EXPERIENCES IN CAPACITY BUILDING ON FOREST MONITORING AT THE NATIONAL LEVEL: THE FCMC PERU MRV ACTIVITY

FOREST CARBON, MARKETS AND COMMUNITIES (FCMC) PROGRAM

APRIL 2015

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The U.S. Agency for International Development (USAID) launched the Forest Carbon, Markets and Communities (FCMC) Program to provide its missions, partner governments, and local and international stakeholders with assistance in developing and implementing REDD+ initiatives. FCMC services include analysis, evaluation, tools, and guidance for program design support; training materials; and meeting and workshop development and facilitation that support U.S. Government contributions to international REDD+ architecture.

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ACRONYMS AND ABBREVIATIONS

CI	Conservation International
CIFOR	Center for International Forestry Research
COP	Conference of the Parties
DETER	Real-time Detection of Deforestation
FAO	Food and Agriculture Organization of the United Nations
FCMC	Forest Carbon, Markets and Communities (FCMC) Program
GFW	Global Forest Watch
GHG	Greenhouse Gas
GLAD	Global Land Analysis and Dynamics
IMAZON	Instituto do Homem e Meio Ambiente da Amazônia
INPE	National Institute for Space Research
IPCC	International Panel on Climate Change
MINAG	Ministry of Agriculture
MINAM	Ministry of the Environment
MRV	Measurement, Reporting and Verification
NDVI	Normalized-Difference Vegetation Index
NDWI	Normalized-Difference Water Index
NRT	Near-Real Time
OTCA	Organization Treaty of Amazonian Countries
PROARCO	Projeto Monitoramento de Queimadas e Incendios
PRODES	Pojeto Monitoramento da Floresta Amazonica Brasiliera por Satelite
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RL	Reference Levels
UMD	University of Maryland
US	United States
USAID	United States Agency for International Development
USFS	US Forest Service
WRI	World Resources Institute

1.0 BACKGROUND

In 2012, the Peruvian government requested support from the United States Agency for International Development (USAID) via its Forest Carbon, Markets and Communities (FCMC) Program in the area of satellite monitoring of forests. This is a central need for countries developing measurement, reporting and verification (MRV) systems that are being developed as part of national programs on reducing emissions from deforestation and forest degradation, conservation of carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks (REDD+).

Peru sought support specifically in two areas: 1) technical advances in the implementation of satellite monitoring conducted by it national environmental agency, and 2) fundamental advances in regional governments in the understanding of MRV and satellite monitoring of forests. The first was an expression of Peru's desire for more efficient production of deforestation data to inform its national greenhouse gas (GHG) estimation. The latter was an expression of its interest to support regional governments to engage with the national government in a national MRV system. FCMC responded by conducting a two-year activity in partnership with the Peruvian government, the United States (US) Government's SilvaCarbon program, and research partners.

The goals of this activity were to assist the government in forest and land cover mapping, evaluation, and validation of mapping products; explore options for near-real time monitoring; and build technical capacity of regional governments. The desired deliverables were national, validated maps of deforestation, demonstrations of near-real time monitoring, and capacity-building workshops.

This report provides contextual information about Peru and FCMC, a summary of the activity's goals and process for achieving them, technical results, and observations on the activity's impact and potential further advances to be made in Peru. Information in this report draws in part from the FCMC Integrated REDD+ Assessment of Peru (FCMC, 2011); reports produced by Ministry of the Environment (MINAM) and their consultant for strategies on Reference Levels (RLs) and MRV; and products and workshop notes from the activity itself, including a peer-reviewed article. The intended audience for this is USAID and other donors who may consider similar activities in Peru or other countries, as well as the scientific community involved with research and capacity building on forest monitoring, especially in the context of national planning and REDD+.

2.0 CONTEXT

2.1 PERU REDD+ AND MRV DEVELOPMENT

As summarized in the Executive Report of the FCMC Integrated REDD+ Assessment of Peru (FCMC, 2011), Peru is on the cutting edge of REDD+ in comparison to most countries in the world. Peru's 72-million-hectare forest estate has the potential to contribute to meeting national and international REDD+ objectives, as well as conserve Peru's rich biodiversity. In 2010, Peru accounted for one-third of global supply of forest carbon credits, and projects have been developed across a variety of Peruvian landscapes. Peru has also demonstrated leadership on nested REDD+, whereby individual project activities operate within a larger national or sub-national accounting framework. The global framework under which Peru is developing its REDD+ strategy envisions a three-phased approach on the national level, comprising 1) national readiness, 2) demonstration and pilot activities, and 3) performance-based payments of verified activities. While pilot activities are underway and domestic and donor financing is flowing to support national readiness, there are numerous capacity and policy gaps that must be filled over the coming years.

To promote increased investment in forest carbon and to meet international readiness criteria, Peru will need to develop and implement national- and regional-level policy and guidance in technical areas, and to build the capacity of a wide variety of stakeholders to make informed decisions on participating in REDD+ opportunities. Peru's continued progress can lead to replicable lessons of national-, regional-, and project-level activities for REDD+ to inform other developing countries in the near future.

Peru has made solid strides in various technical aspects of MRV through internal efforts and support from international donors and universities. For example, MINAM has tested the development of national deforestation maps and has partnered with US-based researchers on testing aerial surveys for biomass estimation. Likewise, MINAM is collaborating with the Food and Agriculture Organization of the United Nations (FAO)-Finland and the US Forest Service (USFS) on in-situ forest inventories.

On deforestation monitoring, one semi-automated approach has been used by the Land Planning Unit (Ordenamiento Territorial), with a team of six analysts working for several years. While mapped estimates of national deforestation have been produced, they have not yet been deemed appropriate for public release. Various divisions in MINAM, the Ministry of Agriculture (MINAG), regional governments, and observers demonstrated in interest to explore issues further related to how quickly products can be generated for reporting, as well as accuracy estimation for use in REDD+ MRV.

