FINAL REPORT for APN PROJECT

Project Reference Number: EBLU2011-02CMY(C)-Skole

Developing an MRV system for REDD+: Scaling up from project level to a national level
REDD+ MRV systems for Lao PDR and Vietnam

Ecosystems, Biodiversity, and Land Use

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

The main objectives of the project were: to develop (1) two sub-national pilot REDD+ project activities in coordination with national efforts in Laos and Vietnam and (2) a scalable, Internet-enable REDD MRV management application that uses remote sensing data and Web-GIS tools to support the two pilot projects. A third main objective is capacity building and training of regional scientists in REDD+, MRV technologies, and climate change topics, including the potential of carbon financing and the technological requirements for measuring biotic carbon on the landscape.

The project co-investigators successfully completed the objectives of the project. Field level plot inventory data were collected in each of the project pilot areas. Forest strata were identified. Plot data and parcel information input to the on-line forest carbon MRV/M&E system were used to compute estimated carbon stocks, mean carbon per hectare values and emission factors in tonnes of dry matter per hectare.

Advanced remote sensing methods for forest carbon mapping were developed that pushed beyond simple IPCC Tier 1 values used in forest cover classes. The methods used IPCC Tier I values down-calibrated to forest cover variance using vegetation continuous fields, or fraction cover, data sets as an input. Tier 3 data from the field plot inventories were also used to calibrate fC pixel values and combined with a land use and land cover stratification map provided a more detailed forest carbon map. A tree area openness product was also developed through regression of field based crown area data with fC data.

The MRV system itself, mostly developed under other funding, allowed us to test the data and method for use as an MRV system supporting REDD+ or Forest carbon activities at project or national scales. Through demonstrations, training, and general introduction of the system to stakeholders and potential users there is strong interest in its capabilities – not only for project management and reporting but also as a training and knowledge learning tool.

Keywords

REDD Plus (+), Monitoring Reporting and Verification (MRV), Forest Carbon

Objectives

The main objectives of the project were:

1. To develop two sub-national pilot REDD+ project activities in coordination with national efforts – one pilot project each in Laos and Vietnam,
2. To develop a scalable, Internet (on-line) REDD+ MRV management application to support the two pilot project activities,
3. To build local and regional capacity through training scientists and agency personnel in REDD+ concepts, MRV technologies and climate change topics, including measurement requirements for forest carbon.

Amount received and number years supported

The Grant awarded to this project was:
US$ 32,000 for Year 1: 2010/11
US$ 33,000 for Year 2: 2011/12

Activity undertaken

The project established biomass plots and collected primary tree inventory data in three pilot areas; two in Laos and one in Vietnam. These data were used to develop carbon stock estimates in the pilot areas and also used to calibrate a forest carbon map derived from Landsat remote sensing data. The project supported the testing and development of an on-line forest carbon MRV/M&E system. Project area, strata, biomass plot location data and tree inventory data were ingested to the on-line system for estimating carbon stocks and as Tier 3 data inputs to an emission calculator for running possible carbon emission scenarios for projected land use and land cover changes.

The project conducted training in advanced methods for remote sensing with project scientists at the two universities and with agency personnel. Team leaders also trained local communities in establishing biomass plots and collected tree inventory data for measurement and monitoring of forest carbon. Demonstrations of the on-line forest carbon MRV/M&E system were conducted in each country for policymakers and potential end users. A final workshop was conducted to train individuals in using the on-line forest carbon MRV/M&E system.

Results

The project results include:

1. Pilot site example projects of carbon stock estimates and emission scenarios from Tier 3 plot inventory data within a fully functional on-line forest carbon MRV/M&E system.
2. A method for remote sensing derived forest carbon maps with examples for the pilot areas.
3. In-country scientists trained in using the on-line forest carbon MRV/M&E system and in the advanced methods of forest carbon mapping with Landsat remote sensing data.

Relevance to the APN Goals, Science Agenda and to Policy Processes

This is a cooperative effort involved scientists from Vietnam and Laos to develop the technological capacity for supporting REDD+ efforts in these two important SE Asian tropical forest countries to support mitigation actions combating climate change. The project emphasized training and capacity building for regional scientists in remote sensing analysis, and Internet-enable MRV systems for REDD+ projects (Goals 1 and 3). The project included meetings and training workshops in the region. Project co-leaders were linked closely with policy-makers in their respective countries (Goal 2). Dr. Thongmanivong in Laos is a member of the national committee responsible for the World Bank FCFP activity in Laos and has close linkages to policy-makers involved in the World Bank Forest Investment Programme. Dr. Khoa, in Vietnam, is a lead member on the first small-scale CDM A/R project in Vietnam and a member of REDD National Task Force in Vietnam. Both he and Dr. Lan have strong linkages to FSIV and MONRE.

The project was cross-cutting with respect to the APN Science Agenda: measuring and monitoring changes in forest cover and land use and the role of biotic carbon fluxes in climate change; supporting the ecosystem services provided by forests and trees; linking measurement and monitoring tools to carbon finance opportunities in REDD+ that support sustainable resource use and sustainable rural development. REDD+ MRV tools are prerequisite to enabling national efforts at improved forest management and natural resource use. The Internet-enables system will support such efforts.

Self evaluation

The tasks and activities completed in the first and second years of the project were accomplished successfully. Generating the remote sensing data products and initial validation of the forest / non-forest data were completed. We had faced some challenges in linking to existing REDD projects in Lao PDR, which is why we developed two pilot areas there – one in Sangthong District where the Faculty of Forestry, NUOL, Training Model Forest area is located and one in Savannakhet Province where an active SUFORD project is located. We were not successful in building any linkages with the SUFORD project but have been able to use some of the ground data to test and validate the on-line system and develop preliminary forest carbon maps using Landsat data. In Vietnam, on the other hand, we established an excellent working relationship with ICRAF-Vietnam who is linked into the UN-REDD efforts in Vietnam. In the second year they helped with training local people and also with collected plot level biomass data. They also shared GIS land cover data sets with us which were used to stratify the forest carbon maps.

The development of the on-line forest carbon MRV/M&E system itself, which is mostly funded under a GEF/UNEP activity called the Carbon Benefits Project, came on later in year two of our APN activity. This delayed the demonstration activities to local stakeholders until Dec 2012 and also delayed the final project meeting which includes training for use of the on-line forest carbon MRV/M&E system until Feb 28 – Mar 2, 2013. The on-line forest carbon MRV/M&E system (with the pilot area sample data sets) and the forest carbon mapping method developed as part of this project are being vetted by the Word Bank Forest Investment Programme pilot countries of Indonesia and Laos. The system is also being considered by the Thailand Greenhouse Gas Management Organization in supporting Thailand's forest carbon activities. We consider this kind of research to application the most important kind of success for a project.

We have outline two papers for peer review publication based on the research conducted under this project. These will be drafted and revised over the next two to four months.

Potential for further work

There is potential for further work along four lines:

1. Expansion of project sites for demonstrating the measurement and monitoring tools in the on-line system at national scale reporting and expanded to other countries in the region (e.g. Cambodia, Philippines, Thailand).
2. Develop additional remote sensing forest carbon methods using high-resolution data for agro-forestry and woodland system; this would use a combination of object (texture analysis) oriented and spectral signature processing coupled with tree biometry related biomass equations such as tree crown area to DBH and biomass.
3. Use of the on-line forest carbon MRV/M&E system within a Knowledge Management or Learning Management Environment. This would integrate the on-line tool with sample project data, video tutorials, workbooks and presentation focused on a series of forest carbon / climate adaptation and mitigation themes (e.g. Community-based forest carbon measurement and monitoring; AFOLU Emissions Scenarios; Forest carbon and GHG Markets, etc.)
4. Developing and testing additional functionality to the -line forest carbon MRV/M&E system for reporting social and ecological co-benefits for forest carbon mitigation and emissions avoidance activities. Such functionality could include biodiversity reporting, supporting provisions for documenting Free Prior Informed Consent (FPIC), ensuring safeguards, etc.)

Publications (please write the complete citation)

We are working on two manuscripts for peer review publications based on the work completed with support from APN for this project. The two manuscripts are:

1. “Developing a scalable forest carbon measurement and monitoring system for supporting MRV and M&E reporting requirements” Authors: David L. Skole, Jay H Samek, Sithong Thongmanivong, Phung Van Khao, Do Xuan Lan

2. “A method for large area landscape carbon mapping linking forestry inventory data with Landsat remote sensing data”, Jay H Samek, David L. Skole, Sithong Thongmanivong, Phung Van Khoa, Do Xuan Lan

References

None

Acknowledgments

We wish to acknowledge the important co-contributions to this research activity by ICRAF-Vietnam; and also our Thai colleagues at Mahasarakham University, the National Research Council of Thailand, the Thai Agriculture and Land Reform Office, and the Thailand Greenhouse Gas Management Organization as participants under the Sumernet (SEI-CDKN) funded project which supported work in all three countries. We also acknowledge the important contribution of the Global Environment Facility, Carbon Benefits Project for its support to MSU for the development of the on-line forest carbon MRV/M&E system.

TECHNICAL REPORT

Preface

On April 9, 2010 at the 16th ASEAN Summit in Hanoi, Viet Nam, heads of state issued a joint response to climate change. The declaration recognized the role of sustainable forest management to "promote environmental sustainability and to mitigate the effects of climate change"; They also reaffirmed an "agreement on and effective implementation of Reduced Emission from Deforestation and Forest Degradation (REDD)-plus mechanisms is critical for contributions by ASEAN Members States to mitigate emissions, and offers major opportunities for enhancing biodiversity conservation and sustainable use of natural resources, as well as supporting the livelihood of local communities in a sustainable manner"; And, they called upon developed countries to support the least developed countries with "transfer of technology, as well as capacity enhancement to enable adaptation efforts and nationally appropriate mitigation actions by developing countries". The development of scalable MRV systems for REDD+ as proposed in this project supports the ASEAN joint response and the APN scientific theme on Ecosystems, Biodiversity and Land Use with a key focus area on Forestry and REDD-Plus. The project emphasized 1) training and capacity building in basic concepts of REDD, REDD+ and MRV systems, 2) the development and testing of a scalable MRV system based on current IPCC guidelines using remote sensing satellite data and geospatial technologies, and 3) technology transfer of national level MRV systems for REDD+.

Two outcomes form the recent UNFCCC "Informal meeting of experts on enhancing coordination of capacity-building activities in relation to using the IPCC guidance and guidelines, as a basis for estimating forest-related greenhouse gas emissions and removals, forest carbon stock and forest area changes" in Bonn, Germany, 25–26 May 2010 were: "a need to explore ways to make monitoring of forest degradation more practical for developing countries and to identify the types of data needed in IPCC methodologies for monitoring forest degradation" (IV.B.34.a) and "Stimulation and enhancement of regional cooperation in order to facilitate the sharing of experiences gained and lessons learned from demonstration activities and use of the IPCC guidance and guidelines, as well as the sharing and exchange of data sources. Regional cooperation could also facilitate the building of critical mass within those regions in relation to the use of the IPCC guidance and guidelines" (V.42.b). This project aimed to support these two identified needs.

