Validation and Registration of the Project on REDD plus through Participatory Land and Forest Management for Avoiding Deforestation in Lao PDR

Technical Cooperation Report
- Analysis Results of Forest Dynamics -

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Chapter 1 Objective

This study was developing reference levels for overall Luang Prabang Province and Houay Khing village cluster (HK-VC) in Phonsay District. To develop reference levels, it is required to estimate changes in carbon stock of each forest type by multiplying changes in area size of each forest type, which was obtained through satellite imagery analysis, by carbon stock per hectare of each forest type (i.e. emission factors determined in this project). As a result, increase or decrease in carbon stock (emission or removal) can be estimated when the area of forest type in the target area changes, and that trend is to be the basis of calculating reference level.

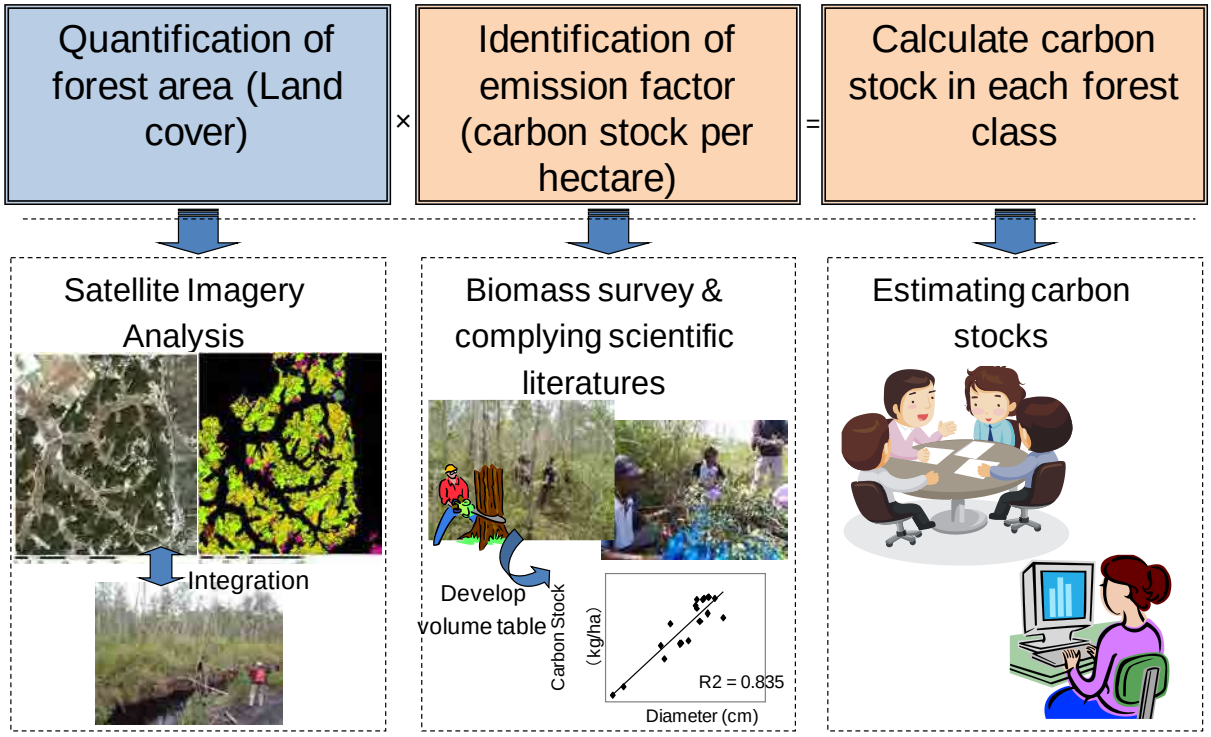


Figure 1 Flow of calculating carbon stock in each forest type

Accordingly, amongst factors of carbon sequestration in forests, emission factor is, in a narrow sense, subdivided into stem volume, conversion factor from stem volume to biomass, and conversion factor from stem biomass to branch and leaf biomass (expansion factor), while it refers to carbon stock per area of each forest type. From the both narrow and broad definition perspectives, it is necessary to quantify the carbon stocks in each forest type; therefore, this study conducted forest plot survey.

To develop reference levels, following three Technical Cooperation Reports were utilized: Technical Cooperation Report “Results of Forest Plot Survey”, Technical Cooperation Report “Results of Destructive Sampling Survey”, and this report Technical Cooperation Report “Analysis Results of Forest Dynamics”. Figure 2 below describes the relationships of these three reports. The reference levels obtained through these three Technical Cooperation Reports were reported in the Final Report in this study.

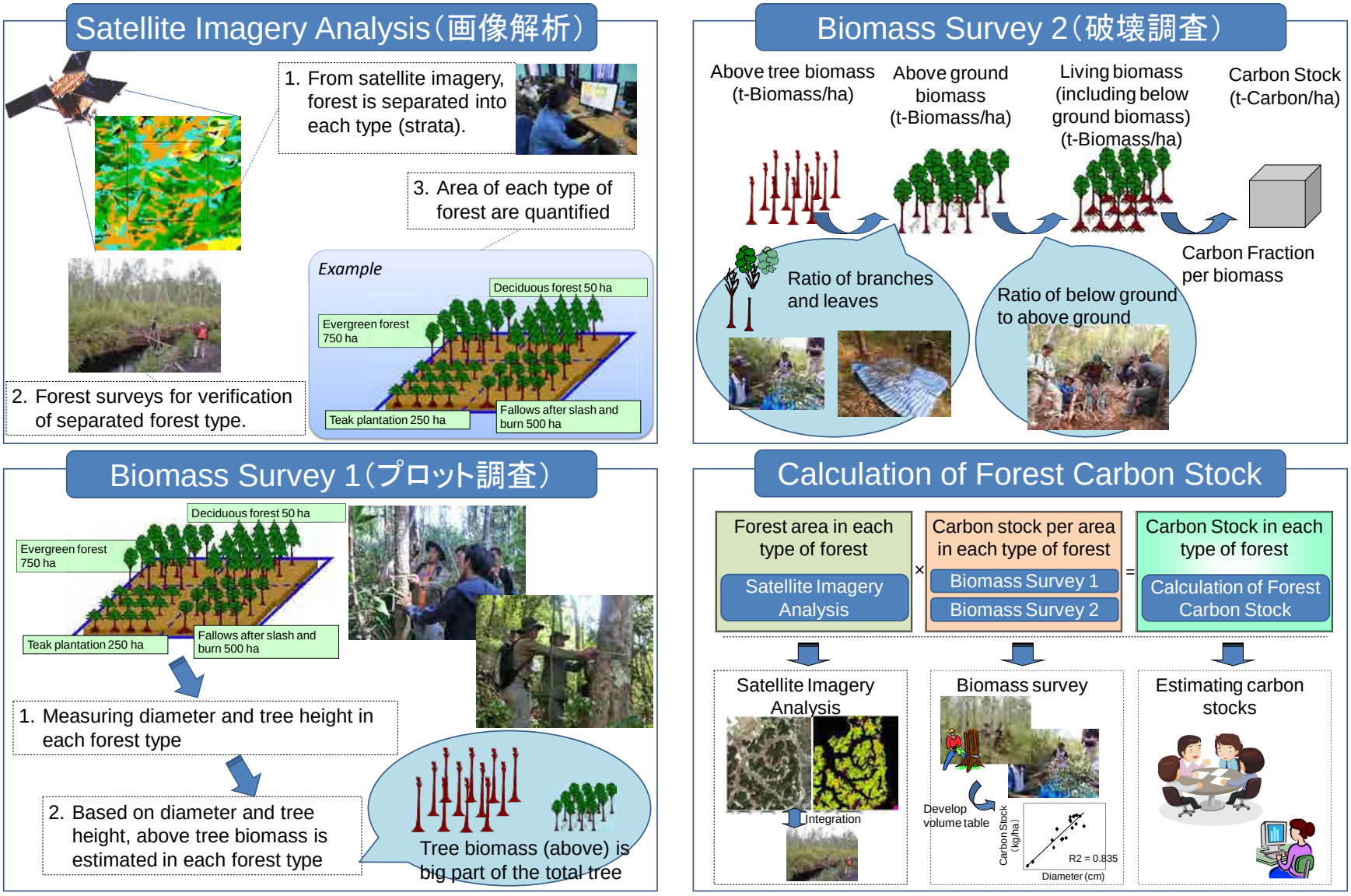


Figure 2　Relationships of Technical Cooperation Reports

Chapter 2 Clarification of the Monitoring Target

1. Property of Forest Dynamics in the Target Area

The main causes of deforestation and forest degradation in the targeted area of this project are slash-and-burn agriculture with short fallow period and expansion of slash-and-burn area (*see* Technical Cooperation Report "Results of Socio-economic Survey" for more detail). Shortening of fallow period refers to practicing slash-and-burn again in the lands being fallowed, where forest regeneration is progressing, before the lands restock sufficient amount of carbon. Therefore, carbon stock per hectare increases as fallow period is extended. Inoue et al (2007) reported that the mean carbon stock increases as fallow period is extended to 2 years, 3 years, 5 years, and 10 years (Figure 3). This indicates that repeating slash-and-burn with short fallow period tends to decrease mean carbon stock, and it lowers the productivity of lands.

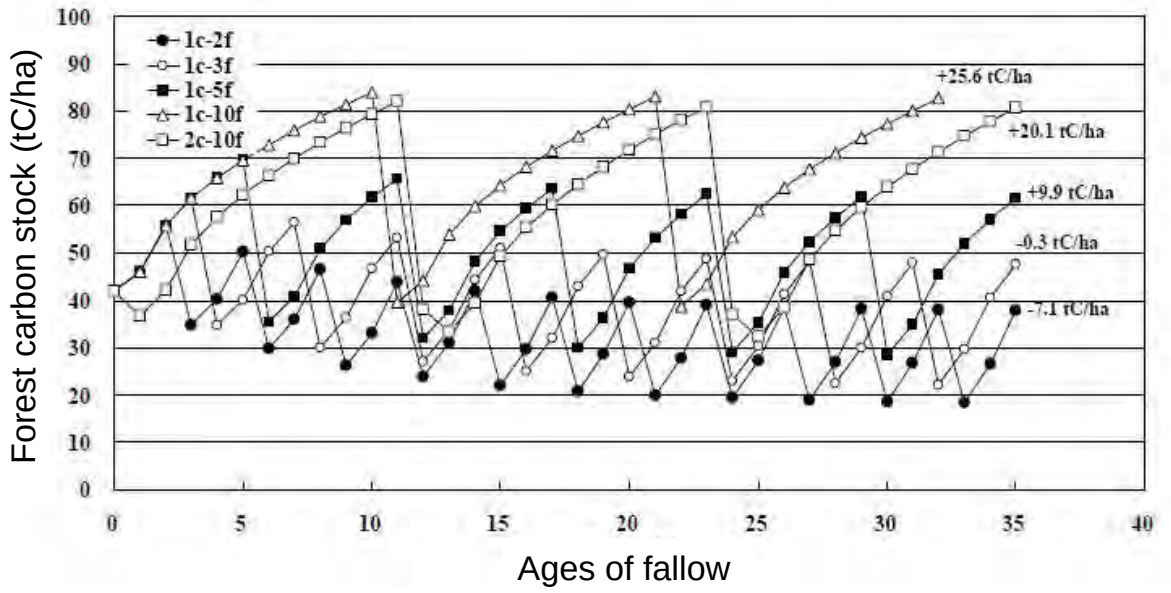


Figure 3 Dynamics of forest carbon stocks in some shifting cultivation rotation periods[1]

Taking account of sustainable forest management, controlling such exploitative agriculture is essential. To do so, it is important to try to extend fallow periods while providing alternative livelihoods such as introducing paddy rice cultivation.

On the other hand, some natural secondary forests have also been converted to slash-and-burn lands in the target area of this project. Interviews with rural people in early March 2012 found out that there was an interest in expanding slash-and-burn lands because the increase in households of individual farmers resulted in shortage of food for family consumption. In addition, for the cash income sake, cash crops cultivation such as gingers, corns, and pineapples etc. was also observed. The suggestion was made from the results that those farmer's behavioral patterns of slash-and-burn may be arose from the effect of the access to the

[1] Cost of the comprehensive promotion of global environment: (Source) Development and assessment of greenhouse gas absorption-controlling technology for agricultural ecosystems (3b), study on methods used to control the ecosystem of shifting cultivation in mountainous areas in Southeast Asia, and the improvement of carbon storage functions (2007)

market. This means that status of opening roads from the central Luang Prabang could be one of the explanatory factors of the expansion of slash-and-burn.

From the above factors and background of deforestation and forest degradation, followings were considered as the essential points of view for forest monitoring:

1. Newly conversion of naturally grown secondary forests to slash-and-burn lands
2. Fallow periods of slash-and-burn lands
3. Opening roads as one of the possible explanatory factors
4. Population increase as one of the possible explanatory factors

As the monitoring is mainly taken place by remote sensing, information of the above 4th point "4. Population increase as one of the possible explanatory factors" can only be examined by the socio-economic survey.

2. Policy for Analyzing Satellite Imagery

Methodology of monitoring relies on the targets to be detected, and monitoring targets are consolidated into three viewpoints: 1. transformation of naturally grown secondary forest to newly slash-and-burn land; 2. fallow period of slash-and-burn land; and 3. opening roads as one of the possible explanatory factor. Based on these, monitoring methodology was set as follows:

1. In order to monitor the areas newly transformed from natural secondary forests to slash-and-burn lands, requirements are: to prove conserved area of naturally grown secondary forest; and to extract the change of translation to slash-and-burn by the past satellite imagery.
2. On the other hand, in order to monitor dynamics of slash-and-burn lands over the past fallow period, it is required to specify slash-and-burn lands by analyzing satellite imagery every year[2]. At that time, in tropical and sub-tropical zones, it is extremely difficult to organize remote sensing information unaffected by clouds disturbance. Therefore, this project examined a system to detect short term cycled slash-and-burn using SAR data.

Provision and analysis of satellite imagery are settled as in Figure 4. In order to meet the consistency of classification of forest distribution map between this project, and environmental grant aid 'FIM' and 'FPP' that are aiming to create the provision of information on forest distribution map at national level, this project decided to use the time series data of forest distribution map in 2010, 2005, and 2000. The retrospective methodology was taken in accordance with the baseline of VCS.

[2] Because there are short term fallow lands of two year in the targeted area.

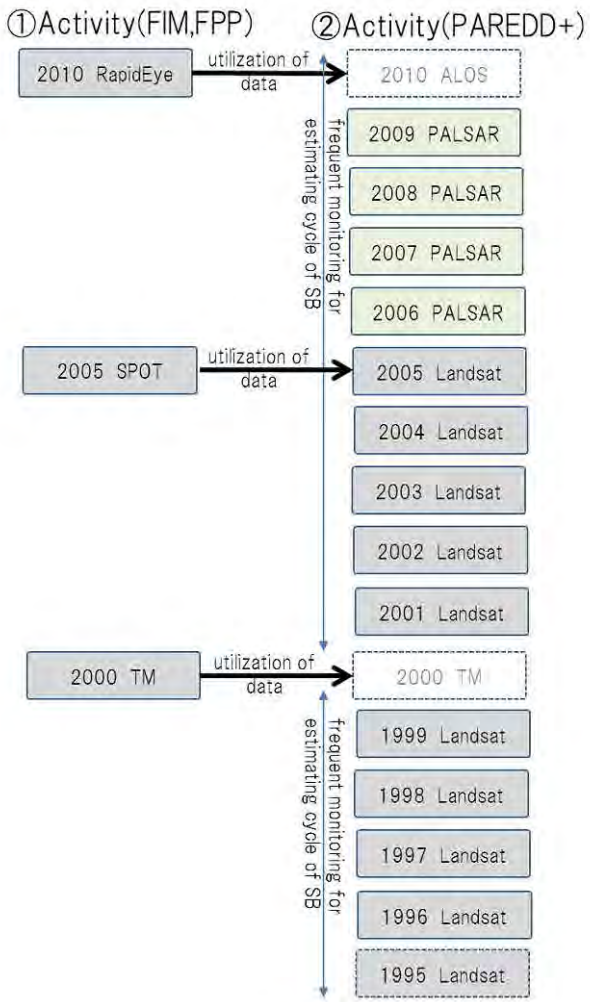


Figure 4 Pattern of analysis in satellite imagery considering the fallow periods of slash-and-burn

3. Overview of Field Survey

3.1 Implementation of preliminary field survey

Preliminary field survey was implemented in order to comprehend the validity of the above mentioned policy for satellite imagery analysis and characteristics of forest types in the target area from February 12th to 18th of 2012. The preliminary survey with GPS was undertaken in six points (number 9 to 15 in Figure 5).

Figure 5 Location of the preliminary field survey

Findings of the preliminary field survey were:

- Forests recover very quickly after slash-and-burn.
- Low shrub is intruded four to five years after slash-and-burning and forest succession proceeds toward dense shrub forest with closed canopy, though the canopy height is low. For this reason, it is very difficult to specify the year of slash-and-burn in every point in time by satellite imagery.
- Suggestion was given that the dynamics of slash-and-burn lands with short term fallow periods would be understood if the provision of satellite imagery adopts very short observation period (ideally every year).

Based on the above findings of the preliminary field survey, primary field survey (March 2012) was planned as described later in this report.

3.2 Implementation of primary field survey

To develop reference levels in this project, based on the method to develop reference levels for project area and reference area, primary field survey (March to April, 2012) was carried out aiming to obtain the Ground Truth data for forest classification map mainly in the targeted area, HK-VC (Figure 6). The point of the survey was to match the interval between rehabilitating speed (years) of the forest after slash-and-burn and the provision of necessary satellite imagery. As a result, rehabilitating speed of the forest is fast in HK-VC, and so required analysis of satellite imagery must to take short interval. The number of the points measured as Ground Truth data was 43 in the HK-VC (*see* Appendix 1).

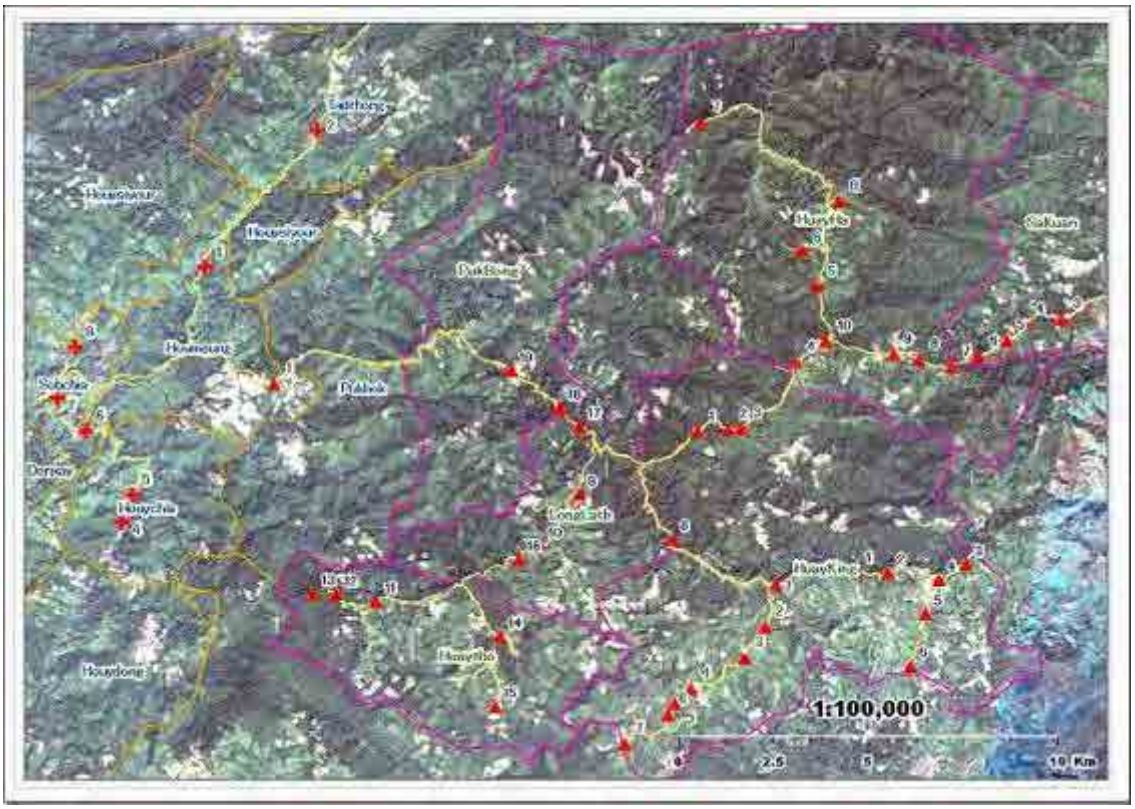


Figure 6 Location of implemented primary field survey

3.3 Implementation of secondary field survey

Secondary field survey (April 2012) was carried out as a complement of the primary survey at a center focuses on Sobchia village cluster where the primary field survey was not sufficiently carried out. In the secondary field survey was conducted in cooperation with FPP, and obtained the information regarding to the status of current carbon stock in each forest type through the output of TA4[3].

[3] The sub-project for approaching satellite imagery analysis, which assists activities of the PAREDD.

Chapter 3 Survey Method

1. Policy for Satellite Imagery Analysis (Setting the Land and Forest Type)

Followings are the issues of classification items of land use based on the field survey results. Categories written in red word in the chart is the classification items that have been changed to 2010 compared with 2005.

Firstly, Table 1 shows the classification items under the activities of FIM. The classification items appeared in this project area is Evergreen Forest (EF), Mixed Evergreen/Deciduous Forest (MED), Dry Dipterocarp Forest (DD), Bamboo (B), Old Fallow Land (OF), Young Fallow Land (YF), and Slash and Burn land (SB). Slash-and-burn is classified as Potential Forest in Lao PDR.

Table 1 Forest classification items under the FIM

Class Groups	2005 Class Items		2010 Class Items	
Current Forest	Dry Evergreen	EG	Evergreen Forest	EF
	Mixed Deciduous	MD	Deciduous Forest	DF
			Mixed Evergreen/Deciduous Forest	MED
	Dry Dipterocarp	DD	Dry Dipterocarp Forest	DD
	Gallery Forest		-	-
	Coniferous	S	Coniferous Forest	CF
	Mixed Conif/Broadleaved	MS	Mixed Coniferous/Broadleaved Forest	MCB
	Forest Plantation	P	Evergreen Forest Plantation	EP
			Deciduous Forest Plantation	DP
Potential Forest	Bamboo	B	Bamboo	B
	Unstocked	T	Old Fallow Land	OF
			Young Fallow Land	YF
	Ray	RA	Slash and Burn Land	SB
Other Wooded Area	Savannah/Open Woodlands	SH	Savannah/Open Woodland	SA
	Scrub, Heath	SR	Scrub, Heath	SR
Permanent Agriculture Area	Rice Paddy	RP	Rice Paddy	RP
	Agriculture Plantation	AP	Agriculture Plantation	AP
	Other Agriculture Area	OA	Other Agriculture Area	OA
Other Non-Forest Area	Grassland	G	Grassland	G
	Swamp	SW	Swamp	SW
	Rock/Barren Lands	R	Rock	R
			Barren Land	BL
	Urban Area	U	Urban Area	U
Water	Water	W	Water	W
Other Land	Other Land	O	Other Land	O
Other	Cloud	C	Cloud	CL
	Shadow	SHA	Shadow	SH

The field survey team had argued about OF and YF is the categories during the field survey. The

argument led the findings that OF and YF cannot be always defined by the years after slash-and-burn, assuming to take the carbon stock per hector at vertical axes and the year after slash-and-burn at horizontal axes. The reason of this was considered as that practiced times of the slash-and-burn (continuously or not), and the difference of the forest rehabilitating speed among the different areas (the difference of land productivity). Following pictures are the example of showing the different stages of the forest rehabilitation while the same duration after the slash-and-burn.

Around Houay Tho

Around Hua Meuang

From this perspective, assumption was made that OF and YF were not necessary to be distinguished in the process of forest rehabilitation model. However, the duration after the slash-and-burn in OF and YF was not obtained from the survey. This information is indispensable if the extension of the fallow period of slash-and-burn is defined as a part of REDD plus activities. This issue is directly linked to the issues to be examined: how to deal with the development of reference level at project base and sub-national base into that of at national base; and the consistency of the classification items. Therefore, those issues are set to be solved in medium- to long-term.

One more issue related to the classification items is about the classification accuracy of bamboo. The survey found that there are many cases of bamboo intruding into the land after slash-and-burn during forest rehabilitation period in Sobchia village cluster, which differentiate the situation in Sobchia village cluster from HK-VC.

Picture of intruded bamboo in Sobchia village cluster (1)

Picture of intruded bamboo in Sobchia village cluster (2)

Classification of bamboo is possible by using the satellite imagery if distribution pattern of bamboo is simply bamboo only. Classification of bamboo would be difficult if bamboo is mixed with evergreen forest or deciduous forest. However, bamboo has small carbon stock per hector compare with naturally grown secondary forest, which may cause over estimation of carbon stock if bamboo is extracted. Therefore, the project decided to take into account of a case that deals with the mixed ratio of bamboo. Based on the above situation, primary classification of optical satellite imagery was taken place.

2. Supplementary Analysis of Optical Sensor Imagery

2.1 Role of optical sensor imagery in this research

There are two ways to observe land cover change through using the time series data; analyzing every satellite of each time series respectively; analyzing data at the beginning or the end of the period to use them to compare with next time series. The former is able to keep enough accuracy of detection if classification accuracy of land cover is high, but become not suitable method if classification accuracy is low because the amount of change will be over detected by calculation than the true amount of change.

The accuracy of detection must be kept in this project which is aiming to detect the slash-and-burn through very short duration of the time. Therefore, the project decided to adopt the latter method, comparing the classification between two periods of time using the beginning or the end of the period. Taking account of the direction of time axes, suitable way of comparing time series data was considered to be taken place after making land cover map at the beginning of the period. However, since LANDSAT TM (30 m resolution) is used at the beginning of the period while the ALOS (2.5 m resolution) is used at the end of the period, selection of the higher ground resolution for the benchmark like information is considered as the best decision. Therefore, this project decided to take the method that the land cover map of the beginning of the period is preceded to be made and then backward the time.

Next step is the object-based classification which is the special feature of analyzing of satellite imagery. This methodology is suitable to identify a homogeneous cluster of forest stand like interpretation of forest type if individual pixel has detailed meaning, such as shadow between forest crowns.

The first step of the object-based classification is dividing the fields of satellite imagery into all homogeneous information. This means that the user need to set Scale Parameter (SP) in the software of the

remote sensing enable to perform the object-based classification so as to set the regional size to be extracted as homogeneous information. Setting small SP causes to divide the homogeneous stand while large SP causes to extract different stand as the same stand. How to set the SP is decided by the complexity of the forest type or landscape structure in targeted area.

After examination of the status adopted object-based classification on ALOS satellite imagery, the primary result classified based on the field survey result is shown as in Figure 7.

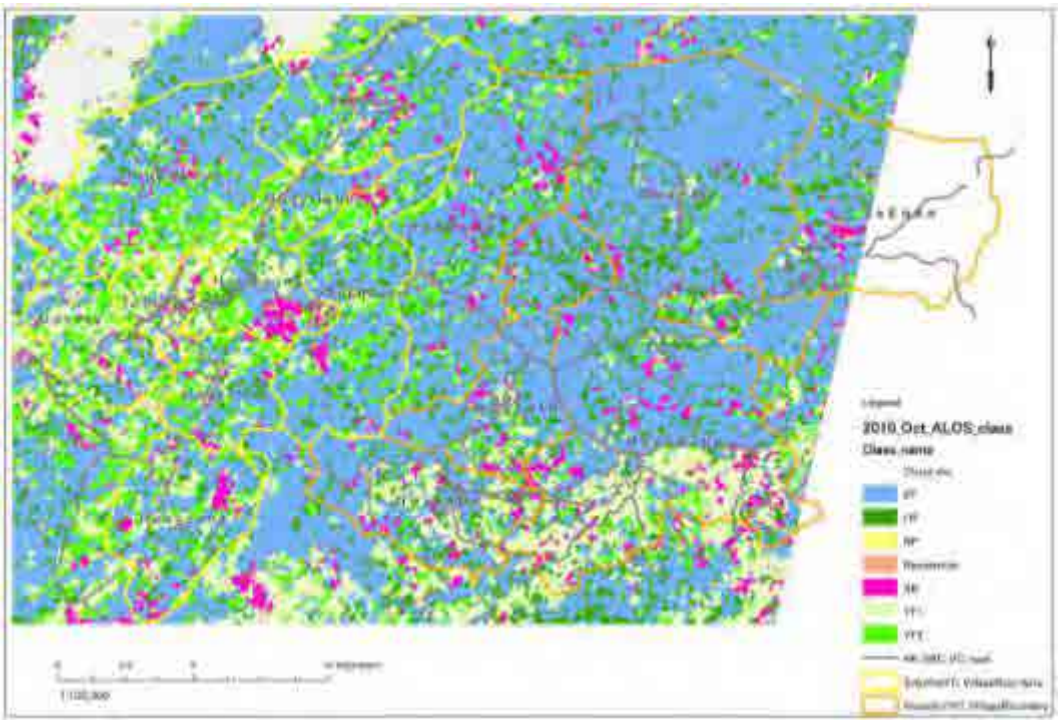


Figure 7　Forest classification map in Sobchia village cluster and HK-VC

(based on the ALOS satellite imagery in 2011)

2.2　Method for classifying optimal sensor imageries

Consistency of the accuracy must be taking into account when carrying out forest classification using several points in time of satellite imagery. If the error of the classification at each point in time exceeds the amount of the change, the trend of the change would not able to be delivered. Therefore, classification methodology, such as updating only changed land, is desirable while respecting the result of one time before the target time. As mentioned above, new slush-and-burn land is required to be extracted primarily as the amount of the change between two points in time. From this, the project decided to extract only changed land from forest to non-forest through comparing two points in time while using the classification result of one time before at the land of not changed. Different method is used for the land changed from non-forest to forest, such as plantation, since remote sensing is difficult to extract them.

From the above points of view, flow of the classification methodology is shown as in Figure 8.

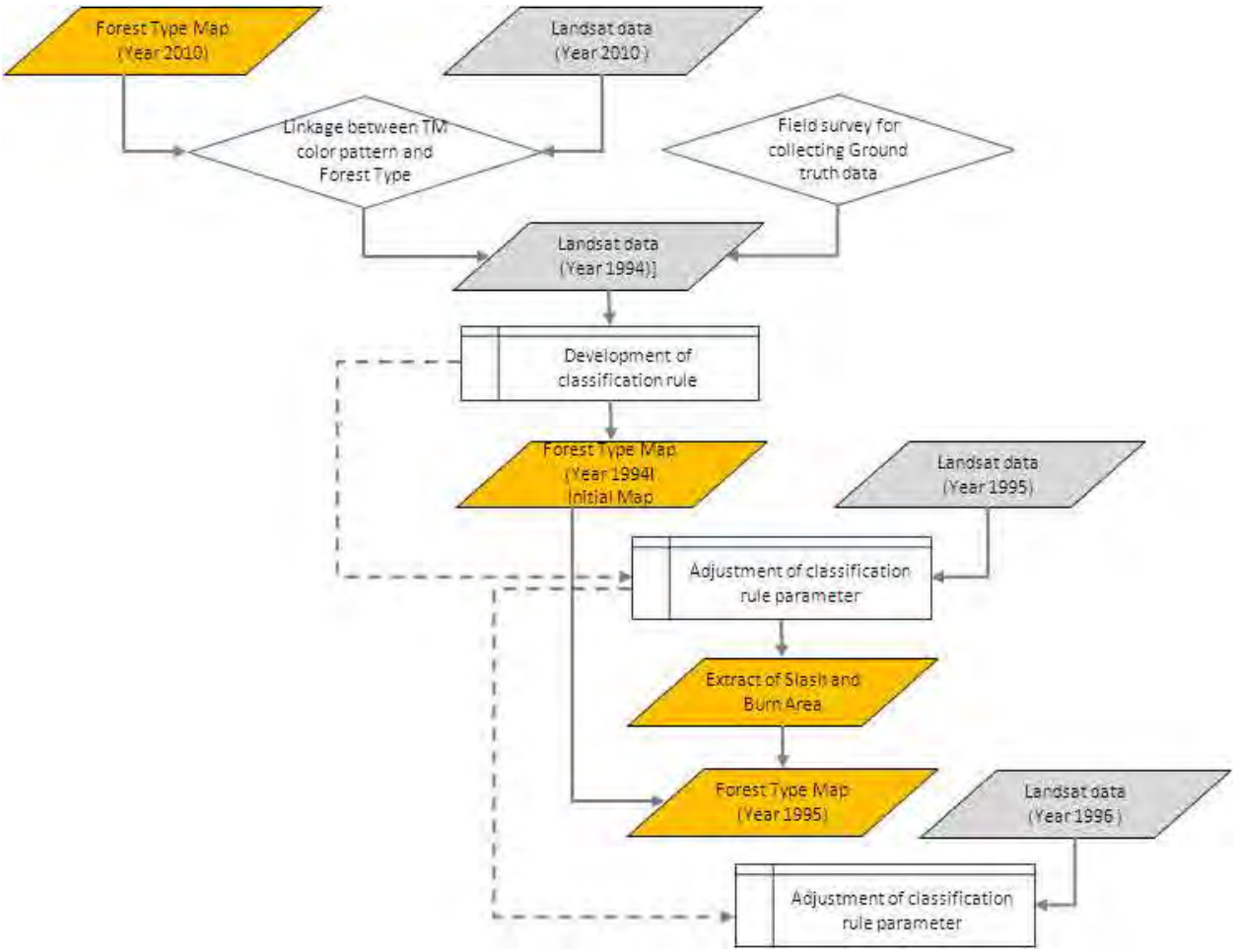


Figure 8 Classification Method

3. Method for Selecting Slush-and-burn Lands

3.1 Importance of selecting slush-and-burn lands in the target area

The project decided to utilize the methodology of keeping consistency of classification accuracy by extracting new slush-and-burn land only by satellite imagery at each point in time while using former classification result at the land of not changed. Consequently, updating the map of changed land from forest to non-forest between two points in time is only required. Considering of the situation that slush-and-burn is the cause of the land change to non-forest in the project site, the methodology would be extracting new slush-and-burn only from LANDSAT satellite imagery at each point in time, as a result.

3.2 Method for selecting slush-and-burn lands

The effective way of extracting slush-and-burn land would be considered as the methodology of excluding each level of classification of other land cover/land use. Making such rule base and changing threshold into suitable value may results in keeping the consistency of the methodology of extraction.

Following Figure 9 is the decision tree to classify each level.

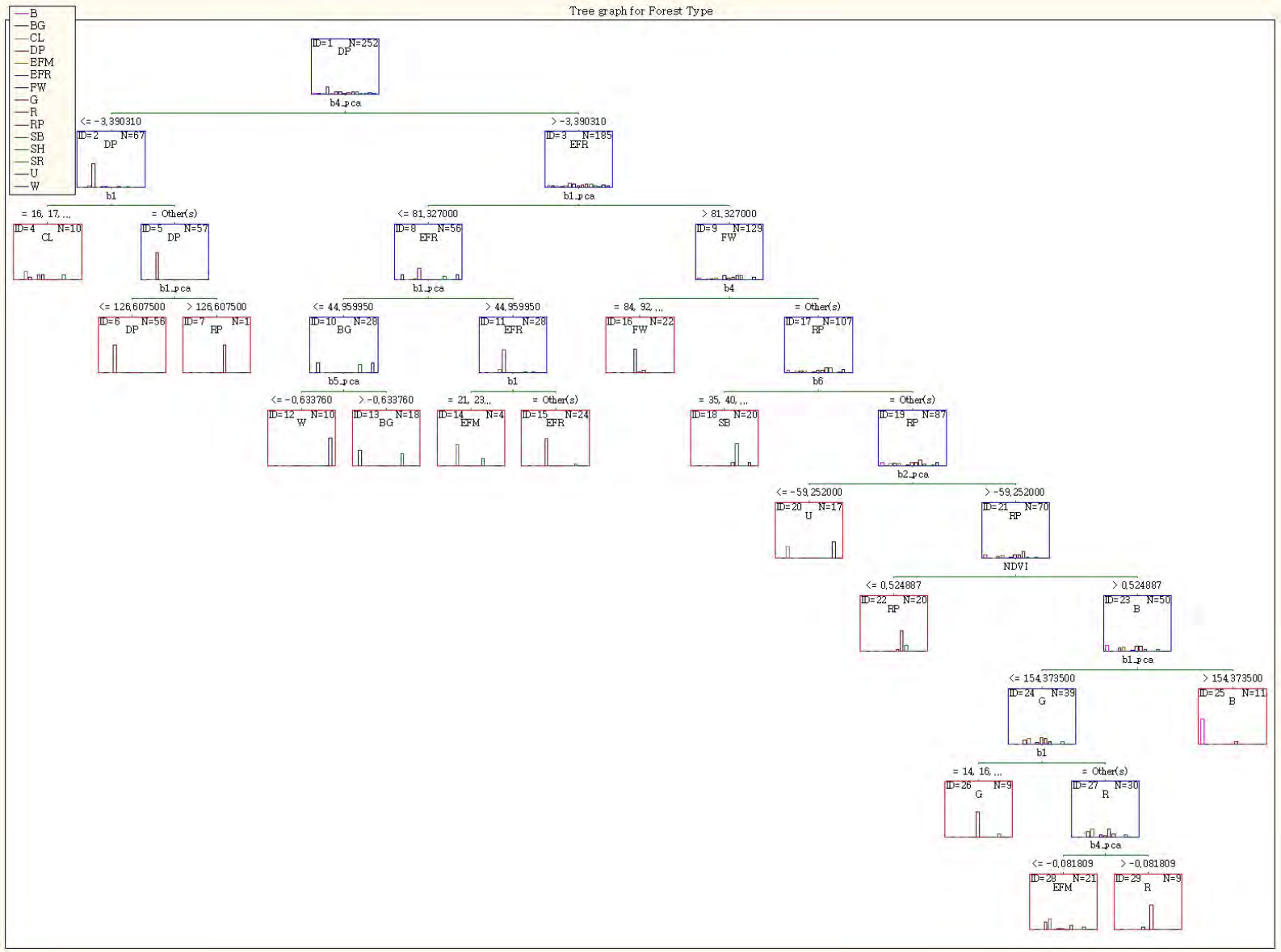


Figure 9 Decision tree for extracting slush-and-burn land

3.3 Considering the method of capturing the incidence of short cycle shifting cultivation land in Houay Khing/Sobchia village cluster

It is shown in that the relationship between the season/time of slash-and-burn and the season/time of ALOS/PALSAR imagery based on the crop calendar of shifting cultivation in Lao PDR. It is also shown in Figure 11 that the image for the method of extracting the occurrence of shifting cultivation by ALOS/PALSAR imagery.

The land cover of shifting cultivation just after slash-and-burn or harvest looks like a bare land. Thus, the backscatter coefficient observed by ALOS/PALSAR is lower in that place, and the brightness value of ALOS/PALSAR imagery is also darker. By utilizing this phenomenon, it is possible to extract the slash and burn land by overlapping ALOS/PALSAR imagery before and after slash and burn. For example, the slash and burn land occurred between January and April 2007 is extracted by overlapping ALOS/PALSAR imagery observed in November or December 2006 and 2007. Therefore, slash-and-burn lands occurred each year from 2007 to 2010 can be extracted by using ALOS/PALSAR imagery observed each year from 2006 to 2010.

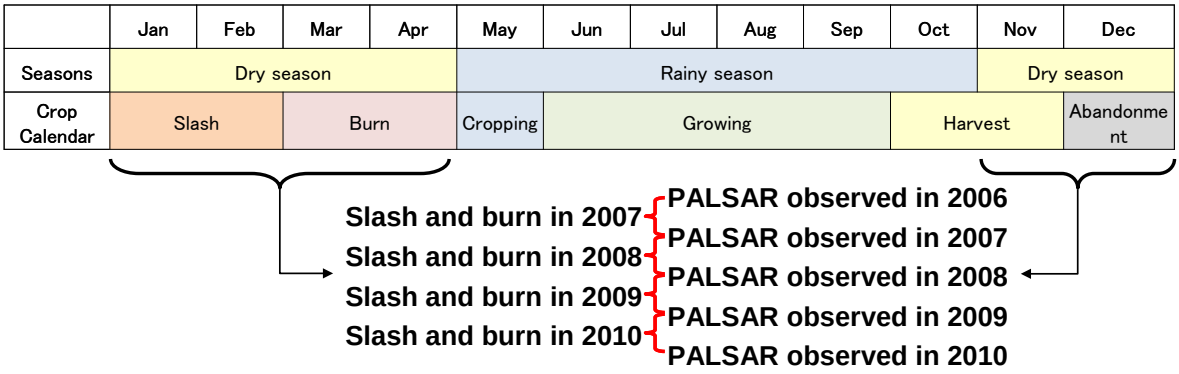


Figure 10 Relationship between the season/time of slash and burn and the season/time of ALOS/PALSAR imagery based on the crop calendar of shifting cultivation in Lao PDR

Figure 11 Image for the method of extracting the occurrence of shifting cultivation by ALOS/PALSAR imagery

Slash-and-burn lands in Houay Khing/Sobchia village cluster each year from 2007 to 2010 were extracted based on the above method (Figure 12 to Figure 15).

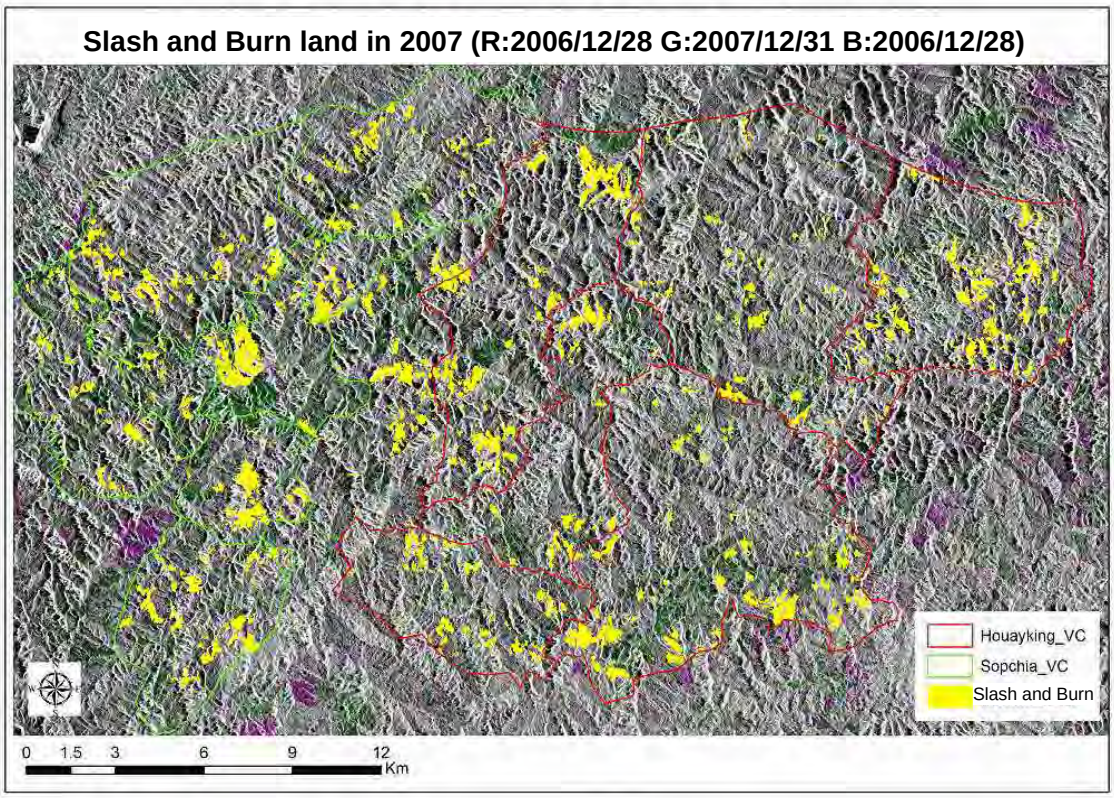


Figure 12 Slash-and-burn land in 2007

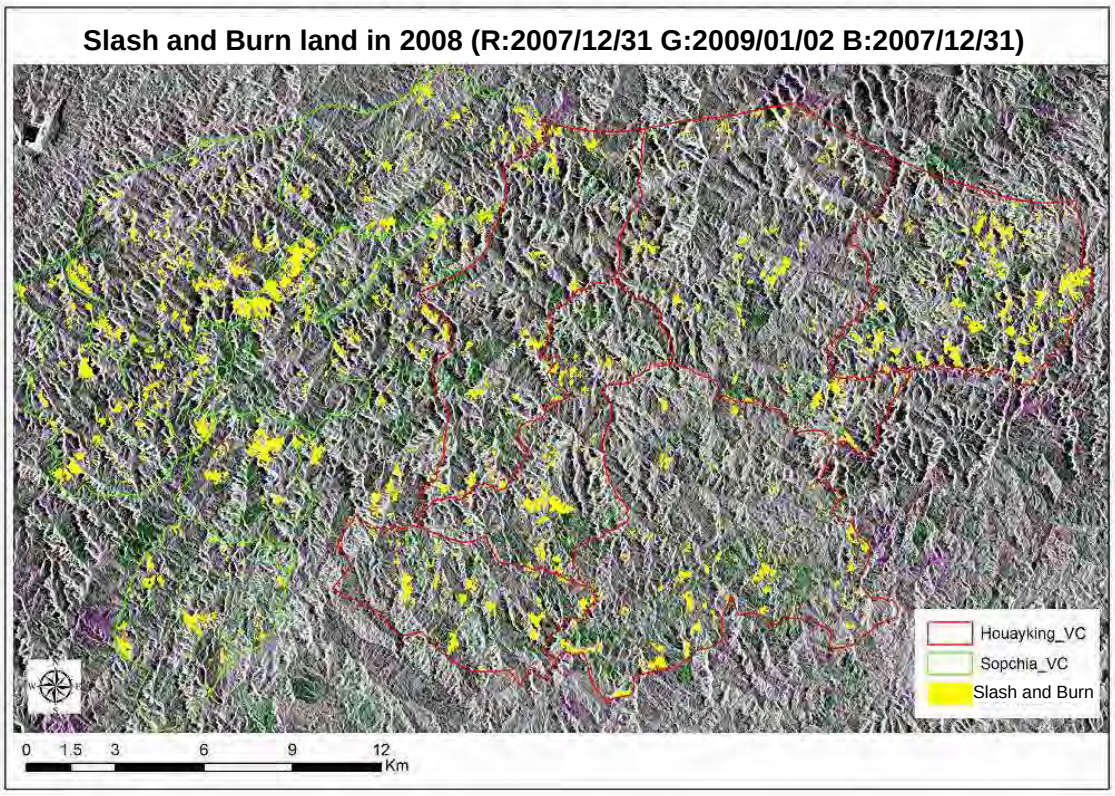


Figure 13 Slash-and-burn land in 2008

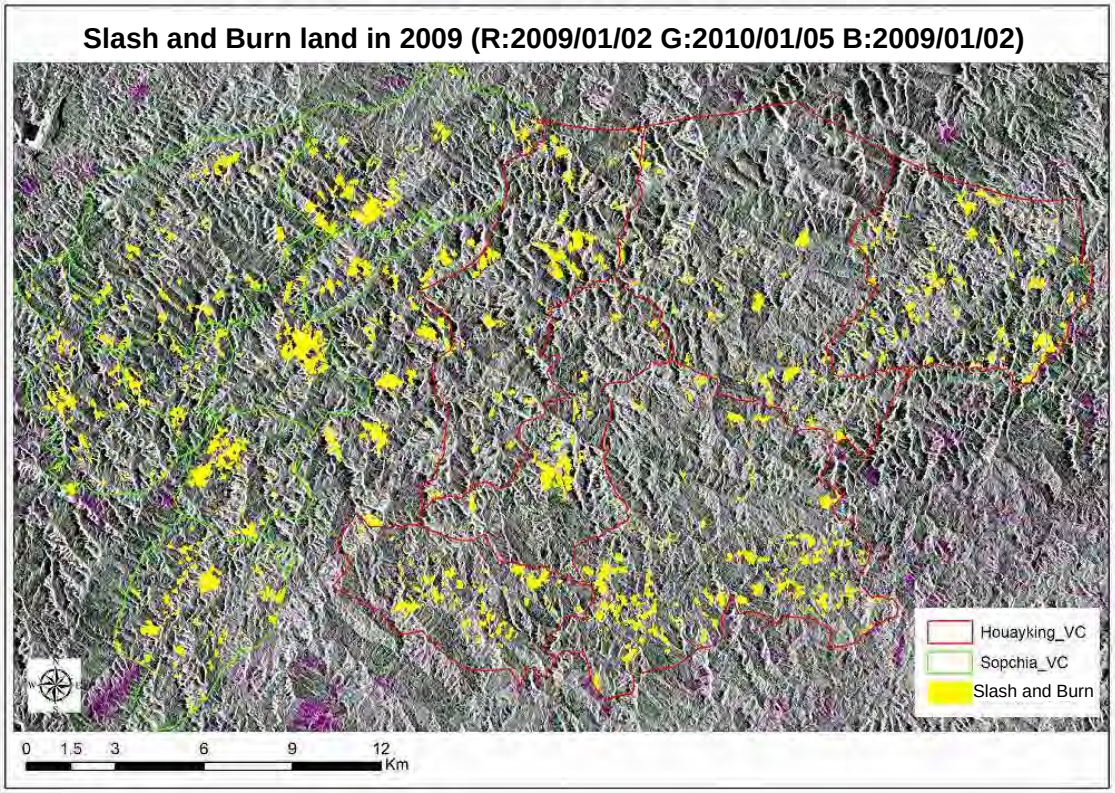


Figure 14 Slash-and-burn land in 2009

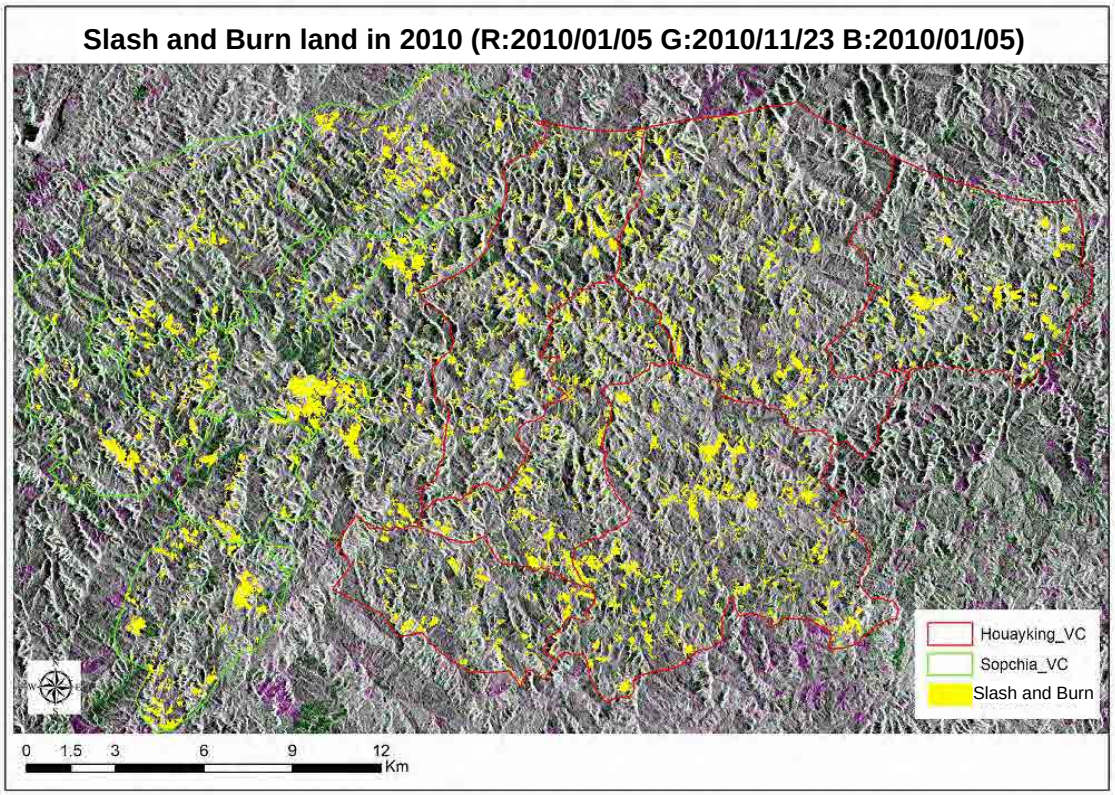


Figure 15 Slash-and-burn land in 2010

Then the pattern of shifting cultivation cycle was defined by the overlay analysis for the extracted slash and burn land for each year (Table 2, Figure 16). In addition, a maximum fallow term of short cycle shifting cultivation land was set up 2 years and 3 years based on the results of field survey and hearing from Laotian remote sensing engineers (Table 3). The distribution map of short and long cycle shifting cultivation land as 2 years and 3 years maximum fallow term is shown in Figure 17and Figure 18. Furthermore, the result of total area is shown in Table 4and Table 5.

Table 2　Pattern of shifting cultivation cycle

Number of occurrence	Occurred years	Fixed maximum fallow term	Pattern of cycle
1	2007	More than 4 years	C
	2008	More than 3 years	D
	2009	More than 3 years	D
	2010	More than 4 years	C
2	2007–2008	More than 3 years	D
	2008–2009	More than 2 years	Unkonwn
	2009–2010	1 year	A
	2007–2009	More than 2 years	Unkonwn
	2008–2010	2 years	A
	2007–2010	3 years	B
3	2007–2008–2009	More than 2 years	Unkonwn
	2007–2008–2010	2 years	A
	2007–2009–2010	1 year	A
	2008–2009–2010	1 year	A
4	2007–2008–2009–2010	1 year	A

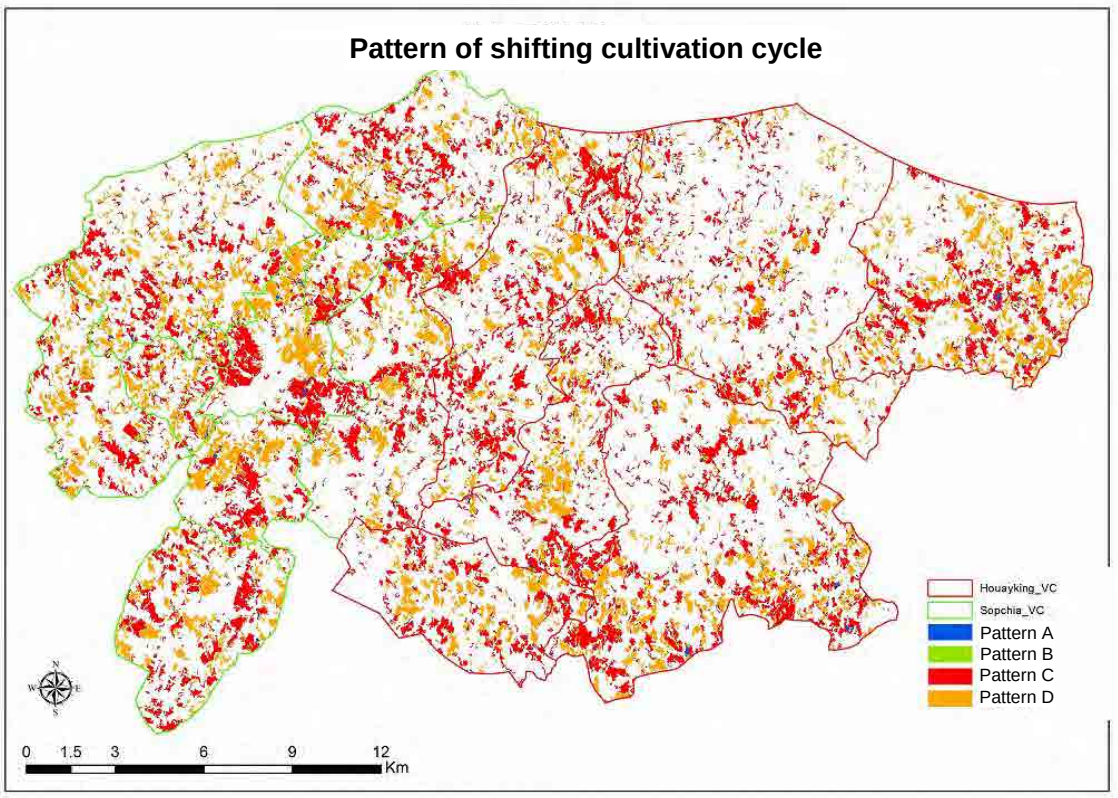


Figure 16 Distribution map for each patterns of shifting cultivation cycle

Table 3 Setting up a maximum fallow term for short cycle shifting cultivation

Pattern of cycle	In case of less than 2 years of fallow term for short cycle	In case of less than 3 years of fallow term for short cycle
A	Short cycle	Short cycle
B	Long cycle	Short cycle
C	Long cycle	Long cycle
D	Long cycle	Unknown

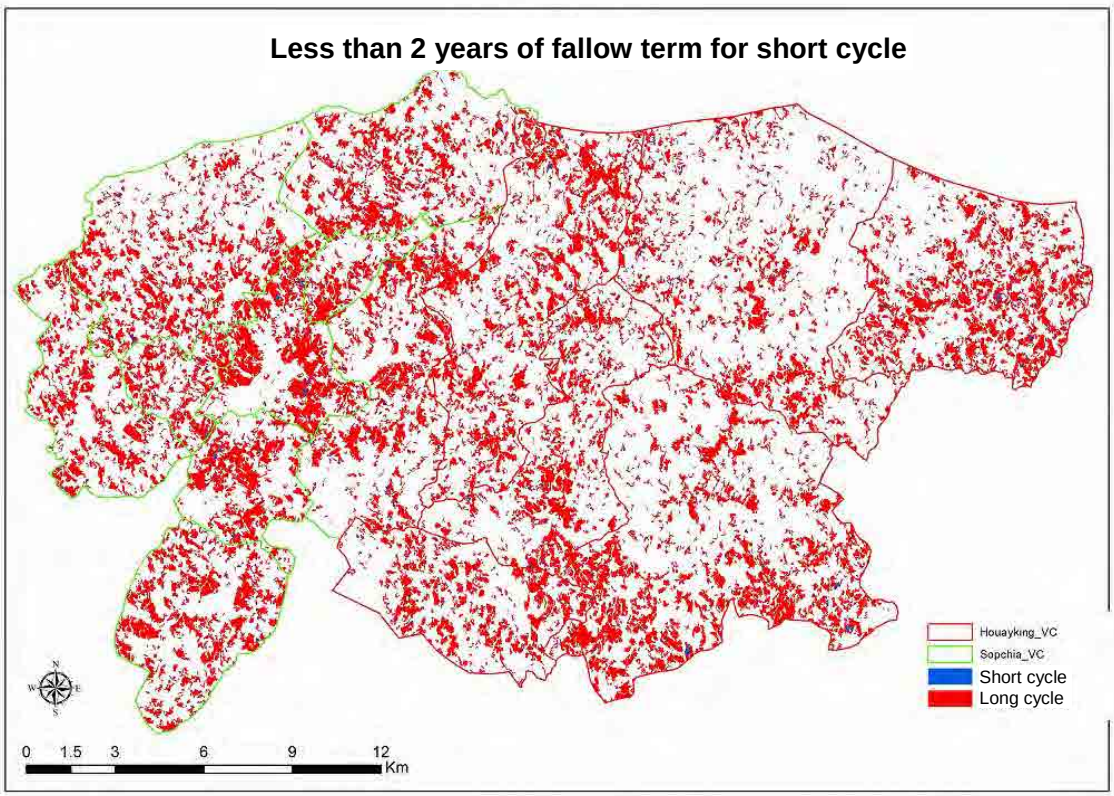


Figure 17 Distribution map for short and long cycle shifting cultivation in case of 2 years maximum fallow term

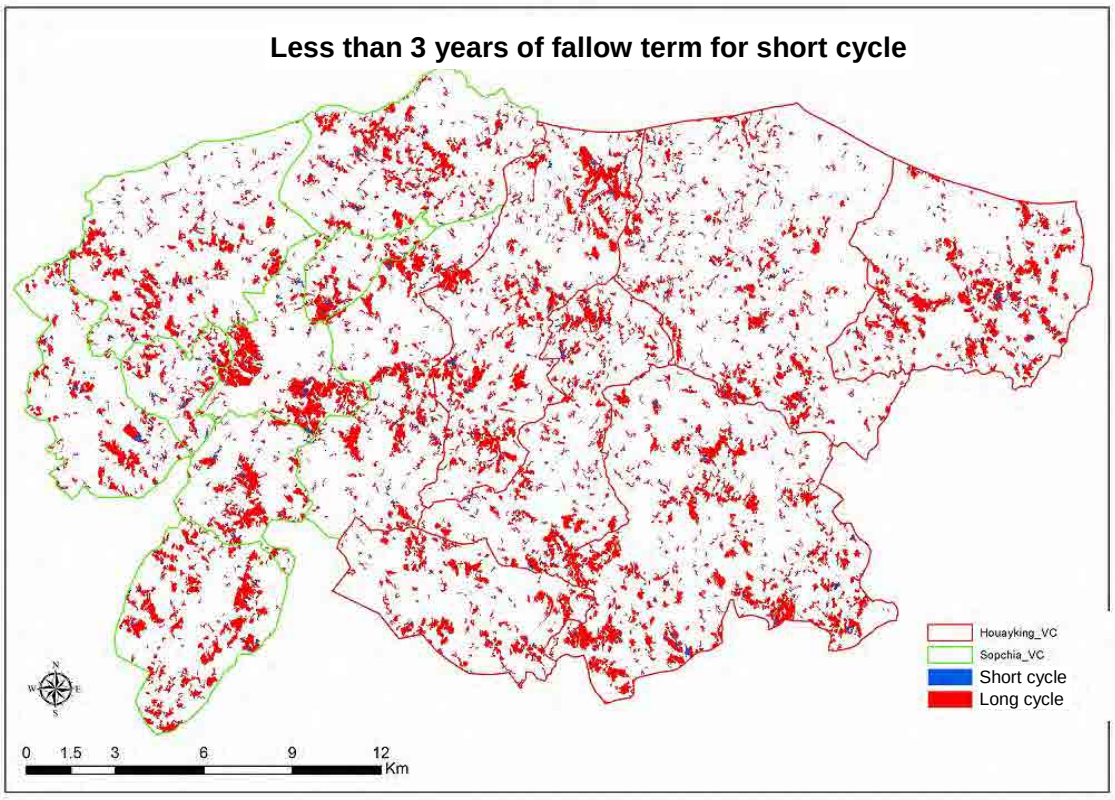


Figure 18　Distribution map for short and long cycle shifting cultivation in case of 3 years maximum fallow term

Table 4　Total area of short and long cycle shifting cultivation land in case of 2 years maximum fallow term

	Less than 2 years of fallow term for short cycle					
	Houayking VC		Sopchia VC		Whole	
	Area(km2)	(%)	Area(km2)	(%)	Area(km2)	(%)
Short cycle shifting cultivation land	1.1	1.5%	0.8	1.3%	1.9	1.4%
Long cycle shifting cultivation land	74.4	98.5%	63.0	98.7%	137.4	98.6%
Total	75.5	100.0%	63.8	100.0%	139.3	100.0%

Table 5 Total area of short and long cycle shifting cultivation land in case of 3 years maximum fallow term

	Less than 3 years of fallow term for short cycle					
	Houayking VC		Sopchia VC		Whole	
	Area(km2)	(%)	Area(km2)	(%)	Area(km2)	(%)
Short cycle shifting cultivation land	1.8	4.1%	1.5	4.4%	3.3	4.3%
Long cycle shifting cultivation land	42.0	95.9%	32.2	95.6%	74.2	95.7%
Total	43.8	100.0%	33.7	100.0%	77.5	100.0%

In case of 2 years maximum fallow terms, the incidence of short cycle shifting cultivation land was about 1 %, in case of 3 years maximum fallow terms, the incidence of short cycle shifting cultivation land was about 4 %. Although the maximum fallow term of short cycle shifting cultivation has to be fixed based on the results of field survey, in any case, it is not much affected to estimate the amount of carbon because the short cycle shifting cultivation land is few.

3.4 Slash-and-burn lands in Luang Prabang Province each year from 2007 to 2010

Slash and burn land in Luang Prabang Province each year from 2007 to 2010 was extracted by analyzing ALOS/PALSAR imagery. Distribution map of slash and burn land each year from 2007 to 2010 is shown in Figure 19. Since the area of slash and burn land is been counting currently, after that the distribution of short and long cycle shifting cultivation land will be defined as it was done for Houay Khing/Sobchia village cluster after fixing the maximum fallow term based on the results of field survey.

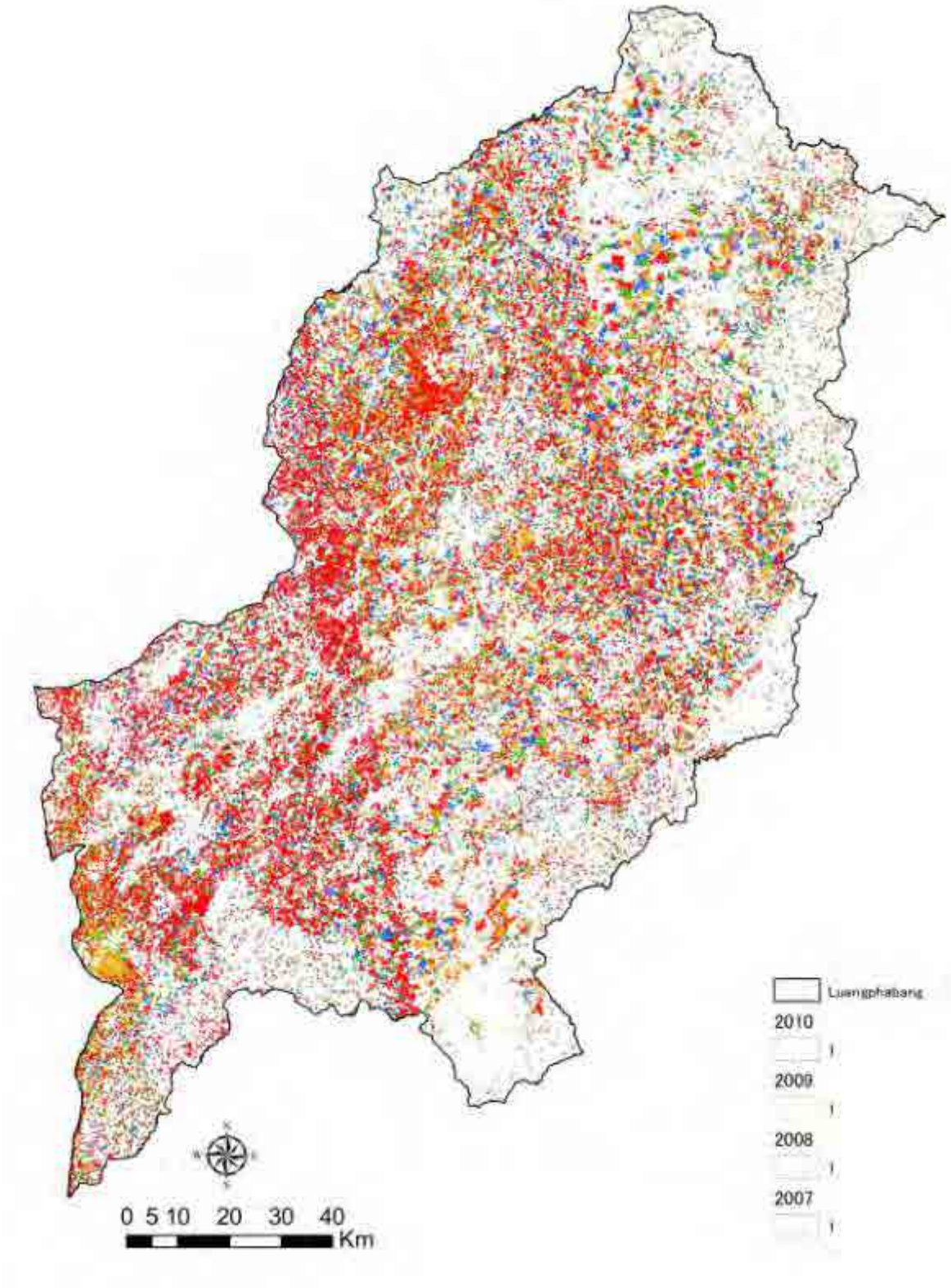


Figure 19 Distribution map of slash-and-burn lands each year from 2007 to 2010 in Luang Prabang Province

3.5 Classification of bench mark data (RapidEye satellite in 2010)

As described above, the forest classification maps of Luang Prabang Province in 2010, which was created by FIM using RapidEye satellite imagery observed in 2010, were adopted. The reason to choose the map was Luang Prabang Province was considered a part of national-based REDD plus in Lao PDR, and it was thought to be important to ensure the consistency with such national-based activities. The forest classification map in 2010 is already completed, and the forest classification map in 2005 will be under creation aiming at the end of November, 2012.

The forest classification map in 2010 was generated using RapidEye satellite imagery observed in 2010 supplied on FIM/FPP, and the ALOS/PALSAR imagery observed in 2009 and 2010 supplied on this project. The specifications of the each satellite imagery used to were shown in Table 6.

Table 6 Specifications of each satellite imagery used to forest classification map generation in 2010

Satellite	Sensor	Spatial Resolution	Observation Period
RapidEye	Multispectral	6.5m	From Oct. 2010 to Mar. 2011
ALOS	PALSAR (SAR)	12.5m	From Oct. 2009 to Mar. 2010
			From Oct. 2010 to Mar. 2011

Orthogeometric correction of the RapidEye satellite imagery observed in 2010 was carried out using GCPs of the whole Lao country acquired by the local consultant on behalf of FIM/FPP. It is assumed that, as the appeared in the validation results in Table 7, it had high positional accuracy.

Table 7 Positional accuracy assessment result of RapidEye imagery in 2010

		GCPs	x	y	total	X (m)	Y (m)	Total (m)
RapidEye	Average	59	0.89	0.85	1.230691	4.45	4.25	6.153454
	Worst 5%	3	2.63	2.5	3.628622	13.15	12.5	18.14311

Generation method of the forest classification map in 2010 is described as follows. First, the forest classification map (Draft) was generated by the object-based classification of the RapidEye imagery. Then, adjustment based on ground truth result, know-how of local engineer and the ALOS/PALSAR imagery observed in 2009 and 2010 was made, and the forest classification map (final version) was generated.

The Laotian engineer who received capacity building by FIM generated the forest classification map (Draft). However, since the work schedule of FIM did not agree with the work schedule of this project, adjustment was made in Japan. But, the forest classification map was adjusted, discussing with Laotian engineer in order to make it consistent with the forest classification map (final version) of the Laos whole country which FIM generates.

The point considered when adjusting is as follows. The 1st point is the classification of evergreen forest and deciduous forest. It is difficult to perform these classifications by automatic classification, and utilized the knowledge of the Laotian engineer who knows a spot well. Moreover, since the place where altitude is

comparatively high had many evergreen forests, DEMs were referred to.

The 2nd point is about a dry dipterocarp. It turned out that the dry dipterocarp grows gregariously in the partial area of Luang Prabang Province. Since automatic classification was difficult, it classified based on a Laotian engineer's knowledge.

The 3rd point is about a forest plantation. Since it was impossible to identify a young forest on satellite imagery, only the forest plantation grown-up to some extent was classified. The teak woods of the deciduous plantation forest had the early afforestation time in Luang Prabang Province compared with other species. And, since the tree form is characteristic, it classified by RapidEye imagery interpretation. On the other hand, the afforestation time of the rubber forest and oil tree of an evergreen plantation forest is late in Luang Prabang Province compared with a teak wood. Therefore, there were few grown forests and the classification based on RapidEye imagery was impossible.

The 4th point is about slash-and-burn land. The classification of the Young Fallow Land (YF) and the Old Fallow Land (OF) was difficult. However, in the slash-and-burn land, it was judged from the abandonment years being important that it was satisfactory. Slash and Burn Land (SB) is the most important classification item, in order to specify burnt field abandonment years and to grasp a burnt field dynamic state. In the automatic classification using a RapidEye imagery, there was a case according to which a paddy field, a bare ground, and SB are incorrect-classified. Therefore, the change area was detected using the difference of the ALOS/PALSAR imagery observed in 2010, and the ALOS/PALSAR imagery observed in 2009. The automatic classification result by a RapidEye imagery was corrected having assumed the change area to be SB which occurred in 2010, and classification accuracy was raised.

The 2010 forest classification map (final version) of Luang Prabang Province is shown in Figure 20. And, area of each forest class items in 2010 of Luang Prabang Province is shown in

Table 8. Current Forest was about 51% and Potential Forest was about 43% of Luang Prabang Province. And, the evergreen forest (about 21%), the deciduous forest (about 29%), and the Old Fallow Land (about 35%) occupied about 86% of the whole.