MINAM expressed an interest to FCMC and SilvaCarbon to explore other approaches, in order to learn about and compare approaches and their products, to build capacity further, and to broaden international partnerships. MINAM also expressed interest in a series of training workshops for regional governments to provide fundamental capacity building on MRV, remote sensing, and near-real time monitoring; explain the approaches used by MINAM for deforestation mapping; and provide a venue for discussions between the national and regional governments on how regional governments could be involved in a national MRV system.

2.2 ROLE OF FCMC

USAID FCMC was created to support the implementation of the US National REDD+ Strategy by several means, including capacity building of host country governments and civil society. One of FCMC's two major activities is to work with countries on REDD+ readiness activities at a scale that will help them to meet their national commitments. Within the MRV Task, FCMC aims to make a significant contribution to a major aspect of MRV in at least one country. The Peru MRV activity was aligned with that deliverable. Besides the FCMC MRV Task Lead, the activity involved FCMC partner Conservation International (CI) staff in its headquarters and its Peruvian field office, as well as the close coordination with the Department of Geographical Sciences at the University of Maryland (UMD), which was contracted by USFS as part of SilvaCarbon.

3.0 SUPPORTING MRV IN PERU

The goals of FCMC support to MINAM and regional governments were:

1. Forest and land cover mapping within an MRV context at the national level (at MINAM);
2. Processes to evaluate and validate forest-cover and land-use estimates;
3. Demonstration and testing of near-real time satellite monitoring; and
4. Regional capacity building and engagement in the development of national forest and land-use monitoring.

The agreed deliverables were:

1. Installation of, and training on, improved image processing systems and guidance on creation of forest and land-cover change products, including documentation of the methodology and results;
2. Validation estimate of forest and land-cover change products through 2011 and documentation of methodology and results;
3. Demonstration, testing, and application results for near-real time satellite information for use in an alert system and documentation of the methodology; and
4. Regional capacity building materials and workshops.

Under an agreement with MINAM, UMD, and SilvaCarbon, the "forest and land-cover change analyses" were limited to deforestation. Other land-cover change analyses, such as attempts to produce maps of the six classes recommended by the International Panel on Climate Change (IPCC), were supported by separate SilvaCarbon grants to UMD. The forest-change analyses and validation activities were first conducted for the 2000–2011 period, then for 2011–2012 and then 2012–2013. The near-real time demonstration and applications were incorporated into the workshop series, which were designed together by MINAM and CI.

3.1 FOREST AND LAND COVER MAPPING WITHIN AN MRV CONTEXT AT THE NATIONAL LEVEL

A major part of this effort was to install the Global Land Analysis and Dynamics (GLAD) system from UMD in MINAM. This was done by providing two workstations with pre-installed software and the pre-processed Landsat satellite-data archive for Peru. Within its REDD+ program, MINAM assigned two part-time analysts to work with the system to produce a national assessment of deforestation as a basis for a forest-monitoring system.

3.1.1 UMD's GLAD System

The GLAD system (Potapov et al., 2012, 2014a, 2014b) has previously yielded nationwide deforestation assessments for the Democratic Republic of Congo, Indonesia, and Peru (e.g., Potapov 2014a; Margono et al., 2014), as well as a global map of tree-cover loss (Hansen et al., 2013).

GLAD is unique in that it mines the entire Landsat data archive for a study area, is applied at the level of mosaics or entire study areas, creates a large set of temporal metrics, and produces a time-series of forest change for all selected dates within a study period. Metrics are based on the archive's image reflectances, temperature measurements from Landsat's thermal band, and spectral indices. The latter include the normalized-difference vegetation index (NDVI) and normalized-difference water index (NDWI). These are calculated as the differences between the reflectances in two spectral bands divided by their sums, and show strong relationships to exposed leaf cover and moisture within the field of view of an image's pixels.

The metrics are used in a supervised classification to estimate percent tree cover and tree-cover loss, forest cover and deforestation, or other types of land-cover change of interest. The metrics represent the majority of the information in the time series of images while greatly reducing data volumes. Metrics relate to trends over image dates, maximum differences over the series, and ranks of values over the series. Users can select which metrics to use in the classification process.

Prior to calculation of spectral indices and metrics, GLAD implements cloud masks and atmospheric corrections to the reflectances. Technical details and a full list of metrics are provided in Potapov et al. (2014b).

GLAD applies a decision tree, which is a classification algorithm that is robust and efficient, yet not dependent on data assumptions such as normal distributions (Breiman, Friedman, and Olshen, 1984). Decision trees are applied via an iterative, supervised approach. The decision tree classifies whether there has been any forest change over the study period, and the year of change is assigned based on evaluation of minimum-annual NDVI throughout the period.

3.1.2 Capacity Building and Production of Deforestation Estimates

Training was provided on the many aspects needed to understand and implement the GLAD system. This includes the fundamental image characteristics and why different vegetation types appear differently in the images. Particular attention was given to the process of defining "training sites" for use in classifications. These are areas delineated by analysts to define each class, such as forest, agriculture or forest loss between two dates. The data within these areas (i.e., the statistics for the values of the various metrics) are used as inputs to the decision tree classification. Finally, the particular details of the GLAD system and different ways it can be applied were addressed over various sessions. This included issues such as the logistics of creating or defining a forest benchmark map prior to estimating forest change, attempting to best align with the national forest definition, and reasons for selecting or un-selecting metrics to use in the classification.

While much of the GLAD methodology is automated, part of it requires analyst interaction. This is true for all other semi-automated methodologies. The activity thus required training on the use of the system and reviews of intermediate maps of deforestation.

The GLAD system was installed in MINAM by providing two workstations with software and pre-processed Landsat products. These are based on the entire available archive of Landsat imagery (11,654 scenes) for the 11-year period for Peru. This enabled MINAM to generate rapid iterations of national classifications of forest and deforestation. After each iteration, classification results were assessed and training sites were adjusted based on the assessments.

