Intend to use satellite monitoring, SPOT data, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest area change monitoring:</b> available and useful; <b>Forest inventory capacity:</b> available & maybe useful	Could not be searched, because data on village locations were not available	Acquire GIS data on village locations and project boundaries, search for / acquire Landsat and Quickbird data
Tanzania	TaTEDO Kahama	<b>Main pressures:</b> Not specified; <b>Intervention objectives:</b> Avoid / reduce deforestation, Avoid / reduce degradation, Restore, rehabilitate, or enhance carbon stocks in existing forest	Intend to use satellite monitoring, data not specified, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest area change monitoring:</b> available and useful; <b>Forest inventory capacity:</b> available & maybe useful	<b>Landsat:</b> Cloudcover <10%: 1994, 1995, 1999-2003, 2008-2010, Quickbird: no	Obtain more information on main pressures, acquire archived Landsat data; acquire new Quickbird data
Tanzania	Kilosa	<b>Main pressures:</b> Not specified; <b>Intervention objectives:</b> Reduced deforestation, Reduced degradation, Enhanced stocks	Intend to use satellite monitoring, Landsat and SPOT data, monitoring not yet started.	Medium resolution satellite data, high resolution satellite data, ground measurements	<b>Forest area change monitoring:</b> available and useful; <b>Forest inventory capacity:</b> available & maybe useful	<b>Landsat:</b> Cloudcover <10%: 1994, 1995, 1999-2003, 2008-2010, Quickbird: no	Obtain more information on main pressures, acquire archived Landsat data; acquire new Quickbird data

## **4.7 Capacities at CIFOR**

The GIS and RS unit at CIFOR is part of the information services unit. They have the capacity (office, software and human resources) to work on small projects. If they need to work on larger projects, the work is outsourced to other companies so additional people can work on it, or dedicated technical project staff is being hired temporarily.

There is expertise with the use of GIS and remote sensing software. They have ArcGIS 9.3 licenses and there is 1 Erdas license. The remote sensing software programme ER mapper (an old version) is used for classification and Idrisi is used to track and model land cover change. There is expertise in acquiring and working with Landsat images for smaller areas. There is also expertise with the use of several models, like Geomod and Clue model to track land use change or to assess land suitability and drivers.

Given the amount of data processing and analysis work to be performed, it requires additional well trained staff to support the component 2 work (in collaboration with component 3). A post-doc is intended to be hired (see section 4.10). In addition, CIFOR may consider the suggestions made in section 4.8 to further ensure the building of technical capacities for C2 implementation.

## **4.8 Institutional collaborations**

To increase the capacities and seek synergies with international expert groups the following four options should be considered:

1. **Expanding in house capacities:** current CIFOR staff has capacities to implement smaller remote sensing tasks; larger ones are commonly outsourced. The GCS C2 work requires substantial remote sensing work and, if desired, CIFOR could upgrade its in-house capabilities in terms of both technical and human resources to directly benefit the implementation of GCS and beyond. Depending on the expertise and focus of the new, to be acquired post-doc, additional training or technical support staff may be needed.
2. **Cooperation with project proponents:** the monitoring of some of the project sites is implemented by well known international institutions such as IMAZON or the University of Maryland. It is advised to build strong cooperation with these groups to benefit in terms of local experience, technical expertise and available data and methods, and thus reduce the efforts needed in C2 monitoring work.
3. **Consideration of national level activities:** As indicated in section 4.5, national investments in MRV system are happening with different levels of initial capacities, capacity building programs and active monitoring implementation. Linkage and joint benefits should be sought on a case by case basis.

4. **Engagement with international expert teams and initiatives:** depending on the area and additional expertise needed, CIFOR could consider to expand or build partnerships with international partners such as those already active in the GCS and others to look for help and synergies. Some regional and global monitoring activities are ongoing, however, it should be considered that the level of detail and certainty they provide is commonly not suitable for specific local studies and applications.

#### **4.9 Budget considerations**

For remote sensing work the several cost factors affecting the budget have to be considered. They include:

- a) Satellite data including data access and processing;
- b) Software, hardware and office resources;
- c) Human resources for data interpretation and analysis;
- d) Monitoring implementation;
- e) Accuracy assessment.