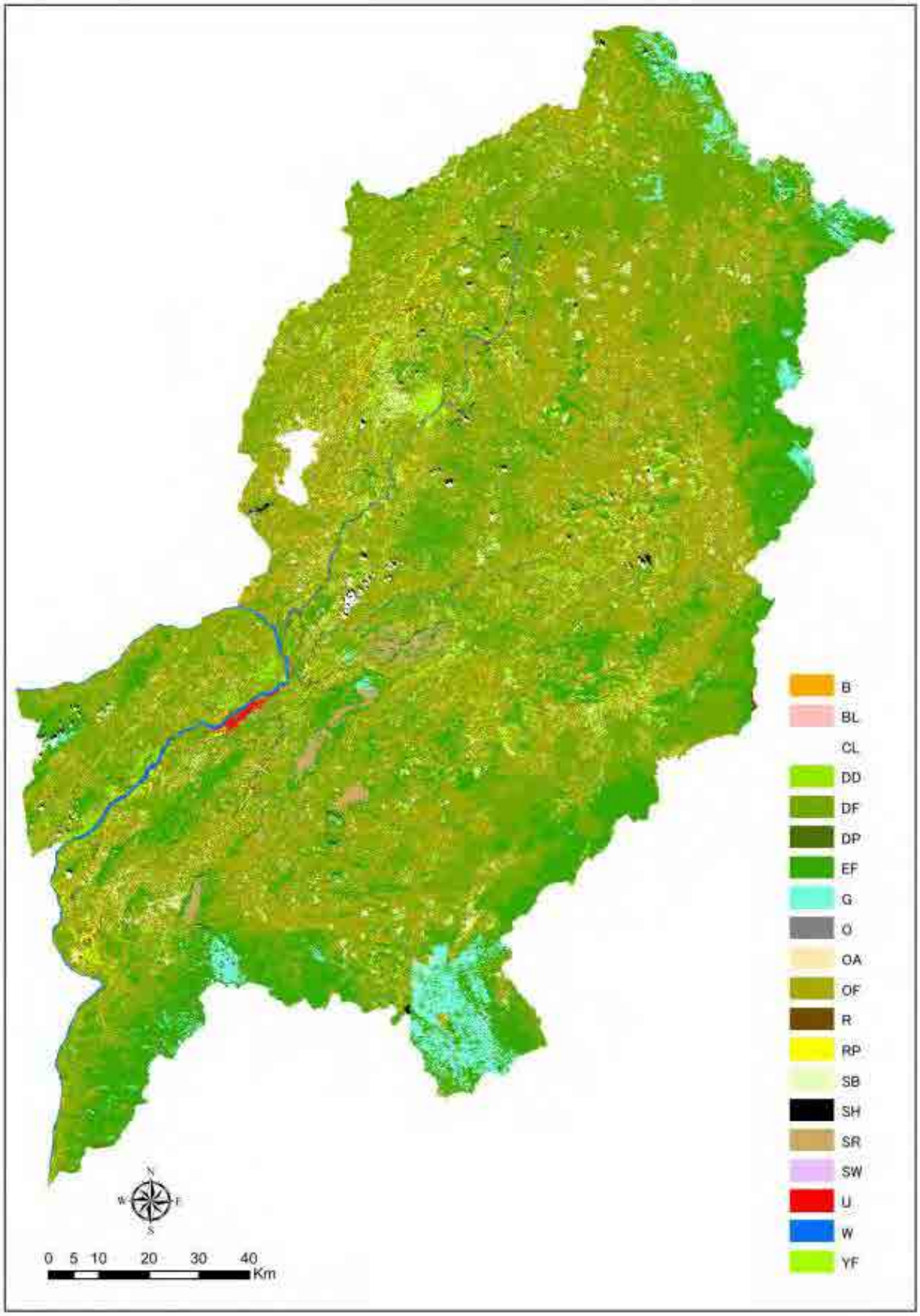


Figure 20 The 2010 forest classification map of Luang Prabang Province

Table 8 Area of each forest class items in 2010 of Luang Prabang Province

Class Groups	FIM Class Items	FIM Class	Area(ha)	(%)
Current Forest	Deciduous Forest	DF	586,086	29.4
	Evergreen Forest	EF	422,196	21.2
	Deciduous Forest Plantation	DP	9,815	0.5
	Dry Dipterocarp Forest	DD	1,662	0.1
Potential Forest	Old Fallow Land	OF	704,787	35.3
	Slash and Burn Land	SB	85,945	4.3
	Young Fallow Land	YF	46,112	2.3
	Bamboo	B	17,928	0.9
Other Non-Forest Area	Grassland	G	45,630	2.3
	Urban Area	U	4,887	0.2
	Rock	R	1,247	0.1
	Barren Land	BL	370	0.0
Other Wooded Area	Scrub, Heath	SR	14,900	0.7
Permanent Agriculture Area	Rice Paddy	RP	12,434	0.6
	Other Agriculture Area	OA	763	0.0
Water	Water	W	12,763	0.6
Other	Cloud	CL	16,874	0.8
	Shadow	SH	5,147	0.3
Other land	Other land	O	4,276	0.2
Total			1,993,822	100.0

3.6 Forest classification map 2005

At the initiation stage of this project, as described above, forest classification map 2005 was going to be modified where change were detected based on the forest classification map 2010 by using the FIM/FPP provided SPOT4/5 imagery observed in 2005. The reason of this was it was aimed to avoid variance with the national forest classification map 2005, which is planned to be generated by FIM.

However, FIM/FPP's satellite imagery analysis targeted the year 2005 was progressing at different speed from this project (FIM/FPP was far behind schedule), and a significant issue was found in its analysis accuracy. For this reason, this project did not use FIM/FPP's forest classification map 2005, and instead independently prepared and analyzed satellite imageries to create forest classification map 2005.

3.7 Classification of initial year's data (LANDSAT 1994)

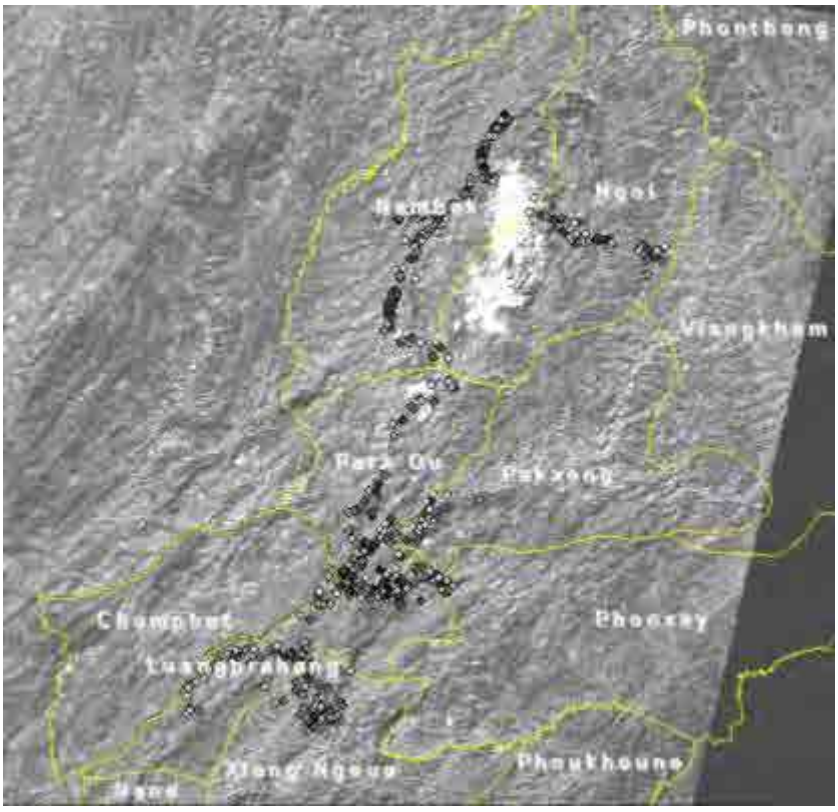
General field observation is conducted or the purpose of collecting ground truth data for imagery analysis referring forest classification map year 2010. Overview of the field survey is shown below.

Objectives: Collecting ground truth data for imagery analysis and general understanding of forest status.

Periods: 20th Oct – 25th Oct (5 days)

Survey area: East region of Luang Prabang Province (8 out of 12 districts)

Survey records: 20th Oct 9 / Vientiane ⇒ Luang Prabang Province
Meeting at PAREDD Office (Preparation and confirmation)
Meeting at PAFO for getting permission
Luang Prabang Province ⇒ Field survey ⇒ NonGieu
21st Oct9 / NonGieu ⇒ Field survey ⇒ Luang Prabang Province
22nd Oct9 / Luang Prabang Province ⇒ Field survey ⇒ Luang Prabang Province
23rd Oct9 / Luang Prabang Province ⇒ Field survey ⇒ Luang Prabang Province
24th Oct9 / Luang Prabang Province ⇒ Field survey ⇒ Luang Prabang Province
25th Oct9 / Hotel ⇒ PAREDD Office for reporting
Luang Prabang Airport ⇒ Vientiane



Survey route and location of ground truth data

Utilizing these ground truth data, image analysis process were conducted and then forest classification map of 1994 (draft) was generated.

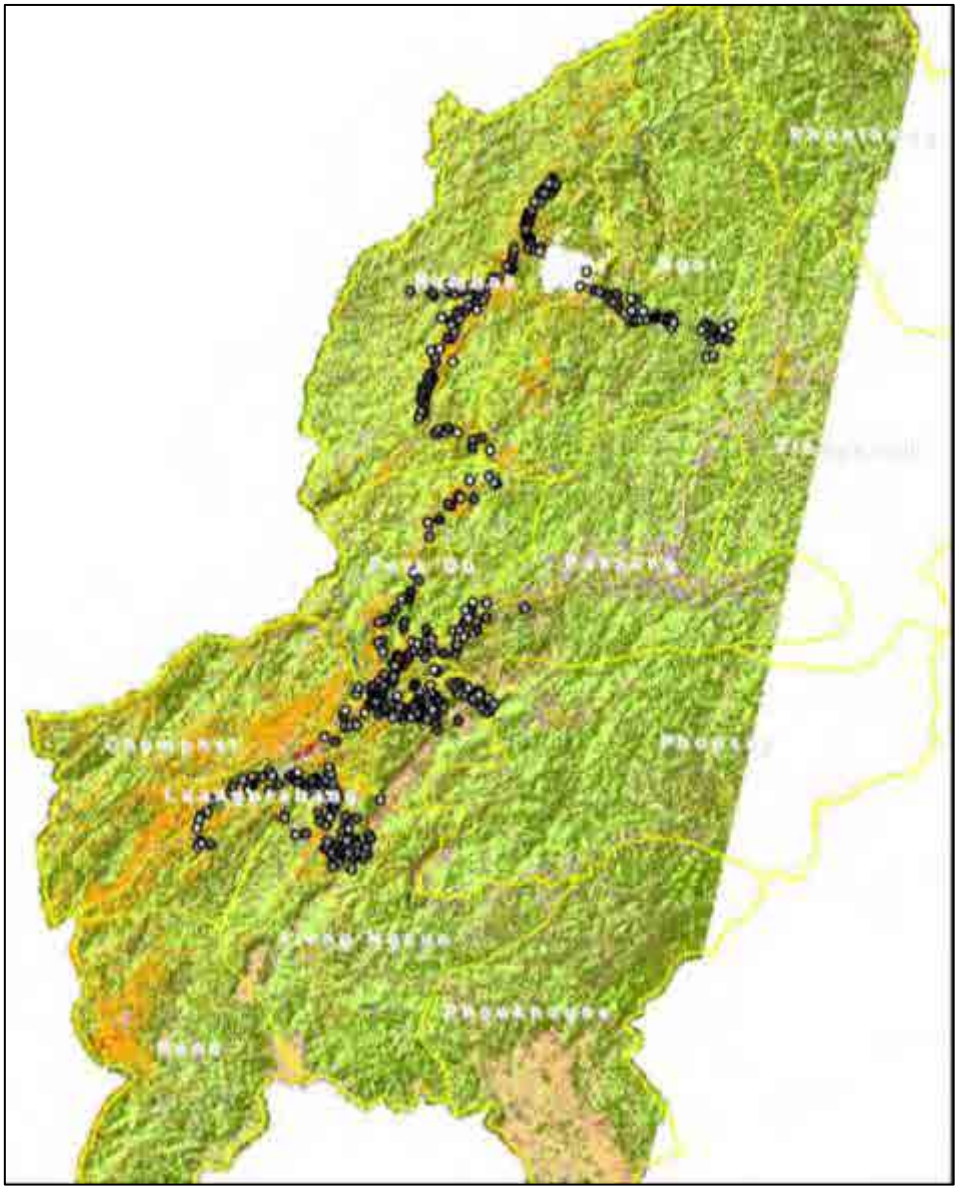


Figure 21 Forest classification map in 1994 (Based on LANDSAT)

In addition to this work, study team conducted geo-correction for every LANDSAT satellite from year 1994 to 2005. In the process of geo-correction, RapidEye satellite in the year2010 was used as a reference GCP data sources. And also, SRTM data was used or digital elevation model as elevation information. Geo-correction accuracy should be met with in 3 pixels respectively and each imagery should have taken 30 GCPs or more.

3.8 Status of analyzing SAR sensor imagery

It is possible to extract the slash-and-burn land by analyzing multi-years SAR imagery. In this project, a shifting cultivation land is assumed Potential Forest as one of forest types. However, it became clear by the results of field survey and discussion with other donor projects that some shifting cultivation land will not become forest due to short fallow term after abandoned (Figure 22). Because short cycle shifting cultivation land which will not become forest should not be regarded as forest, it is necessary to consider that the

incidence of short cycle shifting cultivation land should be subtracted from the whole. Therefore, the method of capturing the incidence of short cycle shifting cultivation land was considered based on ALOS/PALSAR imagery observed every year between 2006 and 2010 in Houay Khing/Sobchia village cluster. Then the method which was considered in Houay Khing/Sobchia village cluster was applied to whole Luang Prabang Province[4].

Figure 22 Image of short cycle and long cycle shifting cultivation

[4] The analysis in Houay Khing/Sobchia village cluster was conducted by FPP/TA4, and the analysis in Luang Prabang Province was conducted by this project.

Chapter 4 Results (Identifying Forest Dynamics)

Based on first field survey conducted from February to April in 2012, additional survey to identify forest dynamics by satellite imagery analysis had been conducted from November 2012 to March 2013, and such surveys were conducted by collaboration with the FPP, and results of the FPP supplied information on carbon stock in each forest type.

Based on the forest dynamics from 1994 to 2004, the forest dynamics covering HK-VC and Luang Prabang Province was quantified (Figure 23 and Figure 24). Also, the forest dynamics of the whole area of Phonsay district which falls under the reference area in the event of targeting HK-VC, and Sobchia village cluster and Ponthong village cluster which falls under the leakage belt were quantified as well.

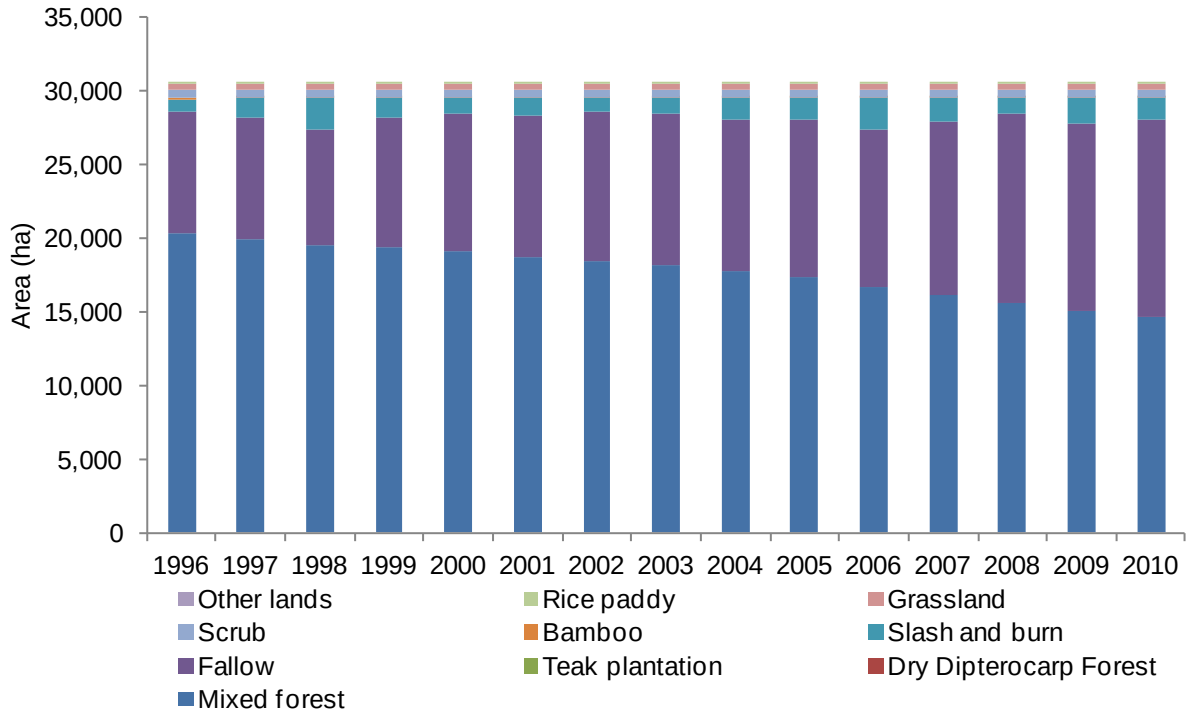


Figure 23 Forest dynamics in HK-VC

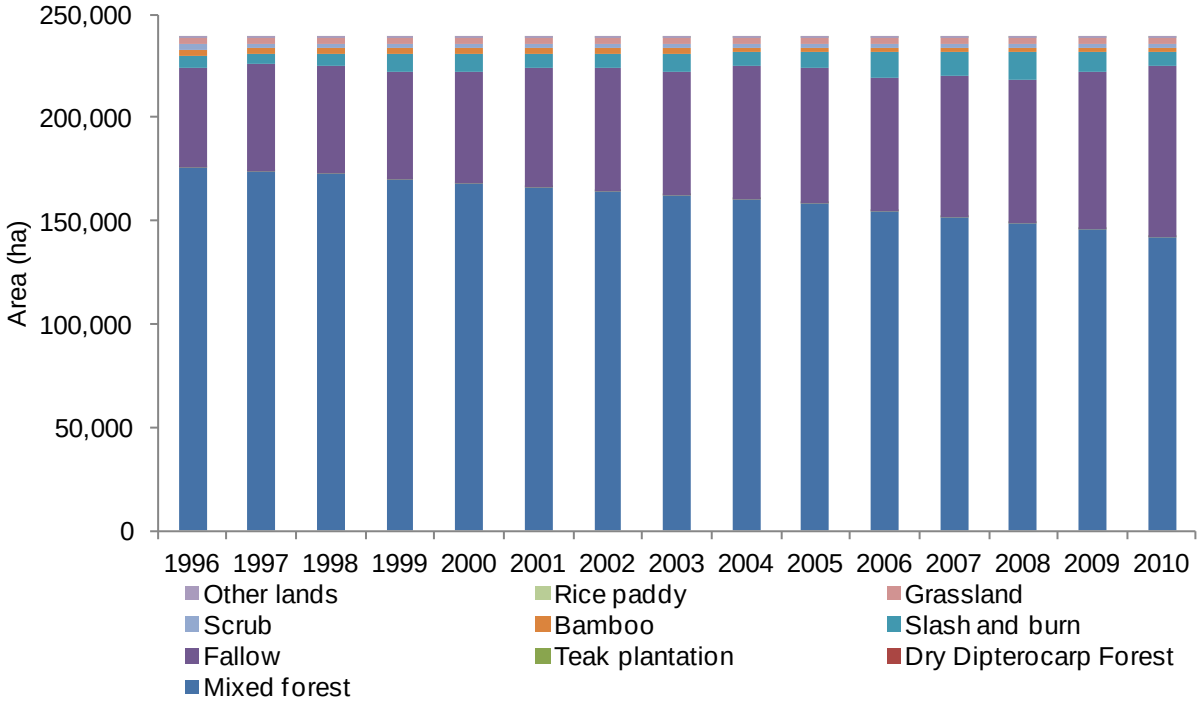
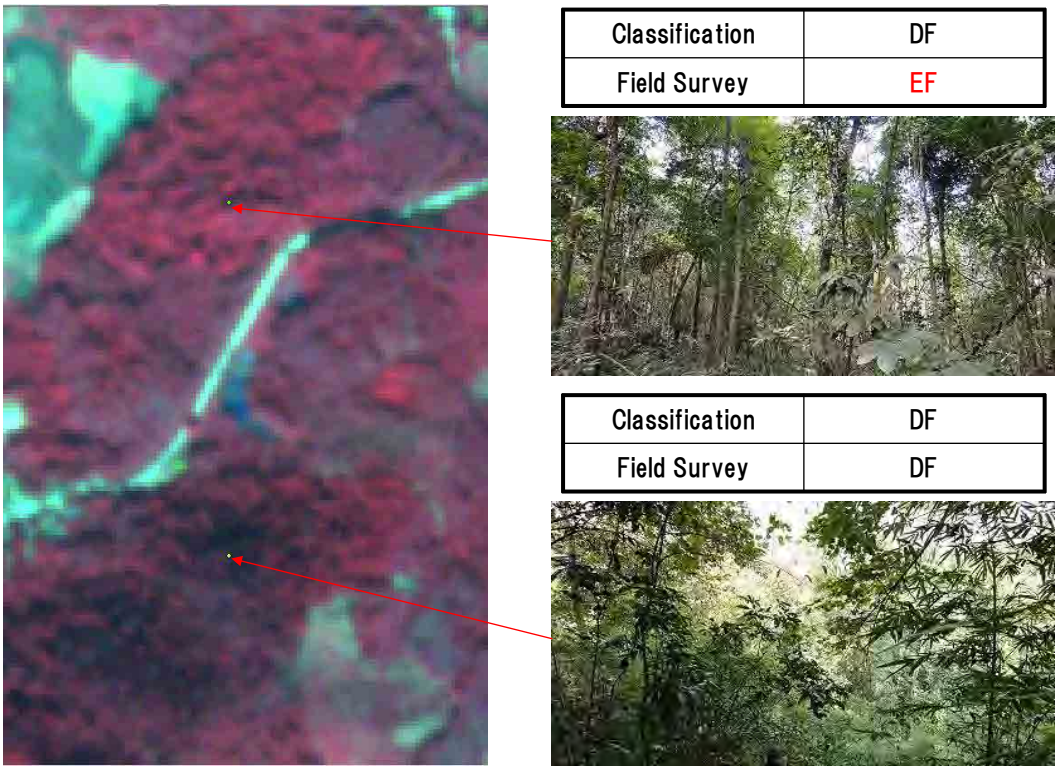
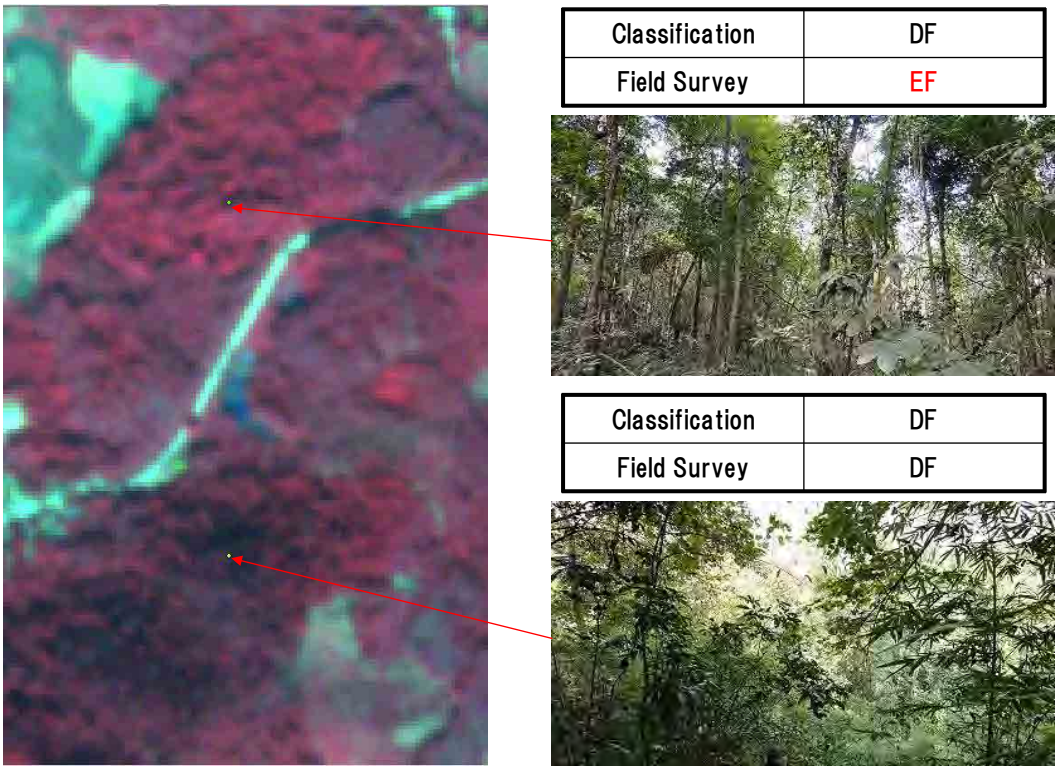


Figure 24 Forest dynamics in Luang Prabang Province

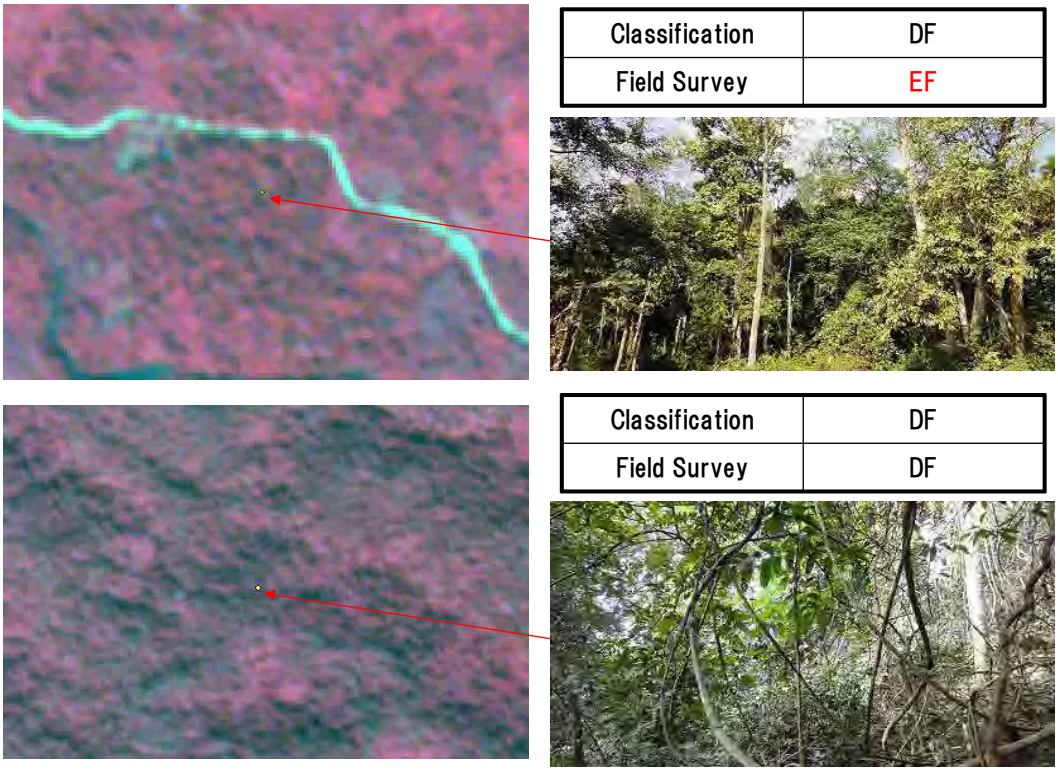
Appendix 1 Difference in deciphering forest type by satellite imagery and field survey



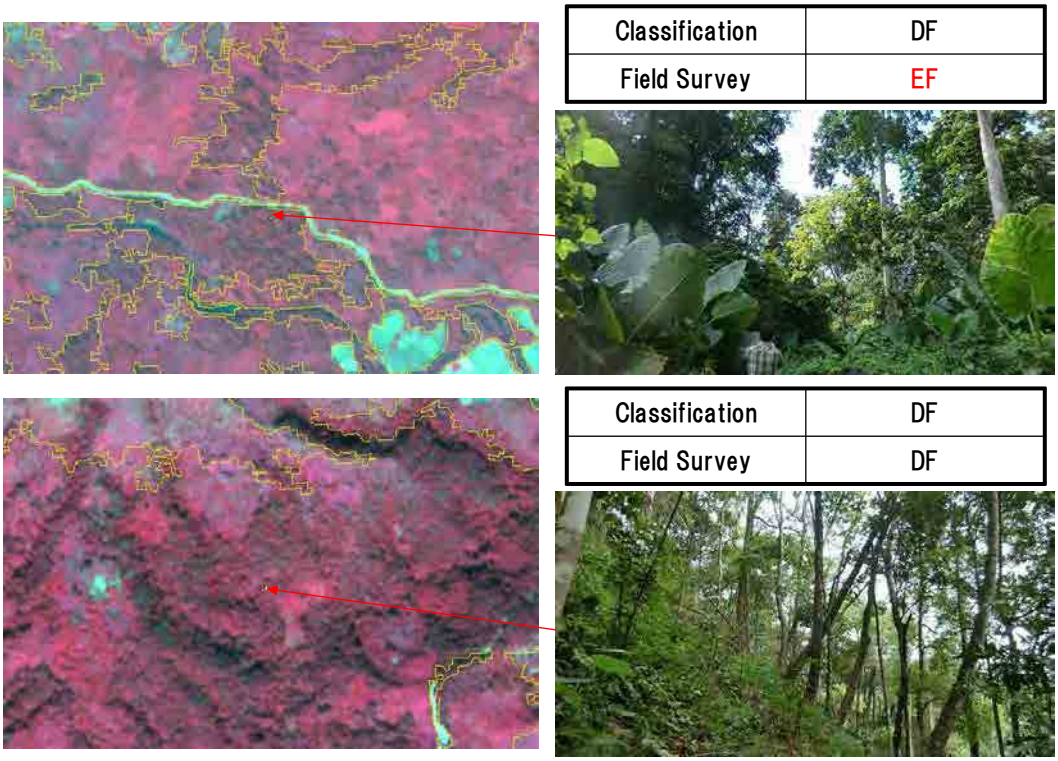
Example 1 Difference in satellite imagery (classification) and field survey



Example 2 Difference in satellite imagery (classification) and field survey



Example 3 Difference in satellite imagery (classification) and field survey



Example 4 Difference in satellite imagery (classification) and field survey

Appendix 2 Forest Dynamics in Luang Prabang Province

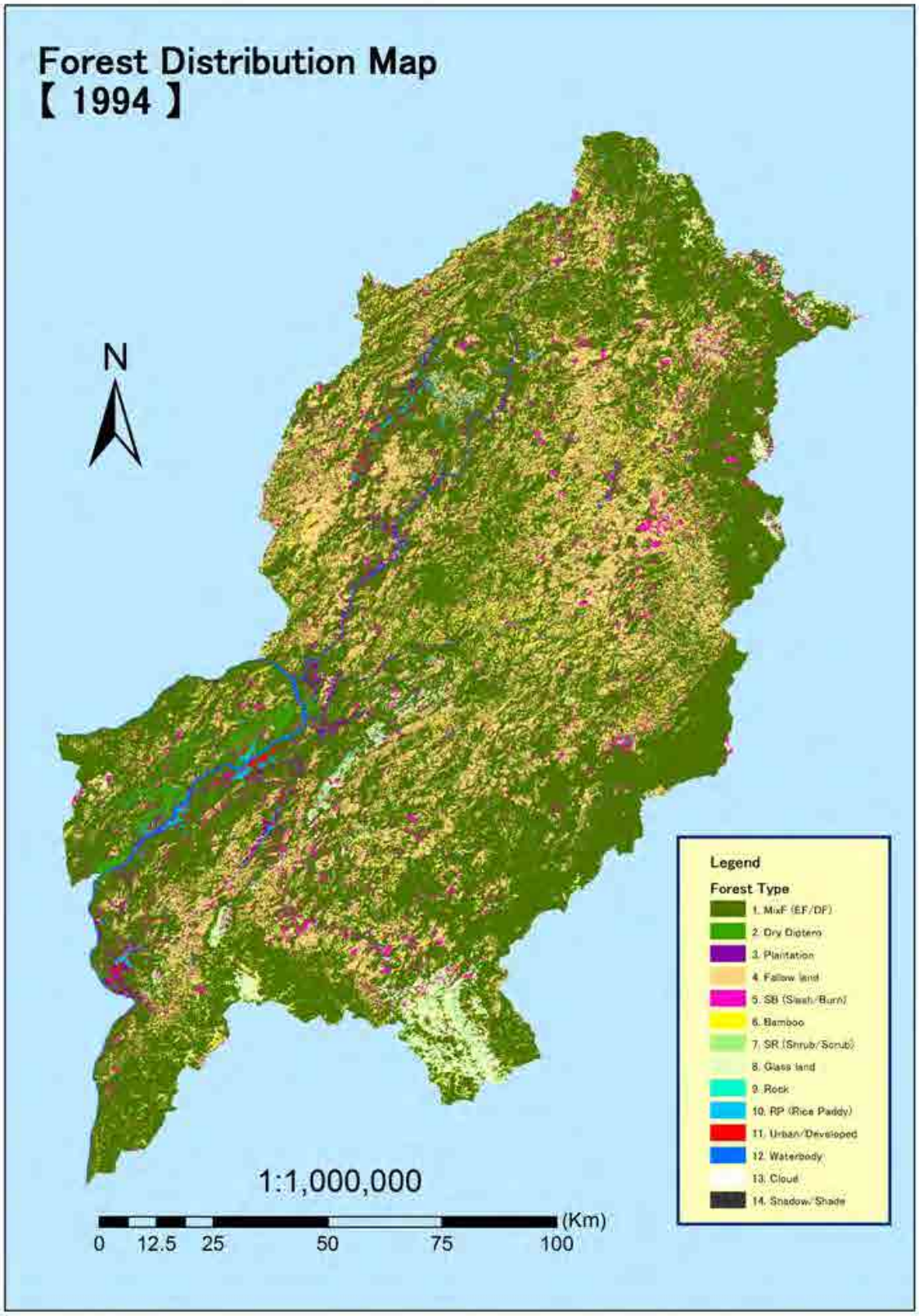


Figure 25 Forest dynamics in Luang Prabang Province (1994)

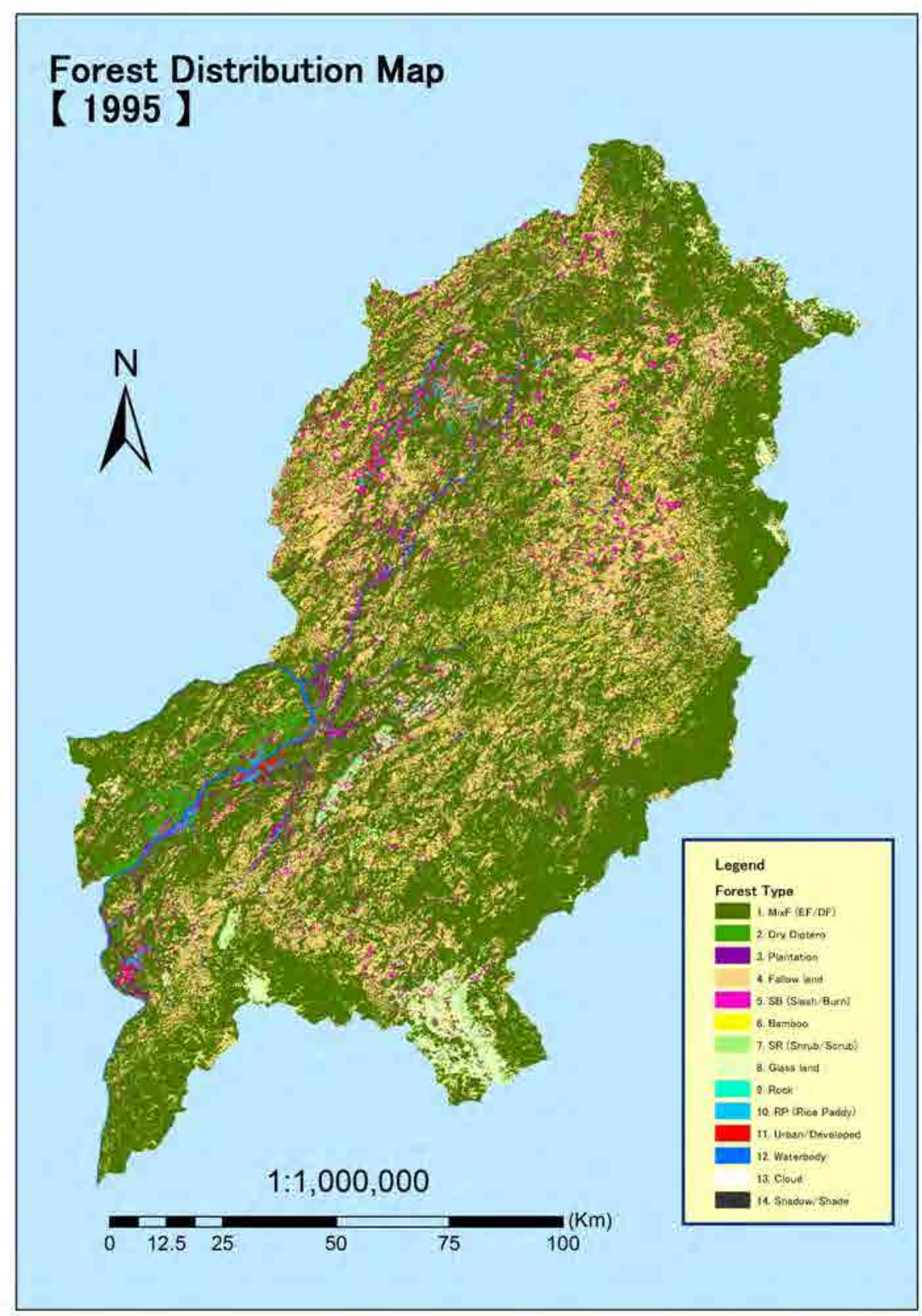


Figure 26 Forest dynamics in Luang Prabang Province (1995)

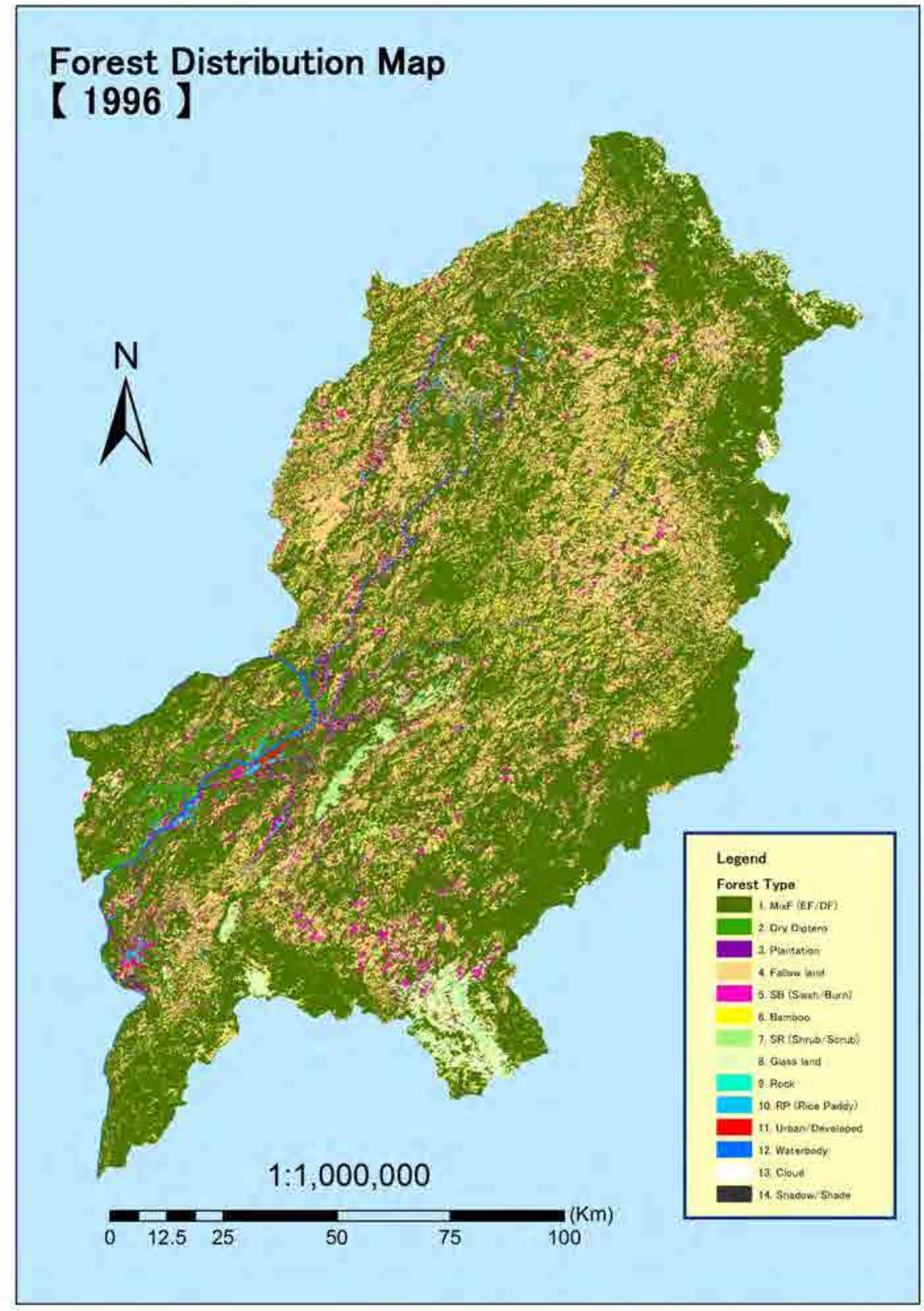


Figure 27 Forest dynamics in Luang Prabang Province (1996)

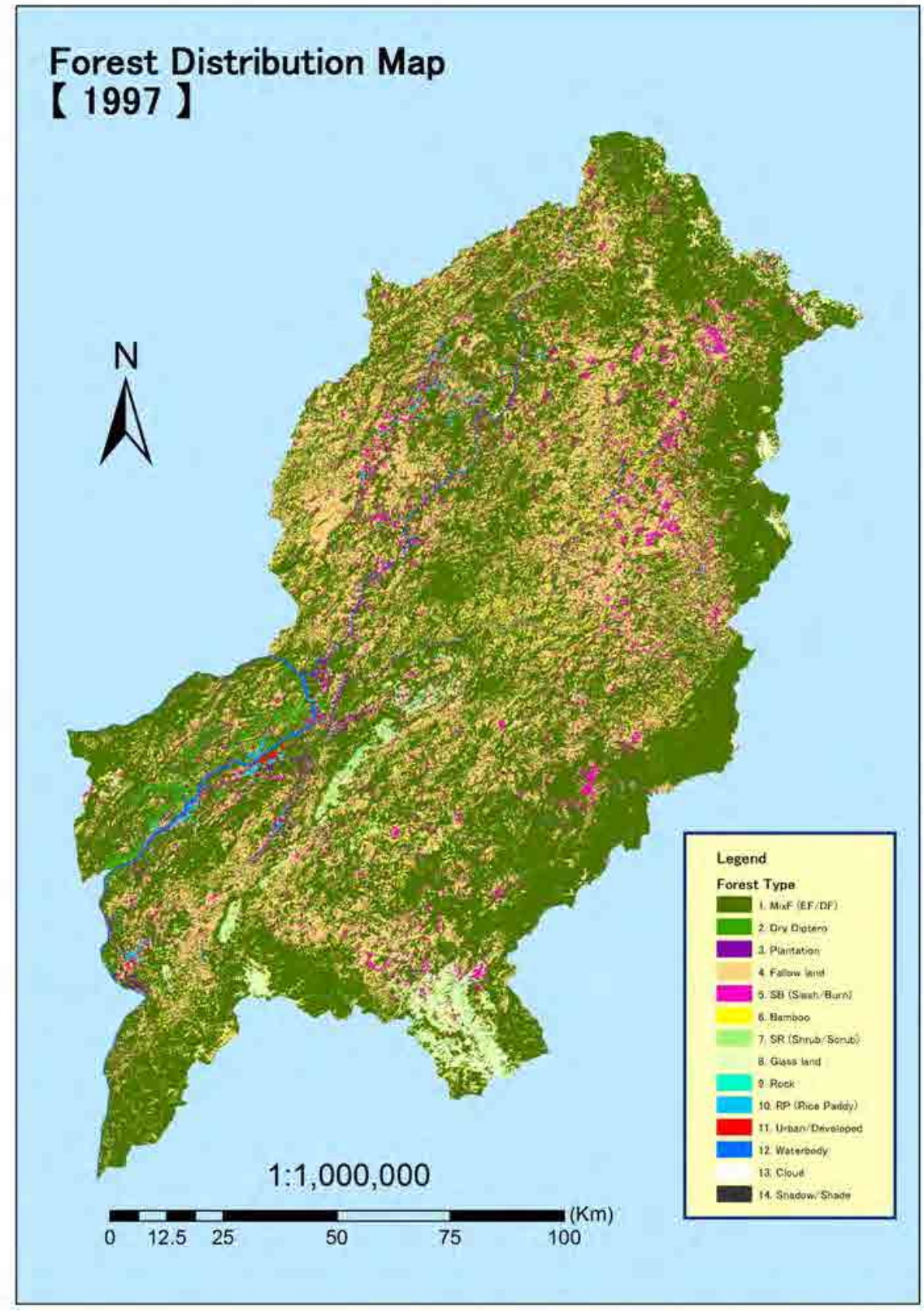


Figure 28 Forest dynamics in Luang Prabang Province (1997)

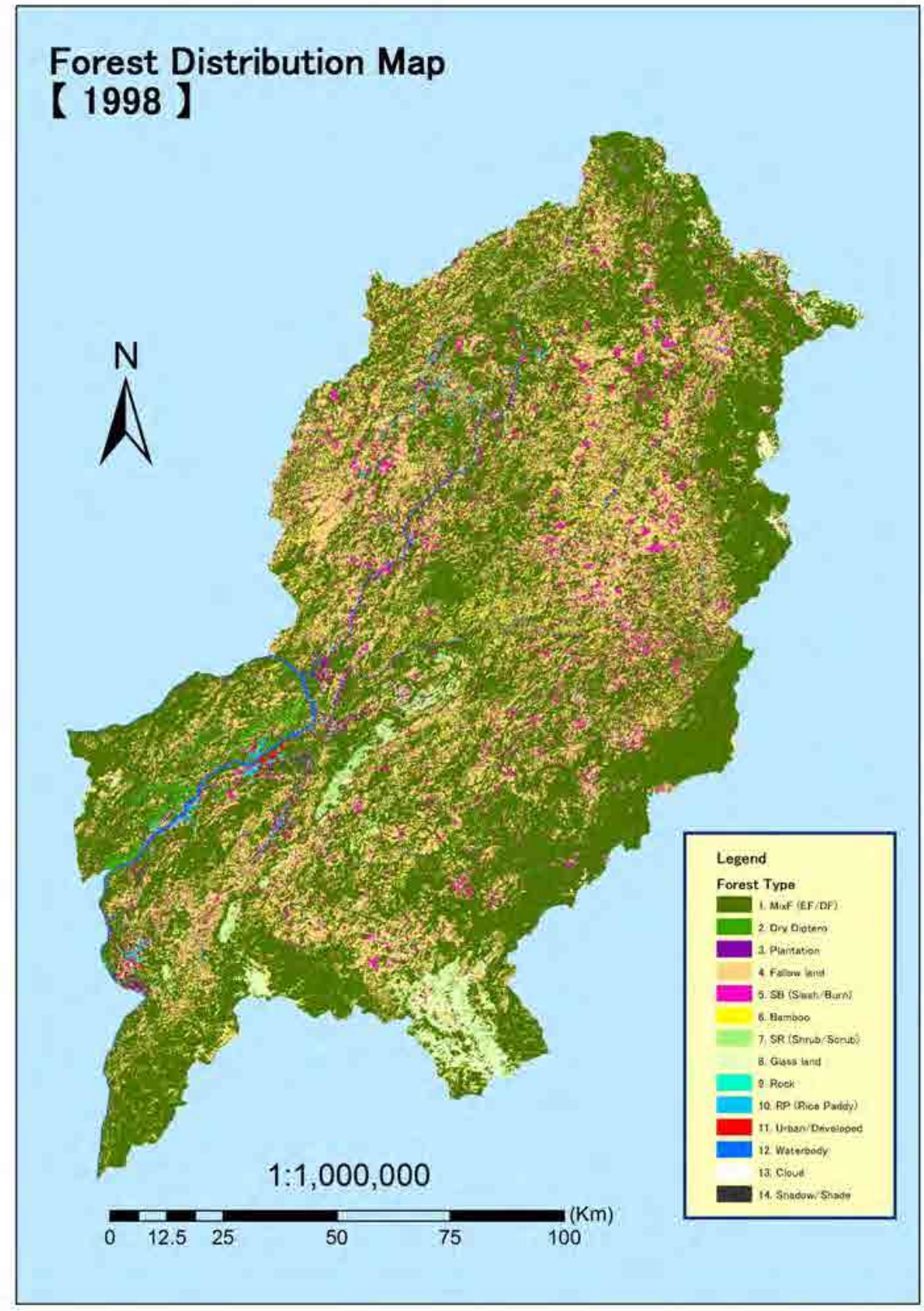


Figure 29 Forest dynamics in Luang Prabang Province (1998)

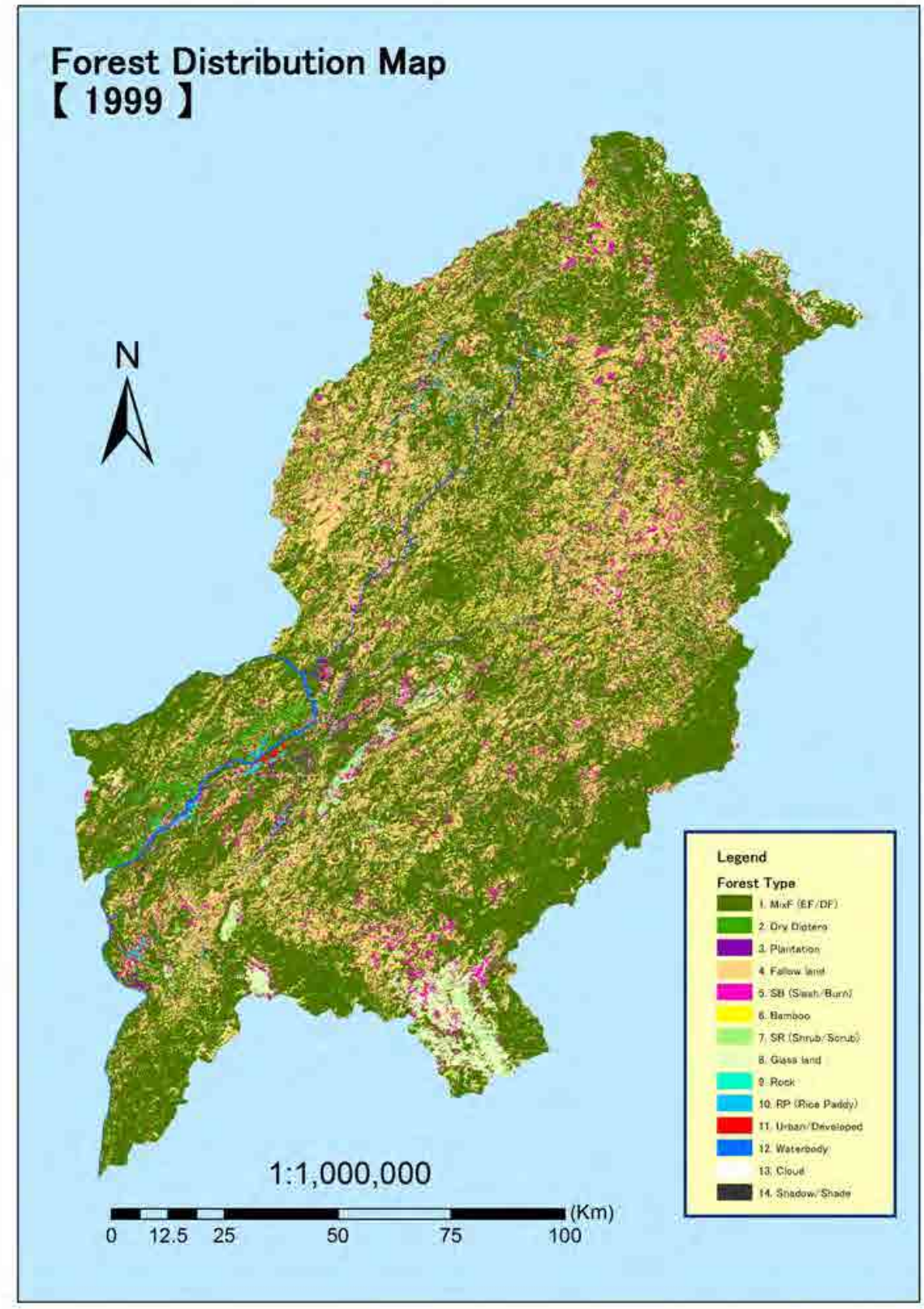


Figure 30 Forest dynamics in Luang Prabang Province (1999)

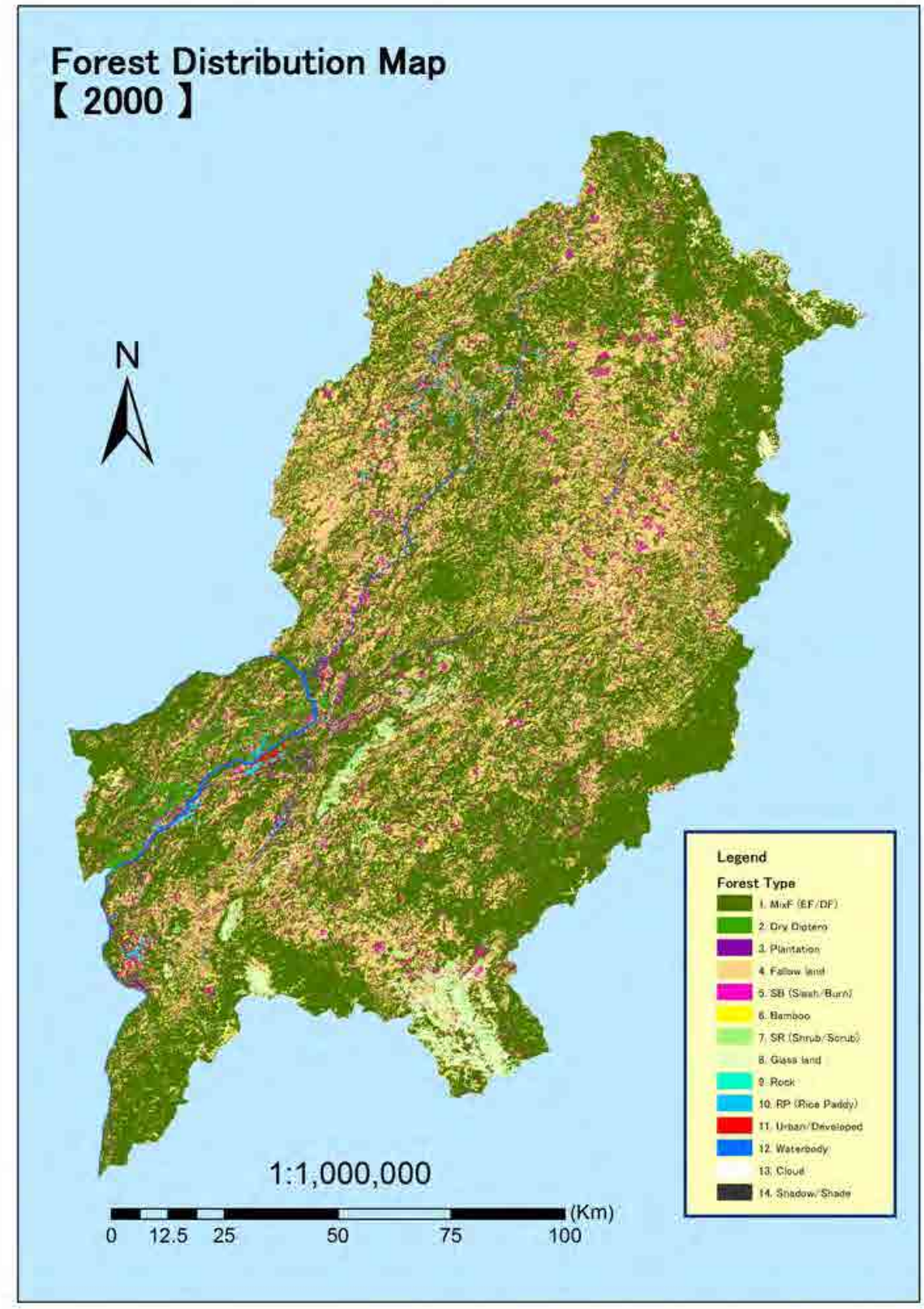


Figure 31 Forest dynamics in Luang Prabang Province (2000)

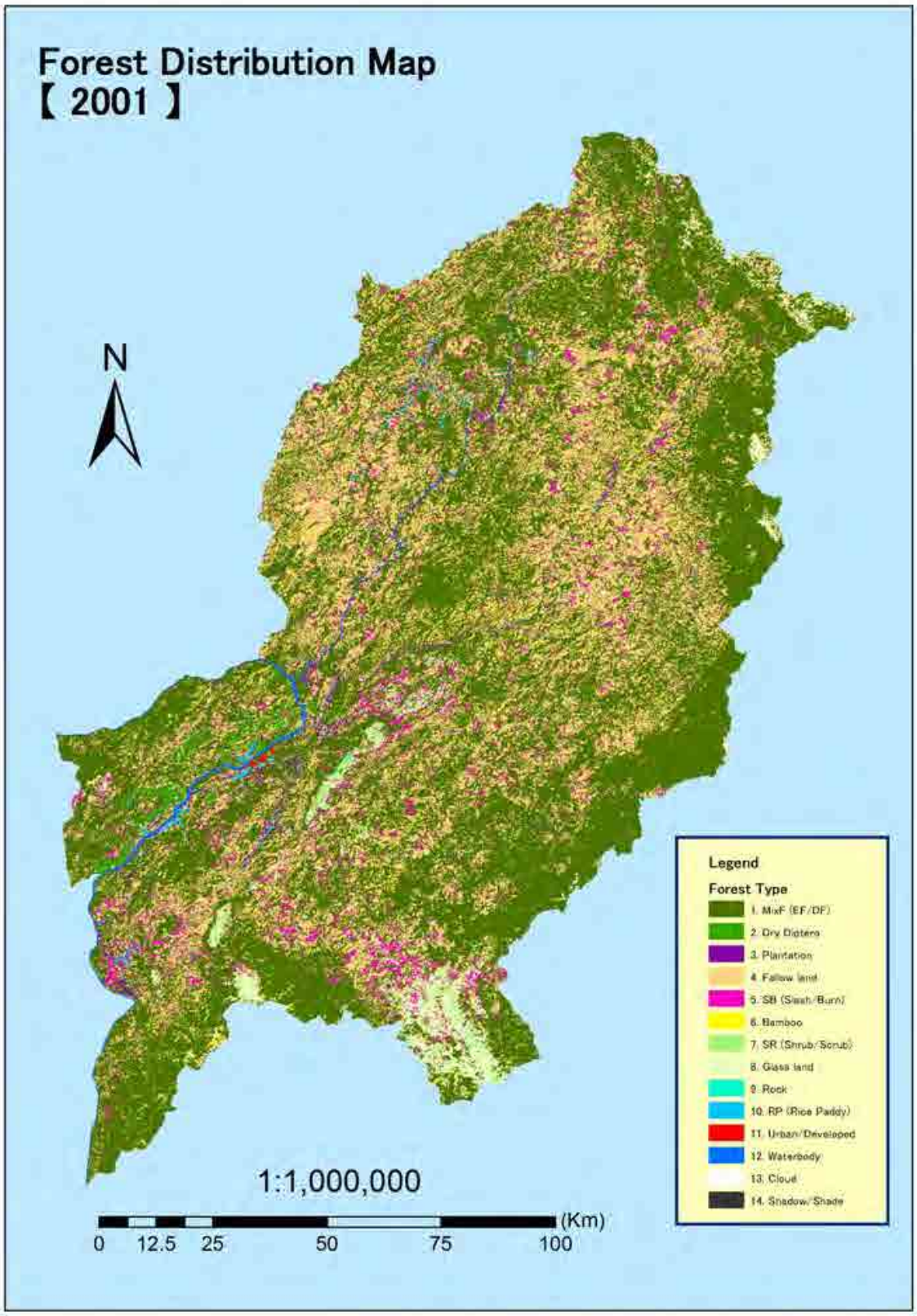


Figure 32 Forest dynamics in Luang Prabang Province (2001)

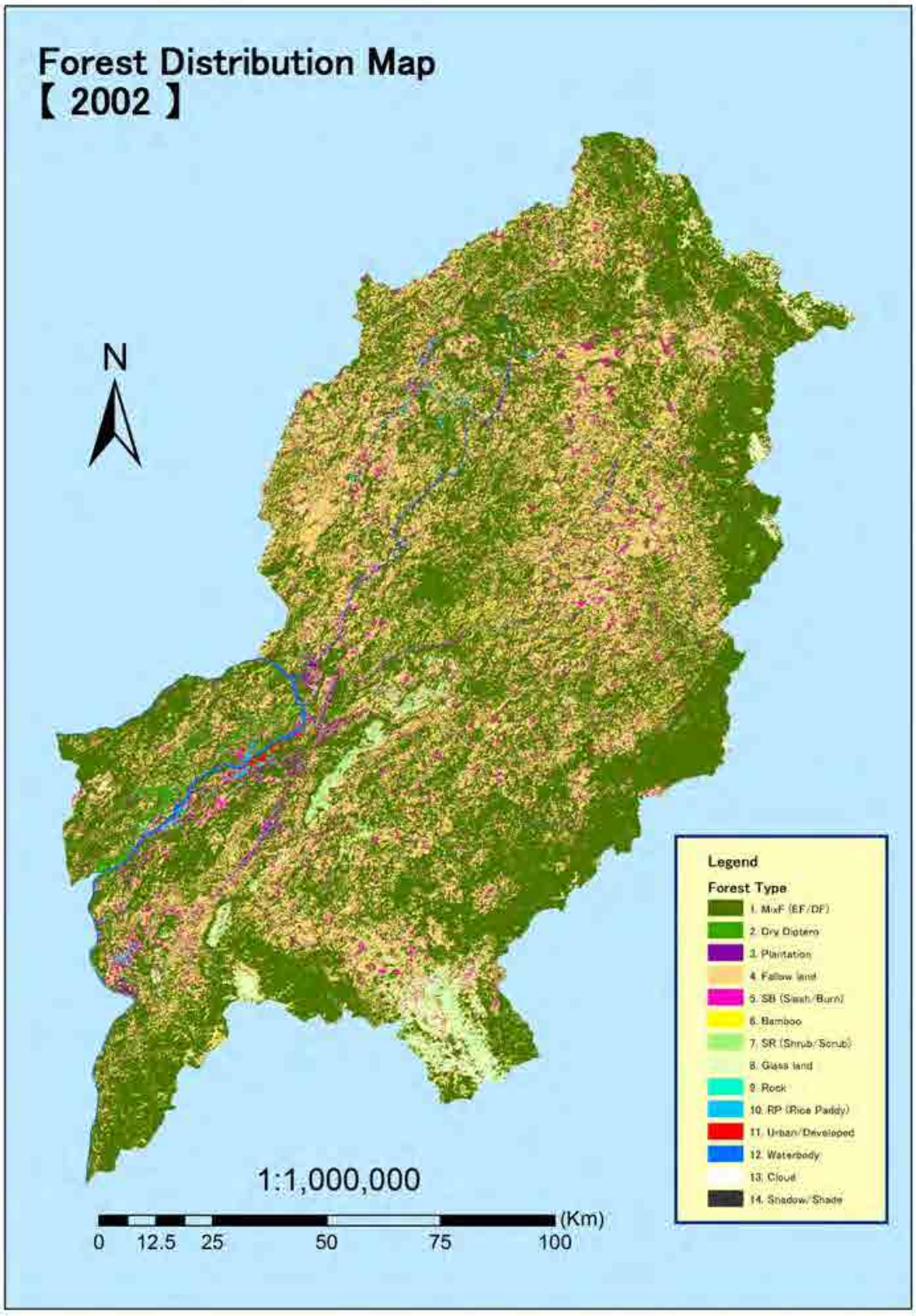


Figure 33 Forest dynamics in Luang Prabang Province (2002)

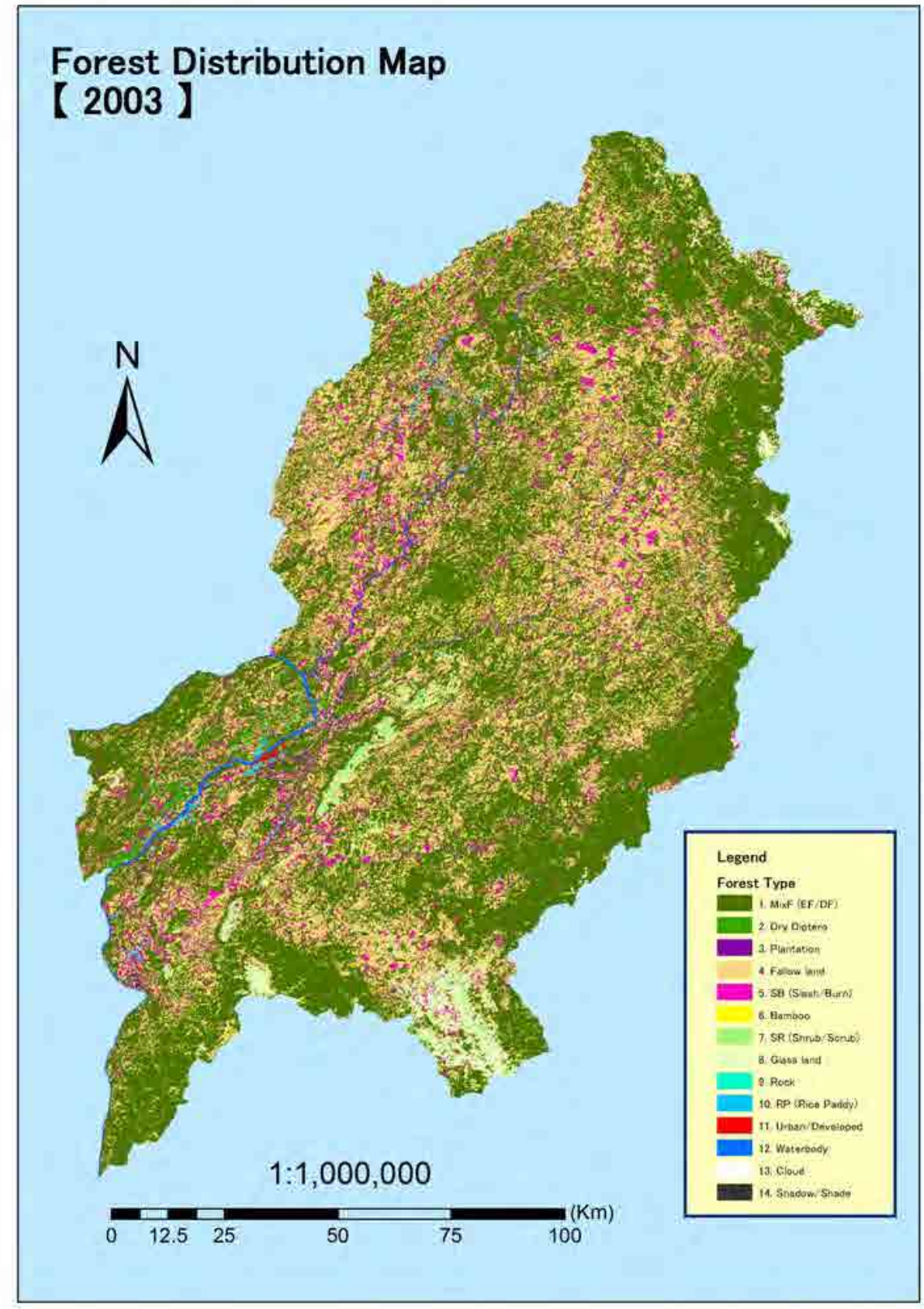


Figure 34 Forest dynamics in Luang Prabang Province (2003)

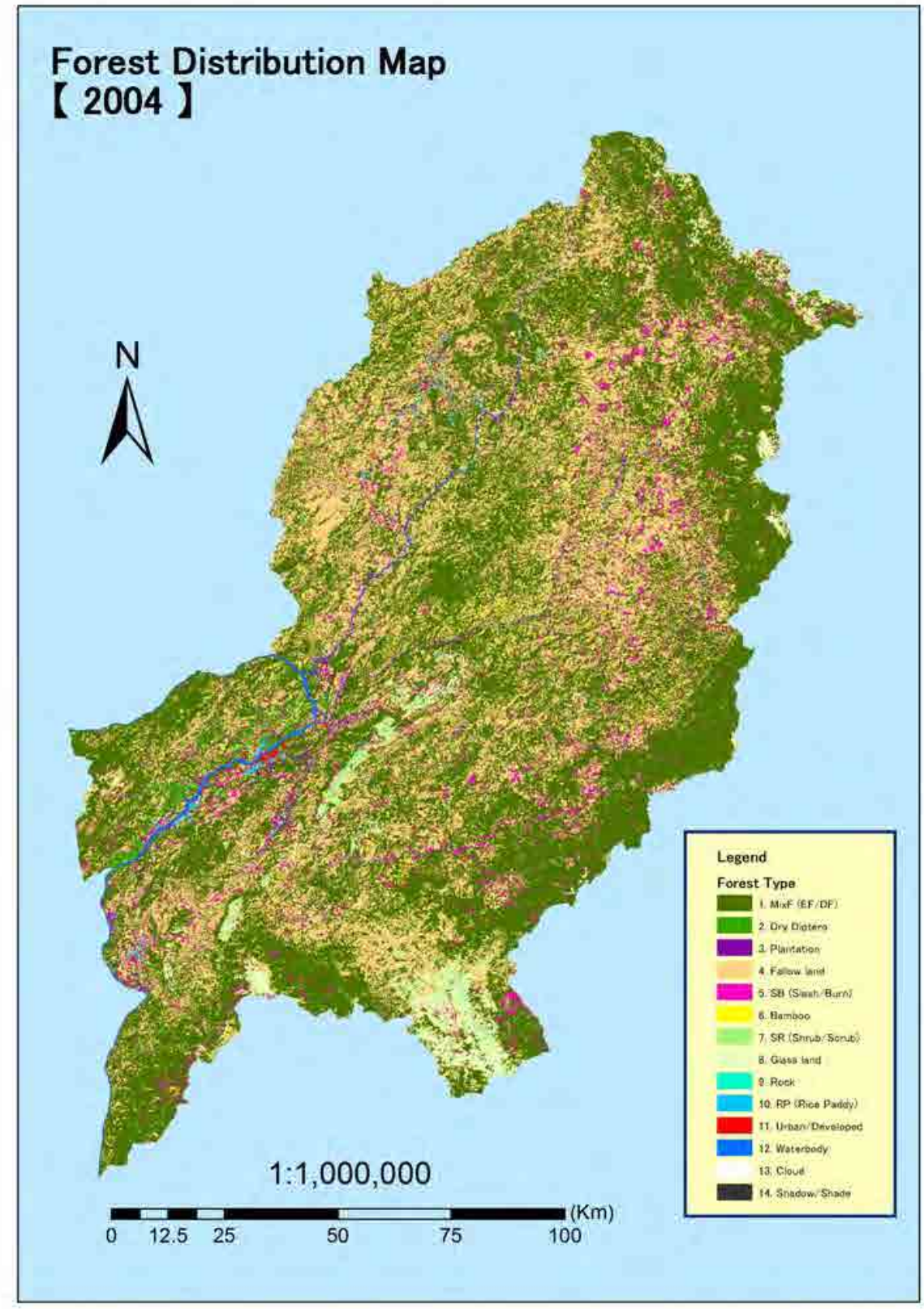


Figure 35 Forest dynamics in Luang Prabang Province (2004)

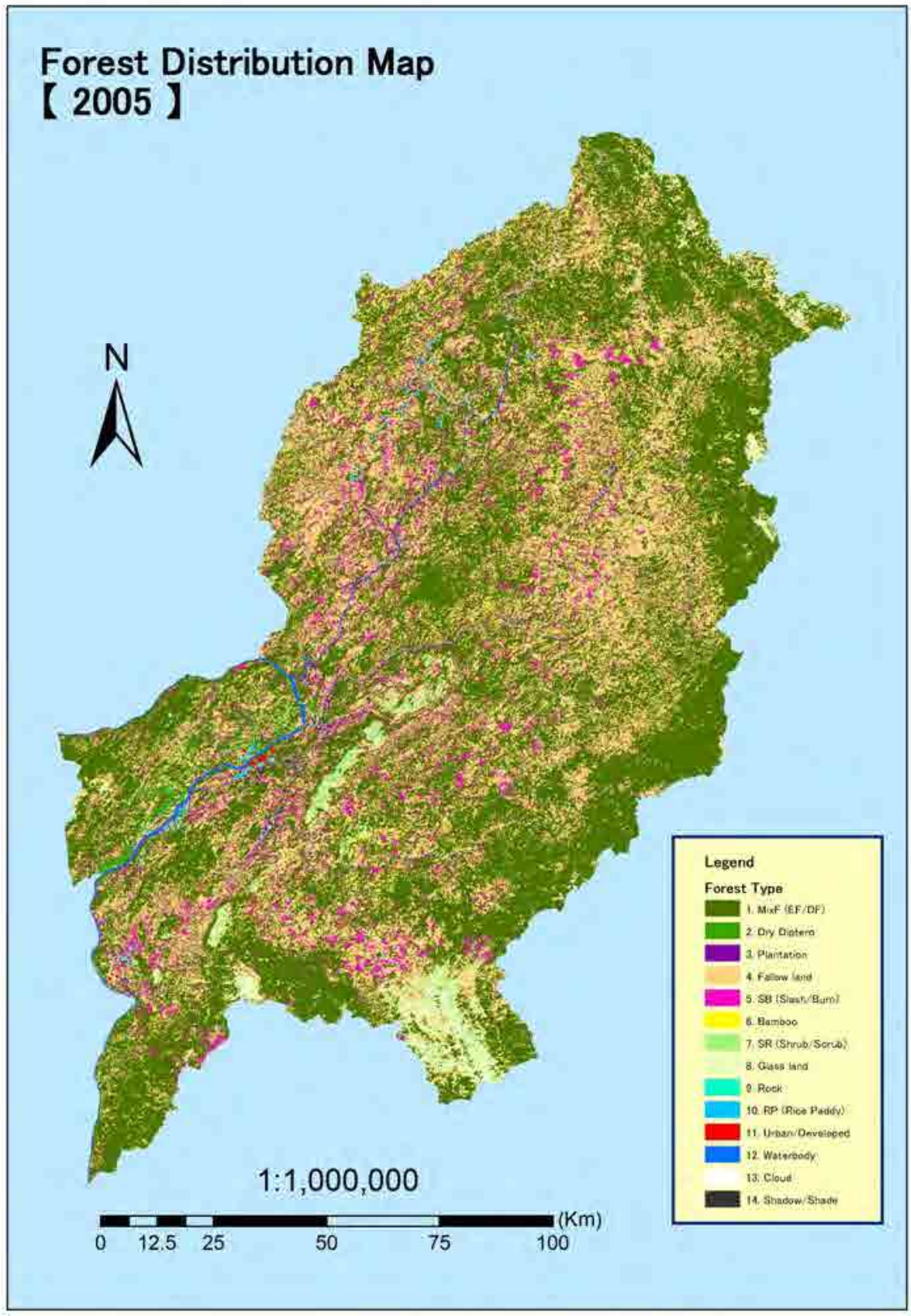


Figure 36 Forest dynamics in Luang Prabang Province (2005)