A start-up workshop and mid-term workshop included representatives from all engaged institutions. Additional training sessions were held in MINAM during visits by UMD or CI staff. During these sessions, images were reviewed, interpretations discussed, the temporal metrics produced by UMD that summarize the Landsat time-series were also discussed, and various iterations of national classifications were reviewed. Remote coordination continued in between these sessions. In these, files were exchanged via ftp, US partners assessed the progress made by MINAM and technical problems, and conference calls were held to further guide MINAM through the process.

Within one year, MINAM had produced a precise, validated map of yearly deforestation from 2000 to 2011 (Vargas, et al 2014). This remains one of the finest-quality deforestation assessments produced by a tropical country. Since then the analysis has been updated to 2013. Validation included a robust sampling scheme, interpretation of acquired high-resolution images, and a statistical assessment, including a bias-adjustment of the final reported rates of forest loss. The product was selected by the Ministry of Agriculture for its contribution to the regional deforestation assessment of the Organization Treaty of Amazonian Countries (OTCA). It was also used for the national emissions estimate produced in 2014 and presented by MINAM at the 20th session of the Conference of the Parties (COP 20) in Lima. UMD led a supplementary analysis that attributed deforestation from anthropogenic causes versus a set of natural causes including river meanders and landslides. This was published in a peer-reviewed journal (Potapov, et al., 2014b), led by UMD and co-authored by MINAM and CI.

The first analysis produced a map that quantified forest loss from 2000 to 2011 within the Peruvian portion of the Amazon Basin. Methodological details are described in Potapov et al. (2014a) and additional details on the approach that was used is further described in Potapov et al. (2014b).

3.2 VALIDATION AND ESTIMATED RATES OF DEFORESTATION

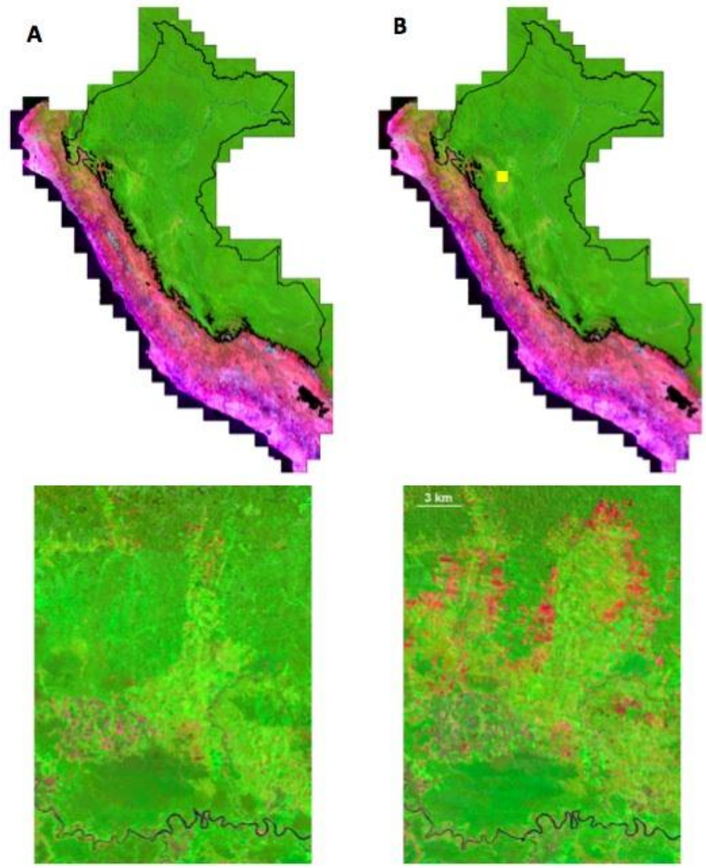
Validation was conducted via a statistically-robust sampling scheme produced by UMD. UMD explained the sampling logic, as well as other options, to MINAM such that they can produce similar samples for later updates of the map. High-resolution images from Rapid Eye were obtained, where individual trees can be observed. A sample of these images were selected for two strata: deforestation and forest persistence, as estimated by the 2000–2011 final map to be validated. Within each of these images, a second random sample was applied to distribute points. These points were interpreted by two independent analysts, observing the multiple Landsat images as well as the high-resolution images.

A stratified sampling design and a combination of Landsat (30 m) and Rapid Eye (5 m) imagery as reference data were used to estimate the primary forest cover area, total gross forest cover loss area, proportion of primary forest clearing, and to validate the Landsat-based map. Sample-based estimates showed that 92.63 percent (SE=2.16 percent) of the humid tropical forest biome area within the country was covered by primary forest in 2000.

Total gross forest cover loss from 2000 to 2011 equaled 2.44 percent (SE=0.16 percent) of the humid tropical forest biome area. Forest loss comprised 1.32 percent (SE=0.37 percent) of primary forest area and 9.08 percent (SE=4.04 percent) of secondary forest area. Validation confirmed a high accuracy of the Landsat-based forest cover loss map, with a producer's accuracy of 75.4 percent and user's accuracy of 92.2 percent. The majority of forest loss was due to clearing (92 percent), with the rest attributed to natural processes (flooding, fires, and windstorms).

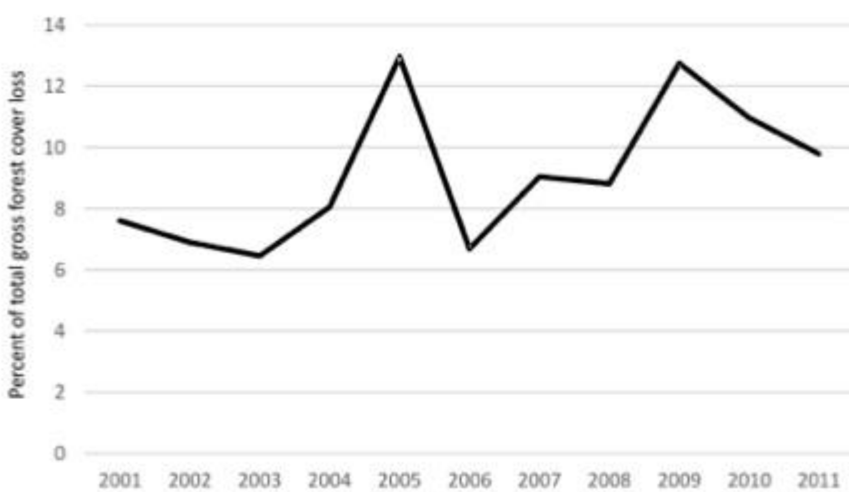
The following figures report the findings, which are reported in national documents as well as published in a peer-reviewed paper (Potapov et al., 2014b).