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1.0 Introduction

Extremely large financial investments are now being made in forestry and agriculture carbon projects for climate mitigation in developing countries (e.g. *Climate Investment Fund - Forest Investment Program, the World Bank - Carbon Partnership Facility*). While these large investments in forest and agriculture carbon initiatives are moving ahead rapidly in response to international climate policy, the basic framework for measurement and verification is almost non-existent. There is a desperate need for rapid development of proofs-of-concepts for what the international community calls MRV systems (Monitoring, Reporting and Verification systems). A recent report from the World Economic Forum's *Task Force on Low-Carbon Prosperity* (2009) has put it this way: "To develop the necessary level of sophistication of systems required for accurate REDD+ monitoring, reporting and verification, a major public-private initiative is required to develop comprehensive Earth Observation systems and field measurement and monitoring systems to be ready for use by 1 January 2013."

The key point is that carbon compliance regulatory regimes, multi-lateral investment programs and markets will need robust, cost effect systems for measuring, reporting and verification (MRV). This, in turn requires the ability to measure deforestation rates and reforestation rates. We are developing such a system using Earth Observation, geospatial technologies and testing this system with pilot projects in Laos and Vietnam. The goal is to deliver a globally-deployable, scalable MRV system that is cost effective and rigorous. This project is developing a scalable MRV system supporting REDD+ activities in Laos and Vietnam.

The main objectives of the project were:

1. To develop two sub-national pilot REDD+ project activities in coordination with national efforts – one pilot project each in Laos and Vietnam,
2. To develop a scalable, Internet (on-line) REDD+ MRV management application to support the two pilot project activities,
3. To build local and regional capacity through training scientists and agency personnel in

REDD+ concepts, MRV technologies and climate change topics, including measurement requirements for forest carbon.

2.0 Methodology

Study site descriptions. The project focused initially on two pilot study sites – one each in Laos and Vietnam. A Third study site was then added at the start of the project – a second site in Laos. The sites were selected at the initial project planning meeting in year one of the project. The project pilot area sites included Bac Kan Province, Vietnam; Sangthong District, Vientiane Prefecture (just northwest of Vientiane, the capital city) Laos; and Savannakhet Province, Laos (Figure 1).

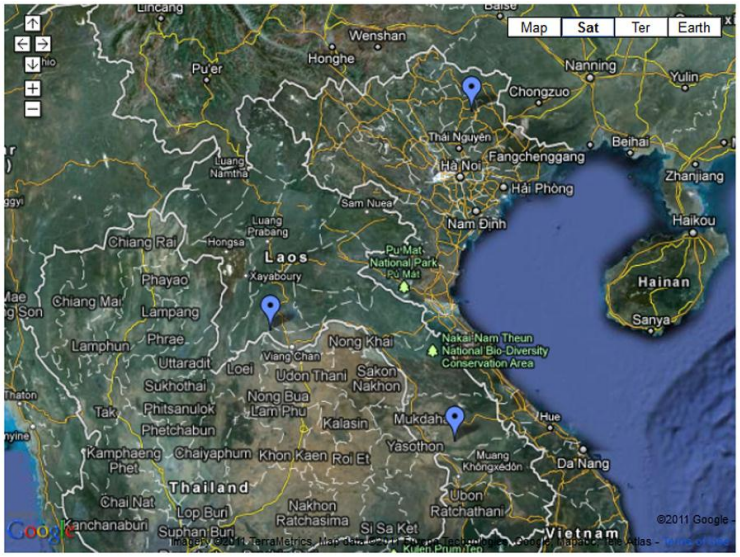

FIGURE 1: LOCATION OF THE PILOT PROJECT AREAS, GOOGLE EARTH KMZ FILE (AVAILABLE ONLINE AT: HTTP://G.CO/MAPS/6M4AD).

In Bac Kan Province, Vietnam we collected data supporting the MRV system at two scales – province wide and also at two community forest areas belonging to Na Muc village, Van Minh Commune and Tu Dooc village Lang San Commune, Na Ri District, Bac Kan Province. These villages are located close to Kim Hy Forest Reserve; an 18,555 ha protected area established in 1997. Tu Dooc village is in the Reserves' official buffer zone. Both communities have "Red Book" documentation (tenure rights) for managing community forests: Na Muc village – 118.3 ha and Tu Dooc Village – 45.1 ha. The area is located about 200 kilometres north of Hanoi. Our work in Bac Kan Province, Vietnam was supported through close collaboration with ICRAF-Vietnam who is implementing a project in these two villages testing REDD+ mechanisms for payments for environmental services.

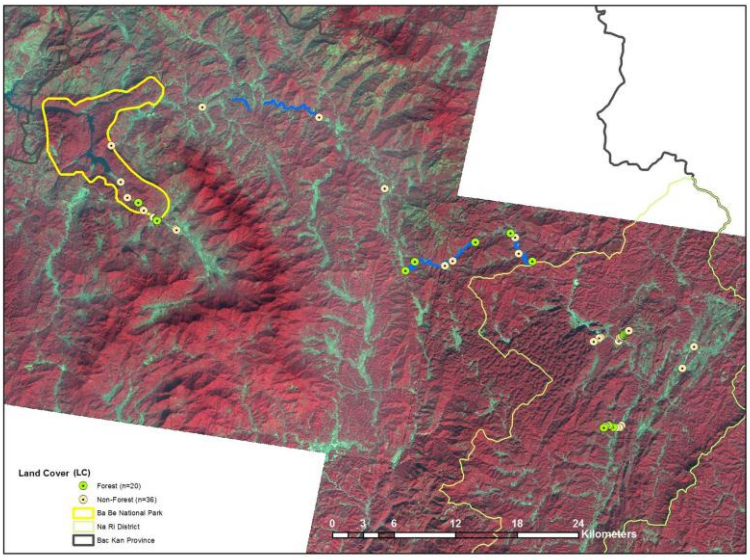

FIGURE 2: LOCATION OF FOREST/NON-FOREST FIELD VALIDATION FROM MAY 2011 IN BAC KAN PROVINCE, VIETNAM.

In Sangthong District, Laos we focused mostly on the ground data and working with local people and district foresters for training community-based measurements supporting the MRV application; Ban Kouy, Ban Napor and Ban Vangma Villages, Sangthong District, Vientiane Prefecture. This area is located approximately 80 kilometres northeast of the capital city of Vientiane. The villages are located in and around the National University of Laos (NUOL), Faculty of Forestry, Training Model Forest (TMF) which covers an area of 4,600 hectares. Land tenure and resource rights are established under the Land Use Planning and Land Allocation programs of the Lao Government which began in the 1990s. These two programs are designed to transfer rights and responsibilities over land and forest resources use and management to villages and local communities.

In the Savannakhet Province, Laos study site we utilized ground data collected under the SUFORD project with colleagues at the faculty of Forestry, N University of Laos to test and develop a method for linking ground-based biomass data with remotes sensing analyses for estimating and mapping forest carbon. The primary data are not included as part of this APN project's data set, but a description of the data used by this project is given and the output of the forest maps is included.

Field data collection. Data were collected in the field for two purposes. Field level land cover data were collected for validation of forest mapping with remote sensing data. Forest cover maps derived from satellite remote sensing data provided strata input areas for the MRV and also were use as part o the remotes sensing method for estimating and mapping forest carbon. Figure 2 shows the location of the Forest / Non-Forest field data points for Bac Kan Province collected in May 2011.

Field data were also collected using standard forest plot inventory methods (MacDicken 1997; Pearson et al. 2005). Data collection sheets were developed to record tree inventory and biometric data in fixed area plots (see data sheet in appendix). GPS data were also collected to map plot locations. Table 1 provides a summary of the plot level field data for each study site.

TABLE 1: TREE PLOT INVENTORY INFORMATION

Study Area	# of Plots	# of Trees Inventoried	Plot Type
Sangthong Dist., Laos	13	711	Circular Nested 25 and 10 m radius
	16	721	Circular Nested 50 and 20 and 10 m radius
Savanakhet Prov., Laos	302	[1]2873	Rect. Nested 20 x 20, 10 x 10, 4 x 4 m
Bac Kan Prov., Vietnam	32	1486	Rectangular Nested 50 x 40; 5 x 40 m
	22	[2]Var. land use systems	Rectangular Nested 10 x 10 m

[1] These data were part of the SUFORD project. Their **Report on Forest Inventory Dongsithuane Production Forest, Song Khone District Savanakhet Province** is included in the appendix. We used these data in the RS Forest Carbon mapping.

[2] These were field data collected by ICRAF-Vietnam for a study, **Carbon stock evaluation in some types of land use in Bac Kan** by Đỗ Hoàng Chung. Paper is included on the project CD-ROM with data. We used these data in the RS Forest Carbon mapping.

We use the plot level tree inventory to then estimate biomass and carbon on a per hectare basis using region and forest type allometric equations (Brown 1997, Chaves et al. 2005, IPCC 2003, IPCC 2006,). We have encoded some of these equations into the MRV.

Remote Sensing forest carbon mapping method. The project developed a method for analyzing medium resolution (30-meter) optical Landsat remotes sensing satellite data for estimating and mapping forest carbon over large areas. The method uses ground data from plot inventories to calibrate remote sensing pixels. Figure 3 is shows a general schema for the processing method. Landsat data are first calibrated converting digital numbers (DNs) to at-sensor spectral radiance and then exoatmospheric top-of atmosphere reflectance as known as in-band planetary albedo (Chander et al. 2004). Data are then converted to a vegetation index using the Modified Soil Adjusted Vegetation Index 2 or MSAVI 2 model (Qi et al. 1994). A vegetation continues fields or "fractional cover" (fC) data set is then developed using a spectral un-mixing algorithm (Matricardi et al 2010) from two end-members (forest and bare soil). The fC data are then stratified using a land cover stratification map. For each strata where we have the mean plot level carbon estimates we then calibrate the fC data using a linear regression equation. This produces a final forest carbon map.