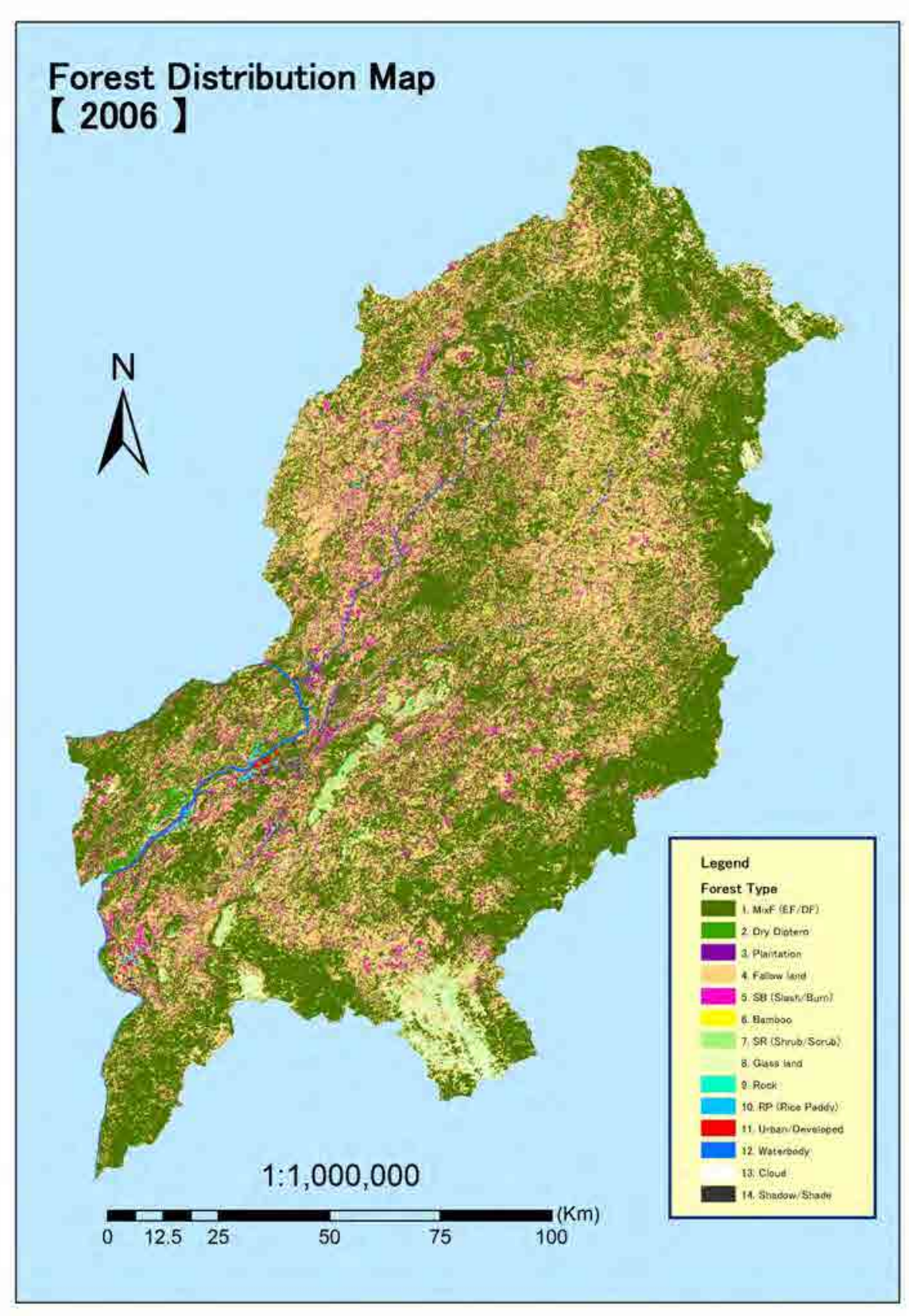


Figure 37 Forest dynamics in Luang Prabang Province (2006)

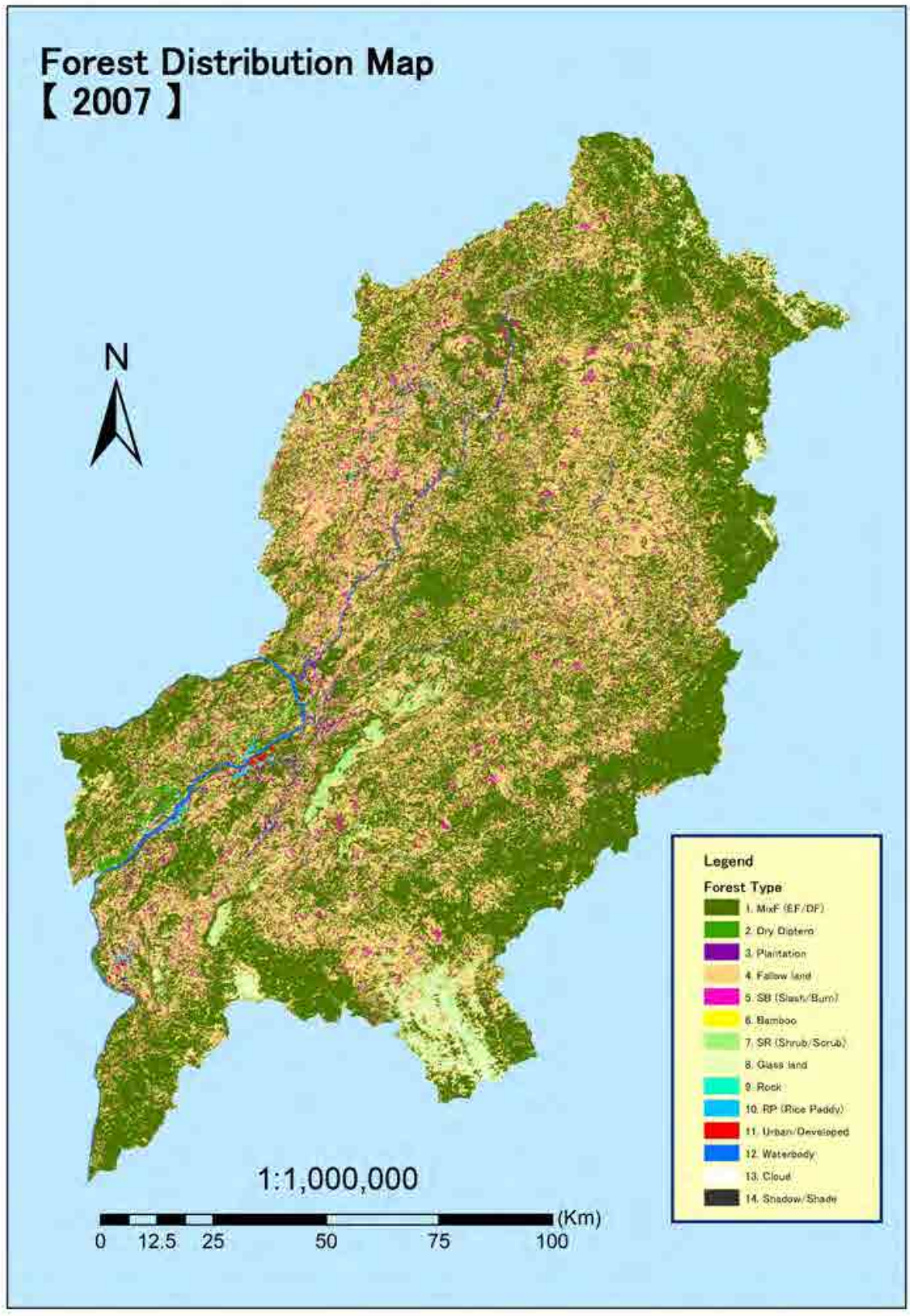


Figure 38 Forest dynamics in Luang Prabang Province (2007)

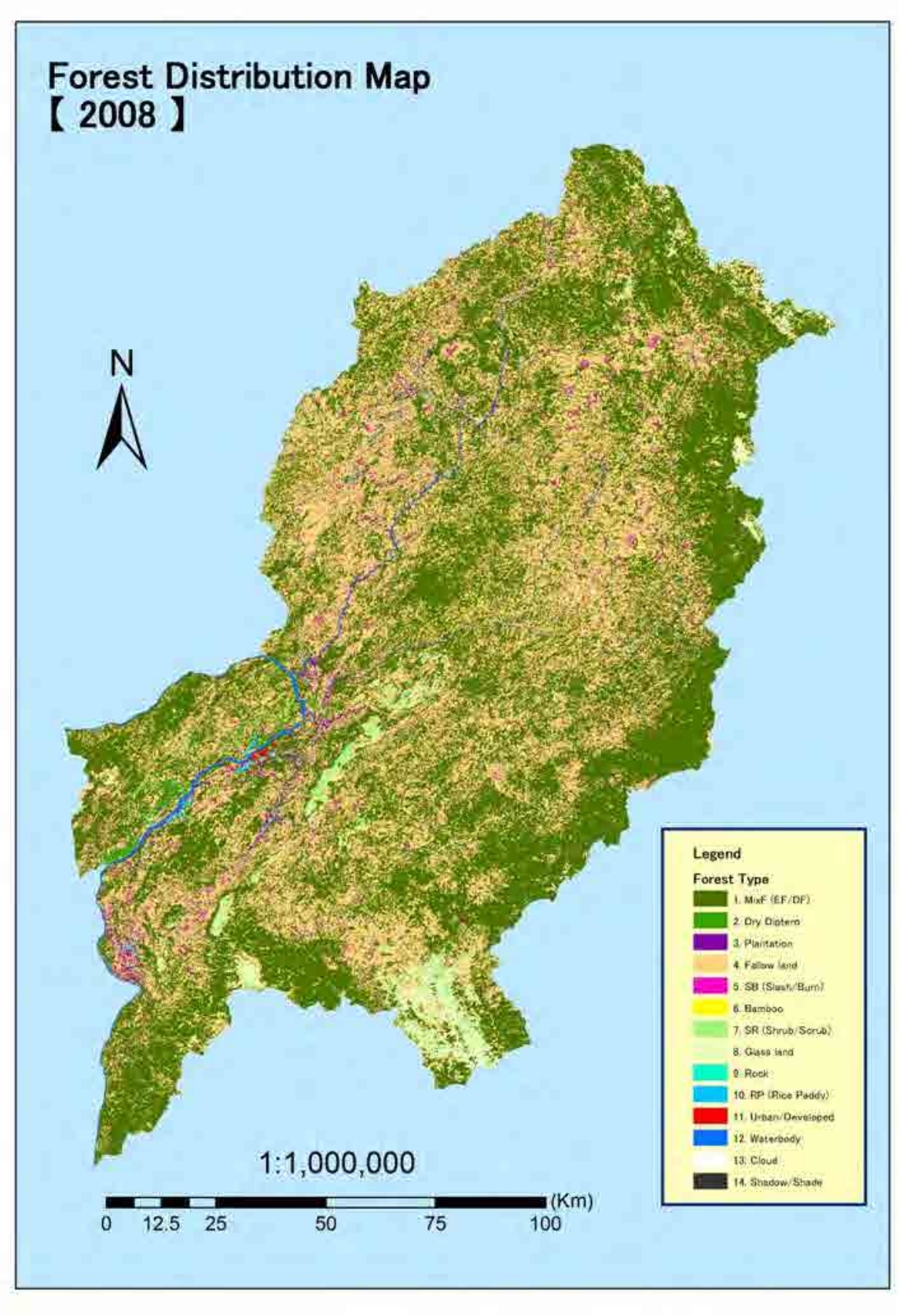


Figure 39 Forest dynamics in Luang Prabang Province (2008)

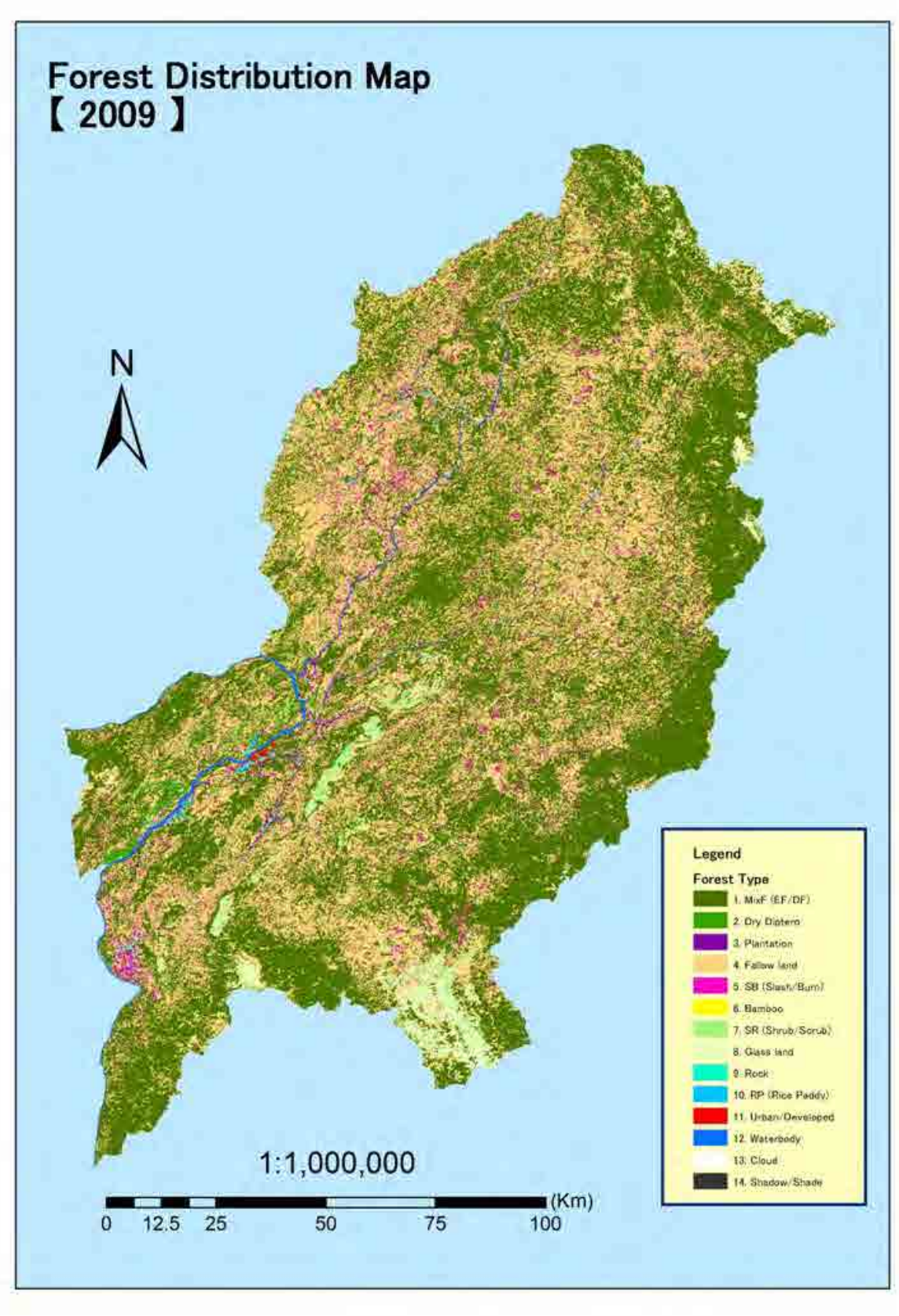


Figure 40 Forest dynamics in Luang Prabang Province (2009)

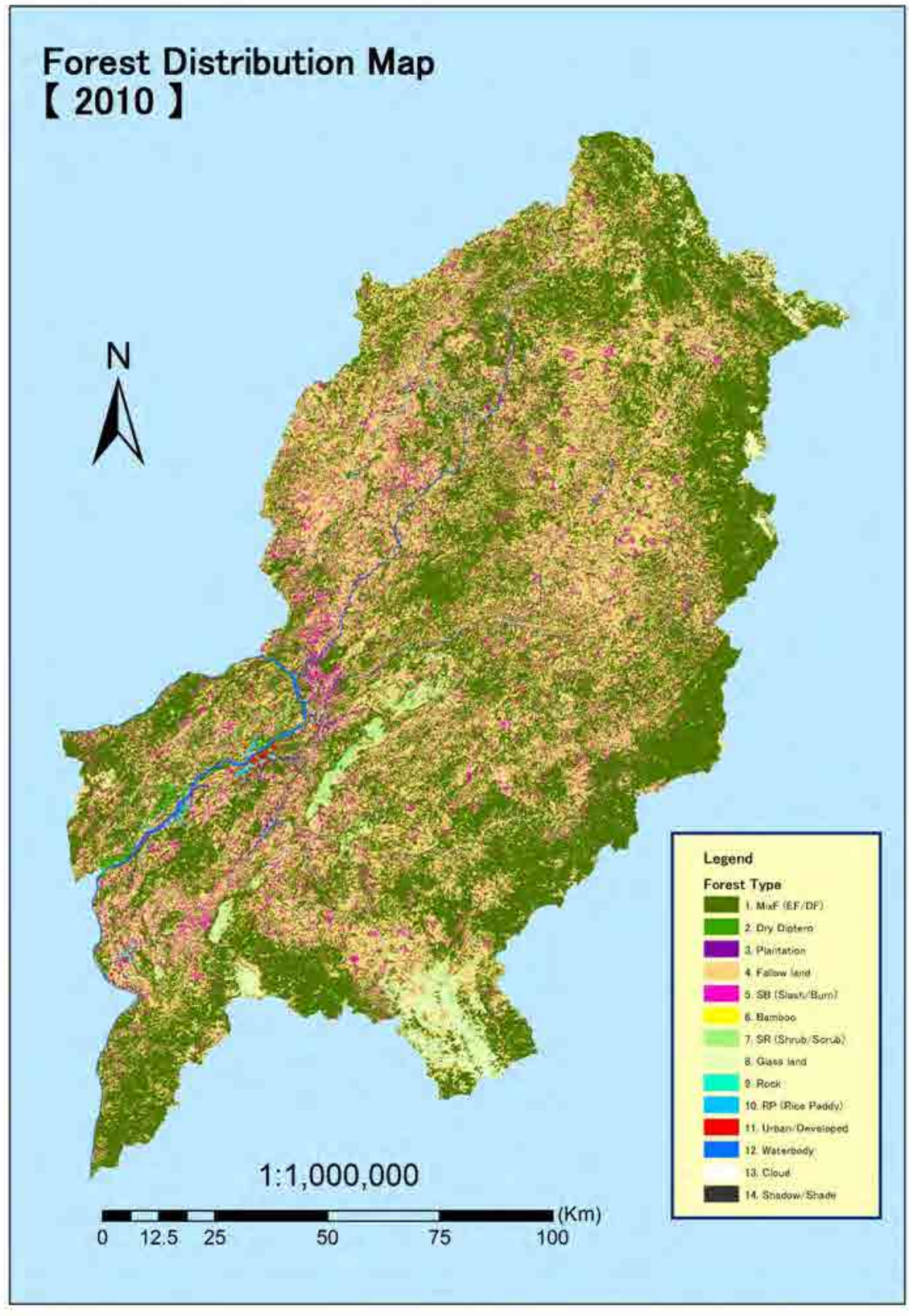


Figure 41 Forest dynamics in Luang Prabang Province (2010)

Appendix 3 Forest Dynamics in Phonsay District

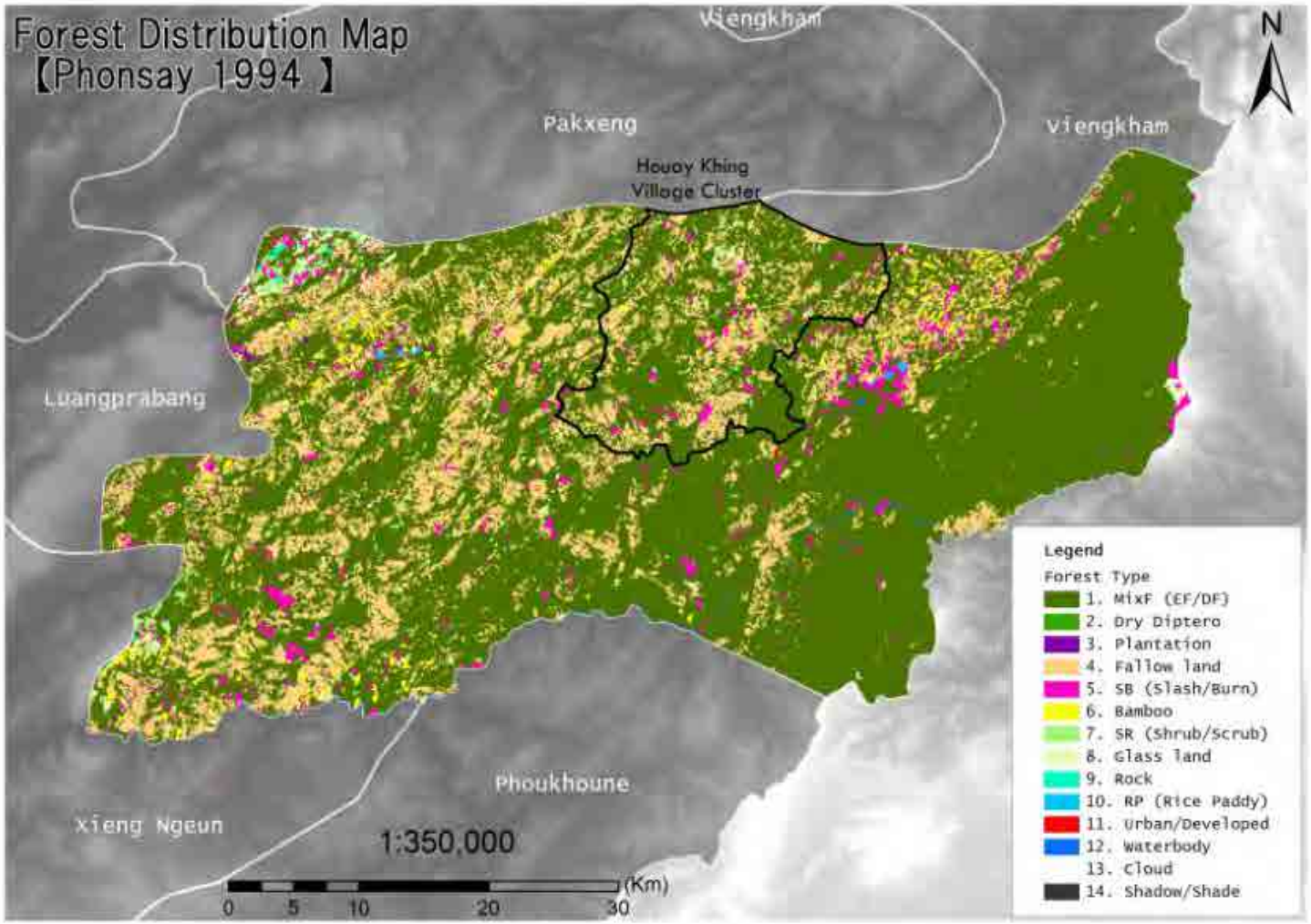


Figure 42 Forest dynamics in Phonsay District (1994)

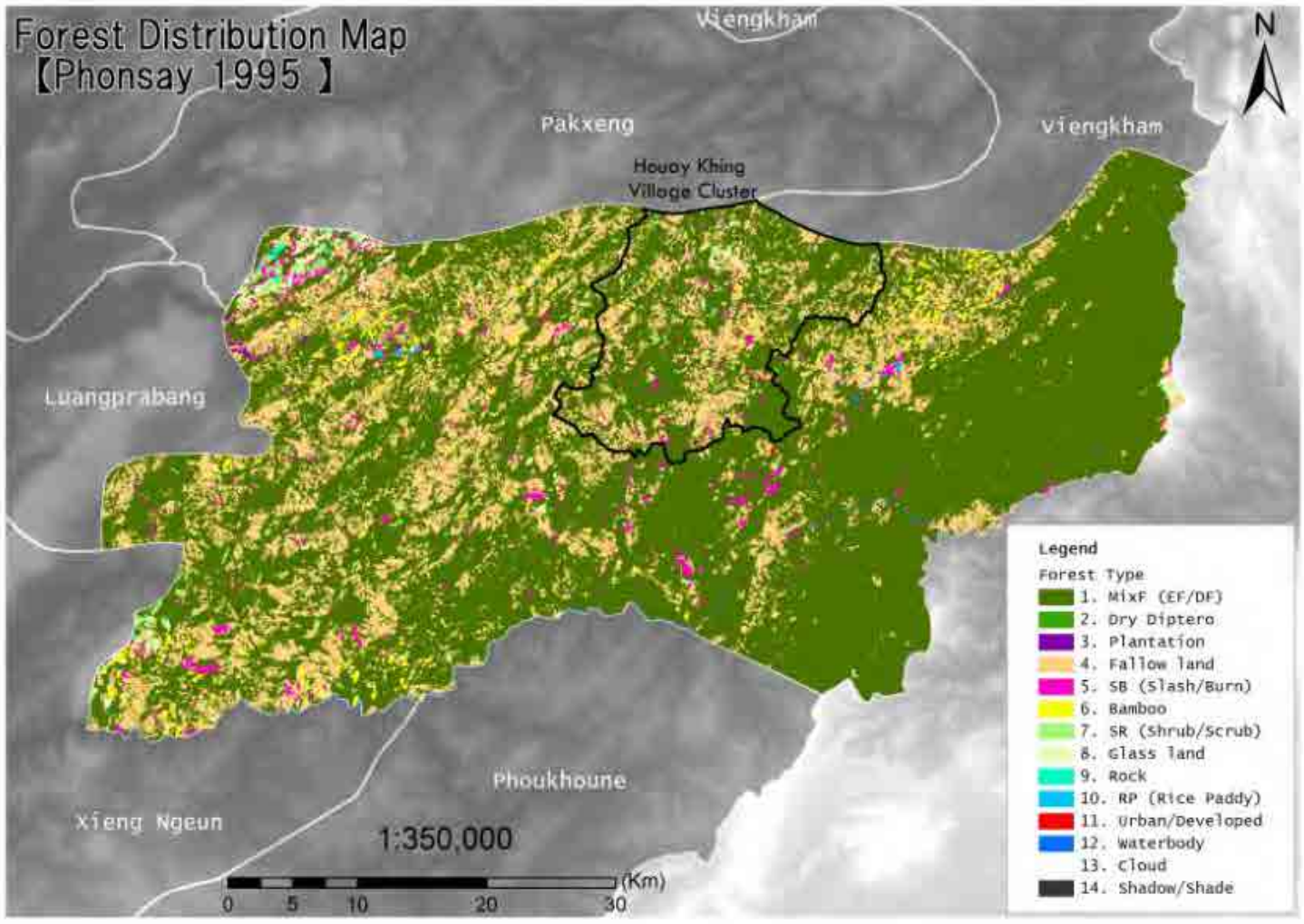


Figure 43 Forest dynamics in Phonsay District (1995)

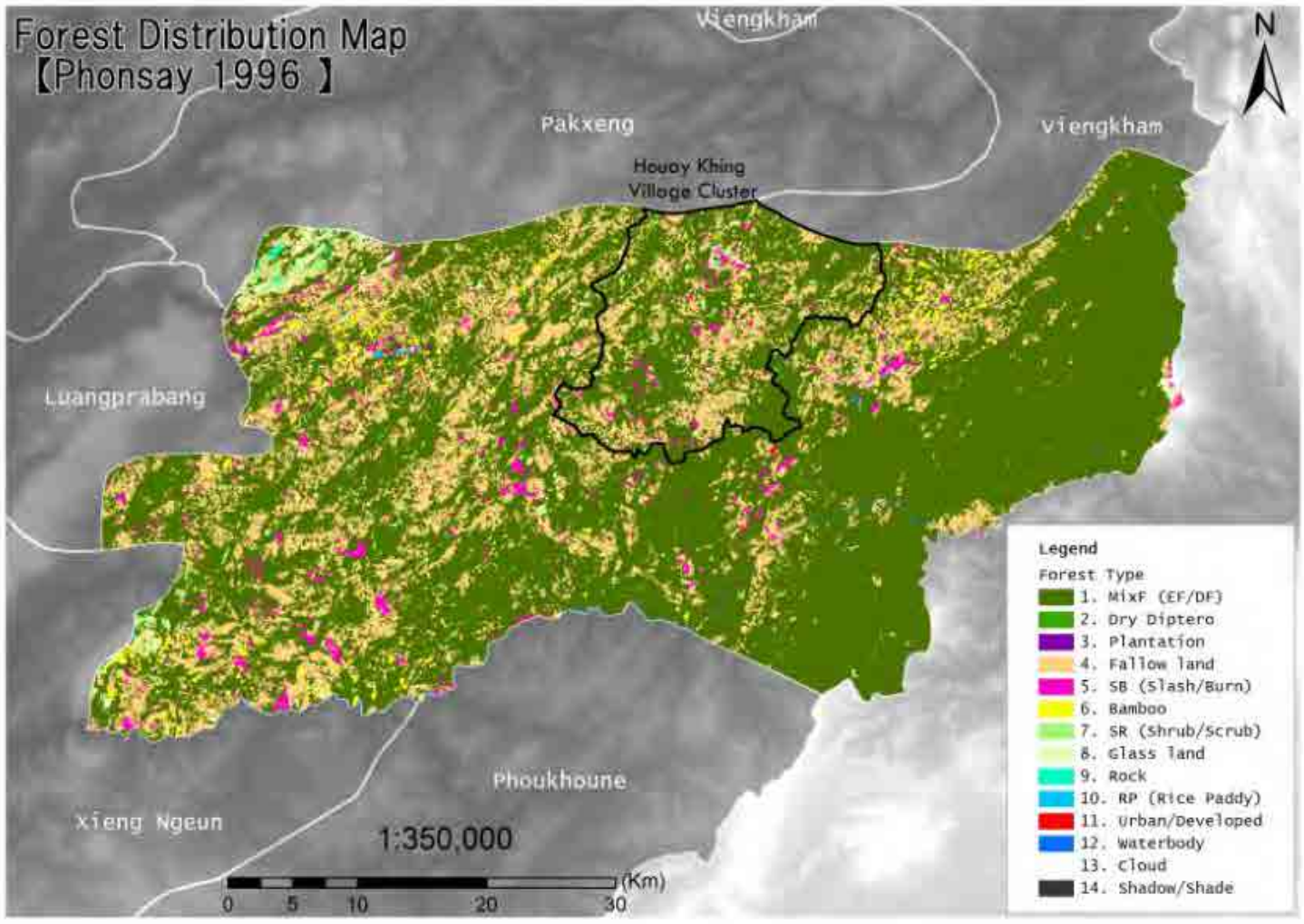


Figure 44 Forest dynamics in Phonsay District (1996)

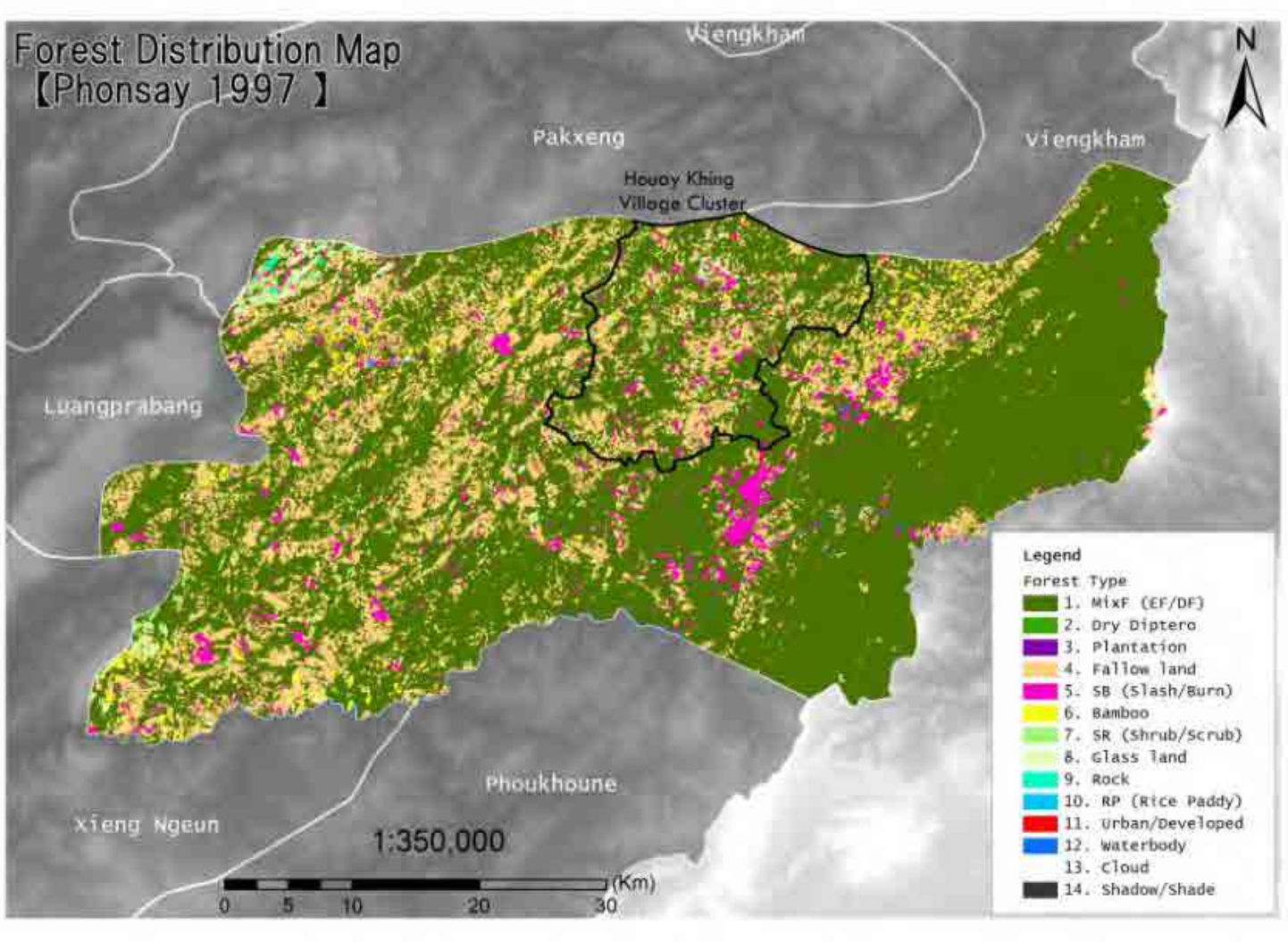


Figure 45 Forest dynamics in Phonsay District (1997)

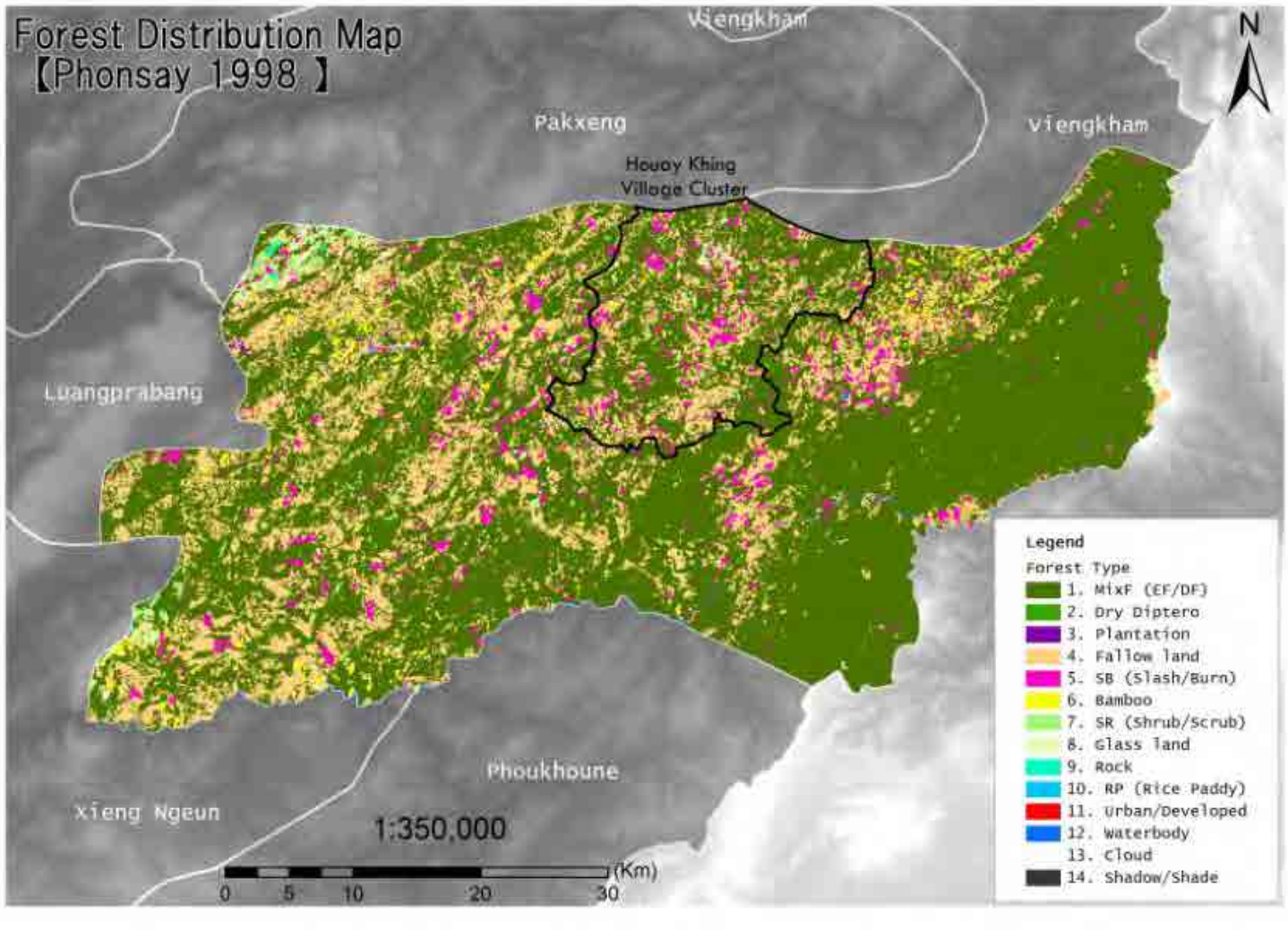


Figure 46 Forest dynamics in Phonsay District (1998)

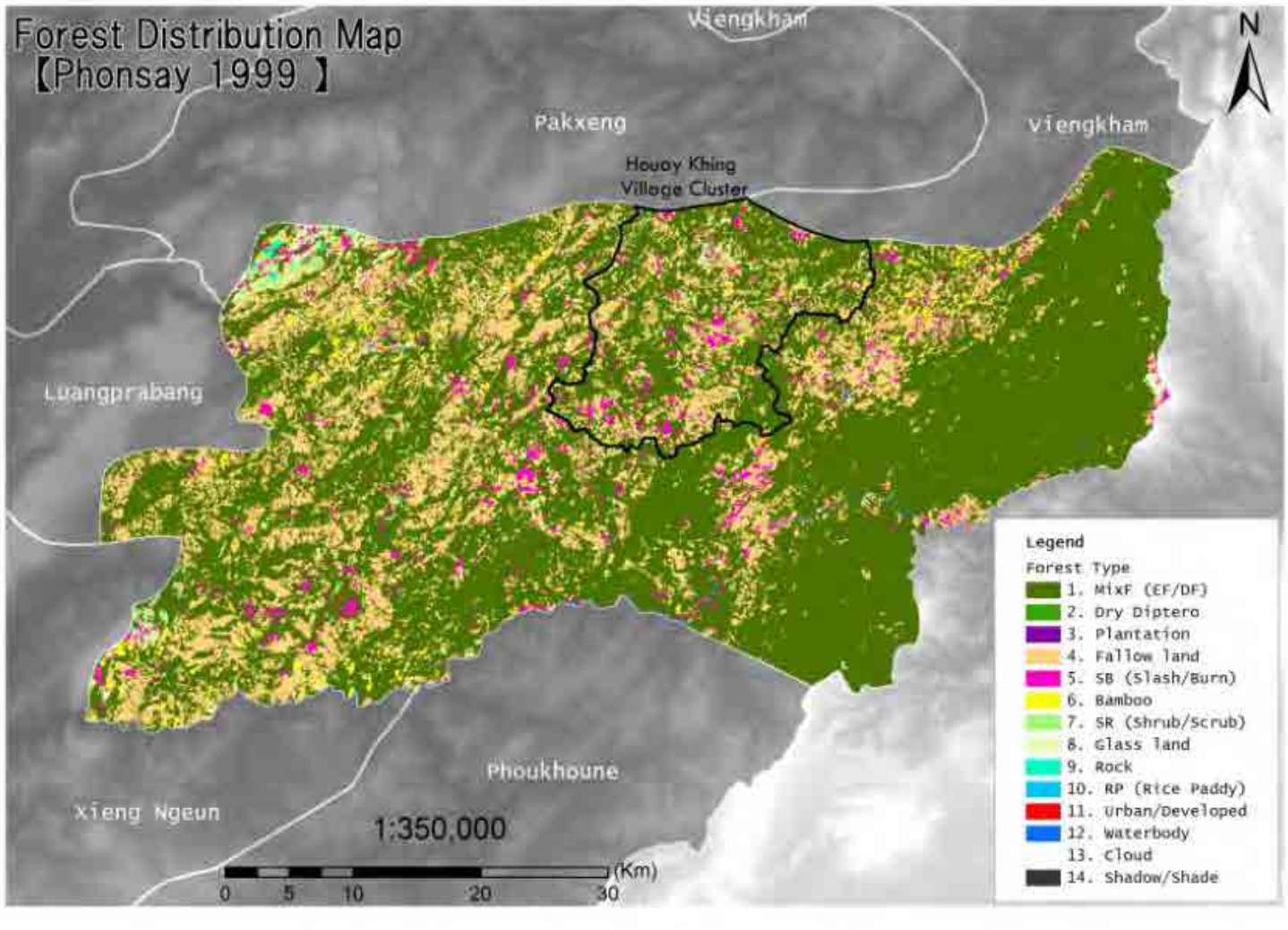


Figure 47 Forest dynamics in Phonsay District (1999)

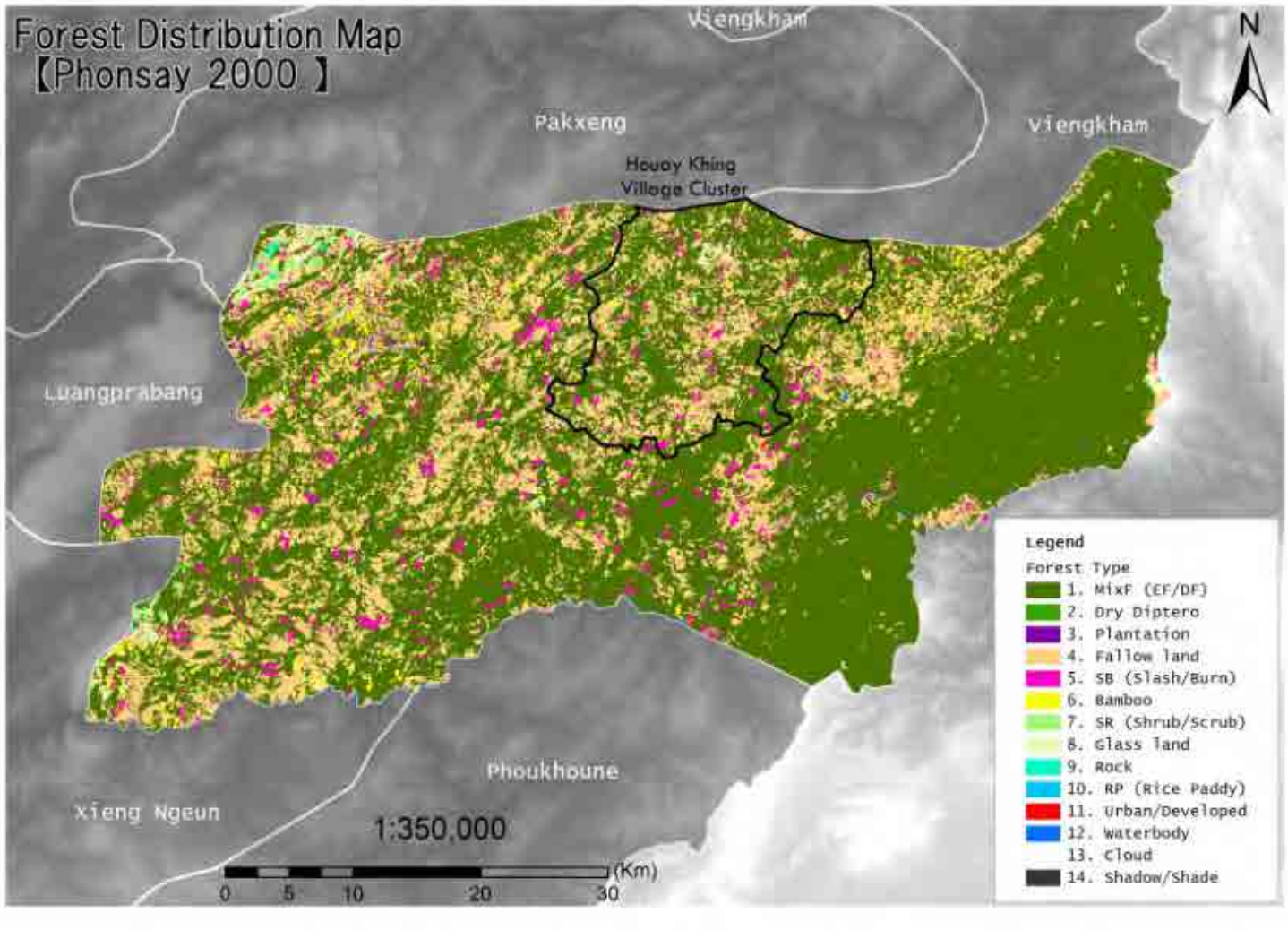


Figure 48 Forest dynamics in Phonsay District (2000)

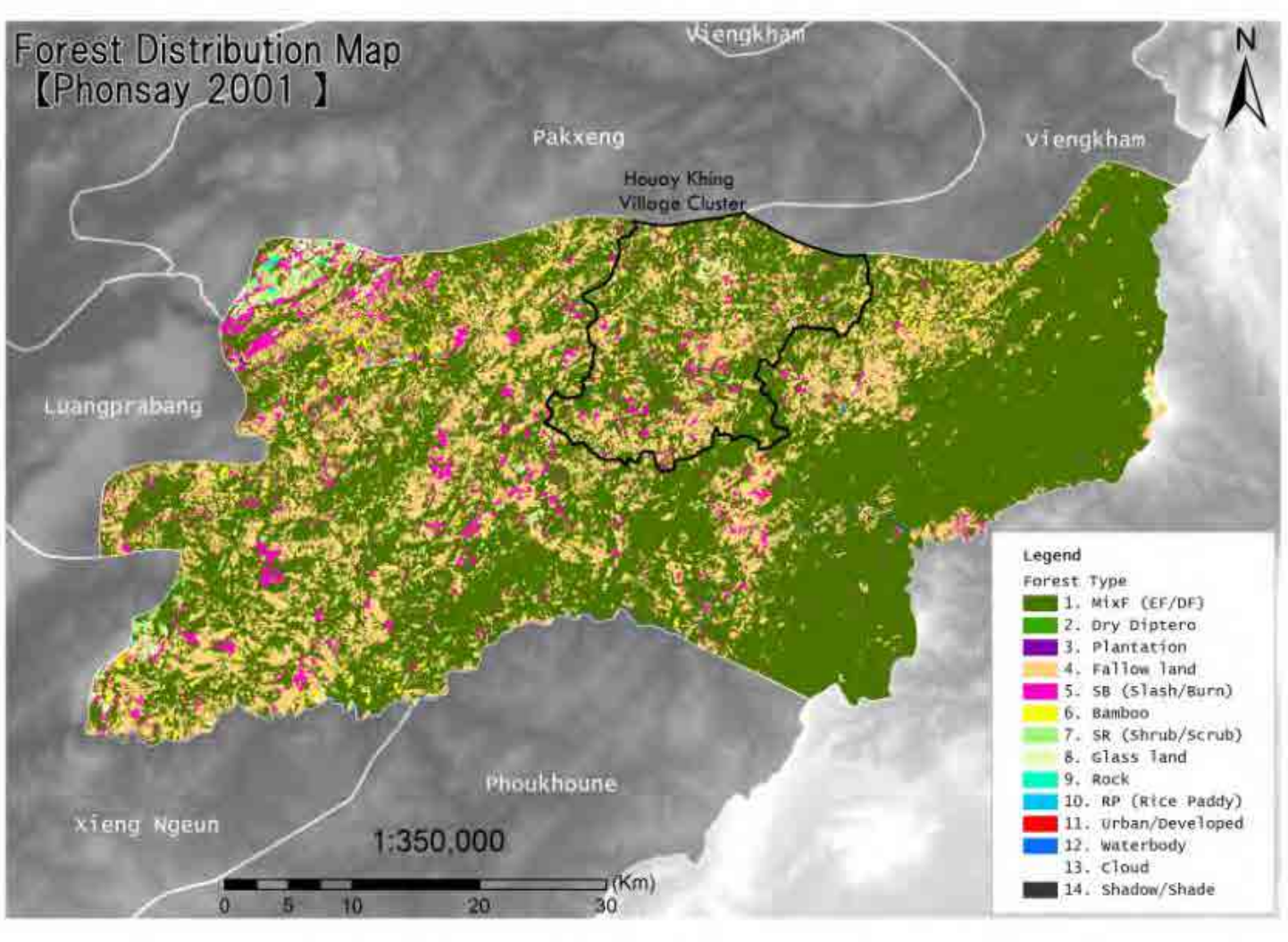


Figure 49 Forest dynamics in Phonsay District (2001)

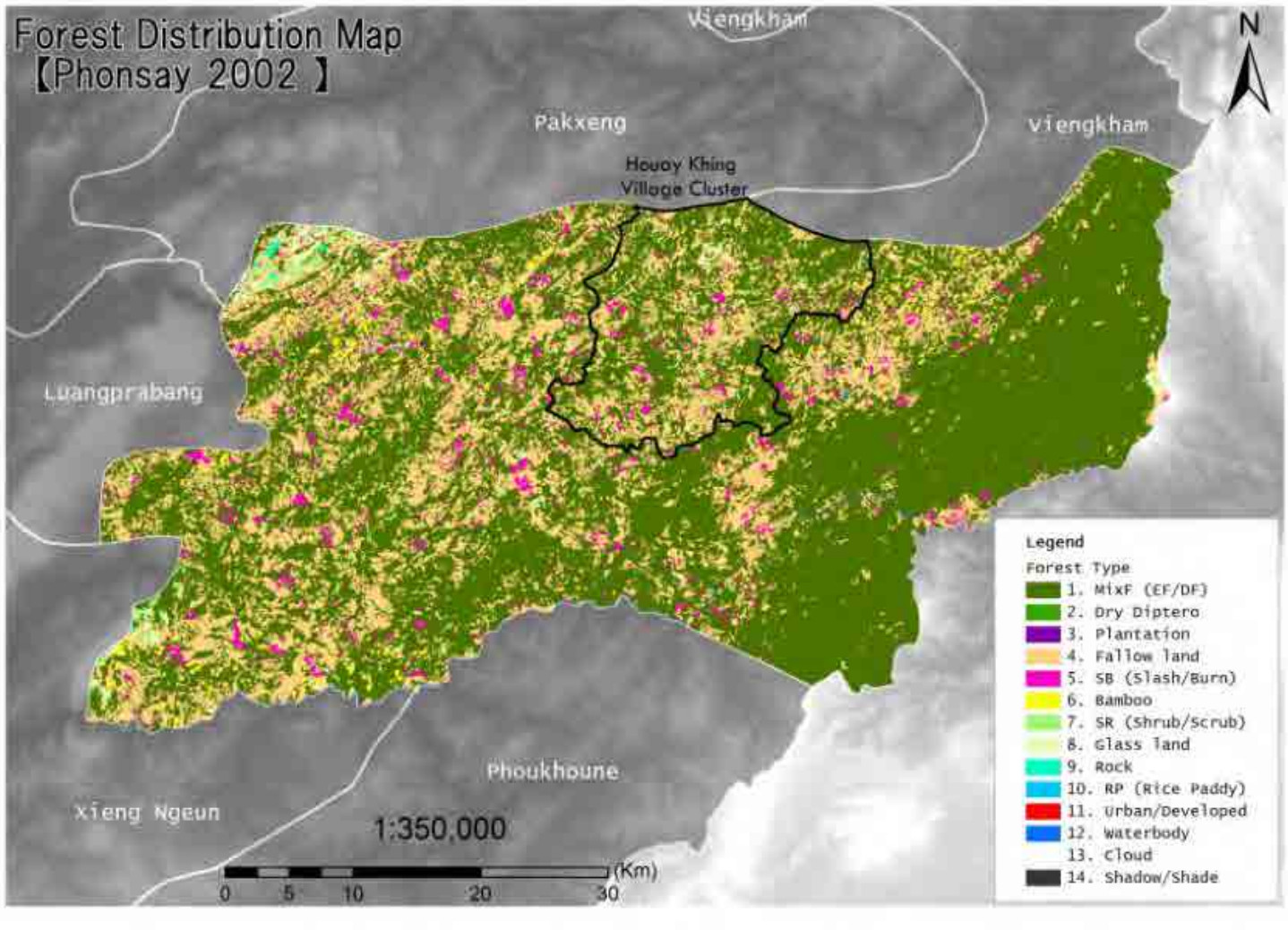


Figure 50 Forest dynamics in Phonsay District (2002)

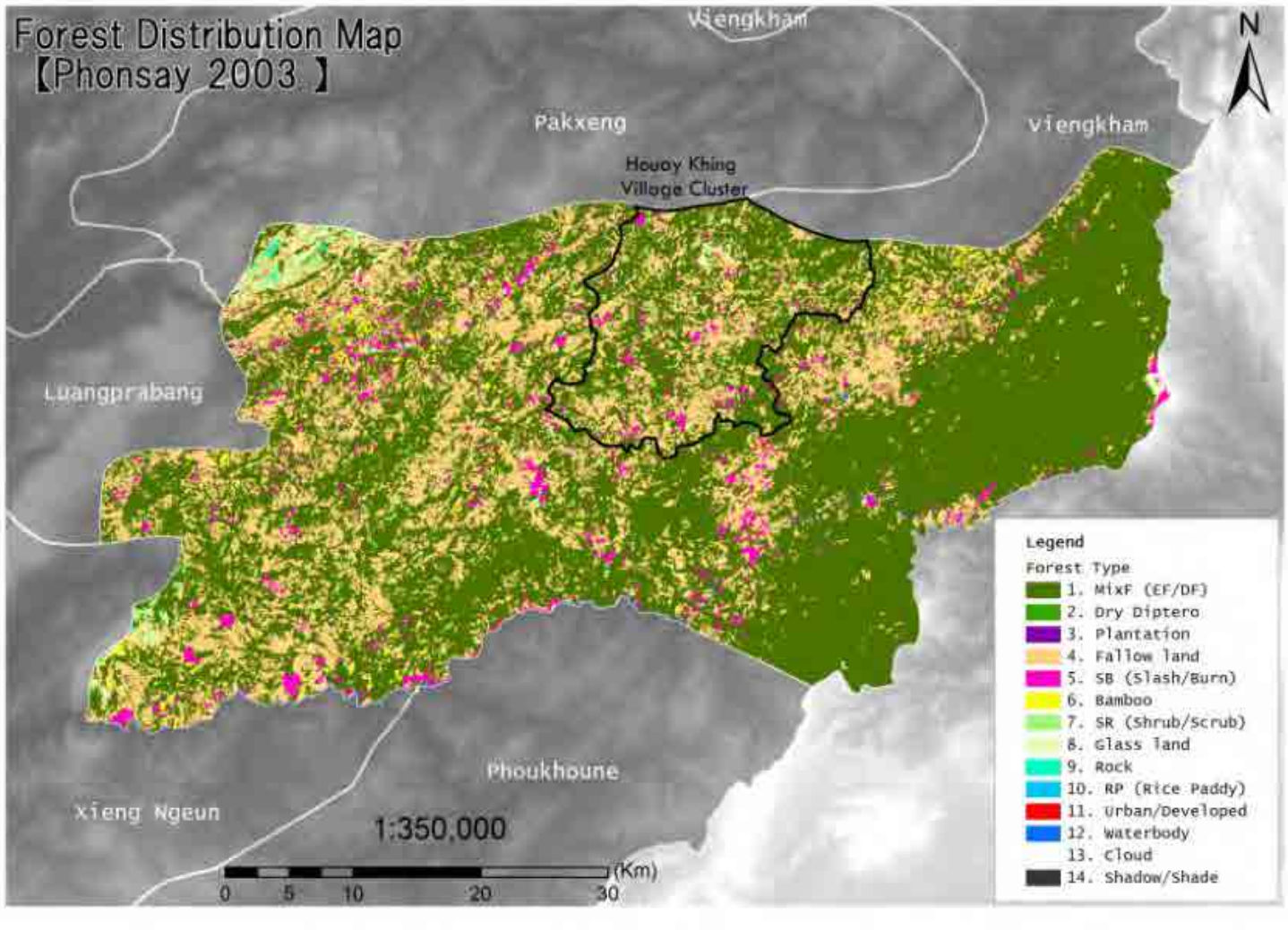


Figure 51 Forest dynamics in Phonsay District (2003)

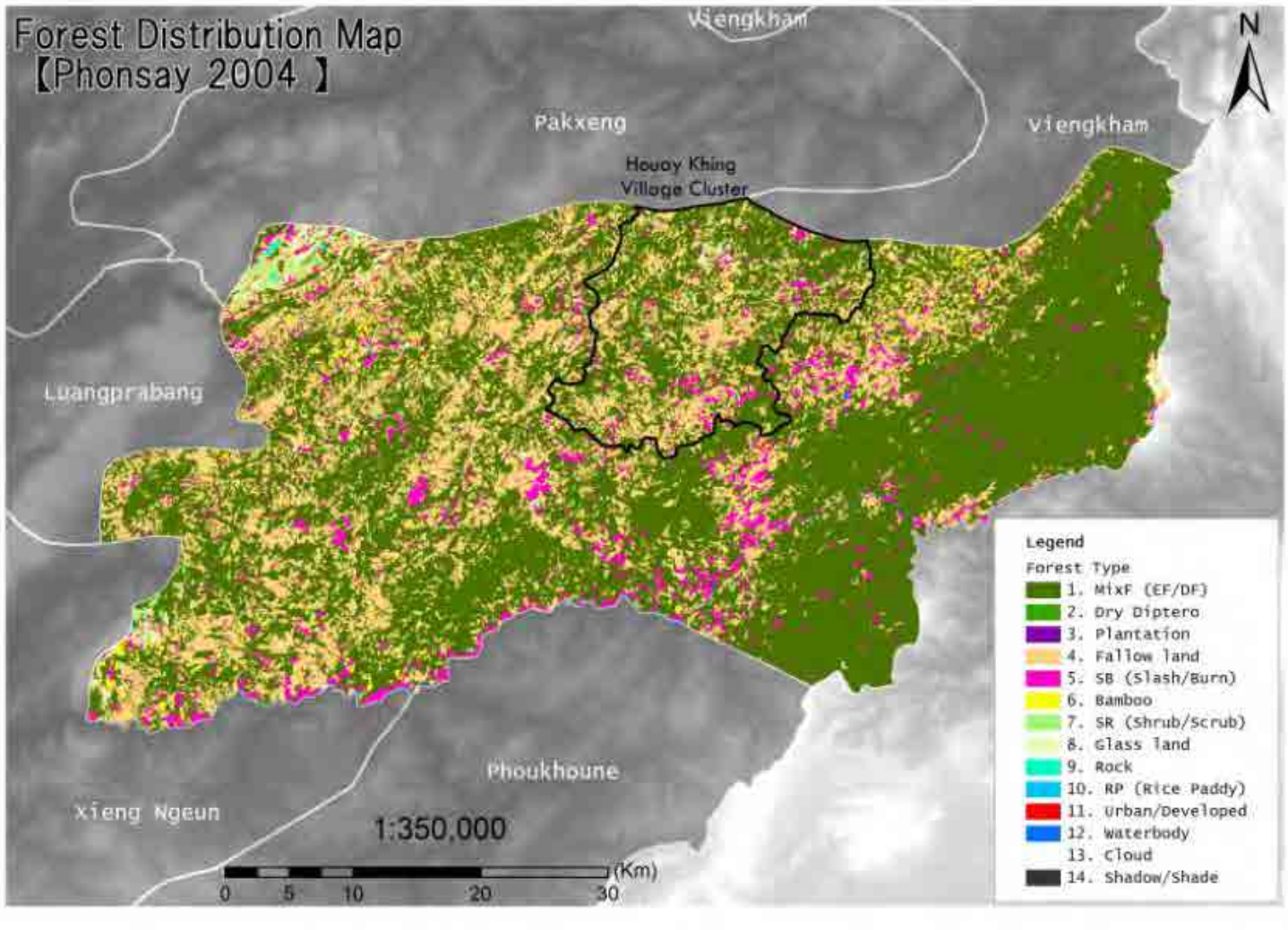


Figure 52 Forest dynamics in Phonsay District (2004)

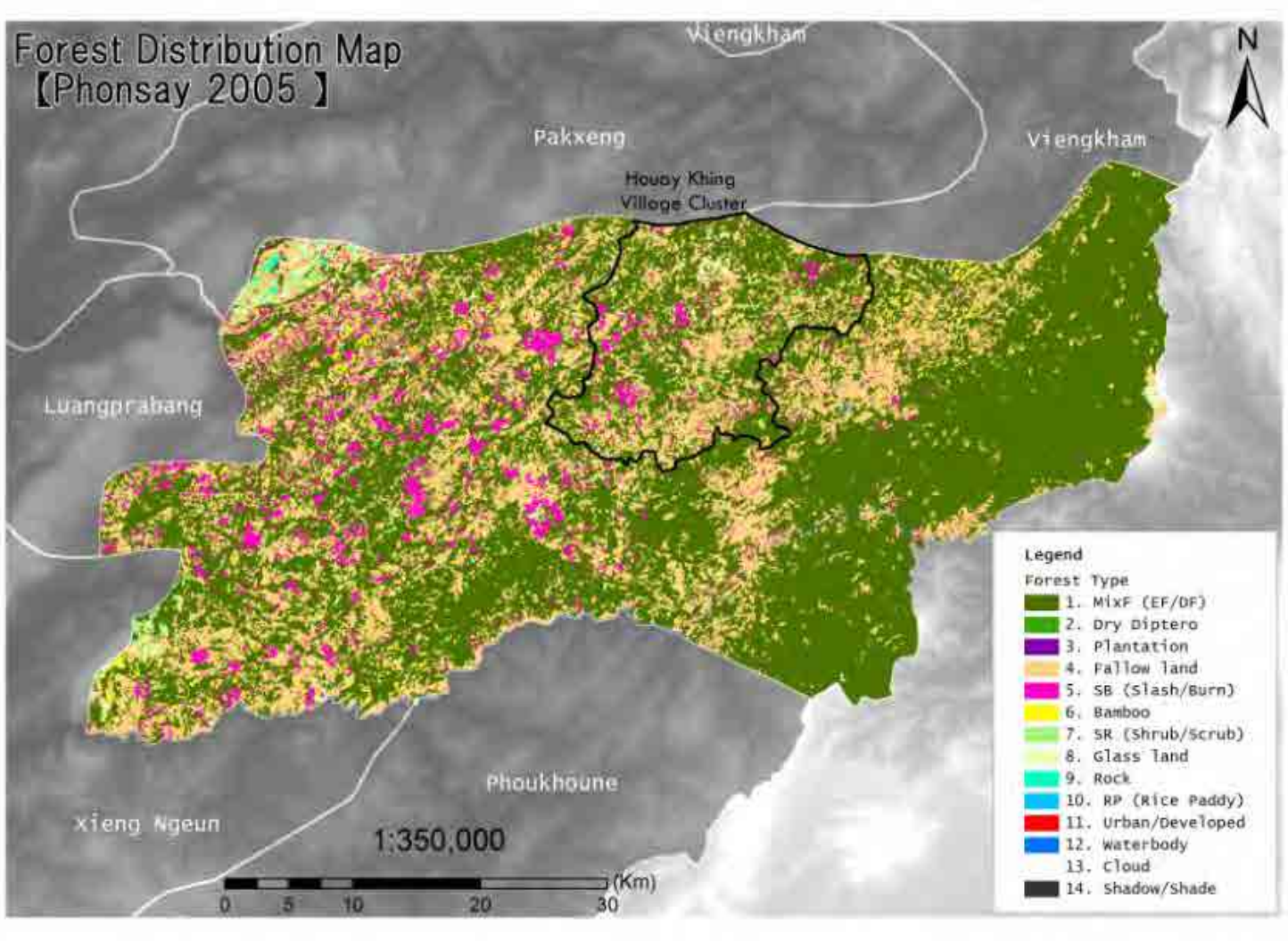


Figure 53 Forest dynamics in Phonsay District (2005)

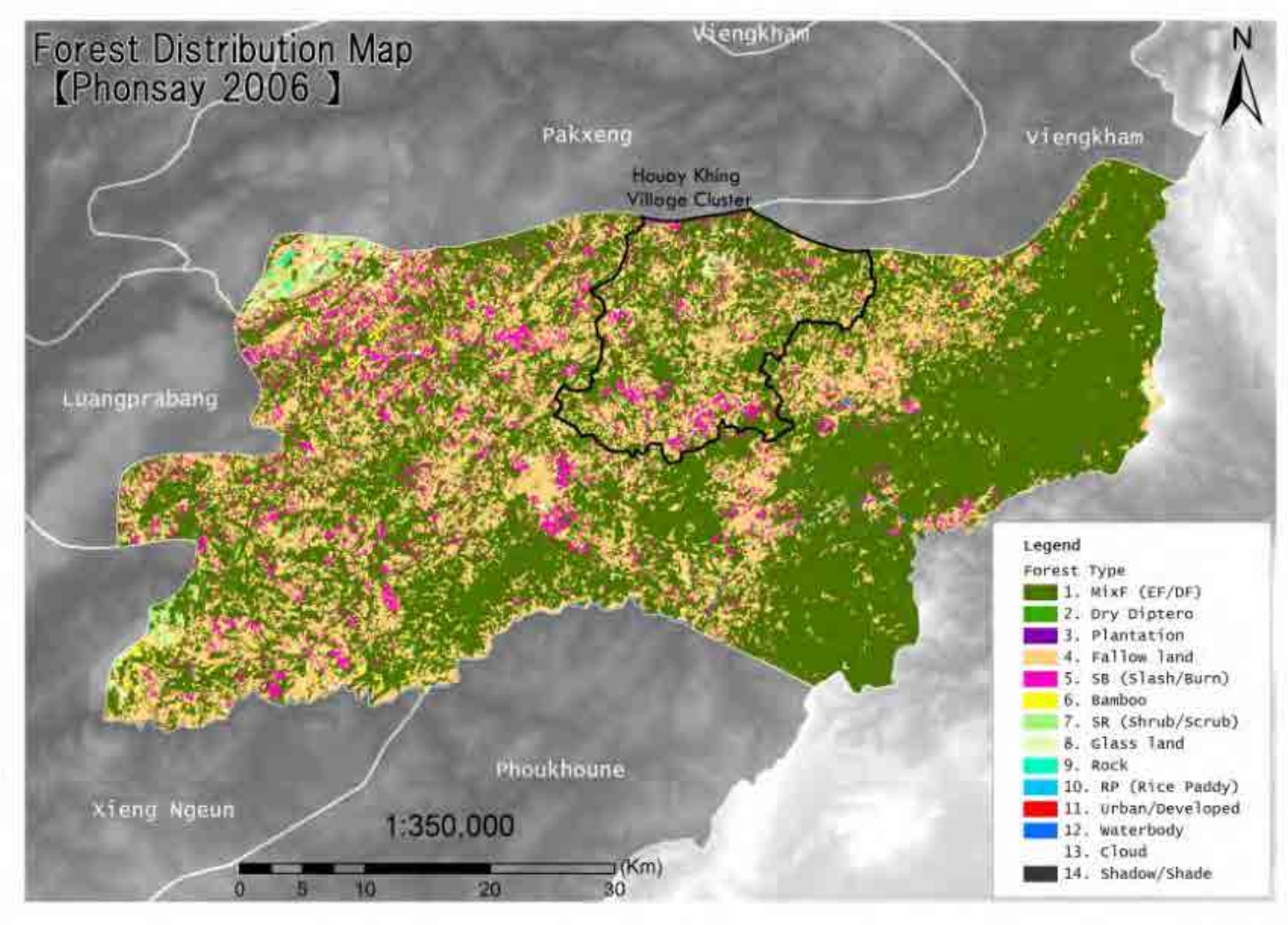


Figure 54 Forest dynamics in Phonsay District (2006)

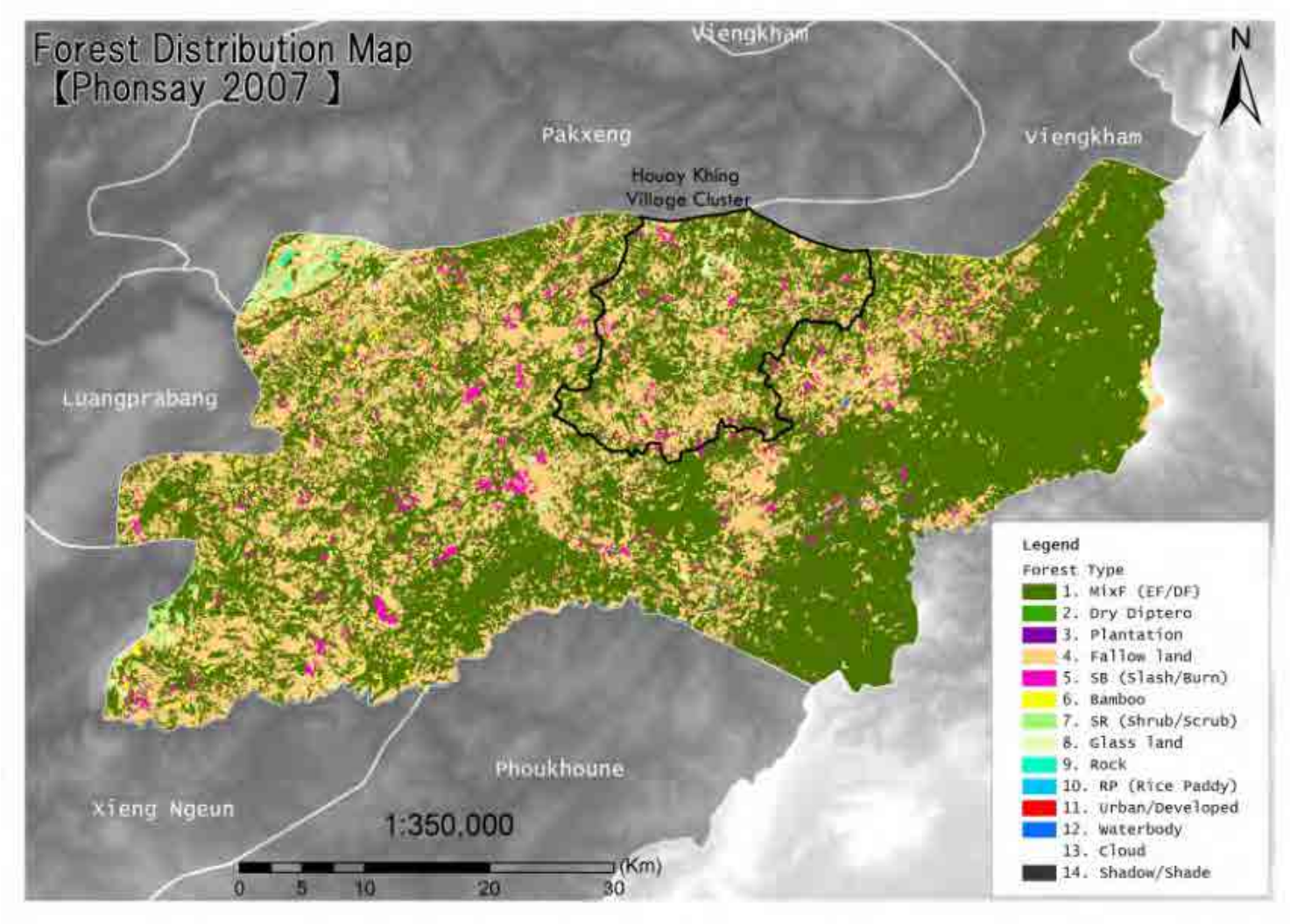


Figure 55 Forest dynamics in Phonsay District (2007)