FIGURE 3.1



Mosaics of Landsat images from circa 2000 (left) and 2011 (right), with details of each shown below. From Potapov et al. (2014b).

FIGURE 3.2

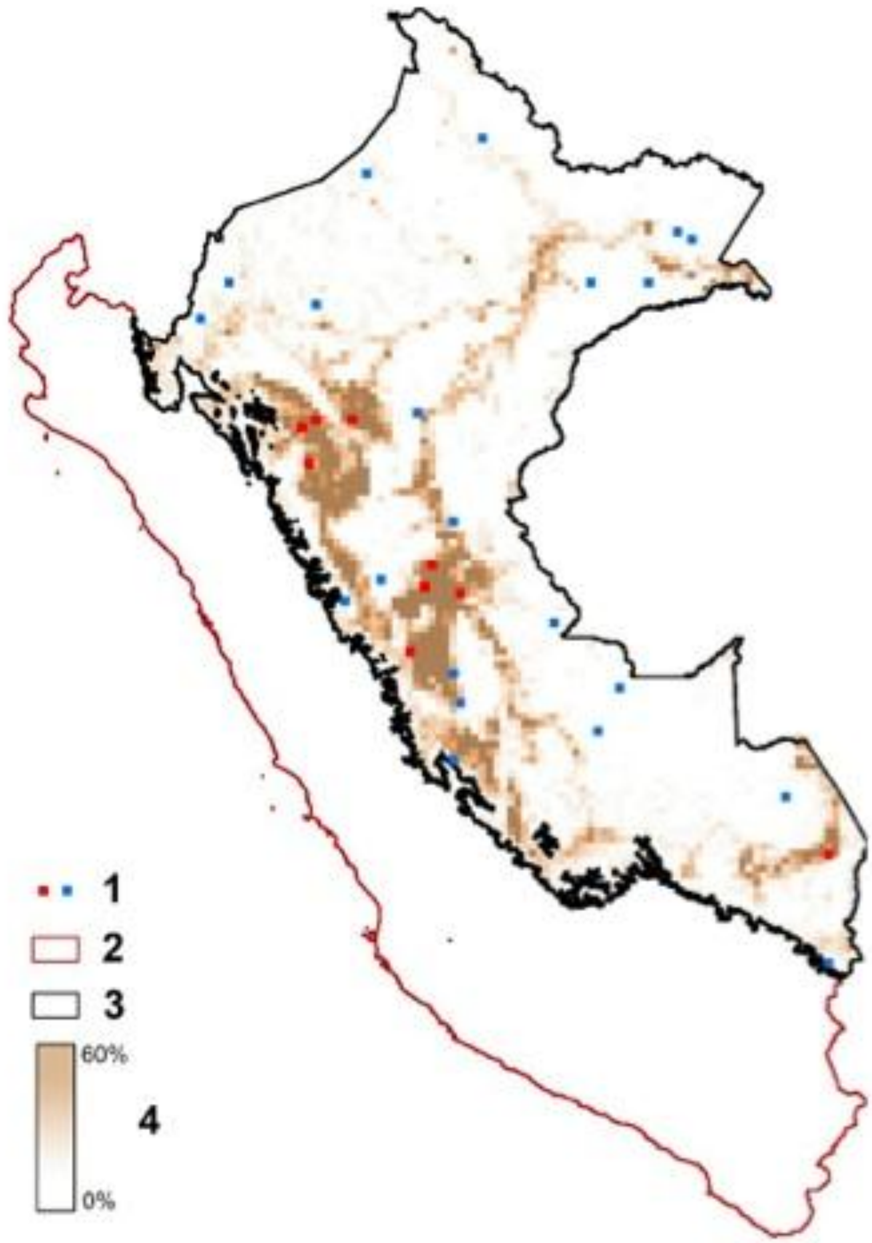


Annual rates of national deforestation from 2000 to 2011 from the MINAM-UMD analysis. From Potapov et al. (2014b).

FIGURE 3.3

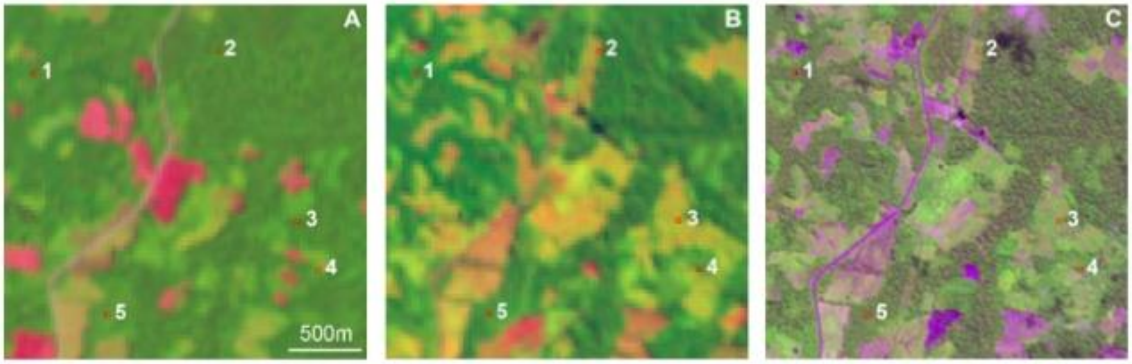
Annual deforestation from 2000 to 2011 from the MINAM-UMD analysis among Peru's regions. From Potapov et al. (2014b).