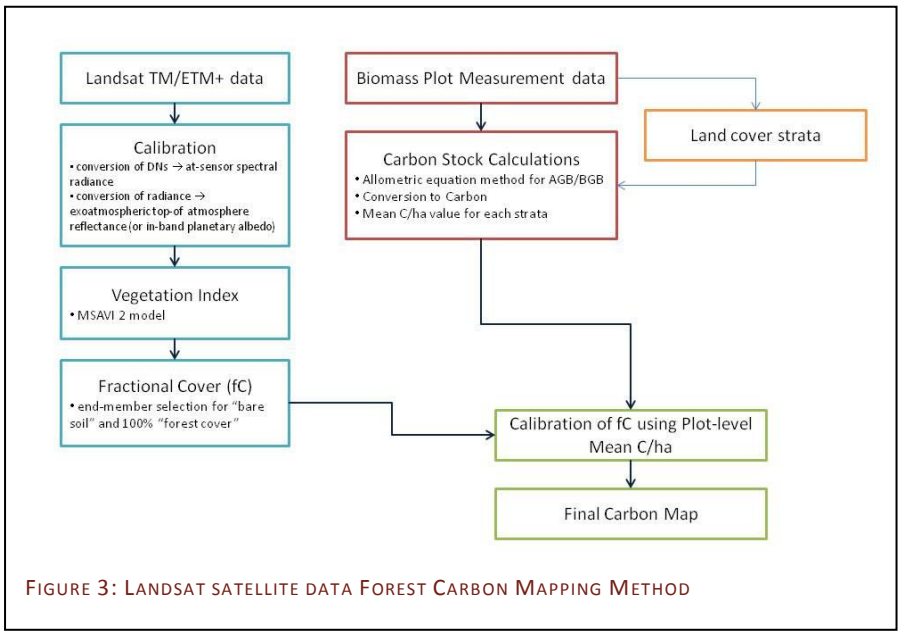

FIGURE 3: LANDSAT SATELLITE DATA FOREST CARBON MAPPING METHOD

We have developed a secondary approach to forest carbon mapping with remote sensing data following a similar method to that described above. The fC data are calibrated using field collected canopy openness data again using regression equation coefficients. IPCC Tier 1 biomass estimates (IPCC 2006) are then applied to the calibrated fC data product for each forest strata. The output is a Tier 1 down-scaled forest carbon map and a more realistic estimate than simply a "paint-by-numbers" approach of assigning the IPCC default value to polygons of the same forest type.

On-line forest carbon MRV/M&E system (MRV for short). The MRV system is designed as a project management system, more in the line of an enterprise application. It is web-enable, but optimized for Firefox web browsers. The system has a secure login. Data are stored in a relational database which has redundant back-up and the application has bi-monthly system snap-shots for restore capabilities.

The core functions of the system include 1) a content management system and project registry, 2) geographic tools designed around a hierarchical project → parcel (or starta) → plot system, 3) plot

inventory data with tools and information to support sample plot design and data collection as well as carbon stock reporting, and 4) an emissions calculator tool designed to use either the Tier 3 biomass estimates from the plot inventory data or Tier 1 IPCC default parameters to calculate emissions ex ante or ex post in a project parcel. See figure 4.

FIGURE 4: SCREEN CAPTURES OF THE ON-LINE FOREST CARBON MRV/M&E SYSTEM

The system is deployed around a three-component design that includes Create Your Project, Work on Your Project, and Report on Your Project. The Tool contains a subsystem for Content Management, which provides a structured way to organize all project documents, budgets, memos and correspondences, reports, routed documents and other project documentation. The Tool also contains a subsystem for Mapping Geographic Information, organized in a three-level hierarchical design around Project-Parcel-Plot structure. It is GPS and GIS compatible and serves to organize all geographic information needed for managing inventory plots and forest or land cover strata. The Tool contains a subsystem for Managing Carbon Inventories from national or project scale field plot data, which is linked to the mapping subsystem. Template field data collection sheets are downloadable in printable or digital formats compatible with most handheld devices. Field data are uploaded into the system and all carbon calculations are performed using standard or custom allometric equations, and then reported out by project, parcel (strata) or plot. These data are then linked to the Tool's subsystem for Emissions Calculations, for a range of ex-ante or ex-post computations using the field inventories or standard data for both Tier 3 and Tier 1 calculations of emissions scenarios.

This MRV supports an organization's needs for developing, managing and reporting carbon projects at the national or project level. It provides an enterprise-wide solution of on-line tools for planning and implementing national forest inventory for carbon, development and management of carbon projects across all of your organization's offices and units, and enterprise training and capacity-building. The MRV supports planning, tasking and implementation, and its distributed, web-enabled approach, allows managers in one office to communicate and interact with field offices and other offices or co-operators across the organization. This structure, and its secure login and workspace design, allows verifiers and others to review the project data, providing a level of transparency and openness needed for most carbon projects today.

Training and Capacity Building. Through the course of the two year project a number of training and capacity building activities were scheduled. Training to project scientists, government agency

personnel and University staff and students was provided in 1) advanced methods for mapping carbon with satellite remote sensing and 2) in using the MRV system. Project team leads in Laos (Dr. Sithong Thongmanivong) and Vietnam (Dr. Phung Van Khoa and Dr. Do Xuan Lan) conducted field training with local communities and local government officials in the project sites focused on collecting plot level tree measurement data for estimating biomass. Table #2 shows details of the training sessions.

TABLE 2: TRAINING AND CAPCITY BUILDING ACTIVITIES

Training	Location	Dates	# of Participants
Advanced Remote Sensing for carbon mapping	Faculty of Forestry, NUOL Vietnam Forestry Univ.	July 7 – 9, 2011 Jan. 12 – 14, 2011	20 24
MRV System - Introduction	Faculty of Forestry, NUOL Vietnam Forestry Univ.	Dec. 7, 2012 Dec. 6, 2012	17 11
Community Training #1	Bac Kan Prov., Vietnam	Mar. 28 – 29 2012	36
Community Training #2	Sangthong Dist. Laos	May 21 – 22, 2012	25
MRV System advanced training	Faculty of Forestry, NUOL	Mar. 1 – 2, 2013	TBD: estimate 30-35

3.0 Results & Discussion

Project results and output. The project successfully completed its objectives. In the two year time period project investigators collected plot level forest inventory field data within two pilot areas. Forest cover data sets were developed and utilized to stratify the project areas. The project leveraged the GEF Carbon Benefits Project at Michigan State University which developed the on-line forest carbon MRV/M&E system. The MRV system served as a test bed with the pilot area plot inventory and geographic data to demonstrate the application under REDD+ activities.

The MRV results of the Sangthong District, Laos and two Community Forest areas in Bac Kan, Vietnam show the carbon stock and emission factors for each demonstration project. Sangthong District has 3628 ha deciduous forest area. The mean tC per ha from the 13 plots is 111.99 tC per ha. The standing stock is 406,288.35 tC. The emissions factors for the deciduous forest based on Tier 3 field data are 198.56 tons of dry matter per hectare and 39.71 tDM per ha (combined 238.27 tDM per ha). Bac Kan has two parcels of community forest. Na Muc is 118 ha and To Duc is 45 ha (total area of 163 ha). These are both broadleaf evergreen forests. The mean tC per ha from the 32 plots is 66.12 tC per ha. The standing stock is 10,777.56 tC. The emissions factors for the deciduous forest based on Tier 3 field data are 112.54 tDM per hectare and 28.13 tDM per ha (combined 140.69 tDM per ha). See table # 3. For these two project sites we used the Brown 1997 Tropical Moist Forest Equation[3] and a default root to shoot ratio for below ground biomass of .20 as suggested by IPCC 2005 table 4.4 for Tropical moist forest with above ground biomass less than 125 t/ha.

[3] AGB = 42.69 - 12.8(DBH) + 1.242(DBH^2)
Where: AGB is Above Ground Biomass in kilograms of dry matter (kg DM) and DBH is Diameter at Breast Height in centimetres (cm)

TABLE 3: CARBON DENSITY, STOCK AND EMISSION FACTORS FOR SANGTHONG DISTRICT, LAOS AND NA MUC AND TO DUC COMMUNITY FORESTS IN BAC KAN PROVINCE, VIETNAM

Project Site	Parcel Type	Area (ha)	Plot mean tC/ha	Carbon stock (tC)	EF tDM/ha
Sangthong	Deciduous	3628	111.99	406288.35	238.27
Bac Kan	Broadleaf evergreen	163	66.12	10777.56	140.68

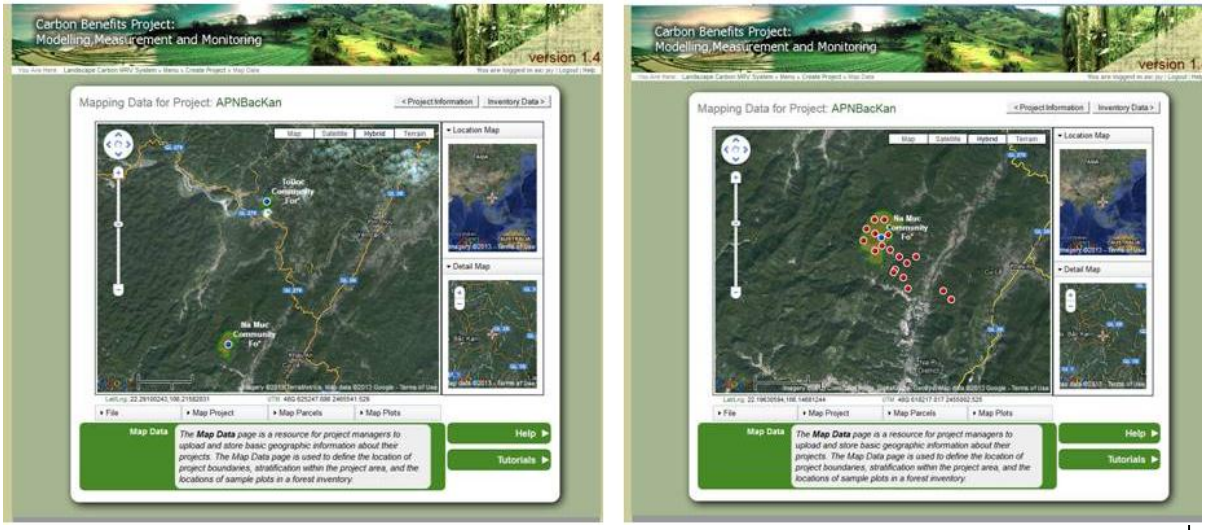

FIGURE 5: MAPPING TOOL OF THE MRV. TWO COMMUNITY FOREST AREAS AND BIOMASS PLOT LOCATIONS IN BAC KAN PROVINCE, VIETNAM

Figures 5 and 6 show the MRV system mapping of project parcels and plots for the Bac Kan community forest areas, and the carbon density, stock and biomass (emission factors) for Sangthong District, Laos.

