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Session 5: R&D Trend about MRV Methods for REDD+

A Case Study on a MRV System for REDD+ in Lao P.D.R.

Mitsuru NASU, Ph.D. *

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1. Outline of the Study

(1) Study Project

- **TITLE**: "The Study on the Strengthening of Methodological and Technological Approaches for Reducing Deforestation and Forest Degradation within the REDD Implementation Framework: Application in Lao P.D.R."

- **Support**: Forestry Agency, Ministry of Agriculture, Forestry and Fishery (MAFF), Japan

- **C/P Organization**: Forest Inventory and Planning Division (FIPD), Department of Forestry, Ministry of Agriculture and Forestry, Loa P.D.R.

(2) Objectives of the Study

- To implement technical development for monitoring system of deforestation and forest degradation including the measurement methods of forest conditions and changes, the estimation method of forest carbon stock and the method of future simulation for forest changes using remote sensing and GIS technologies;
- To assist counterparts in the forest sector in a various ways toward the realization of REDD+;
- To provide capacity development assistances for improving information sharing, knowledge and technical capacity through technical training programs as well as workshops in both Lao PRG and Japan; and
- To contribute the strengthening of regional level's REDD+ approach through implementation of the above activities.

(3) Driving Factors of Deforestation and Forest Degradation*

[Deforestation]

- (Continuous) Farmland Development
- Dam construction
- Road construction
- Mining
- Construction of public facilities
- Illegal logging at a large scale

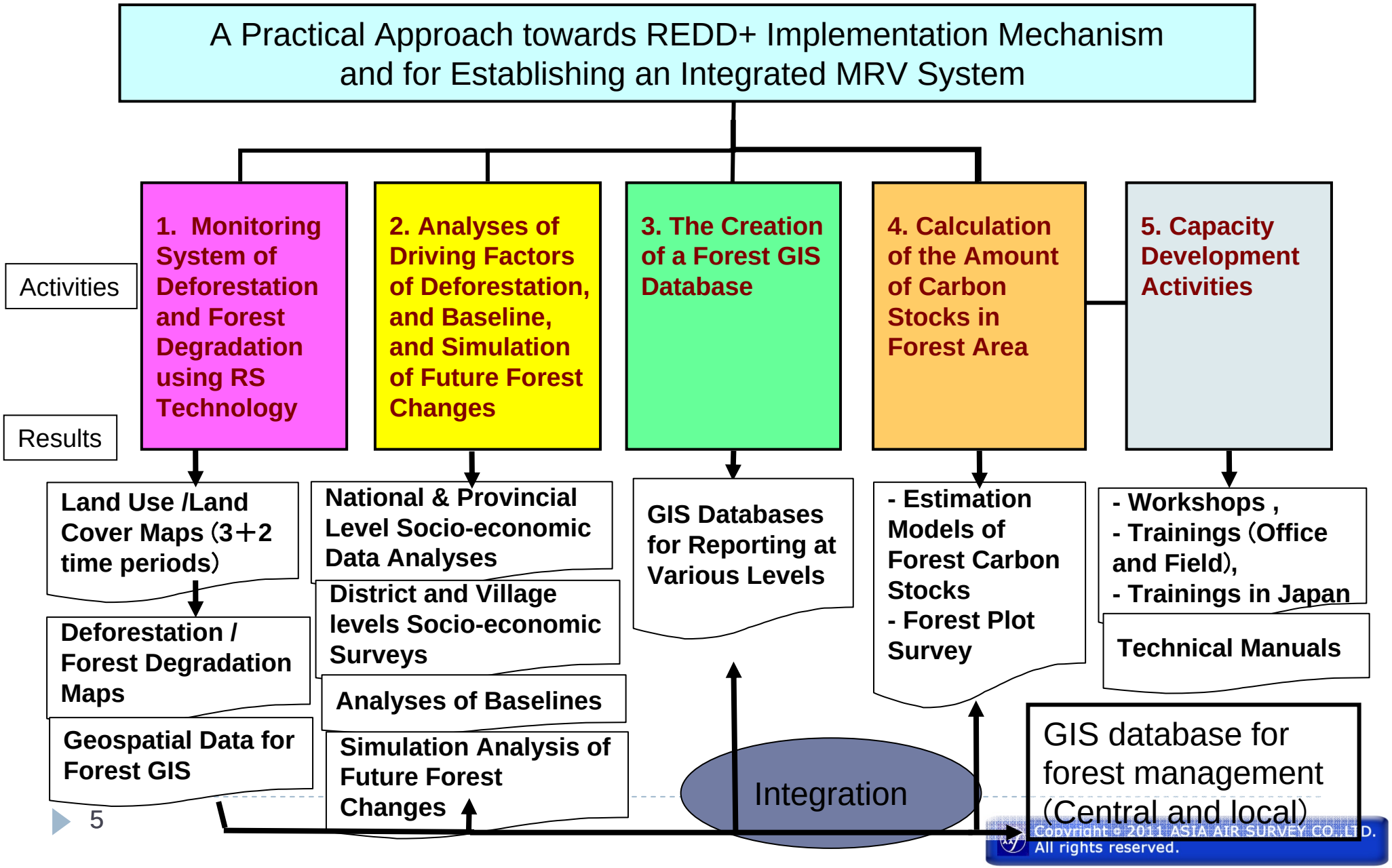
[Forest degradation]

- Slash-and-burn shifting cultivation
- Illegal logging at a small scale (selective logging)

- **Population increase(2%/yr.)**
- **Economical development(8%/yr.)**
- **Forest cover: 70%(1940) →41.5%(2002)(FAO)**

(*): Based on the result of the present study

(4) Contents of the Study (2009 and 2010)



(5) MRV System (Result of the Study)

Measurement (Initial and Monitoring) | **Reporting** | **Verification**

National Level

- Land Use/Cover Maps (Wall-to-wall) based on Medium Resolution Satellite Images (Landsat, Spot Images, etc.)
- Management Unit: Systematic Sample Points Data (ex. 0.25 ºGrid)

Provincial Level

- Land Use/Cover Maps(Wall-to-wall) based on Medium Resolution Satellite Images (Landsat, Spot Images, etc.)
- Management Unit: Unit Watershed

Local/Project Level

- Forest Compartment map based on Medium High Resolution Satellite Images (ALOS/PRISM, AVNIR2, etc.)
- Management Unit: Forest Compartment