FIGURE 3.4



Distribution of high-resolution images used for validation, determined by a random sampling scheme within two national strata of deforestation and persistence. From Potapov et al. (2014b).

FIGURE 5



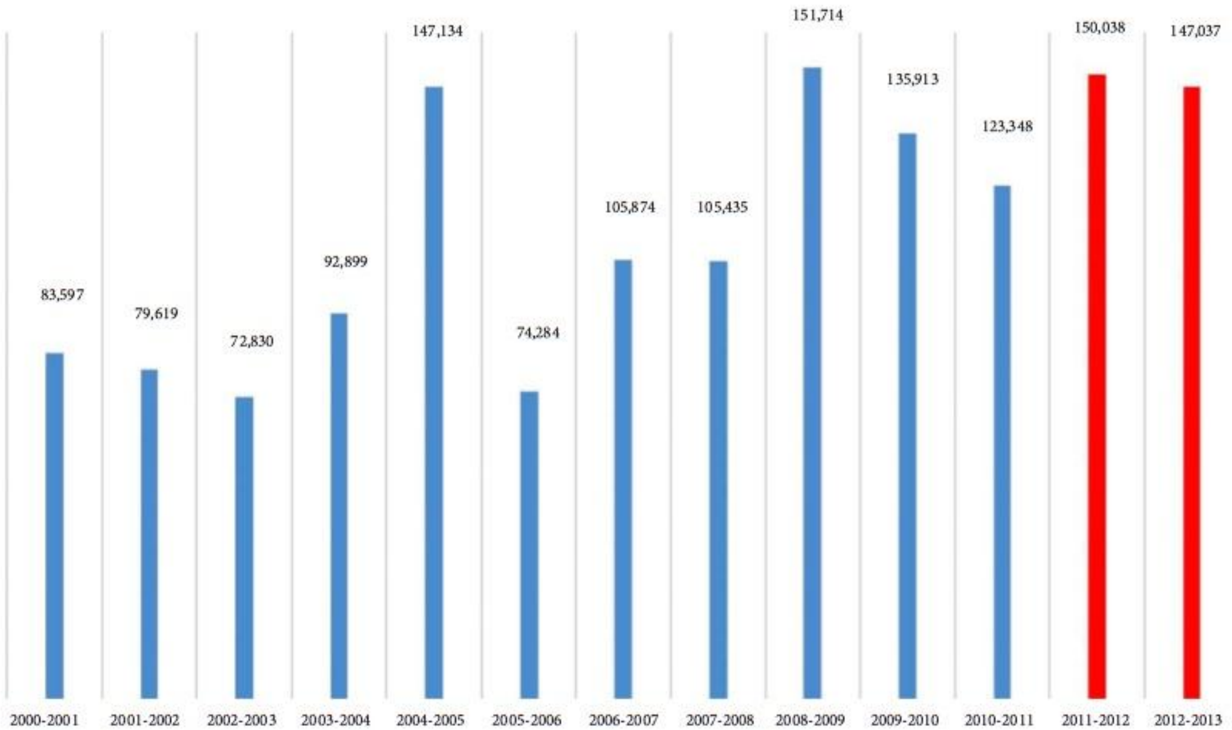
Examples of high-resolution images with stratified-random sample points within: over the 2000 Landsat image (left), the 2011 Landsat image (middle), and the circa 2011 high-resolution image itself (right). From Potapov et al. (2014b).

FIGURE 3.6

Departamento	Bosque 2011	No Bosque 2011	Ríos 2011	Pérdida 2000-2011
Amazonas	2 878 955	660 812	44 226	41 707
Ayacucho	219 388	113 855	5950	6518
Cajamarca	364 489	406 334	2359	9582
Cusco	3 114 635	451 071	69 927	38 140
Huancavelica	17 924	50 733	63	547
Huánuco	1 678 492	473 636	40 789	165 180
Junín	1 917 776	474 005	41 900	77 496
La Libertad	68 791	13 271	509	511
Loreto	35 293 585	991 816	1 005 254	219 671
Madre de Dios	8 036 661	203 908	169 776	87 745
Pasco	1 456 267	230 543	20 750	56 584
Piura	41 541	40 734	196	2188
Puno	1 450 439	126 359	21 836	11 817
San Martin	3 502 802	1 024 068	59 779	277 333
Ucayali	9 569 816	556 574	228 753	177 630
Total	69 611 561	5 817 720	1 712 067	1 172 648

Regional areas of forest and rates of deforestation, in hectares, estimated by the MINAM-CI team. Bosque is forest, No Bosque is non-forest, Rios is rivers and Perdida is deforestation. From Málaga Durán, et al (2014).

FIGURE 3.7



Inter-annual rates of national deforestation, in hectares, estimated by the MINAM-CI team. From Malaga Duran et al. (2014).