Carbon Stocks by Plot

Plot Descriptors				Carbon Density					
Parcel ID	Plot ID	Plot Area (m²)	Trees/ha	AGB tC/ha	BGB tC/ha	SOC tC/ha	Litter tC/ha	Deadwood tC/ha	Total tC/ha
Deciduous_Forest	1	1963.49540849	1,471	137.25	27.45	—	—	—	164.70
Deciduous_Forest	2	1963.49540849	949	252.04	50.41	—	—	—	302.44
Deciduous_Forest	3	1963.49540849	630	201.58	40.32	—	—	—	241.89
Deciduous_Forest	4	1963.49540849	951	85.71	17.14	—	—	—	102.85
Deciduous_Forest	5	1963.49540849	274	28.52	5.70	—	—	—	34.23
Deciduous_Forest	6	1963.49540849	332	63.84	12.77	—	—	—	76.61
Deciduous_Forest	7	1963.49540849	601	108.16	21.63	—	—	—	129.79
Deciduous_Forest	8	1963.49540849	84	27.65	5.53	—	—	—	33.19
Deciduous_Forest	9	1963.49540849	232	47.69	9.54	—	—	—	57.23
Deciduous_Forest	10	1963.49540849	252	58.36	11.67	—	—	—	70.03
Deciduous_Forest	11	1963.49540849	220	36.52	7.30	—	—	—	43.83
Deciduous_Forest	12	1963.49540849	220	100.14	20.03	—	—	—	120.17
Deciduous_Forest	13	1963.49540849	644	65.53	13.11	—	—	—	78.64
Deciduous_Forest	14	1963.49540849	363	93.79	18.76	—	—	—	112.55
Deciduous_Forest	15	1963.49540849	666	112.21	22.44	—	—	—	134.65
Deciduous_Forest	16	1963.49540849	1,294	119.83	23.97	—	—	—	143.79
Deciduous_Forest	17	1963.49540849	792	52.31	10.46	—	—	—	62.77
Deciduous_Forest	18	1963.49540849	448	54.78	10.96	—	—	—	65.73
Deciduous_Forest	19	1963.49540849	737	158.76	31.75	—	—	—	190.51
Deciduous_Forest	20	1963.49540849	470	26.79	5.36	—	—	—	32.15
Deciduous_Forest	21	1963.49540849	295	59.79	11.96	—	—	—	71.74
Deciduous_Forest	22	1963.49540849	269	160.52	32.10	—	—	—	192.62
Deciduous_Forest	23	1963.49540849	331	94.66	18.93	—	—	—	113.59
Mean Value			**545**	**93.32**	**18.66**	**0.00**	**0.00**	**0.00**	**111.99**

Carbon Stocks by Parcel

Parcel Descriptors		Carbon Density					Carbon Stocks					
Values below in ha		*Values below in tC/ha*					*Values below in tC*					
ID	Area	AGB	BGB	SOC	Litter	Deadwood	AGB	BGB	Soil	Litter	Deadwood	Total
Deciduous_Forest	3628	93.32	18.66	0.00	0.00	0.00	338,573.63	67,714.73	0.00	0.00	0.00	406,288.35
Project Totals	**0.00**						**338,573.63**	**67,714.73**	**0.00**	**0.00**	**0.00**	**406,288.35**

Project: SumernetSangthong **Region:** Asia (continental) **Duration:** 30
Climate Zone: Tropical **Moisture Zone:** Moist

Parcel Descriptors			Mean Land Cover Inputs					Allometry
ID	Location	Area (ha)	AGB tDM/ha	BGB tDM/ha	SOC tC/ha	Litter tC/ha	Deadwood tC/ha	Root/Shoot Ratio
Deciduous_Forest	Laos	3,628.00	198.56	39.71	0.00	0.00	0.00	0.20

FIGURE 6: MRV OUTPUT REPORT FOR CARBON STOCKS FOR THE SANGTHONG DISTRICT. LAOS PROJECT AREA

The development of a method to link plot level forest inventory data with satellite remote sensing analysis demonstrates one aspect of scaling up the MRV system from project level to national or regional levels. Forest cover derived maps for national inventories coupled with National Forest Inventory (NFI) data could also be used in the MRV system to scale up from project levels. However, a continuous fields (fractional cover) approach to forest carbon mapping has the advantage over discrete parcel mapping and analysis because it captures more closely the reality of forest transitions and tree density (or stock) variations in the natural forest.

Two remote sensing data output products were developed as part of this project. The first was an analysis of Bac Kan Province using subsets of two Landsat images. The second was an area that covers more than 60% of Savannakhet Province in Laos. Forest carbon maps were developed for Bac Kan province from two Landsat images (WRS2 path: 127 rows: 44-45) acquired December 18, 2010. The province area is encompassed by these two images. Data were processed to fC as per the method described above. A threshold of value fC=30 was used to determine forest and non-forest. A carbon map was then developed by multiplying the fC value of all forest class pixels with the IPCC Tier 1 default biomass value of 130 tDM per ha of above ground biomass from table 4.7 of

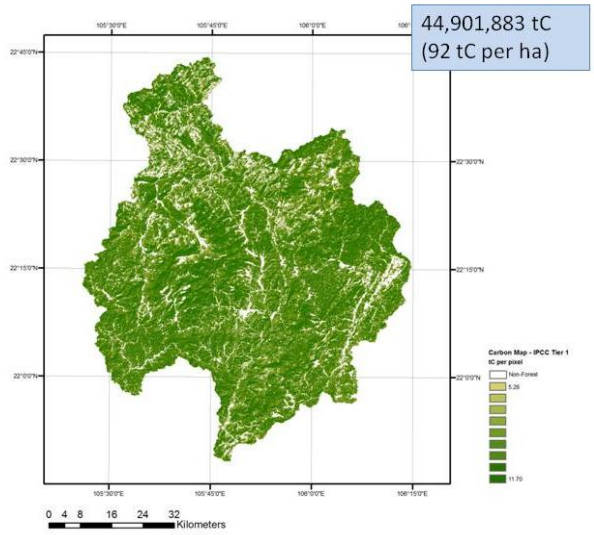

FIGURE 7: BAC KAN PROVINCE CARBON MAP FROM IPCC DEFAULT BIOMASS AND FC DATA

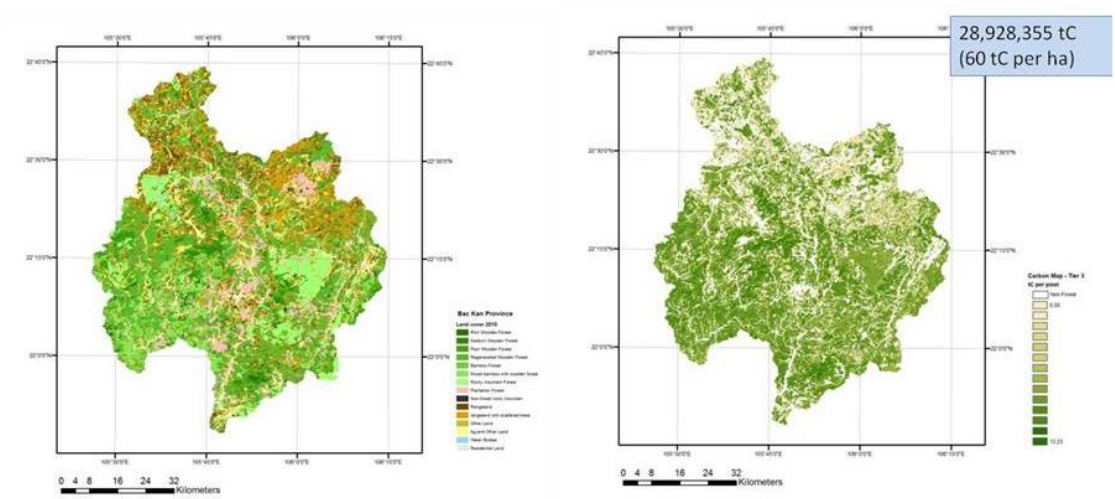

FIGURE 8: BAC KAN PROVINCE CARBON MAP FROM LAND USE STRATA, FIELD BIOMASS DATA AND FC DATA

IPCC 2006. The result is a carbon stock estimate for the province of 44,901,883 tC or an average of 92 tC per ha (Figure 7). A second forest carbon map was developed integrating a land use and land cover data set (Figure 8) and biomass data from field plots with the fC data product. The output map estimates carbon stock in Bac Kan at 28,928,355 tC or an average of 60 tC per ha (Figure 8).

The Forest map developed for the study area in Savanakhet Province, Laos used the canopy openness parameter from the SUFORD project field data to calibrate the forest fractional cover (fC) data to canopy openness. Figure 9 shows the project area and the Landsat data acquired January 30, 2009 used in the analysis. Figure 10 shows the final product calibrated with the field plot data.

Gaps. We acknowledge a few gaps in the project activities that partially impact the results and output from the research. The first is the need for additional field plot inventory data over larger areas and across various forest types throughout the project areas. The carbon stock assessments and the mapping are likely biased from too few field plots. Such efforts, however, are very costly in terms of financial and human resources and likely to be beyond the scope of any APN project. What the research project demonstrates, however, is capacity for the on-line system to compute carbon and a robust method for using remote sensing data coupled with field inventory data for forest carbon mapping. Plot inventory data collection is certainly within the prevue of the forestry agencies in both Laos and Vietnam and in fact improved NFI efforts are part of the World Bank Forest Investment Programme in Laos and the UN-REDD activities in Vietnam.

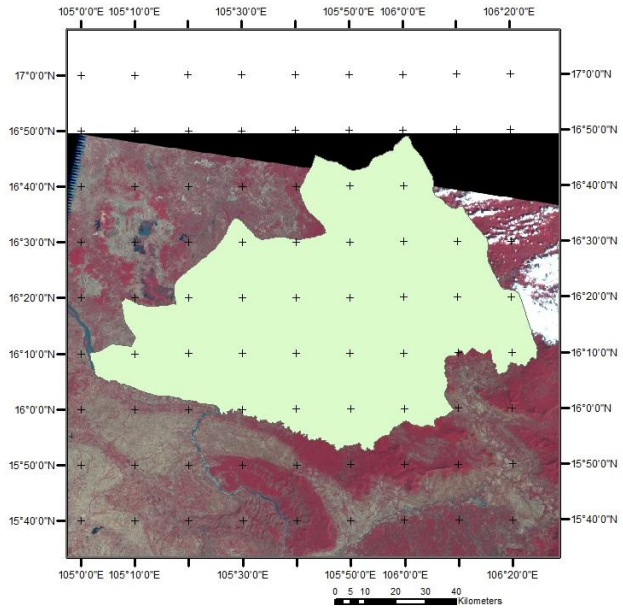

FIGURE 9: SAVANAKHET PROJECT AREA AND LANDSAT DATA USED IN ANALYSIS

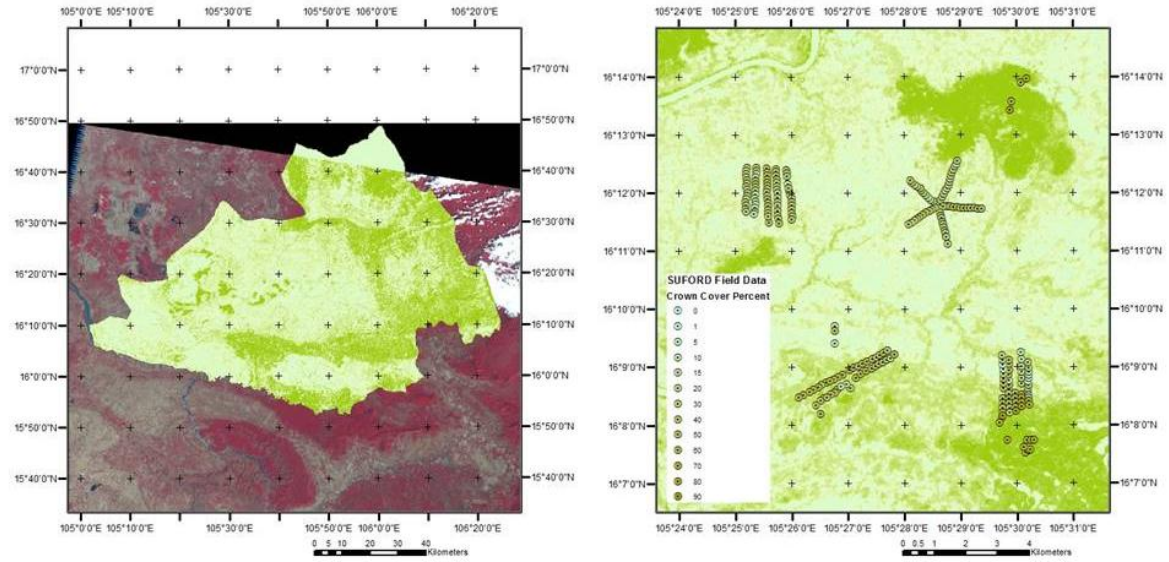

FIGURE 10: OUTPUT OF CALIBRATED FOREST CANOPY OPENNESS DERIVED FROM LANDSAT DATA AND FIELD DATA

More opportunities to involve local communities within forest areas, who are often using the forest resources, and in many cases managing or co-managing these resources is also an area where we could have completed more work under this research project. We did work in this area under the Sumernet funding focused on linking community-based measurement and monitoring with remote sensing analysis and the on-line MRV tool. The project areas included Sangthong District, Laos and

the two community forest areas in Na Ri District, Bac Kan Province, Vietnam. It also included a third project site in Mahasarakham Province, Thailand.