Forest Permanent Plot System

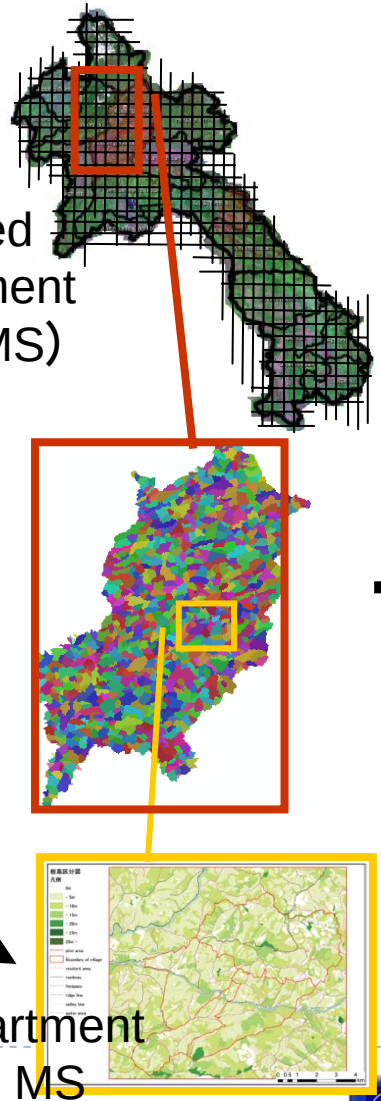
Prediction System for Future Forest Change

Monitoring System

Grid-based Management System(MS)

Watershed-based MS

Compartment -based MS

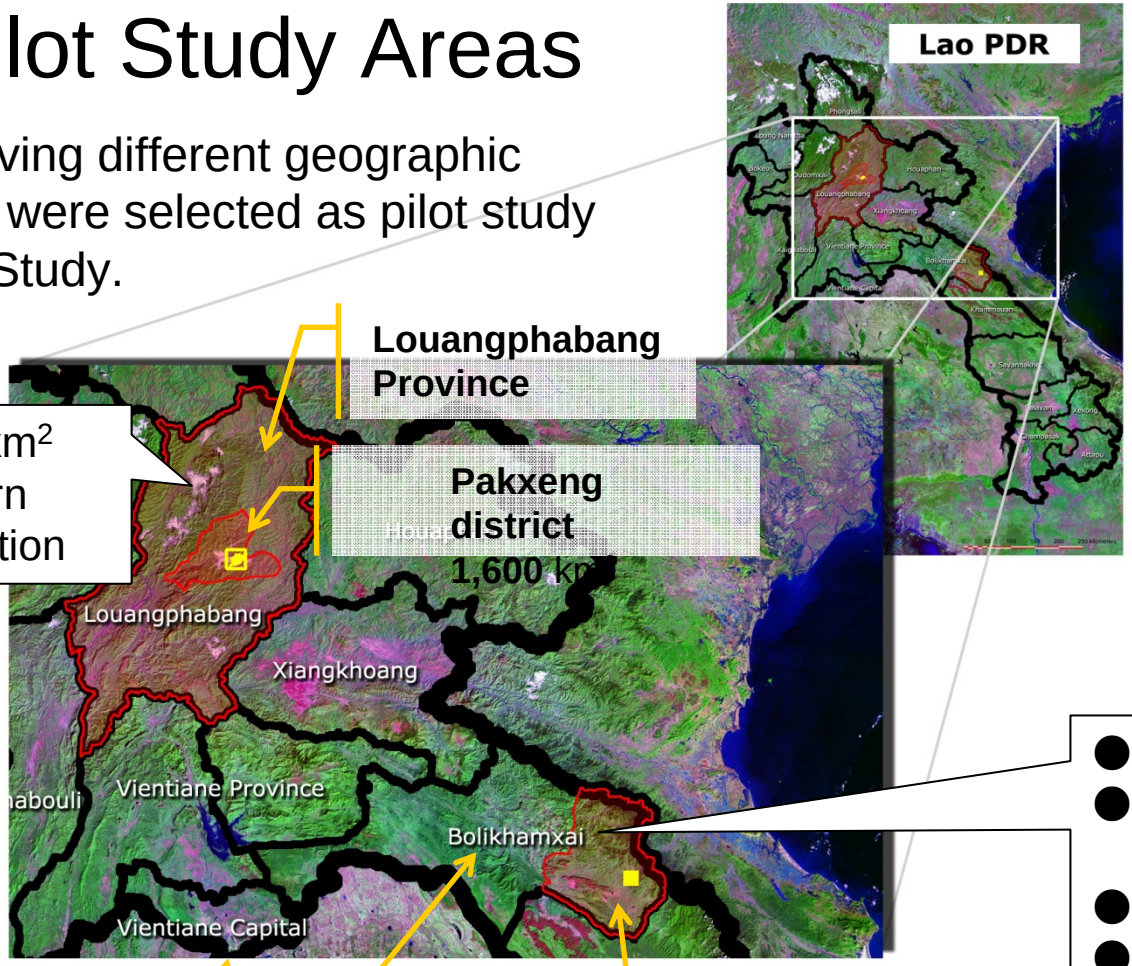


-Publication
-Organizational Auditing
-Verification by a third party

2. Study Activities and Results in 2009 -10

2.1 Pilot Study Areas

Two areas having different geographic environments were selected as pilot study areas for the Study.



- Area:20,000 km^2
- Slash-and-burn shifting cultivation

Louangphabang Province

Pakxeng district
1,600 km^2

- Area: 4,400 km^2
- Slash-and-burn shifting cultivation
- Illegal logging
- Natural forest

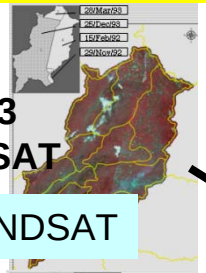
Vientiane Capital

Khamkeut district

Bolikhamxay province

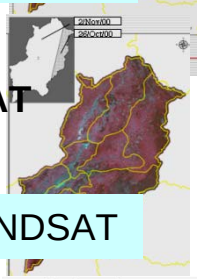
2.2 Monitoring System of Deforestation and Forest Degradation Using RS Technology

Basic Satellite RS Data: Medium Resolution Data



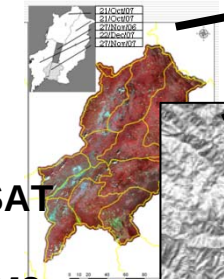
1992/93 LANDSAT

1996 LANDSAT



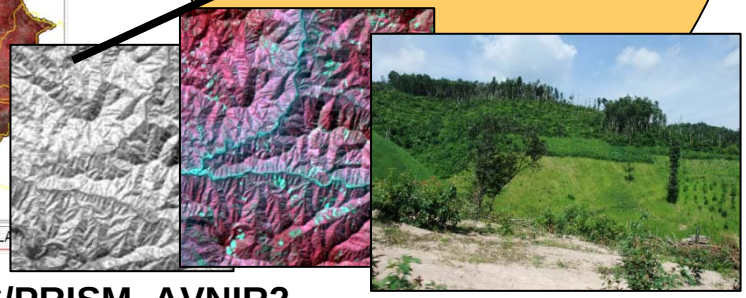
2000 LANDSAT

2004 LANDSAT



2007 SPOT/ LANDSAT

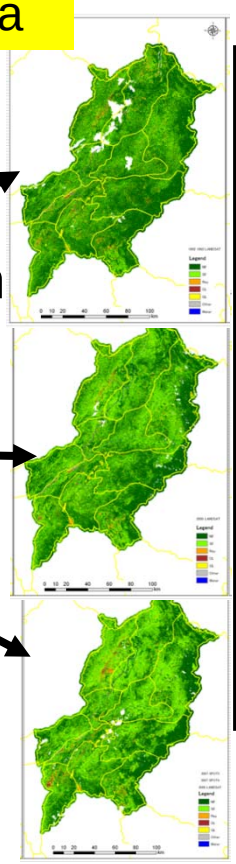
SRTM3 GDEM



ALOS/PRISM, AVNIR2 Aerial Photos

Image Processing/ Analyses/Interpretation

-Preprocessing
-Multi-spectral
-Multi-temporal
-Multi-stage
-Multi-station
etc.