3.3 REGIONAL CAPACITY BUILDING, INCLUDING NEAR-REAL TIME SYSTEMS OVERVIEW

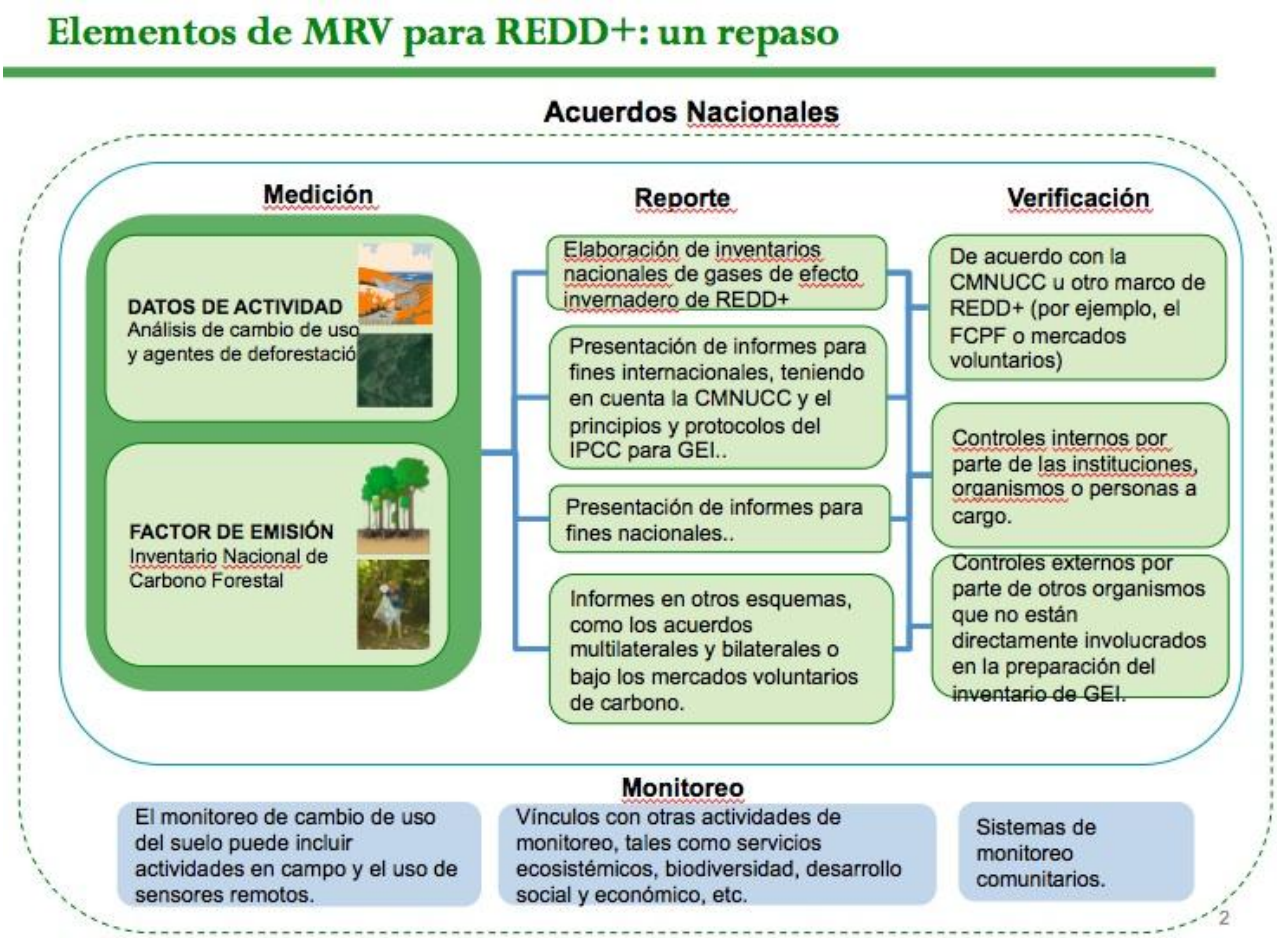
Peru has a decentralized government structure; involving regional governments in all aspects of land-use planning, including REDD+, is even more critical than in most countries. For MRV, the various ways in which the regional governments partner with the national government is not yet fully defined, although there is strong interest on the national and sub-national levels to pilot ways to make this relationship clear. There are two regions that are most advanced in progress toward subnational REDD+: San Martin and Madre de Dios. However, technical capacities for MRV in these regional governments is elementary, especially for those related to monitoring land-use change. MINAM expressed interest in an activity that would include fundamental capacity building in this area, as well as provide a venue for national and regional representatives to discuss issues and potential contributions from the regions. A series of workshops for regional government staff and partners were included in the Peru MRV. Regional representatives from San Martin, Madre de Dios, Loreto, Ucuyali, and Cuzco were invited to participate. All workshops were in Lima and hosted by MINAM.

The first workshop, held in June 2014, was on the fundamental concepts of MRV and forest monitoring within an MRV system. It also included a review of remote sensing basics and common approaches to satellite data analysis for forest monitoring. The second workshop, held in August 2014, was on understanding accuracy and area estimation. It included a contribution from SilvaCarbon partner Boston University.

The third workshop was held in October 2014 and was on near-real time (NRT) alert systems for use in MRV. In this various regional and global NRT systems were presented, such as the Global Forest Watch program (GFW) of the World Resources Institute's (WRI), the suite of Brazilian programs on near-real time detection of deforestation and fires (DETER PRODES and PROARCO) (INPE 2015a, 2015b, 2015c) the Deforestation Alert System of Instituto do Homem e Meio Ambiente da Amazônia (IMAZON), the Interactive Fire Alert Tool of the Center for International Forestry Research (CIFOR), Terra-I, and the Fire Risk Alert System and FireCast of CI. The latter includes both an automated delivery of fire alerts to registered users as well as a simplified methodology for local users to access Landsat data and estimate locations of deforestation with a potential bi-weekly frequency. The audience was shown how to register for the fire alerts and conducted their own hands-on deforestation classification.