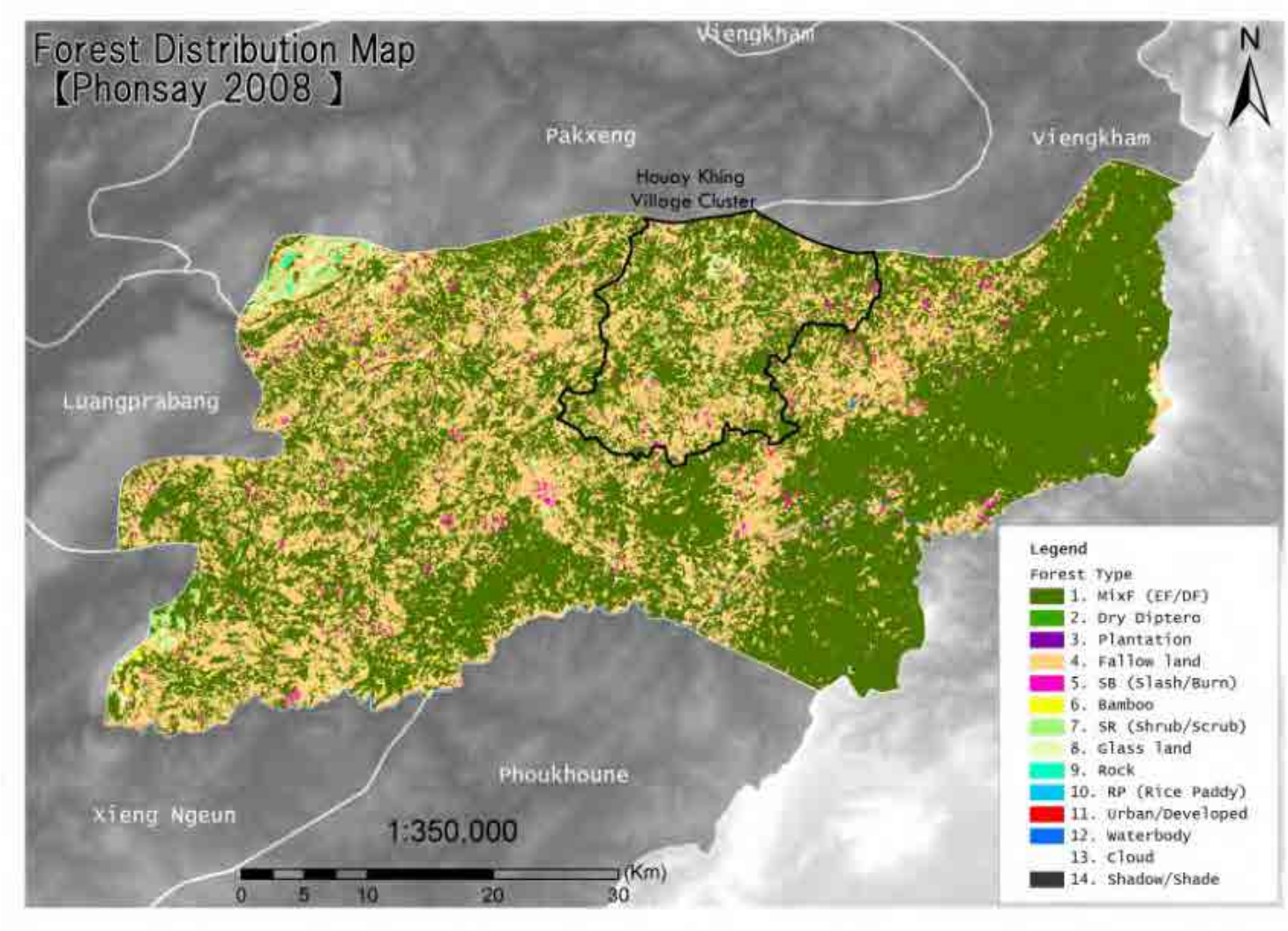


Figure 56 Forest dynamics in Phonsay District (2008)

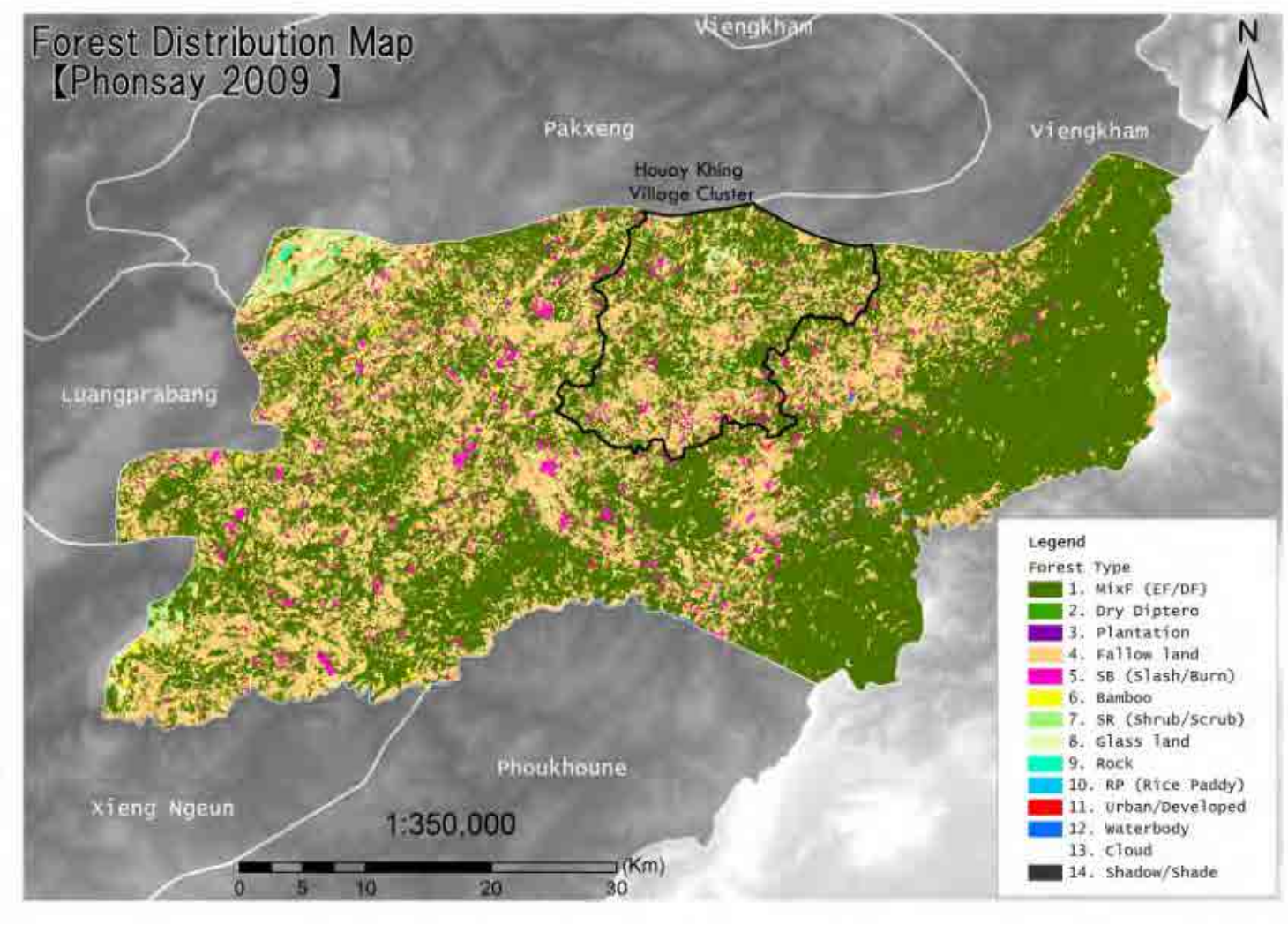


Figure 57 Forest dynamics in Phonsay District (2009)

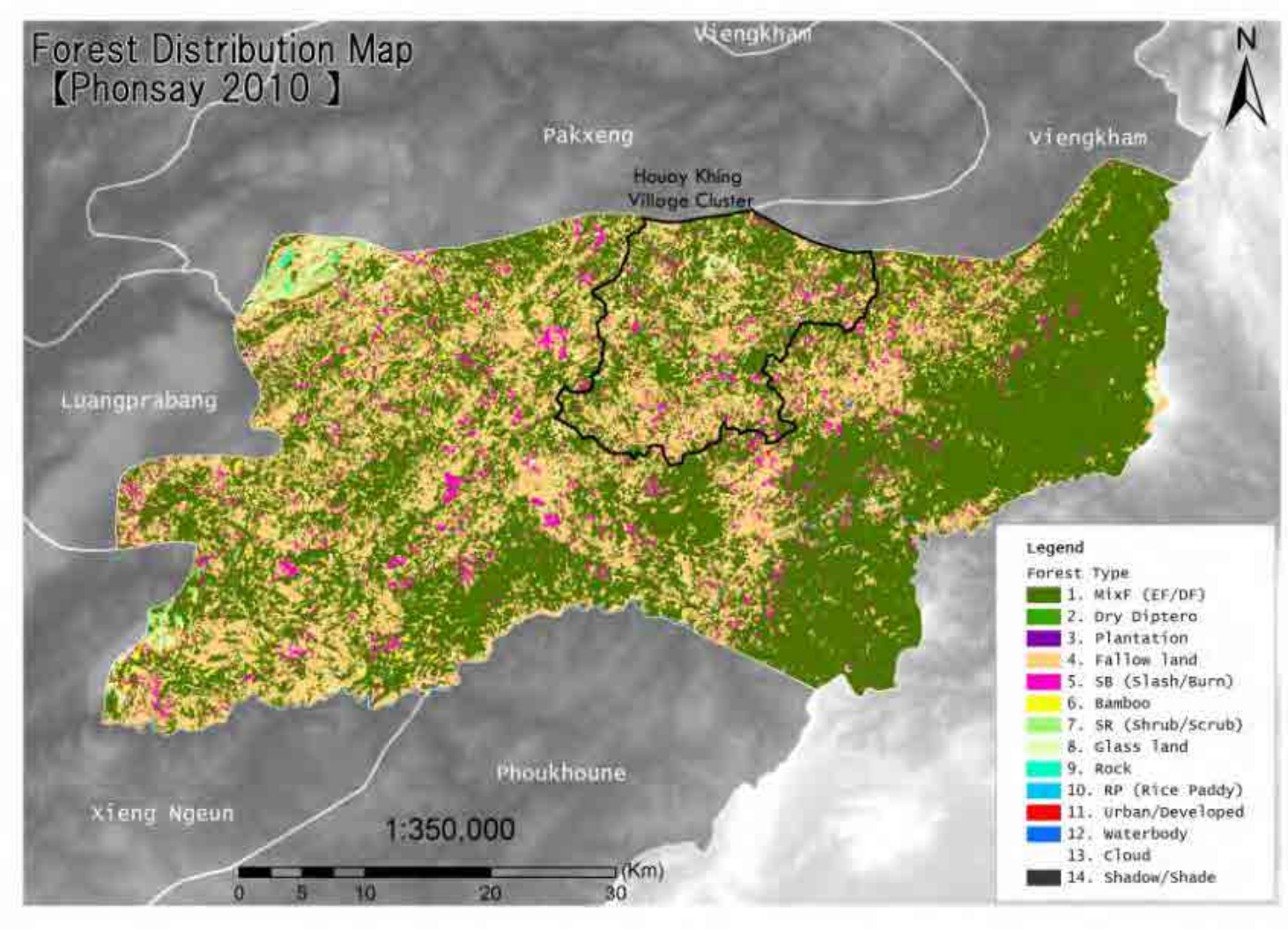


Figure 58 Forest dynamics in Phonsay District (2010)

Validation and Registration of the Project on REDD plus through Participatory Land and Forest Management for Avoiding Deforestation in Lao PDR

Technical Cooperation Report
- Results of Forest Plot Survey -

October 2014

Japan International Cooperation Agency (JICA)

Mitsubishi UFJ Research and Consulting

Japan Forest Technology Association

Validation and Registration Project on REDD plus through Participated Land and Forest Management for Avoiding Deforestation in Lao PDR

Technical Cooperation Report
- Results of Forest Plot Survey -

- Contents -

Chapter 1 Objective

This study was developing reference levels for overall Luang Prabang Province and Houay Khing village cluster (HK-VC) in Phonsay District. To develop reference levels, it is required to estimate changes in carbon stock of each forest type by multiplying changes in area size of each forest type, which was obtained through satellite imagery analysis (*see* Technical Cooperation Report "Analysis Results of Forest Dynamics") for more detail), by carbon stock per hectare of each forest type (i.e. emission factors determined in this project). As a result, increase or decrease in carbon stock (emission or removal) can be estimated when the area of forest type in the target area changes, and that trend is to be the basis of calculating reference level.

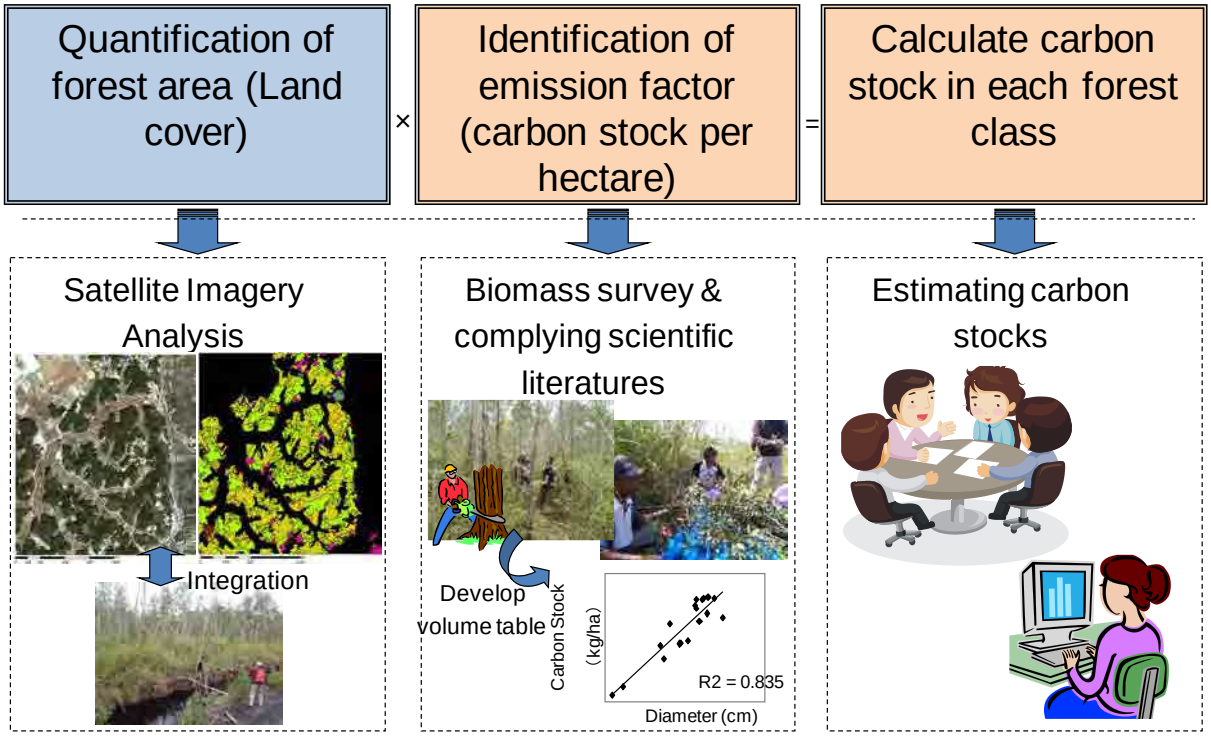


Figure 1 Flow of calculating carbon stock in each forest type

Accordingly, amongst factors of carbon sequestration in forests, emission factor is, in a narrow sense, subdivided into stem volume, conversion factor from stem volume to biomass, and conversion factor from stem biomass to branch and leaf biomass (expansion factor), while it refers to carbon stock per area of each forest type. From the both narrow and broad definition perspectives, it is necessary to quantify the carbon stocks in each forest type; therefore, this study conducted forest plot survey.

To develop reference levels, following three Technical Cooperation Reports were utilized: Technical Cooperation Report "Analysis Results of Forest Dynamics", Technical Cooperation Report "Results of Destructive Sampling Survey", and this report of Technical Cooperation Report "Results of Forest Plot Survey". Figure 2 below describes the relationships of these three reports. The reference levels obtained through these three Technical Cooperation Reports were reported in the Final Report in this study.

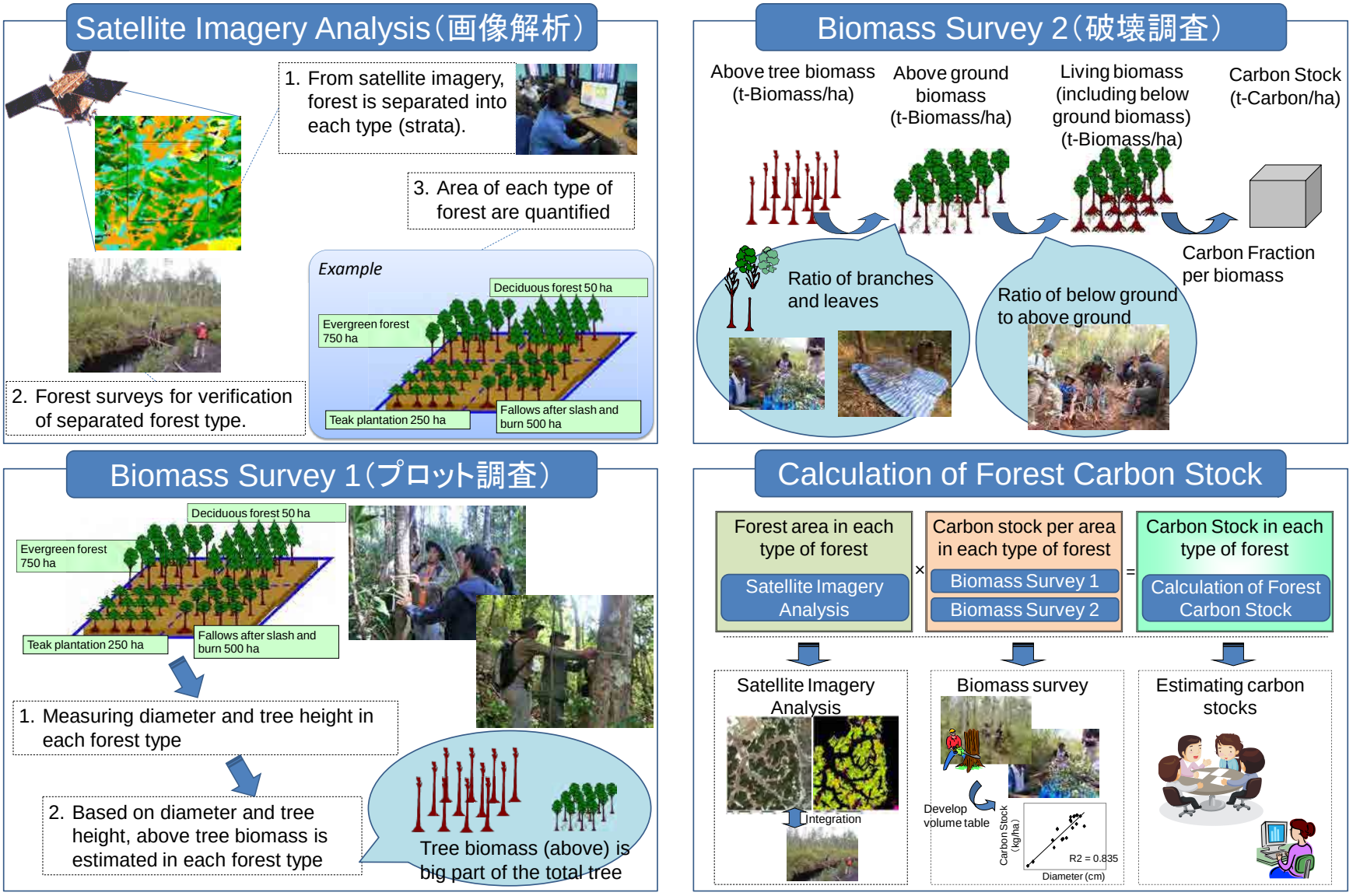


Figure 2　Relationships of Technical Cooperation Reports

Chapter 2 Expected Forest Type in the Target Area before the Survey

1. Temporal Forest Type

This project was pursuing identifying forest type in the target area to undertake plot surveys, and, to ensure the consistency with the advanced environmental grant aid, namely the Program for FIM, Japan's Grant Aid, which was carried out in Lao PDR, forest type provided by the FIM was temporally systematized. It was because the FIM explained that the land and forest type classification had been organized by Lao PDR and the FIM, and the classification reflected Lao PDR's intention would be preferred. As a result, in this project, vegetation was categorized into the seven types in ascending order of biomass volume as shown in Figure 3: Slash and Burn (SB), Young Fallow (YF) 1, YF2, YF3, Old Fallow (OF), Deciduous Forest (DF), and Evergreen Forest (EF).

Figure 3 Forest type in the target area (classification applied temporally)

2. Carbon Pools Subjected to be Measured in Each Forest Type

Carbon pools measured in this study can be divided into five categories based on the IPCC's definition (Figure 4); however, this study measured the two carbon pools, namely above-ground biomass (stems and branches) and below-biomass (roots). Other carbon pools, namely dead trees, fallen branches and leaves, and soil organic carbon, were excluded from the target.

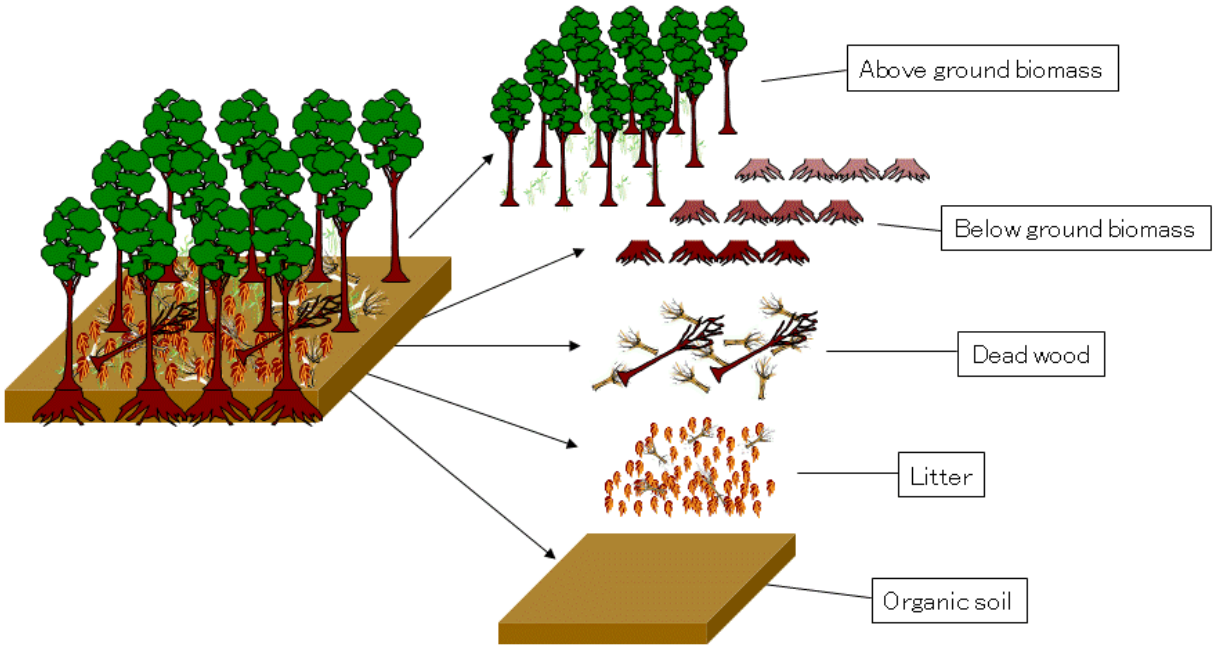


Figure 4 Five carbon pools in forests

Even if forest type is changed by anthropogenic effects, the amount of carbon emissions or removals by dead trees, and fallen branches and leaves is small, and past researches also revealed that soil organic carbon cannot be a significant emission factor if human activities such as shifting cultivation are occurred. For this reason, these pools were excluded (*see* Appendix 1for more detail).

Chapter 3 Re-defined Forest Type in the Target Area in this Project

Based on the field survey undertaken in March 2012, SB was excluded from the measurement as it did not contain carbon stocks (SB was used for agriculture and classified as non-forest). Meanwhile, the below mentioned different two surveys were conducted for YF1 to YF3, and OF, DF and EF. In either way, once dry weight of biomass per hectare was derived, it was converted into carbon stock volume by multiplying it by the carbon content rate of 0.5.

1. Young Fallow in the Target Area

YF1, YF2 and YF3 are the vegetation growing in lands left uncultivated for several years after burning, cultivating, and harvesting, in order to restore fertility. YF3's period of being fallow is longer than YF2 followed by YF1. The volume of carbon stock (biomass) is mostly determined by the number of years that lands lying fallow (the number of years since lands were abandoned); therefore, this study decided to find the correspondence between fallow period and biomass. Satellite imagery analysis classified the vegetation into the three categories, YF1, YF2 and YF3, by using images at a single point of time; however, it aimed to identify the more accurate fallowing duration based on images taken between 1994 and 2010 (counting from November when fallowing period started after harvesting). The field survey was designed to clarify the correspondence between the number of abandoned years and biomass, and the cutting and measuring survey method (estimation by unit area sampling) was mainly used to measure its biomass.

2. Old Fallow, Deciduous Forest, and Evergreen Forest in the Target Area

The other group, OF, DF and EF, is certainly defined as forests. Among these, OF is young secondary forests composed of stands of the same age, which are slightly older than YF but still young. DF and EF, on the other hand, are secondary forests basically composed of trees of various ages, as a result of repeated selective cutting and natural restoration thereafter. DF refers to such forest stand dominated by deciduous trees, while EF refers to the forest stand dominated by evergreens. In view of the difference in stand structure and species composition, survey was made on the forest stands selected at random in each type of forest, and the average value of the respective stands was considered the biomass of the corresponding forest type. The forest biomass survey of OF, DF, and EF was conducted using a method that combines the ordinary technique of researching all individual trees in a plot. For destructive sampling survey, please refer to Technical Cooperation Report "Results of Destructive Sampling Survey".

3. Survey Methods

3.1 Survey of Young Fallow

In this survey, plots were established, and all plants growing in each plot were cut and weighed to measure the biomass. As to the size and number of the plots, one square area with a side length equal to the vegetation height was established in each forest that was deemed to have a uniform height and density. In forests with different heights and densities, the plot area was expanded to the point where its height and

density were considered uniform, or where three or more plots were established in stands with sparse, medium, and dense vegetation, in order to obtain an average value. The cut plants were first divided into assimilatory organs (xylem) and non-assimilatory organs (leaf). Then, their respective weights in raw condition were multiplied by the dry weight ratio to obtain the biomass. The dry weight ratio was obtained by dividing the absolute dry weight of their dried specimens by their weight in a raw condition. The specimens were dried at the temperature of 70ºC for more than 48 hours until constant weight. In the cutting and measurement survey, plants were not basically dug up to the roots, and the biomass in the roots was estimated using the ratio between the parts above-ground and below-ground (roots), which was obtained through destructive sampling survey. The amount of biomass in the underground parts becomes larger as the proportion of the parts above-ground becomes smaller; therefore this factor was also considered in estimating the underground biomass. Souphanouvong University in Luan Prabang helped the project for drying process of estimating dry weight ratio.

3.2 Survey of Old Fallow, Deciduous Forest, and Evergreen Forest (Plot Survey)

In this survey, plot was established and the breast height diameter of trees in the plots was measured, based on which the biomass of the respective trees was estimated by applying the relative growth formula (allometric equation) (*see* Technical Cooperation Report "Results of Sampling Survey" for detail information) of biomass in relation to the tree's breast height diameter obtained by destructive sampling survey. And then the total volume of the biomass was estimated, and it was divided by the total square measure of the area to obtain the biomass per hectare.

Stakes were positioned at the four corners of the plots, and identification tags were attached to the respective measured trees to establish fixed examination plots.

Forests suffered selective cutting by villagers, and the impact of the extent, frequency, and duration of this were believed to be remarkably severe in the areas along pathways. In addition, the growth of trees along the pathways could be unique due to the forest edge effect. For these reasons, areas along the pathways were excluded from the survey area. As areas were more distant from the pathways, it required more time for access and thus became less efficient and more dangerous to conduct survey. Accordingly, in accordance with the methodology VM0015 of the VCS, areas far away from the pathways in excess of a fixed distance were also excluded from the survey area. Thus, the areas distant from the pathways by 50 m or more but 1,000 m or less were finally designated as the survey target. Information on the pathways in the survey area had to be obtained through exploration, as this had not been prepared in sufficient detail.

Two survey teams comprising four-wheeled vehicles, motorcycles, and some on foot were organized, and each team completed its survey in one day. The potential survey area within the distance of 1,000 m from the pathways covered almost half of the total areas of the six villages. Such area was divided into sections of 100 m square each. The dominant covering of each of the sections was identified as the typical vegetation, and candidates for survey points for each forest type were selected at random (Figure 5).

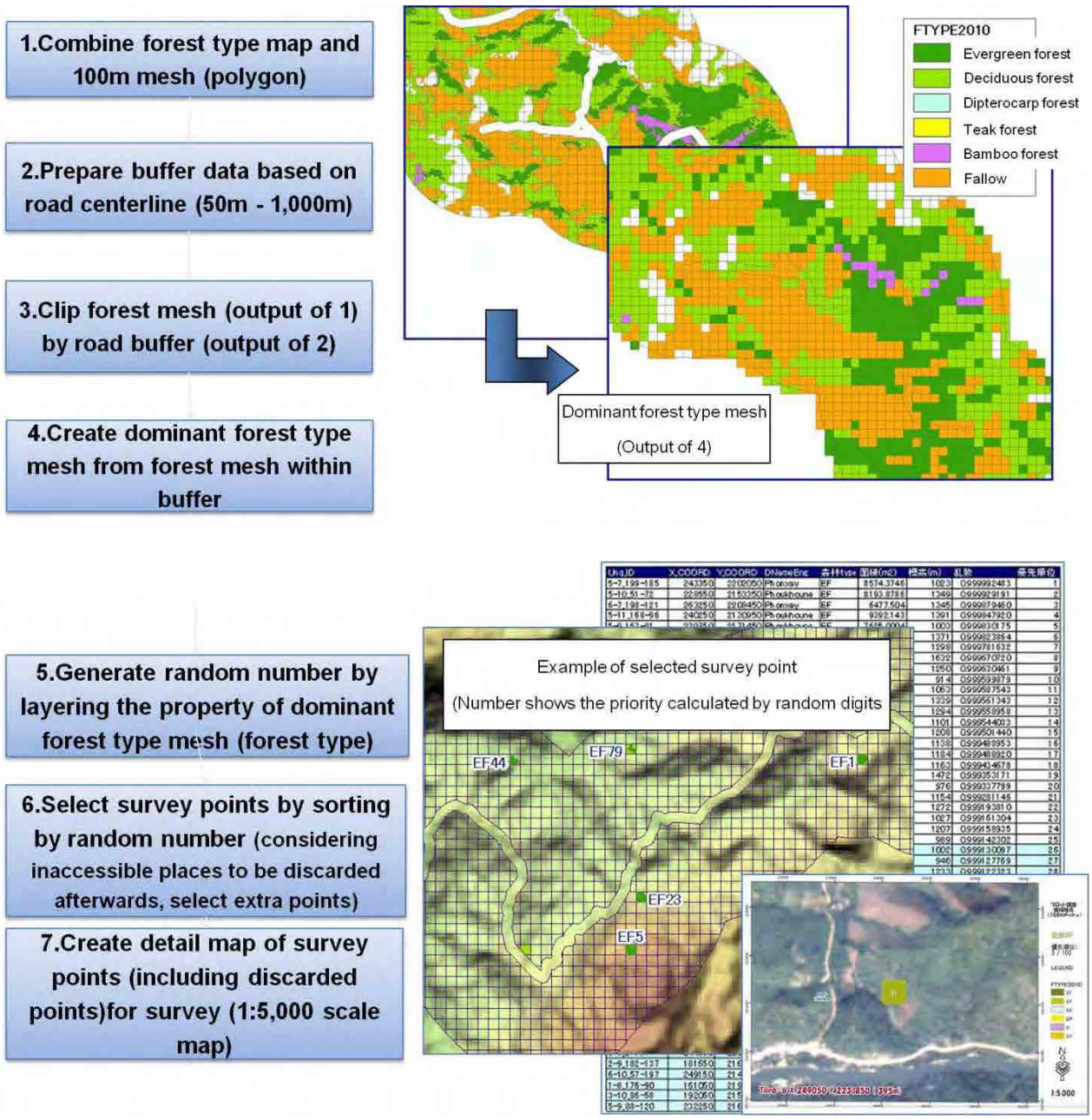


Figure 5 Method for determining plot locations

Coordinates of the center of the 100 m2 sections and the satellite images of the adjacent areas were used to access the selected survey points. Certain locations, the access to which required passing through a point of possible rockfall, crossing a river, or cutting a path through a long section of thorny and low vegetation were, based on the methodology VM0015 of VCS, which was applied to this study, excluded from the survey target, as they were considered difficult to reach. Furthermore, the points that were burnt, logged, or otherwise seriously disturbed after the time of satellite imaging (November 2010) were also excluded from the survey target, even when the survey team managed to access these areas.

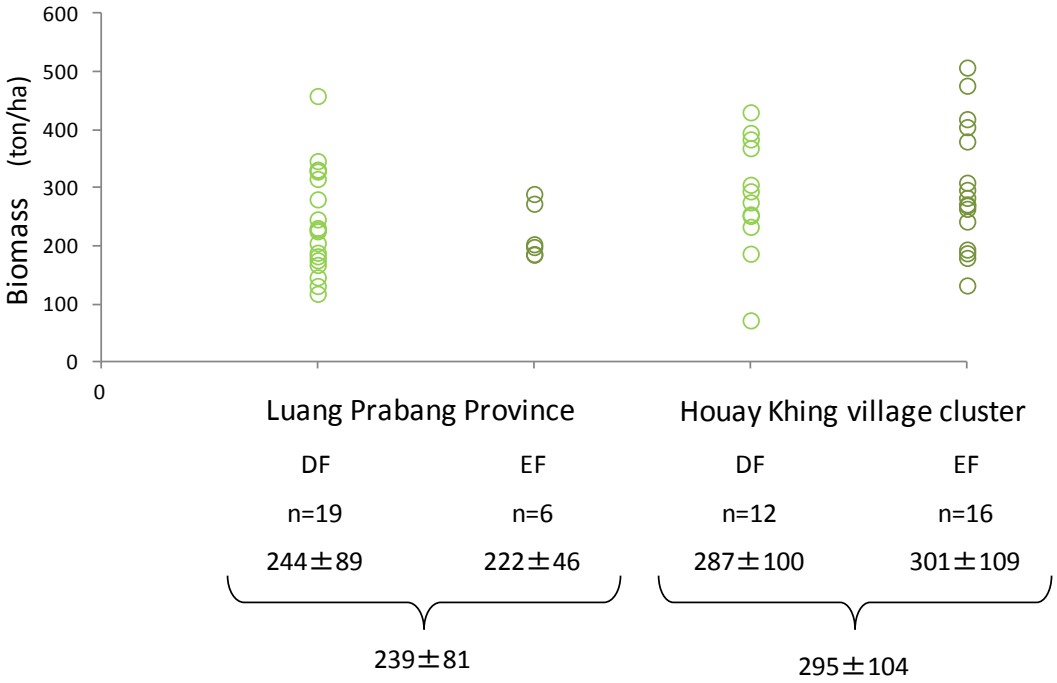
When the points were successfully reached and found undisturbed, the survey team determined whether

or not the vegetation there was the same as the vegetation identified through the satellite images. Even when the vegetation was found to be different, survey plots were established so long as the vegetation was OF, DF, or EF. Survey plots were always established in a single forest type, not across different forest types, as well as on slopes of similar nature whenever possible. Semi-square plots with side lengths of 10, 20, or 30 m in slope distance were established on the slopes. The lengths of the sides were determined to make the plot areas equal to or larger than the square with side lengths equal to the average height of the vegetation, realizing that the square measure of the areas would decrease by about 20% when it was converted into a horizontal square measure. The plots were made larger in size as the height and density of the trees became less uniform. The 3D coordinates of at least one of the four corners of the established plots were registered using a GPS receiver so that their absolute locations and horizontal square measures could be secured, while the slope distance and slope angle between the four sides and one of the diagonal lines were measured and the directional angle of one side was scaled using a compass. Species in the areas with a breast height diameter of 5 cm or more were recorded separately for standing and dead standing trees, and identification labels were attached to each of them. In addition, the tree canopy coverage ratio, degree of disturbance, height and density of low-level vegetation, and surrounding status were observed visually and recorded.

4. Redesign Survey Method

Considering the results of above described field survey, forest dynamics analysis, and satellite imagery analysis, and aiming to develop reference level toward sub-national based REDD plus implementation for Luang Prabang Province, method for survey from October 2012 was redesigned. To redesign the method, this project emphasized again to ensure the competency with the continuing forest monitoring system in Lao PDR, and therefore this project discussed with FIM considering the accuracy of monitoring to be applied, costs, and labor.

In the discussions with FIM, the most important agenda was how to handle deciduous forest (DF) and evergreen forest (EF), which cover most of the forests in northern Lao PDR, or the mixed forest of both DF and EF. The mean above-ground biomass and standard deviation of DF and EF obtained through this research (the biomass of DF and EF in Luang Prabang Province and HK-VC were calculated by using the allometric equations built in Technical Cooperation Report “Results of Sampling Survey”) revealed that there was little difference between overall Luang Prabang Province and HK-VC in terms of the carbon stock of DF and EF (Figure 6)



The value in this figure shows Average±Standard Deviation (ton/ha)

Figure 6 Result of comparison of biomass between DF and EF

As a result, it was determined that the same allometric equation could be applied to the both forest types, DF and EF, and this research defined DF and EF as a same forest type, Mixed Forest (MF) (Table 1).

Table 1 Relation between suggested tentative forest classification based on our filed survey and tentative forest classification by FIM

Forest classification based on our field survey result (tentative) ⇒Corresponded large classification	Forest classification (tentative) designed by FIM ⇒Corresponded small/middle classification segmentalized depend on the case/utilization in each region	Remarks
Mixed Forest (Class name should be considered with Lao government)	Evergreen Forest	Corresponding to FIM's classification: EF /DF / MED / CF are arbitrarily integrated/segmentalized based on regional charactaristics.
	Deciduous Forest	
	Mixed Evergreen /Deciduous Forest	
	Coniferous Forest	
	Mixed Coniferous /Broadleaved Forest	
Dry Dipterocarp Forest	Dry Dipterocarp Forest	→Under consideration: it'll be based on the survey result by our project(implemeted on Mar. 2013)
Plantation Forest	Evergreen Forest Plantation	→Considered safeguard
	Deciduous Forest Plantation	
Bamboo	Bamboo	
Fallow Land	Old Fallow Land	
	Young Fallow Land	
Slash and Burn Land	Slash and Burn Land	

In addition, to apply the new forest type, a support tool for plot survey planning developed by the Forestry and Forest Products Research Institute was utilized to calculate the necessary number of plots (*see* Appendix 2 for more detail).

This project organized the concept of forest type classification in this study, and proposed it to FIM and a successor technical cooperation project, Capacity Development Project for Establishing National Forest Information System for Sustainable Forest Management and REDD plus. What this project proposed is described in Annex 3.

5. Redesigned Survey Scheme

As described above, to quantify the biomass of overall Luang Prabang Province, the required number of plots was calculated by utilizing the support tool for plot survey planning (*see* Appendix 2 for more detail). This tool can output the number of plots necessary for plot surveys once required information is input, including the total area size of the project target area, area breakdown by land cover and land use type, and average and standard deviation of plot size and biomass obtained through ground biomass measurement, average ground biomass, and standard deviation.

In this project, following data was input: forest area of each forest type, which was calculated through Technical Cooperation Report "Results of Forest Dynamics Analysis", actually measured above-ground biomass data, which was obtained in Technical Cooperation Report "Results of Destructive Sampling

Survey", data shared by FIM, and data collected by Asia Air Survey Co., Ltd under a project supported by the Forestry Agency of Japan.

6. Survey Method (Additional Plots)

With the adoption of the support tool for plot survey planning, it was revealed that a total of 72 points (overall 72 points for MF)—32 points for deciduous forest (DF) and 40 points for evergreen forest (EF)—were required in order to quantify forest carbon stock at a certain level in overall Luang Prabang Province. In estimating biomass from the breast height diameter, an estimation formula developed by Kiyono et al. (2007) based on the tree species growing in other tropical areas was tentatively applied, as analysis of the simultaneously undertaken destructive sampling survey (*see* Technical Cooperation Report "Results of Sample Tree Survey" for more detail) was not completed, thus the number of plots were calculated based on it.

$B = 7230.2D$ .....Formula (1)

In this formula, B refers to the total biomass (kg) and D refers to the cross section area (m^2) at breast height.

As described above, although the survey targets were 72 plots, previous surveys (by the end of September 2012) had already examined approximately 10 plots; therefore, target number of plots in dry season, from October 2012 to March 2013, was set as 60 points. For other relatively young vegetation, biomass was estimated based on the vegetation type and its age obtained through annual satellite image analysis. Even though the target number of points for the plot survey was set at 72 points, this was only based on the result of the trial calculation using the support tool for plot survey planning. In other words, the required number of points was expected to alter depending on the vegetation classification system established in Technical Cooperation Report "Analysis Results of Forest Dynamics", the area of each forest type, the average biomass, standard deviation, and plot area obtained as a result of the plot survey.

For this reason, to develop emission factors, it was decided to (1) lower the number of points required by expanding the plot area and (2) apply the so-called PDCA method in which following process was repeated: analyzing data once survey of single plot was finished, calculating the required number of plots by the support tool, and conducting additional plot surveys.

The priority of the survey carried out during the last dry season from February to April 2012 was to make it easy to understand for the staff of PAFO and DAFO, as well as local villagers. For that purpose, square plots of 20 square meters in slope distance were installed using a tape measure. However, as the target area was substantially increased and the number of points grew much larger, it became impossible to complete the survey with the original plot size. Thus, this study planned to expand plot size. Nevertheless, it was obvious to take a significant amount of time and labor to install square plots of 30 or 40 square meters using a tape measure and to conduct an inventory survey. Thus, concentric circular plots were designed for this project. Adopting the following method made it possible to expand the area of installed plots without substantially increasing the time and labor involved. As this method was tested in 2011, it was easier for the staff of the PAFO and the DAFO to understand, and this was another reason for introducing this method.

A concentric circular plot had three circles of a radius of 6 meters, 14 meters, and 22 meters. The measurement targeted a diameter at a breast height of 35 centimeters, 15 centimeters, and 5 centimeters or higher, from outer to inner circles. The area was 113 square meters, 616 square meters, and 1,520 square meters respectively, from the innermost circle. When these figures were converted to the measurement of a square plot, they were equivalent to 113m^2, 616m^2, 1,520m^2, and the side length of them were 10.6 meters, 24.8 meters, and 39.9 meters, respectively, from the innermost circle. When considering diameter of target trees of measurement, these figures were also considered appropriate.

Ideally, a preferable method was repeating following process: firstly, selecting a small number of points from overall Luang Prabang Province randomly, carrying out plot surveys at those points, calculating the necessary number of points to be added based on the result of those surveys, and then selecting a slightly smaller number of points. However, it was not a practical because it was assumed to take so much time to move around across Luang Prabang Province, which has vast land mass (about the same size as Iwate Prefecture in Japan), and it was required to give explanation to districts and villages and hire local staffs. Thus, this study set out several survey periods, and conducted plot surveys in different districts in each period to finally cover the all target 12 districts. Collected survey data was analyzed each time. Although the number of plots in each district was assumed to differ to some extent, it was considered operationally unavoidable. Efforts were made to secure the required number of points while minimizing plots being placed geographically unevenly.

In the pre-survey in 2011 and from March to April 2014, 40 points were examined targeting OF, DF, and EF, while 6 points were researched for YF. In the OF, DF, and EF research, attempts were made to access 28 points. Among them, 23 points were successfully reached, while 5 were not. Three of the unsuccessful accesses were due to difficulty in crossing rivers, while one was due to the danger of falling rocks, and one required a long journey through a bushy area. Among the 23 points successfully accessed, 5 points were found disturbed on a large scale such as by extensive cutting for shifting cultivation, and plot survey was conducted in the remaining 18 points. The most distant survey point from the pathways was 850 m away, while some plots had inclines in excess of 40 degrees. The survey in March led by the writer was conducted by one survey team and covered a maximum of three points a day. Coverage of two points a day was considered satisfactory, as even one point was not covered in a day in some cases.

Chapter 4 Results

1. Survey for Young Fallow (YF1-3)

Figure 7 shows the volume of biomass in relation to the number of years after the forest's abandonment. This figure indicates that in forests up to 10 years old, biomass increased at an average annual rate of 13 t/ha, or at an average annual rate of 6.5 t-C/ha in carbon stock, which was converted by multiplying the biomass by the carbon content ratio of 0.5. Although forest age was provided by villagers in each survey, it was expected to be modified into uniformly calculated value by satellite imagery analysis based on location information of the forests. On the other hand, in addition to possibly inaccurate forest age provided by villagers, some forests of 10 years old or older seemed to be affected more by logging. It was also pointed out that annual forest growth decreases in the areas where slash-and-burning has been practiced in a short cycle for a long time. There was a possibility to clarify these points when they had been extensively reviewed through local biomass survey, interviews, and the retroactive analysis of satellite images.

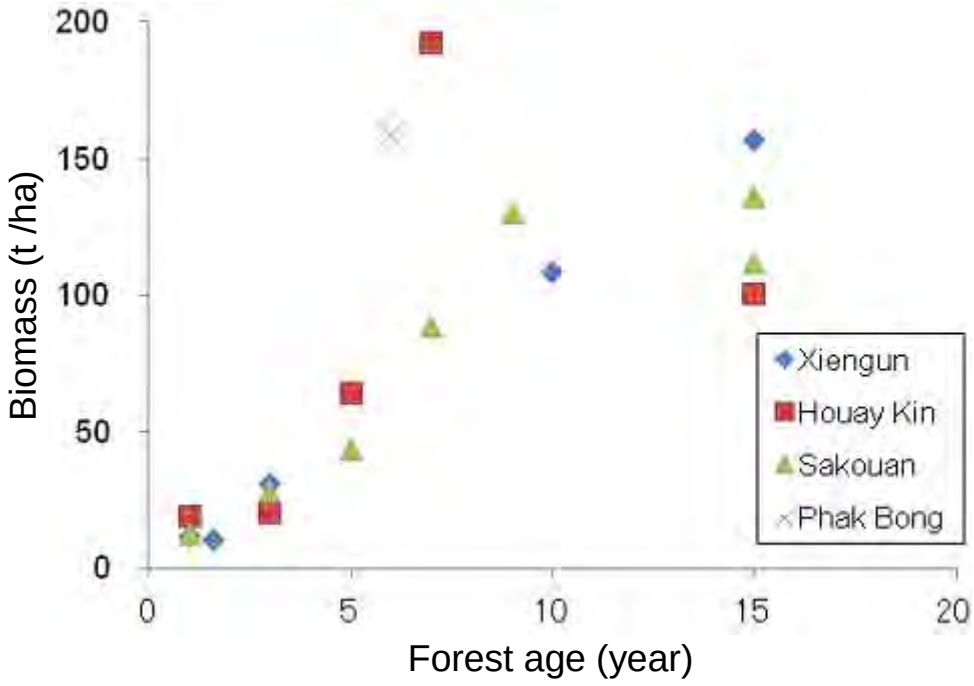


Figure 7 Relationship between forest age and biomass

The biomass survey, interviewing survey and retrospective analysis of satellite imageries indicated that dynamics of YF was necessarily studied comprehensively. Analysis of vegetation heights gathered through filed surveys and vegetation type (forest type) defined by imagery analysis identified that YF becomes equal to OF when fallow lands are left uncultivated for more than about three years after being burned. That makes it difficult to technically distinguish YF from DF by imagery analysis. As a countermeasure against these issues, in this project, amongst YF, Young Forest, which recovers to OF, DF or EF in mid- to long-term period (except lands, which are continuously used for SB) was recognized as the same forest type

as OF and classified as Fallow Land (F) (*see* Table 1).

2. Plot Survey of Mixed Forest

Result of plot survey targeted Fallow Land (F) and Mixed Forest (MF) is shown in Table 2. The 112 plots in total included stands with trees aged 1 year to 19 years, and the results of the plot survey were evenly gained from different stand age (the number of years uncultivated after being burned). By using the results of plot survey together with the destructive sampling (Technical Cooperation Report "Results of sampling survey"), this study enabled to calculate the volume of carbon stock in each forest type. Moreover, the increase or decrease in carbon stock volume over the years was also calculated by the survey, which analyzed change in forest area of each forest type (Technical Cooperation Report "Analysis Results of Forest Dynamics"). Figure 8 shows the dynamics of carbon stock volume in the target area revealed by the three Technical Cooperation Reports.

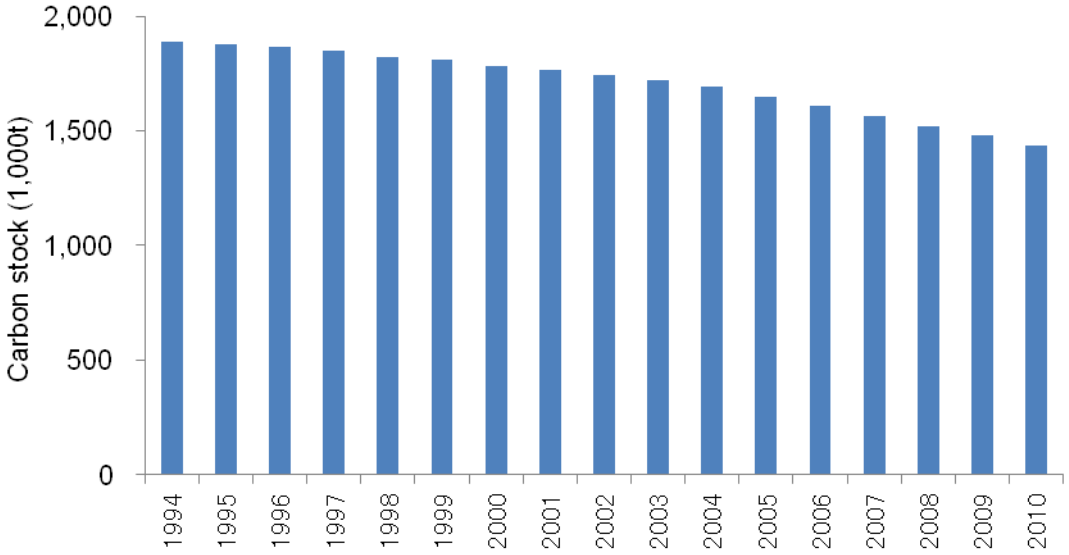


Figure 8 Changes in carbon stock in the target area

Table 2 Results of the all plot surveys

Plot No.	Coordinates (m in UTM zone48)			District	Age		Veg. type		Plot	Tree density (trees/ha)				Mean dbh (cm)				Basal
	Northing	Easting	Elevation		in situ	Sat.	Sat.	in situ	area	5≤dbh<15	15≤dbh<35	35≤dbh	Total	5≤dbh<15	15≤dbh<35	35≤dbh	Overall	area
1				Xiengun	1.6	0.5		OF	616				1,120.6				3.9	1.5
2				Xiengun	10	8.5		OF	201				1,044.5				13.2	15.0
3				Xiengun	15	17.5		OF	616				1,356.1				13.7	21.7
4				Xiengun	1	17.5		OF	3									
5				Xiengun	3	17.5		OF	3									
6				Xiengun	30	17.5		F	616				791.7				10.8	16.7
7				Phonxay	1	8.5		OF	3									
8				Phonxay	3	8.5		OF	104				1,989.4				4.5	3.6
9				Phonxay	5	0.5		OF	53				3,978.9				5.0	8.1
10				Phonxay	7	17.5		OF	616				3,495.7				9.3	26.6
11				Phonxay	15	17.5		OF	616				2,529.4				8.2	13.9
12				Phonxay	60	2.5		F	616				1,518.5				15.7	36.6
13				Phonxay	100	17.5		EF	616				1,157.1				13.2	27.1
14				Phonxay	1	0.5		OF	3									
15				Phonxay	3	3.5		OF	3									
16				Phonxay	5	3.5		OF	4									
17				Phonxay	7	9.5		OF	616				1,530.6				9.9	12.3
18				Phonxay	9	12.5		OF	201				5,321.7				6.2	18.1
19				Phonxay	15	12.5		OF	616				1,912.3				9.1	15.5
20				Phonxay	15	16.5		OF	616				1,871.7				10.9	18.9
21				Phonxay	30	16.5		F	1257				1,213.8				14.1	26.4
22				Phonxay	6	17.5		OF	201				3,481.5				8.5	21.9
23	269,621	2,208,247	–	Phonxay		4.5	DF	OF	323				587.7				10.4	6.7
24	269,356	2,208,822	–	Phonxay		11.5	OF	OF	77				1,303.9				8.3	9.1
25	269,358	2,209,033	1,228	Phonxay		11.5	EF	OF	760				1,013.6				10.3	12.5
26	269,451	2,204,852	1,059	Phonxay		7.5	EF	EF	759				1,001.4				12.9	19.9
27	263,999	2,208,118	–	Phonxay		18.5	DF	EF	339				974.8				19.1	35.5
28	263,142	2,208,655	1,432	Phonxay		18.5	DF	EF	308				2,236.7				10.5	23.8
29	262,839	2,208,657	1,440	Phonxay		18.5	EF	EF	717				989.9				15.5	36.7
30	262,258	2,209,456	1,211	Phonxay		5.5	DF	EF	798				677.0				18.1	28.1
31	262,049	2,204,031	1,223	Phonxay		5.5	EF	EF	328				2,439.1				8.1	17.7
32	258,456	2,204,224	1,047	Phonxay		9.5	EF	DF	341				1,114.9				17.5	38.2
33	263,938	2,217,970	1,183	Phonxay		18.5	EF	EF	323				1,237.4				18.5	47.8
34	267,631	2,216,912	1,526	Phonxay		18.5	EF	EF	796				377.1				22.5	27.3
35	268,143	2,216,649	1,530	Phonxay		10.5	OF	Mix EF&DF	82				853.7				8.4	6.3
36	271,035	2,214,045	1,444	Phonxay		12.5	OF	OF	86				1,506.4				8.5	11.2
37	267,877	2,212,822	1,208	Phonxay	20	15.5	EF	EF or OF	340				1,442.3				10.5	16.8
38	266,217	2,208,868	1,297	Phonxay		18.5	DF	Mix EF&DF	315				2,669.3				9.5	21.8
39	265,736	2,204,439	1,177	Phonxay		1.5	OF	EF	322				1,987.4				12.5	35.3
40	266,791	2,207,667	1,378	Phonxay		16.5	DF	OF	316				1,298.6				12.0	17.8

Table 2 *continued*

Plot No.	Coordinates (m in UTM zone48)			District	Age		Veg. type		Plot	Tree density (trees/ha)				Mean dbh (cm)				Basal
	Northing	Easting	Elevation		in situ	Sat.	Sat.	in situ	area	5≤dbh<15	15≤dbh<35	35≤dbh	Total	5≤dbh<15	15≤dbh<35	35≤dbh	Overall	area
41	272,559	2,204,714	929	Phonxay	24	18.5	EF	EF	363				743.1				17.5	24.2
42	270,876	2,204,851	954	Phonxay	25	17.5	EF	EF	333				1,804.3				11.7	24.6
43	267,684	2,204,538	1,227	Phonxay	25	9.5	EF	EF	387				568.7				17.9	18.4
44	266,973	2,205,157	1,175	Phonxay	9	1.5	DF/OF	EF	349				2,265.3				7.3	9.9
45	266,447	2,207,958	1,511	Phonxay	10-20	18.5	DF	EF	389				2,779.6				9.0	21.3
46	264,549	2,207,843	1,516	Phonxay	30+	18.5	EF	EF	325				553.4				24.8	29.3
47	261,615	2,202,742	1,198	Phonxay	35	18.5	EF	EF	388				1,675.9				15.7	46.4
48	261,067	2,204,148	1,249	Phonxay	15	5.5	DF/OF	EF	370				2,408.4				11.2	29.0
49	261,280	2,204,562	1,358	Phonxay	10+	18.5	DF	EF	375				1,519.6				12.2	24.0
50	264,108	2,207,461	1,455	Phonxay	20	18.5	DF	EF	329				2,826.6				11.7	40.9
51	264,059	2,208,032	1,491	Phonxay	20+	18.5	DF	EF	340				1,293.9				15.4	38.9
52	263,824	2,208,504	1,495	Phonxay	20+	11.5	EF	EF	92				2,812.0				10.1	24.9
53	274,927	2,205,655	971	Phonxay	35	18.5	OF	EF	337				1,097.8				16.8	31.4
54	273,235	2,204,562	986	Phonxay		4.5	OF	EF	358				2,237.7				13.5	43.2
55	271,023	2,204,654	966	Phonxay		18.5	EF	EF	350				1,028.7				14.8	30.5
56	270,635	2,210,340	1,376	Phonxay		18.5	DF	EF	372				2,072.3				12.2	29.1
57	268,695	2,217,337	1,645	Phonxay		18.5	DF	EF	387				1,396.9				13.6	24.1
58	269,967	2,212,758	1,358	Phonxay		18.5	OF	EF	306				1,568.1				13.1	25.4
59	269,819	2,211,104	1,408	Phonxay		17.5	DF	EF	329				1,399.9				13.9	26.5
60	269,925	2,210,835	1,406	Phonxay		17.5	EF	EF	341				850.8				21.5	41.5
61	268,474	2,210,074	1,497	Phonxay		18.5	DF	EF	424				1,274.3				16.7	37.6
62	267,217	2,210,511	1,433	Phonxay		18.5	OF	OF	85				2,122.1				10.1	22.6
63	2,183,200	206,086	862	Xieng Ngur	15+	16.0	DF	DF	0.152	1,149.5	617.1	0.0	1,766.6	10.5	19.8		13.7	30.2
64	2,163,917	209,319	1,098	Xieng Ngur	6-7	7.0	EF	OF	0.152	972.6	48.7	0.0	1,021.3	7.6	19.7		8.2	6.0
65	2,164,030	211,222	1,258	Xieng Ngur	30+	19.0	EF	EF	0.152	530.5	194.9	39.5	764.9	8.8	23.1	42.8	14.2	18.1
66	2,188,017	202,856	395	Xieng Ngur	6-7	19.0	DF	OF	0.152	1,591.5	0.0	0.0	1,591.5	10.7			10.7	15.0
67	2,233,467	266,849	1,041	Pakxeng	-		EF	EF	0.152	1,149.5	211.1	72.3	1,432.9	9.1	23.7	41.5	12.9	28.2
68	2,228,162	243,445	452	Pakxeng	Reseve	19.0	DF	MF	0.152	1,326.3	81.2	6.6	1,414.1	9.0	19.4	43.9	9.8	12.3
69	2,227,829	243,921	375	Pakxeng	Reseve	19.0	DF	MF	0.152	88.4	259.8	39.5	387.7	11.4	27.2	43.2	25.2	22.3
70	2,225,839	236,641	469	Pakxeng	30+		EF	DF	0.152	1,414.7	292.3	0.0	1,707.0	9.7	17.6		11.1	18.7
71	2,232,085	237,802	951	Pakou	20+	19.0	DF	EF	0.152	1,945.2	389.8	19.7	2,354.7	9.8	20.5	39.6	11.8	31.6
72	2,335,584	235,069	557	Pakxeng	8	19.0	DF	OF	0.152	2,122.1	0.0	0.0	2,122.1	8.0			8.0	11.4
73	2,218,847	219,888	440	Pakxeng	10+	19.0	DF	OF	0.152	618.9	146.2	0.0	765.1	8.2	20.4		10.5	8.3
74	2,224,858	232,330	494	Pakxeng	Reserve		EF	DF	0.152	884.2	97.4	46.0	1,027.7	7.0	18.7	58.9	10.5	20.1
75	2,293,049	302,152	519	Phonthong	20+	15.0	DF	EF	0.152	972.6	129.9	6.6	1,109.1	8.4	21.0	38.5	10.0	11.1
76	2,311,869	286,147	1,364	Phonthong	-	11.0	DF	EF	0.152	88.4	308.6	26.3	423.3	13.5	24.5	41.0	23.2	20.2
77	2,305,793	285,546	1,194	Phonthong	-	11.0	DF	EF	0.152	265.3	276.1	65.8	607.1	9.9	20.8	51.8	19.4	27.9
78	2,296,693	286,042	1,186	Phonthong	35	19.0	DF	MF	0.152	353.7	341.0	65.8	760.5	10.8	24.0	48.3	20.0	32.5
79	2,294,755	284,796	1,403	Phonthong	-	19.0	DF	MF	0.152	442.1	178.6	32.9	653.6	11.8	21.1	45.8	16.0	17.1
80	2,294,652	283,071	1,219	Phonthong	80	19.0	DF	EF	0.152	530.5	276.1	111.8	918.4	9.1	22.1	56.3	18.7	45.8

Table 2 *continued*

Plot No.	Coordinates (m in UTM zone48)			District	Age		Veg. type		Plot	Tree density (trees/ha)				Mean dbh (cm)				Basal
	Northing	Easting	Elevation		in situ	Sat.	Sat.	in situ	area	5≤dbh<15	15≤dbh<35	35≤dbh	Total	5≤dbh<15	15≤dbh<35	35≤dbh	Overall	area
81	2,304,440	284,649	1,135	Phonthong	–	19.0	DF	MF	0.152	353.7	454.7	46.0	854.4	8.4	23.1	52.6	18.6	32.7
82	2,249,332	292,105	811	Viengkham	–	2.0	DF	DF	0.152	530.5	308.6	52.6	891.7	9.5	25.2	53.9	17.5	34.3
83	2,252,907	290,212	1,005	Viengkham	30	18.0	EF	MF	0.152	972.6	406.0	6.6	1,385.2	10.1	22.6	35.2	13.9	26.3
84	2,253,158	289,839	987	Viengkham	30	8.0	EF	MF	0.152	265.3	227.4	32.9	525.5	11.2	20.9	51.3	17.9	18.3
85	2,250,750	286,321	1,097	Viengkham	4	9.0	EF	OF	0.152	1,680.0	0.0	0.0	1,680.0	7.7			7.7	8.1
86	2,262,411	283,746	673	Viengkham	4	19.0	DF	OF	0.152	1,237.9	16.2	0.0	1,254.1	8.5	18.0		8.6	8.0
87	2,257,050	287,554	1,140	Viengkham	7	3.0	EF	OF	0.152	2,122.1	81.2	0.0	2,203.3	8.5	16.0		8.8	14.7
88	2,200,631	183,450	432	Chomphet	50+	7.5	DF	DD	0.152	618.9	243.6	0.0	862.5	7.5	23.5		12.0	14.1
89	2,214,381	189,752	631	Chomphet	40	19.5	DF	MF	0.152	530.5	194.9	65.8	791.2	10.8	21.6	43.4	16.2	22.6
90	2,208,235	197,268	444	Chomphet	20	19.5	DF	MF	0.152	2,387.3	259.8	0.0	2,647.2	9.0	17.8		9.8	23.0
91	2,196,111	181,283	427	Chomphet	70+	19.5	DF	DD	0.152	176.8	194.9	52.6	424.3	8.8	23.2	39.7	19.2	16.5
92	2,196,258	180,834	457	Chomphet	50+	19.5	DF	DD	0.152	1,326.3	227.4	19.7	1,573.4	7.2	21.4	47.7	9.8	18.1
93	2,199,852	178,045	512	Chomphet	11	16.5	DF	OF	0.152	530.5	48.7	0.0	579.2	7.4	18.2		8.3	3.6
94	2,154,760	191,996	1,250	Nam	50+	19.5	EF	EF	0.152	0.0	227.4	78.9	306.3		21.8	47.3	28.3	23.4
95	2,156,842	190,627	1,217	Nam	100+	19.5	EF	EF	0.152	1,237.9	292.3	26.3	1,556.5	7.4	18.1	43.4	10.0	17.3
96	2,158,879	185,726	693	Nam	80–90	19.5	DF	EF	0.152	530.5	259.8	52.6	843.0	8.2	20.9	46.6	14.5	22.1
97	2,166,114	807,220	568	Nam	100+	19.5	DF	DF	0.152	353.7	324.8	72.3	750.8	7.8	23.9	41.6	18.0	26.8
98	2,203,277	204,373	313	Luang Prab	40	19.5	OF	DD	0.152	530.5	357.3	6.6	894.4	9.3	22.4	41.5	14.7	19.6
99	2,203,665	194,145	334	Chomphet	20+	2.5	DF	DD	0.152	1,414.7	97.4	0.0	1,512.2	9.7	16.2		10.1	13.2
100	2,206,251	201,081	338	Chomphet	35	19.5	DF	DD	0.152	353.7	194.9	0.0	548.6	10.6	21.9		14.6	10.8
101	2,207,423	200,454	348	Chomphet	40	19.5	DF	DD	0.152	2,298.9	81.2	0.0	2,380.1	8.8	24.2		9.3	19.0
102	2,199,297	188,963	359	Chomphet	50+	19.5	DF	DD	0.152	530.5	276.1	52.6	859.2	6.9	22.5	45.9	14.3	22.4
103	2,209,393	188,878	402	Chomphet	100+	19.5	OF	EF	0.152	442.1	324.8	105.2	872.1	8.3	23.7	62.9	20.6	52.9
104	2,194,512	181,893	345	Chomphet	50	19.5	DF	DD	0.152	176.8	194.9	59.2	430.9	8.8	22.9	41.9	19.7	18.0
105	2,194,933	177,581	434	Chomphet	7–10	19.5	DF	DD	0.152	2,122.1	16.2	0.0	2,138.3	7.7	15.1		7.7	11.0
106	2,225,403	235,869	397	Pakxeng	Reserve	19.0	–	DF	0.152	1,768.4	81.2	78.9	1,928.5	7.5	24.4	74.0	10.9	50.3
107	2,200,291	188,312	341	Chomphet	100	19.5	DF	DD	0.152	0.0	81.2	85.5	166.7		25.6	55.2	40.8	26.3
108	2,207,672	188,234	462	Chomphet	40+	19.5	DF	DD	0.152	353.7	341.0	32.9	727.6	8.8	22.6	37.2	16.6	20.1
109	2,208,152	195,992	381	Chomphet	50+	19.5	DF	MF	0.152	972.6	389.8	72.3	1,434.7	8.1	21.6	43.8	13.5	31.5
110	2,267,973	227,881	737	Namback	40–50	19.5		EF	0.152	0.0	97.4	72.3	169.8		27.1	45.9	35.1	18.3
111	2,276,013	212,886	1,250	Namback	70–80	19.5		EF	0.152	530.5	276.1	39.5	846.1	6.4	23.6	58.3	14.4	25.0
112	2,277,524	215,946	1,038	Namback	50+	19.5		EF	0.152	530.5	178.6	65.8	774.9	9.6	25.6	49.8	16.7	26.6

Appendix 1 Reasons to Exclude Soil Organic Matter from Calculation

1. Abstract

In order to analyze soil carbon dynamics under the land conversion from forest to cropland and/or land use of shifting cultivation which means land use of "reference level" in this project, we reviewed some published scientific literatures.

Murty et al. (20021) reported that, in general, the land conversion from forest to cropland tended to decrease soil carbon over time. That is land use under the reference scenario results in soil carbon decrease and land use under the project activities will result in soil carbon increase compared with reference scenario. In addition, other literatures reported that the soil carbon under the shifting cultivation showed lower carbon contents compared with conserved forest (Chaplot et al., 20102; Wairiu and Lal 20033).

From results mentioned in above, it indicated that soil carbon in land under the project activities does not decrease compared to reference scenario (which is under shifting cultivation). Therefore, it should be in accordance with conservative manner to exclude carbon pool of soil carbon.

This chapter introduces default data provided in the Revised 1996 IPCC Guidelines (1996GL), the Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF), the 2006 IPCC Guidelines (2006GL) and Emission Factor Database.

The IPCC guidelines recommend that country- or site-specific data should be used in estimating greenhouse gas emissions and removals. However, if these data are not available, it is appropriate to use IPCC default data.

2. Results

Detail information of those 3 literatures was mentioned as follows. Each literature was arranged with the topic of Summary, Area / Climate zone, Landscape, Vegetation, and Soil, and showed the result about soil carbon of slash-and-burn land.

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1 Murty D, Kirschbaum MF, McMurtrie RE, McGilvray H (2002) Does conversion of forest to agricultural land change soil carbon and nitrogen? A review of literature. Global Change Biology, 8, 105–123.Wairiu M and Lal R (2003) Soil organic carbon in relation to cultivation and topsoil removal on sloping lands of Kolombangara, Solomon Islands. Soil and Tillage Research, 70, 19–27

2 Chaplot V, Bouahom B and Valentin C (2010) Soil organic carbon stocks in Laos: spatial variations and controlling factors. Global Change Biology, 16: 1380–1393

3 Wairiu M and Lal R (2003) Soil organic carbon in relation to cultivation and topsoil removal on sloping lands of Kolombangara, Solomon Islands. Soil and Tillage Research, 70, 19–27.

2.1 Supplemental information from Muty et al. (2002)

Summary	Reviewed more than 50 study reports.
Area / Climate zone	Mainly tropical area (There was few studies in south-east Asia and no study in Lao PDR)
Landscape	-
Vegetation	-
Soil	-
Result	Most studies mentioned the soil carbon after land conversion from forest to agricultural land was reduced 0-60%. Feature and amount of crop residue influenced on soil carbon after land conversion.

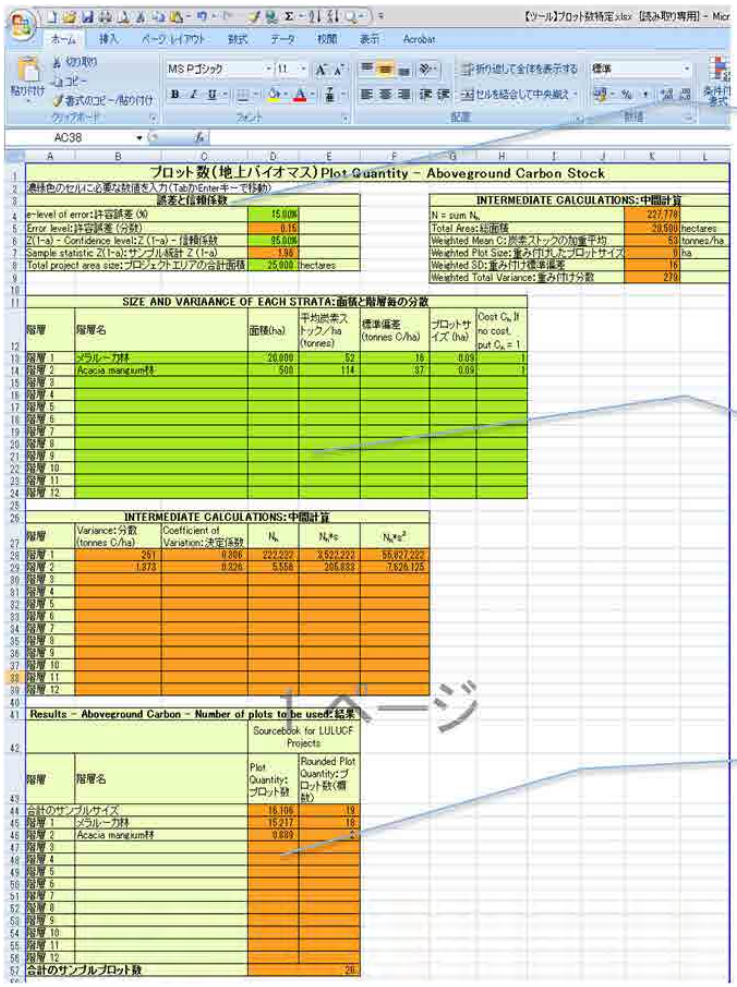
2.2 Supplemental information from Chaplot et al. (2010)

Summary	Measured and compared soil carbon in forest land, slash-and-burn land and agricultural land in overall Lao PDR. Slash-and-burn land was divided 2types with fallow period (less than 5 years or more than 5 years). Effective data plot for analysis was 1,407.
Area / Climate zone	Overall Lao PDR / Tropical rainforest area
Landscape	-
Vegetation	-
Soil	Acrisol (Weathered is occurred by acidity. More than 70% of overall Lao PDR is acrisol land.)
Others	Sample plots were settled in overall Lao PDR based on expert's judgement
Result	Soil carbon (the 0-30cm depth) in slash-and-burn land was decreased around 2.5% compared to forest land.

2.3 Supplemental information from Wairiu and Lal (2003)

Summary	Compared to soil carbon between agricultural land (sweet potato field), which was slashed and burned, and nearby natural forest land. Sample soil survey was done 3 years after the forest was slashed and burned.
Area / Climate zone	Kolombangar, Solomon Islands/ Tropical rainforest area
Landscape	Slope land
Vegetation	Secondary forest was predominantly. Patches of primary forest was remained in lowland on steep slopes.
Soil	Weathered soil (low activity clays was cumulated by weathered)
Result	Soil carbon (the 0-30cm depth) in slash-and-burn land was decreased around 52% compared to natural forest land. Soil carbon with depth, especially the decreasing range in surface soil (the 0-15 cm depth) was large and it was decreased around 60% compared natural forest.

Appendix 2 Tool for Calculating Required Number of Plots Appropriate for Carbon Stock Volume Varying by Forest Type



Input an expected estimation accuracy

Input area, carbon stock volume, standard deviation, and plot size of each forest type.

⇒Situation of the survey area should be taken into account to set the plot size. Likewise, size of each forest type and standard deviation are set based on the analysis results of remote sensing and database respectively.

Based on the input data, necessary number of plots and plot size will be calculated for each forest type.

Appendix 3 Proposal of Forest Classification for the Technical Cooperation Project, 'Capacity Development Project for Establishing National Forest Information System for Sustainable Forest Management and REDD plus'

1. Role of the Project's Field Survey

- In this project, toward to the implementation of REDD plus in Luang Prabang Province in northern Lao PDR, the primary and secondary survey were conducted from March to April of 2012 and from October 2012 to March 2013 respectively, with taking into account status in UNFCCC's negotiations related to forest sector.
- The principal purpose of these surveys was to develop reference levels, which are required to implement REDD plus. To ensure the consistency with the forest management system in Lao PDR, classification was primarily standardized on the FIM classification.

2. Limitations of the Current Forest Areas and Challenges of Satellite Imagery Analysis

- Some field survey results of FIM, a Japan's environmental grant aid and FPP were used to identify forest types by satellite imagery (Table 3). As a result, amongst the forests identified as deciduous broadleaf forests (23 plots in total) by satellite imagery analysis, only 8 plots were actually determined as deciduous broadleaf forests according to the results of the filed survey and the remaining 15 plots were evergreen broadleaf forests. Meanwhile, amongst overall 14 plots of evergreen broadleaf forests, which were classified by satellite imagery analysis, only 13 plots were recognized as evergreen broadleaf forests and the remaining a plot was turned out to be deciduous broadleaf forests[4]. Accordingly, these results revealed that analysis based on FIM forest classification (evergreen broadleaf forest and deciduous broadleaf forest) could only reach about 56.8% of classification accuracy.
- This figure did not meet the analysis accuracy (80%) required by VCS. Moreover, it became clear that FIM's classification, which considers evergreen broadleaf forests and deciduous broadleaf forests as different forest type, cannot identify property of forests in Lao PDR with sufficient accuracy.
- Even if comparing these results with neighbor countries Vietnam and Cambodia, and considering the status of developing forest inventory in Japan, it is not practical to improve the accuracy by using satellite imagery; thus it was suggested to reconsider forest classification itself.
- From the above, it was clarified that it was not practical to adopt the FIM designed forest classification, and therefore, the FIM classification, which was provisionally set out in a customary manner, was required to be reviewed again.