Land Use/cover Maps

Vegetation Index

Forest Degradation/ Analyses

DSM/DEM

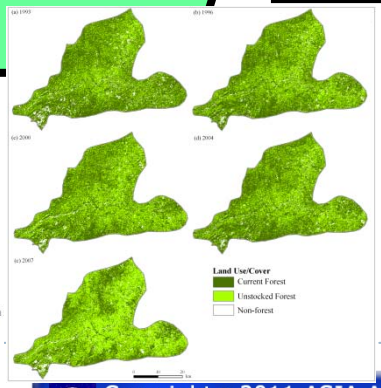
Ortho Image

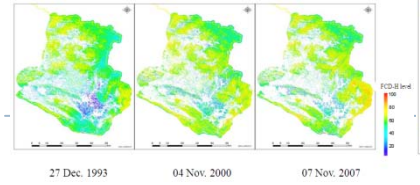
Forest Base Maps

etc.

Data for:

- **Forest GIS Database**
- **Simulation Analyses of Future Forest Cover Change**
- **Forest Carbon Stock Estimation**





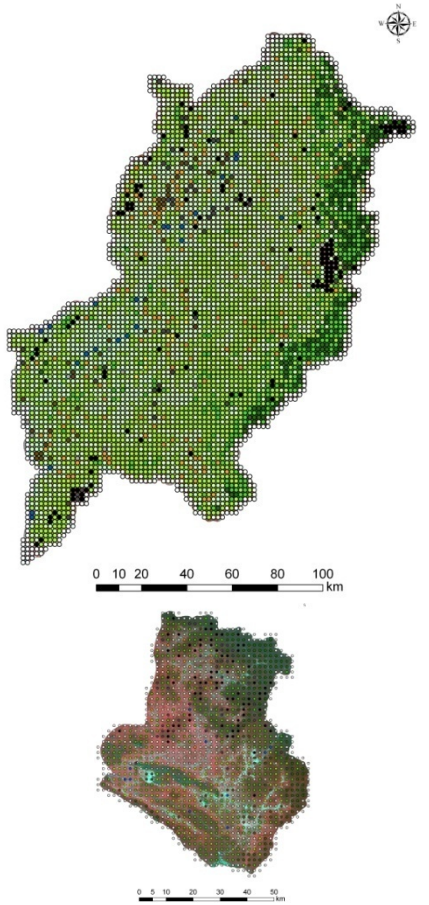
Field Surveys and Ground Truth Data

Accuracy Check of Land Use/Cover Classifications

Louangphabang Province			Interpretation(Class Code)								Total	Users Accuracy
			1	2	3	4	5	6	7	8		
Classification analysis (Class Code & Landuse)	1	Current forest	2066	311	1	2		1		111	2381	87%
	2	Unstocked forest	332	1814	5	6		3	1	69	2161	84%
	3	Ray	1	13	166			3		7	183	91%
	4	Crop Land		1	3	30					34	88%
	5	Grass Land	1	1			10			1	12	83%
	6	Other		2				8			10	80%
	7	Water							23		23	100%
	8	Cloud									0	
Total Grid Points			2400	2142	175	38	10	15	24	188	4804	
Producer Accuracy			86%	85%	95%	79%	100%	53%	96%			
Over All Accuracy												86%

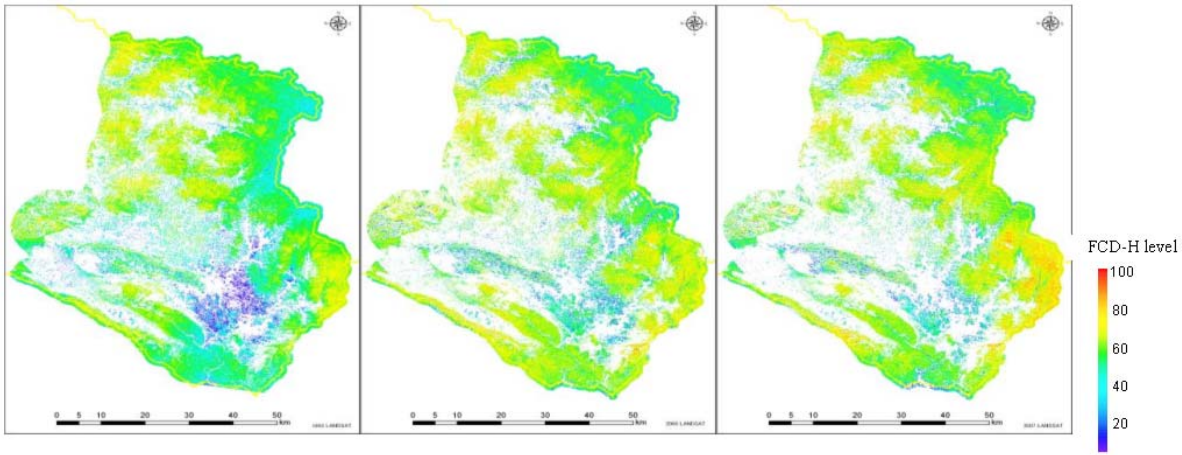
Bolikhamxay province			Interpretation(Class Code)								Total	Users Accuracy
			1	2	3	4	5	6	7	8		
Classification analysis (Class Code & Landuse)	1	Current forest	516	18				4		83	538	96%
	2	Unstocked forest	74	271	2	2		1	2	30	352	77%
	3	Ray	2		26			1		2	29	90%
	4	Crop Land		2	1	20		1			24	83%
	5	Grass Land	1	1		2	5				9	56%
	6	Other		1				13			14	93%
	7	Water		1					8		9	89%
	8	Cloud									0	
Total Grid Points			593	294	29	24	5	20	10	115	975	
Producer Accuracy			87%	92%	90%	83%	100%	65%	80%			
Over All Accuracy												88%

※The number of "Cloud" isn't included in the number of "Total Grid Points".



- Image Interpretation of Pan-sharpen ALOS/AVNIR2 with Field Surveys vs. Digital Image Analyses
- Accuracy Check Points: 2 km Grid Points

Forest Degradation Analyses from Landsat Images



27 Dec. 1993　　04 Nov. 2000　　07 Nov. 2007

Results of FCD-H analyses

（Bolikhamxay province）

May possible to map forest degradation zone.