An initial project goal was to develop the remote sensing tools as an integrated set of on-line tools with the forest carbon MRV/M&E system. This simply proved much too difficult considering the some steps in the analysis are not simply push button routines that can be run as batch processes. Some steps require human interaction and interpretation, such as identifying the forest and soil end-members for each Landsat image used in creating the un-calibrated fC data product. In place of automated on-line tools we have a set of workflows identifying the processing steps necessary for using satellite remote sensing data for forest carbon mapping.

Further work. There are three areas of additional work related to the project activates. The first is to develop advanced methods of forest carbon mapping using hyper-resolution satellite data (e.g. QuickBird, WorldView, GeoEye) coupled with new biometric relationships of tree parameters. For example, in tree orchards and plantations there can be a very good relationship between tree crown area and tree diameter at breast height. With hyper-resolution (sub-meter) satellite data it may be possible to develop an automated tree crown delineation algorithm that uses both spectral and texture to map tree crown areas over large landscapes. Using field collected tree crown areas these remote sensing data sets can be calibrated. Then it is a simple step to calculate biomass and carbon using the tree crown area relationship to DBH and standard allometric equations. We have begun testing this method in Litchi orchard dominated landscapes in Bac Giang, Vietnam (figure 11).

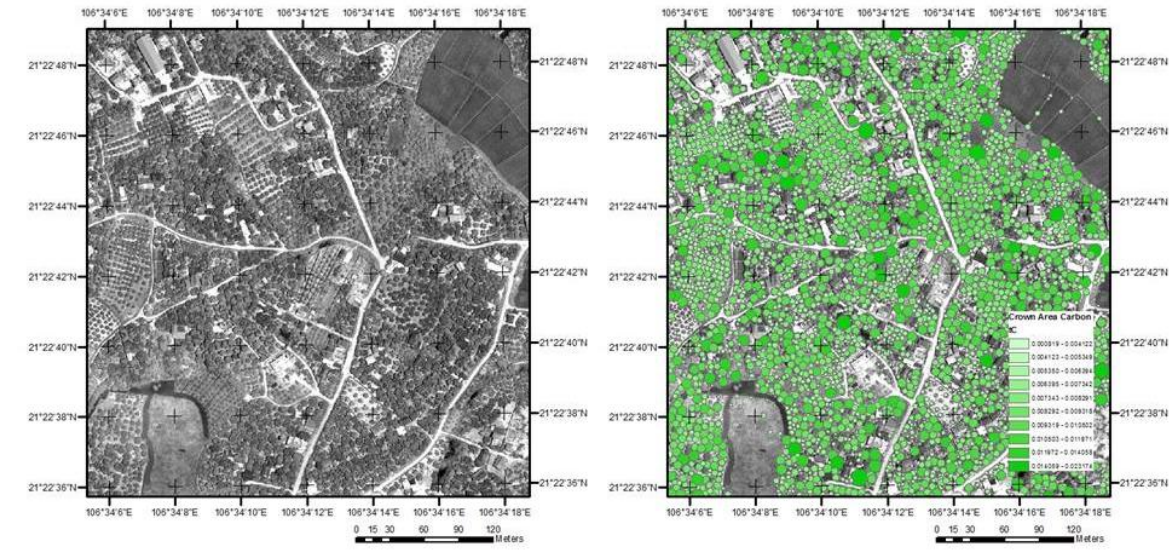

FIGURE 11: LITCHI AREA IN BAC GIANG, VIETNAM WITH CROWN AREA CARBON MAPPING FOR GEOEYE DATA.

A second area of further work is developing general allometric equations for complex agroforestry and trees-on-farm landscapes that, in many parts of the tropics, dominate the rural, non-forest, areas. These systems are challenging to measure and monitor with respect to carbon stock and changes in carbon emissions over time. Developing methods for estimating carbon in these systems, however, will perhaps provide access for small-holders to emerging carbon markets.

A third area for future work includes additional functionality and upgrades to the online MRV system. These include:

- Variable user login access rights and restrictions
- The sharing of data for crowd-sourcing information
- Improved report generation
- Custom, user-defined allometric equations
- Custom user-defined document storage typologies
- Project zip and export (all files, all data)
- Some automated remote sensing processing (e.g. data discovery and acquisition, TAO reflectance, MSAVI2, etc.)
- Additional GIS functionality (query areas on the map)
- Biodiversity indicators
- Social indicators
- Simple cost-benefit analysis

4.0 Conclusions

The main objectives of the project were: to develop (1) two sub-national pilot REDD+ project activities in coordination with national efforts in Laos and Vietnam and (2) a scalable, Internet-enable REDD MRV management application that uses remote sensing data and Web-GIS tools to support the two pilot projects. A third main objective is capacity building and training of regional scientists in REDD+, MRV technologies, and climate change topics, including the potential of carbon financing and the technological requirements for measuring biotic carbon on the landscape.

The project co-investigators successfully completed the objectives of the project. Field level plot inventory data were collected in each of the project pilot areas. Forest strata were identified. Plot data and parcel information input to the on-line forest carbon MRV/M&E system were used to compute estimated carbon stocks, mean carbon per hectare values and emission factors in tonnes of dry matter per hectare.

Advanced remote sensing methods for forest carbon mapping were developed that pushed beyond simple IPCC Tier 1 values used in forest cover classes. The methods used IPCC Tier I values down-calibrated to forest cover variance using vegetation continuous fields, or fraction cover, data sets as an input. Tier 3 data from the field plot inventories were also used to calibrate fC pixel values and combined with a land use and land cover stratification map provided a more detailed forest carbon map. A tree area openness product was also developed through regression of field based crown area data with fC data.

The MRV system itself, mostly developed under other funding, allowed us to test the data and method for use as an MRV system supporting REDD+ or Forest carbon activities at project or national scales. Through demonstrations, training, and general introduction of the system to stakeholders and potential users there is strong interest in its capabilities – not only for project management and reporting but also as a training and knowledge learning tool.

5.0 Future Directions

Considering the advances we have made in the development of the on-line forest carbon MRV/M&E system, the new methods developed for forest carbon mapping using remote sensing data, and the real-world examples demonstrated with data from two pilot areas, we envision that there is potential for further work along four lines:

1. The expansion of project sites for demonstrating the measurement and monitoring tools in the on-line system at national scale reporting and expanded to other countries in the region (e.g. Cambodia, Philippines, Thailand).

2. The development of additional remote sensing forest carbon methods using hyper-resolution data for agro-forestry and woodland system; this would use a combination of object (texture analysis) oriented and spectral signature processing coupled with tree biometry related biomass equations such as tree crown area to DBH and biomass.

3. The use of the on-line forest carbon MRV/M&E system within a Knowledge Management or Learning Management Environment. This would integrate the on-line tool with sample project data, video tutorials, workbooks and presentation focused on a series of forest carbon / climate adaptation and mitigation themes (e.g. Community-based forest carbon measurement and monitoring; AFOLU Emissions Scenarios; Forest carbon and GHG Markets, etc.)

4. The development and testing of additional functionality to the -line forest carbon MRV/M&E system for reporting social and ecological co-benefits for forest carbon mitigation and emissions avoidance activities. Such functionality could include biodiversity reporting, supporting provisions for documenting Free Prior Informed Consent (FPIC), ensuring safeguards, and the like.

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Appendix

Conferences/Symposia/Workshops

PROJECT PLANNING MEETING & RS TRAINING
12 – 14 JANUARY 2011
VIETNAM FORESTRY UNIVERSITY
HANOI, VIETNAM

Agenda (Tentative)

Meeting goals and objectives: review and coordinate the implementation framework for the project activities, identify the two pilot areas for the REDD+ MRV system, training in remote sensing analysis.

Day 1: January 12, 2011 (Wednesday): Project background and goals

08:30 – 09:15	Registration: Room (TBD)
09:15 – 09:30	Welcome speech (VFU Official - TBD)
09:30 – 09:45	Opening Address (VN Climate Change / Forestry Official - TBD)
09:45 – 10:00	Group Photo
10:00 – 10:30	*Morning Coffee/tea break*
10:30 – 11:00	Project overview and meeting objectives (J. Samek, MSU)
11:00 – 11:30	REDD+ General Overview (TBD)
11:30 – 12:00	Report back from COP 16: Cancun (TBD)
12:00 – 13:30	*Lunch*
13:30 – 14:00	Proposed Project MRV: Functions and limitations (J. Samek, MSU)
14:00 – 14:30	Current State of REDD+ Activities in Lao PDR (S. Thongmanivong, FoF, NUOL)
14:30 – 15:00	Vietnam: UN-REDD Vietnam Program (P. Van Laake, UNDP)
15:00 – 15:30	*Afternoon Coffee/tea break*
15:30 – 15:45	Mtg. Goal 1: Identify Pilot Project Sites (J. Samek, MSU)
15:45 – 16:45	Discussion and breakout groups (by country teams)
16:45 – 17:00	Report back on potential selected sites or timeline and strategy for selection
17:00	Logistics announcements
18:30	Dinner hosted by APN project (venue: TBD)