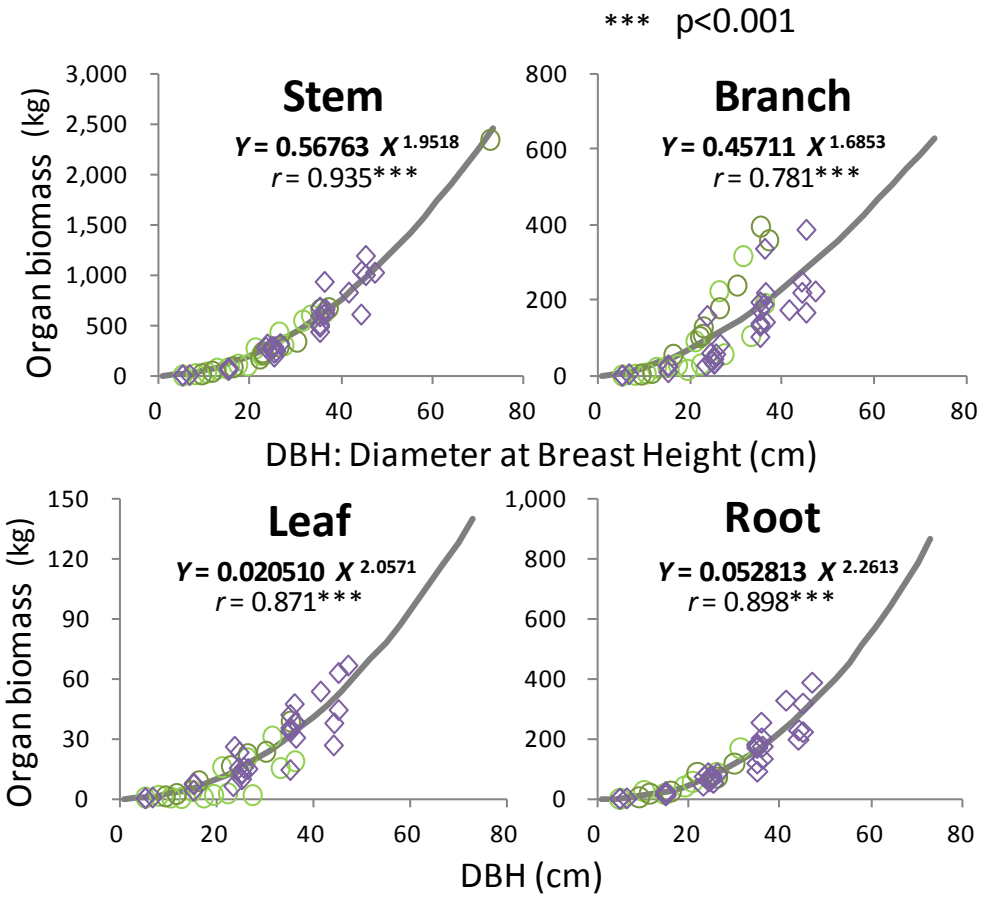
[4] This result was based on the field surveys undertaken by the end of December 2012; however, accuracy of analysis was lower than Table 1 if including the survey result after January 2013 onwards.

Table 3 Accuracy verification of satellite imagery analysis by using field survey results

		Results of field survey		
		Evergreen broadleaf forests	Deciduous broadleaf forests	Mixed evergreen and deciduous broadleaf forests
Results of satellite imagery analysis	Evergreen broadleaf forests	13	1	0
	Deciduous broadleaf forests	15	8	0
	Mixed evergreen and deciduous broadleaf forests	0	0	0

3. Direction for Improvement Derived from Assessment of Carbon Stock Volume

- To calculate biomass of Deciduous Forest (DF) and Evergreen Forest (EF) based on the FIM designed forest type, allometric equations below were developed (Figure 9 and Figure 10). By utilizing the results, it was examined whether there was the difference in carbon stock amount per hectare between DF and EF.



* Light green shows DF. Dark green shows EF. Purple shows Luang Prabang Province and Vietnam DienBien Province where bordered with Luang Prabang.

Figure 9 Allometric relationships between DBH and biomass of each organ

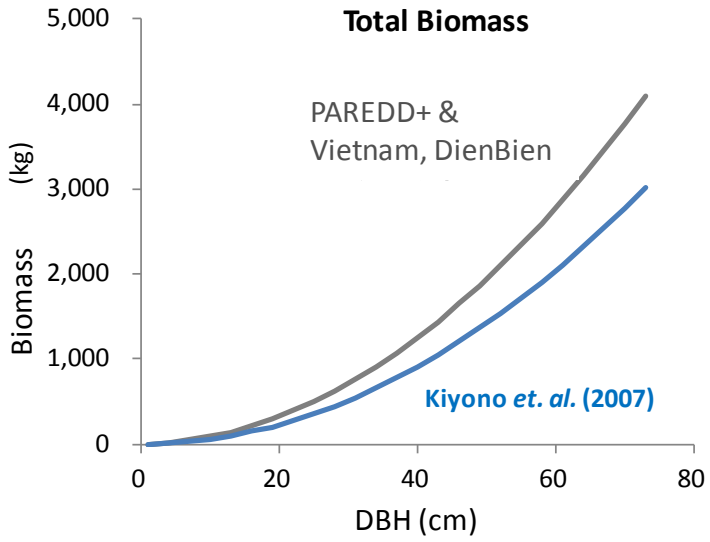
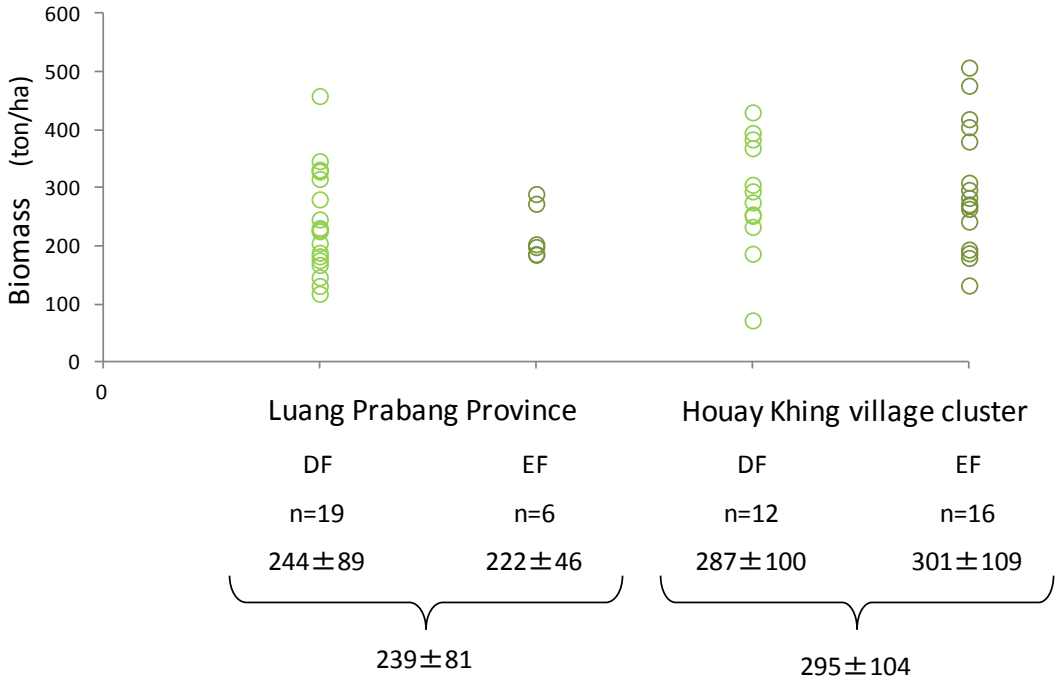


Figure 10 Allometric relationships DBH and total biomass

- All of the allometric equations showed a high correlation when the diameter at breast height was used as the dependent variable. Thus, it enabled to calculate the biomass of DF and EF in overall Luang Prabang Province and the HK-VC by applying these allometric equations.
- The biomass of DF and EF were subsequently calculated for overall Luang Prabang Province as well as the HK-VC using the allometric equations shown above. As a result, it was judged that there was little difference between the two areas in terms of the carbon stock of DF and EF (Figure 11) and therefore it was possible to apply the same allometric equations for both areas. The standard deviation of carbon stock was larger in the HK-VC than in overall Luang Prabang Province, this can be explained with the fact that plots area of overall Luang Prabang Province (1,520 square meters) and Phonsay District (around 350 square meters) are not the same size, and it was thought that it was caused by the difference in survey planning.



The value in this figure shows Average±Standard Deviation (ton/ha)

Figure 11 Result of comparison of biomass between DF and EF

4. Results and Request for the Technical Cooperation Program 'Capacity Development Project for Establishing National Information System for Sustainable Forest Management and REDD plus'

- In implementing the REDD plus project, it is necessary to maintain the analysis accuracy for forest classification at around the 80% level required by international standards. Under this condition, plots for the statistics should be selected randomly in order to quantify the carbon stock in each forest type. However, if the forest classification is too minute, as a result, a larger number of survey plots must be

selected so that there is a plot for all the forest types. If the concept of forest classification suggested by FIM is adopted, more than 15,000 plots are required for overall Lao PDR. This is substantially larger than the number of plots used in other cases in Southeast Asia (around 4,000 in Vietnam and around 2,500 in Indonesia), which is a source of concern as it would require a significant amount of cost and labor. Thus, it was concluded that it is necessary to redesign the forest classification method by accurately understanding the characteristics of forests in Lao PDR.

- The carbon stock in each forest type is an extremely important piece of information not only for the REDD plus project but also for forestry policies regarding timber production, etc. In the forest classification method suggested by FIM, the types of forests were minutely classified. It was revealed, however, that there is little difference in carbon stock (≒ commercial volume) among multiple types of forests[5]. Therefore, it was concluded that minute classification is unnecessary even for timber production.
- Based on the above fact, the project team suggested at "the fourth REDD plus support strategy meeting" held on February 1, 2013 that the forest classification method shown in Table 4 below is desirable for adoption in other projects, such as other projects of FIM, in the times ahead[6].

Table 4 Relation between suggested tentative forest classification based on our filed survey and tentative forest classification by FIM

Forest classification based on our field survey result (tentative) ⇒Corresponded large classification	Forest classification (tentative) designed by FIM ⇒Corresponded small/middle classification segmentalized depend on the case/utilization in each region	Remarks
Mixed Forest (Class name should be considered with Lao government)	Evergreen Forest	Corresponding to FIM's classification: EF /DF / MED / CF are arbitrarily integrated/segmentalized based on regional charactaristics.
	Deciduous Forest	
	Mixed Evergreen /Deciduous Forest	
	Coniferous Forest	
	Mixed Coniferous /Broadleaved Forest	
Dry Dipterocarp Forest	Dry Dipterocarp Forest	→Under consideration: it'll be based on the survey result by our project(implemeted on Mar. 2013)
Plantation Forest	Evergreen Forest Plantation	→Considered safeguard
	Deciduous Forest Plantation	
Bamboo	Bamboo	
Fallow Land	Old Fallow Land	
	Young Fallow Land	
Slash and Burn Land	Slash and Burn Land	

5 The results of this project were derived from Luang Prabang Province and its neighboring areas. Even if carbon stock volume of each forest type in different areas differs, it can be fully handled by sorting middle classification in more detail.

6 Designing forest type in Lao PDR will affect future support to forest sector implemented by JICA or Japanese Government. For this reason, our project suggested tentative outline of forest type based on discussion with FSCAP.

5. Supplement (Role of Forest Inventory)

The technical cooperation project 'Capacity Development Project for Establishing National Forest Information System for Sustainable Forest Management and REDD plus' has been working on forest inventory (developing national forest monitoring system). Forest inventory is closely related to GHG emission inventory of forest sector, which will be reported in BUR 2014 onwards and submitted to the UNFCCC by the Government of Lao PDR. For this reason, forest inventory is supposed to play a role not only for REDD plus or as just a forest inventory but also as a forest management system in forest sector.

To establish a national forest monitoring system in accordance with the UNFCCC, discussions about reporting method considering safeguards and so forth have been held. Therefore, the structure of Post- FIM has to be flexibly designed with due consideration of these international discussions.

Appendix 4 Appearance of Forest Plot Survey

Plot sampling survey
(Feb 2013, Luangprabang district)

Plot sampling survey
(Feb 2013, Luangprabang district)

Plot sampling survey
(Feb 2013, Chomphet district)

Plot sampling survey
(Feb 2013, Chomphet district)

Plot sampling survey
(Feb 2013, Nambak district)

Plot sampling survey
(Feb 2013, Nambak district)

	
Plot sampling survey (Feb 2013, Nane district)	Plot sampling survey (Feb 2013, Nane district)

Validation and Registration of the Project on REDD plus through Participatory Land and Forest Management for Avoiding Deforestation in Lao PDR

Technical Cooperation Report
- Destructive Sampling Survey -

October 2014

Japan International Cooperation Agency (JICA)

Mitsubishi UFJ Research and Consulting

Japan Forest Technology Association

Validation and Registration Project on REDD plus through Participated Land and Forest Management for Avoiding Deforestation in Lao PDR

Technical Cooperation Report
- Destructive Sampling Survey -

- Contents -

Chapter 1 Objective

This study was developing reference levels for overall Luang Prabang Province and Houay Khing village cluster (HK-VC) in Phonsay District. To develop reference levels, it is required to estimate changes in carbon stock of each forest type by multiplying changes in area size of each forest type, which was obtained through satellite imagery analysis (*see* Technical Cooperation Report - *Analysis Results of Forest Dynamics* - for more detail), by carbon stock per hectare of each forest type (i.e. emission factors determined in this project) (Figure 1). As a result, increase or decrease in carbon stock (emission or removal) can be estimated when the area of forest type in the target area changes, and that trend is to be the basis of calculating reference level.

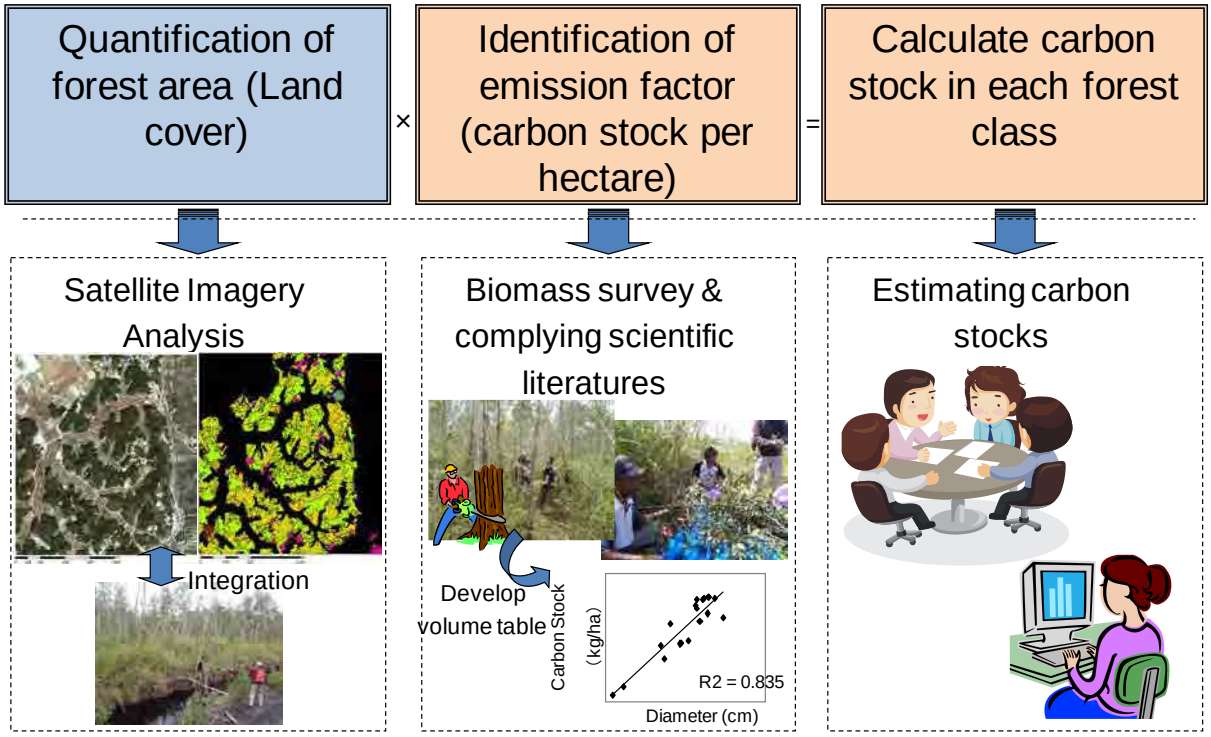


Figure 1 Flow of calculating carbon stock in each forest type

Accordingly, amongst factors of carbon sequestration in forests, emission factor is, in a narrow sense, subdivided into stem volume, conversion factor from stem volume to biomass, and conversion factor from stem biomass to branch and leaf biomass (expansion factor), while it refers to carbon stock per area of each forest type. From the both narrow and broad definition perspectives, it is necessary to quantify the carbon stocks in each forest type; therefore, this study conducted forest plot survey.

To develop reference levels, following three Technical Cooperation Reports were utilized: Technical Cooperation Report "Analysis Results of Forest Dynamics", Technical Cooperation Report "Results of Forest Plot Survey", and this report Technical Cooperation Report "Results of Destructive Sampling Survey". Figure 2 below describes the relationships of these three reports. The reference levels obtained through these three Technical Cooperation Reports were reported in the Final Report in this study.

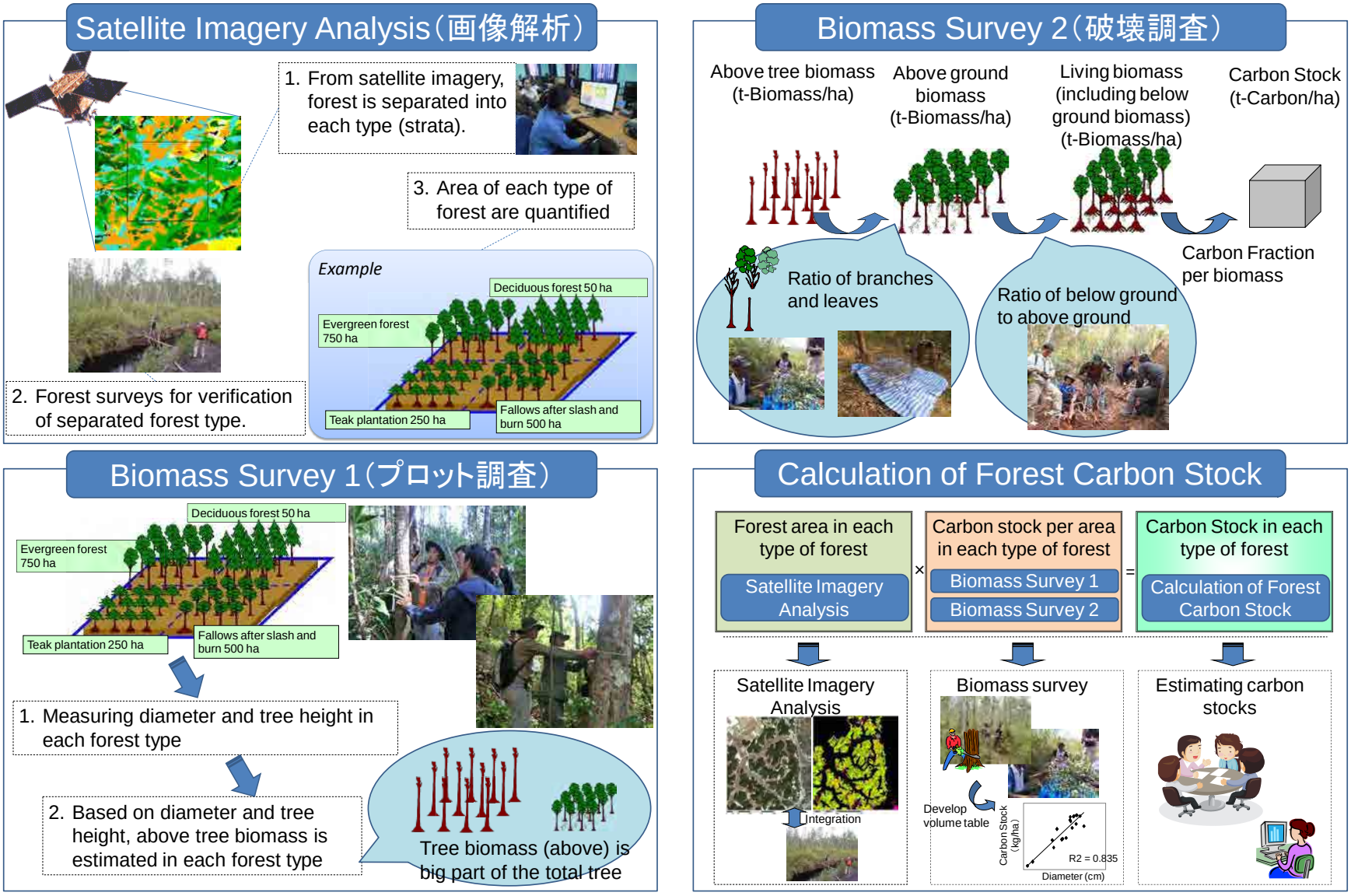


Figure 2　Relationships of Technical Cooperation Reports

Chapter 2 Methodologies

1. Target area

As described above, this study aimed to develop reference levels for overall Luang Prabang Province and HK-VC in Phonsay District, surveys had to be undertaken in average forests of Luang Prabang Province. For this reason, based on results of satellite imagery analysis, which was conducted to prepare Technical Cooperation Report "Results of Forest Dynamics Analysis", as well as ground truth undertaken for the analysis, forests locate at an altitude of about 700m in HK-VC, Phonsay District, Luang Prabang Province, were set as the target area.

Although target area was preferred to be selected from across the whole Luang Prabang Province, it was decided because HK-VC locates roughly in the center of the Province and at average altitude and permission for sampling trees as well as support from the Province, district and university was available.

2. Carbon pools subjected to be measured in each forest type

Carbon pools measured in this study can be divided into five categories based on the IPCC's definition (Figure 3); however, this study measured the two carbon pools, namely above-ground biomass (stems and branches) and below-biomass (roots). Other carbon pools, namely dead trees, fallen branches and leaves, and soil organic carbon, were excluded from the target.

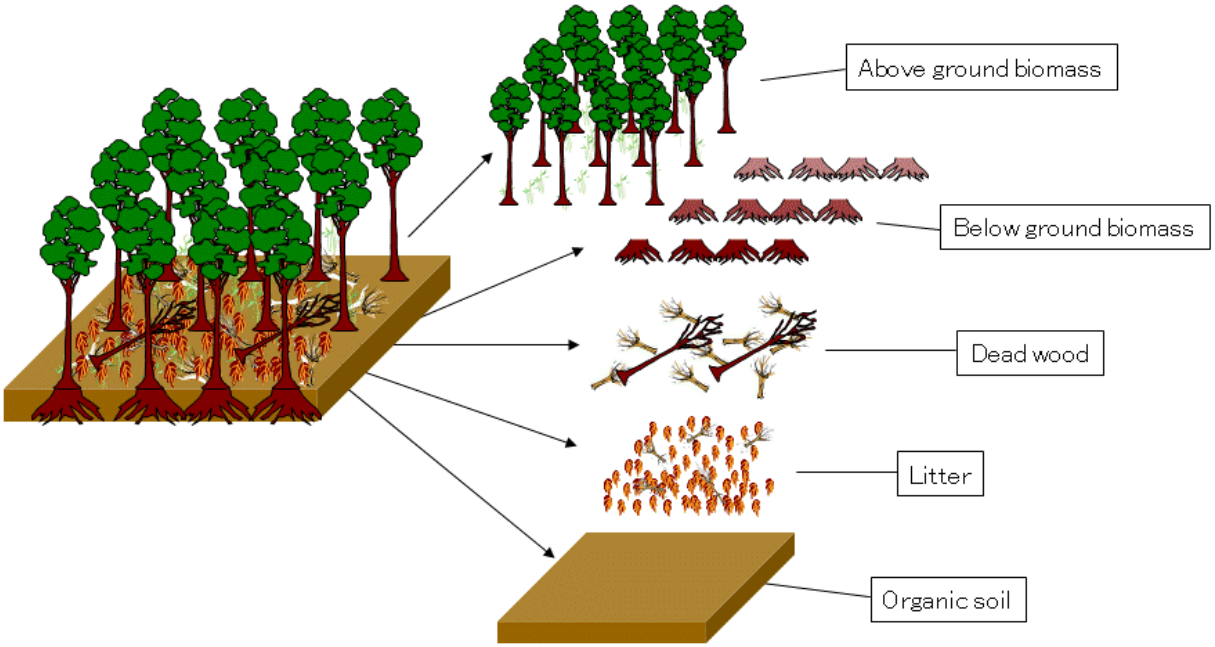


Figure 3 Five carbon pools in forests

Even if forest type is changed by anthropogenic effects, the amount of carbon emissions or removals by dead trees, and fallen branches and leaves is small, and past researches also revealed that soil organic

carbon cannot be a significant emission factor if human activities such as shifting cultivation are occurred. For this reason, these pools were excluded (*see* Appendix 1 of Technical Cooperation Report "Results of Plot Survey" for more detail).

3. Target trees of destructive sampling survey

To develop emission factors, Deciduous Forest (DF) and Evergreen Forest (EF), which account for most of the forest area in the target area, were the subject of destructive sampling survey. Destructive sampling survey is to develop biomass formulae for the respective organs of the trunk, branches, and roots of the trees dominant in the research areas, using the breast height diameter as an independent variable. Preferably, target trees would cover major species, which measured in plot survey (Technical Cooperation Report "Results of Plot Survey"), ranging from the smallest to the largest in individual size. The trees were cut down and measured in their respective organs of trunk, branches, and roots.

Selected trees were identified and recorded its species and type either evergreen or deciduous. Overall 39 trees were selected and trunk biomass of the all trees was measured because trunk accounts for most of the biomass. Meanwhile, compared to trunk, branch, leaf and root have less proportion of biomass, but need much labor and time. For this reason, this study measured branch, leaf and root biomass of 28, 23 and 15 trees respectively.

4. Method of biomass calculation for each target tree

The carbon stock of stem can be estimated by multiplying estimated tree volume by dry weight ratio, based on partially obtained stem dry samples. Procedure of biomass estimation was as follows.

1. To estimate stem biomass, trees were cut into sections of 1 m in length (cross cutting) and measured in diameter at both ends, and then the average value of the square measurements at both ends was multiplied by the length of a section to obtain the volume of the section (i.e. smalian equation). As to the treetop section most distant from the roots, the section volume was obtained using the formula to calculate the volume of triangular pyramids.
2. The organ biomass of branches and roots were calculated from their live weights multiplied by the respective volume densities, which were obtained by dividing the absolute dry weights of their dried test pieces separately prepared by their live weights.
3. As to the trees of large diameter, it was preferable to use the trees already cut down by villagers before they burnt the forests and the roots dug up with heavy machines during road expansion work. Cutting down large-diameter trees just for research purposes was difficult for the district officers to permit and difficult for the villagers to accept.

To estimate dry weight ratio, each organ was sampled, measured its weight, dried to constant weight at 80°C, and then dry weight ratio was measured. Mass per unit volume of stem and ratio of stem biomass to branch, leaf, and root (expansion factor) were derived from the dry weight ratio (Figure 4).

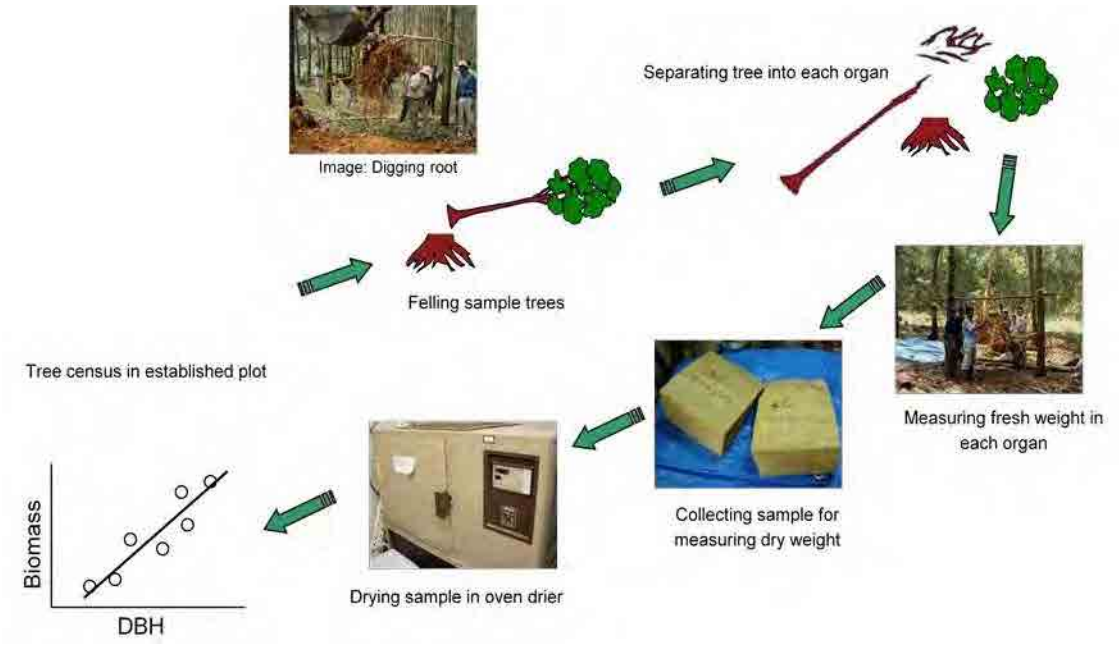


Figure 4 Method for estimating biomass of each organ

5. Developing allometric equation

Breast height diameter of each sample tree and biomass of stem, branch and root were gained from the results of the sampling survey. By using these data, biomass formulae of trunk, branch, and root, with having breast height diameter as independent variable, were developed. Allometric equation is expressed as below.

$B = a \times D^b$ .....Formula 1

B = Biomass of each organ (kg)
D = Breast height diameter (cm)

Chapter 3 Results

1. Analysis result of sample trees

Table 1 shows the property of sample trees. The smallest diameter at breast height was 5.0 cm while largest was 115.0 cm, and trees of its diameter, ranging from small to large, were recorded in a balanced manner. Although local names of the all sample trees were recorded, only half of their scientific names were identified. Hence, identifying tree species remains an issue.

Comparing DBH and tree height, samples are not so tall despite of its large DBH. It seems to be caused by geographic factor observed in mountainous region, but, it may not cause any issue because that was commonly seen, on one level or another, in most of the target areas.

The mass per unit volume of dry sub-samples was 0.54 – 0.86 g/cm^3, and dry weight ratio of branch, leaf and root was 0.44 – 0.81 g/g, 0.38 – 0.69 g/g, and 0.40- 0.63 g/g respectively. There is a little difference from the popular value showed in IPCC guideline (2006), and therefore, it indicated that these values were fully applicable.

Table 1 Property of sample trees

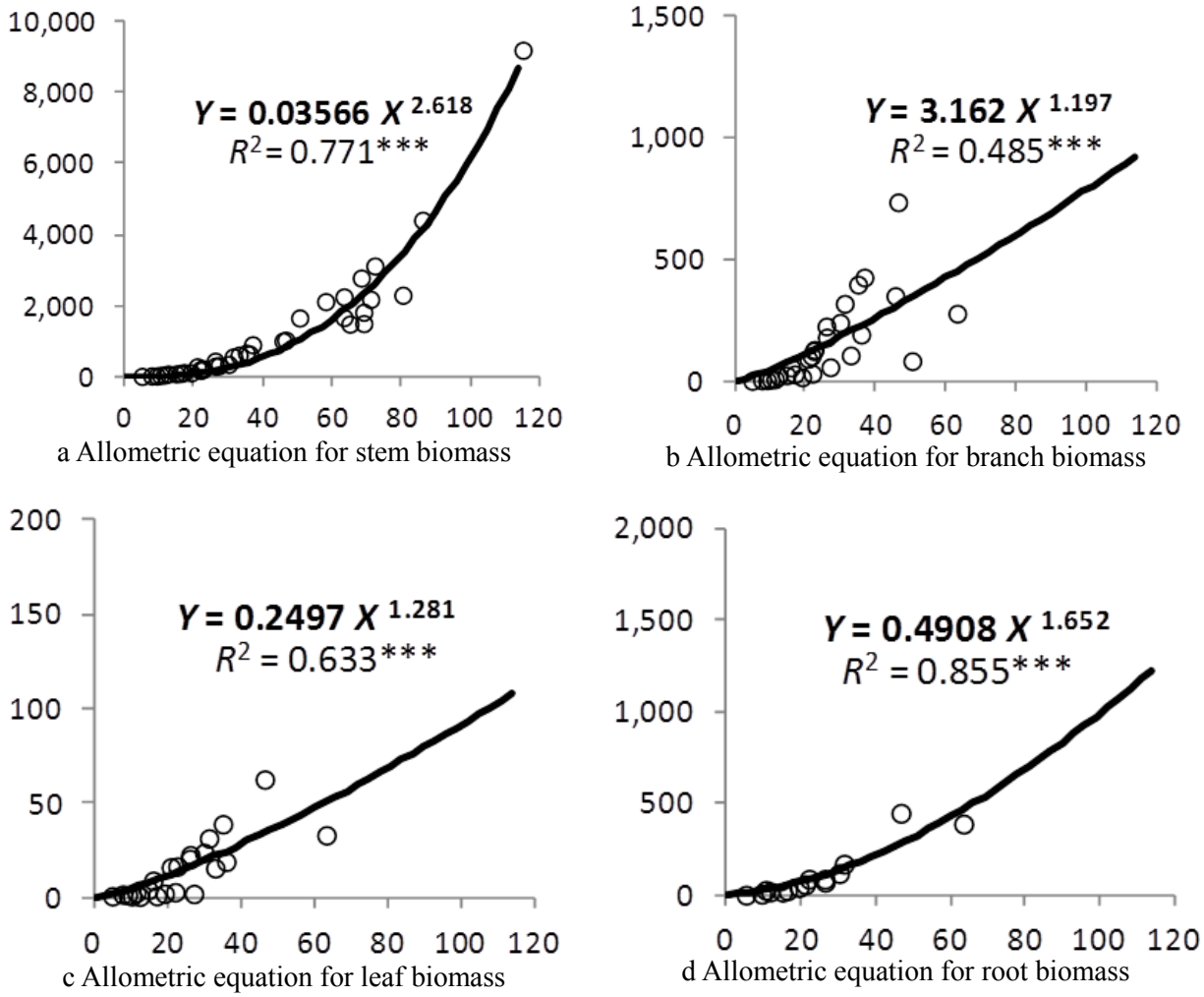
Species		Evergreen/ Deciduous	dbh	height	Stem Volume	Green weight(kg)			Subsamples				Biomass (kg)			
Local	Scientific					Branch	Leaf	Root	Stem bulk density	Weight ratio (g/g)			Stem	Branch	Leaf	Root
			(cm)	(m)	(m^3)				(g/cm^3,ton/m^3)	Branch	Leaf	Root				
Mai Tao		D	5.0	5.80	0.008	2.4	1.8	2.4	0.659	0.59	0.44	0.49	5.1	1.4	0.8	1.2
Salaphid Kham		D	7.8	10.79	0.031	5.0	3.6		0.565	0.63	0.47		17.6	3.2	1.7	
Kor Khee Mu	*Lithocarpus silvicolarum*	E	9.2	7.50	0.024	7.0	2.9	11.3	0.677	0.55	0.49	0.56	16.6	3.8	1.4	6.4
Kor Nung Xang	*Quercus vestita* Rehd. & Wils	D	10.3	9.36	0.046	11.8	1.5	44.0	0.740	0.57	0.56	0.62	33.8	6.7	0.8	27.2
Kor Khee Mu	*Lithocarpus silvicolarum*	E	11.5	10.86	0.058	16.0	5.5	30.9	0.719	0.52	0.47	0.60	42.0	8.3	2.6	18.5
Kor Khee Mu	*Lithocarpus silvicolarum*	E	12.5	11.85	0.102	35.9	1.0		0.704	0.60	0.59		72.0	21.4	0.6	
Kor Nung Xang	*Quercus vestita* Rehd. & Wils	D	14.8	11.53	0.920	42.3	7.1	28.4	0.789	0.57	0.58	0.62	73.0	24.0	4.1	17.5
Mai Kor Kibe	*Castanopsis ceracantha* Hick. et A.Camus	E	16.1	12.40	0.121	87.8	14.1	44.6	0.718	0.64	0.64	0.57	86.9	56.1	9.0	25.3
Mai Mee Kai		D	17.1	15.70	0.167	50.4	1.8		0.674	0.56	0.49		112.7	28.4	0.9	
Mai Mee Kai		D	19.2	13.50	0.189	33.4	4.8	104.9	0.557	0.48	0.45	0.40	105.2	16.1	2.1	42.2
Mi Kor Kak	*Castanopsis ceracantha* Rehder & Wils	E	20.9	18.00	0.326	143.2	25.0	95.5	0.842	0.64	0.64	0.61	274.3	91.9	16.0	58.0
Mai Koh Douey	*Castanopsis argyrophylla*	E	21.9	17.00	0.271	137.7		157.8	0.641	0.75		0.56	173.7	102.9		87.7
Mai Mee Kai		D	22.1	18.10	0.336	56.5	5.1		0.627	0.54	0.57		210.6	30.7	2.9	
Mai Koh Douey	*Castanopsis argyrophylla*	E	22.5	15.80	0.327	208.9			0.627	0.59			204.9	124.1		
Mai Koh Douey	*Castanopsis argyrophylla*	E	22.7	17.16	0.354	235.4	34.0		0.608	0.55	0.49		215.3	128.8	16.5	
Mi Kor Kak	*Castanopsis ceracantha* Rehder & Wils	E	26.1	18.30	0.502	339.4	30.8	145.0	0.861	0.66	0.67	0.60	431.6	224.7	20.5	87.3
Mai Koh Douey	*Castanopsis argyrophylla*	E	26.2	18.30	0.472	321.6	43.6	130.7	0.621	0.56	0.52	0.55	293.3	179.6	22.5	72.0
Mai Mee Kai		D	27.2	16.10	0.494	106.0	3.8		0.619	0.54	0.53		306.0	57.5	2.0	
Mai Koh Douey	*Castanopsis argyrophylla*	E	30.0	16.19	0.573	430.8	53.5	235.3	0.635	0.56	0.44	0.50	341.1	239.7	23.7	118.6

Table 1 Property of sample trees (*Continued*)

Species		Evergreen/ Deciduous	dbh	height	Stem Volume	Green weight(kg)			Subsamples				Biomass (kg)			
Local	Scientific					Branch	Leaf	Root	Stem bulk density	Weight ratio (g/g)			Stem	Branch	Leaf	Root
			(cm)	(m)	(m^3)				(g/cm^3,ton/m^3)	Branch	Leaf	Root				
Mi Kor Kak	*Castanopsis ceracantha* Rehder & Wils	E	31.3	18.95	0.680	468.6	45.7	269.1	0.809	0.68	0.69	0.63	550.1	317.6	31.3	169.8
Mai Mee Kai		D	33.0	24.88	0.979	187.2	27.6		0.613	0.56	0.56		600.6	105.7	15.6	
Mai Koh Douey	*Castanopsis argyrophylla*	E	35.1	22.80	1.047	705.0	76.7		0.630	0.56	0.51		659.9	396.0	38.8	
Mai Mee Kai		D	36.0	25.53	0.999	346.7	29.5		0.631	0.55	0.64		630.2	191.2	19.0	
Mai Koh Khek		E	36.9	20.20	1.065	643.5			0.837	0.66			891.8	425.1		
Mai Mee Kai		D	45.7	25.86	1.839	550.0			0.542	0.63			996.2	349.2		
Mai Kor Lin		D	46.5	21.45	1.627	1338.7	134.9	810.7	0.627	0.55	0.46	0.55	1,021.1	733.6	62.4	447.6
Mai Mee Kai		D	50.5	26.30	2.265	101.3			0.727	0.81			1,645.9	82.4		
Kor Khee Mu	*Lithocarpus silvicolarum*	E	58.0	28.00	3.009				0.700				2,106.2			
Mai Kor San		E	63.3	24.80	4.001	625.9	87.5	910.4	0.559	0.44	0.38	0.43	2,238.3	277.0	33.0	388.6
Mai Koh Khek	*Castanopsis ceracantha* Rehder & Wils	E	63.3	19.49	1.980				0.837				1,657.7			
Mai Mee Kai		D	65.0	18.27	2.363				0.624				1,473.9			
Mai Mee Kai		D	68.3	29.30	4.438				0.624	0.54			2,767.4			
Mai Mee Kai		D	69.0	21.55	2.388				0.624				1,489.4			
Mai Mee Kai		D	69.0	18.60	2.898				0.624				1,807.1			
Kor Khee Mu	*Lithocarpus silvicolarum*	E	71.0	20.40	3.097				0.700				2,168.2			
Mai Kor Kheng	*Lithocarpus silvicolarum(King)Rehd. et wils.*	E	72.2	22.10	3.711				0.837				3,107.0			
Mai Koh Douey	*Castanopsis argyrophylla*	E	80.3	16.80	3.644				0.627				2,285.4			
Mai Hai		?	86.0	34.50	6.563				0.669				4,390.7			
Mai Wa		?	115.0	31.60	13.672				0.671				9,169.8			

2. Developed allometric formulae

Allometric formulae developed based on the above described analysis results (biomass formulae of stem, branch, and root, with breast height diameter assigned as independent variable) were showed below (Figure 5).



a Allometric equation for stem biomass

b Allometric equation for branch biomass

c Allometric equation for leaf biomass

d Allometric equation for root biomass

Note: In the figure, *** shows significance level of 0.1 % and means statistically significant

Figure 5 Regression of trunk, branch, leaf and root biomass on DBH

Stem, as an independent variable, showed wide range of breast height diameter; hence its high correlation delivered a good regression model. Meanwhile, the largest diameter of branch, leaf and root were smaller than that of stem, and power exponents were slightly smaller; however, these also showed good regressions. The fluctuation of branch biomass was a bit large, but it was considered due to the ways of branch splits and its identification particularly occurred by broadleaf trees. When biomass of stem and branch were combined, regression quality was statistically improved, but it caused inconvenience such as making it unable to estimate expansion factor. For this reason, in this research, allometric equations of each organ were developed.

Table 1 includes the biomass estimated by the allometric equations showed in Figure 5. These results indicated that, as breast height diameter became larger, organ biomass increased while below-ground biomass against above-ground expansion factor and above-ground biomass decreased. These trend and value were consistent with IPCC Emission Factor Database (*see* Appendix 1).

3. Dynamics of carbon stock volume in the target area

The allometric equations developed in this survey could estimate carbon stock volume of each forest type by using the results of respectively undertaken plot survey (Technical Cooperation Report "Results of sampling survey"), and furthermore, chronological changes in carbon stock were estimated by using the analysis results of changes in forest area of each forest type (Technical Cooperation Report "Analysis Results of Forest Dynamics"). The dynamics of carbon stock revealed by the three Technical Cooperation Reports was showed in Figure 6.

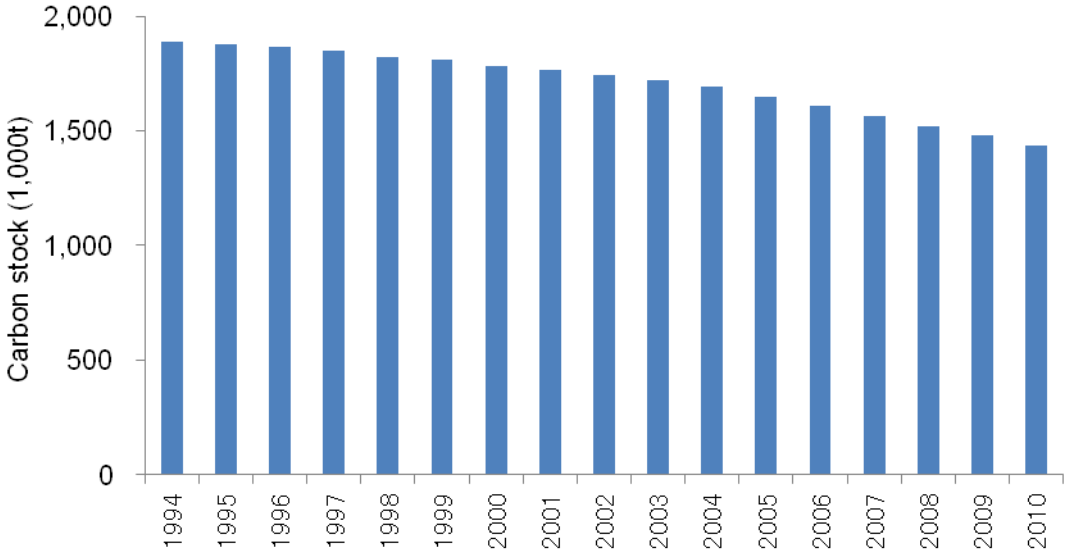


Figure 6 Dynamics of carbon stock in the target area

Appendix 1 Organizing and analyzing IPCC default data

IPCC guidelines for estimating greenhouse gas emissions and removals (Revised 1996 IPCC Guidelines, Good Practice Guidance for Land Use, Land-Use Change and Forestry, and 2006 IPCC guidelines) and organized parameters in the Emission Factor Database were selected and analyzed. Essentially, site-specific data gained in the target area is supposed to be used to set out parameters for the estimation; however, it is recommended to use IPCC default data in case organizing data is difficult. In the tables below, following abbreviations were used.

1996GL: Revised 1996 IPCC Guidelines
GPG-LULUCF: Good Practice Guidance for Land Use, Land-Use Change and Forestry
2006GL: IPCC 2006 Guideline

1. Biomass stocks

1.1 Above-ground biomass

1.1.1 Total forests

Domain		Ecological zone	Unit	Data	References
Tropical Asia	Continental	Tropical rain forest	[t-dm/ha]	225.0	1996GL (V3, Chp5, Table 5-4)
		Tropical moist deciduous forest	[t-dm/ha]	185.0	1996GL (V3, Chp5, Table 5-4)
		Tropical dry forest	[t-dm/ha]	100.0	1996GL (V3, Chp5, Table 5-4)
		Tropical shrubland	[t-dm/ha]	75.0	1996GL (V3, Chp5, Table 5-4)
		Tropical mountain system	[t-dm/ha]	190.0	1996GL (V3, Chp5, Table 5-4)
	Insular	Tropical rain forest	[t-dm/ha]	275.0	1996GL (V3, Chp5, Table 5-4)
		Tropical moist deciduous forest	[t-dm/ha]	175.0	1996GL (V3, Chp5, Table 5-4)
		Tropical dry forest	[t-dm/ha]	-	1996GL (V3, Chp5, Table 5-4)
		Tropical shrubland	[t-dm/ha]	-	1996GL (V3, Chp5, Table 5-4)
		Tropical mountain system	[t-dm/ha]	255.0	1996GL (V3, Chp5, Table 5-4)
Lao RDR		-	[m3/ha]	29.0	GPG-LULUCF (Chp3, Table 3A.1.4)
			[t-dm/ha]	31.0	GPG-LULUCF (Chp3, Table 3A.1.4)

1.1.2 Natural forests

Domain		Ecological zone	Unit	Data	References
Tropical		Tropical rain forest	[t-dm/ha]	300.0	2006GL (V4, Chp4, Table 4.12)
		Tropical moist deciduous forest	[t-dm/ha]	180.0	2006GL (V4, Chp4, Table 4.12)
		Tropical dry forest	[t-dm/ha]	130.0	2006GL (V4, Chp4, Table 4.12)
		Tropical shrubland	[t-dm/ha]	70.0	2006GL (V4, Chp4, Table 4.12)
		Tropical mountain system	[t-dm/ha]	140.0	2006GL (V4, Chp4, Table 4.12)
Tropical Asia	Continental	Tropical rain forest	[t-dm/ha]	280.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
		Tropical moist deciduous forest	[t-dm/ha]	180.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
		Tropical dry forest	[t-dm/ha]	130.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
		Tropical shrubland	[t-dm/ha]	60.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
		Tropical mountain system (R>1000)	[t-dm/ha]	220.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
	Insular	Tropical rain forest	[t-dm/ha]	350.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
		Tropical moist deciduous forest	[t-dm/ha]	290.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
		Tropical dry forest	[t-dm/ha]	160.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
		Tropical shrubland	[t-dm/ha]	70.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)
		Tropical mountain system (R>1000)	[t-dm/ha]	360.0	2006GL (V4, Chp4, Table 4.7), GPG-LULUCF (Chp3, Table 3A.1.2)

1.1.3 Plantations

Domain	Ecological zone		Unit	Data	References
Tropical	Tropical rain forest		[t-dm/ha]	150.0	2006GL (V4, Chp4, Table 4.12)
	Tropical moist deciduous forest		[t-dm/ha]	120.0	2006GL (V4, Chp4, Table 4.12)
	Tropical dry forest		[t-dm/ha]	60.0	2006GL (V4, Chp4, Table 4.12)
	Tropical shrubland		[t-dm/ha]	30.0	2006GL (V4, Chp4, Table 4.12)
	Tropical mountain system		[t-dm/ha]	90.0	2006GL (V4, Chp4, Table 4.12)
Tropical Asia	Broadleaf	Tropical rain forest	[t-dm/ha]	220.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
		Tropical moist deciduous forest	[t-dm/ha]	180.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
		Tropical dry forest	[t-dm/ha]	90.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
		Tropical shrubland	[t-dm/ha]	40.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
		Tropical mountain system	[t-dm/ha]	150.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
	Other species	Tropical rain forest	[t-dm/ha]	130.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
		Tropical moist deciduous forest	[t-dm/ha]	100.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
		Tropical dry forest	[t-dm/ha]	60.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
		Tropical shrubland	[t-dm/ha]	30.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)
		Tropical mountain system	[t-dm/ha]	80.0	2006GL (V4, Chp4, Table 4.8), GPG-LULUCF (Chp3, Table 3A.1.3)

1.2 Dead organic matter

Pool	Climate/Forest type		Unit	Data	References
Dead wood	Tropical		[t-dm/ha]	18.2	GPG-LULUCF (Chp3, Table 3.2.2)
Litter	Tropical	Broadleaf deciduous	[t-C/ha]	2.1	2006GL (V4, Chp2, Table 2.2)
		Needleleaf evergreen	[t-C/ha]	5.2	2006GL (V4, Chp2, Table 2.2)

1.3 Soils

The soil carbon stocks are estimated based on multiplying the reference carbon stocks by stock change factors.

1.3.1 Reference carbon stocks

Climate region	Soil type	Unit	Data	References
Tropical - Wet	HAC soils	[t-C/ha]	44	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	LAC soils	[t-C/ha]	60	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Sandy soils	[t-C/ha]	66	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Volcanic soils	[t-C/ha]	130	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Wetland soils	[t-C/ha]	86	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
Tropical - Moist	HAC soils	[t-C/ha]	65	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	LAC soils	[t-C/ha]	47	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Sandy soils	[t-C/ha]	39	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Volcanic soils	[t-C/ha]	70	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Wetland soils	[t-C/ha]	86	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
Tropical - Dry	HAC soils	[t-C/ha]	38	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	LAC soils	[t-C/ha]	35	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Sandy soils	[t-C/ha]	31	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Volcanic soils	[t-C/ha]	50	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Wetland soils	[t-C/ha]	86	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
Tropical - Montane	HAC soils	[t-C/ha]	88	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	LAC soils	[t-C/ha]	63	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Sandy soils	[t-C/ha]	34	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Volcanic soils	[t-C/ha]	80	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)
	Wetland soils	[t-C/ha]	86	2006GL (V4, Chp2, Table 2.3), GPG-LULUCF (Chp3, Table 3.2.4)

1.3.2 Stock change factors

1）Land use

Land-use category	Level	Temperature regime	Moisture regime	Data	References
Forest land	-	-	-	1.00	2006GL (V4, Chp4, Page 4.25)
Cropland	Long-term cultivated	Tropical	Dry	0.58	2006GL (V4, Chp5, Table 5.5)
			Moist/Wet	0.48	2006GL (V4, Chp5, Table 5.5)
		Tropical montane	-	0.64	2006GL (V4, Chp5, Table 5.5)
	Paddy rice	All	Dry and Moist/Wet	1.10	2006GL (V4, Chp5, Table 5.5)
	Perennial/Tree crop	All	Dry and Moist/Wet	1.00	2006GL (V4, Chp5, Table 5.5)
	Set aside (<20yr)	Temperate/Boreal and Tropical	Dry	0.93	2006GL (V4, Chp5, Table 5.5)
			Moist/Wet	0.82	2006GL (V4, Chp5, Table 5.5)
		Tropical montane	-	0.88	2006GL (V4, Chp5, Table 5.5)
Grassland	All	All		1.00	2006GL (V4, Chp6, Table 6.2)
Settlements	All	All		1.00	2006GL (V4, Chp4, Page 4.40)

2）Input

Land-use category	Level	Temperature regime	Moisture regime	Data	References
Forest land	-	-	-	1.00	2006GL (V4, Chp4, Page 4.25)
Cropland	Low	Tropical	Dry	0.95	2006GL (V4, Chp5, Table 5.5)
			Moist/Wet	0.92	2006GL (V4, Chp5, Table 5.5)
		Tropical montane	-	0.94	2006GL (V4, Chp5, Table 5.5)
	Medium	All	Dry and Moist/Wet	1.00	2006GL (V4, Chp5, Table 5.5)
	High without manure	Temperate/Boreal and Tropical	Dry	1.04	2006GL (V4, Chp5, Table 5.5)
			Moist/Wet	1.11	2006GL (V4, Chp5, Table 5.5)
		Tropical montane	-	1.08	2006GL (V4, Chp5, Table 5.5)
	High without manure	Temperate/Boreal and Tropical	Dry	1.37	2006GL (V4, Chp5, Table 5.5)
			Moist/Wet	1.44	2006GL (V4, Chp5, Table 5.5)
		Tropical montane	-	1.41	2006GL (V4, Chp5, Table 5.5)
Grassland	Medium	All		1.00	2006GL (V4, Chp6, Table 6.2)
	High	All		1.11	2006GL (V4, Chp6, Table 6.2)
Settlements	All	All		1.00	2006GL (V4, Chp4, Page 4.40)

3）Management

Land-use category	Level	Temperature regime	Moisture regime	Data	References
Forest land	-	-	-	1.00	2006GL (V4, Chp4, Page 4.25)
Cropland	Tillage (Full)	All	Dry and Moist/Wet	1.00	2006GL (V4, Chp5, Table 5.5)
	Tillage (Reduced)	Tropical	Dry	1.09	2006GL (V4, Chp5, Table 5.5)
			Moist/Wet	1.15	2006GL (V4, Chp5, Table 5.5)
		Tropical montane	-	1.09	2006GL (V4, Chp5, Table 5.5)
	Tillage (No-till)	Tropical	Dry	1.17	2006GL (V4, Chp5, Table 5.5)
			Moist/Wet	1.22	2006GL (V4, Chp5, Table 5.5)
		Tropical montane	-	1.16	2006GL (V4, Chp5, Table 5.5)
Grassland	Nominally managed (non-degraded)	All	-	1.00	2006GL (V4, Chp6, Table 6.2)
	Moderately degraded grassland	Tropical	-	0.97	2006GL (V4, Chp6, Table 6.2)
		Tropical montane	-	0.96	2006GL (V4, Chp6, Table 6.2)
	Severely degraded	All	-	0.70	2006GL (V4, Chp6, Table 6.2)
	Improved grassland	Tropical	-	1.17	2006GL (V4, Chp6, Table 6.2)
		Tropical montane	-	1.16	2006GL (V4, Chp6, Table 6.2)
Settlements	All	All		1.00	2006GL (V4, Chp4, Page 4.40)

2. Biomass growth (above-ground biomass)

2.1 Natural forests

Climate domain		Ecological zone	Unit	Data	References
Tropical		Tropical rain forest	[t-dm/ha/yr]	7.0	2006GL (V4, Chp4, Table 4.12)
		Tropical moist deciduous forest	[t-dm/ha/yr]	5.0	2006GL (V4, Chp4, Table 4.12)
		Tropical dry forest	[t-dm/ha/yr]	2.4	2006GL (V4, Chp4, Table 4.12)
		Tropical shrubland	[t-dm/ha/yr]	1.0	2006GL (V4, Chp4, Table 4.12)
		Tropical mountain system	[t-dm/ha/yr]	1.0	2006GL (V4, Chp4, Table 4.12)
Tropical Asia	Continental	Tropical rain forest	[t-dm/ha/yr]	2.2	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	7.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
		Tropical moist deciduous forest	[t-dm/ha/yr]	2.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	9.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
		Tropical dry forest	[t-dm/ha/yr]	1.5	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	6.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
		Tropical shrubland	[t-dm/ha/yr]	1.3	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	5.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
		Tropical mountain system	[t-dm/ha/yr]	1.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	5.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
	Insular	Tropical rain forest	[t-dm/ha/yr]	3.4	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	13.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
		Tropical moist deciduous forest	[t-dm/ha/yr]	3.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	11.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
		Tropical dry forest	[t-dm/ha/yr]	2.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	7.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
		Tropical shrubland	[t-dm/ha/yr]	1.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	2.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
		Tropical mountain system	[t-dm/ha/yr]	3.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)
			[t-dm/ha/yr]	12.0	2006GL (V4, Chp4, Table 4.9), GPG-LULUCF (Chp3, Table 3A.1.5)

2.2 Plantations

Climate domain	Ecological zone		Unit	Data	References
Tropical	Tropical rain forest		[t-dm/ha/yr]	15.0	2006GL (V4, Chp4, Table 4.12)
	Tropical moist deciduous forest		[t-dm/ha/yr]	10.0	2006GL (V4, Chp4, Table 4.12)
	Tropical dry forest		[t-dm/ha/yr]	8.0	2006GL (V4, Chp4, Table 4.12)
	Tropical shrubland		[t-dm/ha/yr]	5.0	2006GL (V4, Chp4, Table 4.12)
	Tropical mountain system		[t-dm/ha/yr]	5.0	2006GL (V4, Chp4, Table 4.12)
Tropical Asia	Eucalyptus sp.	Tropical rain forest	[t-dm/ha/yr]	5.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
		Tropical moist deciduous forest	[t-dm/ha/yr]	8.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
		Tropical dry forest	[t-dm/ha/yr]	15.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
		Tropical shrubland	[t-dm/ha/yr]	6.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
		Tropical mountain system (R>1000)	[t-dm/ha/yr]	3.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
	Other	Tropical rain forest	[t-dm/ha/yr]	5.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
		Tropical moist deciduous forest	[t-dm/ha/yr]	8.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
		Tropical dry forest	[t-dm/ha/yr]	7.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
		Tropical shrubland	[t-dm/ha/yr]	6.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)
		Tropical mountain system (R>1000)	[t-dm/ha/yr]	5.0	2006GL (V4, Chp4, Table 4.10), GPG-LULUCF (Chp3, Table 3A.1.6)

3. Biomass expansion factor

Biomass expansion factor is the ratio of above-ground stem volume to above-ground total volume (including branches and foliage). Previously, biomass expansion factor was provided as volume ratio (dimensionless number) until in GPG-LULUCF, but IPCC 2006 Guidelines provided values including wood density. Here both values were provided.

3.1 For expansion of merchantable growing stock volume to above-ground biomass volume

Climate zone	Forest type	Min DBH (cm)	Unit	Data	References
Tropical	Pines	10	[t-dm/t-dm]	1.30	overbark, GPG-LULUCF (Chp3, Table 3A.1.10)
	Broadleaf	10	[t-dm/t-dm]	3.40	overbark, GPG-LULUCF (Chp3, Table 3A.1.10)

3.2 For expansion of merchantable growing stock volume to above-ground biomass stocks

Climate zone	Forest type	Stock level (m3)	Unit	Data	References
Humid Tropical	Natural forests	<10	[t-dm/m3]	10.00	including bark, 2006GL (V4, Chp4, Table 4.5)
		11-20	[t-dm/m3]	4.44	including bark, 2006GL (V4, Chp4, Table 4.5)
		21-40	[t-dm/m3]	3.11	including bark, 2006GL (V4, Chp4, Table 4.5)
		41-60	[t-dm/m3]	2.28	including bark, 2006GL (V4, Chp4, Table 4.5)
		61-80	[t-dm/m3]	1.89	including bark, 2006GL (V4, Chp4, Table 4.5)
		81-120	[t-dm/m3]	1.67	including bark, 2006GL (V4, Chp4, Table 4.5)
		120-200	[t-dm/m3]	1.44	including bark, 2006GL (V4, Chp4, Table 4.5)
		>200	[t-dm/m3]	1.05	including bark, 2006GL (V4, Chp4, Table 4.5)
	Conifers	<10	[t-dm/m3]	4.44	including bark, 2006GL (V4, Chp4, Table 4.5)
		11-20	[t-dm/m3]	1.94	including bark, 2006GL (V4, Chp4, Table 4.5)
		21-40	[t-dm/m3]	1.39	including bark, 2006GL (V4, Chp4, Table 4.5)
		41-60	[t-dm/m3]	1.11	including bark, 2006GL (V4, Chp4, Table 4.5)
		61-80	[t-dm/m3]	0.89	including bark, 2006GL (V4, Chp4, Table 4.5)
		81-120	[t-dm/m3]	0.84	including bark, 2006GL (V4, Chp4, Table 4.5)
		120-200	[t-dm/m3]	0.77	including bark, 2006GL (V4, Chp4, Table 4.5)
		>200	[t-dm/m3]	0.77	including bark, 2006GL (V4, Chp4, Table 4.5)
Dry Tropical	Hardwoods	<20	[t-dm/m3]	5.55	including bark, 2006GL (V4, Chp4, Table 4.5)
		21-40	[t-dm/m3]	2.11	including bark, 2006GL (V4, Chp4, Table 4.5)
		41-80	[t-dm/m3]	0.89	including bark, 2006GL (V4, Chp4, Table 4.5)
		>80	[t-dm/m3]	0.73	including bark, 2006GL (V4, Chp4, Table 4.5)
	Conifers	<20	[t-dm/m3]	6.67	including bark, 2006GL (V4, Chp4, Table 4.5)
		21-40	[t-dm/m3]	1.33	including bark, 2006GL (V4, Chp4, Table 4.5)
		41-80	[t-dm/m3]	0.67	including bark, 2006GL (V4, Chp4, Table 4.5)
		>80	[t-dm/m3]	0.61	including bark, 2006GL (V4, Chp4, Table 4.5)

4. Ratio of below-ground biomass to above-ground biomass

Ecological zone	AGB (t/ha)	Unit	Data	References
Tropical rainforest	-	[t-dm/t-dm]	0.37	2006GL (V4, Chp4, Table 4.4)
Tropical moist deciduous forest	<125	[t-dm/t-dm]	0.20	2006GL (V4, Chp4, Table 4.4)
	>125	[t-dm/t-dm]	0.24	2006GL (V4, Chp4, Table 4.4)
Tropical dry forest	<20	[t-dm/t-dm]	0.56	2006GL (V4, Chp4, Table 4.4)
	>20	[t-dm/t-dm]	0.28	2006GL (V4, Chp4, Table 4.4)
Tropical shrubland	-	[t-dm/t-dm]	0.40	2006GL (V4, Chp4, Table 4.4)
Tropical mountain system	-	[t-dm/t-dm]	0.27	2006GL (V4, Chp4, Table 4.4)
Secondary tropical/Sub-tropical forest	<125	[t-dm/t-dm]	0.42	GPG-LULUCF (Chp3, Table 3A.1.8)
Primary tropical/Sub-tropical moist forest	-	[t-dm/t-dm]	0.24	GPG-LULUCF (Chp3, Table 3A.1.8)
Tropical/Sub-tropical dry forest	-	[t-dm/t-dm]	0.27	GPG-LULUCF (Chp3, Table 3A.1.8)
Conifer forest/Plantation	<50	[t-dm/t-dm]	0.46	GPG-LULUCF (Chp3, Table 3A.1.8)
	50-150	[t-dm/t-dm]	0.32	GPG-LULUCF (Chp3, Table 3A.1.8)
	>150	[t-dm/t-dm]	0.23	GPG-LULUCF (Chp3, Table 3A.1.8)
Temperate/Sub-tropical/Tropical grassland	-	[t-dm/t-dm]	1.58	GPG-LULUCF (Chp3, Table 3A.1.8)
Tidal marsh	-	[t-dm/t-dm]	1.04	GPG-LULUCF (Chp3, Table 3A.1.8)
Pachymorph bamboo	-	[t-dm/t-dm]	0.82	Jumpei Toriyama (dominated communities in slash-and-burn agricultural systems with fallow periods of only 1-3 years common in Luang Prabang Province in Lao PDR)

5. Wood density

Species	Unit	Data			References
		Applied	Min	Max	
Acacia mangium (3 year old)	[t-dm/m3]	0.320			Yoshiyuki Kiyono, Journal of Forest Planning (Indonesia, West Java)
Acacia mangium (5 year old)	[t-dm/m3]	0.419			Yoshiyuki Kiyono, Journal of Forest Planning (Indonesia, West Java)
Acacia mangium (8-10 year old)	[t-dm/m3]	0.457			Yoshiyuki Kiyono, Journal of Forest Planning (Indonesia, West Java)
Adina cordifolia	[t-dm/m3]	0.585	0.580	0.590	2006GL (V4, Chp4, Table 4.13)
Aegle marmelo	[t-dm/m3]	0.750			2006GL (V4, Chp4, Table 4.13)
Agathis sp.	[t-dm/m3]	0.440			2006GL (V4, Chp4, Table 4.13)
Aglaia llanosiana	[t-dm/m3]	0.890			2006GL (V4, Chp4, Table 4.13)
Alangium longiflorum	[t-dm/m3]	0.650			2006GL (V4, Chp4, Table 4.13)
Albizzia amara	[t-dm/m3]	0.700			2006GL (V4, Chp4, Table 4.13)
Albizzia falcataria	[t-dm/m3]	0.250			2006GL (V4, Chp4, Table 4.13)
Aleurites trisperma	[t-dm/m3]	0.430			2006GL (V4, Chp4, Table 4.13)
Alnus japonica	[t-dm/m3]	0.430			2006GL (V4, Chp4, Table 4.13)
Alphitonia zizyphoides	[t-dm/m3]	0.500			2006GL (V4, Chp4, Table 4.13)
Alphonsea arborea	[t-dm/m3]	0.690			2006GL (V4, Chp4, Table 4.13)
Alseodaphne longipes	[t-dm/m3]	0.490			2006GL (V4, Chp4, Table 4.13)
Amoora sp.	[t-dm/m3]	0.600			2006GL (V4, Chp4, Table 4.13)
Anisophyllea zeylanica	[t-dm/m3]	0.460			2006GL (V4, Chp4, Table 4.13)
Anisoptera sp.	[t-dm/m3]	0.540			2006GL (V4, Chp4, Table 4.13)
Anogeissus latifolia	[t-dm/m3]	0.785	0.780	0.790	2006GL (V4, Chp4, Table 4.13)
Anthocephalus chinensis	[t-dm/m3]	0.345	0.330	0.360	2006GL (V4, Chp4, Table 4.13)
Antidesma pleuricum	[t-dm/m3]	0.590			2006GL (V4, Chp4, Table 4.13)
Aphanamiris perrottetiana	[t-dm/m3]	0.520			2006GL (V4, Chp4, Table 4.13)
Araucaria bidwillii	[t-dm/m3]	0.430			2006GL (V4, Chp4, Table 4.13)
Artocarpus sp.	[t-dm/m3]	0.580			2006GL (V4, Chp4, Table 4.13)
Azadirachta sp.	[t-dm/m3]	0.520			2006GL (V4, Chp4, Table 4.13)
Balanocarpus sp.	[t-dm/m3]	0.760			2006GL (V4, Chp4, Table 4.13)
Barringtonia edulis	[t-dm/m3]	0.480			2006GL (V4, Chp4, Table 4.13)
Bauhinia sp.	[t-dm/m3]	0.670			2006GL (V4, Chp4, Table 4.13)
Beilschmiedia tawa	[t-dm/m3]	0.580			2006GL (V4, Chp4, Table 4.13)
Berrya cordifolia	[t-dm/m3]	0.780			2006GL (V4, Chp4, Table 4.13)
Bischofia javanica	[t-dm/m3]	0.580	0.540	0.620	2006GL (V4, Chp4, Table 4.13)
Bleasdalea vitiensis	[t-dm/m3]	0.430			2006GL (V4, Chp4, Table 4.13)
Boswellia serrata	[t-dm/m3]	0.500			2006GL (V4, Chp4, Table 4.13)
Bridelia squamosa	[t-dm/m3]	0.500			2006GL (V4, Chp4, Table 4.13)
Buchenavia latifolia	[t-dm/m3]	0.450			2006GL (V4, Chp4, Table 4.13)
Bursera serrata	[t-dm/m3]	0.590			2006GL (V4, Chp4, Table 4.13)
Butea monosperma	[t-dm/m3]	0.480			2006GL (V4, Chp4, Table 4.13)
Calophyllum sp.	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Calycarpa arborea	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Cananga odorata	[t-dm/m3]	0.290			2006GL (V4, Chp4, Table 4.13)
Canarium sp.	[t-dm/m3]	0.440			2006GL (V4, Chp4, Table 4.13)
Canthium monstrosum	[t-dm/m3]	0.420			2006GL (V4, Chp4, Table 4.13)
Carallia calycina	[t-dm/m3]	0.660			2006GL (V4, Chp4, Table 4.13)
Cassia javanica	[t-dm/m3]	0.690			2006GL (V4, Chp4, Table 4.13)
Castanopsis philippensis	[t-dm/m3]	0.510			2006GL (V4, Chp4, Table 4.13)
Casuarina equisetifolia	[t-dm/m3]	0.830			2006GL (V4, Chp4, Table 4.13)
Casuarina nodiflora	[t-dm/m3]	0.850			2006GL (V4, Chp4, Table 4.13)
Cedrela odorata	[t-dm/m3]	0.380			2006GL (V4, Chp4, Table 4.13)
Cedrela toona	[t-dm/m3]	0.430			2006GL (V4, Chp4, Table 4.13)
Ceiba pentandra	[t-dm/m3]	0.230			2006GL (V4, Chp4, Table 4.13)
Celtis luzonica	[t-dm/m3]	0.490			2006GL (V4, Chp4, Table 4.13)
Chisocheton pentandrus	[t-dm/m3]	0.520			2006GL (V4, Chp4, Table 4.13)
Chloroxylon swietenia	[t-dm/m3]	0.780	0.760	0.800	2006GL (V4, Chp4, Table 4.13)
Chukrassia tabularis	[t-dm/m3]	0.570			2006GL (V4, Chp4, Table 4.13)
Citrus grandis	[t-dm/m3]	0.590			2006GL (V4, Chp4, Table 4.13)
Cleidion speciflorum	[t-dm/m3]	0.500			2006GL (V4, Chp4, Table 4.13)
Cleistanthus eollinus	[t-dm/m3]	0.880			2006GL (V4, Chp4, Table 4.13)
Cleistocalyx sp.	[t-dm/m3]	0.760			2006GL (V4, Chp4, Table 4.13)
Cochlospermum gossypium	[t-dm/m3]	0.270			2006GL (V4, Chp4, Table 4.13)
Cocos nucifera	[t-dm/m3]	0.500			2006GL (V4, Chp4, Table 4.13)

