

A CASE STUDY OF A FOREST CARBON STOCK MONITORING SYSTEM FOR REDD+ IN LAO P.D.R.

M. Nasu^{a*}, T. Sano^a, K. Oono^a, Y. Wada^a, R. Nakada^a, T. Yamase^a, S. Tomimura^a, T. Furuya^a, G. Matteo^a, C. Kamusoko^a,
Y. Gomi^a, T. Isobe^a, A. Iwata^a, H. Moriike^a, S. Hironaga^a, T. Hosokawa^a, T. Someya^a, A. Wachi^a, Khamma Homsysavath^b

^a Asia Air Survey Co., Ltd., 1-2-2, Manpukuji, Asao-ku, Kawasaki-shi, Kanagawa-ken, 215-0004, Japan - (mi.nasu@ajiko.co.jp)

^b Forest Inventory and Planning Division (FIPD), Department of Forestry, Ministry of Agriculture and Forestry, Lao P.D.R.

Commission VIII, WG VIII/7

KEY WORDS: REDD+, tropical forest, carbon, MRV, land use/cover map, biomass class, reference level, tree height

ABSTRACT:

Various technical studies for building forest monitoring system for MRV system of REDD+ has been implemented utilizing satellite remote sensing technology and ground survey upon configuring two pilot study areas, at whole Louangphabang (LPB) province (approximately 20,000 km²) and in Bolikhmxai (BLK) province (approximately 4,400 km²) in Lao PDR. Multi-temporal land use/cover data were prepared for making analyses of deforestation and forest degradation caused by various driving factors, and to establish reference scenario for REDD+. In addition to ordinary method of forest carbon stock estimation based on the forest plot surveys, land use/cover maps and IPCC's emission factors (GOCF-GOLD, 2010), improved methods were studied introducing a concept of biomass classing derived from multispectral data and tree height measurement utilizing ALOS/PRIS stereo images, in order to reduce difficulty of field surveys at high altitude and steep mountain forest, especially in natural forest areas. First, multi-temporal land use/cover maps were prepared for two pilot study areas for analyzing deforestation and forest degradation of the subjected area. Then, the biomass level of "Current Forest" area of the land use/cover maps were classified into three classes as high, medium, and low applying spectral analyses of LANDSAT/TM and SPOT images, and based on visual interpretation results of pan-sharpened ALOS/AVNIR2 images in addition to limited number of field surveys as references. Matching accuracies were around 60% at this stage of study (This number improved to 85% at the later stage). Based on the field survey data, the forest carbon stock vs. tree height model was established, and furthermore it was related to the forest biomass classes. ALOS/PRISM images were used to measure heights at about 1,500 forest stands selected at 2 - 4 km grid intervals. Accuracy analyses showed that the standard deviation of the tree height measurement errors was approximately 4 - 5 m, but the mean value of the measured data were within 1- 2 m comparing to the field survey data. Finally, wall-to-wall, above-ground forest carbon stock estimation maps which would be useful for forest management and REDD+ were prepared. As a conclusion, it can be said that 3D measurement, in addition to multi-spectral information, of the forest provides useful information for monitoring forest carbon stock for REDD+ although further refinement of technologies is to be needed. And, the results and experiences obtained from the studies will provide useful data for establishing actual MRV system.

1. INTRODUCTION

REDD+ refer to efforts and initiatives for the reduction of greenhouse gas (GHG) emission through vigorously increasing forest carbon stocks based on reducing the deforestation and forest degradation and implementing afforestation programs and forest conservation in developing countries. It is anticipated that the reduction of GHG emissions enabled by such efforts can be treated as carbon credits in the same way as carbon credits from use of renewable energies and improvement of energy efficiency, and consequently be used for carbon offsetting, etc.

A case study (Study) entitled "Study on the Strengthening of Methodological and Technological Approaches for Reducing Deforestation and Forest Degradation within the REDD

Implementation Framework" was carried out in order to contribute to the early realization of the REDD mechanism with cooperation of the Forest Inventory and Planning Division, Department of Forestry, Ministry of Agriculture and Forestry, Lao P.D.R., and Asia Air Survey Co. Ltd. (Japan), with a support of the Forest Agency, Ministry of Agriculture, Forestry and Fishery, Japan, from 2009 to 2011.

Objectives of the MRV (Measurement, Reporting and Verification) system in REDD+ are to measure and provide forest carbon stock data arising from REDD+ activities and valid enough for credit trading, etc. Outline and outcomes of the three year's study project are shown in Table 1. The scope of MRV in REDD+ mechanism is broad and complex. In this paper, results of remote sensing and photogrammetric analyses are mainly discussed. More detailed reports are given by Asia Air Survey (2011) and Kamusoko et al. (2011), etc.