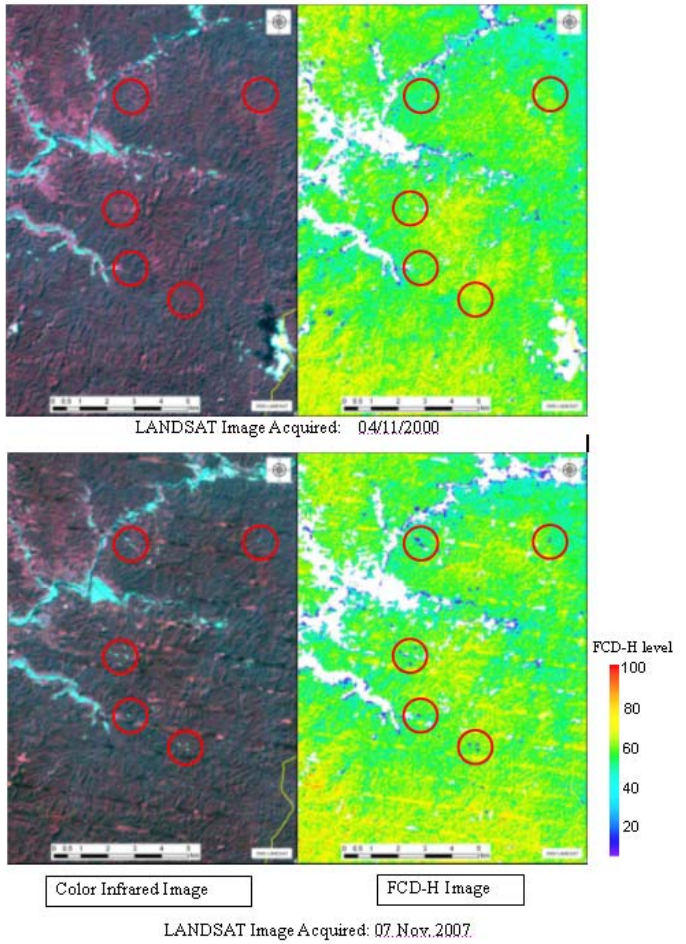
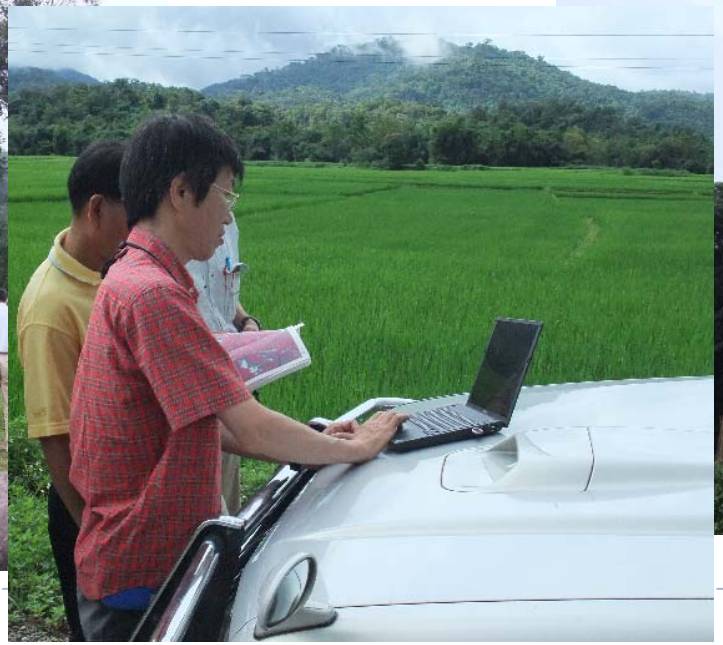


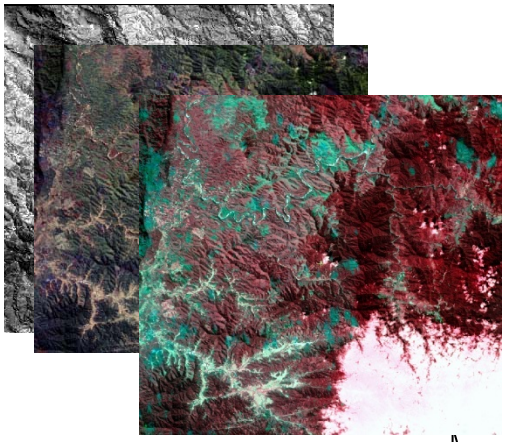
Figure 3-30　FCD-H analysis image showing some forest degradation due to probable selective logging (not verified in the field)

Field Checking Surveys of Image Analysis Results

- Several field surveys were carried out for checking the results of image analyses in 2009 and 2011.
- Based on the results of these field surveys, the methodologies and models for the study were revised.

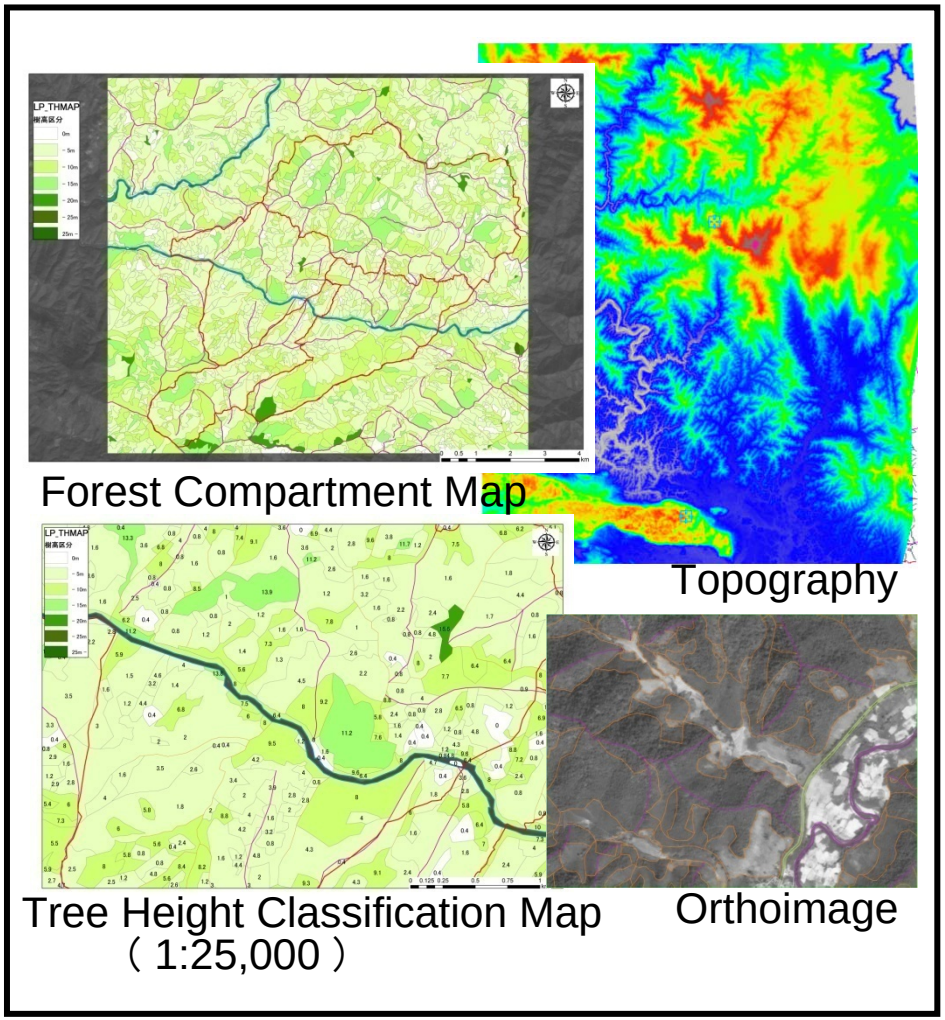


2.3 Development of Three Dimensional Forest Mapping Technologies Using ALOS/PRISM Images



- Colored ALOS/PRISM Stereo images
- GPS points
- Field survey data
- Existing topographic maps