Day 2: January 13, 2011 (Thursday): Work-plan and implementation strategy

09:00 – 09:15	Overview of day 2 meeting goals (J. Samek, MSU)
09:15 – 10:00	Project Work Plan Time Line (review, discussion, revision, and action/tasks)
10:00 – 10:30	*Morning Coffee/tea break*
10:30 – 11:30	Linkages and partners (review, breakout by country teams, report back)
11:30 – 12:00	RS Data Acquisition and Analysis (J. Samek, MSU)
12:00 – 13:30	*Lunch*
13:30 – 13:50	CO2 Efflux in Rubber and Natural Forest – Lao PDR (Souksompong, FoF, NUOL)
13:50 – 14:30	Fieldwork (review, discussion, revision, and action/tasks)
14:30 – 15:30	Data Needs, Existing/Available GIS & Biomass Data (review, breakout by country teams, report back)
15:30 – 16:00	*Afternoon Coffee/tea break*
16:00 – 17:00	Mtg. Goal 2: Finalized implementation strategy, task leads, project timeline
17:00	Logistics announcements

Day 3: January 14, 2011 (Friday): RS Training – Landsat Data

08:30 – 10:00	RS Training (Rm TBD)
10:00 – 10:30	*Morning Coffee/tea break*
10:30 – 12:00	RS Training (continued …)
12:00 – 13:30	*Lunch*
13:30 – 15:00	RS Training (continued …)
15:00 – 15:30	*Afternoon Coffee/tea break*
15:30 – 17:00	RS Training (wrap-up)

- 25 people (50 if doubled up on computers)
- Software ERDAS Imagine
- Sign in sheets (Name, organization/agency, position, email)
- Landsat data analysis: Vegetation Continuous Fields (VCF) and Landscape Disturbance Index (DI)

LIST OF PARTICIPANTS ATTENDING THE
APN EBLU2010-04NMY(C)-SKOLE
PROJECT PLANNING MEETING AND REMOTE SENSING TRAINING WORKSHOP
12-14 JANUARY 2011
VIETNAM FORESTRY UNIVERSITY

No.	Name	Organization	Country
1	Tran Huu Vien	VFU	Vietnam
2	Pham Xuan Hoan	VFU	Vietnam
3	Pham Van Chuong	VFU	Vietnam
4	Nguyen Quang Ha	VFU	Vietnam
5	Pham Van Dien	VFU	Vietnam
6	Nguyen The Nha	VFU	Vietnam
7	Nhu Van Ky	MARD	Vietnam
8	Bui Van Hai	Cao Phong CDM Project	Vietnam
9	Do Anh Tuan	VFU	Vietnam
10	Le Xuan Truong	VFU	Vietnam
11	Tran Viet Ha	VFU	Vietnam
12	Nguyen Thi Bich Hao	VFU	Vietnam
13	Phi Hai Ninh	VFU	Vietnam
14	Kieu Thi Duong	VFU	Vietnam
15	Tang Si Hiep	VFU	Vietnam
16	Bui Van Nang	VFU	Vietnam
17	Tran Quang Bao	VFU	Vietnam
18	Vu Dang Tue	VFU	Vietnam
19	Nguyen Phuc Yen	VFU	Vietnam
20	Phung Van Khoa	VFU	Vietnam
21	Jay H. Samek	GOES, MSU	USA
22	Saykham Bounthoung	FoF, NUOL	Lao PDR
23	Sithong Thongmanivong	FoF, NUOL	Lao PDR
24	Khamla Phanvilay	FoF, NUOL	Lao PDR

ON-LINE FOREST CARBON MRV/M&E TOOL DEMONSTRATION MEETING

Hanoi, Vietnam
Venue: MARD
Dec. 6, 2012; 10:30 – 12:30/13:00

Vientiane, Lao PDR
Venue: NUOL
Dec. 7, 2012: 10:00 – 12:00/13:00 (tbc)

Meeting objectives: The technical team at GOES, MSU-Forestry has developed an On-Line Forest Carbon MRV/M&E System under the GEF, Carbon Benefits Program and with support from APN and Sumernet for pilot projects in Laos and Vietnam. The meeting is to demonstrate the capabilities of the MRV/M&E system to support REDD+ and Forest Carbon Management Programs and Projects in each of the respective countries.

GENERAL AGENDA

(2 – 3 hours)

- Welcome and Introductions (5 - 10 min)
- Brief Introduction to the APN & Sumernet projects (10 – 15 min)
- Forest Carbon MRV Demonstration (60 – 90 min)
    - GEF CBP; WWF; etc
    - An enterprise system for solutions: REDD+, NFI, Training, Community Carbon, etc
    - Project Management, Mapping and Geographic Data, Field Inventory and Carbon stock calculations
    - Carbon Emissions Tool (ex ante, ex post)
    - Remote Sensing add-on
- Questions and comments (15 – 30 min)
- Lunch (tbc)

Handout: Project and On-Line Tool information, website addresses, contact information

Presentation and demo will be lead by research scientists and project manager Mr. Jay H. Samek from the Global Observatory for Ecosystem Services, Forestry Department, Michigan State University.

Participants: Government agency personnel involved with MRV/M&E/Results Framework reporting for FIP in Laos and UN-REDD/FCFP in Vietnam.

Project's Lead Investigators:

Dr. Do Xuan Lan, DoST, MARD, Vietnam
Dr. Phung Van Khoa, VFU, Vietnam
Dr. Sithong Thonmanivong, FoF, NUOL, Lao PDR
Dr. David Skole, GOES, Forestry, MSU, USA

LIST OF PARTICIPANTS ATTENDING THE APN CARBON WORKSHOP

Hanoi, 06/7/2012

#	Name	Agency	Position	Remark
1	Vo Dai Hai	VNForest	Deputy Director General	haivodai@gmail.com
2	Do Xuan Lan	Department of Science Technology and Environment, MARD	Deputy Head of Division	landx.khcn@mard.gov.vn
3	Le Hoang Anh	Department of Science Technology and Environment, MARD	Senior staff	anhlh.khcn@mard.gov.vn
4	Nguyen Huy Dung	Forest Inventory and Planning Institute	Deputy Director General	Dungnh.ln@mard.gov.vn
5	Tran Hieu Minh	VNForest	Senior staff	
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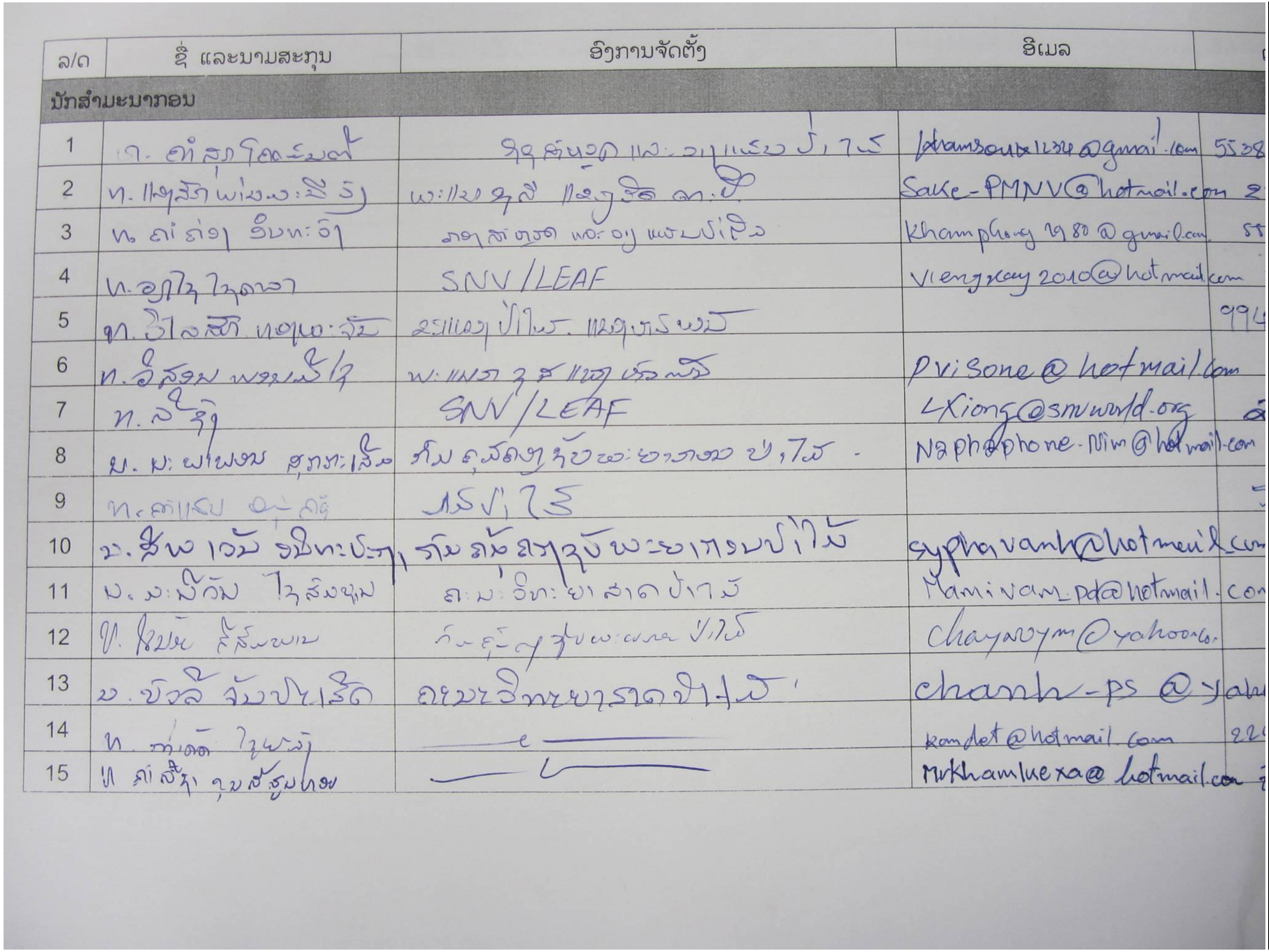
9	Pham Van Duan	Vietnam University of Forestry	Senior staff	
10	Nguyen Cao Tung	Center for forest Information and Consultancy	Director	Caotung_nc@hn.vnn.vn
11	Nguyen Van Thi	Vietnam University of Forestry	Senior staff	