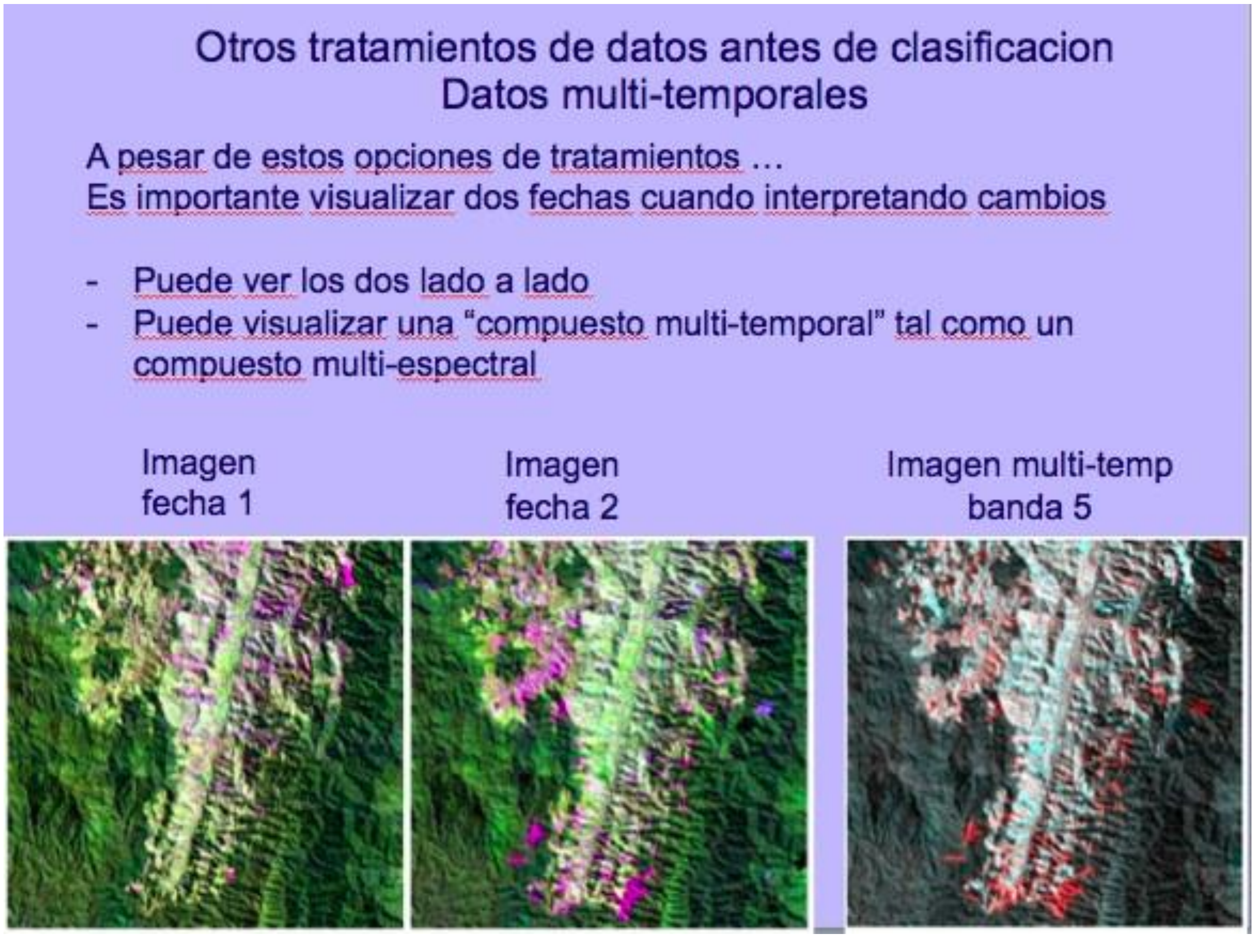
Each of the workshops included sample data and worksheets, such as near-real time satellite images and error-estimation worksheets, for participants to explore on their own computers. Lectures were provided, followed by question sessions. The concluding workshop allowed for a discussion of possible contributions from regional governments. While the audience was composed of technicians who are not responsible for final decisions, several ideas were discussed, including: contributions to interpretation of some of the more complex types of vegetation, such as montane and wetland formations; contributions to interpretation of validation data; contributions to explaining drivers; and linkages to regional enforcement and vigilance. The series served as an initial step to what needs to continue towards thorough national–regional coordination in MRV system development.

FIGURE 3.8



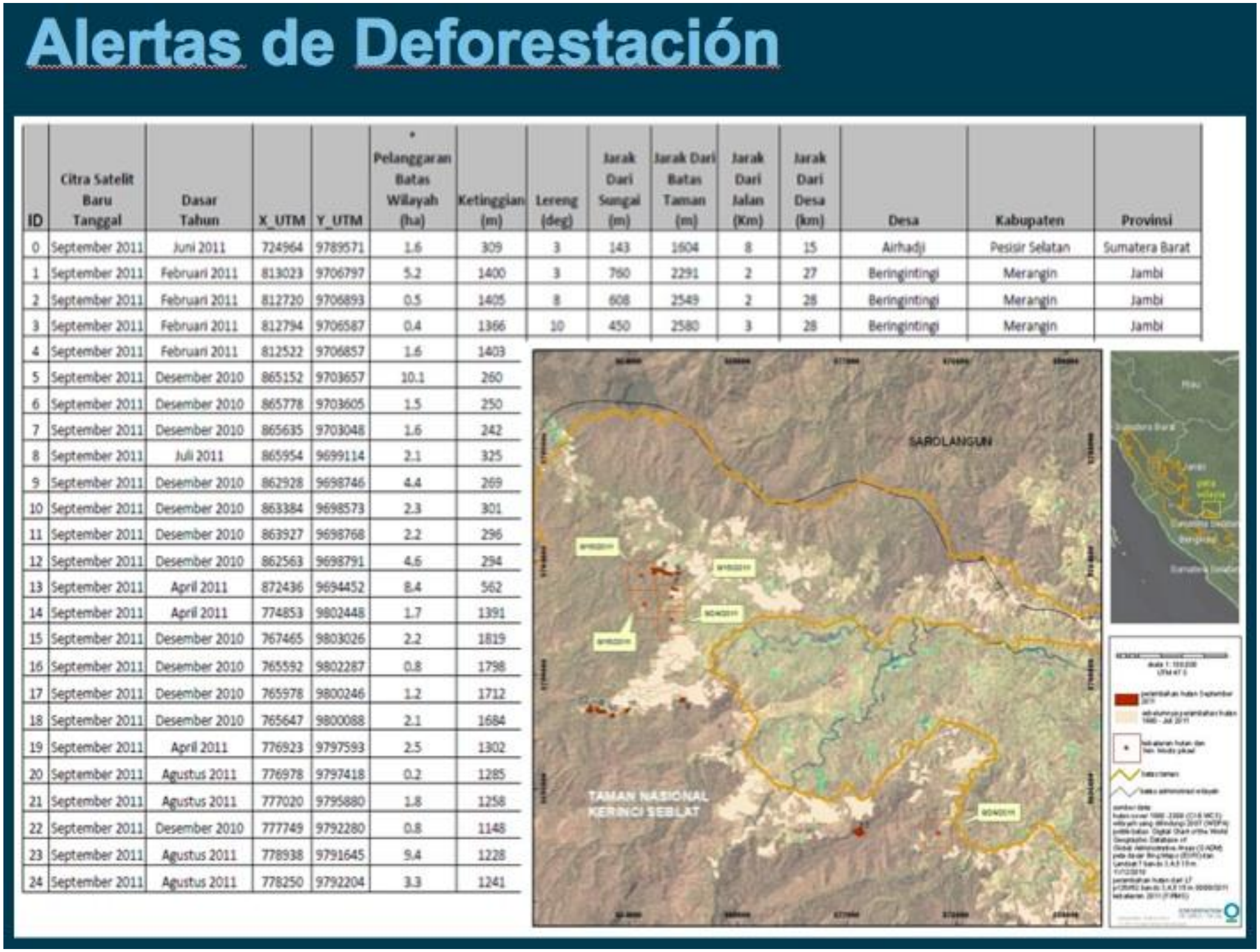
Example of material presented in the first MRV workshop for Peruvian regional governments, which provided a MRV and monitoring overview.