Costs for satellite data are provided in per sq km units, thus countries may estimate potential data cost based on their size. These costs are added up for each new survey, thus more frequent monitoring results in more cost for data. All image data sets by Landsat are made available free of charge and are publicly accessible through the world wide web.

Fine resolution (< 5m) data, such as those collected from commercial sensors (e.g., IKONOS, QuickBird, SPOT-5, KOMPSAT, WORLDVIEW 2) and aircraft, can be prohibitively expensive to cover large areas. However, these data can be used to detect small-scale changes for analyzing medium resolution data and to verify the results, that is, checking the interpretation of satellite imagery or for assessing the accuracy. Such data may also be efficiently used for sampling approaches over larger areas or for detailed local surveys. The cost for such data range between 2-30 \$/km.

Resources for hardware, software and office resources add to the basic set-up costs. Depending on the size of the image processing and analysis unit, this involves:

- a) Workstations for data interpretation (one per interpreter);
- b) Backup system;
- c) In and output devices (scanner, printer, plotter);
- d) Image analysis software (one per interpreter);
- e) Geographic Information System (GIS) software;
- f) Travel (field surveys, conferences);
- g) Field work equipment, i.e. accuracy assessments (cars, GPS, handheld devices etc. - could to be shared with ground team measuring carbon stocks);
- h) Office resources: consumables, rent, equipment, and administrative support.

Assuming that the cost for human resources and monitoring implementation are covered by the post-doc and available (perhaps additional) CIFOR staff and available hard and software, an “average” requirement for a project site where the monitoring of activities can be achieved with remote sensing data alone, the estimated budget may look like this:



<b>Cost item</b>	<b>Cost estimation (US\$)</b>
<b>Data</b>	
Landsat	--
Very-high resolution (4 images)	15.000
Buying additional data (project, national datasets etc.)	1.000
<b>Field work for calibration/validation</b>	
2 field surveys	4.000
<b>TOTAL</b>	<b>20.000</b>

The estimation of (on average) 4 images per project site is based on the assumption that the area covered by such data is small (i.e. 11x11 km) and to cover both the intervention and control sites/villages at 2 points in time (to detect change) and to provide validation of any field or coarser resolution data work. It may also be the case that 1 control and/or intervention site may need to be covered more than twice to track specific activities.

If field carbon measurement field work is needed, the cost to undertake a forest carbon inventory depends heavily on the extent of the study area, the variability of vegetation and the accessibility of the sample locations. The cost of a forest carbon inventory includes the cost for equipment, travel to the study area and other logistic expenses (car rental, accommodation, etc.), the salary for the staff members and for the field workers. As a rule of thumb, it is possible to budget an average cost of 100 US\$ per plot, but the real cost can be defined only after the definition of the study area.

#### **4.10 ToR for post-doc**

##### DRAFT TERMS OF REFERENCE

Post doctoral fellowship on the Effectiveness of REDD Project Sites

Global Comparative Study on REDD – Components 2 and 3

##### Background:

The international community now recognizes reducing emissions from deforestation and forest degradation (REDD) as a critical component of national and international strategies for mitigating climate change. To support the endeavor of producing a post-2012 climate treaty, CIFOR is conducting a four-year global comparative research project on first-generation REDD project sites and national REDD initiatives in selected countries across Latin America, Africa, and Asia. The goal is to provide REDD policy-makers and practitioner communities with the information, analysis and tools they need to ensure effective and cost-efficient reduction of carbon emissions with equitable impacts and co-benefits. The project consists of four components: (1)

national REDD initiatives (policy processes and strategies); (2) REDD project sites; (3) monitoring and reference levels; and (4) knowledge sharing.

Skills sought:

A gifted researcher with strong background in: GIS/remote sensing analysis of forest cover change; and analysis of the underlying causes drivers of land cover change on the local and regional level. Candidacy is favored if there is also background in analysis of forest carbon, ground measurements and systems for Monitoring, Reporting, and Verification Systems (MRV). A PhD in a relevant field is required.

Period of the fellowship:

Two and a half years, or from the date of hiring until June 2013.