Species	Unit	Data			References
		Applied	Min	Max	
Colona serratifolia	[t-dm/m3]	0.330			2006GL (V4, Chp4, Table 4.13)
Combretodendron quadrialatum	[t-dm/m3]	0.570			2006GL (V4, Chp4, Table 4.13)
Cordia sp.	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Cotylelobium sp.	[t-dm/m3]	0.690			2006GL (V4, Chp4, Table 4.13)
Crataeva religiosa	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Cratoxylon arborescens	[t-dm/m3]	0.400			2006GL (V4, Chp4, Table 4.13)
Cryptocarya sp.	[t-dm/m3]	0.590			2006GL (V4, Chp4, Table 4.13)
Cubilia cubili	[t-dm/m3]	0.490			2006GL (V4, Chp4, Table 4.13)
Cullenia excelsa	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Cynometra sp.	[t-dm/m3]	0.800			2006GL (V4, Chp4, Table 4.13)
Dacrycarpus imbricatus	[t-dm/m3]	0.460	0.450	0.470	2006GL (V4, Chp4, Table 4.13)
Dacrydium sp.	[t-dm/m3]	0.460			2006GL (V4, Chp4, Table 4.13)
Dacryodes sp.	[t-dm/m3]	0.610			2006GL (V4, Chp4, Table 4.13)
Dalbergia paniculata	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Decussocarpus vitiensis	[t-dm/m3]	0.370			2006GL (V4, Chp4, Table 4.13)
Degeneria vitiensis	[t-dm/m3]	0.350			2006GL (V4, Chp4, Table 4.13)
Dehaasia triandra	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Dialium sp.	[t-dm/m3]	0.800			2006GL (V4, Chp4, Table 4.13)
Dillenia sp.	[t-dm/m3]	0.590			2006GL (V4, Chp4, Table 4.13)
Diospyros sp.	[t-dm/m3]	0.700			2006GL (V4, Chp4, Table 4.13)
Diplodiscus paniculatus	[t-dm/m3]	0.630			2006GL (V4, Chp4, Table 4.13)
Dipterocarpus caudatus	[t-dm/m3]	0.610			2006GL (V4, Chp4, Table 4.13)
Dipterocarpus eurynchus	[t-dm/m3]	0.560			2006GL (V4, Chp4, Table 4.13)
Dipterocarpus gracilis	[t-dm/m3]	0.610			2006GL (V4, Chp4, Table 4.13)
Dipterocarpus grandiflorus	[t-dm/m3]	0.620			2006GL (V4, Chp4, Table 4.13)
Dipterocarpus kerrii	[t-dm/m3]	0.560			2006GL (V4, Chp4, Table 4.13)
Dipterocarpus kunstlerii	[t-dm/m3]	0.570			2006GL (V4, Chp4, Table 4.13)
Dipterocarpus sp.	[t-dm/m3]	0.610			2006GL (V4, Chp4, Table 4.13)
Dipterocarpus warburgii	[t-dm/m3]	0.520			2006GL (V4, Chp4, Table 4.13)
Dracontomelon sp.	[t-dm/m3]	0.500			2006GL (V4, Chp4, Table 4.13)
Dryobalanops sp.	[t-dm/m3]	0.610			2006GL (V4, Chp4, Table 4.13)
Dtypetes bordenii	[t-dm/m3]	0.750			2006GL (V4, Chp4, Table 4.13)
Durio sp.	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Dyera costulata	[t-dm/m3]	0.360			2006GL (V4, Chp4, Table 4.13)
Dysoxylum quercifolium	[t-dm/m3]	0.490			2006GL (V4, Chp4, Table 4.13)
Elaeocarpus serratus	[t-dm/m3]	0.400			2006GL (V4, Chp4, Table 4.13)
Emblica officinalis	[t-dm/m3]	0.800			2006GL (V4, Chp4, Table 4.13)
Endiandra laxiflora	[t-dm/m3]	0.540			2006GL (V4, Chp4, Table 4.13)
Endospermum sp.	[t-dm/m3]	0.380			2006GL (V4, Chp4, Table 4.13)
Enterolobium cyclocarpum	[t-dm/m3]	0.350			2006GL (V4, Chp4, Table 4.13)
Epicharis cumingiana	[t-dm/m3]	0.730			2006GL (V4, Chp4, Table 4.13)
Erythrina subumbrans	[t-dm/m3]	0.240			2006GL (V4, Chp4, Table 4.13)
Erythrophloeum densiflorum	[t-dm/m3]	0.650			2006GL (V4, Chp4, Table 4.13)
Eucalyptus citriodora	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Eucalyptus deglupta	[t-dm/m3]	0.340			2006GL (V4, Chp4, Table 4.13)
Eugenia sp.	[t-dm/m3]	0.650			2006GL (V4, Chp4, Table 4.13)
Fagraea sp.	[t-dm/m3]	0.730			2006GL (V4, Chp4, Table 4.13)
Ficus benjamina	[t-dm/m3]	0.650			2006GL (V4, Chp4, Table 4.13)
Ganua obovatifolia	[t-dm/m3]	0.590			2006GL (V4, Chp4, Table 4.13)
Garcinia myrtifolia	[t-dm/m3]	0.650			2006GL (V4, Chp4, Table 4.13)
Garcinia sp.	[t-dm/m3]	0.750			2006GL (V4, Chp4, Table 4.13)
Gardenia turgida	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Garuga pinnata	[t-dm/m3]	0.510			2006GL (V4, Chp4, Table 4.13)
Gluta sp.	[t-dm/m3]	0.630			2006GL (V4, Chp4, Table 4.13)
Gmelina arborea	[t-dm/m3]	0.430	0.410	0.450	2006GL (V4, Chp4, Table 4.13)
Gmelina vitiensis	[t-dm/m3]	0.540			2006GL (V4, Chp4, Table 4.13)
Gonocaryum calleryanum	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Gonystylus punctatus	[t-dm/m3]	0.570			2006GL (V4, Chp4, Table 4.13)
Grewia tiliaefolia	[t-dm/m3]	0.680			2006GL (V4, Chp4, Table 4.13)
Hardwickia binata	[t-dm/m3]	0.730			2006GL (V4, Chp4, Table 4.13)

Species	Unit	Data			References
		Applied	Min	Max	
Harpullia arborea	[t-dm/m3]	0.620			2006GL (V4, Chp4, Table 4.13)
Heritiera sp.	[t-dm/m3]	0.560			2006GL (V4, Chp4, Table 4.13)
Hevea brasiliensis	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Hibiscus tiliaceus	[t-dm/m3]	0.570			2006GL (V4, Chp4, Table 4.13)
Homalanthus populneus	[t-dm/m3]	0.380			2006GL (V4, Chp4, Table 4.13)
Homalium sp.	[t-dm/m3]	0.760			2006GL (V4, Chp4, Table 4.13)
Hopea acuminata	[t-dm/m3]	0.620			2006GL (V4, Chp4, Table 4.13)
Hopea sp.	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Intsia palembanica	[t-dm/m3]	0.680			2006GL (V4, Chp4, Table 4.13)
Kayea garciae	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Kingiodendron alternifolium	[t-dm/m3]	0.480			2006GL (V4, Chp4, Table 4.13)
Kleinhovia hospita	[t-dm/m3]	0.360			2006GL (V4, Chp4, Table 4.13)
Knema sp.	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Koompassia excelsa	[t-dm/m3]	0.630			2006GL (V4, Chp4, Table 4.13)
Koordersiodendron pinnatum	[t-dm/m3]	0.670	0.650	0.690	2006GL (V4, Chp4, Table 4.13)
Kydia calycina	[t-dm/m3]	0.720			2006GL (V4, Chp4, Table 4.13)
Lagerstroemia sp.	[t-dm/m3]	0.550			2006GL (V4, Chp4, Table 4.13)
Lannea grandis	[t-dm/m3]	0.500			2006GL (V4, Chp4, Table 4.13)
Leucaena leucocephala	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Lithocarpus soleriana	[t-dm/m3]	0.630			2006GL (V4, Chp4, Table 4.13)
Litsea sp.	[t-dm/m3]	0.400			2006GL (V4, Chp4, Table 4.13)
Lophopetalum sp.	[t-dm/m3]	0.460			2006GL (V4, Chp4, Table 4.13)
Macaranga denticulata	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Madhuca oblongifolia	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Mallotus philippinensis	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Mangifera sp.	[t-dm/m3]	0.520			2006GL (V4, Chp4, Table 4.13)
Maniltoa minor	[t-dm/m3]	0.760			2006GL (V4, Chp4, Table 4.13)
Mastixia philippinensis	[t-dm/m3]	0.470			2006GL (V4, Chp4, Table 4.13)
Melanorrhea sp.	[t-dm/m3]	0.630			2006GL (V4, Chp4, Table 4.13)
Melia dubia	[t-dm/m3]	0.400			2006GL (V4, Chp4, Table 4.13)
Melicope triphylla	[t-dm/m3]	0.370			2006GL (V4, Chp4, Table 4.13)
Meliosma macrophylla	[t-dm/m3]	0.270			2006GL (V4, Chp4, Table 4.13)
Melochia umbellata	[t-dm/m3]	0.250			2006GL (V4, Chp4, Table 4.13)
Metrosideros collina	[t-dm/m3]	0.730	0.700	0.760	2006GL (V4, Chp4, Table 4.13)
Michelia sp.	[t-dm/m3]	0.430			2006GL (V4, Chp4, Table 4.13)
Microcos stylocarpa	[t-dm/m3]	0.400			2006GL (V4, Chp4, Table 4.13)
Micromelum compressum	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Milliusa velutina	[t-dm/m3]	0.630			2006GL (V4, Chp4, Table 4.13)
Mimusops elengi	[t-dm/m3]	0.720			2006GL (V4, Chp4, Table 4.13)
Mitragyna parviflora	[t-dm/m3]	0.560			2006GL (V4, Chp4, Table 4.13)
Myristica sp.	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Neesia sp.	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Neonauclea bernardoi	[t-dm/m3]	0.620			2006GL (V4, Chp4, Table 4.13)
Neotrewia cumingii	[t-dm/m3]	0.550			2006GL (V4, Chp4, Table 4.13)
Ochna foxworthyi	[t-dm/m3]	0.860			2006GL (V4, Chp4, Table 4.13)
Ochroma pyramidale	[t-dm/m3]	0.300			2006GL (V4, Chp4, Table 4.13)
Octomeles sumatrana	[t-dm/m3]	0.295	0.270	0.320	2006GL (V4, Chp4, Table 4.13)
Oroxylon indicum	[t-dm/m3]	0.320			2006GL (V4, Chp4, Table 4.13)
Ougenia dalbergiodes	[t-dm/m3]	0.700			2006GL (V4, Chp4, Table 4.13)
Palaquium sp.	[t-dm/m3]	0.550			2006GL (V4, Chp4, Table 4.13)
Pangium edule	[t-dm/m3]	0.500			2006GL (V4, Chp4, Table 4.13)
Parashorea stellata	[t-dm/m3]	0.590			2006GL (V4, Chp4, Table 4.13)
Paratrophis glabra	[t-dm/m3]	0.770			2006GL (V4, Chp4, Table 4.13)
Parinari sp.	[t-dm/m3]	0.680			2006GL (V4, Chp4, Table 4.13)
Parkia roxburghii	[t-dm/m3]	0.340			2006GL (V4, Chp4, Table 4.13)
Payena sp.	[t-dm/m3]	0.550			2006GL (V4, Chp4, Table 4.13)
Peltophorum pterocarpum	[t-dm/m3]	0.620			2006GL (V4, Chp4, Table 4.13)
Pentace sp.	[t-dm/m3]	0.560			2006GL (V4, Chp4, Table 4.13)
Phaeanthus ebracteolatus	[t-dm/m3]	0.560			2006GL (V4, Chp4, Table 4.13)
Phyllocladus hypophyllus	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)

Species	Unit	Data			References
		Applied	Min	Max	
Pinus caribaea	[t-dm/m3]	0.480			2006GL (V4, Chp4, Table 4.13)
Pinus insularis	[t-dm/m3]	0.475	0.470	0.480	2006GL (V4, Chp4, Table 4.13)
Pinus merkusii	[t-dm/m3]	0.540			2006GL (V4, Chp4, Table 4.13)
Pisonia umbellifera	[t-dm/m3]	0.210			2006GL (V4, Chp4, Table 4.13)
Pittosporum pentandrum	[t-dm/m3]	0.510			2006GL (V4, Chp4, Table 4.13)
Planchonia sp.	[t-dm/m3]	0.590			2006GL (V4, Chp4, Table 4.13)
Podocarpus sp.	[t-dm/m3]	0.430			2006GL (V4, Chp4, Table 4.13)
Polyalthia flava	[t-dm/m3]	0.510			2006GL (V4, Chp4, Table 4.13)
Polyscias nodosa	[t-dm/m3]	0.380			2006GL (V4, Chp4, Table 4.13)
Pometia sp.	[t-dm/m3]	0.540			2006GL (V4, Chp4, Table 4.13)
Pouteria villamilii	[t-dm/m3]	0.470			2006GL (V4, Chp4, Table 4.13)
Premna tomentosa	[t-dm/m3]	0.960			2006GL (V4, Chp4, Table 4.13)
Pterocarpus marsupium	[t-dm/m3]	0.670			2006GL (V4, Chp4, Table 4.13)
Quercus sp.	[t-dm/m3]	0.700			2006GL (V4, Chp4, Table 4.13)
Radermachera pinnata	[t-dm/m3]	0.510			2006GL (V4, Chp4, Table 4.13)
Salmalia malabarica	[t-dm/m3]	0.325	0.320	0.330	2006GL (V4, Chp4, Table 4.13)
Samanea saman	[t-dm/m3]	0.455	0.450	0.460	2006GL (V4, Chp4, Table 4.13)
Sandoricum vidalii	[t-dm/m3]	0.430			2006GL (V4, Chp4, Table 4.13)
Sapindus saponaria	[t-dm/m3]	0.580			2006GL (V4, Chp4, Table 4.13)
Sapium luzontcum	[t-dm/m3]	0.400			2006GL (V4, Chp4, Table 4.13)
Schleichera oleosa	[t-dm/m3]	0.960			2006GL (V4, Chp4, Table 4.13)
Schrebera swietenoides	[t-dm/m3]	0.820			2006GL (V4, Chp4, Table 4.13)
Semicarpus anacardium	[t-dm/m3]	0.640			2006GL (V4, Chp4, Table 4.13)
Serialbizia acle	[t-dm/m3]	0.570			2006GL (V4, Chp4, Table 4.13)
Serianthes melanesica	[t-dm/m3]	0.480			2006GL (V4, Chp4, Table 4.13)
Sesbania grandiflora	[t-dm/m3]	0.400			2006GL (V4, Chp4, Table 4.13)
Shorea assamica forma philippinensis	[t-dm/m3]	0.410			2006GL (V4, Chp4, Table 4.13)
Shorea astylosa	[t-dm/m3]	0.730			2006GL (V4, Chp4, Table 4.13)
Shorea ciliata	[t-dm/m3]	0.750			2006GL (V4, Chp4, Table 4.13)
Shorea contorta	[t-dm/m3]	0.440			2006GL (V4, Chp4, Table 4.13)
Shorea palosapis	[t-dm/m3]	0.390			2006GL (V4, Chp4, Table 4.13)
Shorea plagata	[t-dm/m3]	0.700			2006GL (V4, Chp4, Table 4.13)
Shorea polita	[t-dm/m3]	0.470			2006GL (V4, Chp4, Table 4.13)
Shorea robusta	[t-dm/m3]	0.720			2006GL (V4, Chp4, Table 4.13)
Shorea sp.(balau)	[t-dm/m3]	0.700			2006GL (V4, Chp4, Table 4.13)
Shorea sp.(dark red meranti)	[t-dm/m3]	0.550			2006GL (V4, Chp4, Table 4.13)
Shorea sp.(light red meranti)	[t-dm/m3]	0.400			2006GL (V4, Chp4, Table 4.13)
Sloanea javanica	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Soymida febrifuga	[t-dm/m3]	0.970			2006GL (V4, Chp4, Table 4.13)
Spathodea campanulata	[t-dm/m3]	0.250			2006GL (V4, Chp4, Table 4.13)
Stemonurus luzoniensis	[t-dm/m3]	0.370			2006GL (V4, Chp4, Table 4.13)
Sterculia vitiensis	[t-dm/m3]	0.310			2006GL (V4, Chp4, Table 4.13)
Stereospermum suaveolens	[t-dm/m3]	0.620			2006GL (V4, Chp4, Table 4.13)
Strombosia philippinensis	[t-dm/m3]	0.710			2006GL (V4, Chp4, Table 4.13)
Strychnos potatorum	[t-dm/m3]	0.880			2006GL (V4, Chp4, Table 4.13)
Swietenia macrophylla	[t-dm/m3]	0.510	0.490	0.530	2006GL (V4, Chp4, Table 4.13)
Swintonia foxworthyi	[t-dm/m3]	0.620			2006GL (V4, Chp4, Table 4.13)
Swintonia sp.	[t-dm/m3]	0.610			2006GL (V4, Chp4, Table 4.13)
Sycopsis dunni	[t-dm/m3]	0.630			2006GL (V4, Chp4, Table 4.13)
Syzygium sp.	[t-dm/m3]	0.725	0.690	0.760	2006GL (V4, Chp4, Table 4.13)
Tamarindus indica	[t-dm/m3]	0.750			2006GL (V4, Chp4, Table 4.13)
Tectona grandis	[t-dm/m3]	0.525	0.500	0.550	2006GL (V4, Chp4, Table 4.13)
Terminalia citrina	[t-dm/m3]	0.710			2006GL (V4, Chp4, Table 4.13)
Terminalia copelandii	[t-dm/m3]	0.460			2006GL (V4, Chp4, Table 4.13)
Terminalia microcarpa	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Terminalia nitens	[t-dm/m3]	0.580			2006GL (V4, Chp4, Table 4.13)
Terminalia pterocarpa	[t-dm/m3]	0.480			2006GL (V4, Chp4, Table 4.13)
Terminalia tomentosa	[t-dm/m3]	0.750	0.730	0.770	2006GL (V4, Chp4, Table 4.13)
Ternstroemia megacarpa	[t-dm/m3]	0.530			2006GL (V4, Chp4, Table 4.13)
Tetrameles nudiflora	[t-dm/m3]	0.300			2006GL (V4, Chp4, Table 4.13)

Species	Unit	Data			References
		Applied	Min	Max	
Tetramerista glabra	[t-dm/m3]	0.610			2006GL (V4, Chp4, Table 4.13)
Thespesia populnea	[t-dm/m3]	0.520			2006GL (V4, Chp4, Table 4.13)
Trema orientalis	[t-dm/m3]	0.310			2006GL (V4, Chp4, Table 4.13)
Tristania sp.	[t-dm/m3]	0.800			2006GL (V4, Chp4, Table 4.13)
Turpinia ovalifolia	[t-dm/m3]	0.360			2006GL (V4, Chp4, Table 4.13)
Vateria indica	[t-dm/m3]	0.470			2006GL (V4, Chp4, Table 4.13)
Vatica sp.	[t-dm/m3]	0.690			2006GL (V4, Chp4, Table 4.13)
Vitex sp.	[t-dm/m3]	0.650			2006GL (V4, Chp4, Table 4.13)
Wrightia tinctorea	[t-dm/m3]	0.750			2006GL (V4, Chp4, Table 4.13)
Xanthophyllum excelsum	[t-dm/m3]	0.630			2006GL (V4, Chp4, Table 4.13)
Xylia xylocarpa	[t-dm/m3]	0.770	0.730	0.810	2006GL (V4, Chp4, Table 4.13)
Zanthoxylum rhetsa	[t-dm/m3]	0.330			2006GL (V4, Chp4, Table 4.13)
Zizyphus sp.	[t-dm/m3]	0.760			2006GL (V4, Chp4, Table 4.13)

6. Carbon fraction

Domain	Part of tree	Unit	Data	References
All	-	[t-C/t-dm]	0.47	2006GL (V4, Chp4, Table 4.3)
Tropical and sub-tropical	All	[t-C/t-dm]	0.47	2006GL (V4, Chp4, Table 4.3)
	wood	[t-C/t-dm]	0.49	2006GL (V4, Chp4, Table 4.3)
	wood, tree d<10cm	[t-C/t-dm]	0.46	2006GL (V4, Chp4, Table 4.3)
	wood, tree d>10cm	[t-C/t-dm]	0.49	2006GL (V4, Chp4, Table 4.3)
	foliage	[t-C/t-dm]	0.47	2006GL (V4, Chp4, Table 4.3)
	foliage, tree d<10cm	[t-C/t-dm]	0.43	2006GL (V4, Chp4, Table 4.3)
	foliage, tree d>10cm	[t-C/t-dm]	0.46	2006GL (V4, Chp4, Table 4.3)

7. Biomass burning due to fire

7.1 Fuel biomass consumption values

Vegetation type	Sub-category	Unit	Data	References
Primary tropical forest (slash and burn)	All	[t/ha]	119.6	2006GL (V4, Chp2, Table 2.4)
	Primary tropical forest	[t/ha]	83.9	2006GL (V4, Chp2, Table 2.4)
	Primary open tropical forest	[t/ha]	163.6	2006GL (V4, Chp2, Table 2.4)
	Primary tropical moist forest	[t/ha]	160.4	2006GL (V4, Chp2, Table 2.4)
	Primary tropical dry forest	[t/ha]	-	2006GL (V4, Chp2, Table 2.4)
Secondary tropical forest (slash and burn)	All	[t/ha]	42.2	2006GL (V4, Chp2, Table 2.4)
	Young secondary tropical forest (3-5 yr)	[t/ha]	8.1	2006GL (V4, Chp2, Table 2.4)
	Intermediate secondary tropical forest (6-10 yr)	[t/ha]	41.1	2006GL (V4, Chp2, Table 2.4)
	Advanced secondary tropical forest (14-17 yr)	[t/ha]	46.4	2006GL (V4, Chp2, Table 2.4)
All tertiary tropical forest		[t/ha]	54.1	2006GL (V4, Chp2, Table 2.4)
Eucalyptus forests	All	[t/ha]	69.4	2006GL (V4, Chp2, Table 2.4)
	Wildfire	[t/ha]	53.0	2006GL (V4, Chp2, Table 2.4)
	Prescribed fire – (surface)	[t/ha]	16.0	2006GL (V4, Chp2, Table 2.4)
	Post logging slash burn	[t/ha]	168.4	2006GL (V4, Chp2, Table 2.4)
	Felled and burned (land-clearing fire)	[t/ha]	132.6	2006GL (V4, Chp2, Table 2.4)
All Shrublands		[t/ha]	14.3	2006GL (V4, Chp2, Table 2.4)
Peatland		[t/ha]	41.0	2006GL (V4, Chp2, Table 2.4)

7.2 Emission factors

Gas	Category	Unit	Data	References
CO2	Savanna and grassland	[g/kg-dm]	1,613	2006GL (V4, Chp2, Table 2.5)
	Agricultural residues	[g/kg-dm]	1,515	2006GL (V4, Chp2, Table 2.5)
	Tropical forest	[g/kg-dm]	1,580	2006GL (V4, Chp2, Table 2.5)
	Extra tropical forest	[g/kg-dm]	1,569	2006GL (V4, Chp2, Table 2.5)
	Biofuel burning	[g/kg-dm]	1,550	2006GL (V4, Chp2, Table 2.5)
CH4	Savanna and grassland	[g/kg-dm]	2.30	2006GL (V4, Chp2, Table 2.5)
	Agricultural residues	[g/kg-dm]	2.70	2006GL (V4, Chp2, Table 2.5)
	Tropical forest	[g/kg-dm]	6.80	2006GL (V4, Chp2, Table 2.5)
	Extra tropical forest	[g/kg-dm]	4.70	2006GL (V4, Chp2, Table 2.5)
	Biofuel burning	[g/kg-dm]	6.10	2006GL (V4, Chp2, Table 2.5)
N2O	Savanna and grassland	[g/kg-dm]	0.21	2006GL (V4, Chp2, Table 2.5)
	Agricultural residues	[g/kg-dm]	0.07	2006GL (V4, Chp2, Table 2.5)
	Tropical forest	[g/kg-dm]	0.20	2006GL (V4, Chp2, Table 2.5)
	Extra tropical forest	[g/kg-dm]	0.26	2006GL (V4, Chp2, Table 2.5)
	Biofuel burning	[g/kg-dm]	0.06	2006GL (V4, Chp2, Table 2.5)

8. Fraction of biomass lost in disturbance

Ecological zone	Data	References
Default (stand-replacing disturbance)	1.0	2006GL (V4, Chp2, Page 2.18)
Insect disturbance	0.3	2006GL (V4, Chp2, Page 2.18)

9. CO_2 emission factor for organic soils

Categories		Climate	Unit	Data	References
Forest land	Drained organic soils	Tropical	[t-C/ha/yr]	1.36	2006GL (V4, Chp4, Table 4.6)
Cropland	Cultivated organic soil	Tropical/Sub-tropical	[t-C/ha/yr]	20.00	2006GL (V4, Chp5, Table 5.6)
Grassland	Drained organic soils	Tropical/Sub-tropical	[t-C/ha/yr]	5.00	2006GL (V4, Chp6, Table 6.3)
Peatland	Peat extraction	Tropical	[t-C/ha/yr]	2.00	2006GL (V4, Chp7, Table 7.4)
Settlements	Deep drainage	Tropical/Sub-tropical	[t-C/ha/yr]	20.00	2006GL (V4, Chp5, Table 5.6)
Other land	-	-	-	-	2006GL (V4, Chp9, Page 9.7) It is assumed that the stock changes in organic soils are minimal because drainage is unlikely in "Other Lands".

Appendix 2 Appearance of biomass destructive sampling survey

Partner of biomass survey, Souphanuvong Uniersity
(12. Nov. 2012, Luang Prabang)

Partner of biomass survey, Souphanuvong Uniersity
(12. Nov. 2012, Luang Prabang)

Kickoff meeting of biomass survey
(13 Nov. 2012, Phonsay district)

Kickoff meeting of biomass survey
(13 Nov. 2012, Phonsay district)

Kickoff meeting of biomass survey
(13 Nov. 2012, Phonsay district)

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Validation and Registration of the Project on REDD plus through Participatory Land and Forest Management for Avoiding Deforestation in Lao PDR

Technical Cooperation Report
- Results of Socio-Economic Survey -

October 2014

Japan International Cooperation Agency (JICA)

Mitsubishi UFJ Research and Consulting

Japan Forest Technology Association

Validation and Registration Project on REDD plus through Participated Land and Forest Management for Avoiding Deforestation in Lao PDR

Technical Cooperation Report
－ Results of Socio-Economic Survey －

- Contents -

Chapter 1 Objective of this Technical Cooperation Report

This project was carried out in two different spatial scales; Luang Prabang Province and Houay Khing village cluster (HK-VC) in Phonsay district in Luang Prabang Province; and was developed in order to implement and support the sub-national based and the project based REDD plus projects respectively.

In an approach to targeting Luang Prabang Province as a sub-national base, a sub-national based reference level was developed considering discussions at UNFCCC and REDD plus mechanism in the voluntary market such as VCS. The socio-economic issues were considered to reflect both National and Regional Circumstances to identify and assess the forest dynamics for developing the sub-national reference level.

Similarly HK-VC was selected as a project base to develop a reference level in the same way as the sub-national base. The socio-economic survey was conducted aiming to identify drivers of deforestation and forest degradation in the target area and to select effective measures (Project Activity) to reduce or mitigate the identified drivers. In other words, in the socio-economic survey targeting the project base, socio-economic survey was carried out to contribute to development of PDD to ensure the permanency of REDD plus activities and to strengthen project sustainability by considering inherent issues and problems of the local ethnic groups in HK-VC.

The socio-economic survey was complemented by the basic information on land and forest use in the target areas provided by Technical Cooperation Project "PAREDD". Accordingly the results of the survey were provided to PAREDD appropriately (Figure 1).

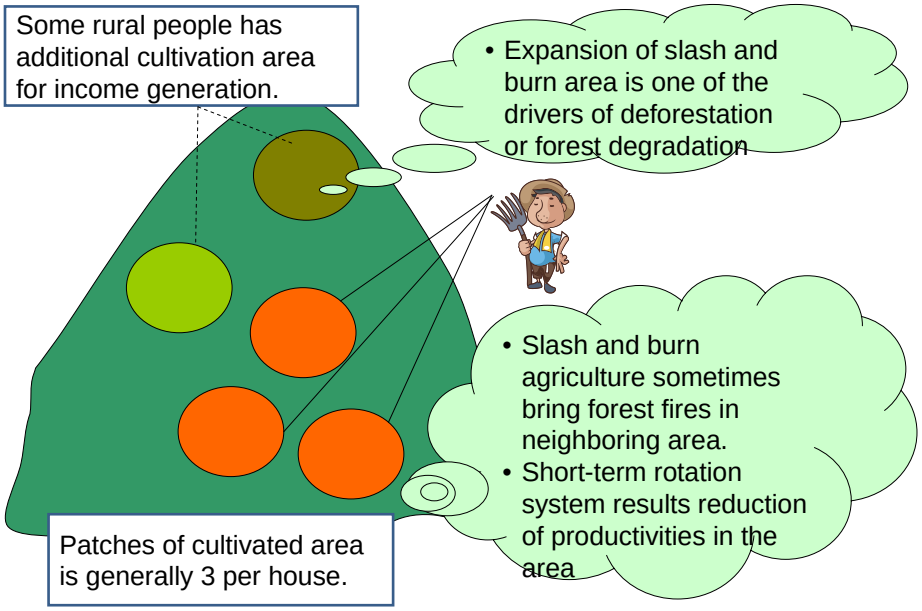


Figure 1 Current state of slash-and-burn land use in the HK-VC

Chapter 2 The Approach Targeting Luang Prabang Province (Sub-national base)

1. Survey Method

In order to develop sub-national reference level of Luang Prabang Province, it was necessary to assess the temporal forests and carbon dynamics which were drawn from Technical Cooperation Reports "Analysis Results of Forest Dynamics", Technical Cooperation Report "Destructive Sampling Survey" and Technical Cooperation Report "Results of Forest Plot Survey", which were useful to reflect the National/Regional Circumstances in Luang Prabang Province. The socio-economic factors were identified from the survey to calculate a reference level considering National/Regional Circumstances. Both national and regional circumstances were considered to assess reference level (blue line as shown in Figure 2), whether which would become linear regression or curve regression.

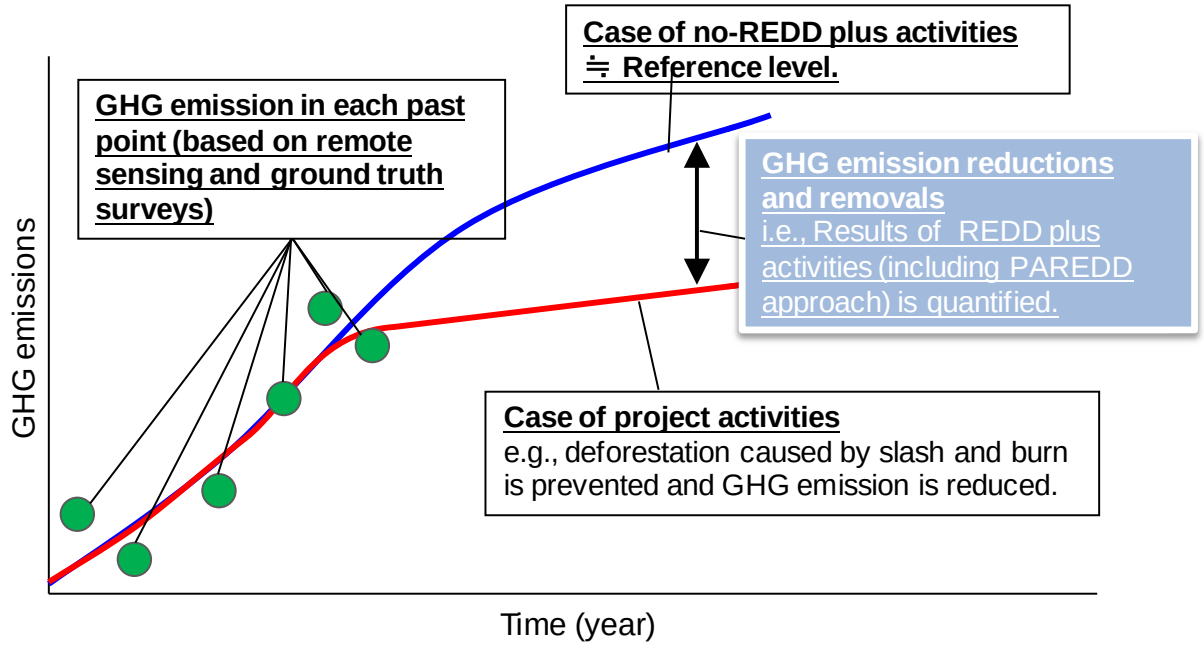


Figure 2 Approach to reference level in Luang Prabang Province

The survey considered the SEDP published annually by PAFO, which includes the socio-economic characteristics and understandings of the drivers of deforestation and forest degradation. In addition, statistical information of Luang Prabang Province such as the population, GDP and agriculture were extracted which had a high correlation with the deforestation and forest degradation in the Province. The socio-economic factors which were important for calculating a reference level were analyzed. In addition, the survey used the related socio-economic data (mainly socio-economic and agriculture statistics) were also obtained from various sources as provided below in Table 1 and synthesized them to.

Table 1 Sources of socio-economic data

No	Name of Documents	Year of Statistics	Year of Publication	Number/Signature, etc.	Source
I	Provincial Documents				
	SEDP	2010-2011	Oct 2010	№02, 13 Jan 2011	DPI
	SEDP and Development Direction towards 2020	2008-2009	Dec 2008	Supported by GPAR-LPQ	DPI
	SEDP	2006-2007	Oct 2006	№292, 1 Nov 2006	DPI
	SEDP	2005-2006	Aug 2005	No signature and stamp	DPI
	SEDP	2003-2004	-	№292, 14 Oct 2003	DPI
	SEDP Five-Year (2006-2010) + SEDP Implementation of 2001-2005	2006-2010 2001-2005	(soft copy)		DPI
	SEDP Five-Year (2011-2015) + SEDP Implementation of 2006-2010	2011-2015 2006-2010	(soft copy)		DPI
	Agricultural Statistics Yearbook 2010	2006-2010	May 2011		MAF
	LPQ Statistical Data Yearbook	1990-1995			DPI
	LPQ Statistical Data Yearbook	1996-2000			DPI
	LPQ Statistical Data Yearbook	2001-2005			DPI
	LPQ Statistical Data Yearbook	2006			DPI
	LPQ Statistical Data Yearbook	2007			DPI
	LPQ Statistical Data Yearbook	2008			DPI
	LPQ Statistical Data Yearbook	2009			DPI
	LPQ Statistical Data Yearbook	2010			DPI
	LPQ Statistical Data Yearbook	2011			DPI
	Industry and Commerce Sector Implementation 2008-2009 and Development Direction 2009-2010	2008-2009 2009-2010		№1280, 8 Oct 2009	DOIC
	Processing and Commerce Development Plan	2011-2015		№0318, 11 Mar 2010	DOIC
	Compiled Strategic Plan on Forestry Management and Protection – LPQ	2008-2020		-	
	2006-2010 Agriculture and Forestry Implementation Report and Development Direction 2011-2015	2006-2010 2011-2015		№1061, 24 Nov 2009	PAFO
	2010-2011 Agriculture and Forestry Sector Implementation and Development Plan 2011-2012	2010-2011 2011-2012		№559, 27 Sept 2011	PAFO
	9-Month Agriculture and Forestry Sector Implementation + the last Quarter Plan and Development Plan 2012-2013	2011-2012 2012-2013		№537, 28 Jun 2012	PAFO

Table 1 continued

No	Name of Documents	Year of Statistics	Year of Publication	Number/Signature, etc.	Source
II	District Documents				
	SEDP – Pak Seng	2012-2013	-	№291	DPI
	SEDP – Xieng Ngeun	2009-2010	5 Mar 2009	-	DPI
	Investment Plan – Xieng Nguen	2009-2010	Feb 2009	-	DPI
	A 9-month (SEDP) implement report and the last-quarter development plan – Pak Ou	2012-2013	-	№30, 26 Jun 2012	DPI
	SEDP Implementation Report and Development Plan for 2011-2012 – Nan	2010-2011		№12, 26 Jan 2012	DPI
	SEDP - Muang Luang Prabang	2012-2013	-	№151, 20 Mar 2012	
	SEDP Implementation Report and SEDP 2011-2012 – Muang Luang Prabang	2010-2011		№120, 12 Dec 2012	
	2010 Implementation and 2011 Plan – Muang Luang Prabang	2010	-	30 Dec 2011	DPI
	Statistical Data on Poverty Assessment…	2010-2011	-	№49, 23 Apr 2011	DPI
	SEDP – Chomphet	2008-2009	-	№023, 21 May 2008	DPI
	SEDP Implementation Report and Development Plan for 2011-2012 – Viengkham	2010-2011		№01, 13 Jan 2012	DPI
	Proposed SEDP – Nam Bak	2012-2013		№29, 23 Mar 2012	DPI
	A First-6-Month SEDP Implementation Report and the Last-6-Month Development Plan – Phon Thong	2011-2012	7 Mar 2012	№16, 09 Mar 2012	DPI
	SEDP – Phonsay	2004-2005	Jun 2004		DPI
	A First-6-Month SEDP Implementation Report and the Last-6-Month Development Plan – Phou Khoune	2006	28 Mar 2006	№98, 28 Mar 2006	DPI
	SEDP- Ngoi	2010-2015	Jan 2010	No signature and stamp	DPI
	District Political Performance Report	2004-2009	Jan 2010	-	-

Table 1 continued

No	Name of Documents	Year of Statistics	Year of Publication	Number/Signature, etc.	Source
III	List of projects (public and private)				
	Public Investment Projects (PIP) – LPQ	2011-2012	-	Approved by MPI/Govt.	MPI/DPI
	Public Investment Projects (PIP) – LPQ	2010-2011	-	Approved by MPI/Govt.	MPI/DPI
	Public Investment Projects (PIP) – LPQ	2009-2010	-	Approved by MPI/Govt.	MPI/DPI
	Public Investment Projects (PIP) – LPQ	2008-2009	-	Approved by MPI/Govt.	MPI/DPI
	Public Investment Projects (PIP) – LPQ	2007-2008	-	Approved by MPI/Govt.	MPI/DPI
	Public Investment Projects (PIP) – LPQ	2006-2007	-	Approved by MPI/Govt.	MPI/DPI
	Public Investment Projects (PIP) – LPQ	2005-2006	-	Approved by MPI/Govt.	MPI/DPI
	Public Investment Projects (PIP) – LPQ	2004-2005	-	Approved by MPI/Govt.	MPI/DPI
	Public Investment Projects (PIP) – LPQ	2003-2004	-	Approved by MPI/Govt.	MPI/DPI
	List of hydro development projects – LPQ	2000	-		MEM
	List of private-foreign investment projects – LPQ	1990-2012	-	№286, 2 Apr 2012	DPI

Note: PAFO = Provincial Agriculture and Forestry Office, MAF = Ministry of Agriculture and Forestry, MPI = Ministry of Planning and Investment, DPI = Provincial Department of Planning and Investment, MEM = Ministry of Energy and Mining, DOIC = Provincial Department of Industry and Commerce

2. Survey Results

2.1 Characteristics of Luang Prabang Province based on Socioeconomic Development Plan (SEDP)

Regarding the socio-economic characteristics including drivers of deforestation and forest degradation in Luang Prabang Province, the following were the characteristics of livelihood related to land use, based on SEDP.

2.1.1 Agriculture and livestock

As of October 2010, there were 782 villages in Luang Prabang Province, 230 of which and 12.4% of the total households (8,847 households) were considered as poor. People's means of livelihoods have been deeply connected to the way of management and utilization of land and forest resources. In order to eliminate poverty, SEDP had focused on measures to address the shifting cultivation which is considered as a unsustainable practice and is unable to provide stable income to the farmers.

Development of paddy, being promoted across the south-eastern Asia, had been picked up by SEDP as an alternative livelihood to shifting cultivation. Although paddy development had been promoted in Luang Prabang Province as well, the rice production from paddy was not sufficient at the time of 2010.

As a result, it could produce and supply rice for only about 9 months consumption in the Province; slow-paced paddy development had become a drag on decreasing the shifting cultivation. Besides rice farming, livestock for sale was also promoted to make it main export products of the Province as an alternative to shifting cultivation. Specifically, the efforts such as on farm livestock grazing grass plantation and vaccination for animals were promoted,

The government of Lao PDR or Luang Prabang Province had promoted the local products, taking advantage of the potential of each area. Major examples are organic vegetables, industrial plants, and commercial timber and fruit trees. The total land use area for such initiatives reached approximately 32,555 ha as of 2010. The major products were job's tear (*Mak douay*), sesame, peanut, soybean, tea leaf, orange, non-timber forest products (such as bloom grass, paper mulberry, natural rubber, and sandalwood), tobacco, corn, natural rubber, paper tree, teak wood, rosewood root, cow (including buffalo), goat, pig, horse and egg.

2.1.2 Forest products industry (sustainable forest management and decrease of shifting cultivation)

Luang Prabang Province was statistically covered with forests for 967,319 ha (57.3%) and it had conservation forests for 63,432ha, protection forests for 628,492ha, and production forests for 275,395ha (as of 2010). By type of production forests, they consisted of teak plantation (26,500 ha) and rubber plantation (13,531 ha).

The Province had so far been considering the forest management and sustainable wood production as its key industry. Thus, the Province had promoted the investigation of infrastructure in the area related to the forest products industry and check/control over sawmills and furniture factories, as well as dealing with monitoring wild animal and water animal.

In addition, the Province has supported the introduction of alternative livelihood as a measure for reducing shifting cultivation, while directing the trainings on plantation, livestock farming and land and forest management and so on.

2.1.3 Energy and mining

The electrification in Luang Prabang Province soared between 2009 and 2010, 630 villages (50,479 households) out of 782 had become electric by 2010. The Luang Prabang Province had planned and implemented a number of hydro electricity projects, taking advantage of its mountainous topography; and the acquired electricity had been exported to overseas, while contributing to the electrification in mountainous area.

As for mining, the government had been conducting the check and control over mining business in accordance with Lao laws and regulations. The Province reserves minerals such as gold that has leaded to attract foreign investment in recent years, of which especially Thailand and China expressed interest in mine business.

2.1.4 Manufacturing and trading

The manufacturing has also been promoted in Luang Prabang Province and there have been industries such as cement, bricks, steel, tile, nails, concrete factory, sawmill and furniture (105 companies in the Province). Producing handicrafts has been encouraged as souvenirs for the tourists from abroad, such as gold and silver products, textile (cotton, silk), wood carving, and hand-made paper.

Close to the border with China and Vietnam, local markets targeting customers from abroad (including tourists) have been developed in Luang Prabang Province and there were 83 markets in total as of 2010. The export volume of Luang Prabang Province amounted to 273 billion Kip approximately (mainly sesame, wood for paper making, job's tear, corn, tobacco, palm fruit, non-timber forest products, teak wood, furniture products were exported to China, Vietnam, Thailand, Korea, Taiwan and so on).

2.1.5 Tourism

In Luang Prabang Province, the tourism has become considered as the most important industry for economic development since City of Luang Prabang was registered as a world's cultural heritage. The Province promoted the development of infrastructure to facilitate tourism, especially giving importance on building roads which connect with the neighboring countries. The Province was also encouraging the private sector to participate in activities such as beautifying the city, airport development to measure up to international standards, road pavement, electricity and water supply, post system, traffic and maintenance of flowerbeds, as well as improving hotel and guest house services. In 2010, 216,864 foreign tourists and 1,084,320 domestic tourists visited Luang Prabang and the tourism brought about economic effect of 130.11 million dollars.

2.2 Identification of drivers of deforestation and forest degradation

In establishing a reference level, to reflect the socio-economic index as National/Regional Circumstances, statistical information that was correlated with the deforestation (change of the forest area) in Luang Prabang Province has been extracted, based on the operation procedure shown in Figure 3 below.

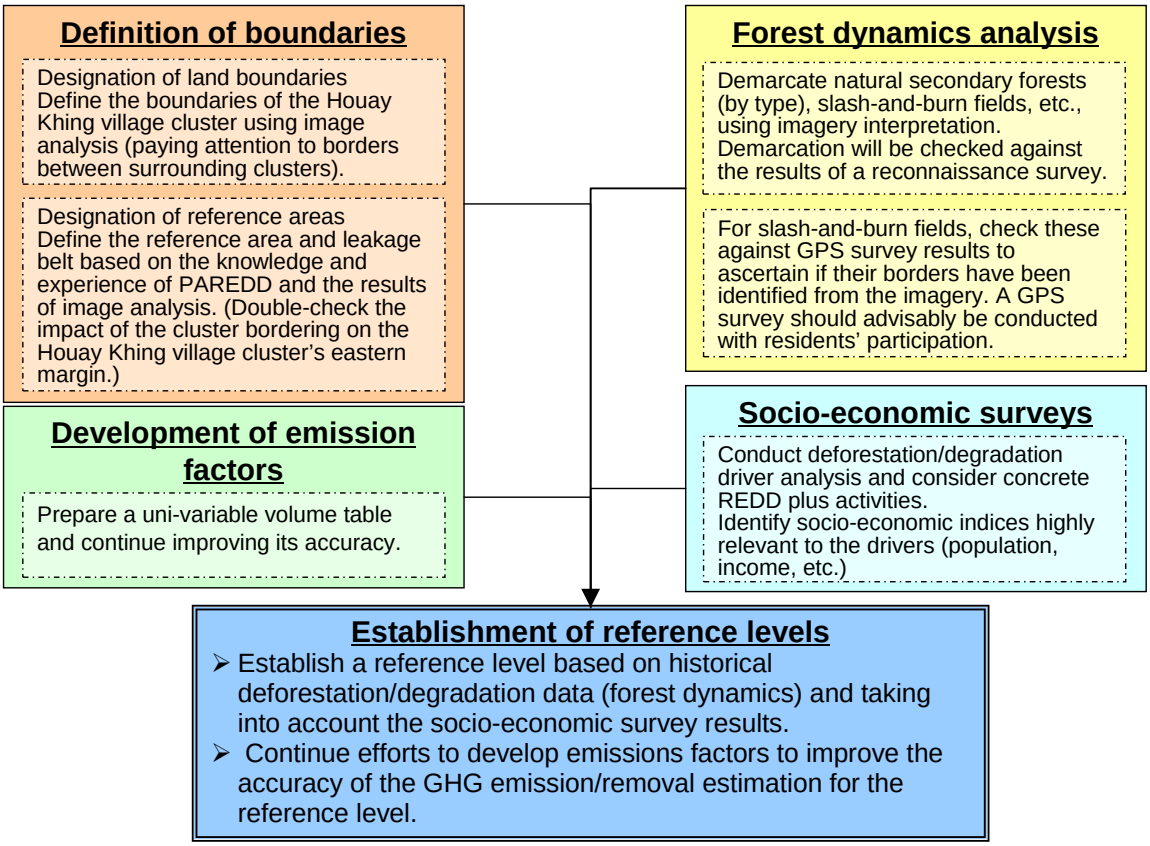


Figure 3 Operation procedures in establishing reference level

It was revealed that there was a positive correlation between the area of rotational upland rice obtained from SEDP and the deforestation obtained from Technical Cooperation Report "Analysis Results of Forest Dynamics". On the other hand, there was a negative correlation between the deforestation and the productions of cash crops, such as irrigated rice, job's tear and sesame (the production of such crops was effective in slowing deforestation) (Table 2). Refer to Appendix 1 for socio-economic circumstances of each 12 district in Luang Prabang Province based on SEDP.

Table 2 Statistic analysis of land use related to dynamics of forest size

		NC 1	NC 2	NC 3	NC 4	NC 5	NC 6	NC 7	NC 8	NC 9	NC 10	NC 11	NC 12	NC 13	NC 14	NC 15	NC 16	NC 17	NC 18	NC 19	NC 20	NC 21	NC 22	NC 23	NC 24	NC 25	NC 26	NC 27	NC 28	NC 29	NC 30	NC 31	NC 32	NC 33	NC 34
NC 1	Forest area	1.00																																	
NC 2	No. of Villages	-0.30	1.00																																
NC 3	Total	-0.40	0.68	1.00																															
NC 4	Male	-0.59	0.61	0.65	1.00																														
NC 5	Female	-0.58	0.61	0.65	1.00	1.00																													
NC 6	No. of HHs	-0.30	0.81	0.56	0.47	0.47	1.00																												
NC 7	Rain-fed rice - napii (ha)	-0.95	0.30	0.36	0.70	0.70	0.27	1.00																											
NC 8	Rain-fed rice - napii (production)	-0.97	0.32	0.38	0.65	0.64	0.35	0.97	1.00																										
NC 9	Irrigated rice - naxeng (ha)	-0.84	0.38	0.43	0.54	0.53	0.45	0.77	0.80	1.00																									
NC 10	Irrigated rice - naxeng (production)	-0.76	0.29	0.41	0.58	0.58	0.36	0.78	0.79	0.88	1.00																								
NC 11	Rotational upland rice (ha)	0.64	-0.29	-0.68	-0.20	-0.19	-0.30	-0.48	-0.56	-0.57	-0.49	1.00																							
NC 12	Rotational upland rice (production)	0.64	-0.32	-0.71	-0.23	-0.22	-0.34	-0.50	-0.58	-0.55	-0.50	0.99	1.00																						
NC 13	Sweet corn (ha)	-0.23	-0.12	-0.23	0.29	0.29	-0.26	0.36	0.32	-0.01	0.11	0.32	0.28	1.00																					
NC 14	Sweet corn (production)	-0.47	-0.02	-0.02	0.43	0.43	-0.18	0.57	0.52	0.19	0.29	0.05	0.02	0.93	1.00																				
NC 15	Jobs tear (ha)	-0.91	0.28	0.28	0.71	0.71	0.21	0.96	0.91	0.75	0.76	-0.35	-0.36	0.40	0.59	1.00																			
NC 16	Jobs tear (production)	-0.85	0.26	0.26	0.64	0.64	0.33	0.88	0.85	0.78	0.77	-0.37	-0.38	0.16	0.32	0.90	1.00																		
NC 17	Roots (ha)	-0.57	0.22	0.04	0.53	0.54	-0.09	0.67	0.59	0.35	0.38	0.00	-0.03	0.56	0.60	0.76	0.58	1.00																	
NC 18	Roots (production)	-0.60	0.32	0.19	0.58	0.59	-0.06	0.68	0.60	0.39	0.39	-0.14	-0.16	0.44	0.52	0.76	0.61	0.97	1.00																
NC 19	Vegetables (ha)	-0.49	0.15	0.01	0.37	0.37	0.14	0.56	0.55	0.36	0.42	-0.09	-0.09	0.44	0.52	0.56	0.41	0.52	0.48	1.00															
NC 20	Vegetables (production)	-0.51	0.29	0.22	0.51	0.51	0.25	0.58	0.58	0.38	0.42	-0.19	-0.19	0.38	0.48	0.53	0.42	0.50	0.50	0.93	1.00														
NC 21	Peanuts (ha)	-0.48	-0.05	-0.24	0.44	0.44	-0.08	0.58	0.55	0.37	0.39	0.25	0.23	0.74	0.69	0.66	0.60	0.71	0.61	0.63	0.56	1.00													
NC 22	Peanuts (production)	-0.72	0.11	0.04	0.65	0.65	0.07	0.80	0.75	0.60	0.60	-0.03	-0.04	0.62	0.70	0.86	0.80	0.72	0.68	0.66	0.63	0.92	1.00												
NC 23	Soy bean (ha)	-0.39	-0.11	-0.00	0.39	0.40	-0.25	0.46	0.38	0.26	0.33	0.08	0.07	0.70	0.80	0.51	0.40	0.46	0.43	0.28	0.24	0.59	0.66	1.00											
NC 24	Soy bean (production)	-0.46	-0.05	0.06	0.43	0.44	-0.25	0.53	0.45	0.27	0.34	-0.01	-0.02	0.71	0.83	0.57	0.40	0.56	0.53	0.36	0.33	0.56	0.65	0.98	1.00										
NC 25	Tobacco leaf (ha)	0.10	-0.03	-0.26	0.16	0.16	-0.04	0.02	-0.01	-0.16	-0.02	0.48	0.39	0.31	0.12	0.11	0.21	0.46	0.36	0.03	0.03	0.49	0.28	0.12	0.07	1.00									
NC 26	Tobacco leaf (production)	-0.23	0.15	0.06	0.33	0.33	0.20	0.30	0.33	0.12	0.18	0.05	-0.05	0.29	0.17	0.27	0.41	0.44	0.41	0.21	0.31	0.54	0.41	0.06	0.03	0.79	1.00								
NC 27	Sesame (ha)	-0.86	0.25	0.33	0.73	0.73	0.18	0.92	0.88	0.66	0.70	-0.35	-0.35	0.53	0.75	0.92	0.81	0.65	0.66	0.60	0.62	0.65	0.87	0.70	0.75	0.00	0.20	1.00							
NC 28	Sesame (production)	-0.89	0.32	0.39	0.79	0.79	0.26	0.95	0.91	0.70	0.73	-0.38	-0.39	0.47	0.68	0.95	0.85	0.70	0.71	0.61	0.65	0.65	0.86	0.61	0.66	0.07	0.28	0.98	1.00						
NC 29	Cow	-0.68	0.25	0.09	0.73	0.72	0.31	0.81	0.78	0.55	0.61	-0.01	-0.03	0.45	0.50	0.83	0.83	0.67	0.62	0.55	0.58	0.76	0.84	0.37	0.37	0.40	0.51	0.78	0.83	1.00					
NC 30	Buffalo	-0.16	-0.14	-0.48	0.33	0.33	-0.07	0.35	0.28	0.10	0.19	0.60	0.58	0.55	0.43	0.44	0.46	0.50	0.37	0.35	0.28	0.80	0.67	0.42	0.35	0.59	0.42	0.40	0.40	0.75	1.00				
NC 31	Pig	-0.30	-0.04	-0.33	0.46	0.46	0.03	0.49	0.43	0.22	0.34	0.44	0.42	0.56	0.47	0.55	0.57	0.57	0.46	0.49	0.45	0.83	0.75	0.42	0.37	0.58	0.49	0.52	0.54	0.85	0.97	1.00			
NC 32	Goat	-0.70	0.25	0.14	0.75	0.74	0.32	0.82	0.80	0.59	0.65	-0.05	-0.07	0.48	0.54	0.83	0.83	0.62	0.58	0.61	0.66	0.78	0.88	0.44	0.43	0.29	0.46	0.83	0.87	0.98	0.71	0.83	1.00		
NC 33	Poultry	-0.64	0.16	-0.03	0.67	0.67	0.20	0.78	0.73	0.50	0.55	0.09	0.07	0.51	0.55	0.82	0.82	0.69	0.63	0.54	0.56	0.82	0.88	0.46	0.45	0.43	0.51	0.77	0.81	0.98	0.83	0.90	0.96	1.00	
NC 34	Horse	-0.45	-0.31	-0.37	-0.05	-0.04	-0.32	0.37	0.33	0.43	0.26	-0.00	0.06	0.24	0.32	0.46	0.37	0.30	0.25	0.24	0.07	0.46	0.50	0.40	0.41	-0.22	-0.21	0.37	0.31	0.20	0.32	0.25	0.22	0.31	1

Note: These values in this table showed the correlation coefficient between deforestation and each land use (range - -1.0 to +1.0). If the correlation coefficient is close to +1.0, there is a strong positive liner relationship between deforestation and such land use. If the correlation coefficient is close to -1.0, there is a strong negative liner relationship between deforestation and such land use.

2.3 Reflection of socio-economic factors to establish a reference level

To establish a reference level, the following four Technical Cooperation Reports were used in this project.

1. Technical Cooperation Report "Analysis Results of Forest Dynamics"
2. Technical Cooperation Report "Destructive Sampling Survey"
3. Technical Cooperation Report "Results of Forest Plot Survey"
4. Technical Cooperation Report "Results of Socio-Economic Survey" (this survey)

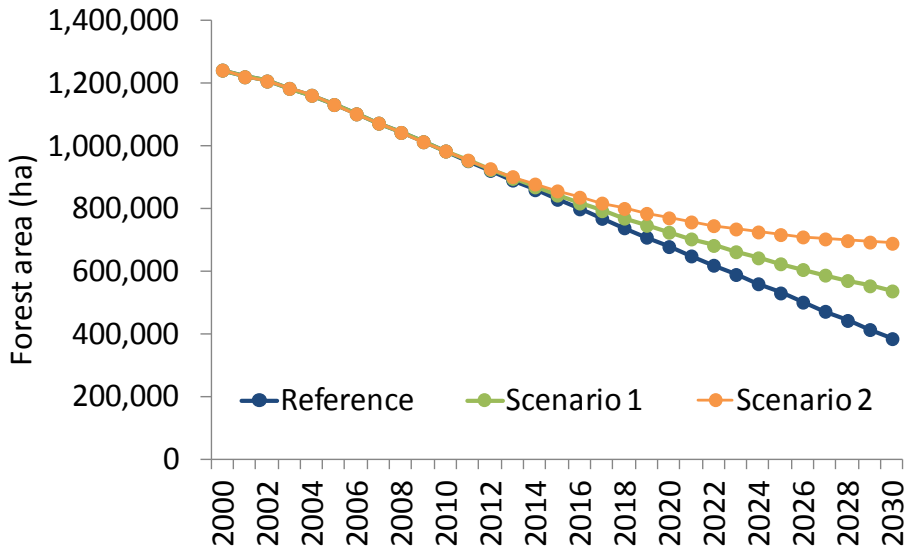
As Lao PDR had not given any specific direction for establishing a reference level as of the end of July 2014, we established a reference level based on the most recent discussion at UNFCCC and the trend of VCS or others by using econometric model, with reference to above four Technical Corporation Reports.

The reference level, the establishing method was detailed in Final Report, was established by the following model, using the socio-economic factors such as population, livestock (Cow was applied, available from the statistics) and the area of paddy field as an alternative livelihood to the shifting cultivation.

$$ForArea_t = -0.0725 \times ForArea_{t-1} - 0.889 \times FA_t - 0.884 \times SBA_t + 1{,}708{,}039$$
$$FA_t = 0.953 \times FA_{t-1} + 1.38 \times SBA_{t-1} - 65{,}867 \quad \text{.....Model 1}$$
$$SBA_t = -0.577 \times SBA_{t-1} - 23.7 \times PF_t + 2.09 \times POP_t - 0.390 \times Cow_t - 560{,}942$$

$ForArea_t$	Total forest area of Mixed Forest, Dry dipterocarp Forest and Teak plantation within the reference region at year t; ha
FA_t	Area of Fallow at time t within the reference region; ha
SBA_t	Area of Slash-and-Burn at time t within the reference region; ha
PF_t	Area of Paddy Field at time t within the reference region; ha
POP_t	Population of within the reference region at time t
Cow_t	Number of Cow as livestock at time t within the reference region
t	1, 2, 3 … t, a year of the proposed crediting period; dimensionless

The future forest area was estimated as follows (Figure 4) by the reference level in Luang Prabang Province which was applied the econometric model (Model 1).



Note: Scenario "Reference" means "Deforestation area is continuing to expand at the current rate. The area of Paddy field and the number of livestock (cow) remain constant until 2030". Project scenario 1 means "REDD plus activities are implemented. The area of Paddy field and the number of livestock (cow) will increase by 10% over the next 20 years". Project scenario 2 means "REDD plus activities are implemented intensively. The area of Paddy field and the number of livestock (cow) will increase by 20% over the next 20 years".

Figure 4 Future forest area based on the established reference level

Chapter 3 The Approach Targeting Phonsay District

Targeting HK-VC in Phonsay district, we advanced an approach assuming the implementation of project-based REDD plus. At the implementation of REDD plus project, the Project Description is required to prepared in advance (refer to Technical Cooperation Report "Project Description (PD) on REDD plus Project") in which the drivers of deforestation and forest degradation in the target area should be identified. We advanced the extraction and analysis of the drivers of deforestation and forest degradation by analyzing the SEDP owned by the district and statistical data related to the population and agriculture, as well as conducting an interview to villagers using survey sheets. Then, in order to identify the effective measures to inhibit deforestation and forest degradation based on the analysis, with understanding Human Resources and Natural Resources in the target area, we performed the selection of Demonstration Activity in order to understand quantitatively the inhibiting effect of deforestation and forest degradation in case the specific Project Activity was implemented (Figure 5).

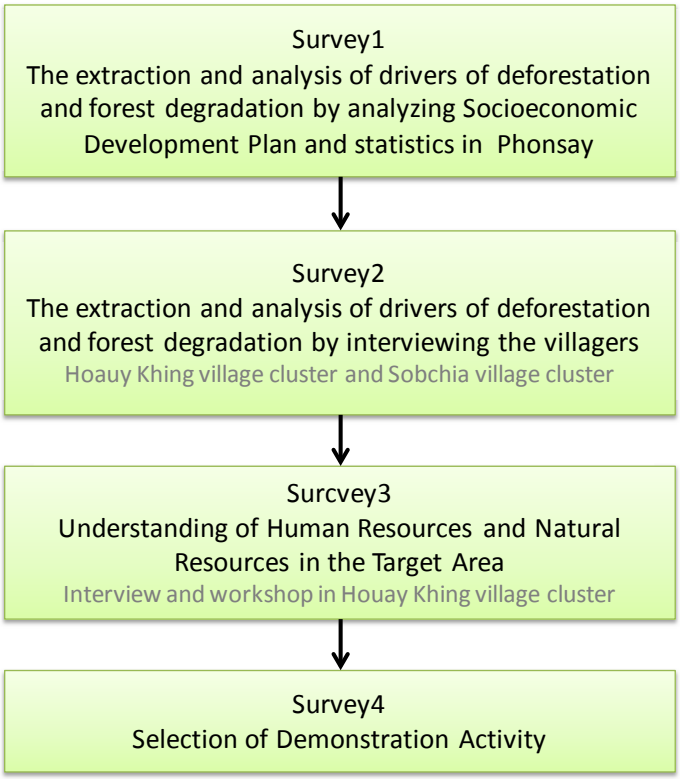


Figure 5 Workflow diagram of conducting socio-economic survey targeting Phonsay district

In addition, the results of the socio-economic survey were reflected in establishing the reference level targeting Phonsay district: we illustrated the over time forest dynamics and carbon dynamics in Phonsay district based on Technical Cooperation Report "Analysis Results of Forest Dynamics", Technical Cooperation Report "Destructive Sampling Survey" and Technical Cooperation Report "Results of Forest Plot Survey" and those were reflected as Regional Circumstances in Phonsay district which were obtained

from this deliverables.

As above, in the socio-economic survey targeting Phonsay district, we aimed at estimating the inhibiting effect of deforestation and forest degradation which was obtained from implementing the project (red line = project scenario), while advancing formulating the reference level (blue line) indicated following Figure 6.

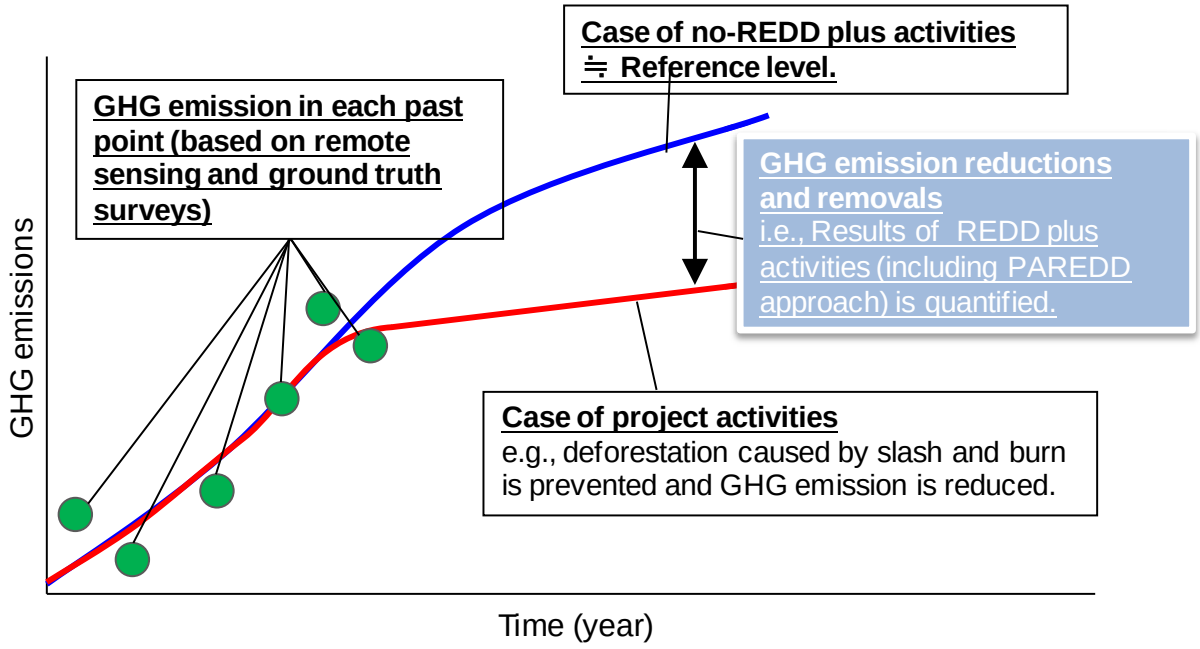


Figure 6 Approach to reference level and project scenario in Phonsay district

From the next page, the socio-economic survey targeting Phonsay district (from survey 1 to survey 4) was detailed based on the workflow indicated in Figure 5.

Survey 1 Extraction and Analysis of Drivers of Deforestation and Forest Degradation by Analyzing Socioeconomic Development Plan and Statistics in Phonsay

In the HK-VC, the target area of this project, population has been increased significantly since 2000. The potential for expanding slush and burn area (abundant forest resources) was cited as one of the major reasons for the significant population increase. Moreover government led integration of villages close to major road network was also another reason for rising population. HK-VC was established as a result of the village transfers led by the government in 2002, where the six neighboring villages were merged into a village cluster. This kind of government-led village transfers is not uncommon in Lao PDR. Moreover, some also suggested that there was a political interest to concentrate population (congestion of population). Therefore, considering the population growth a parameter as reflected in reference curve, its dynamics should be related to socio-economic aspect but also to government-driven aspect (immigration policy), creating a big challenge for the socio-economic survey and the establishment of a reference level.

In this project, HK-VC of Phnsay district was set up as a reference area for REDD plus project, whereas neighboring two village clusters Sobchia and Phonthong were considered as a leakage belt. As a result, the whole Phonsay district was covered for the extraction and analysis of drivers of deforestation and forest degradation.

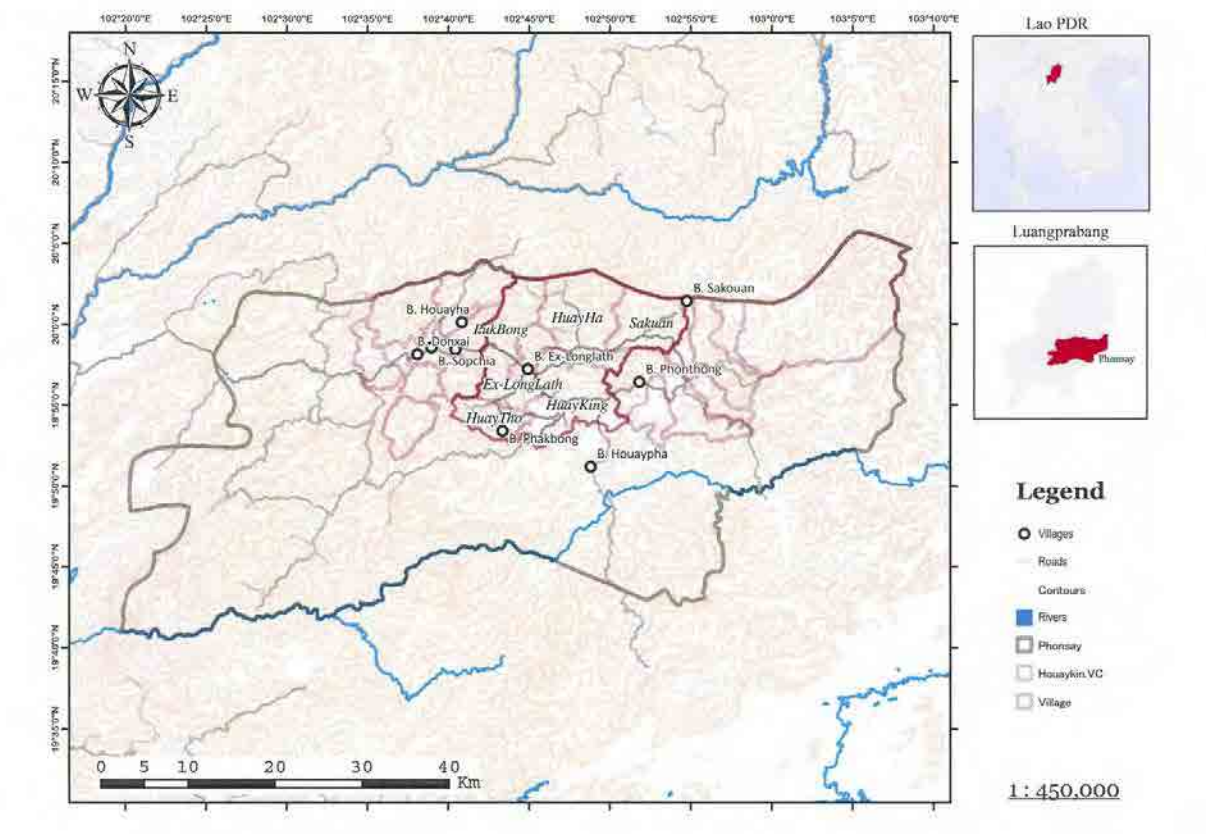


Figure 7 HK-VC as a target of REDD plus project

1. Basic Information of the Targeted Area

Sobchia village cluster, which is located west of HK-VC, secured a distribution channel to the market by improving road access to the city of Luang Prabang city since 1990s. This expanded production, utilization and marketing of agricultural products and non-timber forest products. Due to social infrastructure development such as road improvement and the increasing uses of forest resources by rapidly growing population growth, forest cover and agro-biodiversity has been lost continuously over time. Under these circumstances, the support for rural development by The Agro-biodiversity Initiative has been implemented in Sobchia village cluster since the middle of 1990s.

On the other hand, in HK-VC, the road improvement and the merger and transfer of villages have been implemented since 2000s, while the social infrastructure such as telephone line has started to be developed (Table 3).

Table 3 Road improvement in HK-VC

Year	History
2000–2001	Road construction from Sobchia village cluster (near Luang Prabang City) to HK-VC cluaster by manpower (passable only by motorbike)
2003	Road expansion from Sobchia village cluster to Phonthong village cluster by heavy machinery (passable by automobile)
2004	Road construction from the main road to Houayha and Sakuan villages
2005	Road construction from the main road to Houaytho village
2011–2012	Road expansion and bridge construction from Luang Prabang City to HK-VC

As above, the socio-economic development would be advanced in the future in HK-VC same as Sobchia village cluster which will result increase in deforestation forest degradation. The population and the outline of HK-VC were given in Table 4 and Table 5.

Table 4 Population and ethnic composition in HK-VC

Village Name		Houaykhing	Phakbong	Houaytho	Houayha	Sakuan	Longlath
Number of households (HH)		210	82	59	55	138	81
Population (female)		1,479 (752)	467 (236)	354 (183)	396 (192)	910 (446)	464 (238)
Lao people	No. of HH	5	1	0	0	0	3
	Population (female)	23 (12)	1 (0)	0 (0)	0 (0)	0 (0)	9 (4)
Khmu people	No. of HH	122	81	35	6	464	118
	Population (female)	787 (394)	466 (236)	129 (77)	50 (22)	464 (238)	817 (398)
Hmong people	No. of HH	83	0	24	49	0	17
	Population (female)	669 (345)	0 (0)	225 (106)	346 (170)	0 (0)	85 (44)

Table 5 Outline of HK-VC

	Houay Khing	Phakbong	Longlath	Houaytho	Houayha	Sakuan
Distance from District Center	36 km	27 km	31 km	39 km	38 km	46 km
Land Area	7,425.8 ha	4,781.0 ha	*Work in progress under the PAREDD*	2,731.5 ha	7,497.8 ha	4,626.4 ha
Establishment of the Village	2003	2001	*Work in progress under the PAREDD*	70-100 years ago	Around 1970	Around 1960
Migrated from	Three villages merged into one village; villagers moved to roadside habitations	Phakbong Village was relocated to an area close to the current village area and finally settled to a roadside habitations following merge with Houaysoy Village	*Work in progress under the PAREDD*	Houaytho was known as Khmu Village at the current location; Hmong moved from Napieng Village located 8 km away in 2003	Houayha villagers were moved to an area close to the current village area, finally settling in the present area.	Hmong have lived at the current location for 50 years; Khmu people moved from the Phakseng District in 2002.
Reason for Migration	Government policy to merge small villages into bigger villages and to provide better road access to improved main road	Government policy to merge small villages into bigger villages and to provide better road access to improved main road	*Work in progress under the PAREDD*	Hmong moved to the village in 2003 due to government policy to merge small villages into bigger villages and to provide better road access	Need for arable land	Khum moved from Pakseng District in 2002 due to government policy to merge small villages into bigger villages and to provide better road access

2. Socio-economic Characteristics in Phonsay District

Based on the SEDP[1] of Phonsay district, the socio-economic characteristics including drivers of deforestation and forest degradation were sorted out. The outline was as follows.

2.1 Basic information

There were 55 villages and 4,024 households in total in Phonsay district in the latest year (the statistics of 2004). It consisted of 8 Lao Loum villages (535 households and 2,298 people (9.2% of the total district population)), 36 Khmu villages (2,581 households and 15,167 people (60.7%)), and 11 Hmong villages (908 households and 7,521 people (30.1%)). The total population of the district was 24,986, the population growth rate marked 1.7% per year and the number of members per household was approximately 6.

Phonsay district was considered as the poorest district in Luang Prabang Province and 15 villages (2,318 households in total) were reported to be in poverty in 2003-2004. Under those circumstances, because more than 80% of the total labor force in Phonsay district engaged in slash-and-burn shifting cultivation, the knowledge and skills of the workers in the district were reported to be low level. Due to a shortage of various kinds of basic infrastructure (water supply), the households which had access to clean water remained at 32.9%, access to roads at 59.4% and access to health care service at 73.5%.

Therefore, the government had been providing support to issues such as development of the education network in under-populated areas, training of teachers, improvement of education methods, improvement in the vaccination rate, health care support for under-populated areas, installation of emergency medical-care system in the villages, establishment of clinics in the villages, and improvement of the access to safe and clean water, making these the top priority.

2.2 Agriculture

The climate in Phonsay district is suitable for cultivating various types of vegetables such as job's tear, sesame and maize due to the ample precipitation and long hours of daylight. The most of the district is covered with steep mountains and 16-30% of the district is lowland and 30-55% is highland. The district has limited flatland available for paddy field.

The main sources of economy of the district are agriculture and livestock. As for the households' main occupation, 82.7% households are engaged in shifting cultivation, 2.7% are in service industry and 14.6% are occupied in handcrafts and other industries.. In terms of household number, 202 households engaged in paddy, 67 households in both paddy and slush-and-burn, 3,330 households in slush and burn farming, 107 households in service industry and 318 households in other.

2.3 Effort for forest conservation

The total area of shifting cultivation in Phonsay district (according to district statistics was reported approximately 3,000 ha in 2004. Due to rapid decline in forest area and the quantity of available non-timber

[1] The following description was a summary created from PAFO (2004) Socioeconomic Development Plan Phonsay 2004-2005 (Lao).

forest products in the forest, the district needed to make an effort for forest conservation while creating sustainable job opportunities as an alternative to slash and burn shifting cultivation. The 167 households lived in 3 villages of the district stopped shifting cultivation on a trial basis and established a settled livelihood options by raising livestock (cow, goat, pig and chicken) and by planting tree with government's financial assistance (offer of microfinance). These examples show positive impacts of alternative livelihood system in reducing drivers of deforestation and forest degradation in the district.

Survey 2 Extraction and Analysis of Drivers of Deforestation and Forest Degradation by Interviewing the Villagers

A semi-structured interview was conducted in the five target villages f Phonsay district with the cooperation of DAFO. About 30 households were sampled for interview by random sampling method from each village clusterin HK-VC (Houay Khing, Phak Bong, Houay Tho, Houay Ha, Sa Kuan) and 5 villages in neighboring Sobchia village cluster (Hua Mueang, Phak Hok, Tat Thong, Houay Si Yua, Houay Dong). In order to gather gender segregated opinions, the survey team targeted women in 10 households out of selected 30 households (Table 6).