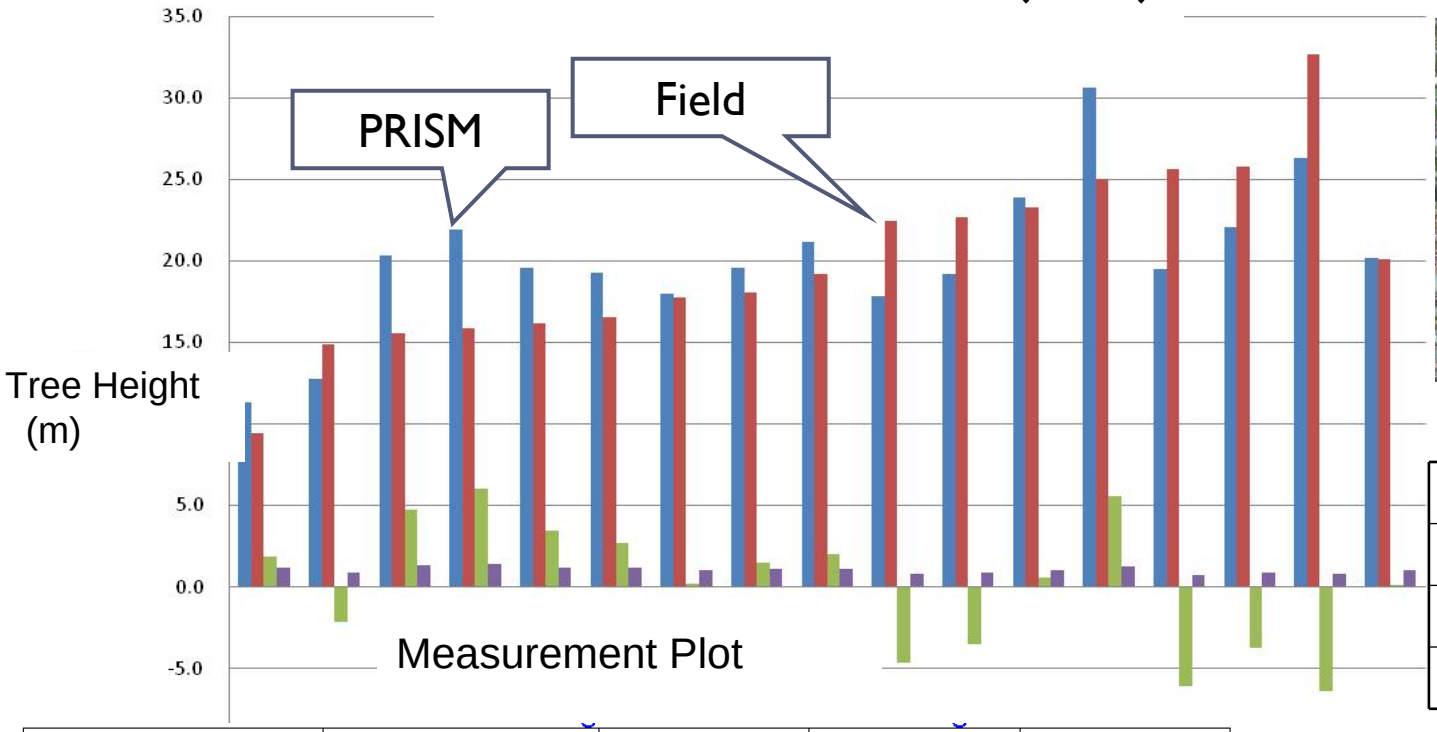
Stereo Photogrammetric Measurements



Forest GIS Database for Regional or Project-based REDD+

Accuracy Analysis of Tree Height Measurement

Data from 17 Forest Plots (2010)



Average Tree Height

PRISM Measurement	20.21
Field Measurement	20.07
Discrepancy	0.14
RMSE	3.8

Province	Number of Check Points	Mean Value of the observed tree height by on-site survey	Mean Value of the Range between on-site survey and PRISM measured	RMSE
Louangphabang	24	6.7 m	-1.7 m	3.5 m
Bolikhamxay	17	13.0 m	-0.9 m	3.9 m

RMSE: About 4m
Average Discrepancy: 1~2 m

Data from 41 Accuracy Checking Points (2009)

2.4 Forest Plot Survey

DBH Measurement

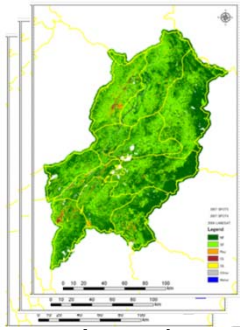
Tree Height Measurement

- 20 x 20 m Plot
- Number of Standing Trees
- DBH
- Average Tree Height
- X,Y,Z Coordinates
- etc.

2.5 Estimation of Forest Carbon Stock

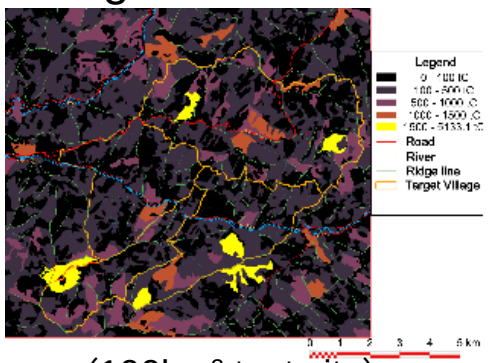
- Forest compartment/tree height maps, Land use/cover maps were prepared.
- Forest sample plot survey was conducted.
- Forest biomass carbon stocks were estimated utilizing several models such as Dr. Kiyono's allometry model and a model in IPCC Guideline using these basic data.