Specific aims of the fellowship:

The post doctoral fellow will be responsible for measuring the effectiveness of REDD project sites in reducing emissions of carbon. The post is a joint appointment with Component 2 (REDD project sites) and Component 3 (monitoring and reference levels) in the Global Comparative Study on REDD (GCS-REDD). The work will be largely based on using measurements at 20-30 REDD project sites in Bolivia, Brazil, Cameroon, Tanzania, Indonesia, and Vietnam and conducting additional surveys using remote sensing primarily and accompanying field surveys. The approach is semi-experimental and the scientist will work with local partners to undertake the measurement and monitoring activities. Comparisons will be made before and after implementation of REDD and incentives, and between intervention and control sites. The candidate is expected to work in a team as part of the CIFOR GCS, with local partners, and international research organizations focusing on remote sensing and forest carbon monitoring.

Terms of reference:

- In the period prior to the application of REDD incentives (2010):
  - Assemble remote sensing and GIS imagery at 20-30 REDD project sites (including both intervention and control locations) through collaboration with REDD proponent organizations and various national and international research organizations.
  - Assemble site-level information on the causes of deforestation and degradation and the approaches pursued by proponents to reduce deforestation and degradation.
  - Assemble information at project sites on carbon stocks and changes (emission factors), reference levels and on approaches for measuring carbon flux over time.
  - Lead the analysis for control and intervention sites for a set of project sites.

- Create a database using these sets of data to lay the foundation for analysis of REDD effectiveness.
- Participate in regional workshops to raise the capacity of project proponents in MRV.
- Collaborate closely with colleagues working analysis of efficiency, equity, and co-benefits in REDD.
- In the period after the application of REDD project incentives (2012) make another round of collection of the three types of data specified above.
- Conduct analysis on the basis of the before-after/control-intervention (BACI ) model.
- Produce journal articles, research reports, and policy briefs.
- Perform other tasks as requested.

The post doctoral fellow will work under the direction of Dr. William Sunderlin (Component 2) and Dr. Lou Verchot(Component 3).

## 5 Conclusions

The study has provided an overview for monitoring requirements to measure the effectiveness of local REDD implementation for a series of project sites studied as part of the REDD global comparative study. The work performed provided results in the areas of:

- Use of remote sensing for monitoring and related requirements
- Available satellite data sources for monitoring
- Project capacities and monitoring status
- Link to national level activities
- Recommendations by project site
- Considerations for capacities, institutional collaborations, budgets and a post-doc

Detailed recommendations have been derived for each of the project sites based on the current status of available data and information. For several project sites key information is missing on the pressures on the forest and the forest intervention goals at the village level. For the sites in Cameroon information is missing on the drivers of deforestation at project level. Also, the status of monitoring progress is not clear for several sites as well as an overview of available or intended monitoring and data sources. For some project sites GIS data on project boundaries and/or village locations are not yet available. It is recommended to fill the gaps and to try to obtain more information on monitoring plans and data (and eventually data sharing) from the project proponents.

Since the GCS is aiming to build upon remote sensing, it is important to note that almost all projects intend to use RS data. However, they have not started their monitoring activities yet, or at least it is not reported. Some proponents mentioned they will collaborate with well known remote sensing institutions like IMAZON and the University of Maryland. The few sites that reported the use of satellite data mentioned they intend to use Landsat and SPOT data. No very high resolution

datasets were mentioned, but this can also be due to lack of information. Based on the analysis here, very high resolution data and field surveys will likely be needed, with which costs are involved depending on the amount and type of images. Also benefits should be sought with national efforts for data sharing.

Many sites intend to make monitoring progress in the next 6 months, so continuous interaction with project proponents is important. Perhaps it is good to start with 1 or 2 “good” project sites. These could be the site KFCP, Kapuas District, Central Kalimantan (Indonesia) or Transamazonia (Brazil), because for these sites the information was most complete and Landsat and Quickbird images are available.

The study further highlighted that the issue of monitoring should also be considered regarding village selection. The definition of intervention versus control villages in terms of their location, distance, representativity (within the project or nationally), what activities to verify and when the project interventions will start has strong implications for the monitoring activities. The report has outlined some of those implications. It is important to establish a close link with monitoring experts of the project sites and there is need and opportunity for joint component activities.

Concerning the latter point the current understanding of the complexity of forest carbon changes (drivers, processes, actors, factors and impacts) seems to be a common ground between the different components with potential to link:

- C1-C3: National policy priorities and learning, and monitoring implications (capacity development, information flows, interim performance indicators),
- C1-C2: Role and experiences from local demonstration and implementation in the context of national priorities and strategies,
- C2-C3: Framework for both national and sub-national monitoring to track key activities and safeguards (leakage, permanence, transparency etc.).