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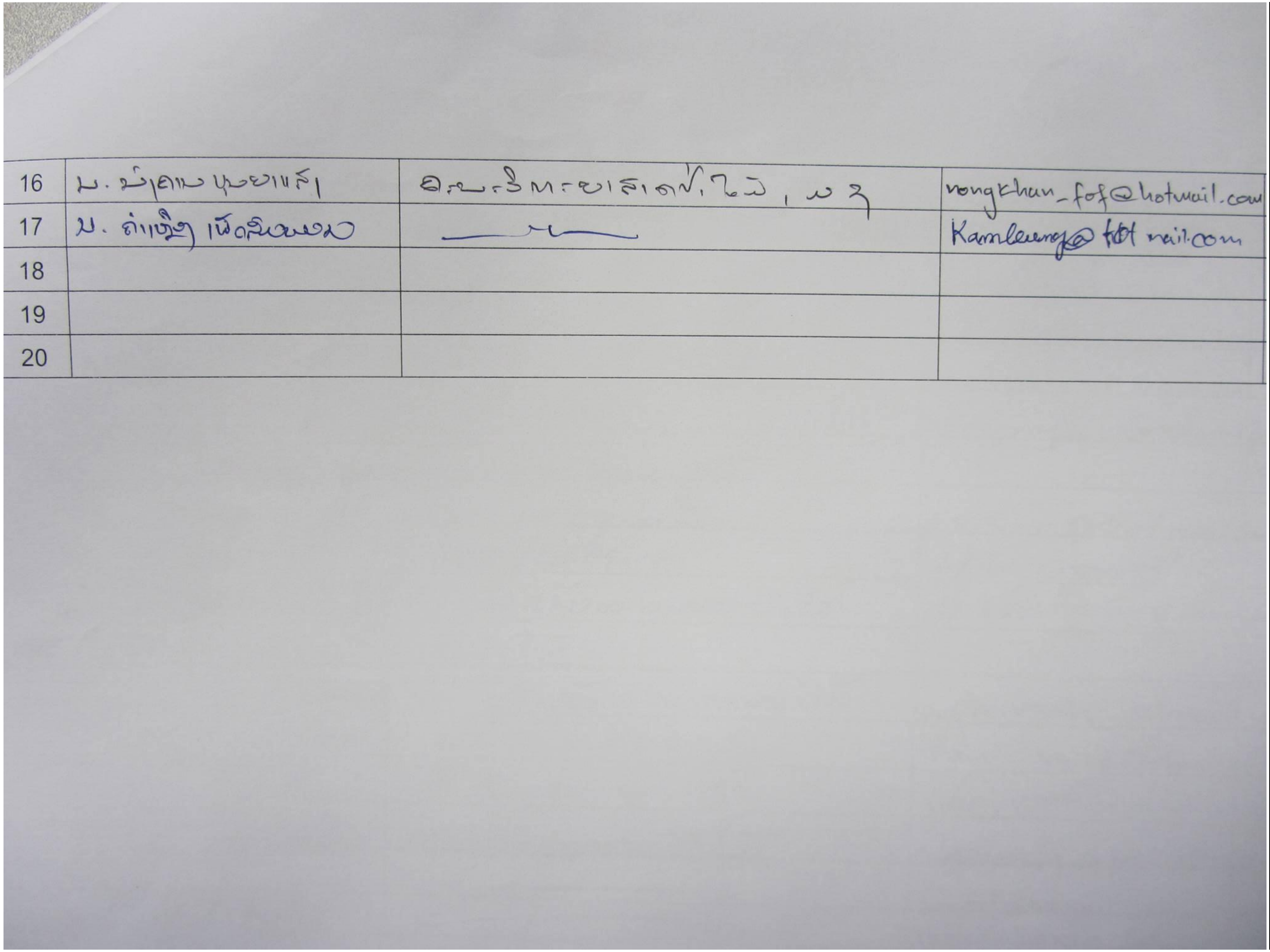

16	ນ. ນົງຄານ ບຸນຍາແສງ	ຄະນະວິທະຍາສາດປ່າໄມ້, ມຊ	nongkhan_fof@hotmail.com
17	ນ. ຄຳເຫຼືອງ ເພັດສີລາວງ	—	Kamleung@htt mail.com
18			
19			
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Developing an MRV system for REDD+: Scaling up from project level to a national level
REDD+ MRV systems for Lao PDR and Vietnam

AGENDA

FINAL PROJECT MEETING AND MRV TRAINING
MARCH 1 - 2, 2013 ● VIENTIANE, LAO PDR

Meeting Objectives: 1) provide hands-on training of the Forest Carbon MRV on-line tool to potential users; 2) demonstrate the tool using the data collected at the two pilot sites; 3) review potential remote sensing methods for forest carbon measurement and monitoring; and 4) seek feedback from users on both the on-line tool as well as the remote sensing methods.

Friday, March 1, 2013 (Day 1)

08:30 – 09:00	Registration
09:00 – 09:30	Opening Remarks and Introductions
09:30 – 10:00	Project Review (Jay Samek, MSU)
10:00 – 10:30	Coffee break
10:30 – 11:00	MRV Tool Introduction (Jay Samek)
11:00 – 12:00	MRV Tool Training – Part 1a (Carbon Stocks)
12:00 – 13:30	Lunch
13:30 – 14:30	MRV Tool Training – Part 1b (Carbon stocks)
14:30 – 15:00	Coffee break
15:00 – 17:00	MRV Tool Training – Part2 (Emissions)
19:00	Dinner (venue TBD)

Saturday, March 2, 2013 (Day 2)

09:00 – 09:30	Questions about the MRV Tool
09:30 – 10:15	Remote Sensing Approach to Biomass Mapping (Jay Samek) - MSU Fractional Cover - MSU Tree Crown Detection
10:15 – 10:45	Coffee break
10:45 – 11:30	RS Approach in Vietnam with SPOT 5 (Dr. Do Xuan Lan, DoST, MARD)
11:30 – 12:00	Discussion on RS methods
12:00 – 13:30	Lunch
13:30 – 14:30	Wrap up, comments

Funding sources outside the APN

Co-Funding:

1. Sumernet (funding from DFID through CDKN and SEI. US$80,000. Project Title: "Research on Integrating Community-based Participatory Carbon Measurement and Monitoring with Satellite Remote Sensing and GIS in a Measurement, Reporting and Verification (MRV) System for Reducing Emissions from Deforestation and Forest Degradation – Plus (REDD+)"; countries included: Laos, Thailand, United States and Vietnam.

2. GEF – Carbon Benefits Project. US$1,300.000.00. Funded primarily the development of the on-line MRV Forest Carbon MRV/M&E system and field testing in Kenya.

In-Kind Support:

1. Faculty of Forestry, National University of Laos (~US$2500.00)
2. Vietnam Forestry University (~US$2500.00)
3. Global Observatory for Ecosystem Services, Department of Forestry, Michigan State University (~US$5000.00)

Glossary of Terms

ASEAN	Association of Southeast Asian Nations
CDKN	Climate and Development Knowledge Network
CDM A/R	UNFCCC Clean Development Mechanism Afforestation/Refordetstion
DFID	United Kingdom Department for International Development
fC	fraction cover, a vegetation continuous fields remote sensing data product
FCPF	World Bank Forest Carbon Partnership Facility
FSIV	Forest Science Institute of Vietnam
GEF	Global Environment Facility
M&E	Monitoring and Evaluation
MRV	Monitoring (Measurement) Reporting and Verification
REDD/REDD+	Reducing emissions from deforestation and forest degradation/plus carbon sequestration
SEI	Stockholm Environment Institute
tDM	tones of dry matter (biomass)
tC	tones of carbon

Sample field data collection sheet

Date:			Start Time:			End Time:	
Crew:							
Stratum ID:							
Plot ID:							
Description:							
Plot Area (m^2):		Other ID:					
Variable OR Fixed Area Plot		Radius =	m	OR Square:		m x	m
GPS Latitude:		GPS Longitude:			Weather:		
Hemi Photo Center:		Horiz Photo North:			Elevation:		
Hemi Photo North:		Horiz Photo East:			Slope Condition:		
Hemi Photo East:		Horiz Photo South:			Deg Up:	Deg Down:	
Hemi Photo South:		Horiz Photo West:			Basal Area:		(m^2)
Hemi Photo West:		Comments:					

Tree	Genus and species	DBH (cm)	Total Ht (m)	Crown D max (m)	Crown D 90° (m)	Multi Stems?	Comments
1							
2							
3							
4							
5							
6							
7							
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28							
29							
30							
31							

Tree	Genus and species	DBH (cm)	Total Ht (m)	Crown D max (m)	Crown D 90° (m)	Multi Stems?	Comments
32							
33							
34							
35							
36							
37							
38							
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Report on Forest Inventory

Dongsithuane Production Forest, Song Khone District

Savanakhet Province

Division of Research, Faculty of Forestry

National University of Laos

March 2009

Contents

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1. Introduction

This report presents the results of a forest measurement in Dongsithouane Production Forest, Savanakhet Province. The fieldwork was carried out in collaboration with the local government officials at the District Agriculture and Forestry Extension Office (DAFEO) include Songkhone and Thapangthong district and villagers.

2. Objectives

The overall aim of the study was to conduct forest measurement to assess the biomass of the forest cover to substitute for the carbon stock assessment using Lidar imageries. It also aims to develop baseline information for use as a benchmark to assess possible changes to the environment in the future.

3. Methodologies

In order to achieve the objective, a survey team composed of 6 lecturers and 6 students from the faculty of forestry conducted forest measurement in areas a long the LIDAR scanning lines. A training was organized to discuss about the fieldwork plan and methodologies to use for this study. After the indoor training all group conducted a field test measurement together at the site.

The fieldwork plan was done with the district staffs, we aim to work intensively in 6 sites each site was defined base on the accessibility, forest cover types, distribution of sample plot and the scan line of Lidar.

Each site we plan to lay out plots along the lines. We divided the survey team into 5 groups each group has team member 5 or 6 people include 1 lecture, 1 students and the rest are district staffs and villagers. Figure 1 below shows the survey sites in the field, there were 5 sites located in the Lidar scan line and one site located in Thapangthong District, outside the scan line of Lidar.

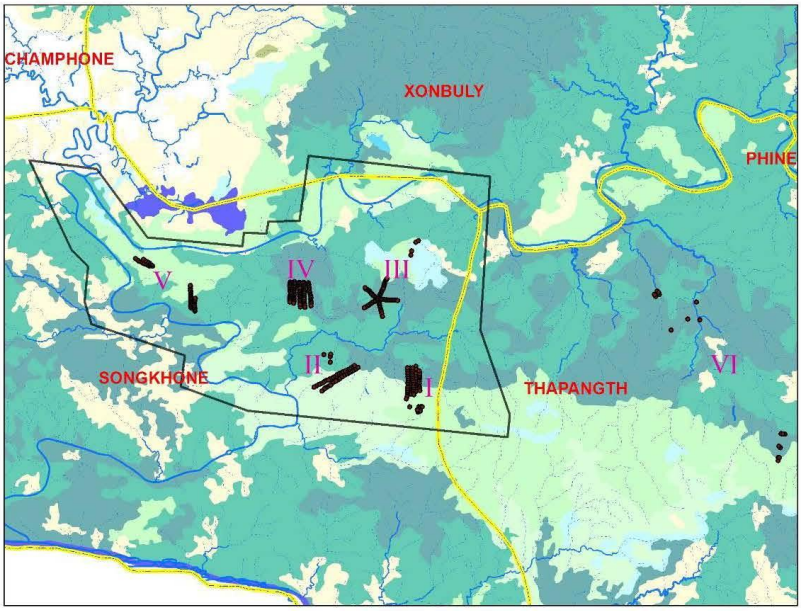

Figure 1: Survey sites

In total, there were 328 sampling plots were established across the study area and plant samples were collected in case the team can not identify the species, they then identified the name after arriving the camp with other group members.

In each sampling location four sample plots were created, they were 20 x 20m and 10 x 10m, 4 x 4m and 2 x 2m. Tree species names, crown cover and land use were recorded. In each sample plot, the location (latitude/longitude) of the plot was measured using a Global Positioning System (GPS). Slope and elevation of the site were measure and adjust the length of the plot as suggested. Details of tree accounting and measurement were made base on the given TOR by the project.