Forest Compartment/
Tree Height Maps

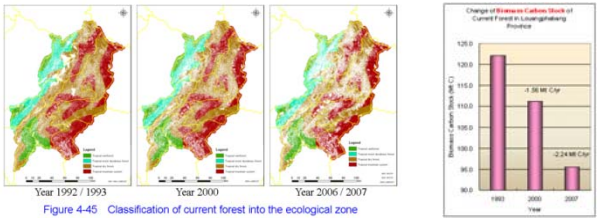


Land use/cover
Maps

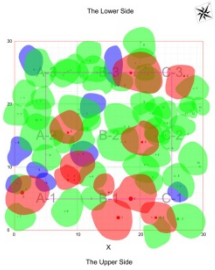
Forest Carbon
Stock Estimation
Models

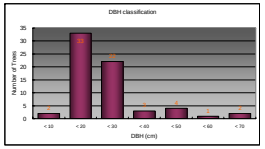


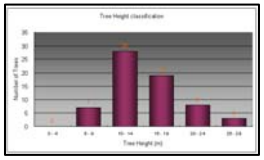
(100km² test site)



Tier1 (Provincial level)





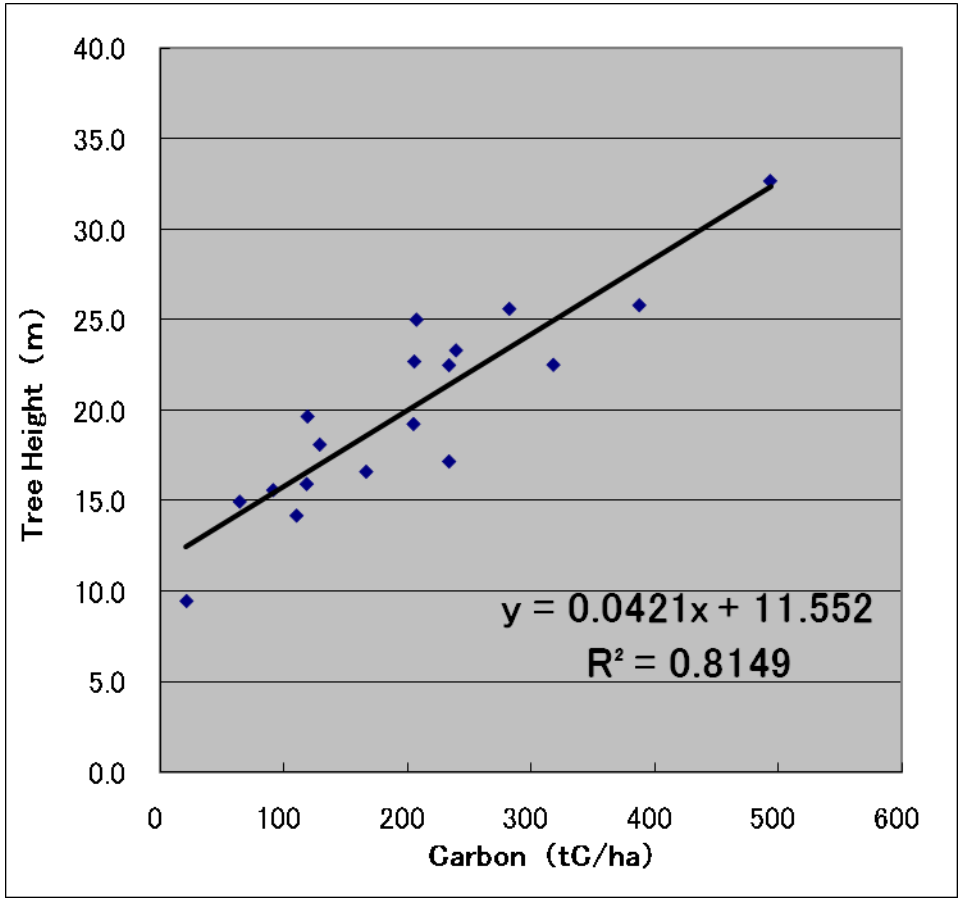


Forest Sample Plot Survey
(DBH, tree height, species, etc.)

Dr. Kiyono's allometry model,
IPCC Guideline

Forest Biomass Carbon
Estimation Data

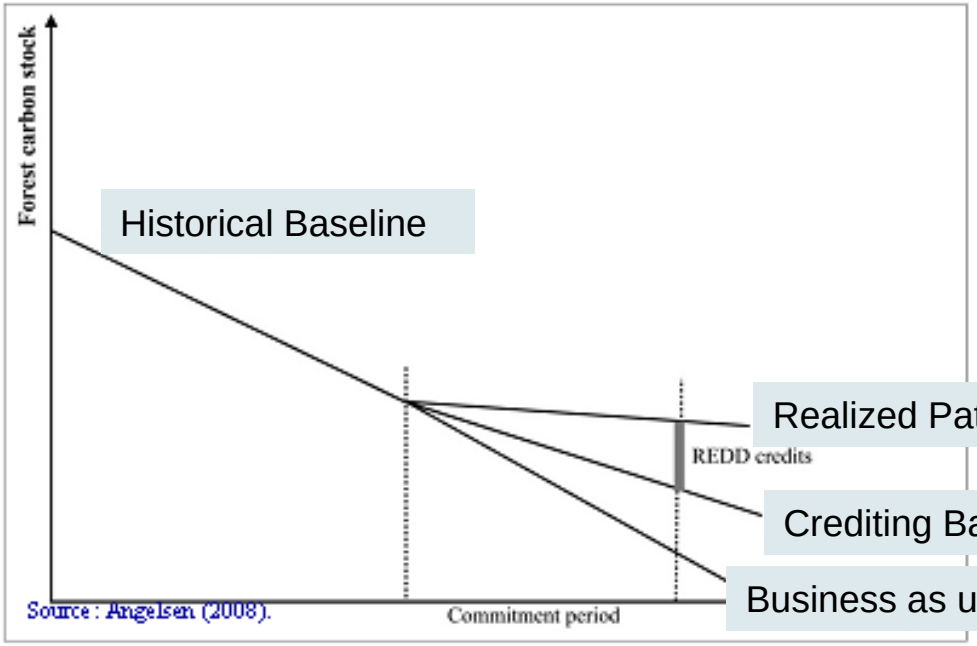
Correlation Analysis of Carbon Stock and Tree Height



2.6 Analyses of Deforestation Trends and Simulation of Future Forest Cover Changes

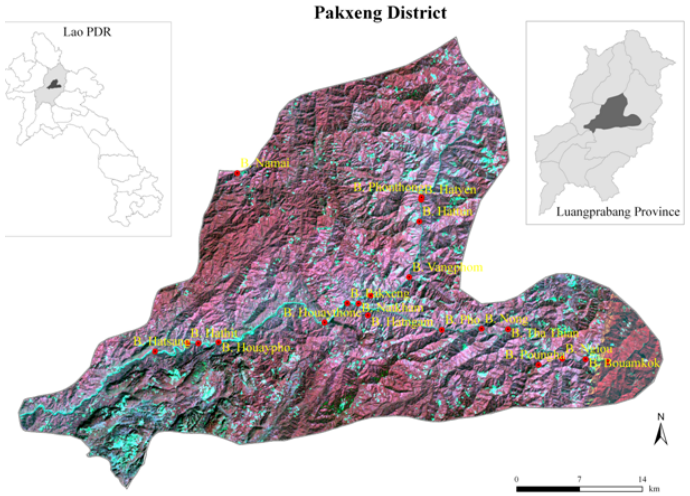
2.6.1 Analyses of Deforestation Trends

- Analyses of national forest cover changes based on the available forest cover statistics (National Forest Inventory Data(1982,1992,2002), FAO(1990,2000,2005))
- Analyses of forest cover changes in the pilot study areas based on remote sensing analyses data (1993, (1996), 2000, (2004), 2007)
- Setting the baselines or reference levels is critical for implementing REDD+ projects.
- Baselines provide a benchmark against which emissions reduction can be calculated.