## **6 Acknowledgement**

We would like to thank the people at CIFOR who gave us a warm welcome and collaborated on the project and helped us with sharing their data and knowledge. Thanks to William and Lou for the opportunity to create a closer link between component 2 and 3 of the global comparative study, Rosita for all the organizational arrangements, Sita and Cecilia for the information about the projects and the proponent appraisals and Agus and Atie for information and data on village points and project boundaries.

NORAD is thankfully acknowledged for support the Global Comparative Study on REDD where this work has been performed.

## 7 References

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## Appendix 1. Specific country profiles

Vietnam		<i>Land area: 310,070 km<sup>2</sup> (FRA 2010)</i> <i>Forest cover: 44.5 % (FRA 2010)</i>
<b><i>Current national forest area monitoring and carbon stock assessment</i></b>		
Forest area change monitoring	Monitoring of forest cover (through the National Forest Inventory Monitoring and Assessment Program, NFIMAP) follows a 5-year cycle and has been started in 1991. Vietnam jointly uses remote sensing and field data. Degradation is considered a serious issue in Vietnam and has been observed in all regions. The annual forest area change rate (2000-2010) has been estimated as 1.8% per year, indicating a considerable increase in total forest area. However, this increase is mainly attributed to expanding plantation forests, regenerating grass/shrub land and to a statistical effect. Actually, a continuous loss of natural forests can be assumed for Vietnam. The country's JPD reports (referring to 2004) only 4.6% remaining rich closed-canopy forest, whereas more than two-thirds of the natural forests are considered poor or regenerating i.e. degraded.	
Responsible institutions	The Forest Inventory and Planning Institute (FIPI) under the <b>Ministry of Agriculture and Rural Development</b> (MARD) is responsible for forest monitoring, inventories and also for the FRA reporting to the FAO. MARD coordinates all activities related to Vietnam's forests and hosts two departments, the <b>Forest Protection Department</b> (FPD) responsible for forest protection and forest law enforcement and the <b>Department of Forestry</b> (DoF) that provides annual monitoring reports and is in charge of forest management and development. At the provincial level, Departments of Agriculture and Rural Development (DARD) represent MARD. at the district level economic or agricultural divisions are entrusted with forest management. The <b>Ministry of Natural Resources and Environment</b> (MONRE) is responsible for biodiversity conservation and general land use inventories and chairs the National Working Group on Climate Change, which conducts consultation on developing REDD programs and stakeholder involvement. REDD participation of Vietnam is rated high (UNFCCC National Communication, REDD submission, R-PIN), the country is engaged in the Southeast Asia Regional Research and Information Network (SEARRIN) and formulated an NFA within the framework of FAO's NFMA project, and is a pilot country in the UN REDD Programme.	
Available remote sensing data	Satellite remote sensing data from Landsat TM, SPOT and CBERS sensors are available for the entire country. The FIPI has completed three Cycles of NFIMAP (1991-1995, 1996-2000 and 2001-2005) and is currently conducting the fourth Cycle (2006-2010). Each cycle has used progressively more advanced satellite imagery. Cycle 1 (1991-1995) used 30m x 30m resolution Landsat TM imagery to make forest cover maps at scale of 1:250,000, Cycle 2 (1996-2000) used 20m x 20m resolution Spot imagery to establish forest cover maps at 1:100,000 and Cycle 3 (2001-2005) used Landsat ETM to produce forest cover maps at 1:100,000. Cycle 4 is using Spot 5 imagery with a resolution of 2.5m x 2.5m to create forest cover maps up to 1:25,000.	
Drivers	<b>Smallholder agriculture</b> forms the livelihood of many Vietnamese (> 72% of the people lives in rural areas) and is of primary importance in respect of the conversion of forest into agricultural land and forest degradation. Given the rather inefficient cultivation practices and a high <b>population growth</b> rate, deforestation	