Using Ms-Excel random number list in the random sampling, we were careful for the unbiased selection of the villagers so that representatives from different ethnic groups, occupation (farming pattern), income level and farming land size were included in the sample.

Table 6 Sample Households in Houay Khing and Sobchia Village Clusters

Village cluster	Village code	Village (economic status)	Total no. of households	No. of sample households (HH, % of total)	No. of female samples (HH)
1. Houay Khing	1-1	Houay Khing (medium)	220	41 (19%)	10
	1-2	Sa Kuan (poor)	123	36 (29%)	9
	1-3	Houay Ha (poor)	56	37 (66%)	10
	1-4	Houay Tho (poor)	58	38 (66%)	8
	1-5	Phak Bong (poor)	82	35 (44%)	10
2. Sobchia	2-1	Pak Hok (medium)	95	36 (42%)	9
	2-2	Hua Meuang (better-off)	83	35 (44%)	10
	2-3	Tad Thong (poor)	82	35 (47%)	9
	2-4	Houay Si Yua (medium)	93	38 (41%)	11
	2-5	Houay Dong (poor)	85	32 (34%)	16
TOTAL			977	363	102

Before conducting household interviews in each village, a workshop was held to explain the objectives of the interview and survey. Participatory resource maps of the villages were prepared and collected the basic information of the villages through the individual interviews. The survey was implemented using five-step assessment related to local circumstances such as land use transformation of the villagers, participation in village meetings, forest utilization and the livelihood focusing on the shifting cultivation (refer to Appendix 2 about the survey questionnaire).

1. Identification of Drivers of Deforestation and Forest Degradation

In order to understand the issues related to identification of drivers of deforestation and forest degradation, it is necessary to understand the land use of the villagers, forest utilization, results of villagers' responses about alternative livelihoods and the villagers' capability and interests toward reducing deforestation and forest degradation. The results of responses were indicated that there is a n need for

villagers' participation in decision-making in the village meetings, they need to develop cooperation among the villagers in agricultural or other activities and there is a need for alternative livelihood.(in detail, refer to Appendix 2 and supplementary volume 1)

1.1 Land use

To clarify land use change, current land use situation and the possibilities of farming land expansion, we interviewed sample households about the transition of land use size since 2003 (on or before 2003 if traceable), the number of farming plots and the crops to cultivate and so on, while taking a survey of production situation of rice necessary for self-consumption (annual rice shortage) and necessary land size to maintain the livelihood (see following section).

1.2 Land use transformation

The land use area by land use type of sample households in both HK-VC and Sobchia village cluster were indicated as the following.

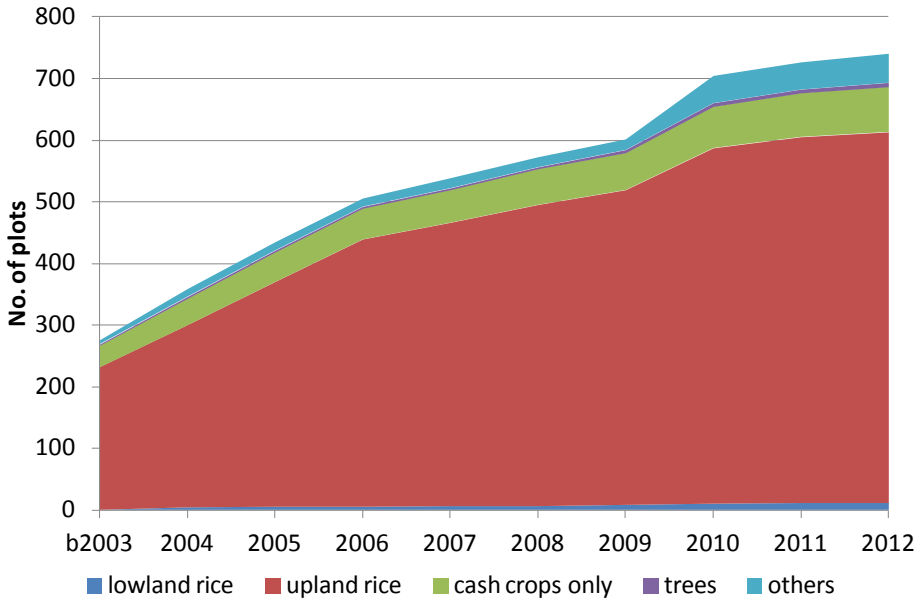


Figure 8 Changes in agricultural plots by land use type in HK-VC

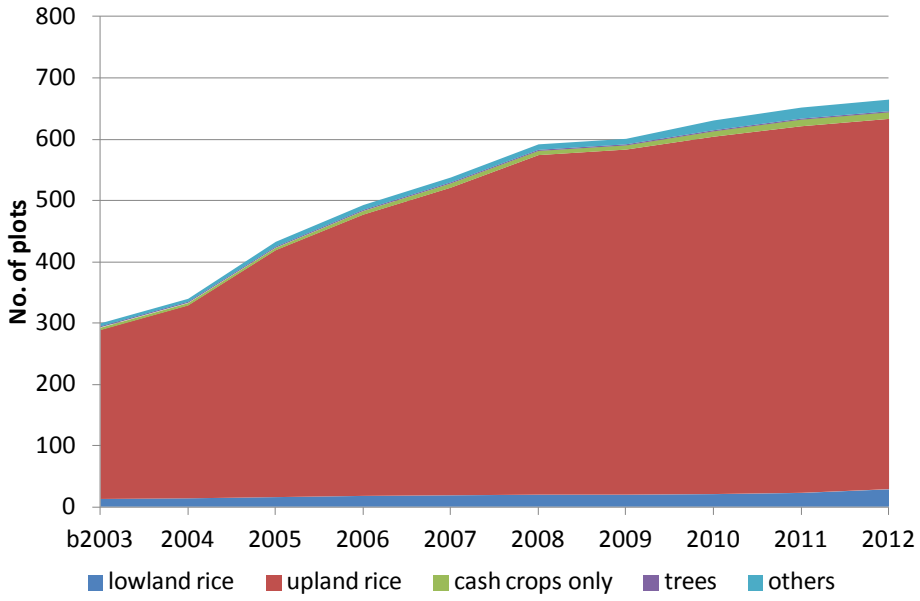


Figure 9 Changes in agricultural plots by land use type in Sobchia village cluster

Note: Figure 8 and Figure 9. In both figures, "lowland rice" means paddy field, "upland rice" means the farmland used for slash and burn rice only or mixed cropping with cash crops. "Cash crops only" means the farmland cultivated only for cash crops, "tree" means plantation and orchard, "others" means other land use including fallow land.

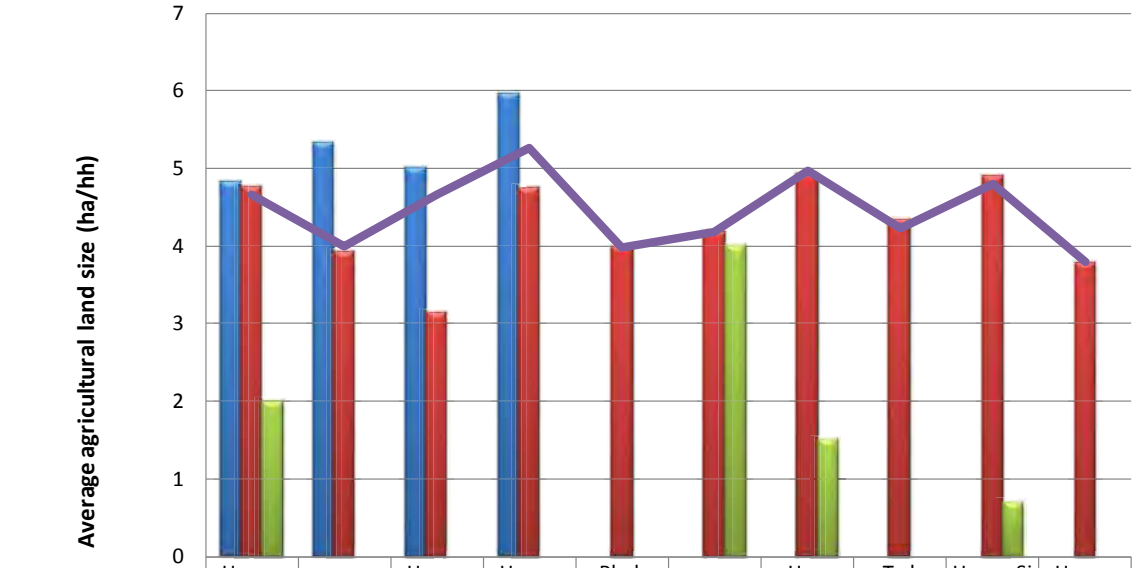
In both HK-VC and Sobchia village cluster, upland rice had been on the increase since 2003 and the increase rate varied depending on the time. In HK-VC, the increase rate of upland rice was sharp up to 2005 and became slightly moderate afterward. On the one hand, "cash crops only" started to increase from 2006 onward. The improvement of the road access to and from the district during 2005-2007 was considered as a major reason for this increase.

In Sobchia village cluster, "upland rice" showed a high rate of increase up to 2008. The increase rate of "upland rice" was especially high from 2004 to 2008. The rapid increase in "upland rice" from 2004 to 2008 was partly because of establishment of the new village (Tad Thong) and partly because of improved road accesses in some areas. Another feature of Sobchia village cluster was the mixed cropping of rice and cash crops in the same slash and burn field, unlike in HK-VC where the farmland were divided into slash and burn rice and cash crops. The difference of land use transformation between HK-VC and Sobchia village cluster was considered partly because of the difference of agricultural production method.

1.3 Current farmland size and the number of slash and burn plots per household

The farmland size per sample household was 4.47 ha on average. The farmland size was different among the ethnic groups: the survey results of the four villages in HK-VC (Houay Khing, Sa Kuan, Houay Ha, Houay Tho that the Hmong ethnic group owned and cultivated farmland about 1.3-1.6 times larger than those of Khum ethnic group. Compared among the villages, in Houay Tho, Hua Meuang, Houay Si Yua villages had large land size per household, higher number of slash and burn plots used per household, each

owning more than 4 plots. The number of plots used in Houay Dong and Phak Bong and Sa Kuan villages was smaller compared to other villages (Figure 10).



	Houay Khing	Sa Kuan	Houay Ha	Houay Tho	Phak Bong	Pak Hok	Hua Meuang	Tad Thong	Houay Si Yua	Houay Dong
Hmong	4.82	5.34	5.01	5.97	0	0	0	0	0	0
Khmu	4.77	3.92	3.14	4.75	3.99	4.19	4.93	4.35	4.91	3.79
Lao Loum	2.00	0	0	0	0	4.00	1.50	0	0.70	0
Average in village	4.66	4.00	4.65	5.26	3.99	4.18	4.97	4.22	4.79	3.79

Figure 10 Average farmland size per sample household (by ethnic group / total of sample households)

1.4 Possibilities of farmland expansion

Figure 11 showed the results of the response that the average size of current farmland per household and the average size of additional farmland that the villagers require and are considering to secure the to produce enough rice for domestic consumption.

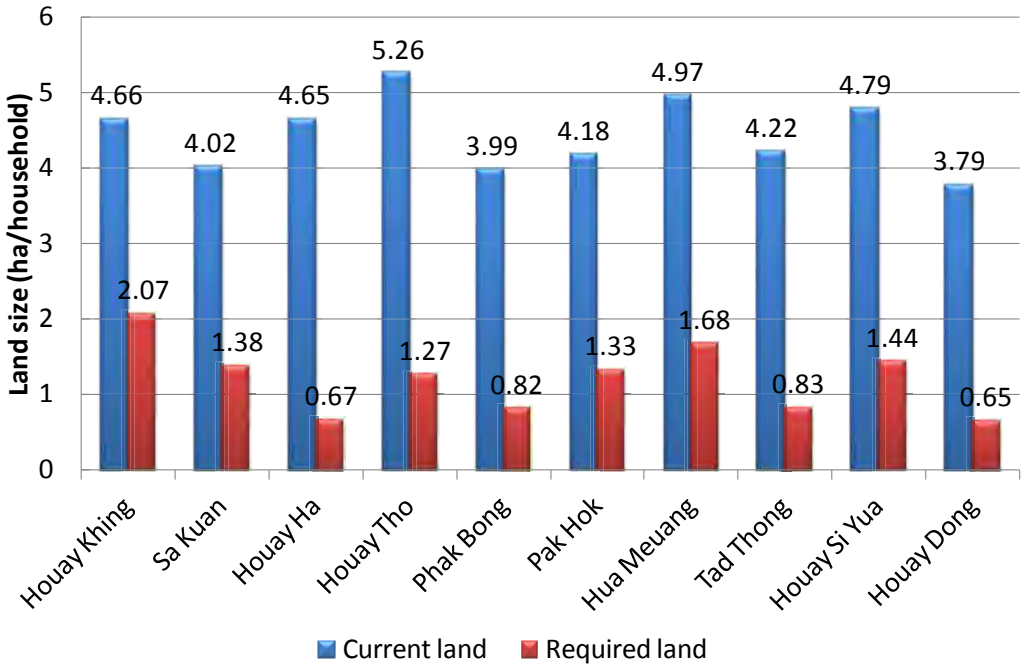


Figure 11 Current and required farmland size (average of sample households)

Sample households in Houay Khing, Sa Kuan, Hua Meuang and Houay Si Yua responded that they needed additional farmland (for shifting cultivation) and also their needs for farmland size were relatively large. In fact, these villages had had a high percentage of households that fell into rice shortage and the amount of rice shortage had been also large (Figure 12). In Houay Khing, Sa Kuan and Houay Si Yua many households had 3 or less plots of shifting cultivation which was not enough for them to secure sufficient amount of production as productivity reduced due to reduction in the fallow period (Figure 13).

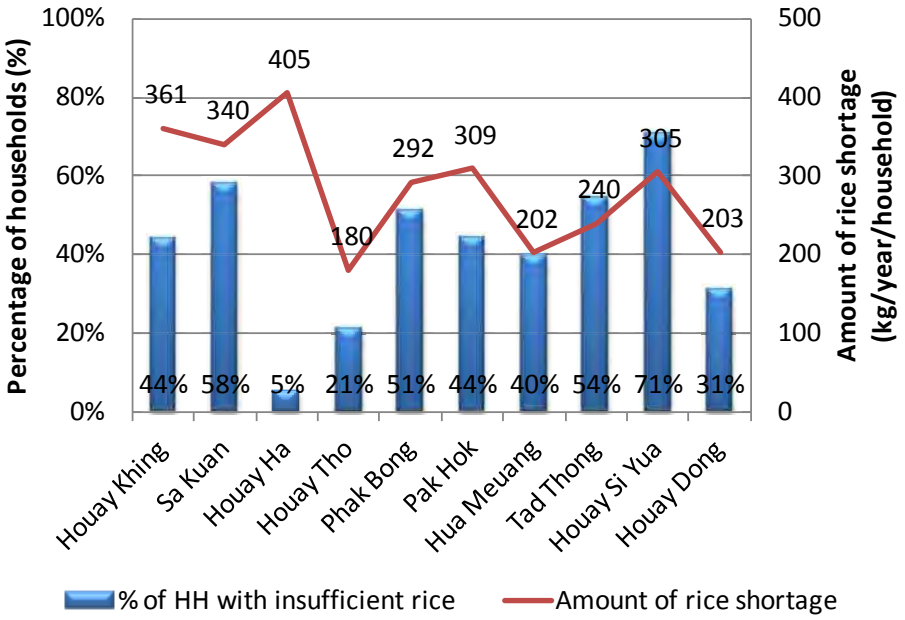


Figure 12 Household suffering rice shortage and the amount of shortage (sample households)

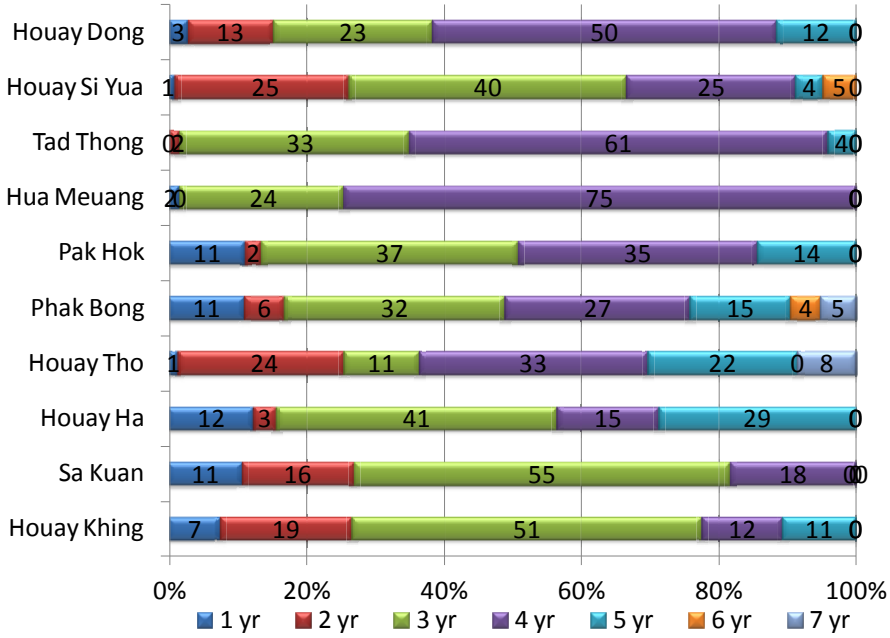


Figure 13 Fallow periods of upland agricultural plots (sample households)

By using the statistics of land use plan of Phonsay district bureau of land management, we calculated the farmland area per household from the total area of farmland and reserved farmland, and the farmland area allocable to each household, which was showed in Figure 14. As a result, it became clear that households in each village would be able to own enough farmland theoretically, although there was a range in the size (the smallest was 15 ha per household in Houay Khing village and the largest was 74 ha in Houay Ha). In reality,

however, not all the land that was zoned for farmland had been developed or utilized due to difficult access to distant farmland or shortage of labor. This was confirmed during the interview that a number of villagers responded that they would like to increase their farmland to improve their livelihoods, but they were shortage of necessary labor.

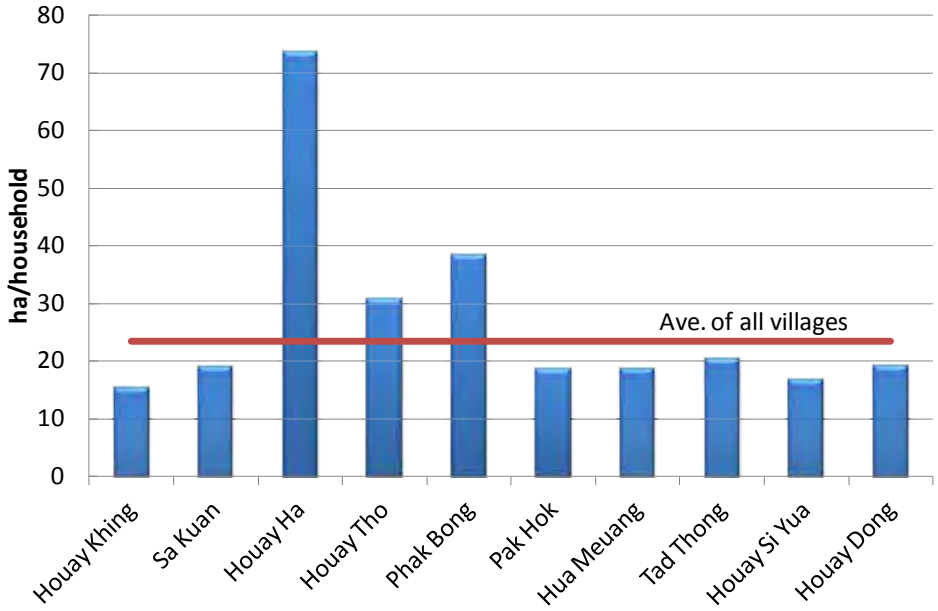


Figure 14 Farmland potential of each village (farmland size available to each household)

However, in Houay Khing, Hua Meuang, Houay Si Yua and Sa Kuan, although the average current farmland owned and utilized by sample households were more than 4 ha, the required additional farmland size was larger compared to other villages. It was because they had enough labor or they were ready to secure the labor by hiring people. In addition, because of increasing pressure on land use caused by the expansion of the primitive shifting cultivation in Houay Khing, Sa Kuan and Hua Meuang where the size of farmland was relatively small for their population size; the appropriate monitoring and management of land use would be necessary by villager group.

2. Utilization of Forest and Forest Resources

Figure 15 showed the utilization of fuel wood per month, usage frequency of non-timber forest products, usage frequency of construction material and usage frequency of forest as livestock husbandry. It showed that both village clusters were heavily dependent on forests for fuel wood which is becoming indispensable energy for cooking and heating in the clusters.

Houay Ha village used the largest amount of fuel wood out of ten villages and the average amount of utilization per sample household was 4,580 kg/year/household, which was around as 1.9 times as Houay Khing (2,443 kg/year/household), that uses the smallest amount of fuel wood. More than 90% of fuel wood used were

dead and dry wood and branches. The villagers in HK-VC had a tendency to collect fuel wood in the community forest which was allocated in the village to use for various purposes, while a number of households in Sobchia village cluster tended to collect around their residential areas.

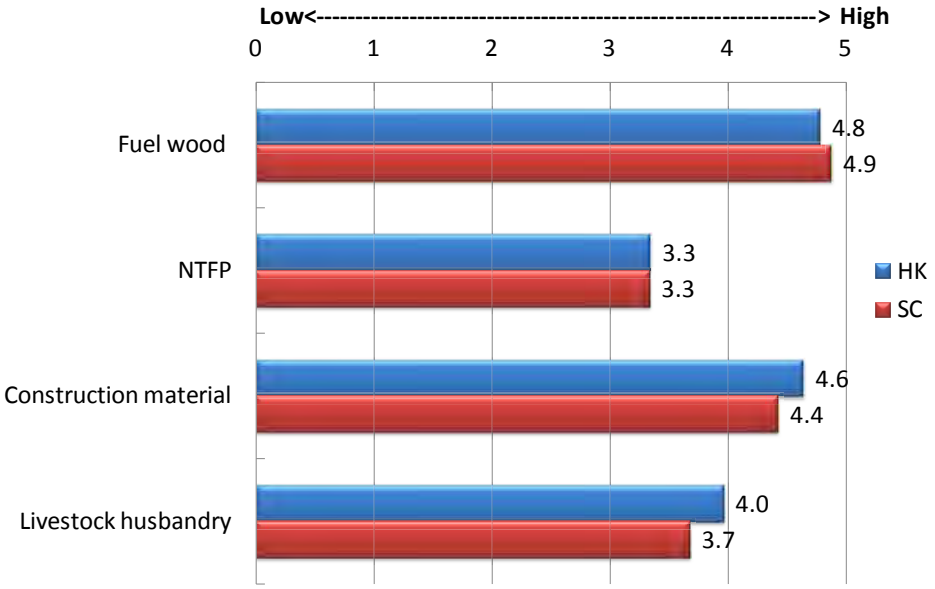


Figure 15 Frequency of forest use by purpose (Ave. of 5 step assessment)

The usage frequency of livestock grazing was also high. Figure 16 showed the kind of site where the villagers used for grazing. Around 40% of sample households in both clusters individually raised their livestock, mainly cow and buffalos, in natural forests. Another 35% of the households raised livestock in common land for grazing set up by village. They used the land designated by group when they grazed in common land and the villagers rotated a watchdog to guard the livestock from theft. Very few households raised livestock in their fallow land as it did not provide enough pasture grass (Fallow land: 4% in HK-VC, 1% in Sobchia village cluster).

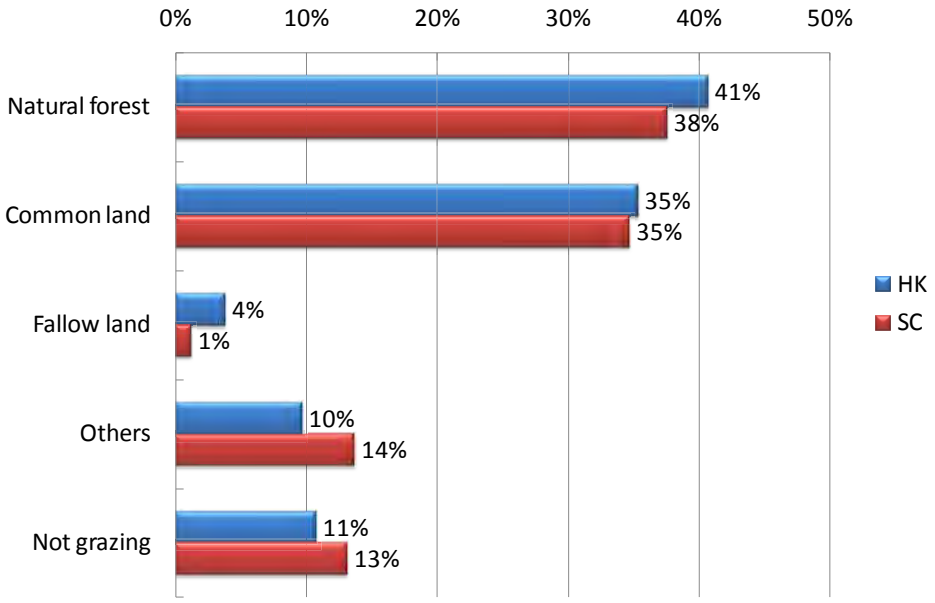


Figure 16 Location of grazing (percentage by sample households)

3. Current Situation of Capabilities for Maintaining Livelihood

In order to assess villagers' perception about their capacities for maintaining and improving livelihoods, the sample households were asked whether their skills and assets necessary for improving their livelihoods were sufficient, and were asked to evaluate their satisfaction level by five grades. The evaluation items were as follows: assets (the size of agricultural land[2]), farming skills (production techniques), food security (rice productivity), access to resources (agriculture water, agricultural land) and economy (incomes) (refer to Appendix 2 for survey questionnaire).

The results showed that the items rated more than 3 in average in both clusters were the size of agricultural land (Agri land: 3.7 in HK-VC, 3.6 in Sobchia village cluster) and the amount of rice production (Rice Production: 3.5 in HK-VC, 3.1 in Sobchia village cluster). This meant that there was a relationship between the sufficient land to cultivate and the food security, which was especially often the case with HK-VC. The production techniques (Production tech: 3.1 in HK-VC, 2.6 in Sobchia village cluster), access to farmland (Access to farms: 3.0 in HK-VC, 2.6 in Sobchia village cluster) and incomes (Incomes: 2.6 in HK-VC, 2.3 in Sobchia village cluster) were given medium to somewhat low rating, although and the villagers were hoping improvements on those aspects. The sample households in HK-VC were more confident in farming skills compared to Sobchia village cluster as shown in Figure 1717. However, both village clusters did not have sufficient farming techniques and run the primitive agriculture by using rainwater conventionally. Both VC need to take some measures against this problem, in order to secure the enough amount of production while maintaining their livelihoods. The access to irrigation water was given low evaluation in both village clusters (Agri water: 1.1 in HK-VC, 1.4 in Sobchia village cluster),

[2] Agricultural land here includes all the lands used for various agricultural activities: upland farms, lowland paddy fields, crop fields and fruit orchards (Suan in Lao), livestock grazing land.

indicating the shortage of agriculture water was a widespread problem in each village. Due to this reason, it was considered that to be effective in terms of improving the capacity of sustainable forest management, programme should incorporate techniques or systems to manage water by a village or villagers groups as a Demonstration Activity.

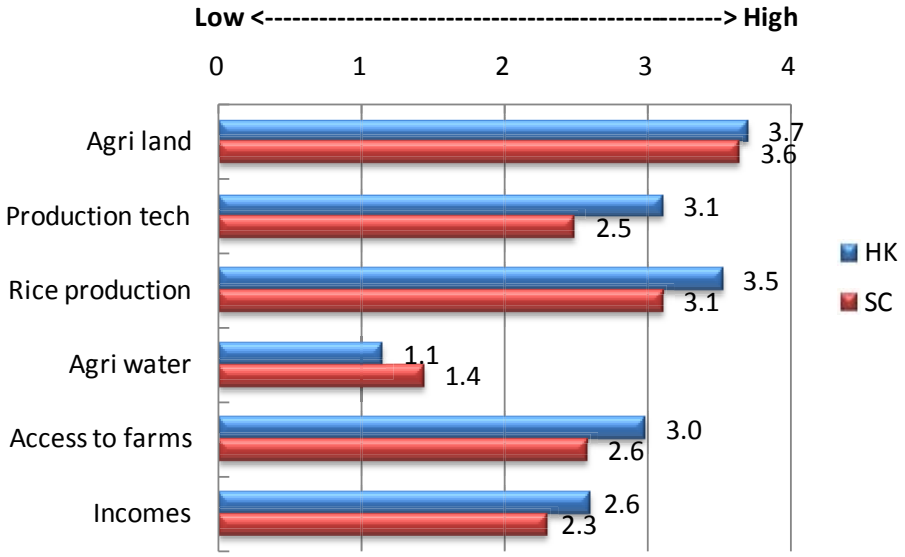


Figure 17 Evaluation for various capabilities for maintaining/improving livelihoods (Ave. of five step assessment)

3.1 The situation of decision making at village meeting

In order to advance the sustainable forest management, it is important to develop a land use plan participatory and implement the plan with adding improvement. The development of participatory land use plan is also promoted in an effort of PAREDD approach. To assess the villagers' decision –making capability before the start of the project activity, the villagers were asked to response the following by five steps assessment: the frequency of attending the village meeting, an immediate discussion opportunity to the villagers, the participation level in decision making (Making statement) and their interest or the level of understanding in the participatory decision making process (Figure 18).

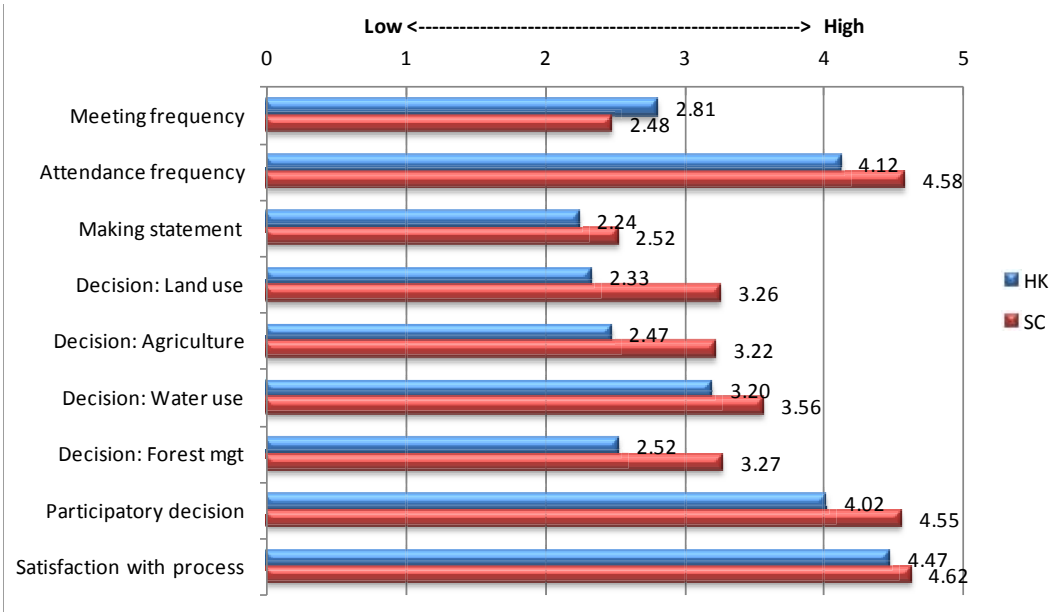


Figure 18 Participation in village meeting and frequency of making statement (Ave. of five step assessment)

Results showed that village meetings had been organized about two to three times per month in both village clusters (Meeting frequency).

As for the frequency of attendance at village meetings, a number of households in both clusters attended almost every meeting, especially the attendance frequency in Sobchia village cluster tended to be high (Attendance frequency: 4.12 in HK-VC, 2.52 in Sobchia village cluster). However, the frequency of making statement was low indicating less active participation (Making statement: 2.24 in HK-VC, 2.52 in Sobchia village cluster). Referring to the making statement on individual topics (Decision: Land use, Decision: Agriculture, Decision: Water use, Decision: Forest mgt), Sobchia village cluster showed a higher interest in participating in discussion. Also, concerning the way of developing the land use plan, both village clusters considered that participatory land use planning was essential; though Sobchia village cluster showed a higher level of agreement to participatory process than HK-VC (Participatory decision: 4.02 in HK-VC, 4.55 in Sobchia village cluster).

The higher frequency of making statement and the higher interest or understanding in the participatory decision making process in Sobchia village cluster was thought to be due to the fact that the government-led land use planning with another assistance project had been developed in Sobchia village cluster earlier than in HK-VC, providing the villagers in Sobchia village cluster with the opportunity to gain experience in, and realize the importance of, participatory process in land use planning. While Sobchia village cluster is an ethnically homogeneous village (consisting mostly of Khmu), the ethnic diverse HK-VC was considered to have a high tendency to feel the necessity to receive support from the village committee or government in order to gain the whole village agreement.

3.2 The situation of cooperation among villagers in village activity

Figure 19 summarized the results of the level of participation in group activities by activity type such as village events, shifting cultivation and paddy cultivation, and their perceptions about the benefits of group activities.

The level of cooperation in the general village events such as ceremonial occasions or cleaning was high in both clusters (Frequency: 4.40 in HK-VC, 4.43 in Sobchia village cluster). However, for other specific activities such as slash and burning or paddy irrigation, the sample households in Sobchia village cluster had higher level of cooperation than in HK cluster (slash-and-burn: 3.57 in HK-VC, 4.25 in Sobchia village cluster, irrigation: 1.11 in HK-VC, 1.56 in Sobchia village cluster). The traditional custom of helping each other when needed still remained deeply rooted in the community of Sobchia village cluster, which was considered as one of the reasons of their lively cooperation activity. On the other hand, the frequency of cooperation activities in slash-and-burn in HK-VC was considered low because the cluster had multiple ethnic groups and the cooperation among the ethnic groups was limited.

It was revealed that villagers' understanding on the benefits of cooperation activities (enhanced decision making and the effective problem solving) was high (Benefit: influence: 4.20 in HK-VC, 4.46 in Sobchia village cluster, Effective prob solving: 4.61 in HK-VC, 4.69 in Sobchia village cluster).

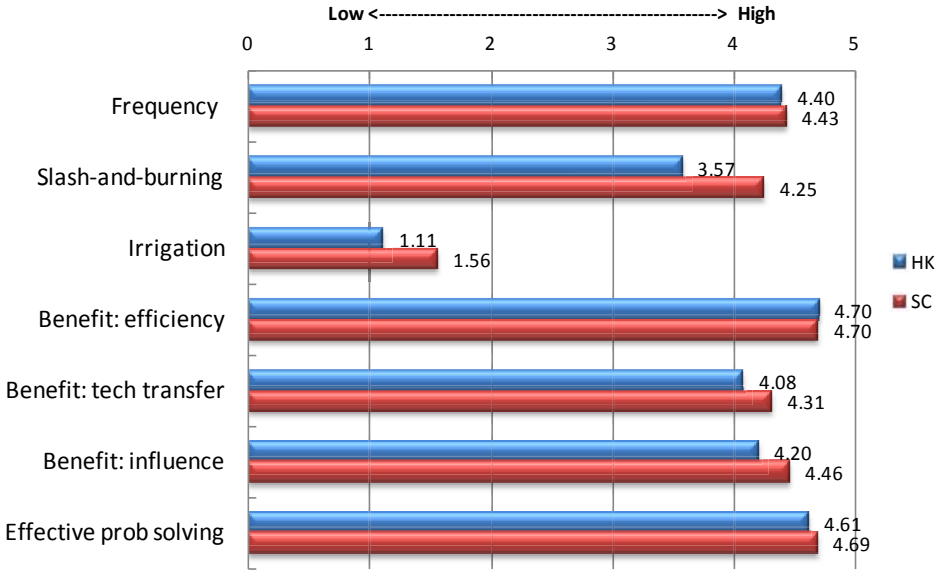


Figure 19 Participation in cooperation activities (Ave. of five step assessment)

3.3 Needs for alternative livelihood

In the survey the sample households were also asked what kind of alternative livelihoods to shifting cultivation they were interested in or they had already engaged in (Figure 20). In both clusters, more than 40% of households showed their interests in livestock raising and more than 30% in cash crops. As the good soil for paddy field existed only in Houay Khing village, the lower percentage of households showed their

interests in lowland rice in HK-VC compared to Sobchia village cluster. There were a few households stated non-timber forest products domestication as an alternative livelihood in HK-VC where various non-timber forest products still played an important role as food security or household income.

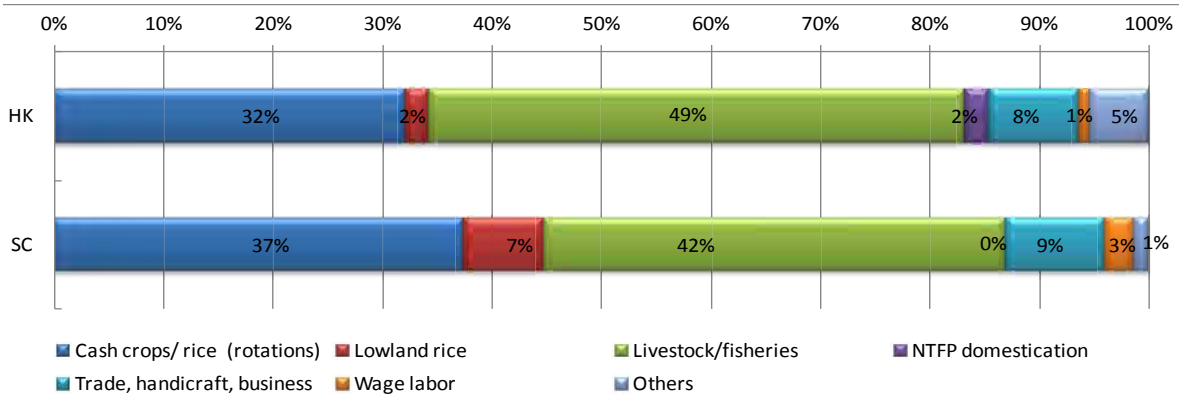


Figure 20 Needs for alternative livelihood (results of free answers by villagers)

Livestock raising was the most popular alternative livelihood not only because livestock was an important assets for the villagers but also because the government in Phonsay district had promoted livestock raising as a main industry. Recent improvement of road access to Vietnam and the rapidly increasing demand from Vietnam made livestock raising a promising industry in Phonsay district.

Survey 3 Understanding of Human Resources and Natural Resources in the Target Area

HK-VC, the project area of project-based REDD plus, targeting Houay Khing village where the typical land use was executed, the socio-economic situations, Human Resources and Natural Resources were evaluated and a survey was implemented to choose a specific Project activity for reducing deforestation. The survey was evaluated by applying Capability Approach. Also, the evaluation was executed based on the potential natural resources such as the land use or the land productivity, and the potential human resources such as the techniques, knowledge, interests concerning livelihood. From the above, the drivers of deforestation and forest degradation in HK-VC and the specific project activity for them were shown below (refer to Supplementary volume 2 for details).

1. The Current Situation of Houay Khing Village Cluster (HK-VC)

The expansion of slash and burn area, shortened fallow period, conversion of forest to agricultural land and the expansion of grazing land and others were found to be the major causes of deforestation in HK-VC, the project area of REDD plus. In addition, the various circumstances were occurring at the same time such as the lack of irrigation facilities, declining the land productivity due to the double-cropping based on insufficient land management, leaving villagers were no choice but to depend on shifting cultivation. In order to understand the reality of socio-economic situation, the three aspects were sorted out: the forest resources sector, the agricultural sector and the market access.

1.1 Forest resources sector

As any specific forest management activity didn't exist in the village, the collection of non-timber forest products or fuel wood, or the expansion of slash and burn shifting cultivation were being carried out on the basis of voluntarism, without setting any specific regulations. Although land zoning or government regulation of land use had been strengthened in recent years, they did not become recognized sufficiently among the villagers. As the forest was full of various resources and also there were markets of forest products in China, Thailand, Vietnam and so on, the villagers were collecting non-timber forest products including bamboo, elephant yam (doukdua), wild mushroom, rattan and medical herbs as sources of revenue. Although some villagers wanted to or tried to cultivate non-timber forest products in the agricultural land in order to utilize those products in a sustainable and stable way, they did not have knowledge or skills about the cultivation.

1.2 Agricultural sector (shifting cultivation, paddy farming, livestock raising)

Most villagers in HK-VC were engaged in shifting cultivation. Although the survey results showed each household owned three plots in total with the size of 1 ha per plot supposedly considering the government's policy, the reality was different. The most of them had cultivated in more than 5 plots. Despite cultivating in more than five plots, the agricultural productivity was low due to the limited land management and cultivation skills. As a result of on-site checking of the situation of entire households in Houay Khing

village, approximately 35% households were not able to produce enough rice for a year, especially this applies for Khmu ethnic group that approximately 56% households were not able to produce the rice for domestic consumption a year (Table 7). If the land use regulations became strict, it would be more difficult to produce sufficient rice.

Table 7 The characteristics of agricultural land by ethnic group

	Khmu	Hmong	Lao loum	Total
Total number of fallows (by each ethnic group)	352	294	15	661
Average number of fallows (by each ethnic group)	3	3	1.4	2.97
Number of paddy field owners	16	31	1	48
Total size of paddy fields	11 ha	24.1 ha	0.5ha	35.6 ha
Number of families with rice sufficiency (12 months or more)	51 (44%)	81 (84%)	8 (73%)	140
Number of families with rice deficiency	65 (56%)	8 (8.3%)	3 (28%)	76
Number of families with rice deficiency more than three months	47 (40%)	2 (2.1%)	1 (9%)	50

Some households were engaged in paddy cultivation in Houay Khing Village. The sizes of the paddy fields were very small, ranging from 0.3 ha to 2.0 ha. Once the irrigation facilities or terraced paddy fields were developed, paddy cultivation would expect the sufficient rice production with less effort than shifting cultivation. The skills necessary for paddy field expansion or cultivation and group agriculture system were not widespread under the circumstances. Next, the livestock held a prominent position as an asset of the households: approximately 43%of the households were raising large domestic animals such as buffaloes or cows, 60% households were raising pigs or goats and more than 80% households had poultry. However, the poor rearing skills and the open forest grazing became factors for the livestock's disease due to contacting wild animals. The open grazing system in the forest caused deforestation and forest degradation.

1.3 Market access

The lack of market system for agricultural and forestry products was one of the constraints for income generation in the Houay Khing village. Although the village had a potential to commercially produce vegetables, livestock, fruits, non-timber forest products and many other cash crops, there were no existing markets or direct linkage with the market system to sell these products. The villagers depended upon middlemen to sell their products, who control both demand and price of the products. As they had no system for selling the agricultural products or non-timber forest products to the markets, there were problems such as not finding the buyers or not having the stable trading prices. Therefore, we regarded the Demonstration Activity in the village market as one of the approaches of the project. There were several problems about the situation of village's agriculture and natural resources, whereas the villagers were found to have various useful knowledge or experience. Along with the skills at traditional vegetable garden for domestic consumption, there were differences about the skills and abilities on non-timber forest products among the ethnic groups. The Khmu were found to be good at bamboo work or weaving and the Hmong were good at embroidery or forge skills. Some villagers had knowledge on coffee plantation, traditional

herbal usage or terraced paddy fields. Such local knowledge was considered to be promoted and transferred locally through the appropriate extension education. Therefore, the weaving production system was considered as one of the Demonstration Activities to promote alternative livelihood in the village.

2. Problem and Objective Analyses of Deforestation and Forest Degradation

Based on the above survey results, the problems toward drivers of deforestation and forest degradation in the village were sorted out by using Project Cycle Management. Although various problems were mentioned when we had on-site discussions with the villagers and got very complicated results of problem analysis, the followings are the results of extracting and rearranging the problems that related deeply to the deforestation and forest degradation (refer to supplementary volume 2 for the detailed results of analysis). The scientific re-zoning of land with clear land tenure system was needed toward the appropriate forest management; the technical and financial assistance for the development of market system and the improvement of agricultural system, and community awareness raising were considered to contribute to the improvement of the livelihood in the village and avoiding deforestation and forest degradation.

2.1 Problem analysis

Figure 21 shows the relationship between the problems occurring in the village with relation to the deforestation and forest degradation. Increasing shifting cultivation due to lack of opportunities to start new livelihoods, forest conversion due to the expansion of agricultural land, low skill of livestock management (e.g. forest conversion due to the expansion of grazing land) and no accessibility to the market were found to be the major causes of deforestation and forest degradation (Figure 21).

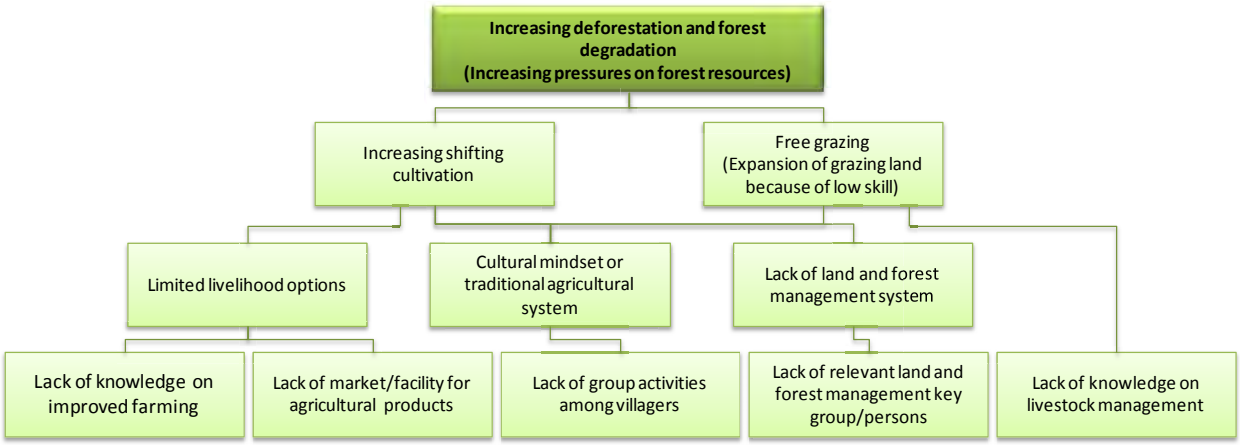


Figure 21 The Problem Analysis Based on PCM

Shifting cultivation itself was not a problem of deforestation and forest degradation, but it was revealed that deforestation and forest degradation were caused by overlapping the several fundamental problems of the village. The slash and burn activities were being operated by the traditional approach or knowledge that the villagers had taken over from their ancestors. Therefore, the most of the villagers had no experience in

the agricultural technologies such as permanent slash and burn fields in the style of rice terrace, mixed cropping, paddy cultivation and irrigation etc. In the same way, there had not been any technical support by the government or Non Governmental Organization with regard to the improvement of agricultural system. The villagers also indicated that lack of permanent water sources or irrigation facilities had forced them to depend on upland rice production. The subsistence agriculture without appropriate land management had decreased the productivity of land, resulting in shifting cultivation in a new land every year. Moreover, the villagers feared taking a risk of introducing new techniques and they were not able to introduce them until getting sure that those techniques would definitely produce benefits.

As a number of villagers were operating agriculture by family members, the limited labor force restricted them from introducing intensive agriculture technologies. Group farming or labor exchange system had not been incorporated in their traditional agricultural system. As the community in Houay Khing village was new, group farming or labor exchange system had not been established yet. Moreover, the distant and scattered agricultural lands made them difficult to build a relationship of cooperation for such as labor exchange in each other's land.

Similarly, the lack of market system for selling the agricultural products had discouraged people to produce fruits, vegetables and other crops for commercial purposes. Although most villagers depended upon middlemen to sell their products, it was found that they did not consider it as a reliable system.

The livestock was an important source of income in the village, being blessed with a good market. However, the livestock raising technique was very primitive and unscientific. The villagers grazed livestock in the forest without appropriate management. As a result, the villagers were not only using livestock manure efficiently as compost but also making their livestock susceptible to diseases due to the contact with wild animals. As mentioned so far, the villagers had already experienced the increase of cattle mortality rate by forest grazing.

2.2 Objective analysis

Based on the results of problem analysis, the objective analysis was conducted to select some direct and indirect activities implementing in the project in order to inhibit deforestation and forest degradation. Taking into consideration the circumstances of village or village cluster, the activities to be addressed and their necessity were sorted out as follows (Figure 22):

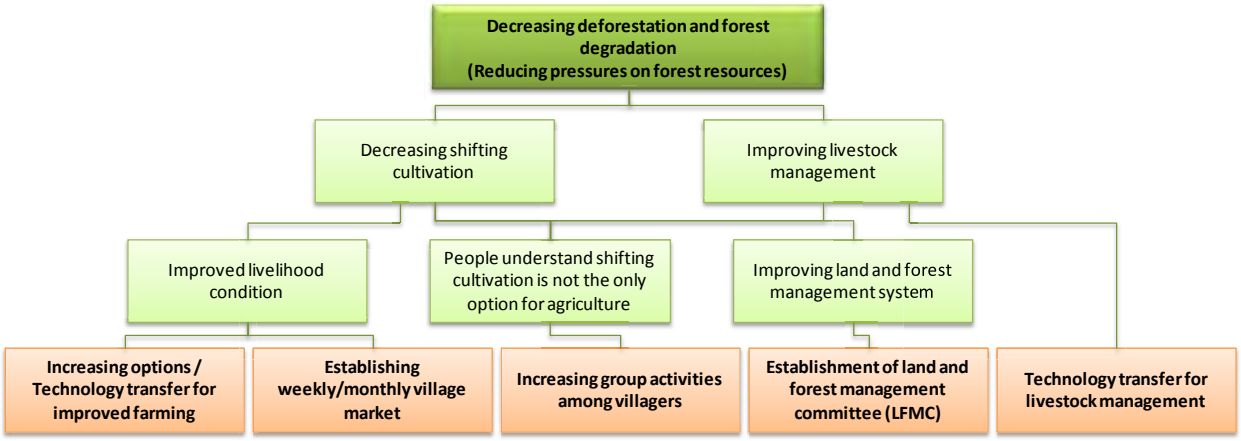


Figure 22 The Objective Analysis Based on PCM

2.2.1 Improvement of cooperation activities

As for the cooperation activities by the villager groups shown in the objective analysis in figure 22, the following effects would be expected by promoting the activities:

- As many of the problems of livelihood and community are complicated, efforts by cooperation among villagers would be required in solving them. Working in groups promotes the villagers to be organized and strengthens capabilities of villagers for resolving community problems.
- Village land and forest resources are communal properties and their management should be community-based or communal activity in nature; they must be managed by a whole community and its members should receive an equitable share of benefits from land and forest resources.
- Working in groups improves the flow of members' assets and resources, which can be effectively utilized for achieving common objective of the villagers: improving livelihoods and further developing the village.
- Cooperation activity will lead to develop an effective and sustainable organization, which manages the fund received by the project and allocates the village fund to the villagers to give them equal access to the fund. It is indispensable to establish such contact point because the project fund is limited and not be able to support all the villagers at the same time.

2.2.2 Improvement of land and forest management (establishment of LFMC)

The current land and forest management regulations have focused only on rules and restrictions for forest utilization but have nothing about technical aspect of forest management. From preliminary survey which clarified village or village cluster circumstances, it is clear that development and implementation a systematic forest management plan is indispensable. Therefore, in the target area it was considered important to establish LFMC by PAREDD and advance efforts effectively to improve land and forest toward achieving long-term goals.

2.2.3 Improvement of livelihood (increase of options)

The livelihood options in the target area were very poor. Most villagers were heavily dependent on shifting cultivation because they did not have alternative livelihoods. From the objective analysis shown in Figure 22, nursery management system, livestock management system, weaving production system and other options were considered potential activities based on the needs and abilities of the villagers.

2.2.4 Establishment of weekly/monthly village market

The establishment of the village market was selected as a necessary project activity in order to improve the agricultural technologies and the skills and systems necessary for new livelihoods as well as widen the options of alternative livelihood.

2.3 Suggestions from the problem analysis and the objective analysis

Sorting out the results of the problem analysis and the objective analysis as mentioned above, the villagers discussed the feasibility of the options in detail (Table 8). As a result, the villagers were highly concerned with the alternative livelihood such as paddy field development (terraced), coffee plantation and weaving especially for women. The survey showed that the introduction of these livelihoods had high applicability to the village and also high possibility to secure the market in the Luang Prabang Province city.

Table 8 Number of families interested in different types of livelihood development options

	Khmu	Hmong	Lao loum	Total
Interests in livestock				
Chicken/ducks	38	24	4	66
Pig and goats	40	13	2	55
Buffalo and cow	16	25	1	42
Introduction of improved livestock raising	6	8	0	14
Interests in improved agriculture				
Paddy field development (Terracing)	8	20	0	28
Development of irrigation system	8	9	0	17
Coffee plantation	16	17	0	33
Bamboo plantation	3	3	0	6
Corn cultivation	2	1	0	3
Cassava	3	1	0	4
Fruit tree plantation	8	6	0	14
Fisheries	0	2	0	2
Other interests				
Weaving	16	13	0	29
Construction training	3	1	0	4
Cooking training	1	0	0	1
Non-timber forest products promotion	3	2	1	6
Furniture business	3	0	0	3
Mechanical works	1	7	1	9
Business development	2	10	3	15
Iron works	0	1	0	1
Other	0	2	1	3

The options of alternative livelihood indicated in Table 8 were the results which had been widely collected from the workshop or interviews with the villagers, not taking into consideration the fact that the project activity was conducted within budget of PAREDD.

Survey 4 Selection of Demonstration Activity

1. Selection of Demonstration Activity

1.1 Necessity of consideration for diversity; ethnic and gender

The two major ethnic groups, Khmu and Hmong lived in HK-VC and therefore it was necessary to carry out the activities considering each ethnic's custom, knowledge, capability and others. The consideration for the socially vulnerable group such as poor households and women was also considered necessary. Then, the general information concerning the household budget, agricultural calendar and land use system was identified as basic information to select a Demonstration Activity based on the ethnic's capacity. As the introduction of paddy, which was one of the major alternative livelihoods in HK-VC, was indicated to contribute to the decrease in shifting cultivation plots per household; the capability of each ethnic, the difference such as the characteristics of the villagers, the current life style and the agricultural system were analyzed. The survey was conducted with both Khmu and Hmong; the analysis was developed based on the data of interview with 41 households, in the light of the current possession situation of paddy field.

1.2 Difference in land use and livelihoods

The customs and the land use tendency of each ethnic group were evaluated. The villagers were analyzed by dividing into the following four groups, based on the survey results such as the household's income, the agricultural calendar and the land use system (Figure 23). The four groups were: Khmu/Slash and burn farming (Saohai in the local language), Khmu/Paddy field farming (Saonar in the local language), Hmong/ Slash and burn farming and Hmong/ Paddy field farming.

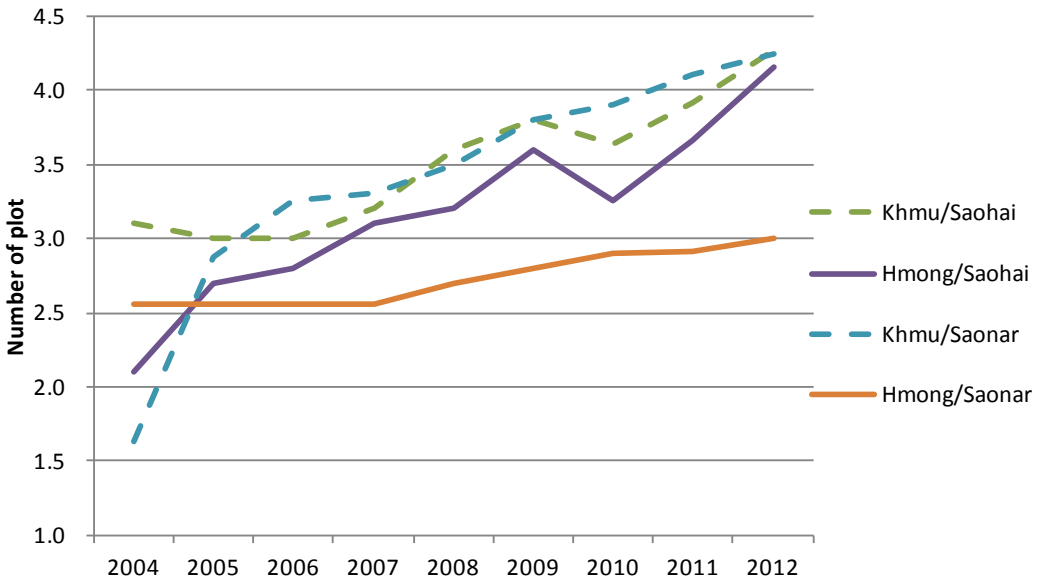


Figure 23 Transition of number of plots per household (the average of sample households)

Note: The samples were extracted randomly from the village's list of every household, so that the number of ethnic groups and forms of farming would be the same. The numbers of the sample households were: 12 households of Khmu/Saohai, 12 households of Khmu/Saonar, 13 households of Hmong/Saohai and 12 households of Hmong/Saonar.

According to Figure 23, although the number of plot per household was increasing in all groups, the tendency of each group was different and the following characteristics were picked up:

- The number of plots of shifting cultivation had increased in the Khmu, regardless of whether they were Saohai or Saonar.
- The number of plots of shifting cultivation had increased in Hmong/Saohai group, but the number was smaller than the Khmu.
- In Hmong/Saonar group, the increasing rate of upland rice plots cultivated per household was smaller than the other groups.

These characteristics indicated that the level of the Khmu's daily life was financially poor and it was difficult to transfer to paddy cultivation for maintaining/improving their livelihood. For example, Compared to Hmong, the Khmu people was critically suffering from rice shortage and differences between rice shortages of two ethnic groups were statistically significant at $p<0.05$. The rice shortage period of the Khmu was more than two months a year in average which was less than a month for Hmong people. In addition, the Khmu tended to sell the rice to deal with the sudden changes in their household finances such as the children's education expense and medical expense. Their poor planning for the household finances was considered one of the causes of these straitened circumstances.

Comparing the amount of annual rice production between Hmong/Saohai and Khmu/Saohai, the annual production of Hmong/Saohai was higher than the other (Figure 24). However, there was no difference in the amount of monthly consumption between the both groups. As indicated in Figure 24, Khmu/Saonar could not produce sufficient amount from paddy due to the lack of agricultural techniques. On the other hand, Hmong/Saonar produced large amount from the paddy, which was considered one of the factors that Hmong/Saonar could inhibit the number of upland rice plots.

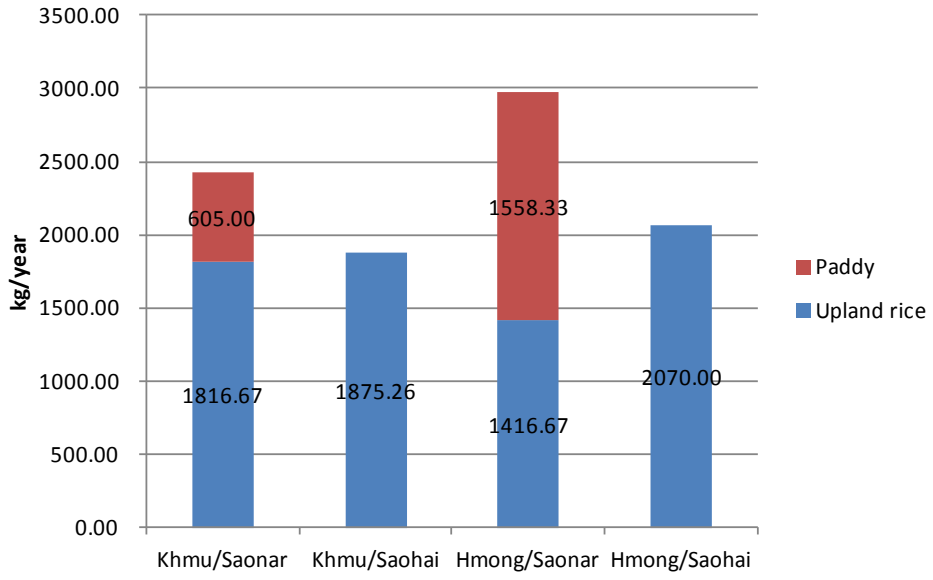


Figure 24 Annual household production (mean)

1.3 Ethnic group differences in capabilities

The capabilities and the functions of livelihood could explain the ethnic differences in lifestyle as mentioned above.

The Khmu/Saohai was the most fragile in the four groups and in a difficult condition to maintain a daily life. The Hmong/Saonar demonstrated an improvement in agricultural techniques or in daily life, comparing to other groups. From the above, the options of livelihood of each group were sorted out, based on the socio-economic analysis (Table 9 and Table 10).

Table 9: The livelihood options of Khmu

	Saonar	*Saohai*
Khmu	<Conditions of daily life> Expanding the number of upland rice plots Unable to achieve surplus production from paddy cultivation	<Conditions of daily life> Expanding the number of upland rice plots. Unable to achieve adequate production from shifting cultivation; lack of other opportunities to improve their livelihood.
	<Capabilities & functions> ● Resources related to paddy cultivation: Shortfalls in information, understanding, techniques, capital, machinery, and labor ➢ Some households borrowed money from the policy bank or sold their livestock for cash flow. ➢ Lacked experience and knowledge in working cooperatively with other farmers. ● Irrigation: ➢ Installed the water channels from the water-source to the paddy field individually. ● Demonstrated poor planning for household budgets	<Capabilities & functions> ● Primitive farming techniques rely on the weather ● More than 70% of the sample households suffered from shortfalls in rice production necessary for family consumption (ranging from two to six months per year)[1] ● Received low productive land ● Some villagers were hired by Hmong people for weeding during the farming season, resulting in failure to complete farming tasks in their own lands. ● Some villagers obtained a loan from the policy bank to buy the livestock, but were not able to pay loan due to contracting foot-and-mouth disease[2] ● Lacked knowledge of paddy cultivation ● Demonstrated poor planning for household budgets

1: According to the interviews, each household consumed approximately 120 kg of rice per month.

2: In the whole village, about 90% of villagers who obtained loans of the policy bank had the same problem according to the interview.

Table 10: The livelihood options of Hmong

	Saonar	*Saohai*
Hmong	<Conditions of daily life> The number of plots of upland rice was constant or slightly increasing The paddy production much higher than Khmu/*Saonar*	<Conditions of daily life> The number of plots of upland rice was expanding, but the area used was relatively smaller than Khmu Able to produce enough rice for family consumption
	● Resources related to paddy cultivation: The Hmong conventionally had a tendency to save money, could afford to buy the land and tractors and to hire the labor. (Some households started paddy with the income from opium cultivation before regulation) ➢ Some households planned study tours with their relatives to learn paddy cultivation outside village. ● Lack of techniques: Lack of understanding how to use compost by paddy straw, and storing and managing of agricultural water ● Irrigation: ➢ Some households shared their agricultural water with other *Saonar*. ➢ Some households formed a group to buy materials to make a storage dam, dealing with the securement of agricultural water	● Some villagers hired another villagers (most of them were Khmu) to finish their work as scheduled (hiring around 10 people at a time when needed the heavy labor such as weeding). ● Some villagers earned income from surplus rice. ● Highly-motivated to learn the techniques for increasing production and income: The current farming style was primitive, being affected by weather.

2. Analysis of Enforcement Approach Taking Account of Villagers Characteristics

To consider the approach group-by-group, the differences among the groups were analyzed concerning customs and capabilities related to cooperation activities and decision-making in the village. These capabilities were considered to be important for sustainable forest management by the villagers who relied on forest resources.

2.1 Difference of capability in corporation activity by farming style and ethnic group

The cooperation activity is an important factor in improving livelihood and implementing REDD plus. The survey indicated that the villages lacked a custom of group management of agriculture, livestock, or forest. For example, the maintenance of shifting cultivation land (e.g. weeding) and irrigation are one of the hard works for the villagers. However, the villagers had not much experience to cooperate with others for such activities. In Figure 25 (b) and (c) indicated that both Saonar and Saohai had fewer experience in cooperation for those activities. However, the survey showed a different result between Saonar and Saohai about the general activities of the villages (e.g. cleaning of the community space in schools or village meeting rooms, ceremonial occasions and others) (Figure 25 (a)); Saonar had a high tendency to cooperate with others in the daily life such as the management of domestic water (Figure 26).

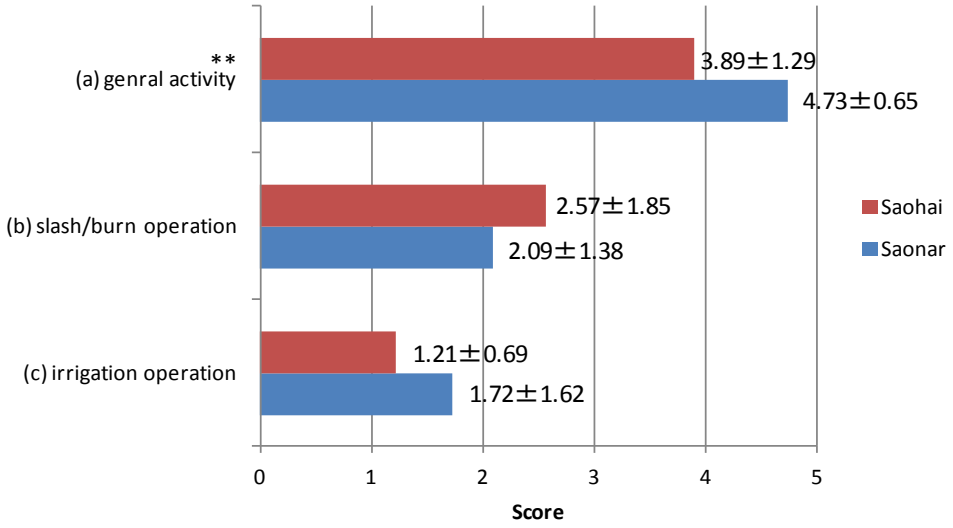


Figure 25 Experience in cooperation activities

Note: Figure 25 shows the results that the villagers evaluated their experiences concerning the following questions on a scale of one to five. (a) frequency of the cooperation activities in a group to improve their daily life, (b) experience in cooperation activity in land consolidation before slash and burn, (c) experience in cooperation activity in paddy irrigation. The difference of response results between Saohai and Saonar was analyzed by one-way analysis of variance (confidence level 5%; **p < 0.05). The bar graph in the figure shows the average of the evaluation results by group and the numbers shows the standard deviation.

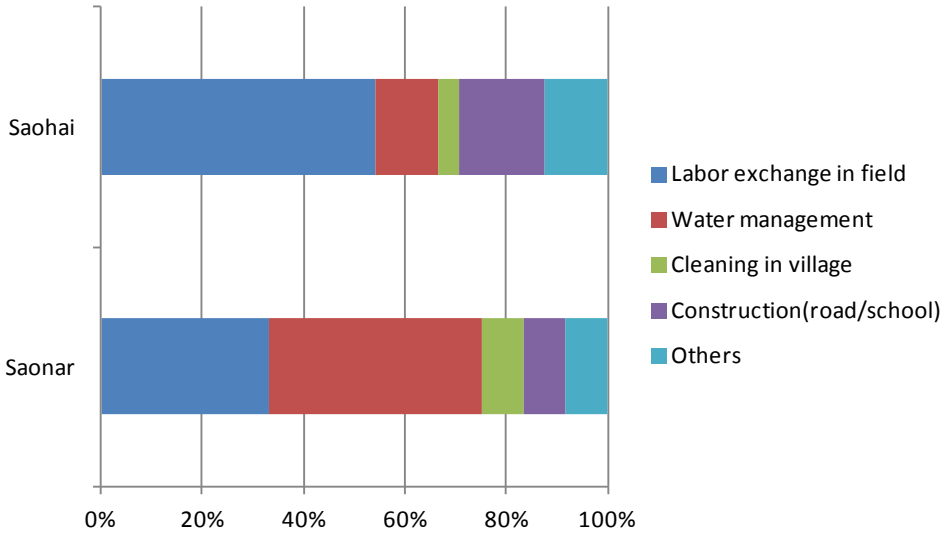


Figure 26 Type of cooperation activities

The above characteristics were not seen in every Saonar, but in the limited villagers even in the Hmong/Saonar. The characteristics of the villagers who had an experience of cooperation activity

(Hmong/Saonar) are follows:

- Recognized as a good farmer in village
- Formed paddy water management group on their own
- Planned/implemented study tour voluntarily to learn agricultural techniques
- Current/Former member of village committee

Some ordinary villagers answered that it was difficult to deal with the activities which created a conflict among the interests of villagers such as the management of domestic/agricultural water, because it was difficult for them to adjust the interests among the villagers. The difficulties in adjusting an interest among the villagers were considered as one of the reasons for lack of labor exchange in the village.

2.2 Difference of participation in decision-making and capability by gender

Women's empowerment is also important. Women faced many problems not only in agricultural activities but also in community/village discussions. Figure 27 indicated the survey results of the villagers' experience in making a statement in four discussions at the village meetings: land use, agriculture, water management and forest management. It showed that there was a significant difference between men and women in making a statement. Women, compared to men, were not able to make a firm statement in the decision-making process. Village custom and difficulty in understanding Lao Language were some of the factors making women difficulty to make a statement. Women has much knowledge about the land and forest in the village, which were obtained from their daily life activities such as livestock management, collection of fuel wood or non-timber forest products and transport of domestic water. Therefore, it is important to promote the women's empowerment by a project activity and to seek women's more active participation in the meetings in order to make good use of the women's knowledge obtaining from their daily life, in the forest management and preservation.

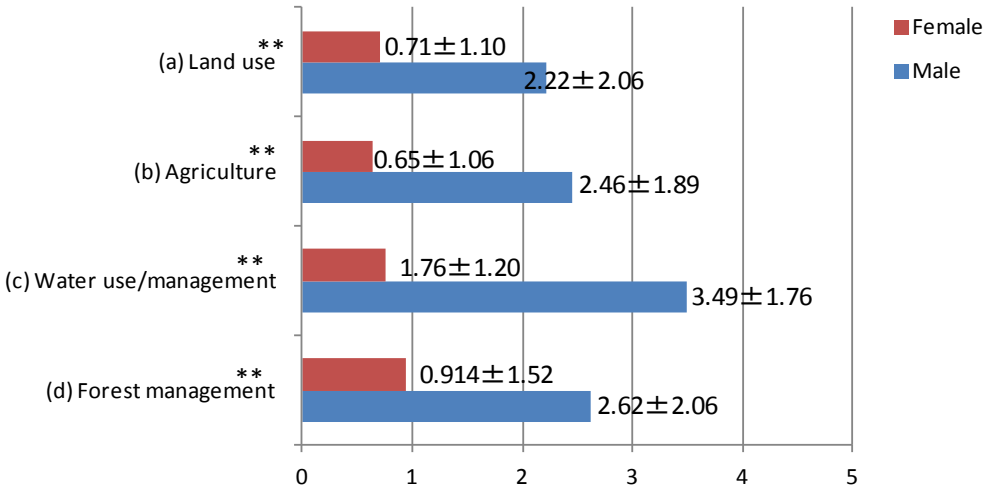


Figure 27 Utterance situations in village meetings

Note: The above figure shows the results that the villagers evaluated their recognition concerning the following questions related to the decision-making in the village meetings, on a scale of one to five. (a) experience in making a statement in discussions about land use, (b) experience in making a statement in discussions about agriculture, (c) experience in making a statement in discussion about water use/management, (d) experience in making a statement in discussions about forest management. The difference of response results between men and women was analyzed by one-way analysis of variance (ANOVA; confidence level 5%; **$p < 0.05$). The bar graph in the figure shows the average of the evaluation results by group and the numbers shows the standard deviation.

As a result of the survey, the Hmong/Saonar group showed a good practice of inhibiting the shifting cultivation (Figure 27). Their abilities related to livelihood maintenance were higher than other three groups (Table 9 and Table 10). For example, the Hmong/Saonar acquired the resources necessary for cultivating paddy by themselves. Also, some households being highly-motivated to acquire the knowledge for improving livelihoods implemented the study tour. The paddy cultivation became a factor in making groups to manage agricultural water. From the past analyses, introducing paddy cultivation was considered to becoming one of the alternative livelihoods to reduce the shifting cultivation in Houay Khing village. Also, when we focused on the difference of ethnic group, farming type and gender, their capabilities were significantly different among the groups. When implementing the project activities, the necessity of focusing and involving vulnerable groups such as Khmu/Saohai and women has been backed up by the survey.

Conclusion (Phased implementation of Project Activity)

At the implementation of REDD plus project in HK-VC, Phonsay district, the followings were considered suitable as Project Activities to be described in the Project Description, based on findings of the above-mentioned Survey 1 to 4. As notes, demonstration activity was not implemented during this survey. Demonstration activities should be trialed as next step to make the detail work plan and verify the effectiveness of the project activities.

Project Activity to be described in Project Description (PD)

Deforestation has occurred over many years in the target site due to pioneer shifting cultivation and unsustainable forest resource use. This project seeks to restrict the expansion of pioneer shifting cultivation (by clearing primary and secondary forest) and to promote longer fallow periods than before the project, thereby forest carbon stock should be kept or increased. These goals require additional efforts to develop alternatives to the rural people's dependence on forestry resources.

A preliminary socio-economic and natural and human resources surveys in the HK-VC undertaken in readiness phase confirmed the relationship between the lifestyles of the rural people and their dependence on forestry resources for their livelihood. These surveys also assessed natural human resources in the village, and conducted problem and objective analysis to consider alternative livelihoods. Based on the results of the preliminary surveys, the project developed a three-phase approach which adopts JICA's PAREDD Approach (Figure 28).