2.6.2 Simulation Analyses of Future Forest Cover Changes using the Markov-cellular Automata Model and GIS Data

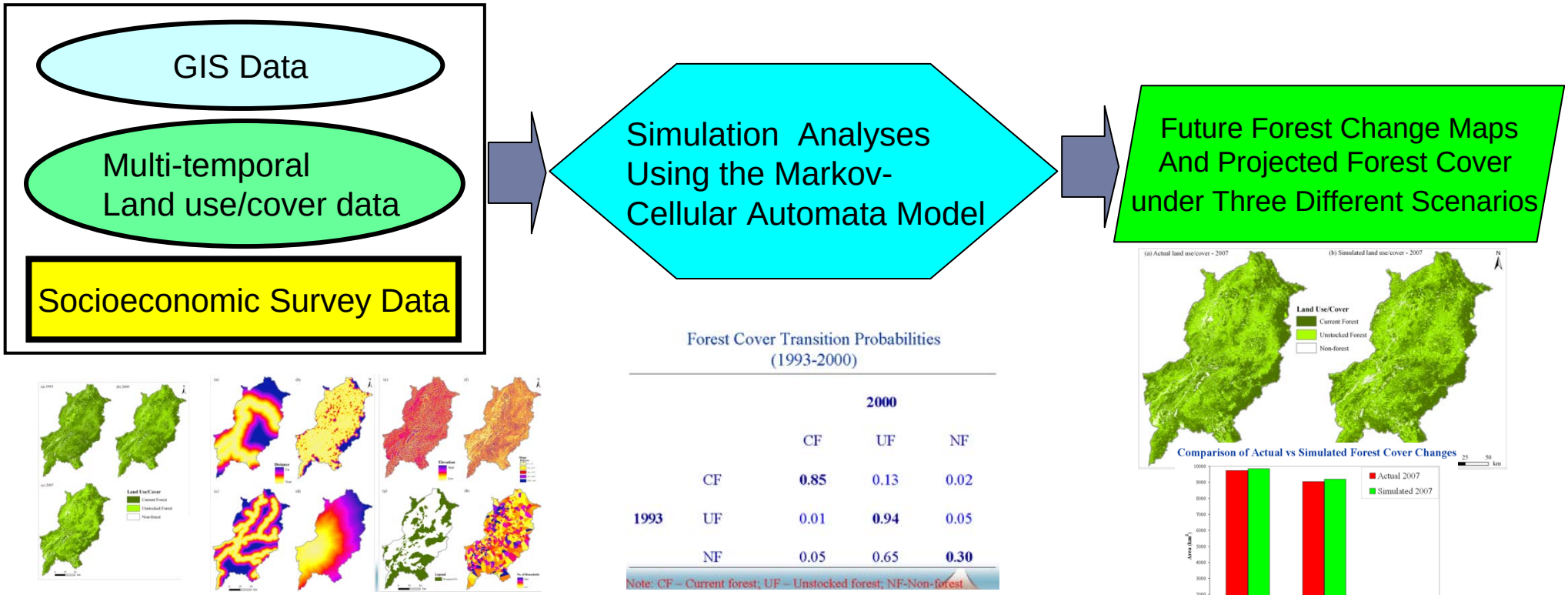
- Village surveys（4 and 20 villages in 2009 and 2010, respectively）
- The household survey used a semi-structured questionnaire for 2000 and 2007.
- The sample was drawn using a two-stage stratified random sampling procedure.
- Sample frame is drawn from the 2008 Lao PDR Department of Statistics.
- A sample of 460 households from 20 villages at 95% confidence level was used.
- Approximately 23 households were selected per village.



(2) Preparation of Biophysical Data and Integrated GIS Data

- Land use/cover maps (1993, (1996), 2000, (2004), 2007), slope map, road networks, distance measures
- Integration of socioeconomic and GIS data based on village surveys

(3) Implementation of Future Simulation for Land Use/cover Changes for the Provincial and District Levels with 3 Scenarios



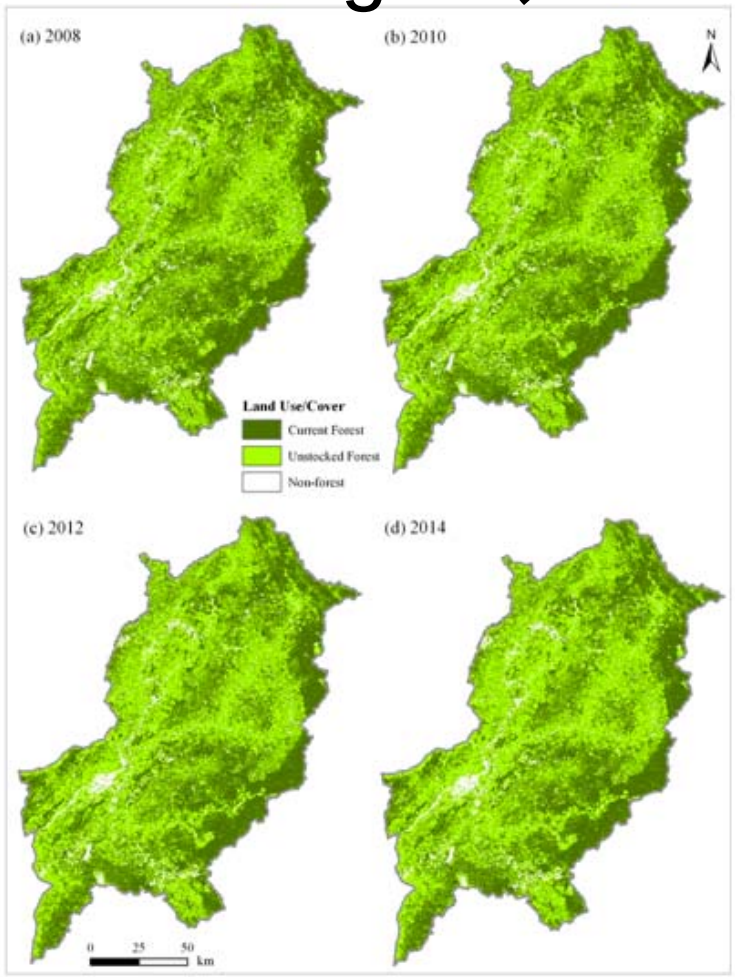
Forest Cover Transition Probabilities
(1993-2000)

		2000		
		CF	UF	NF
1993	CF	**0.85**	0.13	0.02
	UF	0.01	**0.94**	0.05
	NF	0.05	0.65	**0.30**

Note: CF – Current forest; UF – Unstocked forest; NF-Non-forest

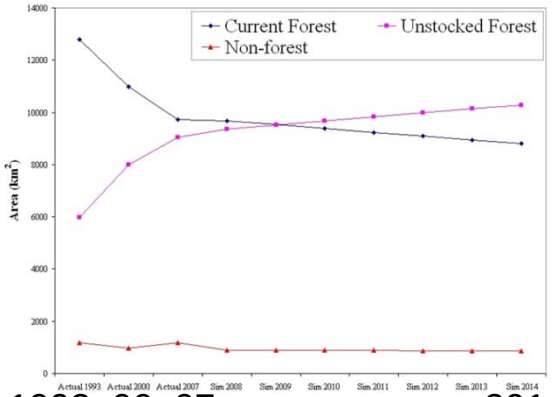
- Simulation was also carried out for a district level.