Carbon measurements	<p>and forest degradation will be a constant threat. <b>Agricultural goods for export</b> revenue (especially coffee, cashew, pepper) add to the demand for farmland. Furthermore, the plans to improve the country's infrastructure by means of <b>road construction and hydropower</b> utilization to support <b>economic development</b> will affect forested areas and can contribute to a potential increase of pressure on forest land by providing better accessibility. <b>Deficient law enforcement, land tenure issues and corruption</b> facilitate <b>illegal logging</b> activities (30-50,000 forest violations yearly are estimated)</p> <p>There is no national estimate of carbon emissions from deforestation and forest degradation available for Vietnam. Indicative values were reported with Vietnam's draft Second National Communication to the UNFCCC. Vietnam and FAO collaborate within the NFMA program. Data for the estimation of forest biomass and forest carbon stocks is not collected within NFIMAP (with the possible exception of living biomass of forest trees, available data is inconsistent) and the existing program is inadequate for the monitoring of forest degradation.</p>
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<b>Bolivia</b> <span style="float: right;"><i>Land area: 1,084,380 km<sup>2</sup> (FRA 2010)</i> <i>Forest cover: 52.7 % (FRA 2010)</i></span>	
<b><i>Current national forest area monitoring and carbon stock assessment</i></b>	
Forest area change monitoring	<p>Annual deforestation rate is estimated at 0.5% annually in the period 2000-2010 (FRA 2010). The monitoring of deforestation uses methodology of INPE/Brazil and is focused rather on illegal interventions than on the detection of area changes. The Forests Superintendence implemented a monitoring system in 2005. Hot spot areas of deforestation in Bolivia are known.</p>
Responsible institutions	<p>The <b>Vice-Ministry of Environment, Biodiversity and Climate Change</b> (part of the Ministry of Environment and Water) is in charge of developing and implementing policies, plans, programs and projects related to climate change that are deployed by the General-Directorate for Environment and Climate Change and the National Climate Change Program. Under the umbrella of the Ministry of Rural Development and Land two agencies are important for the REDD+ process, the <b>Vice-Ministry of Forest Management and Development</b> and the <b>Authority for Social Control of Forests and Land (ATB)</b>. The former is in charge with policy definition and implementation (through the Directorate-General for Forestry) regarding forest preservation and sustainable management. The ATB is the successor of the Forest Superintendence and the Agricultural Superintendence and responsible for the monitoring and prevention of deforestation, forest degradation and for the promotion and control of sustainable use of forest resources. It also reports to the FAO for FRA. The Vice Ministries of Environment, Biodiversity and Climate Change/Forest Management and Development established a bi-ministerial co-operation developing the National Forest and Climate Change Strategy and its REDD+ component. Bolivia pays special attention to the participation of indigenous people and native communities and intends to promote their involvement via the <b>National Institute for Agrarian Reform (INRA)</b>, which is responsible to create a viable socio-economic base through the (re-)distribution of lands and the coordination of associated policies and programs. Engagement of Bolivia in the REDD process is high (National Communication to the UNFCCC, several REDD submissions to</p>

	<p>SBSTA, R-PIN to FCPF), it is one of the nine pilot country in the UN-REDD Programme. A bi-lateral co-operation with Cameroon exists aiming at technology transfer for emission accounting and the development of reference emission scenarios that was initiated in 2007.</p>
Available remote sensing data	<p>Bolivia is regularly covered by Landsat and CBERS sensors. However, optical satellite imagery is affected by high cloud coverage (mean annual: 57%), recent cloud-free SPOT data (2006-2008) is only available for about one-quarter of the county area in average and also cloud-free historical SPOT data is only available for one year during the 1990-2005 period. The approach used to detect deforestation in Bolivia is currently based on MODIS data and considered unsuitable to accurately quantify forest area change. To update the national database (since 2005) processing of Landsat and CBERS imagery is conducted by the Noel Kempff National History Museum (MHNKM). Furthermore, ALOS data is explored to complement degradation assessment for dry deciduous forests (optical data suffering from seasonality effects).</p>
Drivers	<p>The <b>expansion of agricultural lands</b> is the primary cause of deforestation in Bolivia driven by various incentives for agricultural utilization of lands (e.g. through an increasing demand for food and other agricultural products on domestic and international markets on the one side, and lack of knowledge, funding and assistance to make use of the economic potential of forests on the other side). Another major driver is <b>illegal logging</b> – actors benefit from weak law enforcement and governance, corruption and unclear land tenure. The <b>development of public infrastructure</b> (construction of roads, pipelines, electrification) and forest fires also contribute to deforestation and forest degradation. The <b>domestic use of (fuel) wood</b> and <b>unsustainable management practices</b> occurring also within the framework of <b>legal forestry activities</b> add to the processes driving forest degradation.</p>
Carbon measurements	<p>GHG emissions from the LULUCF sector were estimated for 1990, 1994, 1998 and 2000. These emissions were progressively increasing up to nearly 45 million tonnes of CO<sub>2</sub>. Bolivia has 540 permanent plots of biomass that are periodically re-measured. They are monitored to roughly equal parts by the Bolivian Institute of Forest Research (IBIF) and the Fundación Amigos de la Naturaleza (FAN) Bolivia. However, until now Bolivia was not able to establish a comprehensive national biomass inventory covering all forest types. This is due to the high diversity of forests in Bolivia with a broad range of biomass. All forest concessions have forest inventories (5-year frequency) as specified by Bolivian forest law but a central register is currently not implemented. Impact of degradation is not monitored operationally but currently investigated using methodology based on Normalized Difference Fractions Index (NDFI).</p>