| Components Of the Study | Results of the Study |
|--|---|
| 1. Deforestation and forest degradation analyses using remote sensing technology | <ul style="list-style-type: none"> -Land use/cover maps of 1993, 2000, and 2007 (Sub-national, LPB province, Khamkeut district, BLK province by LANDSAT and SPOT) -Land use/cover maps of 1993, 1997, 2000, 2004, and 2007 (Pakxan district, LPB) -Land use/cover map (JICA PAREDD project area, Phongxai district, ALOS/AVNIR2) -Forest/Non-forest cover maps of Lao PDR (National level, 2001, 2004, 2007, 2010 by MODIS) -Forest degradation map (Khamkeut district, BLK) -Tree height measurement (LPB) and Khamkeut district (BLK) by ALOS/PRISM -Accuracy verification of various maps -Ray (slash-and-burnt cultivation field) analysis -Biomass classification map (LPB,BLK by LANDSAT, ALOS/AVNIR2) -UAV aerial photography and analysis of digital canopy model |
| 2. Forest GIS database | <ul style="list-style-type: none"> -Base map from ALOS/PRISM images -DEM/DSM(SRTM, GDEM, ALOS/PRISM) -Orthoimage(ALOS/PRISM) -Forest compartment map -Forest management parcel -Maps prepared by remote sensing analyses -Updating methodology of forest GIS database -MRV system design and analysis |
| 3. Forest carbon stock estimation | <ul style="list-style-type: none"> -Tier 1 estimation of forest carbon stock (LPB) -Tier 2 estimation (LPB, BLK) -Tier 3 estimation (Test areas) -Carbon stock estimation model based on tree height -Wall-to-wall carbon stock estimation based on biomass classes |
| 4. Deforestation trend analysis and future forecasting simulation analysis | <ul style="list-style-type: none"> -Analysis of driving factors of deforestation and forest degradation -Village surveys (Socio-economic surveys) -Reference scenario analyses -Simulation analyses of future forest cover changes using the Marcov-Cellular Automata model (Village, district, provincial, and national levels) |
| 5. Technology transfers | <ul style="list-style-type: none"> -Technical trainings -On-the-job trainings -Workshops and seminars -Training in Japan |

Table 1 Outline and outcomes of the Study

2. PILOT STUDY AREAS

Study activities were implemented upon configuring two pilot study areas, namely entire Louangphabang (LPB) province and Khamkeut district in Bolikhamxai (BLK) province (Figure 1). LPB province is experiencing extreme deforestation and forest degradation as a result of extensive human activities such as slash and burnt shifting cultivation.

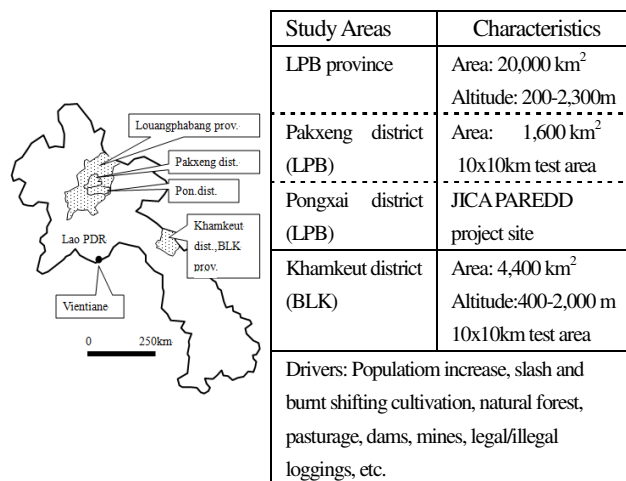


Figure 1. Locations and characteristics of the pilot study areas in Louangphabang (LPB) and Bolikhamxai (BLK) provinces in Lao PDR

Khamkeut district (BLK) contains abundant forest resources including natural forests, and human activities here include paddies, slash and burnt cultivation, pasturage, dams and mines. There is a risk that the district suffers from deforestation and forest degradation, both legal and illegal.

3. FOREST MONITORING SYSTEM UTILIZING REMOTE SENSING

3.1 Land Use/Cover Mapping for Forest Monitoring

3.1.1 Satellite Images Used for Sub-national Level: Multitemporal land use/cover maps provide the basis for (1) analysing deforestation and forest degradation, (2) estimating wall-to-wall forest carbon stocks, (3) obtaining base data for simulation analysis of future deforestation, and (4) setting the reference level of REDD+ credit, etc.

Medium resolution satellite images (LANDSAT and SPOT) obtained from 1990 to 2010 were selected to prepare land use/cover maps for sub-national level (provincial level) monitoring of forest through combining digital image processing with visual interpretation and field survey. In selecting the images, search was conducted during the period immediately after the rainy season (October-December) before the start of defoliation and slash and burnt when the impact of moisture vapour and smoke in the atmosphere is small in the pilot study areas, and images from the same period were selected to reduce the occurrence of classification error arising from different timing of images for conducting multitemporal comparisons. However, in cases where images from the period in question were not available, the most recent images were selected. As the results, many multi-dated images were subjected to various image analyses and interpretations.

3.1.2 Land Use/Cover Categories for Forest Monitoring: In the survey of deforestation, forest degradation, forest carbon stock, etc. necessary for REDD+, first the approach that entails grasping forest state based on survey of land use/cover and monitoring of changes is