FIGURE 3.9



Example of material presented in the second MRV workshop for Peruvian regional governments, which provided a remote sensing overview.

FIGURE 3.10



ID	Citra Satelit Baru Tanggal	Dasar Tahun	X_UTM	Y_UTM	* Pelanggaran Batas Wilayah (ha)	Ketinggian (m)	Lereng (deg)	Jarak Dari Sungai (m)	Jarak Dari Batas Taman (m)	Jarak Dari Jalan (Km)	Jarak Dari Desa (km)	Desa	Kabupaten	Provinsi
0	September 2011	Juni 2011	724964	9789571	1.6	309	3	143	1604	8	15	Airhadji	Pesisir Selatan	Sumatera Barat
1	September 2011	Februari 2011	813023	9706797	5.2	1400	3	760	2291	2	27	Beringintingi	Merangin	Jambi
2	September 2011	Februari 2011	812720	9706893	0.5	1405	8	608	2549	2	28	Beringintingi	Merangin	Jambi
3	September 2011	Februari 2011	812794	9706587	0.4	1366	10	450	2580	3	28	Beringintingi	Merangin	Jambi
4	September 2011	Februari 2011	812522	9706857	1.6	1403								
5	September 2011	Desember 2010	865152	9703657	10.1	260								
6	September 2011	Desember 2010	865778	9703605	1.5	250								
7	September 2011	Desember 2010	865635	9703048	1.6	242								
8	September 2011	Juli 2011	865954	9699114	2.1	325								
9	September 2011	Desember 2010	862928	9698746	4.4	269								
10	September 2011	Desember 2010	863384	9698573	2.3	301								
11	September 2011	Desember 2010	863927	9698768	2.2	296								
12	September 2011	Desember 2010	862563	9698791	4.6	294								
13	September 2011	April 2011	872436	9694452	8.4	562								
14	September 2011	April 2011	774853	9802448	1.7	1391								
15	September 2011	Desember 2010	767465	9803026	2.2	1819								
16	September 2011	Desember 2010	765592	9802287	0.8	1798								
17	September 2011	Desember 2010	765978	9800246	1.2	1712								
18	September 2011	Desember 2010	765647	9800088	2.1	1684								
19	September 2011	April 2011	776923	9797593	2.5	1302								
20	September 2011	Agustus 2011	776978	9797418	0.2	1285								
21	September 2011	Agustus 2011	777020	9795880	1.8	1258								
22	September 2011	Desember 2010	777749	9792280	0.8	1148								
23	September 2011	Agustus 2011	778938	9791645	9.4	1228								
24	September 2011	Agustus 2011	778250	9792204	3.3	1241								

Example of material presented in the third MRV workshop for Peruvian regional governments, which provided an overview of near-real time alert systems capabilities and hands-on exercises.

4.0 CONCLUSION AND OBSERVATIONS

This activity has had a major impact in Peru's readiness process. The country now has one of the most advanced forest-monitoring systems in the tropics. It now has one of the most precise, accurate, and complete assessments for incorporation into national reference levels estimation and for a basis for ongoing monitoring.

Capacity-building should certainly continue. MINAM staff did an excellent job, although they should consider adding higher-level staff to direct such work, as well as a statistician to support the entire MRV process. These recommendations were made early on in this activity, and MINAM has such positions written into its strategy and fund-raising plans.

Further collaboration with UMD would be valuable, and expansion to regional collaboration could make this more cost efficient. SilvaCarbon has taken this approach by forming collaborations among UMD and Ecuador and Colombia, although those are not as in-depth as the Peruvian activity was.

Regional capacity building continues to be very important. It can also be costly. Remote training, or training sessions for regional staff from multiple countries could be ways to increase cost-efficiency. The regional workshops begun a process which should continue. There is much interest from both the national and regional governments for coordination in national MRV, although further discussions and training is needed, including the inclusion of additional regions that could not join this series of workshops. Piloting different types of coordination would be valuable. Possibilities raised in the workshops include regional contributions to describing some of the more difficult areas to interpret in satellite images, validation, explanation of different patterns of deforestation, and partnering on the use of NRT information.

Peru has gained much momentum in various aspects of developing its national MRV system, and some major advances were catalyzed by this FCMC activity in coordination with SilvaCarbon. The strength is in the approach to capacity building via partnering in major aspects of MRV, going far beyond just training workshops. Continued collaboration between US Government and Peru can be expected to help Peru progress towards one of the stronger national MRV systems in the tropics. Both the MRV advances and the productive international partnership can not only help Peru to meet its reporting requirements but also serve as a model for other countries.

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