<b>Indonesia</b>	<p><i>Land area: 1,811,570 km<sup>2</sup> (FRA 2010)</i>  <i>Forest cover: 52.1 % (FRA 2010)</i></p>
<b><i>Current national forest area monitoring and carbon stock assessment</i></b>	
Forest area change monitoring	<p>The control of forest and protected areas in Indonesia is generally weak despite large personnel numbers and good education and training. Forest inventory statistics were based on a national forest inventory carried out between 1990-1994 with regional updates applied in 1996-2000. Remote Sensing capacity in</p>



Responsible institutions	<p>Indonesia is high because land cover maps and deforestation measurements were done by using Landsat imagery. For covering total land area about 350 Landsat scenes are required. Integration between central institutions (such as a national forest inventory) and regional capacity is lacking and needs improvement.</p> <p>The <b>Ministry of Environment (MoE)</b> develops the environmental policy, its responsibility for the collaboration with the UNFCCC transferred to the <b>National Council on Climate Change (DNPI)</b>. The DNPI was created in 2008 and beyond its assignment for negotiations with the UNFCCC is in charge of the coordination among various government agencies, The DNPI consists of six working groups (adaptation, mitigation, technology transfer, finance, forestry, post-Kyoto mechanisms). The <b>National Development and Planning Agency (BAPENNAS)</b> is responsible for the coordination and implementation of bi- or multilateral cooperation (both technical and financial). The <b>Ministry of Forestry (MoFor)</b> has a leading role for the REDD process in Indonesia. In 2007 it established the <b>Indonesian Forest Climate Alliance (IFCA)</b> which started efforts for REDD readiness. Furthermore, MoFor provides guidance for the implementation of the national REDD policy and developed the Indonesian National Carbon Accounting System (NCAS) and the Forest Resources Information System (FRIS) which will serve for monitoring and reporting purposes as well as for payment mechanism. It provides REDD support through the development of various projects. MoFor is responsible for planning, management and monitoring of the forestry sector</p> <p>Indonesia was among the first countries that submitted a R-PP to the FCPF and belongs to the member countries of the UN-REDD Programme, Indonesia is also is engaged in the GOFC-GOLD SEARRIN Regional Network.</p>
Available remote sensing data	<p>Indonesia is regularly covered by Landsat TM &amp; CBERS. For monitoring land cover/forest cover and degradation satellite imagery, basically Landsat TM is used. The country experiences persistent cloud coverage. In the long-term yearly average, 84,55 % of the country is covered by clouds.</p>
Drivers	<p>Indonesian forests suffer from severe impact of <b>illegal logging</b> due to weak governance, corruption and poor law enforcement. It is known that import data for various countries differ significantly from officially reported Indonesian exports, typically the imports exceeded the exports by a factor of three to five (Schroeder-Wildberg &amp; Carius 2003). It is estimated that about 80% of the timber logged in Indonesia is illegal. Domestic and international demand and the production capacity of mills lie far above the licensed (legal) or the sustainably reachable supply. <b>Expanding plantation areas</b> required to meet the <b>demands of the pulp and paper and the palm oil industry</b> are another factor leading to deforestation of primary forest. Since peat soils are considerably more productive than mineral soils, carbon emissions are exceptionally high on these preferred sites.</p> <p><b>Smallholder agriculture</b> and <b>forest fires</b> belong also to major drivers of deforestation and forest degradation in Indonesia. Fires are used to clear areas for agricultural purposes (small scale farming as well as plantation planting); they spread easily into already logged-over forest areas and are able to ignite the peat soils where they can persist a long time continuously releasing large amounts of carbon into the atmosphere. Fire impact can become particularly threatening in drought periods as occurring with El Niño events.</p>
Carbon measurements	<p>Carbon stocks were estimated using Tier 1 default factors in the FAO FRA 2010. Indonesia did not report GHG emissions from forestry in their national Communication to UNFCCC in 1999. Permanent measurement plot exists, but there is some inventory capacity. GMES carries out GHG inventories for five pilot</p>