Data input and calculation

All data recoded from the field had been input into the spreadsheet in excel format, the structure of the spreadsheet was developed base on the information deriving from the field measurement. Three types of volume estimation ware calculated, they were Bole volume, Total stem volume and form factor volume. The equation of each type of volume estimation derives from the previous report done at the PFA in Savannakhet. To make the calculation easy, all tree species, village concern to each plot, forest type, etc., were coded and the extra sheet were added beside the plot data sheet to explain the code.

4. Findings

Based on the survey, forest is predominant by deciduous and mixed deciduous forest. There were totally 318 sample plots created through out the study area in which 252 plots were located in the deciduous forest, 51 plots in the mixed deciduous and the rest were in the paddy field or other area surrounding the village residence. There are 268 plant species have been found in the 318 sample plots.

During the field survey it was observed that most of the forest area accept the mixed deciduous were burn by surface fire. According the discussion with local villagers they said that this fire were burn by villagers in all area to stimulate the new grasses for their cattle. They believe that the burn will not only make better for new grasses but will also improve the growth of the tree as well.

Nearly all of the forest areas were used by local villagers for their livestock raising and for paddy rice cultivation, according to the local villagers who were consulted in this study. Although, there is no appearance of shifting cultivation the forest is threatening by local uses as a lot of timber logging were observed through out the study area.

The survey found that most of area are disturbed and have been logged for timber, most of existing trees are are young which have diameter at breast high 20-40 centimeters and 10-20 cm. the figure 2 belows shows the number of trees in each DBH class of DD and MD forest.

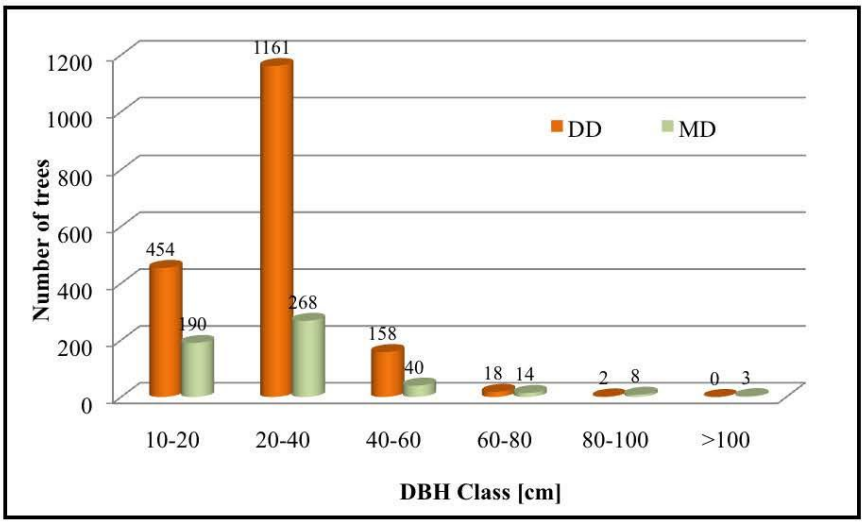

Figure 2: Number of trees in each dbh class from the sample plot

The biomass assessment

As we lack of information regarding the wood density of different species. We use allometric equation (Brown et al. 1989) to estimate the above ground biomass of the trees in each sample plot. This equation is for broad leaved species in tropical humid regions that have annual rainfall between 1500-4000 mm and the dbh 5-130 cm. This equation model are as follows:

$$AGB=Exp(-3.1141+0.9719*ln(DBH^2*H))$$

Where:

AGB = above ground biomass of a tree (kg)

DBH = diameter at breast heigh (cm)

H = total height of the tree (m)

The result of volume and biomass estimation of each forest type are as the following:

Deciduous forest

Major tree species in the deciduous forest were dipterocarpaceae families such as *Dipterocarpus tuberculatus, Pterospermum magalocarpum, Dipterocarpus alatus, Pentacme siamensis, Shorea obtusa.* The crown cover of this forest type ranged between 10 – 70%. Some area in this forest type we also observed paddy rice cultivation. The crown cover in paddy area was between 5-30%. The average tree volume per plot is 3 cubic meter or 75 cubic meters per hectare. The biomass estimation in the DD forest is 62.3491 tons per hectare. Table 1 bellow presents the average number of trees and volume in the sample plot of DD forest.

Table 1: The average trees and volume per plot in DD forest type (252 plots)

Plot size	No of trees/plot	Bole volume (m3)	Total stem volume (m3)	Form factor volume (m3)	Above grown biomass (ton)
20x20	5.3175	3.2537	2.6350	3.0135	1.9927
10x10	1.8056	0.1688	0.1461	0.1398	0.0986
4x4	1.0833	0.0008	0.0002	0.0057	0.0043
2x2	2.7262				

Mixed deciduous forest

Mixed deciduous forest were considerably dense forest, with crown cover ranged between 70 - 90%, an average tree volume per plot of 7 cubic meters (approximately 175 cubic meters per hectare). The biomass estimation in the MD forest is 171.6937 tons per hectare. Table 2 bellow presents the average number of trees and volume in the sample plot of MD forest. These forests appear to provide good habitat for wildlife. During the field survey, we found animal tracks and footprints including a variety of birds and wild pigs. In this forest type, the dominant tree species included those belonging to the Ebenaceae, Sterculiaceae,

Leguminosae – Papilionatae and Barringtoniaceae family such as *Pterospermum semisagittatum, Diospyros malabarica, Peltophorum dasyrachis Barringtonia annamica,* and *Erythrophleum fordii*.

Table 2: The average of tree volume per plot (51 plot)

Plot size	No of trees/plot	Bole volume (m3)	Total stem volume (m3)	Form factor volume (m3)	Above grown biomass (ton)
20x20	6.5294	8.0018	6.1249	7.9642	5.0774
10x10	3.7255	0.4410	0.3581	0.4029	0.2815
4x4	4.1315	0.0081	0.0025	0.0357	0.0266
2x2	11.4706				

The table shows that there were more trees in the smaller plot in comparison with the sample plot of the DD forest this due to the DD forest has not much tree stories and combine with the disturbance of villagers especially the forest fire each year.

Paddy rice field

Paddy rice field in the study area is an important land cover type. Local people use the land for rice planting and at the same time keep the large tree. There were 14 sample plot located in the paddy rice field. Most of paddy rice fields are cover by deciduous forest which have crown cover range between 5-30% In average each plot will have 2.5 trees and have about 2 cub meter per plot or about 50 cub meter per ha. The biomass estimation in this land use is 38.2911 tons per hectare.

Plot size	No of trees/plot	Bole volume (m3)	Total stem volume (m3)	Form factor volume (m3)	Above grown biomass

					(ton)
20x20	2.5000	2.4164	1.8732	2.3687	1.5316
10x10	-	-	-	-	
4x4	-	-	-	-	
2x2					

6. Conclusion

Although, the re-measurement was not success, it can be said that the forest inventory had been completed successfully. The measurement is difficult in finding its location due to the available information is limited, there were in degree. The new 318 plots had been established and scattered through out the area, the new sample plot ware created and recorded precisely. It is expected that they could be used for carbon stock monitoring in the future.

In general, the forest cover in the PFA is still abundance, although there is not much high value timber available. It is observed that the threatening on the forest is increasing through out the area by local use and forest fire. If there is no immediate pay attention and support the forest cover in this area will be degraded soon. There should be more studies about the timber use by local people and try to set up proper strategies to manage the forest use.

Base on our observation, the project may take into consideration some activities in the future as follows:

- If possible there should be a research on the use of forest resource by local villagers. Forest fire could be an important topic, as we know from the discussion with local people they understand that the forest fire is good for new grasses for their animal and it is also good for the threes. If there is no forest fire, they believe that the pest or insect will increase. In this regards, there should be some permanent plots establish in the area to study about the succession of forest cover that have not been disturb by the fire.
- Land tenure issue seems to be a major constrains for the sustainability of forest managment. Although the area was declare by the government as the PFA but in reality

all of forest area are used by villagers as their traditionally practices. Clearer land use planning and strict regulation should be redone or improved sot that the implementation of REDD project can be more secured.

- There needs to be a better coordination between stakeholders in regard to logging, and enforcement of rules to control informal logging in the area, there needs to be measures to control the current illegal log taking.

Reference:

- Brown, S., A.J.R. Gillespie and A.E. Lugo. 1989. Biomass estimation methods for Tropical forests with applications to forest inventory data. Forest Science, tropical forests with applications to forest inventory data. Forest Science, 35:881-902.

Attachment 1: Fieldwork activities

Field survey was conducted between Feb 25 –March 10, 2009. Details activities each day can be summarized as followings:

25 Feb	Workshop at FOF with 6 teacher to mobilize the teamwork and to discuss about the fieldwork plan; Depart Vientiane at 4 O'clock for Bolikhamsay Province
26 Feb	Depart from Bolikhamsay to Savanakhet, pick up Mr. Khamkeo at khammuane and arrive Kaisorn Phomvihan district around noon and have lunch there with Vorasit, the PAFO staff of Savanakhet; at 1:30 meeting with Mr. Somsakun, the head of Forestry sector at Savanakhet province. 4:00 meeting with the head of DAFOE, Songkhone district to present the plan of field work
27 Feb	Workshop with DAFOE staff and final year students, the total number of the team has 16 persons, the rest of the team member had to identify with village leaders in each site. The discussion in the workshop include – Objectives and work plan of the fieldwork. – Details activities, and learn how to use equipment and team work organization – Demonstrate actual practice and note taking for each team work – The team stay overnight at guesthouse af Songkhone district
28 Feb	Begin actual fieldwork at the forest near to Ban Huaykhai. 5 Villagers from Ban Huaykhai were asked to join the team.
01 March	Continue working at the same area

02 March	Conduct field work at Ban Huaykho and a team were send to find the old sample plot near Ban Huaykhi; the team could not find the location of the old plot and can not find any mark on the tree.
03 March	The fieldwork conducted at Ban Nasano
04 March	One day break
05 March	Conduct fieldwork at Ban Donmuang and Ban Lakkam
06 March	The team was dividied into two teams, one team conduct fieldwork at Ban Nathang-Thaphee, while another team go back to the old plots try to find its location and establish the sampling plot at Ban Huaykhai.
07 March	Conduct fieldwork at Ban Donkhiao
08 March	Depart Songkhone district to Thapangthong district and meeting with the DAFEO staffs
09 March	Conduct fieldwork at Ban Bak
10 March	Conduct field work at Ban Nonsavang and travel back to stay overnight in Savannakhet
11 March	Depart from Savannakhet for Vientiane

Appendix 2: TOR

List of Data, Documents and Presentation on the Project DVD

1. Plot level field data (Excel)
2. Field and workshop pictures
3. Presentations from the Jan 2011 Meeting (Powerpoint)
4. GIS and RS Data for project pilot sites
5. Remote Sensing Processing Models ERDAS Imagine
6. ICRAF-Vietnam Report