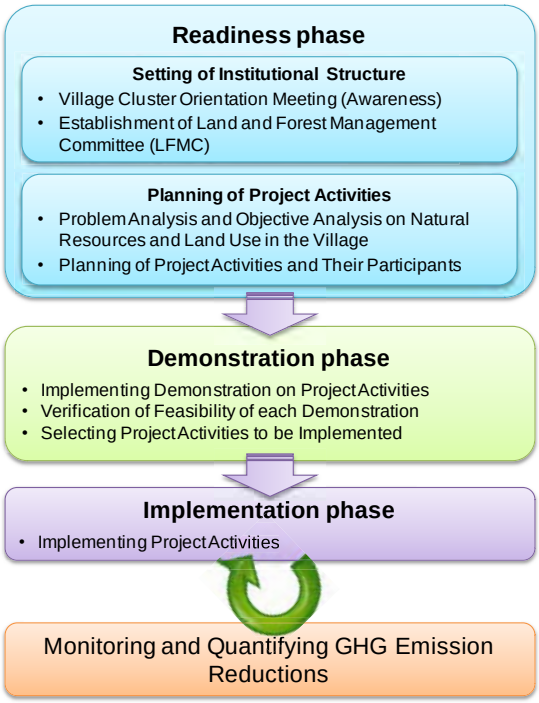


Figure 28 REDD+ activities adopting JICA PAREDD Approach

Readiness phase (preparatory phase) of REDD+ activities focuses on capacity development, raising awareness among villagers regarding forest conservation, land use management and knowledge-sharing on global warming and the REDD+ strategy of central government of the Lao PDR. Capacity development had been undertaken based on the characteristics and circumstances of all types of rural people.

Based on the preparatory activities achieved under the readiness phase, the project carried out demonstration of selected activities in the next phase. Through demonstration activities, which was based on the rural people's interests and needs, the project implemented several demonstration

activities to assess their effectiveness as long term REDD+ activities (i.e. project activities). The demonstration activities helped encourage and motivate rural people to participate in project plans and activities. Following demonstration activities, the project verified activity's results to identify suitable project activities. Verification was based on the capability approach to assess the capacity of the rural people to adapt new practices and their response to the outcomes of the demonstration activities.

Finally, the project moved to the long-term implementation phase of project activities. Based on the verification of demonstration activities, the project developed or revised long-term strategies with suitable project activities which are alternatives to shifting cultivation and the project has been implementing them in the target site.

Preparation Phase

Specific features of the phase: Readiness or preparation for REDD+ activities at the village level is required by UNFCCC decisions and conducting them were good practices in case of rural area development. As part of the readiness phase for REDD+ in Lao PDR, the project designed an approach for future REDD+ implementation at the village and village cluster levels for demonstration in the HK-VC, reflecting community-based/participatory-based land and forestry management approach efforts and readiness phase activities. Some features specific to this REDD+ demonstration are described below.

Setting of Institutional Structure: After village cluster orientation meeting and village meetings using some materials for awareness, to implement project activities at the village and village cluster level, the project set up a village land and forestry management committee (LFMC) in each village in the target site. Each LFMC is one of the proponents of the project and has task to play a central role in project management at the village level (Figure 29). In the readiness phase, based on human resources analysis, a LFMC was established with input from all stakeholders (e.g. villager of each ethnic group) to determine the specific rules and procedures for the LFMC.

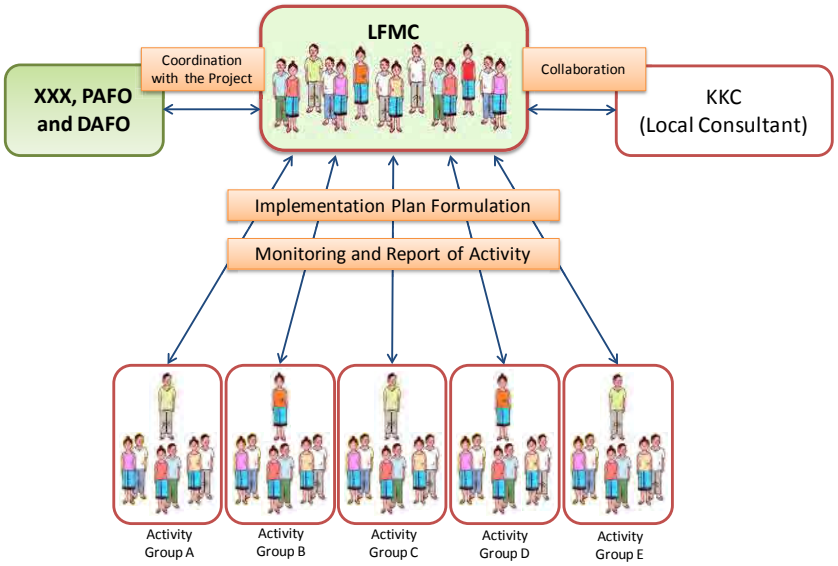


Figure 29 Structure of the LFMC

Planning of Project Activities: Rural people who rely on shifting cultivation for livelihood play a key role in successful REDD+ implementation. This is not only because deforestation has deep associations with local land and forest use but also local knowledge of natural resources is crucial to improve local livelihoods. As part of the readiness phase for REDD+ at the village level, the project focused on capacity-building among both villagers and local authorities for village land and forest management. In particular, the project focused on the following aspects as capacity building: village land and forest management, including training of land zoning; alternative land use practices and income generation activities; and building awareness of forest conservation and the natural environment.

Village meeting

Village meeting

Moreover, according to the problem and objective analysis in the preliminary survey, the project decided some demonstration activities as candidates of project activities and their Participants. After village meetings, following demonstration activities of Mitigation Activities are decided.

Demonstration Phase

Based on the results of above Readiness Phase (Preparation Phase) which was prepared according to rural people's interests (needs) and capacity to plan and manage project activities, several demonstration activities were or are being implemented in order to verify their long term effectiveness as project activities (Figure 30).

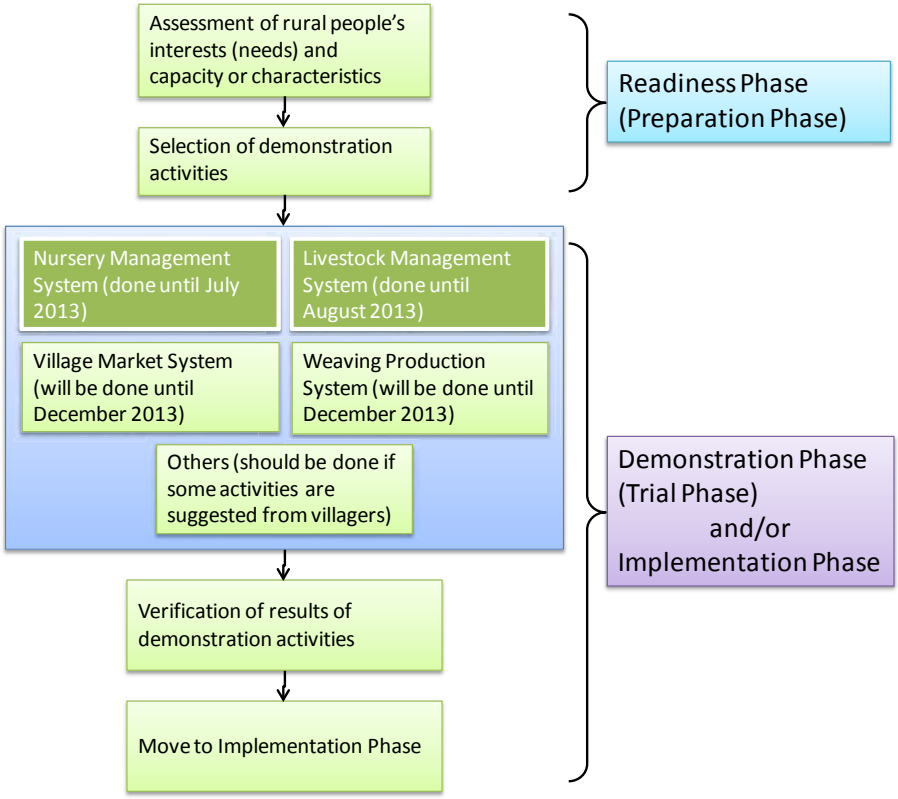


Figure 30 Procedure and status of demonstration activities in the project

Grouping activities as fundamental capability: Through nursery management activities, effectiveness of group activities of rural people were assessed as a key feature of agricultural system in the village and to verify fundamental capability of rural people to implement some project activities in the future. In addition, through the learning from activities, the specific capacity building activity was conducted to encourage group activity for increased labor efficiency in agricultural activities such as group farming or establishing cooperation for labor exchange. Based on results on difference of income and rice shortage periods between households with group activities and without group activities, it was clear that group activities were effective and essential for sustainable livelihood system in the target site. Therefore, from verification of the demonstration,

group activities must be effective as each project activities as bellow.

Nursery management system: Nursery Management System has already been successfully introduced in other villages in Luang Prabang Province which would provide technical experience for the successful operating of the nursery in the village. Therefore, based on available natural resources, market potential and experiences from other villages, cash crop species were verified as alternative future livelihood sources. As a result of nursery management process, a Nursery Management Committee (NMC) was established under the LFMC. Similarly, a nursery management guideline was prepared with clear rules and procedures of NMC which was agreed by NMC and LFMC members and is going to be endorsed by village meeting. The rules and procedures developed for nursery management will provide guideline for other "group activities" such as Weaving Production System by woman group and village market system by villagers with croplands (*see* below), with necessary modifications and adjustments. In demonstration activity of Nursery Management System, some actions (e.g. the coffee group) were trained on coffee plantation and pre-processing through NMC. In addition, activities of NMC have encouraged and built up capacity on the cultivation of cash crops and non-timber forest products (NTFPs), and also encouraged to get necessary inputs and techniques such as seeds and fertilizer for the cultivation of such crops.

Meeting of Nursery Management Committee

Land preparation (grading)

Seedlings which produced from the nursery fulfilled villager's interests (needs) of cash crop management. Also, from market analysis in Luang Prabang City, some kind of seedlings (coffee or dukduwa) had big potential of commodity for sale. Therefore, from verification of the demonstration, nursery management system must be effective as alternative livelihood in the village.

Livestock management system: The project encouraged the development of an improved livestock raising system (in sheds or confined areas). Based on market potential and experiences from other advanced villages, livestock management system was verified as alternative future livelihood sources. In this project, from problem analysis, it was clear that villager's livestock management method was quite a poor and is required additional technology transfer. Therefore, some training on breeding, feed utilization, vaccine administration and study tour to advanced village had been applied as trial. After them, the project verified effectiveness and continuity of livestock management system in target sites.

Pig management gage

After training and study tour, villager's livestock management practices were changed drastically and death rate of livestock decreased very much. Therefore, from results of verification of the demonstration, the project decided that livestock management system must be effective as

alternative livelihood in the village.

Weaving production system: Weaving will be one of the integral cultural part of women life in northern Lao PDR. Many village women are skillful in weaving works. During initial discussions many women showed interests in building their capacity on high quality weaving works and to develop cooperative weaving system under the Weaving Production Committee (WPC) which will be established in village as a part of alternative livelihood. Weaving was chosen as one of the demonstration activities as it could have immense and immediate social impacts including women empowerment, their social role and positive impacts to the children. The women cooperative weaving would also enhance women group dynamics in the future to enhance group cooperation, social mobilization and support of implementing REDD+ activities.

Village market system: In the target villages, coffee, tobacco, mulberry, bamboo handicrafts and dukduwa have potential market opportunities that can be produced at commercial level and preprocessed at the village level. Such alternative activities could provide employment opportunities for farmers. Entrepreneurs in Luang Prabang City took an interest in cooperating with villagers to promote such cash crops. The project plans to launch a weekly or monthly village market under the Market Management Committee (MMC) which will be established to promote markets for village products and to develop links to urban markets. Since this activity is consistent with district policies, the District Government will provide the necessary support (e.g., infrastructure and vehicles) to villages and villagers.

Others: From villager's interests and market situation, the project will apply other demonstration activities. The long term plan for next phase of the approach will be developed or revised based on evaluations and reports on the demonstration activities in this phase.

Implementation Phase

Based on the verification of demonstration activities in above phase, the long term strategy and action plan will be developed or revised and implemented to eliminate pioneer shifting cultivation practices and to increase fallow period in shifting cultivation area. In this project, following actions are scheduled to implement as project activities. From results of demonstration activities, some of the verified activities will be continued during implementation phase.

Fundamental action of improvement of "Grouping Activities" to apply following actions: Once villagers learn improved agricultural practices and begin boosting land productivity through demonstration activities, they can be encouraged for permanent agricultural systems. Initially, villagers may combine the practices of shifting cultivation and permanent agriculture (e.g., nursery management, livestock management and so on). Once assured that permanent agriculture is capable of sustaining their lives, the project can then move to discourage them from expansion of pioneer shifting cultivation. Additionally, both legal and incentive measures can be set in place to motivate farmers to improve and maintain the physical characteristics of the land. To supply the labor required for intensive farming, villagers can be encouraged to establish smaller groups based on interests, ethnicity, or other criteria to develop a system of cooperation for labor exchange or group farming, thereby solving the problem of labor requirements for initial farm preparations (e.g., terrace making) in the villages. The project promoted group activities and asked participating villagers to work in groups. Working in groups enables effective and equitable operation of project activities and produces various benefits for participating villagers.

Specific Activities: According to results of each demonstration activity mentioned above, suitable activities should be implemented. Nursery management system and Livestock management system should be implemented as project activities and other activities should be implemented after verification and review.

Appendix 1 Summary of Socioeconomic Development Plan in each District

Each 12 district in Luang Prabang Province is annually establishing Socioeconomic Development Plan (SEDP). Following pages showed summery of recent SEDP which we could collect by field survey.

I. Luang Prabang District[3]

1. Location, Administration and Population

Luang Prabang District (LPQ-D) shares borders with 5 districts (Pak Ou, Nga, Xieng Nguen, Phonsay, and Chomphet). It is located between 247 and 1,425 meters above sea level. The highest temperature is 41°C.

LPQ-D had 118 villages administratively divided into 2 zones: (1) *khed thedsabaan* (municipal zone) that consisted of 64 villages and (2) a village cluster zone that consisted of 6 *kumban* with 54 villages. The number of household totaled 14,616. The population stood at 83,743 people of which 59,315 lived in *khed thedsabaan*. Lao Loum accounted for 72.52%, followed by Lao Theung 14.60% and Lao Soung 12.88% respectively. The population growth rate was 1.8% annually.

The majority of the population was engaged in tourism services, trade followed by agricultural and livestock activities.

2. Land and Forest

LPQ's land size is 774.06 square-km (or about 774,060 hectares). Reforestation taking place in the district was together carried out with industrial tree plantation activities such as teak (in 1,595 hectares), rubber trees (in 250 hectares), agrawood (in 10 hectares), etc. About 70 hectares of forest were expanded across the district. Reforestation was associated with activities pertaining to poverty reduction. Farmers or villagers primarily engaged in slash and burn farming were encouraged to do other cropping and livestock. The approach so-called "*song pouk neung liang*" or "grow 2 raise (animal) 1" was introduced such as to kumban kok waan, kumban xieng muak, kumban meung khai, kumban senkhalok, kumban phousouang, and kumban pakseang.

3. Poverty and Rural Development

In total there were reportedly 6 poor villages e.g. Houay Long, Houay Han, Houay Chia, Houay Siew, Bor Hae, and Long Lan, covering 300 households of 1,710 people.

Measures taken to address poverty in target villages and households included the commercial cropping and livestock and access to funding; and those practicing slash and burn rice farming (*hai*)

[3] This information available in this profile is derived from the socioeconomic development plans (SEDP) implementation 2010-2011 and 2011-2012 SEDP of Luangprabang District.№120 date 12 December 2011.

were encouraged to do other activities by relocating them to settle down in the designated locations. As a result, 4 villages (Houay Chia, Houay Han, Houay Long and Houay Siew) were relocated.

4. Sectoral Development

The 3 main sectors are represented by agriculture, manufacturing-handicraft and service. The service sector accounted more than half of the economic output (61%), followed by agriculture (23%) and manufacturing-handicraft (16%) (2011). GDP per capita was about US$1,632 (LAK7600/$). The economic growth averaged 14% annually.

LPQ-D is the business center of the Province equipped with better facilities that attracts investments.

Agriculture and Livestock

Efforts have been made to transform the people's subsistence farming to commercial farming and production. As a result, the agriculture and forestry sector grew up to 13% annually. Clean vegetable production grouping was done in 4 villages as shown in following Table.

Table Villages Growing Clean Vegetables

Village	**No. of Groups**	**No. of HHs**
Ban Xieng Lom	6	79
Ban Pong Waan	1	18
Ban Na Deua	2	34
Ban Na Xay	2	38

The district as a whole could produce 10,707 tons of rice of which 9,360 tons were from *napii* in 2,294 hectares (4.2 tons/hectares), 682 tons was from *naxeng* in 110 hectares (6.2 tons/hectares), and 228 tons were from upland rice farming in 170 hectares (1.32 tons/hectares). Livestock subsector also expanded. There were 208,562 animals/poultry.

Together with rice production, other crops were promoted for commercial purposes as shown in following Table.

Table Some Crops Grown in LPQ-D (2011)

Crops	**Area (ha)**	**Production (ton)**	**% ↓↑ (ha)**
Sesame	236	401.2	↑ 76
Maize	832	1,778.6	↑ 18
Jobs tear	599	1,377.7	↑ 89
Vegetables/leaves	217	1,519	↑ 5
Soy bean	15	14	↓ 2
Peanut	275	330	↓ 5

Investments

The district registered 1,059 business units. 2011 alone saw 272 newly registered units (mostly trade and services).

5. Infrastructure

Roads

Compared to other districts in the Province LPQ-D has better transportation networks (air, land and river). The Mekong River and National Route №13, running through the district, are an important transport hub for transporting agricultural products and passengers.

Irrigation

The district had 217 irrigation facilities.

Schools

The district had 9 kindergartens, 39 pre-primary schools, 83 primary schools, 7 lower and 6 upper secondary schools.

Health

The district has 1 hospital, 7 dispensaries, 54 pharmacies, and a mobile medicine providing fund that covers 26 villages. 95% of women and children had vaccination. 42 villages were labeled "hygienic or clean".

II. Xieng Nguen District[4]

1. Location, Administration and Population

Xieng Nguen is a 25-minite drive from Luangprabang district. It shares borders with 6 districts: Phonsay, Phou Khoun, Nan, Luangprabang, Chomphet, and Kasi of Vientiane Province.

As of 2011, Xieng Nguen had 68 villages of 5824 households. The population of the district was 32432 comprising Lao Theung (58.6%), Lao Loum (21.2%), Lao Soung (20.2%). The population of the district was engaged mainly with agriculture and services.

2. Land and Forest

The land size of the district is 1210 km^2 (121000 ha). Xieng Nguen is another mountain district of Luangprabang Province.

Reduction of slash and burn farming practices was carried out in association with poverty reduction. Xieng Nguen administration had tried to encourage farmers to be engaged in permanent farming practices through implementing projects like village resettlement (11 villages); land use titling completed in 9 villages (e.g. 24471 plots titled covering 21828.57 ha), 5371 plots measured covering 6365.61 ha. This helps reduce slash and burn farming land. As a result, shifting cultivation land was down to 552.9 ha in FY2009-2010 from 700 ha in FY2008-2009 and 10 villages stopped shifting cultivation practices. As of FY2009-2010 there were 43 villages still engaged in shifting cultivation.

[4] This information available in this profile is derived from the district's socioeconomic development plans (SEDP) 2009-2010 (5 March 2009).

3. Poverty and Rural Development

In association with the above section (land and forest) participatory consultation with farmers by authorities was carried out to do planning for production and livestock and to help poor families access to funding e.g. village development fund, rice bank, and so forth. As of FY2009-2010 the district had 121 poor households and 5 poor villages.

4. Sectoral Development

Xieng Nguen's economy was structured by agriculture accounting for 61.14%, followed by services 23.31% and manufacturing 15.55%. GDP per capita was LAK6.8 million.

The 2009-2010 saw Xieng Nguen's total rice production of 5326.5 tons in 2185 ha. Details are given in following Table.

Table Rice production

Rice	**Production (ton)**	**Area (ha)**	**Productivity (ton/ha)**
Napii (rain-fed)	2194.5	627	3.5
Naxeng (irrigated rice)	1032	258	4.0
Hai (shifting cultivation)	2100	1300	1.2

In addition, *khao ka kip dew* was also promoted and grown in 11 ha involving 16 households living in Na Thor, Na Kha, Houay Khang, Pholsavang, Phonsay, and Thin Keo.

Transforming shifting cultivation of rice into growing commercial crops was significant in part of the district in form of various projects. The following Table shows crops, plants and trees being promoted in the district.

Table Commercial Cropping and Tree Plantation

Crops/Plants/Trees	**Production (ton)**	**Area (ha)**	**Location**
Short-life crops			
Vegetables	864000.00	677.80	KB Suan Luang, some villages (Ban Yai)
Roots	5542.65	369.51	Ban Kua (Nam) Ming
Melons	1565.72	120.44	Ban Kew Ta Loun I
Corns (*salee, saloi*)	1117.00	583.82	KB Kew Ka Jam and Tad Ka Jam
Banana	465920.00	560.81	Ban Pholsavang, Kew Ta Loun I & II
Sesame	4322.00	454.95	KB Pak Bak, KB Nam Ming
Mungbean	714.38	357.19	KB Kew Ka Jam esp. Ban Phou Tha
Jobs tear	1570.00	713.64	KB Pak Bak and Kua Nam Ming
Medium-life plants			
Mulberry bark	1562.54	781.27	Ban Pholsavang, Kew Ta Loun II
Broom grass	1112.06	556.03	Ban Kew Mak Nao 2 (growing the most)
Coffee	-	130.7	Kumban Kew Ka Jam and Kew Yaa
Tea (*sha je*)	-	159.71	Kumban Kew Ka Jam and Kew Yaa
Oil tree (bio)	-	24.90	Kumban Kew Yaa
Long-life trees			
Teak	-	2127.97	6 kumban and Ban Yai
Rubber trees	-	760.32	Kumban Tad Ka Jam
Agrawood	-	65.49	Kumban Tad Ka Jam
Fruit trees	-	137.00	Kumban Suan Luang (esp. Ban Long Or)
Trees (quickly grown-up)	-	17.50	Kumban Kew Ya and Kew Ka Jam

Together with rice and crop production, livestock was another activity witnessing expansion in terms of numbers (188258 heads). The animals raised were cattle, buffalos, goats, pigs, poultry, etc.

5. Infrastructure

Roads

The national route №13 north cuts through the district. A number of roads between villages were being built and rehabilitated or improved. More than 90% of the villages can use the existing roads all year round.

Electricity

44 villages of 32099 households had access to electricity.

Irrigation

-

Schools

Xeing Nguen has 65 schools with 98% of children attending.

Health

97.5% of the population had access to clean water covering 30483 people. 61 villages used gravity-fed water facilities, 8 with water supply (*nampapa*).

III. Nan District[5]

1. Location, Administration and Population

With 80 km away from the Province's capital, Luangprabang, Nan is the southernmost district in the Province and shares borders with Luangprabang, Xieng Nguen, Vientiane Province (Mad, Phou Khoun and Kasi) and Sayabouly Province. It has 55 villages of 4022 households.[6] Pak Xeng is administratively divided into 7 kumban[7] and 11 villages put under the *thedsabaan* administration or district's capital. There are 54 villages (5491 households) in total in the district. The population was 28554 (2011). Lao Loum accounted for 57% of the total population, followed by Khmu (34%) and Hmong and Il Mian (9%).

2. Land and Forest

The land size of the district is 1516 km^2 (151600 ha). The district has 37600 ha of protection forest, 33800 ha of watershed protection forest, 1240 ha of district's Phou Sa Kaen, 1890 ha of regeneration forest (of Phou Jong area), 2450 ha of Pha Khon Long – Pha Dang Khuay protection forest, 2300 ha of Nam Pak protection forest, and 2790 ha of Pha Haen – Pha Nuan. 45 villages stopped slash and burn activities involving 5076 households. The shifting cultivation land was reduced to about 64 ha in 2011. The following is the land by type in the district.

Table Type of Land use

Type of Land	**Size (ha)**
Agriculture	48412.4
Cropping (*pouk fang*)	363.52
Land for security purpose	26.83
Forest	100457
Industry	4.65
Culture	118.87
Public work (transportation)	155.4
Watershed	2066.1

Other industrial trees such as oil trees, teak and rubber were planted in the total area of 162 ha. Rubber plantation accounted for more than 95%.

3. Poverty and Rural Development

The district had 9 poor villages covering 595 households (16.7%). Compared to the previous years

5 This information available in this profile is derived from the district's implementation of socioeconomic development plans (SEDP) 2010-2011 and plan for 2011-2012.

6 National Committee for Rural Development and Poverty Reduction, Prime Minister's Office, May 2011.

7 They are Kumban Sivilay (6 villages), kumban Thalee (6 villages), kumban Na Meuang (4 villages), Houay Hoy (7 villages), kumban Kok Toum (7 villages), kumban Pak Mone (6 villages) and Pak Nuen (7 villages)

the number of poor household was increased by 70.[8] To address the issue, 8 village development funds were established. Two of the funds failed due to the management issue (e.g. in villages of Simoungkhoun).

4. Sectoral Development

Nan's economic growth stood at 8.2% (2011). The agriculture-forestry accounted for 63% of the growth, followed by services (20%), and manufacturing-handicraft (17%). GDP per capita was LAK6.2 million or $779.

In 2011 the district could produce rice of 16179 tons of which 9.979 tons were grown from *napii* (paddy rice field) 2010 ha, *naxeng* 650 tons in 535 ha, rotational rice production 204 tons in 186 ha. Other than rice, other crops were also grown such as jobs tear (4219 ha, 12657 tons), maize (287 ha, 1128 tons), mungbean (82 ha, 183 tons), and so forth. Livestock was another activity supporting the rural livelihoods.

5. Infrastructure

Roads

The district's main is road №A4 connecting Sayabouly Province before joining national route №13 north. This road facilitates transportation of agricultural products of farmers.

Electricity

About 89.58% of the total households had electricity, covering 31 villages. Of which 3 villages (188 households) used solar panels and 13 villages (327 households) used water turbines and 35 households in 7 villages used generators.

Irrigation

The district had altogether 137 irrigation facilities that could water 181137 ha.

Schools

There were 47 primary schools with 99% of schooling kids, 6 lower secondary schools with 92.28% of student attendance, and 2 upper secondary schools with 42.30% of attendance.

Health

51 villages (99%) could access clean water. There were 1 hospital and 7 dispensaries. The district had 32 village-based first aid kits/services of which 22 were active.

IV. Pak Ou District[9]

1. Location, Administration and Population

Pak Ou shares borders with 5 districts of Nam Bak, Pak Xeng, Luangprabang, and Chomphet, and

[8] The reason for the increase in number is due to redefinition of the national poverty line (Decree №285/PM).

[9] This information available in this profile is derived from the 9-month implementation of the district's socioeconomic development plans (SEDP) 2012-2013 and the last 3 month plan.

Nga of Oudomxay. Pak Ou is administratively divided into 7 kumban with 49 villages and 5092 households. The population stood at 26019 in 2011.

2. Land and Forest

The size of the district is 720 km^2, the smallest district among the Province's 12 districts. The rice farmland is 1503.33 ha, including the newly cleared 68.61 ha. The shifting cultivation for rice covered 1025.31 ha and 185.21 ha were reduced as part of the government efforts to reduce the area of slash and burn cultivation. The land for commercial cropping was 1099.5 ha, including starchy crops (995.19 ha), fruit trees (601.8 ha) and vegetables (142.84 ha). Land use planning was carried out for 50 villages.

3. Poverty and Rural Development

15 villages were poor with 760 households.

4. Sectoral Development

(relevant info not available)

5. Infrastructure

Roads

32 villages had access to roads during both seasons (dry and rainy) and 15 could only use the roads during the dry season. 3 villages did not have road access.

Electricity

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Irrigation

-

Schools

The district had 53 schools, including 3 secondary schools.

Health

18560 people in 38 villages (76%) had access to clean water. 32 mobile medicine funds were established across the district.

V. Nam Bak District[10]

1. Location, Administration and Population

Nam Bak District shares borders with 5 districts of Ngoi, Pak Ou (of Luangprabang), Nga, La (of

[10] This information available in this profile is derived from the district's implementation of socioeconomic development plans (SEDP) 2012-2013.

Oudomxay), and Khao (of Phongsaly). It has 83 villages of 11666 households.[11] Nam Bank is administratively divided into 9 kumban. The population was 64700 (2011). The majority of them was engaged in subsistence farming practices relying on forests and nature, and raising animals.

2. Land and Forest

The land size of the district is 1524 km^2 (152400 ha). The rain-fed rice farming (*napii*) land was 3097 ha in 2011, increased from 2911 ha in 2010; the irrigated production (*naxeng*) land was only 951 ha in 2011. The district had the permanent upland production (*hai khongthii*) land of 3500 ha (2013 planned) and the shifting cultivation land of 1000 ha (2013 planned). However, the *hai* area reported in 2011 was 6647 ha of which the district has aimed to reduce it to 4500 ha for FY2012-2013 covering 12 villages of 983 households.

The district aims to manage the forests in 3 types: conservation forest, protection forest and production forest. The shifting cultivation needs to be tackled in order to increase the forest coverage for the district.

3. Poverty and Rural Development

21 of 83 villages were considered poor, consisting of 1649 households.

4. Sectoral Development[12]

Main commercial crops (short-cycle) being promoted included maize, jobs tear, sesame, melon, etc. Other plants (medium-cycle) included fruit trees (orange, coffee, mulberry bark, cardamom, and so forth). The long-cycle trees were rubber trees (150 ha), teak (100 ha)

5. Infrastructure

Roads

The national route №13 North and Road №1C become important routes for the villagers to transport their products and communication.

Electricity

More than 70% of all households had access to electricity (2011). The electricity network would be expanded to remote villages (e.g. Phou Kou, Thong Theung, Lao Lao, etc.)

Irrigation

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Schools

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Health

11 National Committee for Rural Development and Poverty Reduction, Prime Minister's Office, May 2011.

12 The information here provides expected outputs for FY2012-2013.

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VI. Ngoi District[13]

1. Location, Administration and Population

Ngoi district is about 142 km far away from the Province's capital, Muang Luangprabang. It shares borders with 5 districts of Pak Ou, Pakseng, Viengkham, Nam Bak and Muang Mai of Phongsaly Province and also borders with Vietnam in the north. The district has Nam Ou (Ou River) running through it from north to south. It is 344 m above sea level.

Ngoi district had 105 villages comprising 6787 households and was administratively divided into 14 kumban before two of its kumban which comprised 24 villages (1299 households or 8739 people) were transferred to Phonthong district in November 2009. Phonthong was a newly established district in the Province.

As of January 2010 Ngoi had 10 kumban and 5 villages dependent to the district administration. In total there were 82 villages of 5603 households under the district. The population decreased to 30594 after the completion of the transfer. The population comprised 3 ethnic groups of Khmu, Lao Loum and Hmong. Khmu population accounted for 56% of the total population followed by 23% of Lao Loum and 21% of Hmong.

The population of the district was engaged mainly in subsistence agriculture, livestock, and services and relied on nature and forests.

2. Land and Forest

The land size of the district is 3492.4 km^2 (349240 ha) decreased by 1496.8 km^2 (or 149680 ha) after the abovementioned transfer. Of the total land, 91.35% was mountainous, followed by residential are (4.44%), tree plantation and production land (2.54%), and agricultural land (1.65%).

Ngoi is a mountain district with the total forest land of 810.23 ha of which protection forest accounted for 227.7 ha, 3.82 ha of conservation forest, 13.65 ha of regeneration forest, and 565.06 ha of industrial forest (planting rubber trees (45.15 ha), teak (478.32 ha), and agrawood (41.61 ha)), and 2 ha was pasture. Nam Ou is the main river with 15 tributaries allowing convenience for irrigation and transportation of goods and for tourism.

3. Poverty and Rural Development

Poverty remained 6.65% covering 21 villages. The villagers living in more rural remote areas were vulnerable and relied mostly on nature and forests and subsistence farming for livelihoods. Land use planning was done in 7 villages of 362 households in 7123 ha. The number of households practicing slash and burn farming was down to 2019 in 2010 from 4358 in 2004. Of which 435

[13] This information available in this profile is derived from the district's socioeconomic development plans (SEDP) 2010-2015 presented to the district's party congress IX between 7-8 Jan 2010.

households were engaged in paddy rice farming (*na*), 1346 in commercial cropping, 62 in raising animals and 176 in services. Compared to the 2004 numbers this was decreased by 46.33%.

4. Sectoral Development

The economic growth averaged 8% annually for the past 5 years until 2009. The agriculture and forestry contributed the most (83.89%) to the district's economy followed by services (14.15%) and manufacturing and handicraft (only 1.96%). GDP per capita was LAK3.9 million. 250 projects on socioeconomic development were launched for the past 5 years concentrating on food security, reduction of slash and burn farming practices, commercial production, and infrastructure development.

Between 2008 and 2009 the district could produce 8151.25 tons of rice of which paddy rice (*napii*) accounted for 3505.5 tons in 1001 ha, irrigated rice (*naxeng*) accounted for 709.65 tons in 157.7 ha and upland rice (*khao neun soung*) accounted for 3939.1 tons in 1165.68 ha. Ngoi had rice surplus for about 7 months.

Together with rice production, other crops were also promoted from commercial purposes. For instance, sesame production was increased in terms of land from 862.8 ha in 2004 up to 1112.8 ha in 2009; the same was for maize whose production land went up from 1339 ha in 2004 to 2659 ha. The most signification production taking place was in kumban Phou Thid Pheung. Pigeon pea also saw an increase from 334.1 ha in 2004 to 688.2 ha in 2009.

Livestock was another activity witnessing expansion in terms of numbers. The animals raised were cattle, buffalos, goats, etc.

5. Infrastructure

Roads

The district has №1 going through 12 villages. Many roads in other villages could be used during the dry season only making it difficult for farmers to transport their agricultural products.

Electricity

82 villages had access to electricity. Of which 1128 households used water turbines (*nam yord*) and 690 used generators. As a result, 3343 households could have an access to electricity, accounting for about 60% of the total households in the district.

Irrigation

Ngoi had 328 irrigation facilities including permanent and nonpermanent ones which could water 1157.7 ha of rice fields. Three water users' association or groups were established to manage the water use in kumban Sop Khan, kumban Sop Van and kumban Muang Seun.

Schools

Ngoi had 105 schools in total including primary and secondary schools with 9502 students. The number of children attending schools was 94%.

Health

The proportion of women and children reaching vaccination was 82% and 66 villages had gravity-fed water systems benefiting 26845 people (68.66% of the total population). Ngoi had 1 hospital, 5 dispensaries, 18 pharmacies, and the medicine fund covering 69 villages and those in remote areas.

VII. Pak Xeng District[14]

1. Location, Administration and Population

Pak Xeng shares borders with 5 districts of Luangprabang, Phonsay, Viengkham, Ngoi, Pak Ou. It has 55 villages of 4022 households.[15] Pak Xeng is administratively divided into 8 kumban. The population was 23333 (2011). The majority of them were engaged in subsistence farming practices relying on forests and nature, and raising animals.

2. Land and Forest

The land size of the district is 1314 km^2 (131400 ha). The rain-fed rice farming (*napii*) land was about 223 ha in 2011, increased from 181 ha in 2010; the irrigated production (*naxeng*) land was less than 10 ha. However, the rotational cultivation land was 623 ha and the rotational cultivation land was increased from 643 in 2010 ha to 1187 ha in 2011.

3. Poverty and Rural Development

35 of 55 villages were considered poor, consisting of 600 households (2011). In 2012 the number of poor households went down to 576 and planned to make it 403 or 10.21% of the total households.

4. Sectoral Development

Like other districts in the Province, Pak Xeng is dominated by agriculture and forestry (more than 60%), followed by manufacturing (24%) and services (15%). GDP per capita was expected to be LAK6.2 million (FY2012-2013). Main commercial crops were maize, jobs tear and sesame with a combined total of over 3100 ha.

5. Infrastructure

Roads

The district relies mainly on road №2505 which needs to be rehabilitated. Other roads in the district have been planned for construction (e.g. Houay Phiang of Viengkham district – Houay Thong of Pak Xeng).

[14] This information available in this profile is derived from the district's socioeconomic development plans (SEDP) 2012-2013.

[15] National Committee for Rural Development and Poverty Reduction, Prime Minister's Office, May 2011.

Electricity

-

Irrigation

-

Schools

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Health

-

VIII. Phonsay District[16]

1. Location, Administration and Population

Located in the northwestern part of Luang Prabang (LPQ) Province and being 64 kilometers far away from the Province's capital, Phonsay District (PX) shares borders with 6 districts, namely Pak Seng and Viengkham (North), Phou Khoun (South), Viengthong of Huaphan Province and Phou Khud of Xieng Khuang Province (East) and LPQ and Xieng Ngeun (West). It is 1,800 meters above sea level.

There are 62 villages of 4,944 households in PX, an increase from 55 villages, 4,024 households in 2004. Administratively, PX is divided into 9 village clusters or "*kumban*" and 1 district municipality (*thedsabaan*). The total population stood at 32,480 in 2011. Khmu (Lao Theung) accounts for the majority of the population (64.53%, 3,316 HHs or 20,100 people). Followed is Hmong (Lao Soung) accounting for 26.16% (1,083 HHs or 8,154 people) in 2009.

The majority of the population was engaged in upland rice farming (*khao hai* or *khao neun soung*). The supportive livelihood activities were cropping, raising animals, and family trading. The people rely mainly on nature and forests for livelihoods. In 2004, 82.75 percent of the population practiced slash and burn farming (*hai*) whereas 14.6 percent made handicraft and the remaining was in the family business in services.[17]

2. Land and Forest

PX's land size is 24,437.4 square-km (or about 244,374 hectares) and 93.28 percent is mountainous making it difficult for paddy field expansions. In 2004 the district had a total agricultural land of 7,322.14 hectares (following Table).

16 This information available in this profile is derived from the socioeconomic development plans (SEDP) 2004-2005 (published in June 2004 by the district office for statistics and planning) and SEDP 2010-2015.

17 PX SEDP 2004-2005.

Table Land Use (2004)

No	Detail	2004 (ha)
	Napii – paddy land	190.3
	Naseng – irrigated land	19.65
	Rotation farming land	3,011
	Dry-season cropping land	364.90
	Wet-season industrial cropping land	3,736.29
	Total	**7,322.14**
	Residential land	1,161.63
	Forest (appx.)	4,209.08
	Road	530.4
	Fish pond	2.95
	Pasture	3,000
	River and stream	71,318.87
	Others	112,554.93
	Total	**192,777.86**

Source: PX-SEDP 2004-2005.

The majority of the land area of the district is the conservation forest (*pa sa nguan*), watershed forest (*pa yod houay*), and regeneration forest (*pa feun fou*). According to PX SEDP 2010-2015, in 2009 a total forest area covered 26,924 hectares whereas the conservation forest area was 5,114 hectares, the regeneration forest area was 4,490 hectares, the protection forest area was 24,440 hectares and 212.33 hectares went to pasture or livestock.

Reforestation was expanded in 254.16 hectares. In addition, industrial trees were planted like Agra wood (45.63 hectares), teak (140.45 hectares), rubber trees (156.45 hectares), and *mai zui per mu* (128 hectares).

Non-timber forest products such as mulberry bark trees (134.5 hectares) and broom grass (185.25 hectares) were domesticated.

The main rivers and streams are Nam Pa, Nam Vee, Nam Therr, Nam Bak, Nam Pha, Nam Khan and other streams with potential sources for irrigation.

3. Poverty and Rural Development

The poverty rate stood at 40% covering 47 villages or 75.8% of the total villages. In other words, there were 1,373 poor households.

Measures were taken to tackle the poverty issue of the villagers. The government staff was dispatched to work with grass-root levels. Thirty two funds for instance were created to help the poor access the funding for commercial cropping and raising animals.

Together villagers were encouraged not to practice slash and burn activities and provided with new opportunities by relocating the villages to appropriate locations. For example, 8 villagers were relocated and they were Mok Jok, Kew Ya, Mok Trang, Phol, Kew Mee, Long Laet, Kew Peng, Houay Xieng, Phol Ngam, and Pak Vee.

The land use planning (LUP) was completed in 5 villages of 322 households. The completed LUP

covered 3,864 hectares and 3 villages with 1,757 households were announced "not-slash-and-burn-farming villages". Of 12 households were engaged in practicing paddy farming, 1301 in cropping, 324 in raising animals, 110 in services and about 10 engaged in other activities. As a result, the slash and burn farming land was down by 205.14 hectares.

4. Sectoral Development

The district's economic growth was 7.5% during 2004-2009. The sectoral growth was that agriculture accounted for 70%, followed by services for 25% and 5% for manufacturing and handicraft. The gross domestic product (GDP) per capita was LAK4575000.

In the 5 years (2004-2009) 5,600.5 tons of rice was produced of which 1,034.92 tons were from *napii* (rain-fed paddy) in 246.41 hectares (4.2 tons/hectare), 99 tons from *naseng* (irrigated) in 18 hectares (5.5 tons/hectare), 3,198 tons from upland rice in 2,805.86 hectares (1.14 tons/hectare). The average paddy rice was 139 kilograms/person/year.

Other crops were also promoted. For instance, sesame was grown in 1,129 hectares producing 628.15 tons. Compared with the 2004 figure it went up to 25.64%. The major sesame producing kumban were Don Kham, Phol Thong and Nam Bor.

Maize was another most grown crop in the district with 1,388 hectares producing 3,399.25 tons increased by 15% compared to the 2004 outputs. The major maize producing kumban were Sobchia, and Nam Bor.

Jobs tear was grown in 603 hectares producing 929.38 tons with an increase of 30.83% compared to the 2004 figures. There were other crops as shown in following Table.

Table Main Crops

Crops	**Area (ha)**	**Outputs (ton)**	**Increase (%)**	**Location (kumban)**
Sesame	1129	628.15	25.64	Don Kham, Phol Thong, Nam Bor
Maize	1388	3399.25	15	Sobchia, Nam Bor
Jobs tear	603	929.38	30.83	-
Bean	187	187.24	-	-
Thua hae	377.18	302.24	-	-
Cabbage	10.93	90.16	-	-
Tomato	12.6	123	-	-
Garlic and onion	15.94	14.37	-	-

Source: PX SEDP 2010-2015.

The district witnessed the increase in the number of livestock in the past year (2004-2009) as shown in following Table.

Table Livestock (2009)

Animals	**No of heads**	**% ↓↑ compared to 2004**
Cattle	10,196	↑ 11.25
Buffalo	5,485	↑ 14.97
Goat	12,152	↑ 12.7
Pig	15,862	↑ 17.9
Poultry	105,356	↓ 7.0

Source: PX SEDP 2010-2015.

There were 148,051 animals of which 10,196 were cattle (an 11.25% increase), 5485 buffalos (a 14.97% increase), 12,152 goats (a 12.7% increase).

Regarding the manufacturing and handicraft sector, most businesses are small-sized. 230 businesses were registered witnessing a 74% increase in numbers when compared to 2004.

5. Infrastructure

Roads

The district has a main road (№5204) heading to Xieng Khuang Province. During the dry season, 95.23% of the existing road is accessible in all villages. The development of road networks to remote areas or villages are made depending on the funding. 28 road development projects with 231.4 kilometers were implemented.

Irrigation

There are 122 weirs (*fai am loun*) including 3 permanent ones (e.g. Houay Loung, Houay Nga, and Nam Therr).

Schools

There are vocational training center, secondary schools and primary schools in each village. There were 69 schools (e.g. 1 kindergarten with 40 children, 15 pre-primary schools with 579 children, 66 primary schools with 6,713 pupils, 3 lower secondary schools with 1,144 pupils and 1 upper secondary school with 310. 95.41% of children attended schools.

Health

The district has 1 hospital, 8 dispensaries, 6 pharmacies, and a mobile medicine providing fund that covers 48 villages. 99% of women and children had vaccination. 23 villages were labeled "hygienic or clean". 57 villages had gravity-fed water system (*namlin*) accounting for 91% of the total population.

Energy

1,614 households had access to electricity of which 11 villages covering 891 households used power grid networks, 8 villages covering 357 households used solar panels, 313 households used (homemade) water turbine (*fai fah nam yod*), 53 households used generators. This saw a 19% increase in household electricity use.

IX. Chomphet District[18]

1. Location, Administration and Population

Chomphet District shares borders with Pak Ou, Luangprabang, and Hongsa of Sayabouly (East) and Nga district of Oudomxay (North), Xayabouly (South).

It had 67 villages of 5,143 households, administratively divided into 9 *kumbans*. Three of them were "focal" development village clusters aimed to become small towns. 20 were Lao Loum, consisting of 2,276 households; another 20 were Lao Theung of 2,157 households; and 7 were Lao Soung with 710 households. And 20 villages were ethnically mixed villages. The population totaled 28,872 of which 12,031 were Khmu, 11,702 were Lao Loum, and 5,139 were Hmong.

The majority of the population was engaged in rice farming and *hai* or shifting cultivation, followed by raising livestock, weaving, pottery, etc.

2. Land and Forest

Chomphet's land size is 1,241.1 square kilometers (or 124,110 hectares). 1,618.11 hectares were rice field (or *na*); 569.24 hectares were used of shifting cultivation fields (*hai*) of which 328 hectares were for rotation cultivation having 849 households involved; 9,584 hectares were for cropping cultivation field; 9,428 hectares were used for pasture; 790 hectares were for residential and the rest was mountainous and forest. 46 villages or 1646 households were engaged in shifting and rotation cultivation activities.

Non-timber forest products included *mak tao* (sugar palm fruits), wild orchids, broom grass, mulberry bark, bamboo shoots, etc.

3. Poverty and Rural Development

As of 2008 the district had 195 poor households (or 1,029 people) in 30 villages. Of which 115 were Lao Theung households in 13 villages, followed by 55 Lao Soung in 7 villages and 25 Lao Loum households in 1 village.

Measures taken to address poverty in the villages and households included the commercial cropping and tree plantation (e.g. pigeon pea, mulberry bark, agrawood, rubber trees) and livestock. Land use planning was completed for 57 villages, accounting for 85% of the total villages in the district. In 2008, 137.26 hectares of shifting cultivation land (*hai*) were eradicated and 158 households shifted from *hai* cultivation practices into other occupations; and 569.24 hectares of shifting cultivation land remained.

The district has the village development fund already covering 36 villages (54% of the total villages) with 1,675 members.

[18] This information available in this profile is derived from the socioeconomic development plans (SEDP) 2008-2009.

4. Sectoral Development

To the economic outputs, the agriculture-forestry accounted for 78.60% whereas the service stood at 12.23% and 9.05% went to manufacturing. FY2007-2008 witnessed 70% and 44% growth in tourism-driven services and manufacturing respectively, and agriculture-forestry saw only a 13% growth. The district's annual economic growth was 8% and GDP per capita was about US$601.

In agriculture the district had concentrated on the *napii* production (or rain-fed rice production) in 8 flat lands with a total area of 1,617 hectares and a 4.2 ton-per-hectare output. The *naxeng* rice farm land (or irrigated rice) covered 285 hectares with a 4.5-ton-per-hectare output. Shifting cultivation fields covered about 569 hectares with a 1.5-ton-per-hectare output. In 2008 the district could produce 8,930 tons (or equivalent to 309 Kg of paddy rice per person) and the district faced the rice shortage for about 2 months, equivalent to 1,175 tons.

In addition, other crops were promoted and grown in 20 hectares. Livestock and fishery for commercial purposes were also promoted. Following Table is a list of some crops grown in the district.

Table Some crops grown in Chomphet (2008)

Crops	**Area (ha)**	**Production (ton)**
Sesame	713.36	1,070.04
Maize	383.75	1,036.12
Pigeon pea (*thua hae*) for sticklac production	276.14	-
Roots	187.98	1691.82
Vegetables/leaves	181	539.6
Peanut	133.41	106.72
Chilly, egg plants	115.3	334.37
Mung bean	66.15	39.69
Jobs tear	70.06	189.16
Sugarcane	71.67	310.01

Other fruit trees and hard wood trees were planted. Following Table shows main tree planted in the district. Significantly, rubber tree plantation was increased by 200.4 hectares (or a 56% increase) from previous years.

Table Fruit trees and hard wood

Trees	**Area (ha)**
Teak	444.64
Rubber trees	357.4
Mulberry bark	110.53
Fruit trees	52.84
Agrawood	11.65

The development of tourism in the district has gained momentum attracting more number of tourists (4420 tourists recorded). The tourism sites include cultural, natural and historical attraction

such as Xieng Ngeun Temple, Chomphet Temple, Ethnic Village, and pottery village.

5. Infrastructure

Albert its location next to Luangprabang district, Chomphet's infrastructure situation is relatively underdeveloped. It was reported that a new city would be built in Chomphet a bridge over the Mekong River linking the two districts of Luangprabang and Chomphet was planned. Thus, the infrastructure development projects were planned.

Roads

A number of road construction and rehabilitation projects were proposed and implemented e.g. Xiengman-Hongsa road rehabilitation. The survey work of 6 roads were carried out (Ban Muang Kham – Ban Buam Lao (14km), Xieng Man – Ban Chan (8km), Pak Leung – Song Tai (24km), Pak Hang – Nam Hang (15km), Houay Miang – Kengken (19km) Buam Lao – Houay Tham (14.4km). The roads in the district can be used all year round and the Mekong River is the district's main transportation of agricultural goods and passengers.

Electricity

In 2008 16 villages or 1,048 households had access to state electricity (23.88%). 395 households used water turbines (*nam yord*), 52 used generators and 20 used solar panels.

Irrigation

There are 16 streams providing irrigation. The streams are Nam Houay Hang, Houay Khan, Houay Song, Houay Kaen, Houay Leum, Houay Leung, Houay Chan, Houay Tan, Houay Hong, Houay Yok, Houay Kaen, Houay Ving, Houay Sin, Houay Kohn, and Houay Hang.

Schools

The district had 71 primary schools and 4 secondary

Health

The district has 1 hospital and 6 dispensaries, and about 77% of the villages have access to gravity-fed water systems.

X. Viengkham District[19]

1. Location, Administration and Population

Viengkham is located in the northeast of and about 200 Km from the Province's capital, Muang Luangprabang. It shares borders with 5 disrticts of Phonthong, Pakseng, Phonsay, Ngoi, and Huaphanh's Viengthong.

Viengkkham had 69 villages of 4925 households administratively divided into 9 kumbans and 1 large village or district's capital. The population of the district was 29031 of which 76.1% was Khmu, followed by Lao Loum (14.3%) and Hmong (13.1%) respectively.

[19] This information available in this profile is derived from the district's socioeconomic development plans (SEDP) 2010-2011 and Planned 2011-2012 SEDP.

The majority of the population was engaged mainly in upland rice farming, followed by cropping, raising animals, etc. respectively.

2. Land and Forest

The land size of the district is 2143.67 km^2 (214,367 ha). It is a mountain district with rough terrain covering about 78% of the total land. The district had 9455 ha for raising animals. The industrial plantation was promoted to grow agrawood (77 ha), rubber trees (74 ha) and teak (277 ha). The agricultural production in the district relied mainly on shifting cultivation practices and the people continued to exploit natural forests resulting to a significant decrease in forests and natural resources. The agricultural land was 5200 ha, including 176.4 ha of paddy rice field, 1932.6 ha of shifting cultivation land (*hai*), 3091 ha of cropping land (maize, jobs tear, sesame, etc.)

3. Poverty and Rural Development

Viengkham is one of 4 poor districts in Luangprabang Province. The district's poverty was reportedly 29.17% covering 35 villages covering 1437 households. They relied on subsistence farming techniques and forests for living. The village development fund was established in 61 villages valuing LAK2.52 billion.

4. Sectoral Development

The economic growth stood at 8.7% in 2011 which was represented by agriculture and forestry (64.7%), services (32.4%), and manufacturing (2.9%). GDP per capita was US$738. In the same year 40 investment projects were approved focusing on agriculture and forestry (11 projects) and a few each for other subsectors.

The main export products were rice, agriculture products and non-timber forest products being traded with the Chinese and Vietnamese. In 2011 22 development projects were implemented mostly concentrating on agriculture-forestry instanced by the 150-ha paddy rice field in 6 kumban, agricultural land allocation, and so forth.

5. Infrastructure

Roads

As a mountain district, 8 villages did not have road access, especially kumban Vang Bong and few others. Many of the existing roads were rough and could be used in one season – the dry season.

Electricity

Electricity and telecommunication were limited to remote areas and villages in the district. 89.37% of the total households had access to electricity accounting for 12 villages. 21 villages spreading across 9 kumbans resorted to other sources of energy such as water turbine (*nam yord*).

Irrigation

-

Schools

The district had 3 secondary schools, 35 primary schools, and 32 pre-primary schools or *mulapathoum*.

Health

About 87% of the population could access gravity-fed water system accounting for 60 villages.

XI. Phou Khoun District[20]

1. Location, Administration and Population

Phou Khoun shares borders with 5 districts of Phonsay, Xieng Nguen, Xiengkhuang's Phou Khout, Vientiane's Kasi and Vangvieng. As of 2011 it had 39 villages of 3468 households. The population was 21332, an increase of 8% compared with the 2006 number. The 2006 report indicated that Lao Theung accounted for almost 67% of the total households, followed by Loum Soung, 28% and Lao Loum, 4%. It is administratively divided into 7 kumban.[21] The population was engaged mainly in subsistence farming, shifting cultivation and raising livestock.

2. Land and Forest

The land size of the district is 979 km^2 (97900 ha). In 2006 the district had 1491 ha of shifting cultivation fields, 1146 ha of rotation farming (fallow with rotation), 345.09 ha of paddy fields, and 345 ha of permanent *hai*. It was reported in 2006 that the district had rice shortage for 6 months (or about 3250 tons). Reduction of shifting cultivation was concentrated on the villages e.g. Na Nan, Tang Ou, Pha Keng Yai, Phonsay, and Sen Sii. Land allocation was done in 10 villages: Pha Wai, Chim, Phou Lang Jang, Phou Vieng Noi, Phou Vieng Yai, Phon Kham, Long Miang, Phou Soung, Phou Yang, and Sam Yaek.

3. Poverty and Rural Development

In 2006 there were 1164 poor households in the district. According to the 2011 report, the number of poor households remained 290 households spreading in 17 villages.[22]

4. Sectoral Development

The economic growth of the district reportedly stood at 7% and GDP per capita was LAK1.7 million ($172). The 2006 economic structure was that 67% was contributed by agriculture and

[20] This information available in this profile is derived from the 6-month implementation of district's socioeconomic development plans (SEDP) 2006.

[21] They were kumban Thedsabaan consisting of 6 villages, kumban Long Phod (5 villages), kumban Pha Keng Noi (6 villages), Phou Leuy (7 villages), kumban Phou Soung (7 villages), kumban Phou Vieng Noi (7 villages) and Buam Phor (6 villages).

[22] National Committee for Rural Development and Poverty Reduction, Prime Minister's Office, May 2011.

forestry, followed by services (19%), and manufacturing (14%).The crops grown for commercial purposes in the district were shown in the following table.

The crops grown for commercial purposes in the district were shown in the following Table.

Table Some crops grown in Phou Khoun (2008)

Crops/Plants/Trees	**Production (ton)**	**Area (ha)**
Maize	1661.15	664.46
Sweet corn	410.52	171.05
Sesame	364	182
Peanut	520.8	173.6
Soybean	85.1	42.55
Roots	1770.8	178.86
Ginger	715.27	310.99
Cassava	3527.16	396.31
Chilly	208.95	139.3
Vegetables	1663.39	178.86

Together with cropping, livestock was also promoted, including cattle, pig, poultry, etc. Livestock kumban were Chim, Phou Vieng Noi, Phou Soung, Thedsabaan, and Pha Kieng Noi. Poultry villages included Jang Euan, Phou Leoy, and Houay Sa Taep.

5. Infrastructure

Roads

The national route №13 North passes through part of the districts (10 villages) and Road №7 cuts through the district (linking 7 villages in the district) and connects with Route №13 to Xieng Khuang Province. There were about 17 villages located in remote areas with difficult road access.

Electricity

70% of all households had access to electricity (2011)

Irrigation

-

Schools

Phoukhoun had 39 schools. 36 were primary ones and the rest were secondary ones. These 39 schools accommodated 5167 students. Non-formal education was also offered to illiterate people. With this 1712 people in 24 villages could read and write.

Health

-

XII. Phonthong District[23]

1. Location, Administration and Population

Phonthong was established in 2009. Two kumban of Ngoi district comprising 24 villages (1299 households or 8739 people) were put under the newly established Phonthong administration. Phonthong district shares borders with 4 districts: Ngoi and Viengkham (Luangprabang), Mai (Phongsaly), Viengthong (Huaphan) and Vietnam. Phonthong had 38 villages of 2589 households and administratively divided into 5 kumbans. The population totaled 18,920 represented by Hmong (33.67%), Khmu (33.05%) and Lao Loum (33.26%). The majority of the population was engaged in subsistence rice farming and *hai* or shifting cultivation, followed by raising livestock, weaving, pottery, etc.

2. Land and Forest

The size of the district is about 2089 km^2. The district's forest coverage is 120235 ha, followed by agriculture land of 86499 ha, residence 696 ha and so forth (following Table).

Table Type of Land use

Land Types	**Size (ha)**
Forest	120,234.76
Agriculture	86,498.79
Residence	696.21
Culture	392.64
Roads	202.35
Manufacturing	195.98
National defense and security	61.23

Land allocation was still ongoing. For instance, the residential land of 17 hectares was assigned for 7 villages (e.g. Nam Luang, Pak Tha, Houay Tha, Na Vat, Vang Xieng, Poung Bor, and Houay En). The agricultural land was also measured for the 3 villages of 314 households to manage and use covering 550 hectares. Together the land use planning was done at the village and kumban levels across the district. The total rice field area was 609.37 hectares and 23.5 hectares were cleared for rice farming.

3. Poverty and Rural Development

Phonthong is one of the 4 poorest districts in the Province.[24] 30 out of 38 villages were categorized "poor".

[23] This information available in this profile is derived from the 6-month implementation of the district's socioeconomic development plans (SEDP) 2011-2012 and the last 6 month plan (March 7, 2012).

[24] The other three poorest districts were Phonsay, Pak Xeng, and Viengkham (according to the implementation report of the agriculture and forestry development sector of the provice (№537 of June 28, 2012).

4. Sectoral Development

(info not available)

5. Infrastructure

Phonthong is a relatively new district of the Province. Infrastructure like public facilities / offices (e.g. schools, DAFO office, Health office…) were being planned and constructed.

Roads

An important road of the district is road № 2508 of 55 Km, connecting Phou Thid Pheung to Vietnamese border.

Electricity

-

Irrigation

-

Schools

The district had 54 schools (1 secondary school, 18 primary schools, and 22 *mulapathoum*) with 4101 students in total. FY2011-2012 aimed to reach 99% of the schooling age in the district.

Health

The district has 1 hospital and 2 dispensaries. 18 villages (11245 people) have access to gravity-fed water systems or equivalent to 61.13% of the total population. 34 villages had 76 health volunteers stationed in the village.

Appendix 2 Household Survey Questionnaire

Date_____

Name of Interviewer_____

Questionnaire sheet in Phonsay District
Study on consciousness of villager to land use change

1. Basic information

1) Kumban and village names:_____
2) Interviewee_____
   Age_____Ethnic_____Sex_____Relationship with Household head:_____
3) Household head_____Age_____Ethnic_____Sex_____(☐same person as above)
4) Family member:_____, Women:_____, Labor:_____, Children(under15):_____, Absentee*:_____
   *"Absentee" means he / she lives in other places more than six months a year.)____
5) Occupation of HH head & Interviewee

5.1. Occupation of HH	**Choose [Yes/No]**	**Monthly Earning (Kip)**	**From Month to Month**
[On-farm (including livestock)]			
a) ☐*Sauna*	Yes / No		
□Farming on own land	Yes / No		
□Farming on rented land	Yes / No		
□Others_____	Yes / No		
b) ☐*Saohai*	Yes / No		
□Farming on own land	Yes / No		
□Farming on rented land	Yes / No		
□Others_____	Yes / No		
[Off-farm]			
c) ☐Civil servant / teacher / army	Yes / No		
d) ☐Wage Labor (short-term employed labor)	Yes / No		
e) ☐Self-employed business / vender	Yes / No		
f) ☐ Others_____	Yes / No		

5.2. Occupation of Interviewee	**Choose [Yes/No]**	**Monthly Earning (Kip)**	**From Month to Month**
[On-farm (including			

livestock)]			
a) ☐*Sauna*	Yes / No		
□Farming on own land	Yes / No		
□Farming on rented land	Yes / No		
□Others_____	Yes / No		
b) ☐*Saohai*	Yes / No		
□Farming on own land	Yes / No		
□Farming on rented land	Yes / No		
□Others_____	Yes / No		
[Off-farm]			
c) ☐Civil servant / teacher / army	Yes / No		
d) ☐Wage Labor (short-term employed labor)	Yes / No		
e) ☐Self-employed business / vender	Yes / No		
f) ☐ Others_____	Yes / No		

6) Migrated year of Household: _____Year

Move from village in reason; / Born here

7) Education Level of Household head

	Primary	Lower secondary	Upper secondary	Post secondary
graduate/dropout	1 2 3 4 5	1 2 3 4	1 2 3	1 2 3 4 5 6 7

8) Household head has never attended schools _____

9) Household head attended training relating to farming improvement, etc. _____

2. Current land use & land use change: draw resource map & fill in blank

	Information of land	Before 2003	2003	2004	2005	2006	2007	2008	2009	2010	2011
ex.	Crop's name: upland rice[1]ha [0.5]t [3]plots(rotation, use no.1-3) Fallow: 3 yrs Place/Dist.: beside --- stream / 30min by walk Acquisition process: ☐ Gov. provide, ☐ Others( ) Occupation: Own/common/borrow/lend land				←		Change upland rice to job's tear		Gov. took		→
1	Crop's name:_____[ ]ha [ ]t [ ]plots Fallow:_____ Place/Dist.:_____ Acquisition process: ☐ Gov. provide, ☐ Others( ) Occupation: Own/common/borrow/lend land										
2	Crop's name:_____[ ]ha [ ]t [ ]plots Fallow:_____ Place/Dist.:_____ Acquisition process: ☐ Gov. provide, ☐ Others( ) Occupation: Own/common/borrow/lend land										
3	Crop's name:_____[ ]ha [ ]t [ ]plots Fallow:_____ Place/Dist.:_____ Acquisition process: ☐ Gov. provide, ☐ Others( ) Occupation: Own/common/borrow/lend land										
4	Crop's name:_____[ ]ha [ ]t [ ]plots Fallow:_____ Place/Dist.:_____										

	Acquisition process: ☐ Gov. provide, ☐ Others( ) Occupation: Own/common/borrow/lend land											
5	Crop's name:_____[ ]ha [ ]t [ ]plots Fallow:_____ Place/Dist.:_____ Acquisition process: ☐ Gov. provide, ☐ Others( ) Occupation: Own/common/borrow/lend land											
6	Crop's name:_____[ ]ha [ ]t [ ]plots Fallow:_____ Place/Dist.:_____ Acquisition process: ☐ Gov. provide, ☐ Others( ) Occupation: Own/common/borrow/lend land											
	NTFP:_____ Place:_____											

Check sheet for Interviewee

Please check the lists below, after you got information about interviewee's land use trend.

☐ Total land size (current). / Divide shifting cultivation and paddy.

☐ Total plot size of shifting cultivation (current).

☐ Process of getting land
- ☐ When did they start the farming in this village?
- ☐ Who gave the land? : Ex. Government, village head, parents, other villager, by himself and so on.
- ☐ What is the former land use? : Did they develop the forest or fallow land of others?

☐ Farming style:

- ☐ Rotation or Pioneer
  - ☐ Fallow year / Continuously used period
- ☐ How many plot does interviewee use in a year (farming season)?

☐ Land occupation

☐ Past utilization : (If interviewee can answer, please check.)

In case of interviewee changed or abandoned farming land

- ☐ Reason
- ☐ Former utilization : Ex. Change from shifting cultivation to paddy

Please answer 5 step assessments.

3. Consciousness of Decision making in village

Purpose: To clarify the villager's bottom-up participation in village meeting	Level of appreciation 1-Never 2-Seldom 3-Middle 4-Often 5-Everytime	Remarks
Q1. How often village meeting is held at one month?	_____times per month	
Q2. How often do you attend the meeting to discuss village policy and activities or village rule (regular meeting)	1 2 3 4 5	
Q3. How often do you make a statement in the village meeting?	1 2 3 4 5	
	Level of appreciation 0-Never 1-Low 2-Middle Low 3-Middle 4-Middle High 5-High	
Q4. Have you participated in any discussion to decide land use in a village?	0 1 2 3 4 5	
Q5. Have you participated in any discussion to decide agricultural topic?	0 1 2 3 4 5	
Q6. Have you participated in any discussion of using water sources (water spring, well)?	0 1 2 3 4 5	
Q7. Have you participated in any discussion to decide rules for forest management/operation?	0 1 2 3 4 5	
Q8. How do you think it is necessary to make a decision by all villagers to decide village land use plan?	1 2 3 4 5	
Q9. Who should decide the village land plan for better land use in the future?	☐Government, ☐Village head(include village committee), ☐Yourself or family, ☐Ordinary villager, ☐ Others( )	
Q10. Are you satisfied with a process of decision making in the village meeting?	1 2 3 4 5	

4. Consciousness of Group activity

Purpose: To clarify villager's recognition or behaviour of cooperation activities as group	Level of appreciation 1-Low 2-Middle Low 3-Middle 4-Middle High 5-High	Remarks
Q11. How often do you join the group activity to cooperate with each other for improving your daily life?	1 2 3 4 5	
And what kind of cooperation?		
Q12. Have you cooperated with others to implement slash/burn operation for farming land?	1 2 3 4 5	

Q13. Have you cooperated with others to implement irrigation operations for paddy field?	1 2 3 4 5	
How do you think these are benefits of group activity or not?		
Q14. Making products efficiency	1 2 3 4 5	
Q15. Transferring technique or knowledge among villager (farmer to farmer)	1 2 3 4 5	
Q16. Enforcing insistence of group among village	1 2 3 4 5	
Q17. How do you think group is better than individual to resolve your problem such as improving productivity, earning much money?	1 2 3 4 5	

5. Consciousness of forest

Purpose: To clarify the impact of deforestation and forest degradation by villager's forest utilization.	Level of appreciation 1-Low 2-Middle Low 3-Middle 4-Middle High 5-High	Remarks
Q18.How often do you use the forest for collecting fuel wood? *If the interviewee buys it, please note at Remarks.*	1 2 3 4 5	
Q19. How much fuel wood do you collect?	_____/week or month or year Total:_____kg/year	
Q20. What kind of wood do you collect for fuel wood?	☐Cutting living wood, ☐Dead wood	
Q21. Where do you get the fuel wood?	☐Natural forest, ☐Plantation	
Q22. How often do you collect the NTFP in the forest?	1 2 3 4 5	
Q23. How often do you use the forest to get timber for construction?	1 2 3 4 5	
Q24. How much timber do you collect? And What kind of wood do you collect?	_____/week or month or year _____	
Q25. How often do you use the forest for livestock grazing?	1 2 3 4 5	
Q26. Where do you use for grazing? If they use common land, ask place and number of household using it.	☐Natural Forest ☐ Common land, place:_____,___ HH ☐Fallow land, ☐ Others( )	
How do you think about the benefit (value) of forest?	Level of appreciation 1-Low 2-Middle Low 3-Middle 4-Middle High 5-High	Remarks
Q27. Getting firewood	1 2 3 4 5	
Q28. Getting NTFP	1 2 3 4 5	
Q29. Getting timber	1 2 3 4 5	
Q30. Getting compost materials	1 2 3 4 5	
Q31. Role of reserve area for farming	1 2 3 4 5	
Q32. Providing fertile into soil	1 2 3 4 5	
Q33. Keeping water source	1 2 3 4 5	
Q34. Protecting land slide	1 2 3 4 5	

6. Capacity of maintaining livelihoods

Purpose: To clarify villager's capacity to maintain their livelihood.	Level of appreciation(satisfaction) 1-Low 2-Middle Low 3-Middle 4-Middle High 5-High	Remarks
Q35. Do you have enough land size for farming? If you lack the farming land, how much land do you want?	1 2 3 4 5 Current:_____ ha, Need:_____ha	
Q36. Do you have enough knowledge or techniques to get necessary products for a living?	1 2 3 4 5	
Q37. Can you get enough rice production for family?	1 2 3 4 5	
Q38. How much rice do your family consume per month?	_____Kg/month	
If interviewee suffers the food shortage, ask Q38 & Q39.		
Q39. Food shortage period and shortage amount	from_____to_____;_____kg	
Q40. The way of getting food *If they have to pay some money or interest, please note at Remarks.*	☐buying at market, ☐borrow from rice bank, ☐borrow from relative, ☐consume other food like cassava or taro, ☐ Others( )	
Q41. Do you satisfy the situation of water for farming?	1 2 3 4 5	
Q42. Accessibility to farming places	1 2 3 4 5	
Q43. Do you satisfy your income?	1 2 3 4 5	

7. Options of daily life

How do you feel the satisfaction about these situations?	Level of appreciation 1-Low 2-Middle Low 3-Middle 4-Middle High 5-High	Remarks
Q44. Situation of water for daily life use	1 2 3 4 5	
Q45. Situation of health service And ask the reason of interviewee's answer	1 2 3 4 5	
Q46. Situation of education for your family And ask the reason of interviewee's answer	1 2 3 4 5	
Q47. Situation of transportation	1 2 3 4 5	
Q48. How often do you go outside village?	1 2 3 4 5	
Q49. What is your purpose going outside? If interviewee has several options, please ask top three.	☐Selling products at _____, ☐Buying products at _____, ☐Go to hospital, ☐Go to day work at_____, ☐ Others( )	
Q50. How do you go to outside village? If interviewee has several options, please ask top three.	☐By bike, ☐By bicycle, ☐By public vehicle, ☐By walk, ☐ Others( )	

8. What kind of alternative livelihoods do you want instead of slush & burn farming?

9. Please rank (1-14) the following alternative livelihoods you think the most suitable to help reduce or stop slash and burn farming.

Alternative Activities	**Ranking (1-14)**
• Commercial cropping	
• Rice farming	
• Trading	
• Raising small livestock	
• Raising large livestock	
• Shifting cultivation	
• Laboring	
• Planting fruit trees	
• Weaving (silk, cotton)	
• Weaving bamboo, rattan, etc.	
• Planting industrial trees: teaks..	
• Planting industrial trees: rubber trees.	
• Fishing	
• Others: ____	

Appendix 3 Appearance of socio-economic survey

Filed survey in HK-VC 11. Oct. 2012-13. Nov. 2012

Meeting with village head
(12. Oct. 2012, Houay Khing village)

Landscape
(12. Oct. 2012, Houay Khing village)

Landscape
(12 Oct. 2012, Houay Khing village)

Landscape
（12. Oct. 2012, Houay Khing village）

Start-up workshop
(13. Oct. 2012, Houay Ha village)

Start-up worshop
(13. Oct. 2012, Houay Ha village)

Interview with villager
(13. Oct. 2012, Houay Ha village)

Interview with villager
(13. Oct. 2012, Houay Ha village)

Interview with villager
(15. Oct. 2012, Houay Khing village)

Pineapple garden near rice field
(26. Oct. 2012, Houay Khing village)

Paddy(Houay mian area)
(26. Oct. 2012, Houay Khing village)

Private check dam to keep water for paddy
(26. Oct. 2012, Houay Khing village)

Simple irrigation
(26. Oct. 2012, Houay Khing village)

Water source of paddy
(26. Oct. 2012, Houa Khing village)

Slash and burn area near paddy field
(26. Oct. 2012, Houay Khing village)

Thrashing of rice
(26. Oct. 2012, Houay Khing village)

Slash and burn farming area
(27. Oct. 2012, Houay Khing village)

Slash and burn farming area
(27. Oct. 2012, Houay Khing village)

Slash and burn farming area
(27. Oct. 2012, Houay Khing village)

Slash and burn farming area
(27. Oct. 2012, Houay Khing village)

Interviewe with villager
(27. Oct. 2012, Houay Khing village)

Interview with villager
(27. Oct. 2012, Houay Khing village)

Sanam at slash and burn farming area
(27. Oct. 2012, Houay Khing village)

Sanam at slash and burn farming area
(27. Oct. 2012, Houay Khing village)

Interview with villager
(10. Nov. 2012, Houay Tho village)

Bamboo house
(10. Nov. 2012, Houay Tho village)

Coffee in kitchen garden
(10 Nov. 2012, Houay Tho village)

Kitchengarden
(10. Nov. 2012, Houay Tho village)

Common area for livestock raising
(10. Nov. 2012, Houay Tho village)

Common area for livestock raising
(10. Nov. 2012, Houay Tho villgae)

Field survey in HK-VC and Sobchia village cluster Apr 2013

Nursery house
(24 Apr. 2013, Phak Bong Village)

Nursery
(24 Apr. 2013, Phak Bong Village)

Nursery
(24 Apr. 2013, Phak Bong Village)

Nursery
（24 Apr. 2013, Phak Bong Village）

Nursery
(24 Apr. 2013, Phak Bong Village)

Doukdua stocked in the village
(24 Apr. 2013, Phak Bong Village)

Coffee Nursery supported by TABI
(25 Apr. 2013, Houay Khing Village)

Coffee Nursery supported by TABI
(25 Apr. 2013, Houay Khing Village)

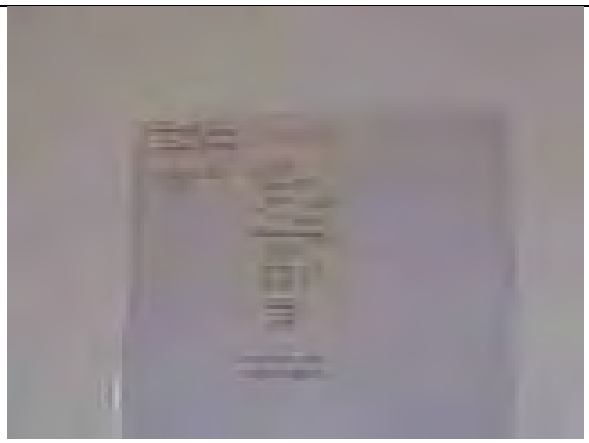
Village market by Chineese trader
(25 Apr. 2013, Houay Khing Village)

Fence for chicken
(25 Apr. 2013, Houay Khing Village)

Meeting for demonstration activities
(26 Apr. 2013, Houay Khing Village)

Meeting for demonstration activities
(26. Apr. 2013, Houay Khing Village)

Meeting for demonstration activities
(26 Apr. 2013, Houay Khing Village)



Meeting for demonstration activities
(26 Apr. 2013, Houay Khing Village)

Candidate site of nursery
(26 Apr. 2013, Houay Khing Village)

Landscape of the REDD plus target village
(26 Apr. 2013, Houay Khing Village)