areas. Inventories on national level are not available; NGOs implemented several project-based initiatives. There is a lack of technical capacity throughout the forestry sector. The NCAS is set to monitor terrestrial carbon and other terrestrial GHG emissions. The consideration of biomass, soil and litter carbon pools for forested and agricultural lands is intended. For the purpose of forest monitoring and the associated assessment and reporting

<b>Cameroon</b>		<i>Land area: 472,710 km<sup>2</sup> (FRA 2010)</i> <i>Forest cover: 42.1 % (FRA 2010)</i>
<b><i>Current national forest area monitoring and carbon stock assessment</i></b>		
Forest area change monitoring	A MINFOF (Ministry of Forestry and Wildlife)/WRI (World Resources Institute) collaboration through their GFW (Global Forest Watch) initiative, is currently the only forest monitoring programme. The GFW project is limited to the monitoring of the PFD (Permanent Forest Domain), the nPFD (non-Permanent Forest Domain) is not monitored although being more susceptible to deforestation and forest degradation. A national forest program is being implemented since 2004. Deforestation rates are estimated at 1% of forest cover loss per year for the period 2000-2010.	
Responsible institutions	UNFCCC related activities and monitoring of conservation activities are coordinated by <b>MINEP (Ministry of Environment and Nature Protection)</b> that is responsible for the REDD+ framework leading the <b>National REDD Steering Committee</b> . MINFOF is in charge of forest monitoring and forest inventories, the management of protected areas, the legal framework of forestry, carries out FRA reporting to the FAO and holds a co-chair in the National REDD steering Committee. Cameroon is highly engaged in the REDD initiative (UNFCCC National Communication, SBSTA submissions, R-PIN) and participates in the regional GOFC-GOLD network OSFAC (Observatoire Satellital des Forêts d'Afrique Centrale) and (together with other central African countries) in the Central African Forest Commission (COMIFAC). A south-south co-operation with Bolivia was initiated in 2007 by GTZ to facilitate technology transfer. Recently (May 2010) Cameroon signed a Voluntary Partnership Agreement with the EU, an instrument under the FLEGT (Forest Law Enforcement, Governance and Trade) Action Plan obliging the country to trade only legal timber.	
Available remote sensing data	Several small-scale remote sensing operations have been developed by the FAO and the Observatory for Central African Forests (OFAC). Given the limited availability of good quality satellite imagery ascertained for SPOT and ASTER data, currently DMC (Disaster Monitoring Constellation) images are analyzed, which were acquired in collaboration with GTZ in the framework of a multi-user partnership. Recent Landsat data is not available since the central African region lacks a receiving station.	
Drivers	The single most important driver for deforestation and forest degradation is the <b>development of agricultural activities</b> mostly based on slash and burn practice. <b>Population growth</b> increases the pressure on forests, promotes the conversion into agricultural land and is itself stimulated locally through the <b>development of the mining sector</b> (bauxite, cobalt, iron). National strategies for <b>economic development and poverty alleviation</b> include also the construction of roads that	