Results of Simulated Future Forest Cover Changes (Provincial Level)



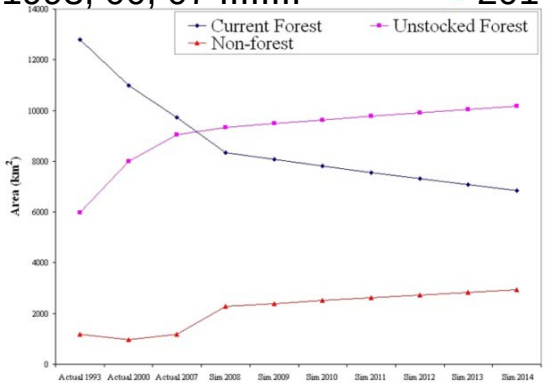
Forest Cover of BAU Scenario

(1) BAU Scenario



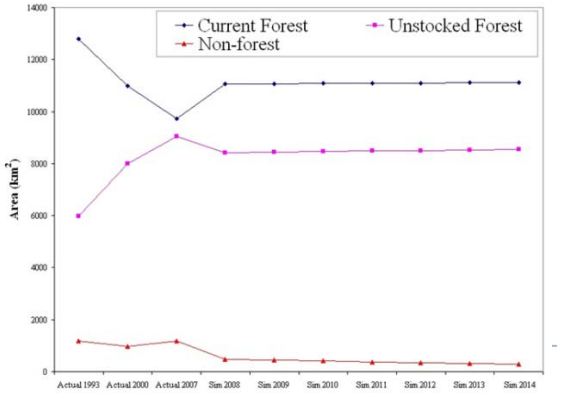
1993, 00, 07 2014

(2) Pessimistic Scenario



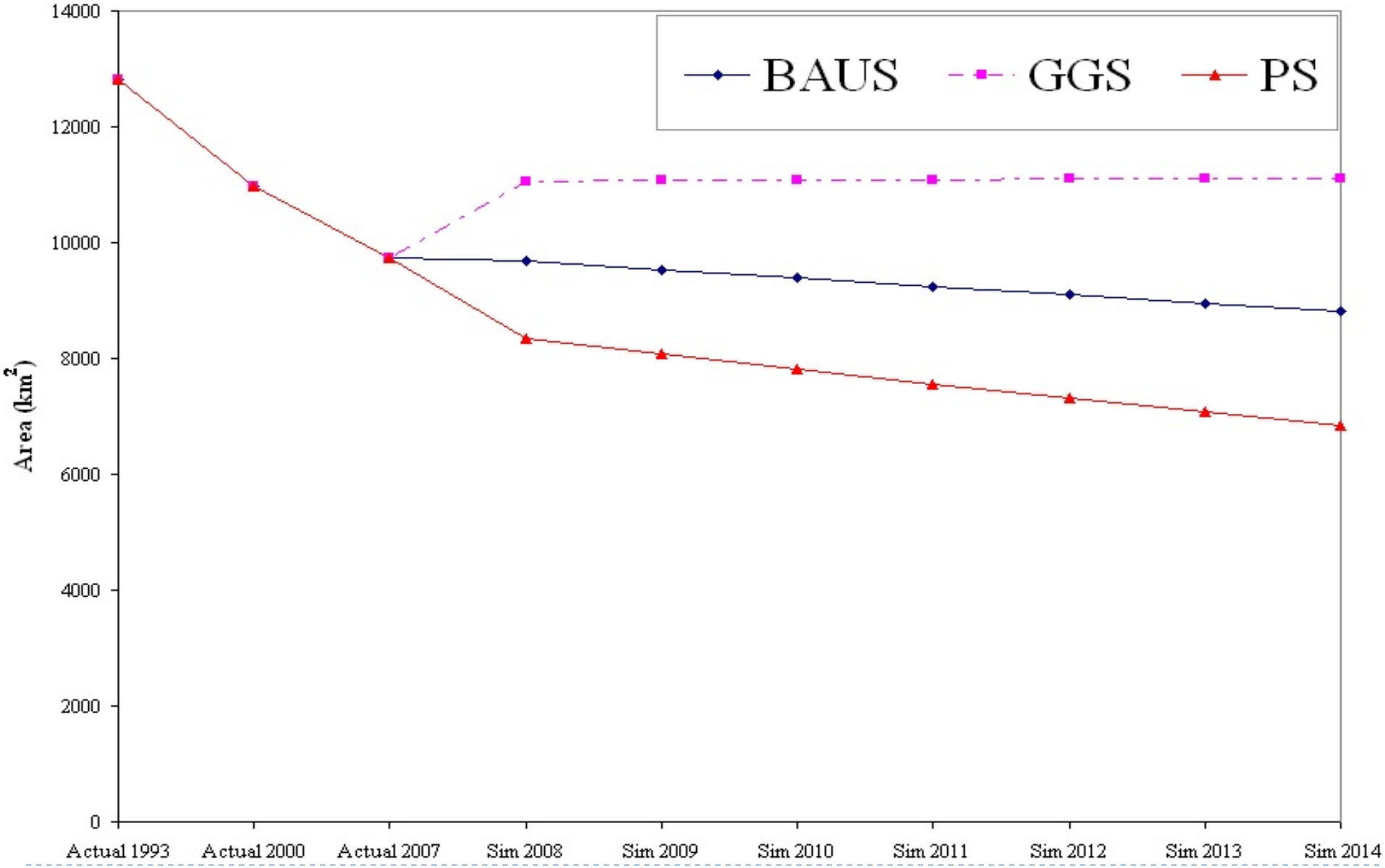
1993, 00, 07 2014

(3) Good Governance Scenario



1993, 00, 07 2014

Comparison of Simulation Scenarios (Current Forest)



2.7 Capacity Development Activities

- On-site and off-site capacity building activities have been carried out in various technological disciplines on REDD+ as follows:
  1) Workshops（4 times）
  2) On-the-Job Trainings（8 field surveys）
  3) Short-term Trainings（Satellite image analyses（4）, Forest GIS DB development（2）, Simulation Analyses（3））
  4) Training in Japan（two weeks）

  Two officers were also invited from Vietnam for workshops and training in Japan in 2010





3. Lessons Learned

- Analyses of various kinds of satellite images from different sources are needed to obtain good coverage of the wide area. And, reasonably high quality of data should be prepared for establishing a reliable MRV system.
- The MRV system needs an integrated approach of various technologies as shown in the study.
- Three dimensional information of forest stand (i.e. tree height) seems to be one of the important information for forest carbon estimation with high correlation.
- A multi-stage approach from national level to sub-national and district/project level may be one solution for realizing a MRV system for REDD+.