Carbon measurements	<p>may facilitate the expansion of deforestation and forest degradation activities into currently well protected areas. Unsustainable <b>extraction of fuelwood</b> may contribute (with unknown but distinct impact especially within mosaicked and savannah landscapes) as may the <b>illegal exploitation of timber</b>. The <b>industrial exploitation with inappropriate management practices</b> today became less important thanks to the efforts towards forest certification and reasonable forest management, e.g. in the framework of FLEGT. The impact of <b>forest fires</b> is also rated less significant since large scale forest fires are rather uncommon, though they certainly possess a major threat potential in the forest/savannah transition zone.</p> <p>Carbon emission estimations from deforestation and forest degradation provided with Cameroon’s national communication to the UNFCCC are not considered reliable. A national inventory is available from 2003/2004, developed with the assistance of FAO. Cameroon received funding in the framework of FAO’s National Forest Monitoring and Assessment (NFMA) project. Following Hardcastle et al. (2008) the forest inventory capacity developed in collaboration with FAO arrived at the level of IPCC Tier 2. Furthermore, a REDD pilot project in Cameroon aims to develop a national biomass and GHG emissions inventory for the forestry sector and to establish a national biomass inventory and monitoring system.</p>
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<b>Tanzania</b>		<i>Land area: 885,80 km<sup>2</sup> (FRA 2010) Forest cover: 37.7 % (FRA 2010)</i>
<b><i>Current national forest area monitoring and carbon stock assessment</i></b>		
Forest area change monitoring	Several land cover/land use maps are available for different regions of Tanzania. For eastern Tanzania 2,800 forest plots and 500 km of forest disturbance transects were assessed with help of the GEF. Tanzania collaborates with the FAO work NFMA and its NFA is implemented but not yet completed. A National Forest Database (NAFOBEDA) and a National Forest Assessment and Monitoring Programme (NAFORMA) will be established with assistance from the UN-REDD Programme. FAO estimates the deforestation rate at 1.1% of forest cover annually for the 2000-2010 period.	
Responsible institutions	The Forestry and Beekeeping Division (FBD) of the Ministry of Natural Resources and Tourism (MNRT) coordinates monitoring, forest inventories and law enforcement. Latest FRA reporting was conducted by FBD in collaboration with the Tanzania Forest Conservation and Management Project. Other agencies (Wildlife Division of MNRT, Tanzania National Parks Agency - TANAPA) participate in forest management through their responsibility for various reserves and national parks. A separate forest agency (Department of Commercial Crops, Fruits and Forestry) exists for the island of Zanzibar. The country is highly engaged in the REDD process; Tanzania currently (May 2010) prepares an R-PP for the FCFP, submitted a national communication to the UNFCCC and participates in the Southern African Fire Network (SAFNet) as well as in the Miombo Network. As one of the nine pilot countries participating in the UN REDD Programme, Tanzania also submitted a National Joint Programme Document.	
Available remote sensing	Landsat data is available for the whole country area, CBERS covers about 73% of Tanzania. Availability of good quality imagery may be constrained by the high	

data	degree of mean annual cloud coverage (55%). Sokoine University of Agriculture and Ardhi University are supposed to have remote sensing maps available at 5 years intervals since 2000 and 1990 respectively.
Drivers	A growing population primarily dependent on natural resources and a shortage for foreign exchange drive a number of factors contributing to deforestation and forest degradation. These underlying causes result in expanding smallholder and commercial agriculture, a growing demand for construction wood and energy, the latter usually met by charcoal and fuel wood. Weak/corrupt governance and unclear land tenure further aggravate this situation. Moreover, preparation of areas for cultivation and charcoal production trigger forest fires. Both, charcoal production itself and forest fires (among over-grazing) are largely responsible for forest degradation. A recent trend threatening Tanzanian forests are the increasing areas for bio-fuel production. More activities aiming at an improved economic/infrastructural development (e.g. construction of roads, mining) are mentionable as they facilitate deforestation and forest degradation opening up land areas and new livelihoods. Among the national and international factors, there was also a regional component affecting Tanzania as parts of the country suffered from the large number of civil war refugees (Burundi, DRC, Rwanda) that were seeking sanctuary at the beginning of the millennium.
Carbon measurements	National carbon emissions from deforestation and forest degradation in Tanzania are unknown. Smaller scale studies were conducted for the Eastern Arc Mountains and lowland coastal forests, and for a few of the reserved areas of woodlands. It is estimated that 500,000 ha of forests and woodlands are degraded annually but the impact on carbon stocks is unknown. No thorough national forest inventory data is available. In the period 1971-73 FBD inventoried natural forests and woodlands in Mtwara, Kilimanjaro, Tabora, Tanga regions and in the Kilombaro district. However, Tanzania is working on conducting a national forest inventory in partnership with FAO's NFMA project until 2010. GHG inventory has been reported to UNFCCC based on Tier 1.